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Leveraging gender, youth and social networks for inclusive and transformative livestock production in the tropics and subtropics

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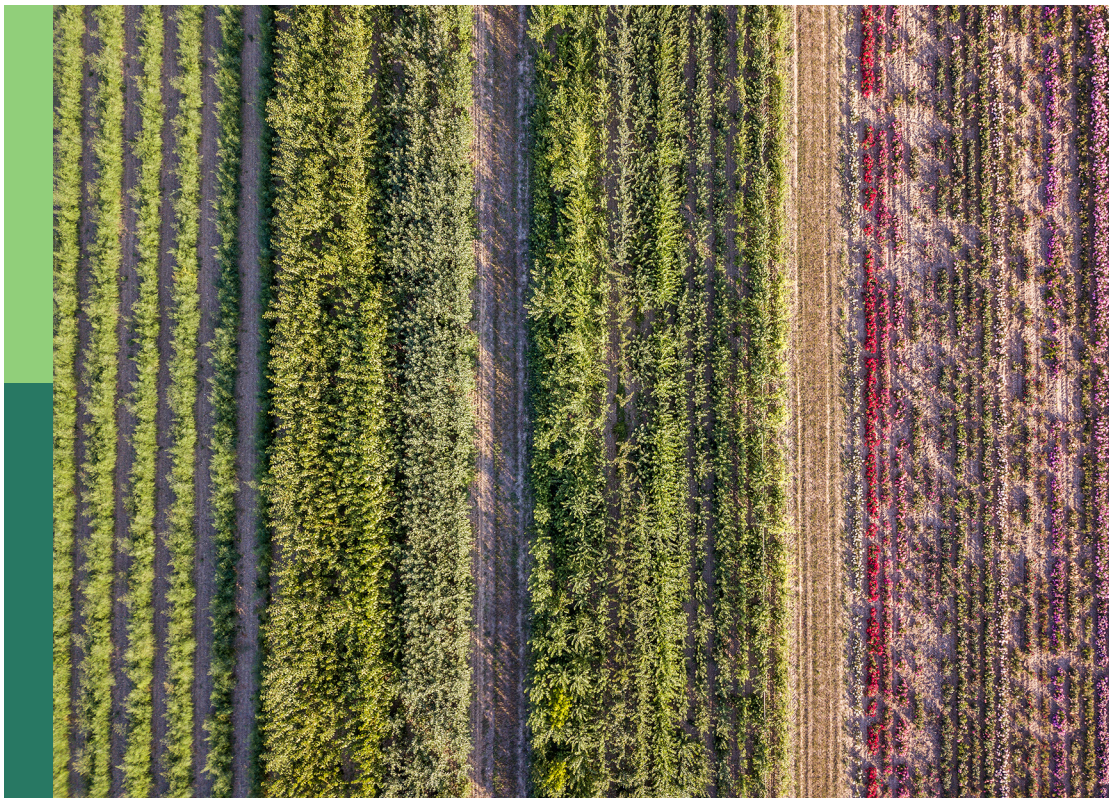

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Leveraging gender, youth and social networks for inclusive and transformative livestock production in the tropics and subtropics

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Editorial: Leveraging gender, youth and social networks for inclusive and transformative livestock production in the tropics and subtropics

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Editorial on the Research Topic
Leveraging gender, youth and social networks for inclusive and transformative livestock production in the tropics and subtropics

The Research Topic titled *"Leveraging Gender, Youth, and Social Networks for Inclusive and Transformative Livestock Production in the Tropics and Subtropics"* is an exploration of the interconnected social dynamics that shape livestock systems in these regions. The articles within this Research Topic underscore the necessity of integrating social factors such as gender roles, youth engagement, and community networks into the broader agenda of sustainable livestock production.

Gender dynamics in livestock value chains

A recurring theme in this Research Topic is the gendered nature of livestock value chains. As an example of this, Kinati et al. provide an in-depth analysis of small ruminant value chains in Ethiopia, examining how gender affects market participation, decision-making, and income control. Their findings reveal significant gender imbalances, with men typically holding more control and decision-making power than women. Nonetheless, the study also indicates that women's involvement in value chains can encourage more equitable decision-making behaviors, although it does not necessarily lead to empowerment. This highlights the need to pair value chain participation with targeted interventions addressing underlying gender inequalities. Nagasha et al. explore how incorporating gender perspectives can improve milk safety and value chains in Uganda's smallholder farming systems. The authors stress the importance of women's roles in dairy production and the need for specific interventions to tackle gender-related challenges. Their research examines ways to enhance milk quality, market access, and economic opportunities for smallholder farmers, with a particular focus on empowering women in the livestock sector. Farnworth, Galiè et al. investigate women's seed entrepreneurship in aquaculture, maize, and poultry value chains in Ghana, Kenya, and Tanzania. Authors highlight the challenges and opportunities for women in these sectors, focusing on their roles in food security and economic development. This study emphasizes the need

for gender-inclusive policies and access to resources such as finance, technology, and training to support women entrepreneurs. It also discusses the broader implications for sustainable food systems and the necessity of creating supportive environments for women's participation in agriculture.

Furthermore, the study conducted by Brückner and Sardavar discusses the often-overlooked contributions of households and unpaid labor in global agrifood chains, underscoring the necessity for gender-responsive analysis. The authors argue that research in agrifood chains has traditionally centered on production and economic factors while neglecting the vital roles of consumption and domestic work, typically performed by women. In this regard, Farnworth, Ravichandran et al. address the complexities of achieving transformative change at the intersection of caste and gender in India. They assess the impact of strategies implemented by a dairy cooperative to empower women across various castes. Their findings show that these strategies have improved gender relations within households and enhanced decision-making related to dairy activities. However, these forms of empowerment remain largely confined to the dairy context and do not address the implications of broader caste norms. The cooperative they study has established a new norm allowing marginalized caste women to become dairy farmers, yet it has not tackled the wider structural disadvantages these women face, resulting in unequal benefits from empowerment.

In a different setting, Hernandez et al. explore the cultural and economic barriers affecting women's involvement in crop and livestock production systems in Guatemala. They reveal that cultural constraints often confine women to household roles and unpaid activities, limiting their participation in income-generating tasks like crop production, which is predominantly male-dominated. Even when men migrate or engage in non-agricultural jobs, women rarely assume crop-related tasks, they argue. Women's aspirations generally focus on small-scale livestock activities or emigration to improve their livelihoods, though emigration is both risky and costly. They also face difficulties in envisioning futures outside the household and articulating their ambitions. Economic barriers, such as limited resources and market access, further hinder women's ability to expand and commercialize small-scale livestock activities. Regarding context-responsive strategies, Bullock et al. analyze how climate change adaptation strategies in livestock production need to be tailored to different locations and systems in Ethiopia, taking into account social factors like gender, wealth, age, and education. Their findings suggest that youth are engaged with various livestock species, including chickens and dairy cows, with gender and location influencing which species are reared. Adaptation practices are generally low among youth, with gender differences in practices and household relationships affecting engagement. Although opportunities for women to inherit or acquire land have improved, gendered access to resources and labor continues to be a challenge.

Youth in livestock farming

Youth engagement is another crucial aspect covered in this Research Topic, with migration and involvement in livestock farming under climate change being especially pressing for young people in livestock-dependent regions. Nchanji et al. explore shifts in youth participation in livestock production across Sub-Saharan Africa, addressing the challenges posed by a growing youth population and the need for agricultural job creation. The authors point out the limited research on this Research Topic, particularly focusing on countries such as Kenya, Uganda, Nigeria, Chad, and Ethiopia, and emphasize difficulties such as language barriers and existing social conflicts. Their study shows that current literature primarily covers pastoral communities, with less attention given to agropastoral and zero-grazing systems. Youth empowerment in livestock production often comes from self-initiated methods like animal gifting, savings groups, and community engagement. Education plays a crucial role, with some young women acquiring more knowledge than their male peers and youths in certain regions using education to transition from traditional livelihoods. The also study highlights that, despite enduring gender norms and traditions, youths are overcoming obstacles through strategies like experience-sharing events and advocacy against harmful practices. Information and Communication Technology (ICT) is identified as a vital factor in boosting youth engagement, offering access to educational resources and modernizing livestock farming practices. In a similar fashion, Tilahun and Holden examine the factors influencing rural youth in Ethiopia regarding their decision to stay in agriculture or migrate, particularly in the context of efforts to rehabilitate degraded lands. Their study finds that improving asset endowments (such as oxen) and enhancing land access can encourage youth to remain in agriculture, thus supporting sustainable livelihoods and mitigating migration.

Social networks, collaboration, and cultural dynamics

Another key theme in this Research Topic is the role of social networks, collaboration, and cultural dynamics in shaping livestock systems. Research on small-scale cattle farming in Mexico's Yucatán Peninsula highlights that local social organization and cultural practices significantly influence how farmers adapt to climate variability and other challenges (Pérez-Lombardini et al.). Using participatory modeling techniques, the study demonstrates that social factors are as crucial as technical and environmental considerations for promoting sustainable livestock farming. These findings emphasize the need for approaches that are both environmentally sound and socially inclusive, while respecting existing cultural practices.

Similarly, Kotobiodjo et al. examine the factors affecting the adoption and expansion of integrated crop-livestock-forestry (ICLF) systems by rural households. Their study includes a systematic review and bibliometric analysis to identify the main drivers, barriers, and enablers of scaling up these sustainable agricultural practices. It underscores the significance of socioeconomic, environmental, and policy factors in encouraging the widespread adoption of ICLF systems, which are vital for enhancing food security, resilience, and environmental sustainability in rural areas. Slayi et al. conduct a systematic review of the potential of communally established cattle feedlots as a sustainable livelihood strategy to improve climate change resilience and food security in sub-Saharan Africa. Their synthesis

of existing literature highlights the benefits and challenges of these communal feedlots, such as sustainable livestock management, economic impacts, and their role in strengthening climate resilience. The review stresses the importance of socio-economic and institutional factors in determining the success of these initiatives, identifying key challenges like land tenure, community engagement, and resource allocation that need to be addressed for successful implementation.

Finally, Perin and Enahoro explore future challenges and potential transformations in the dairy sector in Kenya and Senegal. The authors identify key challenges including population growth, climate change, and socio-economic issues, which require a comprehensive approach to dairy production. The trend toward intensification in dairy farming—driven by land fragmentation, government incentives, and market opportunities—may result in fewer but more productive farms. However, this intensification brings environmental and socio-economic risks such as feed and water scarcity, health threats to animals, and reduced milk quality. Population growth exacerbates these challenges with issues related to market access, land pressure, and high production costs. While intensification could offer opportunities for women and youth, it also presents challenges. High production and investment costs may limit benefits to those who can afford intensified systems, and youth migration to cities and potential conflicts over land and resources could affect the sector's resilience. The authors recommend adopting climate-smart practices, effective policy design, and efficient production coordination. Balancing dairy production with agro-climatic conditions, land availability, and socio-economic contexts is essential for maintaining resilience and sustainability in the dairy sector.

Toward a holistic approach to livestock production

Collectively, the articles in this Research Topic advocate for a holistic approach in the study of livestock production in the tropics and subtropics. Such an approach recognizes that social factors, such as gender roles, youth engagement, and social networks and collaboration, are not peripheral to livestock systems but are central to their success. By integrating these social dimensions with technical and environmental strategies, it is possible to create livestock systems that are not only more sustainable but also more equitable and inclusive. This Research Topic calls for a paradigm shift in how livestock production and producers themselves are being approached. Traditional models that focus solely on technical improvements or environmental sustainability are insufficient to address the complex challenges faced by producers and their systems in these regions. Instead, there is a need for approaches that also consider the social dynamics at play, ensuring that all stakeholders, especially those who are often marginalized, have a voice and a stake in the future of these systems. In conclusion, this Research Topic provides valuable insights into the critical role of gender, youth, and social networks in livestock production. By highlighting the importance of these social dimensions, the issue sets the stage for more inclusive and transformative livestock systems that are resilient in the face of climate change, equitable in their distribution of benefits, and sustainable for future generations.

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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.

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Livelihood diversification and migration intentions among land-poor youth in Tigray, Northern Ethiopia: do they correlate with livestock assets, trust, and trustworthiness?

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Youth unemployment has been prevalent in Ethiopia. Over the past decades, efforts to rehabilitate degraded communal lands have been taking place in Ethiopia. This has created the opportunity to organize landless and land-poor youth and implement a policy of allocating rehabilitated lands for youth to engage in agriculture as a livelihood option. However, whether these rural youth will remain in agriculture or choose other livelihood options including migration, and how their trusting behaviors (trust and trustworthiness) and other factors influence their choices are worth investigating and are the aims of this study. This will help our understanding of what would incentivize the youth to enhance their livelihoods. We used data collected from samples of 1,138 youth group members in the 2016 survey and from 2,427 youth group members in the 2019 survey in five districts of the Tigray region of Northern Ethiopia. Our results from panel data multinomial logit and probit models show that the number of oxen, access to land in the land rental market, and income from youth group activity significantly correlated with youth group members' choices for livelihood options and planning for migrating out of the country. A higher number of oxen owned by the youth group members are associated with a higher likelihood that the youth choose agriculture as a livelihood. Youth group members with a larger number of oxen are also less likely to plan for migration. We also found that more trusting youth group members are more likely to choose off-farm employment relative to staying in agriculture than less trusting members. More trustworthy members are less likely to migrate and more likely to stay in agriculture because trustworthiness is associated with better access to land in the rental market. Thus, improving youth group members' access to land and their asset endowments such as oxen for increasing the productivity of youth group activity and hence income would incentivize youth group members to stay in agriculture and enhance youth group activity as a sustainable livelihood.

KEYWORDS

youth, livelihood, livestock, migration, trust, trustworthiness, Ethiopia

1. Introduction

Youth unemployment has been a major global concern over the last decade and major global events like the financial crisis of 2009, the recent COVID-19 pandemic, and conflicts in different parts of the world have triggered a sharp rise in youth unemployment. The global youth unemployment rate in 2022 was estimated to be 14.9%, it was 15.6% in the previous year, and unemployment among young people is more than three times more common than among adults [International Labour Organization (ILO), 2022]. The youth unemployment rate in Africa is 12.7 % and looks lower than the global average, but young people in Africa have had to face the consequences of the recent setbacks to the global economy. The COVID-19 pandemic put significant socio-economic pressure on the region, with the impacts of global and local lockdowns, value chain disruptions, and widespread economic downturns. Furthermore, recent environmental hazards and erupting conflicts in some parts of the region have taken a heavy toll on the economic prospects of many countries. Going forward, recent food price spikes and disruptions to energy markets are creating additional challenges for the region [International Labour Organization (ILO), 2022].

Ethiopia is the second most populous country in Africa with a total population of 120.28 million in 2021 of which 77.83 % live in rural areas (World Bank, 2023) with agriculture as the main livelihood. The country like other Sub-Saharan African countries has the youngest population in the world. Ethiopia's youth in the age group of 15–29 and children in the age group of 0–14 accounted for 29.9 % and 39.6% of the country's population in 2021, respectively (World Bank, 2023). Although the country has been able to register sustained and fast economic growth over the last one and half decades, the rate of growth in the youth population is higher than the economy's capacity to create employment opportunities. Recently, the youth is facing significant social-economic pressures due to several shocks such as the COVID-19 pandemic, a devastating armed conflict, drought, and soaring inflation. Unemployment, especially among the youth, in Ethiopia is pervasive, and in 2021, the unemployment rate among youth aged 15–29 was 11.8 % (or 7.4 % of male youth and 16.4 % of female youth) [Central Statistical Agency (CSA), 2021]. The youth unemployment rate is higher than the 8 % national unemployment rate among the economically active population aged 10 years and above reported in the 2021 labor force and migration survey of Ethiopia [Central Statistical Agency (CSA), 2021].

Most of the youth in Ethiopia live in rural areas with agriculture as their main livelihood. All land in Ethiopia is owned by the state, and there are restrictions on the land market and land cannot be sold. Rural residents have been guaranteed access to land through a law that grants them a right to obtain agricultural land for free with a user right. However, it has become increasingly more difficult to fulfill this right for the youth and the country is facing severe land scarcity in parts of the highlands where population densities have become very high and farm sizes have become very small. Land as a safety net is eroding, and landlessness is rising among the youth who are unable to stay on their parents' land (Bezu and Holden, 2014). This is true in the Tigray region of northern Ethiopia and many other parts of the highlands of Ethiopia where most farmers cultivate less than one hectare of land.

In Ethiopia, there are restrictions on land markets, and selling and buying of land are illegal, but farmers can rent out lands for which they have use rights. In addition, there are almost no or very few large commercial farms that can provide farm-wage employment to land-poor rural youth (Bezu and Holden, 2014). In such conditions, access to farmland and oxen are important factors that determine whether a rural resident youth can depend on smallholder agricultural livelihood (Gebru et al., 2019; Gebrehiwot and Holden, 2020; Holden and Tilahun, 2021b). In Ethiopia's smallholder crop-livestock production system, oxen are used as traction power, while the market for such traction power functions poorly; therefore, oxen ownership is crucial for the ability to farm. In addition, addressing youth unemployment requires youth-inclusive policies that could generate livelihood options for the youth. Ethiopia has been investing in sustainable land management and rehabilitation of degraded lands since the 1990s through community-based land management and support from international donors through food for work and productive safety net programs. Tigray Region of northern Ethiopia received the Future Policy Gold Award 2017 from the World Future Council and the United Nations Convention to Combat Desertification (UNCCD) for its youth-inclusive land restoration policy (World Future Council, 2017). The region has been implementing a policy of allocating rehabilitated hillsides to landless and unemployed youth by forming youth business groups (Holden and Tilahun, 2018). The aim of the policy of allocating the rehabilitated land to organized youth groups was to let the youth engage in sustainable livelihood options such as beekeeping, livestock rearing/fattening, horticulture/irrigation, forestry, and, at the same time, sustainably managing the allocated land that was rehabilitated by communities (Holden and Tilahun, 2018). It is, therefore, worth assessing the choices of youth group members for diversifying their livelihood and their intention for migration and the factors that determine such choices.

In this study, we assess rural youth group members' planned livelihood choices in northern Ethiopia based on primary data collected in 2016 and 2019 and using panel data multinomial logit model. We assessed youth group member-level planned livelihood strategies and how they are correlated with member-level variables that include their characteristics, endowments, trusting behaviors, and parents' endowments because youth group members' choices may be largely driven by their parents' decisions and priorities (Bezu and Holden, 2014). District and group activity dummies were included to control unobserved heterogeneity.

What is novel in our study is that we assessed the correlation between trusting behaviors (trust and trustworthiness) of youth group members and their planned livelihood strategy and intention to migrate out of the country. Holden and Tilahun (2021b) found that more trustworthy youth group members were more able to rent land from other households and thereby establish themselves as farmers by also investing in oxen. Their study implies that being trustworthy positively correlates with youths' access to land in the rental market and engagement in agriculture as a livelihood. As far as our knowledge is concerned, no study investigated how trust and trustworthiness affect youth's choices for livelihood diversification,

including migration, and their decision for international migration. In this study, we investigate how the trusting behaviors of the youth affect their livelihood diversification decisions and their intentions for migrating out of the country. Based on Holden and Tilahun (2021a) who reported that group trust was important for group performance, we anticipate low internal trust and trustworthiness are an indication of poor group performance, which in turn is correlated with a higher probability of migration. In our analyses, we controlled selection bias due to the past migration history of the respondents and tested for the endogeneity of the oxen endowment of youth group members.

Section 2 reviews related literature and is followed by data and estimation strategy in Section 3. Section 4 presents the results, and we present the discussion and conclusion in Sections 5 and 6, respectively.

2. Literature review

Ellis (1998) defines rural livelihood diversification as a process by which rural residents construct a diverse portfolio of activities and social support capabilities in their struggle for survival and to improve their standards of living. According to this definition, a livelihood is more than just income and encompasses income as well as the social institutions (kin, family, compound, village, and so on), access to and benefits derived from public services (education, health, water supply, and transport), gender relations, and property rights required to support and sustain a given standard of living. Ellis (1998)'s definition of livelihood diversification contends with Amartya Sen's capability approach (CA) of measuring welfare. In Sen's CA, it is people's capabilities to function (or what people can be or do) that are the central focus of wellbeing analysis (Sen, 1993). In rural areas of Sub-Saharan Africa, livelihood diversification is mostly derived from rural residents' limited risk-bearing capacity in the prevalence of incomplete or almost non-existent financial and insurance markets coupled with imperfect labor and land markets and changing and uncertain climatic conditions (Kassie, 2018). Heterogeneity of labor markets due to differences in culture, location, gender, and technical skills (Davies and Hossain, 1997), the existence of risk (Bryceson, 1996), seasonality (Ellis, 2008), and low access to credit to smooth consumption (Taylor and Wyatt, 1996) are among the factors for rural livelihood diversification. Some argue that deterioration of assets, disasters, migration of a household member or members of the whole family (Bigsten, 1996), and population pressure (Malmberg and Tegenu, 2007) are other determinants of livelihood diversification.

The new economics of labor migration theory pioneered by Stark (1978, 1991) conceptualized migration as a collective decision by a household or family as a co-insurance strategy aimed at diversifying income through risk spreading. On the contrary, the neo-classical theory of migration, based on the classical assumption of an individual's rational decision for income maximization, considers migration choices as a reflection of rational cost–benefit analysis and thereby focuses on factors such as wage differentials between origin and destination (Todaro, 1996; Borjas, 2001; De Haas, 2014). Push–pull theories are a prototype version of neo-classical migration theories, and like neo-classical theory, they see migration at the macro-level as a function of income and other opportunity gaps between origin and destination areas (De Haas, 2014). Rural livelihood diversification can be associated both with opportunity-led diversification under improving economic conditions (or prevalence of pull factors) and survival-led diversification under deteriorating conditions or prevalence of push factors (Niehof, 2004). It has been argued that it is mainly among richer rural residents or in regions with favorable agricultural conditions that livelihood diversification driven by motives to raise incomes or accumulate wealth prevails (Loison, 2015; Makita, 2016). However, our view is that poor people also strive to raise their incomes, and this is not necessarily in conflict with having to focus on short-term survival, but their constraints may limit their ability to get out of a poverty trap.

Pull factors are positive, and these may attract farm households to pursue additional livelihood activities to improve their living standards. These factors provide incentives for farmers to expand their range of income activities outside farming by increasing the returns from non-farm activities. Such factors tend to dominate in less risky and more dynamic agricultural environments. In other words, opportunity-led livelihood diversification occurs when wealthier rural households engage in high-return non-farm activities, with accumulation objectives, to increase household income by maximizing returns from their assets (Loison, 2015). Income diversification is positively associated not only with wealth accumulation (Barrett et al., 2001a) but also with an increased ability to withstand exogenous shocks, at least in terms of partial consumption smoothing (Block and Webb, 2001; Dressler et al., 2016).

It is often argued that livelihood diversification push factors force rural residents into a variety of low-return options, leading to more stable but lower-income-generating activities (Lohmann and Liefner, 2009). Rural residents are pushed into low-return non-farm activities or to survival-led diversification if they have low endowments of assets such as land, capital, livestock, and credit, making them less resistant to seasonal and other risk factors (Barrett et al., 2001b). In this context, diversification is considered an involuntary relapse of the process of specialization, brought on by crises such that the multiplication of activities is an adaptation necessary to ensure survival (Cinner et al., 2010). The most common push factors are related to different forms of risk, such as seasonality and climatic uncertainty (Ellis, 2008; Kassie, 2018). Others include land constraints driven by population pressure and fragmented land holdings, missing or incomplete factor markets, and market access problems due to poor infrastructure and high transaction costs (Barrett et al., 2001a; Dercon, 2002).

Rural residents in marginal environments are portrayed in the growing livelihood literature as experts in the craft of survival under conditions of adversity (Ellis, 2008; Toulmin, 2009). Smallholder farmers use a variety of practices to adapt to climate variability and change. These practices include crop and livestock management, diversification of livelihood strategies, and land use management. Holden and Tilahun (2018) evaluated the early performance of land-poor youth in youth business groups, which were allocated rehabilitated land for establishing livelihood activities, against Elinor Ostrom's design principles for collective resource management and found a high degree of compliance with

the design principles. In the context of high youth unemployment and growing youth migration, Holden and Tilahun (2018) argue that the youth employment strategy of allocating rehabilitated communal lands to youth groups is a win–win strategy for proactively mobilizing the youth as a resource in the creation of sustainable livelihoods.

Holden and Tilahun (2021a) found that group trust was important for group performance in these youth business groups. They also found substantial variation in individual and group trust and trustworthiness. Trust and trustworthiness may be important for being successful in establishing a rural livelihood. It may, therefore, also be important for being able to invest in and build an individual livestock endowment. Holden and Tilahun (2021b) found that the more trustworthy youth group members, measured with the incentivized trust game, were more able to access land in the land rental market. Such success may reduce the likelihood that youth give up their rural livelihood and migrate to other places. However, there is no evidence on how the trusting behaviors of the youth affect their decision to choose other livelihood options, including migration and off-farm activities, and their intention for deciding to migrate out of the country. For example, we may ask whether more trusting youth are more daring and therefore more likely to migrate.

Based on the above brief review of the literature on rural livelihood diversification and following Bezu and Holden (2014) who investigated the livelihood choices of youth in southern Ethiopia, we conceptualize rural youth group members' livelihood choices [such as agriculture, and non-agricultural activities (such as migration, off-farm employment in nearby districts, or going for further education)] as a constrained optimization problem. The existing set of push and/or pull factors signal the relative return from the diverse livelihood options and where the amount of owned and otherwise accessed resources determine the capacity to engage in these livelihood options. In the case of choice of non-agricultural livelihood options relative to agriculture, the push factors include subject- and group-level resource poverty and might also be related to the performance of agriculture including the performance of youth group activities. This includes basic production potential, given available technologies, and agro-ecological characteristics as well as risk factors that may cause cyclical and transitory declines in agricultural income, chronic food insecurity, and fluctuation of income from agriculture and/or youth group activities (Reardon et al., 2007; Ellis, 2008; Bezu and Holden, 2014; Kassie, 2018). Incomplete and or missing factor markets such as missing or incomplete land, credit, insurance, and labor markets in rural areas are another source of push factors (Binswanger and Rosenzweig, 1986; Barrett et al., 2001a). In the absence of access to financial markets, individuals and households diversify their sources of income to self-insure themselves and provide working capital (Barrett et al., 2001b). Rural residents who do not own agricultural land in the face of missing land markets experience the ultimate push factor. However, farmers who have land to cultivate but face frequent weather shocks may be forced to diversify into the non-farm sector as *ex ante* risk management and/or *ex post* risk-coping mechanism (Bezu and Holden, 2014).

The pull factor arises if expected gains from non-agricultural livelihood options are assessed to be higher than gains from agriculture. Higher returns to mobile factors of production such as labor and capital in non-agricultural livelihood options compared to agriculture make agriculture a less attractive livelihood option, but, in the presence of a strong and vibrant non-agricultural sector in rural areas, some rural residents may diversify into the non-agriculture sector while engaging in agriculture and achieve efficiency in labor and capital allocation while others may specialize in non-agricultural activities (Bezu and Holden, 2014). However, rural areas with strong push factors with few local non-agricultural livelihood options may experience high levels of outmigration, especially if they are not located within commuting distance to other sources of employment.

The push and pull factors represent the incentive that motivates rural residents to diversify their livelihood options. Whether and to what extent rural residents including the youth diversify their livelihoods depend on their individual, household, and community endowments, preferences (Bezu and Holden, 2014), and possibly their trusting behaviors. The estimation strategy of the next section provides further details on how trusting behaviors and endowments of youth group members are used as key variables of interest to model livelihood choices and the intention to migrate out of the country.

3. Materials and methods

3.1. Data

In February–March 2016, we conducted a census of 742 youth groups in five districts of Tigray (Holden and Tilahun, 2018). The groups were formed as primary cooperatives between 2011 and 2016 with an average of about 20, a minimum of 2, and a maximum of 193 members per group (Holden and Tilahun, 2018) based on a policy initiative to create new livelihoods for landless and unemployed youth. Youth groups are formalized as primary cooperatives under the Cooperative Law in Ethiopia. They self-organize and elect a board of five members and establish their group bylaw. The members in a group all come from the same community (*tabia*). Based on the census, we sampled 119 youth groups and then sampled randomly up to 12 members from each youth group among those available during the first-round survey in July to September 2016. In this first-round survey, a total of 1,138 members in the 119 youth groups took part in the survey and experiment. We followed up with an extended survey of 246 youth groups (2,427 members as sample respondents) in 2019. The main activities that the youth group members were engaged in include beekeeping, irrigation/horticulture, animal rearing, and forestry. Details on the distribution of the youth groups and youth group members by main activities are presented in Table 1 of Section 4. Nearly 60% of the respondents in the 2016 survey and close to 28% of the respondents in the 2019 survey reported that their families were at least quite severely affected by the 2015/16 drought and at least about 7% in the 2016 survey and close to 26% in the 2019 survey reported that the health of the heads of their parents was in either poor or very poor conditions.

Holden and Tilahun (2018) reported trust within a group as perceived by group leaders as one of the youth group performance

TABLE 1 Distribution of sample youth group members by main activity, districts, and survey year.

Youth group's main activity	Number of group members by *Woreda*					Total	Number of youth groups
	Raya Azebo	Degua Temben	Seharti Samire	Kilite Awlalo	Adwa	Members	
Survey 2016							
Beekeeping	60	89	74	99	75	397	41
Irrigation/horticulture	93	37	30	36	76	272	28
Animal rearing	92	76	41	12	107	328	38
Forestry	12	47	0	0	82	141	12
N	257	249	145	147	340	1,138	119
Survey 2019							
Beekeeping	17	249	183	0	284	733	76
Irrigation/horticulture	140	142	120	0	94	496	47
Animal rearing	251	136	73	0	357	817	86
Forestry	74	46	9	0	252	381	37
N	482	573	385	0	987	2,427	246

indicators and found a strong correlation between such group trust and the degree of compliance with Ostrom's design principles for collective resource management. They suggested that group trust can be a good early performance indicator for business groups. We anticipate low internal trust and trustworthiness are an indication of poor group performance, which in turn is correlated with a higher probability of migration. Our definition of trust in this study is based on Fehr (2009) who defines trust as the behavior of an individual (trustor) who voluntarily places resources at the disposal of another party/individual (the trustee) without any legal commitment from the latter. The act of trust is associated with an expectation that the act will pay off in terms of the trustor's/investor's goals. If the trustee is trustworthy, the trustor is better off than if the trust was not placed, whereas if the trustee is not trustworthy the trustor is worse off than if the trust was not placed. If trust is a behavior involving trusting acts, then it is shaped by our beliefs about others' trustworthiness and our willingness to accept the risks involved in trusting acts (Fehr, 2009). Trust defined this way can be measured using the standard incentivized trust game (Berg et al., 1995). A potential drawback of behavioral trust measures taken from the trust game is that the investor may send money for purely altruistic reasons (Cox, 2004). These transfers might not be "trusting," although they place resources at the disposal of another party without any real commitment because the transfers are not associated with an expectation of a back transfer that renders the investor better off. Therefore, controlling for altruistic motives seems advisable because they might affect investors' behavior (Fehr, 2009). Holden and Tilahun (2021a), however, reported that altruistic preferences were associated with higher outgroup and ingroup trustworthiness and trust and hence are associated with stronger norms to reciprocate.

The surveys were combined with incentivized lab-in-the-field experiments (experiments that complement traditional randomized control trials in collecting data in the field to test theoretical predictions and explore behavioral mechanisms) to elicit the trust and trustworthiness of the youth group members. Following the standard incentivized trust game (Berg et al., 1995), we derived measures of trust and trustworthiness. The incentivized trust game has become a common and recognized tool for the measurement of trust and trustworthiness (Fehr, 2009; Johnson and Mislin, 2011; Al'os-Ferrer and Farolfi, 2019; Holden and Tilahun, 2021b). We tripled the amount that a youth group member that plays the role of a trustor has invested before it is given to another random and anonymous member of the same youth group that plays the role of a trustee. The trustee decides freely how much of this amount to send back to the anonymous trustor. We used the strategy method to elicit returned amounts for varying received amounts and stated amounts to return were binding. Each member played both roles as trustor and trustee in the game. Trusting behavior was measured as the share of the endowment (Ethiopian Birr (ETB) 30) that was sent to the trustee whereas trustworthiness was measured as the share of a received amount (= tripled amount sent by the trustor) that was returned by the trustee in the game where all sampled members played both roles while anonymity was ensured. The survey also included questions about what livelihood options members would have chosen other than their current engagement as a youth group member, their intention to make international migration, and questions about the characteristics of individual members and their parents including their land and livestock endowments and income from youth group activities. For this study, we rely on the unbalanced panel data of both the 2016 and 2019 surveys.

3.2. Estimation strategy

Based on the random utility framework (Maddala, 1983) for limited dependent variables, the theoretical considerations on our

key variables of interest discussed in Section 2 as factors that could influence the choice of planned livelihood strategy of youth group members, and our dataset of repeated observations from youth group members in the surveys of 2016 and 2019, we can specify the utility that a youth group member derives from livelihood choice as follows:

$$U_{ijt} = \alpha_{1j}T_{it} + \alpha_{2j}TW_{it} + \alpha_{3j}OE_{it} + \alpha_{4j}GI_{it} + \alpha_{5j}T_{it}{*}GI_{it} + \alpha_j LA_{it} + \alpha_j C_{it} + v_{ij} + \varepsilon_{ijt} \quad (1)$$

where U_{ijt} *i*s the utility of the ith youth group member with i = 1, …, N, from choosing intended livelihood strategy j with j = 1, …, J, where J = 4 (1 = agriculture, 2 = migration, 3 = off-farm employment, and 4 = further education), and t is the survey time and t = 1, …, T_i with $T_i = 2$.

The right-hand side variables include measures of ingroup trust (T) and ingroup trustworthiness (TW), oxen endowment (OE), income from group activities (GI), row vector of land access variables (LA), and row vector of control variables (C). The control variables include youth group member-level variables (age, sex, marital status, birth rank, education, and perception about level of satisfaction on current livelihood), parent-level covariates (land per own child and livestock), covariate shocks (drought effect on the household), idiosyncratic shocks (health condition of the household head), and location and group activity fixed effects. The location variables are included to capture heterogeneity in agroecology, access to infrastructure, and other unobservable differences whereas the group activity variable is included to control the effect of the difference in current youth group activities that members are engaged in. The unobserved part consists of two error terms. The first, v_{ij}, refers to panel-level heterogeneity which may arise because livelihood strategy choices made by individual youth group members are not independent over time because of underlying individual preferences or characteristics that are unobservable to the researchers and remain unobserved in the data. The second error term, ε_{ijt}, captures heterogeneity at the observation (time) level.

In this model specification, taking agriculture as a base category of the four livelihood strategies specified above, we would like to test the following hypotheses:

H1: $\alpha_{1j} > 0$, *for* $j = 2$: Higher ingroup trust is likely to be associated with more likelihood of the youth choosing migration relative to staying in agriculture. In other words, more trusting youth group members might be more daring to migrate and hence less likely to choose agriculture as their planned livelihood option.

H2: $\alpha_{2j} < 0$, *for* $j = 2$: Higher ingroup trustworthiness is likely to be associated with less likelihood of the youth choosing migration relative to staying in agriculture. In other words, more trustworthy youth group members want to continue trustworthy to their fellow group members engaged in the same youth group and hence are more likely to choose agriculture as a planned livelihood option.

H3: $\alpha_{3j} < 0$, *for* $j = 2$: The larger endowment of oxen by a youth group member is likely to be associated with less likelihood of the youth choosing migration relative to staying in agriculture. In other words, the larger the number of oxen that a youth group member owns, the more likely he/she will choose agriculture as a planned livelihood option.

H4: $\alpha_{4j} < 0$, *for* $j = 2$: Higher income from youth group activities is likely to be associated with less likelihood of the youth choosing migration relative to staying in agriculture. In other words, the higher the income from youth group activities, which is an indicator of better group performance, the more likely the youth group member will choose agriculture as his/her planned livelihood option.

Following Holden and Tilahun (2018), who reported trust within a group correlates with group performance measured in terms of the degree of compliance with Ostrom's design principles for collective resource management, it is worth investigating the effect of the interaction of ingroup trust and income from group activities, which is a group performance indicator, on the planned livelihood choice of youth group members and test the following hypothesis.

H5: $\alpha_{5j} > 0$, *for* $j = 2$: A positive coefficient of the interaction term of ingroup trust and income for the youth group implies that an increase in one of the variables, for example in ingroup trust, will increase the effect of the other variable, say income from youth group activity. In H4, we hypothesized that larger group income is associated with less likelihood of the youth choosing migration relative to staying in agriculture. Thus, higher ingroup trust enhances youth group income, which in turn reduces the likelihood of the youth choosing migration than staying in agriculture. However, if the coefficient for the interaction term is negative, it implies that the combined effect of the two predictors is less than the sum of the individual effects.

H6: α_j *for the LA* < 0, *for* $j = 2$: More access to land either through the land rental market, land redistribution, or inheritance from family is associated with less likelihood of the youth choosing migration relative to staying in agriculture. In other words, youth group members with more access to land are more likely to choose agriculture as his/her planned livelihood option.

For simplicity, we can rewrite equation 1 a multinomial logit model with a random-effects estimator (Hartzel et al., 2001; Grilli and Rampichini, 2007) by condensing the RHS key observables and control variables into a row vector of variables, X, using the following equation:

$$U_{ijt} = \alpha_j X_{it} + v_{ij} + \varepsilon_{ijt} \quad (2)$$

Assuming a standard Gumbel distribution or type 1 extreme value distribution for the second error term, ε_{ijt}, and denoting the outcome variable as y_{it} will give rise to the multinomial logit model:

$$Pr\left(y_{it} = k \middle| X_{it}, \alpha_j, v_{ij}\right) = \frac{exp(X_{it}\alpha_k + v_{ik})}{\sum_{j=1}^{J} exp(X_{it}\alpha_j + v_{ij})} \quad (3)$$

For model identification, equation 3 needs to be normalized to a base category, say in our case livelihood strategy 1 = agriculture, by setting both the elements in α_j and v_{ij} to zero for one category of the outcome variable, y_{it}. Given that $F(.)$ is defined as a cumulative logistic distribution function and we let the base outcome be outcome 1 = agriculture, the likelihood that the ith individual chooses outcome k at time t is as follows:

$$\Pr\left(y_{it}=k\middle|X_{it},\alpha_j,v_{ij}\right)=F\left(y_{it}=k,X_{it}\alpha_j+v_{ij}\right)=\begin{cases}\frac{1}{1+\sum_{j=2}^{J}exp(X_{it}\alpha_j+v_{ij})} & if\ k=1\\ \frac{exp(X_{it}\alpha_k+v_{ik})}{1+\sum_{j=2}^{J}exp(X_{it}\alpha_j+v_{ij})} & if\ k>1\end{cases} \quad (4)$$

We can estimate equation 4 using the *xtmlogit* command in STATA 17 using either fixed-effects or random-effects specifications. We used the *xtmlogit* command in STATA 17 to estimate equation 4 using both fixed-effects and random-effects estimators using agriculture as the base outcome and estimated the probabilities that a youth group member chooses migration, off-farm employment, and further education (Model 1). We fitted the observables, X_{it}, in the multinomial logit (MNL) model using the key variables of interest and control variables specified above in Equation 1.

Close to 40% of our sample had a history of migration and are returnees from temporary internal and international migration. We suspected this may cause selection bias. We constructed a dummy variable for members' migration history as a selection variable, and we ran panel data random-effects probit regression as a selection model with demographic characteristics of the respondents and constructed an Inverse Mills Ratio (IMR) for possible selection bias associated with groups with past migration history. We included the selection dummy and the IMR with livelihood multinomial choice as the dependent variable to test for the significance of selection bias (Model 2).

We also assumed the oxen endowment of the youth group member as an endogenous variable. For correcting endogeneity bias, we used the control function approach following Petrin and Train (2010), and we ran a random-effect generalized least square regression of oxen as a first-stage equation with all independent variables stated in model 2 and additional three variables that we considered are correlated with oxen endowment of the youth group member. These variables are time spent on work activities to help family, time spent on work for complementary income sources, and members' perception of the amount of work in youth group activities. Youth group members who allocate more time to complementary income-generating activities are more likely to generate more complementary income that could allow them to buy oxen, which will further enhance their access to land in the land rental market. Although youth group members who allocate more time to work on activities to help families are less likely to have a larger number of own oxen as in most cases labor contributions to family work have no monetary returns. In addition, those youth group members who perceive that the workload in youth group activities is too small have a larger number of oxen than those who perceive the workload in youth group activities is either average or too much. We anticipate that these instrumental variables satisfy the exclusion restriction and affect the outcome variables only through their effect on the endogenous variable.

Using xtivreg2, we further tested the validity of these variables as instruments, and they satisfy the identification restrictions. The Sargan statistic for over-identification restriction is insignificant indicating that the instrumental variables used in the model were valid instruments and uncorrelated with the error term of the structural equation and that they were correctly excluded from the estimated equations. The Anderson Lagrange Multiplier statistics for the under-identification test were also significant (at $p < 10\%$) indicating that the models were correctly identified. We also tested the exogeneity of oxen owned by the youth group member using *xtivreg* and running the *dmexogxt* command in STATA 17. The null hypothesis of the test is that an ordinary least square (OLS) estimator of the same equation would yield consistent estimates. A rejection of the null indicates that endogenous regressors' effects on the estimates are meaningful. Our test results show that the Davidson-MacKinnon test of exogeneity test statistics is insignificant, and the p-value is 0.45 for the livelihood choice as a dependent variable. The same test for the equation of intention for international migration as the dependent result is also insignificant, and the p-value is 0.22. These show that the number of oxen is exogenous to both outcome variables. We have not reported the detailed results from the *xtivereg2* and *xtivreg* models and the *dmexogxt* exogeneity test, but these can be accessed upon request by the authors. Furthermore, we included the suspected endogenous variable (oxen endowment of the youth group member) and the error term from the first-stage equation with livelihood multinomial choice as the dependent variable (Model 3). If the coefficient for the error term is significant, it implies endogeneity of the oxen variable. We found that the coefficient for the error term is insignificant.

To assess youth group members' plans for international migration, we estimated a logit model of migration outcome using *xtprobit* in STATA 17 using the same variables as in the multinomial logit model above (Model 1). The dependent variable is a binary variable that takes the value one if the youth group member considers migrating out of the country and zero otherwise. Our main hypotheses in this migration model are that youth group members who are better endowed with their livestock (specifically, oxen) and land and/or expect to get land either from inheritance or land redistribution in their communities are less likely to consider migrating out of the country. We also hypothesize that (a) members in poorly performing groups are more tempted to leave their group and migrate; (b) poorly performing groups are also characterized by low internal trust and low trust (Holden and Tilahun, 2018) are therefore also correlated with a higher probability of migration due to poor performance of the group; and (c) individual and parent endowments are more important than group performance as individual livestock endowments are driven by parent endowments.

We included the selection dummy and the IMR with youth group members' intention for international migration as the dependent variable. We found a significant correlation between the self-selection dummy and the international migration choice variable indicating significant selection bias (Model 2). To check for the endogeneity of oxen to youth group member's intention for international migration, we ran the *xteprobit* model in STATA

17, which is an extended probit model that allows including a suspected endogenous variable as an ancillary equation and test for the correlation between errors from the main equation and the errors from the ancillary equation (Model 3). If any of these correlations are statistically significant, it implies the dependent variable in the auxiliary equation is endogenous.

4. Results

In this section, we will first describe the panel data of the distribution of sample youth groups and youth group members and provide a summary of the data on main variables that are used in modeling youth group members' livelihood choice and intention for international migration, whose results are presented in the following sub-sections.

4.1. Descriptive statistics

Table 1 shows the distribution of sample youth group members by main activity, districts, and survey years. In terms of the distribution of the samples by group main activity, beekeeping accounts for the largest number of samples in the 2016 survey whereas animal-rearing groups account for the largest number in the 2019 survey. In terms of the distribution by districts, 29.9% and 40.7% of samples in the 2016 and 2019 surveys were from the Adwa district, whereas the remaining close to 70% and 60% of the samples are from the other four districts.

Table 2 provides summary statistics of variables. Out of the total sample of youth group members, 16.5% responded in the 2016 survey that they would have chosen migration (would have migrated to urban areas to search for employment and/or migrated to another country) as their livelihood strategy if they did not join the youth group activity. In the follow-up 2019 survey, slightly a higher number (21.0%) responded to the same question that they would have chosen migration as their livelihood strategy if they did not join the youth group activity. The number of samples who would have chosen off-farm employment (would have looked for another employment opportunity in the neighborhood/*tabia*/nearby woreda center) and those who would have gone to school for further education as a livelihood strategy if they did not join the youth group decreased from 40.1 and 9.1% in 2016 to 26.7 and 3.5% in 2019, respectively. Our second outcome variable is the member's responses to the question "Do you consider migrating out of the country?" In the 2016 survey, 8.7% of the samples responded Yes to this question, whereas, in the follow-up survey of 2019, 6.6% of the respondents replied Yes to the same question.

The results from the trust game experiment indicate that the trust, which is the share of the endowment [Ethiopian Birr (ETB) 30] that was sent to the trustee, slightly increased from 40.6% in 2016 to 41.3% in 2019 and trustworthiness, which is the share of a received amount that was returned by the trustee to the trustor, increased from 29.4% in 2016 to 54.8% in 2019 (Table 2).

Regarding youth group members' endowments, the average livestock units owned by sample youth group members were 0.74 oxen in tropical livestock units (TLU) in the survey year 2016 and 0.91 TLU in 2019. The details for the remaining variables are presented in Table 2.

4.2. Livelihood choice

Table 3 shows the determinants that youth group members would have chosen migration, off-farm employment in nearby districts, and going to further education if they did not join as a member of the youth groups. Agriculture is the reference livelihood outcome in the reported models in Table 3. Model 1 shows the results from panel data random-effects multinomial logistic regression without controlling for selection bias associated with past migration history. Model 2 refers to panel data random-effects multinomial logistic regression with IMR and selection variable for controlling selection bias associated with past migration history, and Model 3 is the same as Model 2 but includes error term from a first-stage regression of suspected endogenous variable (oxen endowment of the youth group member) with livelihood multinomial choice as the dependent variable. If the coefficient for the error term is significant, it implies endogeneity of the oxen variable. Our results show that the history of migration and IMR are significantly correlated with migration as a livelihood choice than staying in agriculture, indicating significant selection bias. The IMR is also significantly correlated with off-farm employment as a livelihood choice than staying in agriculture, but the coefficient of the error term from the regression oxen as the first-stage equation is not significantly correlated with either migration, off-farm employment, or further education as livelihood options than staying in agriculture. Thus, our analyses of results for the livelihood choice model are based on Model 2 of Table 3, which controls for the selection bias.

The coefficient for the trust variable, which is the value of the share of the endowment (Ethiopian Birr (ETB) 30) that was sent to the trustee in the within-group trust game, is negative, but the correlation with migration as planned livelihood strategy relative to agriculture is not significant. Thus, we reject our hypothesis (H1). Rather we found that the variable trust is positive and significantly (at $p < 1\%$) correlated with off-farm employment as a planned livelihood strategy relative to agriculture (Table 3). This implies more trusting youth group members are more likely to choose off-farm employment relative to staying in agriculture than less trusting members. The variable trustworthiness, which is the value of the share of a received amount that was returned by the trustee to the trustor in the within-group trust game, is negative and significantly (at $p < 1\%$) correlated with youth group member's choice of migration as intended livelihood options relative to staying in agriculture (Table 3). This implies that we cannot reject our hypothesis (H2) that states an increase in the trustworthiness of youth group members decreases the likelihood of youth group members choosing migration relative to agriculture as a planned livelihood option. Marginal effects in Table 4 also show that an increase in the trustworthiness variable is associated with an increase in the likelihood of a youth group member choosing agriculture as a livelihood whereas an increase in trusting behavior is associated with a decrease in the likelihood of a youth group member choosing agriculture as a livelihood.

TABLE 2 Description and summary statistics of key variables by survey year.

Variable description	2016				2019			
	N	Mean	Std. dev.	%	*N*	Mean	Std. dev.	%
Outcome variable								
Livelihood strategy	1,135			100.0	2,427			100.0
1 = Agriculture	187			16.5	510			21.0
2 = Migration	390			34.4	1,184			48.8
3 = Off-farm employment	103			9.1	84			3.5
4 = Further education	455			40.1	649			26.7
Consider migrating out of the country (1 = Yes, 0 = No)	1,138	0.09	0.28		2,427	0.07	0.25	
Youth group member-level variables								
Sex (1 = Female, 0 = Male)	1,138	0.32	0.46		2,427	0.31	0.46	
Birth rank (mean)	1,138	3.11	1.995		2,427	3.33	2.12	
Marital status	1,138			100.0	2,427			100.0
1 = Unmarried	369			34.8	600			24.7
2 = Married	687			60.4	1,726			71.1
3 = Separated	6			0.5	7			0.3
4 = Divorced	36			3.2	72			3.0
5 = Widowed	13			1.1	22			0.9
Age	1,138	29.07	9.80		2,427	32.05	9.24	
Trust (share sent in trust game)	1,138	0.41	0.22		2,427	0.41	0.27	
Trustworthiness (share returned in trust game)	1,138	0.29	0.19		2,342	0.55	0.26	
How satisfied are you with your current livelihood situation?	1,129			100.0	2,427			100.0
1 = Very satisfied	162			14.4	169			7.0
2 = Quite satisfied	374			33.1	826			34.0
3 = Acceptable situation	431			38.2	1,093			45.0
4 = Not satisfied	150			13.3	310			12.8
5 = Very unsatisfied (unbearable situation)	12			1.1	29			1.2
Education	1,138	5.38	3.96		2,427	4.78	3.94	
Oxen in Tropical Livestock Units (TLU)	1,138	0.73	0.95		2,427	0.91	0.95	
Expect to inherit land from parents	1,045			100.0	2,427			100.0
1 = Yes	313			30.0	590			24.3
0 = No	654			62.6	1,612			66.4
2 = Do not know	78			7.5	225			9.3
Applied to the *tabia* land administration to get land through land redistribution (1 = Yes 0 = No)	1,138	0.68	0.47		2,422	0.71	0.45	
Have got land from land redistribution in the *tabia* (1 = Yes 0 = No)	922	0.31	0.46		2,427	0.27	0.44	
Has access to any land in the land rental market (1 = Yes 0 = No)	1,138	0.42	0.49		2,427	0.46	0.50	
Income from the youth group work activity in ETB	1,138	647	2,866		2,427	1,589	9,630	
Parents/household level variables								
Parents land in ha per own child	1,128	0.15	0.22		2,427	0.14	0.18	
Livestock of parents in TLU	1,138	3.56	2.62		2,427	2.99	3.17	
How seriously was the household of your parents affected by the recent drought?	1,132			100.00	2,121			100.0

(Continued)

TABLE 2 (Continued)

Variable description	2016				2019			
	N	Mean	Std. dev.	%	*N*	Mean	Std. dev.	%
0 = Not at all	111			9.8	1,012			48.7
1 = Somewhat affected	345			30.5	513			24.2
2 = Quite severely affected	383			33.8	377			18.8
3 = Very severely affected	293			25.9	219			10.3
Health status of household head of parent of the youth group member	1,138			100.0	2,126			100.0
1 = Very good	381			33.5	225			10.6
2 = Good	667			58.6	1,349			63.5
3 = Poor	82			7.2	487			22.9
4 = Very poor	8			0.7	65			3.1

Some of the youth member-level endowment variables show a statistically significant correlation with some of the livelihood choices. The number of oxen owned by a youth group member and having access to land from land redistribution and access to land in the land rental market have negative and statistically significant correlations (mostly at $p < 1\%$) with the choice of migration, off-farm employment, and further education as planned livelihood strategies relative to staying in agriculture (Table 3). This indicates that an increase in the number of oxen owned by a youth group member decreases the likelihood of the youth group member either choosing migration, off-farm employment, or going for further education as a planned livelihood strategy relative to staying in agriculture. Thus, we cannot reject our hypothesis (H3) that a larger endowment of oxen by a youth group member is likely to be associated with less likelihood of the youth choosing migration relative to staying in agriculture. Similarly, having access to land from land redistribution or access to land in the land rental market decreases the likelihood of youth group members choosing migration, off-farm employment, or going for further education relative to staying in agriculture, respectively. Thus, we cannot reject our hypothesis (H6) that more access to land either through the land rental market, land redistribution, or inheritance from family, is associated with less likelihood of the youth choosing migration relative to staying in agriculture. The marginal effects in Table 4 also show that an increase in the number of oxen owned by a youth group member is associated with an increase in the likelihood of a youth group member choosing agriculture as a livelihood, which supports H3, and similarly, an increase in access to land from either land redistribution or the rental market is associated with an increase in the likelihood of a youth group member choosing agriculture as a livelihood and supports H6 (Table 4).

The income of members from youth group activity has a negative and statistically significant correlation with youth group members' choice of migration and off-farm employment (at $p < 1\%$) as well as with choosing further education (at $p < 5$) relative to agriculture, respectively (Table 3). This supports our hypothesis (H4) that higher income from youth group activities is likely to be associated with less likelihood of the youth choosing migration relative to staying in agriculture. The interaction of trust and income from youth group activity has a positive and statistically significant correlation with youth group member's choice of migration, which supports our hypothesis (H5), and off-farm employment (at $p < 1\%$) as well as with choosing further education (at $p < 5$) relative to agriculture, respectively (Table 3). This implies an increase in average income from youth group activity decreases the likelihood of youth group members choosing migration, off-farm employment, or going for further education as planned livelihood options relative to agriculture. Moreover, the positive and significant interaction term implies the correlation of income with either choosing migration or off-farm-employment, or further education as a planned livelihood strategy is more negative and significant with increasing trusting behavior of the youth group member. This suggests that trust improves performance (here income from group activity), and income from youth group activity in turn negatively correlates with choosing either migration, off-farm employment, or going for further education as a planned livelihood strategy relative to staying in agriculture. This is consistent with Holden and Tilahun (2018) that reported a positive correlation between trust and group performance. Table 4 also shows that an increase in income from youth group activity is associated with an increase in the likelihood of youth group members staying in agriculture. The positive and significant interaction term also implies the correlation of trust with off-farm-employment as a planned livelihood strategy is more positive and significant with increasing income from youth group activity.

In the case of household/parent-level variables, parents' land per own child has a negative and significant (at $p < 1\%$) correlation with youth group members choosing migration and has a positive and significant correlation with choosing further education relative to agriculture (Table 3). We found no significant correlation between the recent past drought effects on parents to youth group members' livelihood choices. Location and youth group activity have some correlations with youth group members' livelihood choices (Tables 3, 4).

4.3. Determinants of youth's intention for international migration

Table 5 presents the results from a panel data logit model of out-of-country migration intention of youth group members.

TABLE 3 Multinomial models of determinants of livelihood choice by youth group members (Agriculture = base outcome).

Variables	Migration			Off-farm employment			Further education		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Migration history_Dummy		0.690a (0.206)	0.703b (0.284)		0.016 (15.290)	0.138 (0.880)		0.057 (0.156)	0.137b (2.170)
Trust	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.004)	0.003a (4.72E-04)	0.003a (0.001)	0.004c (0.002)	−0.003 (0.005)	−0.003 (0.006)	−0.006 (0.007)
Trustworthiness	−0.004a (4.12E-04)	−0.004a (4.03E-04)	−0.004 (0.011)	−0.003 (0.002)	−0.003 (0.002)	−0.003 (0.006)	−0.008c (0.004)	−0.008c (0.005)	−0.009 (0.010)
Income from youth group activity in ETB	−1.22E-04a (4.05E-05)	−1.22E-04a (4.04E-05)	−1.12E-04a (3.77E-05)	−4.39E-05b (1.82E-05)	−4.46E-05b (1.86E-05)	−2.51E-05a (7.66E-06)	1.95E-05b (9.04E-06)	1.93E-05b (8.61E-06)	−2.25E-05 (4.19E-05)
Trust*Income from youth group_Interaction	1.88E-06a (4.66E-07)	1.85E-06a (4.48E-07)	1.85E-06a (4.21E-07)	6.93E-07a (1.93E-07)	6.88E-07a (1.94E-07)	7.50E-07a (2.82E-07)	2.72E-07a (7.12E-08)	2.98E-07a (5.56E-08)	2.91E-07a (8.55E-09)
Access land in the land rental market	−1.177a (0.211)	−1.156a (0.231)	−0.613a (0.176)	−1.069a (0.220)	−1.062a (0.226)	0.356 (1.425)	−2.042a (0.144)	−2.051a (0.153)	−4.715c (2.636)
Have got land from land redistribution	−0.564a (0.062)	−0.568a (0.046)	−0.484a (0.035)	−0.798a (0.203)	−0.797a (0.195)	−0.633a (0.139)	−0.483a (0.096)	−0.486a (0.085)	−0.752c (0.387)
Applied to land redistribution	0.153 (0.198)	0.105 (0.229)	0.126 (0.433)	0.238 (0.179)	0.234 (0.173)	0.211 (0.249)	0.094 (0.319)	0.120 (0.319)	0.260 (0.407)
Expect to inherit land from parents	0.065 (0.075)	0.073 (0.074)	0.119 (0.281)	−0.154a (0.013)	−0.153a (0.011)	−0.051 (0.148)	0.171a (0.024)	0.157a (0.020)	−0.075 (0.283)
Oxen in TLU	−0.449a (0.113)	−0.446a (0.116)	−1.299a (0.153)	−0.366a (0.137)	−0.361a (0.139)	−2.462 (1.676)	−0.777b (0.325)	−0.767b (0.321)	3.113 (3.976)
Education	0.075a (0.003)	−0.059a (0.011)	−0.074a (0.021)	0.068a (0.010)	−0.026a (0.006)	−0.055 (0.053)	0.332a (0.044)	0.220 (0.146)	0.252 (0.188)
Parents land per own child	−0.736a (0.134)	−0.825a (0.135)	−0.485 (0.472)	−0.522 (0.536)	−0.544 (0.517)	0.108 (0.070)	1.334a (0.192)	1.287a (0.190)	0.090 (0.779)
Livestock of parents in TLU	0.041b (0.019)	0.044b (0.020)	0.050b (0.021)	0.019 (0.018)	0.020 (0.018)	0.033 (0.026)	0.010 (0.094)	0.014 (0.095)	−0.023 (0.119)
Effect of drought on the household of Parents	−0.038 (0.052)	−0.049 (0.049)	−0.054b (0.034)	0.025 (0.120)	0.025 (0.119)	0.006 (0.102)	0.126 (0.181)	0.128 (0.178)	0.175 (0.205)
Health status of household head of parent	−0.079 (0.166)	−0.091 (0.169)	−0.069 (0.259)	−0.084c (0.046)	−0.088b (0.044)	−0.114 (0.186)	0.117a (0.042)	0.124a (0.043)	0.107 (0.276)
Satisfaction with current livelihood	0.234b (0.118)	0.235c (0.129)	0.121 (0.103)	0.225 (0.209)	0.226 (0.211)	−0.033 (0.078)	0.022 (0.117)	0.017 (0.118)	0.439 (0.303)
Sex (Female =1 Male =0)	−0.753a (0.067)	3.211a (0.360)	3.373a (0.138)	−0.151 (0.175)	2.586a (0.611)	2.613c (1.572)	0.312 (0.255)	3.646 (2.521)	4.247 (5.671)
Birth rank	−0.015 (0.026)	−0.025 (0.024)	−0.012 (0.026)	−0.023a (0.004)	−0.027a (0.003)	−0.011 (0.010)	0.070c (0.040)	0.061 (0.042)	0.022 (0.016)

(Continued)

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TABLE 3 (Continued)

Variables	Migration			Off-farm employment			Further education		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Marital status	−0.155a (0.053)	−0.451a (0.019)	−0.389b (0.173)	−0.160a (0.054)	−0.375a (0.094)	−0.210 (0.200)	−0.673 (0.511)	−0.955 (0.729)	−1.411 (1.277)
Age	−0.045a (0.003)	−0.056a (0.003)	−0.038c (0.020)	−0.040a (0.001)	−0.046a (0.001)	0.006 (0.044)	−0.172b (0.083)	−0.175b (0.082)	−0.275a (0.039)
Woreda (Baseline = Raya Azebo)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Group main activity (baseline = animal rearing)	No	No	No	Yes	Yes	Yes	No	No	No
IMR from panel probit model (xtprobit) of migration history		−3.808a (0.528)	−3.932a (0.462)		−2.722a (0.469)	−2.748c (1.540)		−3.393 (3.034)	−4.251 (6.249)
Error term from random-effects GLS regression of Oxen in TLU as dependent			0.853 (0.106)			2.089 (1.789)			−3.822 (3.755)
_cons	1.742a (0.287)	5.829a (0.918)	5.934 (0.041)	2.036a (0.535)	5.009a (0.043)	4.766a (1.277)	1.431a (0.209)	5.108 (3.477)	6.645 (6.169)
N	2,869	2,869	2,743	2,869	2,869	2,743	2,869	2,869	2,743
No. of groups (year: 2016 and 2019)	2	2	2	2	2	2	2	2	2
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log pseudolikelihood	−2852.060	−2836.305	−2666.465	−2852.060	−2836.305	−2666.465	−2852.060	−2836.305	−2666.465

Levels of significance: c = p < 0.10, b = p < 0.05, and a = p < 0.01; values in parentheses are robust standard errors.

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TABLE 4 Marginal effects of variables on the probability of choosing agriculture as a livelihood strategy.

Variables	Marginal effects (dy/dx)	
	Model 1	Model 2
Migration history_Dumy		−0.023a (0.005)
Trust	−6.65E-05b (3.09E-05)	−5.80E-05b (2.45E-05)
Trustworthiness	2.07E-04a (5.63E-05)	2.06E-04a (5.70E-05)
Income from youth group activity in ETB	4.04E-06a (1.42E-06)	4.00E-06a (1.36E-06)
Trust*Income from youth group_Interaction	−6.52E-08a (1.66E-08)	−6.36E-08a (1.59E-08)
Access land in the land rental market	0.069a (0.012)	0.068a (0.013)
Have got land from land redistribution	0.040a (0.009)	0.040a (0.008)
Applied to land redistribution	−0.011 (0.011)	−0.010 (0.012)
Expect to inherit land from parents	0.003 (0.002)	0.003c (0.001)
Oxen in TLU	0.025a (0.005)	0.025a (0.005)
Education	−0.005a (3.83E-04)	0.001c (0.001)
Parents land per own child	0.027c (0.016)	0.030c (0.016)
Livestock of parents in TLU	−0.002 (0.001)	−0.002 (0.001)
Effect of drought on the household of parents	−4.88E-04 (0.006)	−2.61E-04 (0.006)
Health status of household head of parent	0.004 (0.005)	0.004 (0.005)
Satisfaction with current livelihood	−0.012 (0.010)	−0.012 (0.010)
Sex (Female = 1 Male = 0)	0.020b (0.008)	−0.168a (0.003)
Birth rank	0.001a (2.77E-04)	0.001a (2.24E-04)
Marital status	0.011a (0.001)	0.026a (0.001)
Age	0.003a (3.87E-04)	0.003a (3.97E-04)
Woreda (Baseline = Raya Azebo)	Yes	Yes
Group main activity (baseline = animal rearing)	Yes	Yes
IMR from panel probit model (xtprobit) of migration history		0.185a (0.009)

Levels of significance: c = $p < 0.10$, b = $p < 0.05$, and a = $p < 0.01$; values in parentheses are robust standard errors.

Model 1 shows the results from panel data random-effects probit regression without controlling for selection bias associated with past migration history. Model 2 refers to panel data random-effects probit regression with IMR and selection variable for controlling selection bias associated with past migration history, and Model 3 is panel data extended probit regression model used to check for the endogeneity of oxen to youth group member's intention for international migration. Our results show that the history of migration and IMR are significantly correlated with the dummy for youth group member's migration intention, indicating significant selection bias, but the correlations between errors from the main equation and the errors from the ancillary oxen endowment equation (in Model 3 of Table 5) are not significant. Thus, our analyses of results for the intention for the international migration model are based on Model 2 of Table 5, which controls for the selection bias. Gender, birth rank, and level of satisfaction of youth group members in current livelihood situation, livestock endowment, and land access variables are youth group member-level variables that are correlated with youth group members' intention for migrating out of the country.

We found no statistically significant correlation between trusting behaviors (both trust and trustworthiness) and youth group member's intention to migrate out of the country (Table 5). The number of oxen owned by a youth group member has a negative and statistically significant correlation with the youth group member's intention for migrating out of the country. This indicates that youth group members with a larger number of oxen are less likely to intend for out-of-country migration.

In the case of land access variables, having an expectation to inherit land from parents and having applied to land to tabia land administration for getting land through land redistribution have positive and statistically significant correlations with youth group members' intention of migrating out of the country, and access to land in the land rental market has a negative and statistically significant correlation with the intention to migrate out of the country (Table 5).

Among the household/parent-level variables, land per own child and livestock of parents have positive and statistically significant correlations with youth group members' intention for international migration. The likelihood of a youth group member to intend for international migration increases with increasing his/her parent's land per child and livestock endowments. The effect of past drought on parents has a positive and significant correlation with youth group member's intention for migrating out of the country. We found no significant correlation between location and youth group member's intention for immigrating out of the country regarding the group's main activity, and the coefficient for forestry as the main group activity has a positive and statistically significant correlation but only at <10%.

5. Discussion

The aim of the policy of allocating the rehabilitated land in northern Ethiopia to organized youth groups was to let the youth engage in sustainable livelihood options. The main objective of this study was to assess how the trusting behaviors of the youth and their endowments affect their livelihood diversification decisions. This study also examines determinants of youth group members' intention for international migration.

TABLE 5 Youth group members' out-of-country migration intention panel data models.

Dependent: plan for international migration (1 = Yes 0 = No) (main equation)	Model 1	Model 2	Model 3
Migration history_Dumy		0.514a (0.041)	0.448b (0.227)
Trust	−4.16E-04 (0.002)	−4.48E-04 (0.002)	−3.94E-04 (0.001)
Trustworthiness	−4.70E-04 (0.001)	−3.89E-04 (0.001)	−4.15E-04 (0.001)
Income from youth group activity in ETB	4.48E-06 (6.27E-06)	4.33E-06 (5.93E-06)	−2.41E-05a (9.02E-06)
Trust*Income from youth group_Interaction	−2.01E-07 (1.90E-07)	−2.07E-07 (1.95E-07)	−4.23E-08 (2.63E-08)
Access land in the land rental market	−0.144a (0.026)	−0.118a (0.023)	−0.112 (0.070)
Have got land from land redistribution	−0.130 (0.095)	−0.138 (0.088)	−0.13 1 (0.133)
Applied to land redistribution	0.194a (0.056)	0.152b (0.073)	0.132a (0.019)
Expect to inherit land from parents	0.104a (0.020)	0.107a (0.023)	0.087a (0.013)
Oxen in TLU	−0.121a (0.012)	−0.111a (0.004)	0.487 (0.762)
Education	0.020a (0.002)	−0.048b (0.019)	−0.029 (0.026)
Parents land per own child	0.243a (0.037)	2.04E-01a (3.08E-02)	0.082a (0.022)
Livestock of parents in TLU	0.019a (0.005)	0.020 (0.004)a	0.014a (0.010)
Effect of drought on household of parents	0.121b (0.048)	0.112b (0.051)	0.097a (0.008)
Health status of household head of parent	0.073 (0.058)	0.062 (0.049)	0.060a (0.002)
Satisfaction with current livelihood	0.053a (0.010)	0.054a (0.019)	0.045 (0.065)
Sex (female = 1 male = 0)	−0.266a (0.003)	1.781a (0.599)	1.322a (0.379)
Birth rank	−0.009a (1.59E-04)	−0.016a (0.001)	−0.015b (0.006)
Marital status	0.077a (0.008)	−0.067 (0.058)	−0.03 8 (0.090)
Age	−0.002 (0.007)	−0.008 (0.008)	−0.008b (0.003)
Woreda (baseline = Raya Azebo)	No	No	
Group main activity (baseline = animal rearing)	Yes	Yes	
IMR from panel probit model (xtprobit) of migration history		−1.907a (0.564)	−1.379a (0.365)
Constant	−2.155a (0.021)	−0.174 (0.643)	−0.755 (0.784)
Oxen in TLU (Auxiliary equation)			
Time spent on work activities to help a family in days per month			−0.009a (4.05E-04)
Time spent on complementary (other) income-generating activities in days per month			0.004 (0.005)

(Continued)

TABLE 5 (Continued)

Dependent: plan for international migration (1 = Yes 0 = No) (main equation)	Model 1	Model 2	Model 3
Amount of group work: 1 = Too much work activity 2 = Appropriate amount of work activity 3 = Too little labor investment			0.019a (0.006)
_cons			0.815a (0.045)
var (e. Oxen)			0.863 (0.019)
corr (e. Oxen; e. plan for international migration)			−0.558 (0.647)
var [plan for international migration (year)]			2.24E-14
var [Oxen (year)]			1.21E-14
corr [Oxen (year); plan for international migration (year)]			0.641
N	2,869	2,869	2,743
No. of groups (year: 2016 and 2019)	2	2	2
Prob > chi^2	0.0000	0.0000	0.0000
Log likelihood (Log pseudolikelihood)	−699.128	−679.296	−4345.230

Levels of significance: b = $p < 0.05$, and a = $p < 0.01$; values in parentheses are standard errors.

We found that more trusting youth group members are more likely to choose off-farm employment relative to staying in agriculture than less trusting members (Table 3). Off-farm employment in the study area usually requires the youth to move to the nearby urban centers. Those who are more trusting of fellow youth group members may think that their fellow members will not evict them from membership in the youth group, for example, because of absence from youth group activity for search and/or engagement in off-farm employment in nearby urban centers. We also found that more trusting behavior is associated with a decrease in the likelihood of the youth staying in agriculture. On the contrary, we found that more trustworthy youth group members are less likely to choose migration than staying in agriculture. This result on livelihood diversification choice is consistent with our hypothesis that low internal trustworthiness correlates with a high probability of choosing migration as a livelihood option. Being more trustworthy is also associated with an increase in the likelihood of a youth group member choosing agriculture as a livelihood. This might be because being more trustworthy might be associated with more altruistic behavior and those who are more trustworthy may feel responsible to continue with their membership in the youth group, which they cannot do if they choose to migrate. Holden and Tilahun (2021a) reported that stronger norms to reciprocate, such as more ingroup trust and ingroup trustworthiness, are highly associated with altruistic and egalitarian preferences. Our results did not support our hypothesis (H1) that states more trusting youth groups are less likely to choose migration as a planned livelihood strategy relative to agriculture is not significant. We used ingroup trust in our study and did not consider the outgroup trust and trustworthiness behavior of our sample youth groups, which is a limitation that needs further research.

The number of oxen owned by the youth group member and access to land in the land rental market has a negative and statistically significant correlation with the likelihood of youth group members choosing migration as well as off-farm employment as planned livelihood options than staying in agriculture. An increase in the number of oxen endowment of the youth group member is also associated with an increase in the likelihood of the youth choosing agriculture as a livelihood. Our result also shows that youth group members with a larger number of oxen are less likely to plan for migrating out of the country. As oxen are the main factor of production in smallholder farming in Ethiopia, a better personal endowment of oxen may encourage youth group members to engage in agriculture given that they have more access to land through, for example, the land rental market. Several studies on the land rental market in Ethiopia reported that oxen endowment of the land poor including the youth is a key factor in determining access to land in the land rental market (Gebru et al., 2019; Gebrehiwot and Holden, 2020; Holden and Tilahun, 2021b). In the context of high-risk agriculture and poverty, poor rural residents without the necessary assets such as land and livestock may be pushed to seek alternative livelihood activities by engaging in low-return and sometimes risky non-farm activities (Barrett et al., 2001a) including rural–urban migration (Bezu and Holden, 2014) as well as migration to other countries despite facing serious risks, including reported physical and sexual violence as well as abduction and required ransom payments to human traffickers, all the way of the illegal migration routes (Demissie, 2018).

We also found that an increase in the number of livestock owned by parents increases the likelihood of youth group members choosing further education relative to staying in agriculture. An increase in the number of livestock endowments of parents also decreases the likelihood of youth group members choosing migration relative to staying in agriculture. Like Bezu and Holden (2014), who reported a positive and significant association of farm size with the probability of youth choosing agriculture

as a livelihood, we found a significant positive association, though only at $p < 10\%$, for land size per own child with the likelihood of the youth group member choosing agriculture as a livelihood.

Access to land from land redistribution and access to land in the land rental market are important determinants of youth group members' choice of planned livelihood diversification. Both access to land in the land rental market, which is mostly in the form of sharecropping arrangement, and having access to land from land redistribution, which is mainly small plots of land for housing/homestead, have negative and statistically significant correlations with youth group member's choices of migration, off-farm employment, and further education than staying in agriculture. Our results from the marginal effects also confirm that the coefficients for both of these land access variables are positively and statistically significant indicating that youth group members' access to land either for farming through the land rental market or for constructing a house through land redistribution is positively associated with the likelihood of the youth to stay in agriculture.

Expectations to inherit land from parents and having applied to land to the *tabia* land administration for getting land through land redistribution have positive and statistically significant correlations with youth group members' intention of migrating out of the country, but access to land in the land rental market has a negative and statistically significant correlation with the intention to migrate out of the country. This might be because the land to the youth from land redistribution in the study area is mainly to provide small land for the youth to use as homestead and this land is not sufficient to establish an agricultural livelihood. Thus, those who got such land or expect to inherit from their parents may search for other livelihood options which include migration out of the country. On the contrary, access to land in the rental market is for undertaking farming activities and those with such access are more likely to prefer staying than planning for migrating out of the country. These results are consistent studies on land rental markets in Ethiopia that report access to farmland as an important factor that determines whether a rural resident youth can depend on smallholder agricultural livelihood (Gebru et al., 2019; Gebrehiwot and Holden, 2020; Holden and Tilahun, 2021b).

Our study also indicates that annual income from youth group activity has a negative correlation with the likelihood of youth group members choosing migration, off-farm employment, and further education as planned livelihood options relative to staying in agriculture. We also found that the income from youth group activities has a statistically significant correlation with the likelihood of the youth staying in agriculture. This is a very good indication that improved performance of youth group activities, measured in terms of increased income from youth group activities, would incentivize youth group members to stay in agriculture and enhance their group activities as a sustainable livelihood option. Holden and Tilahun (2018) evaluated the early performance of 742 land-poor youth in youth business groups, from which our samples are drawn, against Elinor Ostrom's design principles for collective resource management and found a high degree of compliance with the design principles as early performance indicators.

In the context of smallholder agriculture in Ethiopia, land, labor, and oxen are important complementary factors of production. Previous studies indicated that tenants' land access through the land rental market was positively affected by their endowments of labor and oxen (Gebru et al., 2019; Gebrehiwot and Holden, 2020; Holden and Tilahun, 2021b). Our results also confirm that both access to land in the rental market and oxen endowment are important factors for youth to choose agriculture as a livelihood option. However, if markets for such factors are incomplete or missing, they become a source of push factors (Binswanger and Rosenzweig, 1986; Barrett et al., 2001a) and force the youth to migrate in search of livelihood options elsewhere.

6. Conclusion

Our results indicated that the trusting behaviors of the youth (trust and trustworthiness) significantly affect some of the livelihood diversification choices. More trusting youth group members are more likely to choose off-farm employment relative to staying in agriculture than less trusting members. Having a more trusting behavior is also associated with the decline in the likelihood of a youth group member choosing agriculture as a livelihood. More trustworthy youth group members are less likely to choose migration as a planned livelihood option relative to staying in agriculture. Being more trustworthy is also associated with an increase in the likelihood of a youth group member choosing agriculture as a livelihood. We found no correlations between the trusting behaviors of the youth (both trust and trustworthiness) and youth group members' intention for international migration.

Our study shows that personal endowment of oxen and access to land in the land rental market and access to land from land redistribution are important factors that positively influence the likelihood of the rural land-poor youth staying in agriculture. In addition, the oxen endowment of the youth and the land access variables have a significant negative correlation with youth group members' choices of migration as well as off-farm employment as livelihood options relative to staying in agriculture. Moreover, both oxen endowment and the land access variables have almost consistently negative and significant correlations with land-poor youth group members' intention for migrating out of the country. Thus, improving youth group members' access to land and their asset endowments such as oxen for increasing the productivity of youth group activity and hence income would incentivize youth group members to stay in agriculture and enhance youth group activity as a sustainable livelihood. Creating access to credit for the youth would be one policy intervention that would incentivize the youth. Rural credit services for the youth would enable the land-poor youth to buy and own oxen and other inputs and strengthen their youth group activities, which would intern enhance their access to land in the land rental market as well as their income from youth group activities, and hence incentivize them to make agriculture a sustainable livelihood option.

Our study is based on a reasonably large dataset collected from land-poor rural youth group members in the Tigray region of northern Ethiopia. It was conducted before the conflict in the region that devastated the lives and livelihoods of many people including the youth in the region and northern Ethiopia at large. Therefore, the findings of this study may not reflect

the current situation of youth group members in the study area. Devastating shocks like the civil war that occurred in the country will have important implications in changing peoples' behaviors and their coping strategies for re-establishing their livelihoods. Further research is required on the status of the youth group members, how their behaviors of trusting (including outgroup trust and trustworthiness, which our study did not address) and risk preferences have changed due to the civil war, and what coping strategies and interventions are needed for re-establishing their livelihoods.

Data availability statement

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

Ethics statement

Ethical approval was not provided for this study on human participants because the study was conducted with the consent of respondents and data has been analyzed anonymously. The participants provided their informed consent to participate in this study.

Author contributions

MT and SH contributed to the conception and design of the study and organized the database. MT performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to the manuscript revision and read and approved the submitted version.

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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.

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References

Al'os-Ferrer, C., and Farolfi, F. (2019). Trust games and beyond. *Front. Neurosci.* 13, 887. doi: 10.3389/fnins.2019.00887

Barrett, C. B., Bezuneh, M., and Aboud, A. (2001a). Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. *Food Policy* 26, 367–384. doi: 10.1016/S0306-9192(01)00017-3

Barrett, C. B., Reardon, T., and Webb, P. (2001b). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy* 26, 315–331. doi: 10.1016/S0306-9192(01)00014-8

Berg, J., John, D., and Kevin, M. (1995). Trust, reciprocity, and social-history. *Games Econom. Behav.* 10, 122–142. doi: 10.1006/game.1995.1027

Bezu, S., and Holden, S. T. (2014). Are rural youth in Ethiopia abandoning agriculture? *World Dev.* 64, 259–272. doi: 10.1016/j.worlddev.2014.06.013

Bigsten, A. (1996). The circular migration of smallholders in Kenya. *J. Afr. Econ.* 5, 1–20. doi: 10.1093/oxfordjournals.jae.a020893

Binswanger, H. P., and Rosenzweig, M. R. (1986). Behavioral and material determinants of production relations in agriculture. *J. Dev. Stud.* 22, 503–539. doi: 10.1080/00220388608421994

Block, S., and Webb, P. (2001). The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy* 26, 333–350. doi: 10.1016/S0306-9192(01)00015-X

Borjas, G. J. (2001). *Heaven's Door: Immigration Policy and the American Economy*. Princeton, NJ, USA: Princeton University Press.

Bryceson, D. F. (1996). Deagrarianization and rural employment in sub-Saharan Africa: a sectoral perspective. *World Dev.* 24, 97–111. doi: 10.1016/0305-750X(95)00119-W

Central Statistical Agency (CSA) (2021). *Labour Force and Migration Survey Key Findings*. Addis Ababa, Ethiopia. Available online at: http://www.statsethiopia.gov.et/wp-content/uploads/2021/08/Final-2021-LABOUR-FORCE-AND-MIGRATION-SURVEY_Key-finding-Report-.17AUG2021.pdf (accessed May 24, 2023).

Cinner, J. E., McClanahan, T. R., and Wamukota, A. (2010). Differences in livelihoods, socioeconomic characteristics, and knowledge about the sea between fishers and non-fishers living near and far from marine parks on the Kenyan coast. *Mar. Policy* 34, 22–28. doi: 10.1016/j.marpol.2009.04.003

Cox, J. C. (2004). How to identify trust and reciprocity. *Games Econ. Behav.* 46, 260–281. doi: 10.1016/S0899-8256(03)00119-2

Davies, S., and Hossain, N. (1997). *Livelihood Adaptation, Public Action, and Civil Society: A Review of the Literature*. Available online at: https://opendocs.ids.ac.uk/opendocs/handle/123456789/3361 (accessed May 24, 2023).

De Haas, H. (2014). *Migration Theory: Quo Vadis?* Oxford, UK: International Migration Institute (IMI), University of Oxford.

Demissie, F. (2018). Ethiopian female domestic workers in the Middle East and Gulf States: an introduction. *Afr. Black Diaspora Int. J.* 11, 1–5. doi: 10.1080/17528631.2017.1405518

Dercon, S. (2002). Income risk, coping strategies, and safety nets. *World Bank Res. Observer* 17, 141–166. doi: 10.1093/wbro/17.2.141

Dressler, W., de Koning, J., Montefrio, M., and Firn, J. (2016). Land sharing not sparing in the "green economy": the role of livelihood bricolage in conservation and development in the Philippines. *Geoforum* 76, 75–89. doi: 10.1016/j.geoforum.2016.09.003

Ellis, F. (1998). Household strategies and rural livelihood diversification. *J. Dev. Stud.* 35, 1–38. doi: 10.1080/00220389808422553

Ellis, F. (2008). The determinants of rural livelihood diversification in developing countries. *J. Agric. Econ.* 51, 289–302. doi: 10.1111/j.1477-9552.2000.tb01229.x

Fehr, E. (2009). On the economics and biology of trust. *J. Eur. Econ. Assoc.* 7, 235–266. doi: 10.1162/JEEA.2009.7.2-3.235

Gebrehiwot, D. B., and Holden, S. T. (2020). Variation in output shares and endogenous matching in land rental contracts: evidence from Ethiopia. *J. Agric. Econ.* 71, 260–282. doi: 10.1111/1477-9552.12345

Gebru, M., Holden, S. T., and Tilahun, M. (2019). Tenants' land access in the rental market: evidence from northern Ethiopia. *Agr. Econ.* 50, 291–302. doi: 10.1111/agec.12484

Grilli, L., and Rampichini, C. (2007). A multilevel multinomial logit model for the analysis of graduates' skills. *Stat. Methods Applic.* 16, 381–393. doi: 10.1007/s10260-006-0039-z

Hartzel, J., Agresti, A., and Caffo, B. S. (2001). Multinomial logit random effects models. *Stat. Modelling* 1, 81–102. doi: 10.1177/1471082X0100100201

Holden, S. T., and Tilahun, M. (2018). The importance of Ostrom's design principles: youth group performance in Northern Ethiopia. *World Dev.* 104, 10–30. doi: 10.1016/j.worlddev.2017.11.010

Holden, S. T., and Tilahun, M. (2021a). Preferences, trust, and performance in youth business groups. *PLoS ONE.* 16, e0257637. doi: 10.1371/journal.pone.0257637

Holden, S. T., and Tilahun, M. (2021b). Are land-poor youth accessing rented land? Evidence from northern Ethiopia. *Land Use Policy* 108, 105516. doi: 10.1016/j.landusepol.2021.105516

International Labour Organization (ILO) (2022). *Global Employment Trends for Youth 2022: Africa*. Available online at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/briefingnote/wcms_853322.pdf (accessed May 24, 2023).

Johnson, N. D., and Mislin, A. A. (2011). Trust games: a meta-analysis. *J. Econ. Psychol.* 32, 865–889. doi: 10.1016/j.joep.2011.05.007

Kassie, G. W. (2018). Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. *Environ. Syst. Res.* 6, 1–14. doi: 10.1186/s40068-017-0085-6

Lohmann, C., and Liefner, I. (2009). Location, non-agricultural employment, and vulnerability to poverty in rural Thailand. *Erdkunde* 63, 141–160. doi: 10.3112/erdkunde.2009.02.03

Loison, S. A. (2015). Rural livelihood diversification in Sub-Saharan Africa: a literature review. *J. Dev. Stud.* 51, 1125–1138. doi: 10.1080/00220388.2015.1046445

Maddala, G. S. (1983). "Limited-dependent and qualitative variables in econometrics," in *Econometric Society Monographs in Quantitative Economics*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511810176

Makita, R. (2016). Livelihood diversification with certification supported farming: the case of land reform beneficiaries in the Philippines. *Asia Pac. Viewp.* 57, 44–59. doi: 10.1111/apv.12106

Malmberg, B., and Tegenu, T. (2007). Population pressure and dynamics of household livelihoods in an Ethiopian village: an elaboration of the Boserup-Chayanovian framework. *Popul. Environ.* 29, 39–67. doi: 10.1007/s11111-007-0060-7

Niehof, A. (2004). The significance of diversification for rural livelihood systems. *Food Policy* 29, 321–338. doi: 10.1016/j.foodpol.2004.07.009

Petrin, A., and Train, K. (2010). A control function approach to endogeneity in consumer choice models. *J. Market. Res.* 47, 3–13. doi: 10.1509/jmkr.47.1.3

Reardon, T., Berdegue, J., Barrett, C. B., and Stamoulis, K. (2007). "Household income diversification into rural nonfarm activities," in *Transforming the Rural Nonfarm Economy: Opportunities and Threats in the Developing World*, eds T. Reardon, S. Haggblade, and P. Hazell (Baltimore, MD: Johns Hopkins University Press).

Sen, A. (1993). "Capability and well-bing," in *The Quality of Life*, eds M. Nussbaum and A. Sen (Oxford: Oxford Academic).

Stark, O. (1978). *Economic-Demographic Interactions in Agricultural Development: The Case of Ruralto-Urban Migration*. Rome, Italy: FAO.

Stark, O. (1991). *The Migration of Labour*. Cambridge, UK: Basil Blackwell.

Taylor, J. E., and Wyatt, T. J. (1996). The shadow value of migrant remittances, income, and inequality in a household-farm economy. *J. Dev. Stud.* 32, 899–912. doi: 10.1080/00220389608422445

Todaro, M. P. (1996). A model of labor migration and urban unemployment in less-developed countries. *Am. Econ. Rev.* 59, 138–148.

Toulmin, C. (2009). Securing land and property rights in sub-Saharan Africa: the role of local institutions. *Land Use Policy* 26, 10–19. doi: 10.1016/j.landusepol.2008.07.006

World Bank. (2023). *Data. Population, Total - Ethiopia*. World Bank. Available online at: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=ET (accessed May 24, 2023).

World Future Council (2017). *Tigray's Conservation-Based Agricultural Development-Led Industrialization*. Available online at: https://www.futurepolicy.org/healthy-ecosystems/biodiversity-and-soil/tigrays-conservation-based-adli/ (accessed May 24, 2023).

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Empowering women across gender and caste in a women's dairy cooperative in India

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Mulukanoor Women's Dairy Cooperative (Mulukanoor Dairy) in India has been run by women for women since 2002. From the beginning it created strategies to empower women members, including mixing milk provided by the marginalized caste with milk from other castes; paying women exclusively for milk; providing technical training to women; and seating women together in training and governance events. Caste norms are not observed in these interactions. This article examines the effectiveness of Mulukanoor Dairy's strategies for overcoming gender and caste disadvantage through empirical research. We hypothesized that if women members of Mulukanoor Dairy had become empowered over the past 20years we should be able to see evidence for this in the form of women's empowerment in relation to dairy decision-making at intra-household level. And if caste divisions had been largely overcome we should observe collegial relationships among women of different castes, and similar levels of women's empowerment at intra-household level regardless of caste. Research was carried out in four villages provisioning Mulukanoor Dairy through focus group discussions with women members of Mulukanoor Dairy, and men spouses of different women members. In total 21 women and 23 men participated. FGDs were sex-and caste disaggregated. The introduction of a new sorghum forage, CoFS-29, provided the entry point to start talking about gender and caste norms. The findings show a remarkable transition of the dairy industry from elite non-marginalized caste men to marginalized and non-marginalized women. Caste norms have changed within the safe space of Mulukanoor Dairy and to a limited extent in the community. A new norm has been instituted that marginalized caste women are dairy farmers. Women across caste experience considerable decision-making power over milk and dairy income. However, men remain primary decision-makers over whether forage is grown. Men engage with key dairy chain actors. Knowledge on new technologies is passed only within castes, and mostly between persons of the same gender. Over the process of knowledge transmission, knowledge networks become increasingly masculinized. Knowledge networks are stronger among non-marginalized men who are best able to make use of new technologies.

KEYWORDS

intersectionality, caste norms, empowerment, dairy cooperative, India, gender transformative change

Introduction

Feminist activists in the Global South were prominent in attempts to define and enact women's empowerment from the 1970s to mid-1990s and beyond. Batliwala (2007) describes how Global South activists fought for radical societal transformations through mass mobilization and seeking policy change. Activists worked, from the start, with intersectionality. "The spread of "women's empowerment" [was] a […] political and transformatory idea for struggles that challenged not only patriarchy, but the mediating structures of class, race, ethnicity—and, in India, caste and religion—which determined the nature of women's position and condition in developing societies" (Batliwala (2007), p. 558). Conceptual links between women's self-understanding, their capacity for self-expression, and women's access to resources were developed and various manifestations of power were developed and described (Kabeer, 1999; Cornwall and Rivas, 2015; Cornwall, 2016).

Yet moving into the 2000s progress was uneven. In some cases, the terms "empowerment" and "gender equality" were depoliticized through top-down gender mainstreaming processes, thereby becoming "eviscerated of conceptual and political bite" (Cornwall and Rivas, 2015, p. 396). Although there have been enormous achievements, including Sustainable Development Goal (SDG) 5 on gender equality, and other high level policy commitments, a substantial body of development work on gender equality and women's empowerment has become instrumentalist, focusing more on what empowered women can do for achieving desirable development goals rather than on building an understanding and supporting of women's empowerment as an end in itself (Cornwall, 2016). Today, the achievement of women's empowerment and gender equality can seem as far away as ever (Whitelaw, 2022).

In the Global South, though, some organizations took on the mantle of women's empowerment and have been articulating it ever since in their praxis. Mulukanoor Women's Dairy Cooperative in Warangal, Telangana, India (henceforth Mulukanoor Dairy) is an example. Founded in 2002 it has been run by women for women with an explicit rural women's empowerment agenda ever since.[1] Mulukanoor Dairy was established when women's self-help groups (SHG) approached the Mulukanoor Cooperative Rural Banking and Marketing Society Ltd. to seek advice on how to invest the substantial funds that had been accumulating in SHGs over the years. The bank advised investing in the dairy industry as this was considered to hold significant potential (Swamy et al., 2014). The National Dairy Development Board agreed to provide technical support to set up the new cooperative's dairy processing plant. Villages wishing to join Mulukanoor Dairy had to commit to selling solely to Mulukanoor Dairy through dedicated Mulukanoor village dairy societies (the incentive being that Mulukanoor Dairy pays above the market rate) and villages had to agree to exclusive women membership. By 31st March 2020, Mulukanoor Dairy was operating in 192 member villages with 22,605 women members.

Studies of Indian dairy cooperatives (Dohmwirth and Hanisch, 2017; Christie and Chebrolu, 2020; Dohmwirth and Liu, 2020), provide a mixed picture regarding their ability to strengthen women's empowerment. Some evidence suggests that well-intentioned, top-down interventions aimed at empowering women by instituting women-only dairy cooperatives nevertheless have limited potential to empower women if they do not actively challenge gender and caste norms. For instance, cooperative bylaws, intended to guarantee caste and gender equality, are not necessarily transformative in themselves (Stuart, 2007; Basu and Chakraborty, 2008; Ravichandran et al., 2021). Women leaders may be appointed yet men may rule behind the scenes through directing the decision-making of women leaders (Ravichandran et al., 2021). Sometimes, women's dairy cooperatives are imposed on villages resulting in increased work yet weak benefits to women due to insufficient effort paid to getting the whole community enthused about the goals of the cooperative (Dohmwirth and Hanisch, 2017). Nevertheless, this experience is not uniform. Some women-only dairy cooperatives strengthen women's social networks and capacity development, and provide a route to genuine women's leadership (Dohmwirth and Liu, 2020).

Prior to the establishment of Mulukanoor Dairy, women and men tended buffalo and cows, but men sold morning milk to private sector milk vendors and kept the income. Women used evening milk to make curd and ghee. As shown in Figure 1 non-marginalized caste farming men dominated the industry and owned almost all dairy livestock. Caste norms meant there was no commercial market for milk from the marginalized caste as their milk was considered untouchable.

Mulukanoor Dairy entered this fraught terrain by developing several strategies for women's empowerment (Ravichandran, 2018; Ravichandran et al., 2021). They are grouped below in relation to their primary objective.

Strengthening women's empowerment

Women farmers across caste are offered technical training on livestock care and milk handling at headquarters and village level.

At the governance level, board members at headquarters, and in village dairy societies are women—unless there is a male secretary (which is relatively common) at the latter. Women from any caste can stand for election.

Payments are made fortnightly in cash in women's names. Husbands are permitted to collect these payments and must provide them to their wives. Women receive two annual bonuses, a dairy and a society bonus. The size of bonus received depends on how much milk the members of a dairy society have provided.

Strengthening intra-caste relations

Milk from all castes is mixed—"poured"—together, thus removing untouchability from milk produced by the marginalized caste. This allows marginalized women—who previously could not join the milk value chain—to become dairy chain actors.

Women across caste are seated and eat together at Mulukanoor events.

The membership of Indian SHGs is typically caste-based. However, since the founding members of Mulukanoor Dairy came from different SHGs—along with their funds—membership was opened to all. Marginalized caste women could thus insist that their

1 https://www.mulukanoordairy.com/about.html

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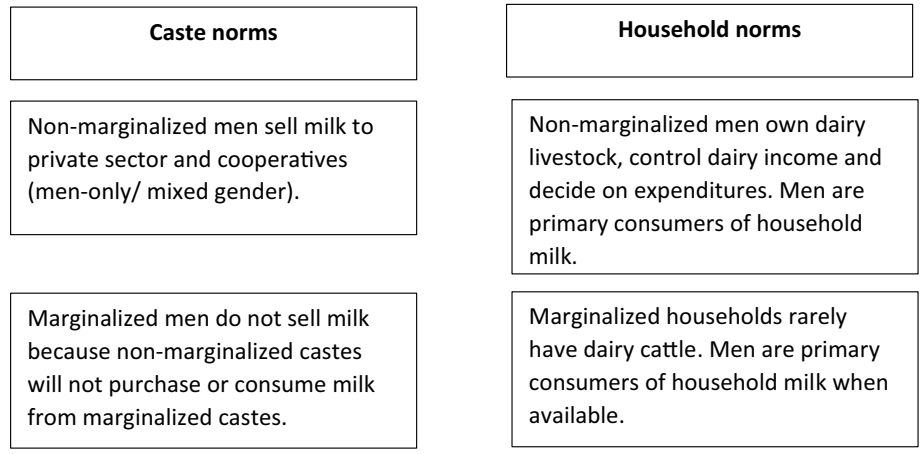

FIGURE 1
The gender and caste normative situation prior to Mulukanoor Dairy.

milk be poured together with that of non-marginalized women, and they could expect to join meetings, and participate in governance, as equals.

In this study we explored whether women members of Mulukanoor were able to improve gender-based power dynamics in the household, and caste-based power dynamics in their community, and how. To help explore changes in gender and caste dynamics at Mulukanoor Dairy, we used the introduction of a new forage, CoFS-29—an improved multi-cut perennial sorghum, as an entry point to start talking about locally prevalent gender and caste norms and whether they had changed over the past 20 years. CoFS-29 was introduced, in partnership with the International Livestock Research Institute (ILRI) by Mulukanoor Dairy in 2017 to increase milk productivity. A lack of green forage represents one of the most critical constraints to improving dairy production in India (Singh et al., 2022). CoFS-29 has high levels of crude protein thereby contributing to higher levels of milk production and consequent income and other benefits. CoFS-29 is sweet, does not need a chaff cutter and there is little wastage (Blümmel, 2017; Ravichandran et al., 2019).

Conceptual framework and research questions

Our conceptual framework engages with the concepts of intersectionality (in the form of caste and gender), power, and gender-transformative change. When conceptualizing this study, we were interested in understanding how gender and caste identities influence each other, and how they combine to influence women's ability to empower themselves. To understand these issues, we took the stance that it was important to test these concepts in a real-life situation. For this, qualitative empirical work was considered necessary. We further decided it was important to ensure that research participants were able to contribute their thoughts on these large topics effectively. We therefore designed research instruments – primarily focus group discussion (FGD) schedules, and key informant interview (KII) questionnaires – around the everyday lives of our women and men participants.

The "real-life" situation we chose was whether the efforts made by Mulukanoor Dairy to change caste and gender dynamics through various initiatives is indeed contributing to changes in these dynamics. We hypothesized that if women members of Mulukanoor Dairy had become empowered over the past 20 years, we should be able to see evidence for this in the form of women's empowerment (or more equitable gender relations) in various aspects of dairy decision-making at household level. And secondly, if caste divisions had been largely overcome, we should be able to see forms of collegial relationships among women of different castes in the community, for instance through knowledge sharing.

A clear starting point against which our hypotheses could be tested was necessary. We therefore selected the introduction of CoFS-29 4 years prior to our research (conducted in 2021). Our rationale was that technological innovations such as new types of forage are not neutral in their effects. They interact with locally prevalent gender, caste and other norms to influence who accesses, utilizes and benefits from them (Theis et al., 2018). Our starting point enabled us to frame questions to Mulukanoor Dairy women members, and their male spouses, around their experience of adoption and how—and if—this affected gender and caste dynamics in their everyday lives. Our research questions were:

1) Changes in gender relations at intra-household level.

- RQ1a. Are gender dynamics in intra-household dairy management changing?
- RQ1b. Are there differences in intra-HH gender dynamics by caste?
- Topics of enquiry. (i) changes in the gender division of labor in dairy, (ii) Milk allocation decisions, and (iii) Milk expenditure decisions.

2) Changes in caste relations at village level.

- RQ2. Are caste dynamics among women and men belonging to different castes changing?

- Topic of enquiry. (i) CoFS-29 information exchange between castes.

On the basis of the research questions, questions on each of the topics were developed, and discussed in focus group discussions (FGDs) with women and men in sex-and caste disaggregated groups, as detailed in the methods section. We now discuss the three core elements of our conceptual framework in a little more detail.

Gender-transformative change

Gender is a social characteristic that shapes systems of power across all cultures based on perceptions around male and female identities. Gender is a primary means of making sense of who we are in relation to the others, before considering ethnic, age, class, or other social markers, and is therefore a key organizing principle in most societies (Ridgeway and Correll, 2004). Gender norms are comprised of informal rules and social expectations which determine, assign and regulate—through the application of social sanctions—acceptable roles, behaviors, and responsibilities to male and female identities in particular communities and geographies (FAO, IFAD, and WFP, 2022). Gender norms directly, and differentially, affect the choices, freedoms and capabilities of women and men in the arenas in which they live their lives: at home, in the field, in organizations and community settings, the marketplace, and others.

Gender-transformative change aims to encourage critical awareness among men and women of gender norms (McDougall et al., 2021). Transformative approaches challenge the distribution of resources and allocation of duties between men and women, address unequal power relationships between women and men, and embrace intersectional understandings (Kleiber et al., 2019; MacArthur et al., 2022). They identify and tackle the structural root causes of entrenched gender inequalities at multiple scales, including gender norms and roles, rather than merely responding to the symptoms of gender inequality (CGIAR, 2017; Farhall and Rickards, 2021; Farnworth et al., 2021). While the concept of gender-transformative change has been central in gender discourses for a decade, less is understood about how gender-transformative approaches contribute to the achievement of gender-transformative change.

Intersectionality

Feminist scholars and social justice advocates have long sought to integrate intersectionality: the recognition that there are multiple intersecting and overlapping forms of social difference, tied to structures of privilege and inequality—into research and action (Keddie et al., 2022). "Human lives cannot be explained by taking into account single categories, such as gender, race, and socio-economic status. People's lives are multi-dimensional and complex. Lived realities are shaped by different factors and social dynamics operating together" (Hankivsky, 2014, p. 3). Intersectional research focuses less on the individual characteristics of people (their race, class, caste, gender, age, etc.) but rather on how *structural processes* (racism, classism, casteism, patriarchy, ageism, etc.) combine to create and perpetuate intersectional inequalities (MacArthur et al., 2022, p. 8). The power dynamics behind processes which privilege or denigrate specific intersectional identities need to be understood and interrogated (Tavenner et al., 2022). Different forms of intersectionality can layer disadvantage upon disadvantage resulting in multi-faceted discrimination (Kabeer, 2016).

Our intersectional focus is caste together with gender. Caste is a Hindu system of ordered inequality in status built around concepts of superiority and purity (Bidner and Eswaran, 2015; Mudliar and Koontz, 2018). "Caste membership has been ingrained into Indian society and has remained one of the most salient identities in the country" (Surendran-Padmaja et al., 2023, p. 2). Caste identity tends to have negative implications for the well-being of marginalized castes (Surendran-Padmaja et al., 2023) Officially these castes are termed Scheduled Castes (SCs, also Dalits). Indigenous (Adivasi) people are categorized as Scheduled Tribes (STs) and are similarly marginalized. There are two non-marginalized castes. The General Caste (GC) are understood to be the highest caste. They are followed by the mid-level Other Backward Castes (OBCs). The OBCs vary in the degree of their advantage and disadvantage. Overall, the non-marginalized castes feel belongness and self-esteem (Surendran-Padmaja et al., 2023, p. 2). Sankaran et al. (2017) suggest that "high caste norms are associated with moral values while the lower caste norms are associated with immorality."

Thousands of sub-castes exist within each caste, and each caste/sub-caste has, to some extent, its own social norms and traditions. These shape, among other things, men's and women's roles, responsibilities, benefits, and agency (Lamb, 2013). Caste norms frequently prohibit mixing between castes, particularly with the SC to whom norms of untouchability frequently (despite government prohibition) apply in everyday life, including eating or drinking with non-marginalized castes (Mudliar and Koontz, 2018). People who breach caste norms can be severely penalized (Sankaran et al., 2017). In this article, we mostly use the term non-marginalized to refer to GC/OBC castes, and marginalized to refer to SC/ST. The abbreviations are only used if specific data is disaggregated further by caste.

Power

We need to understand how power operates if we are to examine how processes of change associated with Mulukanoor Dairy's empowerment strategies have unfolded. Here, we describe six forms of power.

First, *Power within* (Rowlands, 1997) is considered the starting point of empowerment processes. It describes a transformation in individual consciousness which leads to a sense of dignity, self-esteem, and self-confidence. A woman becomes aware of her situation and wants to change it (VeneKlasen and Miller, 2002).

Second, *power to act* expresses the ability to exercise agency. It is the power to do something to bring about a desired outcome (Allen, 1999).

However, women's *power within* and *power to act* can be denied. The third concept of power—*power over*—is widely used to describe a negative state with actors on one side holding much more power than actors on the other side (Pansardi, 2012). Readily discernible negative forms of *power over* include situations whereby men determine which household resources a woman is permitted to use, such as land or machinery, or in decision-making, for example how (and if) women are to spend money they have earned (Sen, 1990).

Power over can also describe a situation whereby a dominant group (defined by their ethnicity, class, caste or other intersectional identities) exercise more power over resources and decision-making, for example in organizations or in community decision-making bodies—than a less powerful group. Our starting point is that men are more likely to have *power over* women, and that non-marginalized castes are more likely to have *power over* marginalized castes.

The concept of *power over* is not always negative, though. Chambers (2006) concept of the *power to empower*, our fourth form of power, suggests that powerful actors can use their *power over* less powerful actors to positively to create situations and provide spaces which people can exploit to empower themselves (*ibid.*). Our case study is premised on the idea that Mulukanoor Dairy, as a dairy cooperative, has the *power to empower* women dairy farmers across caste. They can do this through creating "opportunity spaces," such as training events and elections, within which women can come together to learn and to share (Sumberg and Sumberg and Okali, 2013). We posit that women members of Mulukanoor, regardless of their intersectional identity, can use these opportunities to strengthen their power as individuals and as groups.

Fifth, *power with* describe forms of power which emerge through processes of collective action for empowerment such as in women's movements (Gammage et al., 2016). In the case of Mulukanoor, we speculate whether women member have developed a sense of *power with* that transcends caste boundaries.

Sixth, *power through* suggests that an individual's power can be lost, or won, through a change in the empowerment status of others closely associated with that individual (Galiè and Farnworth, 2019). An individual may become empowered through their association with powerful people, for example through being born into a wealthy family in the community. In this, they may benefit from *power over* others in the community, even though they themselves have never deliberately or even consciously enacted this power. They may benefit through having more choices in their lives—as a consequence of experiencing a good education in childhood for instance—through no effort of their own. Conversely, a woman (or man) could be disempowered simply as a consequence of being born into a less powerful group in society. In both cases, the empowerment or disempowerment involved is involuntary. The concept of *power through* has particular relevance in the context of caste since caste is an inherited structure with associated privileges.

Means and methods

This study is qualitative. In 2021 a woman gender expert from India (and co-author) conducted 12 FGDs with a total of 21 women and 23 men. She was acquainted with Mulukanoor as she had previously conducted research with its members. A qualitative small-N study was considered the most appropriate approach to explore in great depth the views and lived experiences of women and men associated with Mulukanoor *vis-à-vis* changes in gender and caste dynamics (Crouch and McKenzie, 2006; Mahoney and Goertz, 2006). The data produced during the FGDs was translated into English and coded utilizing both a deductive and inductive approach: some codes were pre-determined based on the issues that the authors wanted to explore. New codes were added as they emerged from the data. The authors identified patterns of changes in gender and caste dynamics in the data, and, also, changes that were not experienced by other respondents. All are reported in the Findings. The study received ethical approval in October 2021: ILRI-IREC2021-46.

The section below provides an overview of the study sites and the introduction of CoFS-29. This is followed by details of respondent selection and the research tools. We then share the findings under the two main research questions on changes in gender relations in the household, and changes in caste relations in the villages.

Overview of study sites and the introduction of CoFS-29

Mulukanoor Dairy and its member villages are situated around 100 km from Hyderabad. Key crops include rice, cotton, maize, and sorghum. Landholdings tend to be small (less than two hectares), and irrigation is available only to a few, mostly among the non-marginalized caste. In general, marginalized castes do not grow fodder due to the poor quality of their land which is either non-irrigated or marshy making it unsuitable for fodder. They thus buy fodder or graze their livestock along paths and in common grazing areas. Marginalized castes typically do not have sufficient crop surplus for sale: paddy is cultivated during the rainy season with most retained for home consumption. Marginalized men work as day laborer's on the farms of non-marginalized households, and they also work on government schemes—as do marginalized women—which guarantee employment, such as road and pond construction. In contrast, non-marginalized castes rely less on farming as a primary livelihood. Non-marginalized men work in service occupations such as teaching. Although non-marginalized women are usually educated, men are much more likely to obtain off-farm work in service occupations in this region.

Mulukanoor Dairy has been experimenting with various forages, including CoFS-29, for several years to boost dairy cow productivity and improve milk quality. The process of obtaining forage seed is as follows. Secretaries in Mulukanoor Dairy village diary societies are charged with providing information about CoFS-29 (as with other technologies) to members. They send requests for seed to Mulukanoor Dairy headquarters which then passes seed back to the village secretary for distribution. Table 1 shows that non-marginalized caste members received more seed than marginalized caste members. The rather low overall figures are reflective of the fact that most village secretaries refer interested farmers to other farmers growing CoFS-29

TABLE 1 CoFS-29 forage seed distribution in Mulukanoor Dairy 2017–2019.

Year	Distribution of CoFS-29 seeds by caste		Total farmers receiving CoFS-29 seeds from Mulukanoor Dairy
	Marginalized caste	Non-marginalized caste	
2017	10	26	36
2018	92	137	229
2019	80	216	296
Total orders	182	379	561

Mulukanoor Dairy, 2021.

to obtain their seeds informally. These transactions are not recorded by Mulukanoor Dairy.

Respondent selection

Mulukanoor Dairy holds details of its members by village, caste, and by technology adoption. These rosters were used to select respondents. First, four villages were selected from the roster. The selection criteria were (i) villages have been offered CoFS-29 through the village dairy society, (ii) villages include enclaves/ hamlets with marginalized and non-marginalized caste members, and (iii) villages have not been subjected to any other surveys over the past 5 years to avoid respondent fatigue. The four villages are shown in Table 2.

Once the villages had been selected, FGD participants were selected. The criteria were: (i) respondents have adopted CoFS-29, and (ii) 50% of participants should be members of marginalized castes and 50% of participants should be members of non-marginalized castes. In a further step, gender balance was sought within each caste, with (iii) 50% women members, and (iv) 50% men married to women members. Regarding the latter, male spouses had to come from different households to those of selected Mulukanoor Dairy women members. In total 21 women and 23 men participated. Some respondents participated across all three FGDs. Their participation depended on their availability and personal interest.

Research methods

Three FGD discussion guides were developed to cover the research questions. As a reminder, they are.

1. *Changes in gender relations at intra-household level.* RQ1a. Are there new gender dynamics in intra-household dairy management? RQ1b. Are there differences in intra-HH gender dynamics by caste? The topics of enquiry are: (i) changes in the gender division of labor, (ii) Milk allocation decisions, and (iii) Milk expenditure decisions.
2. *Changes in caste relations at village level.* RQ2. Are there changes in caste dynamics among women and men belonging to different castes? The topic of enquiry is (i) CoFS-29 information exchange between castes.

The topic guides focused on (i) changes in caste dynamics at village level, (ii) changes in gender dynamics in intra-household dairy management, and (iii) changes in intra-household decision-making. Each FGD discussion guide covered the relevant domains of enquiry, and they allowed for triangulation by asking some of the same questions. The guides allowed for additional probing by the facilitator should new relevant information emerge. In each discussion guide, questions were asked about the situation in relation to the discussion topic prior to the establishment of Mulukanoor Dairy, and changes over the past few years. With respect to research question 2, respondents were asked to draw simple diagrams showing who they shared knowledge about CoFS-29 with by caste and gender. They were then asked to explain their diagrams. Each FGD took around 60–90 min. A total of 12 FGDs were conducted with 22 women and 23 men. Some participants joined more than one FGD (Table 3).

Findings

We start the Findings by providing descriptive statistics. We abbreviate the sources of direct citations to improve readability. Non-marginalized men are abbreviated to NMM, non-marginalized women to NMW, marginalized men to MM, marginalized women to MW, and village is abbreviated to V.

Overall dairy cooperative membership as a percentage of the study village population

Marginalized and non-marginalized castes occupy separate enclaves within each study village with marginalized castes living further from the center. Non-marginalized castes in the four villages dominate Mulukanoor Dairy membership (76%) with marginalized castes representing about one quarter (24%) of members. Across all four villages, two fifths of households are members (39%). Table 4 provides an overview of membership by overall caste (marginalized

TABLE 2 Number of households by caste and Mulukanoor membership in the four selected villages.

Village	Total households by caste					Total membership by caste				
	Non-marginalized		Marginalized		Total	Non-marginalized		Marginalized		Total
	GC	OBC	SC	ST		GC	OBC	SC	ST	
Village 1	114	99	9	44	266	70	50	10	0	130
Village 2	125	283	306	16	730	49	148	30	5	232
Village 3	215	192	34	8	449	30	60	35	5	130
Village 4	238	245	289	252	1,024	120	202	136	10	468
Total	692	818	639	320	2,469	269	460	211	20	960
Percentage of members by caste and overall membership	28%	33%	26%	13%		28%	48%	22%	2%	39%

Authors' elaboration, Mulukanoor Dairy database, 2021.

TABLE 3 Focus group discussions.

Village name	Gender	Caste	FGD	Respondents		FGD topic
				Women	Men	
Village 1	Women	Non-marginalized	1	9	–	Changes in caste dynamics at village level
	Women	Non-marginalized	2	9	–	Changes in gender dynamics in intra-household dairy management
Village 2	Women	Non-marginalized	3	6	–	Changes in intra-household decision-making
Village 3	Men	Non-marginalized	4	–	6	Changes in caste relations at village level
	Men	Non-marginalized	5	–	6	Changes in gender dynamics in intra-household dairy management
	Men	Non-marginalized	6	–	6	Changes in intra-household decision-making
Village 3	Women	Marginalized	7	6	–	Changes in caste relations at village level
	Women	Marginalized	8	6	–	Changes in gender dynamics in intra-household dairy management
	Women	Marginalized	9	6	–	Changes in intra-household decision-making
Village 2	Men	Marginalized	10	–	9	Changes in caste relations at village level
	Men	Marginalized	11	–	9	Changes in gender dynamics in intra-household dairy management
Village 2 and 4*	Men	Marginalized	12	–	8	Changes in intra-household decision-making

Authors' elaboration.
*Combined FGD because only a few households adopted CoFS 29 in villages 2 and 4. In order to create a viable discussion format the men agreed to come together.

and non-marginalized) and then by caste affiliation within these categories.

Respondent profile

Table 5 provides some descriptive statistics about the respondents. Broadly, the data show that non-marginalized respondents have experienced more formal schooling, and for longer, than marginalized respondents. Around two thirds of marginalized respondents have not been to school compared to one third of non-marginalized respondents. Men have received more formal education than women across marginalized and non-marginalized respondents.

Table 6 provides details of respondent livestock and land-holdings.

Table 6 shows that households are quite large. Among the respondents the number of people living in a household ranged from 2 to 9 people (non-marginalized caste) and 2 to 6 people (marginalized caste). Nearly half of non-marginalized respondent households own both dairy cows and buffaloes whereas only one marginalized community household owns both. Marginalized households are more likely to own buffalo than non-marginalized households because they typically rely on bunds or communal land

TABLE 4 Number of Mulukanoor dairy members by caste in selected villages.

Village	Total HH/ village	Mulukanoor dairy membership by caste				Total members by HH
		Non-marginalized		Marginalized		
		GC	OBC	SC	ST	
Village 1	266	70	50	10	0	130
Village 2	730	49	148	30	5	232
Village 3	449	30	60	35	5	130
Village 4	1,024	120	202	136	10	468
Total	2,469	269	460	211	20	960
Percentage of members by caste / overall membership		28%	48%	22%	2%	39%
		76%		24%		
% of members by no of HH of each caste in each village						

Authors' elaboration, Mulukanoor Dairy database, 2021.

TABLE 5 Descriptive statistics for respondents.

Characteristics	Non-marginalized caste		Marginalized caste	
	Women	Men	Women	Men
Respondents	15	6	6	17
Average years of education (range of years)	4.6 (0–10)	8 (3–10)	1 (0–6)	4.3 (0–13)

Authors' elaboration.

for grazing. Buffalos are better suited to the climate, particularly in summer, can walk longer distances, and can tolerate poorer quality fodder than dairy cows. These are generally cross-bred and suffer heat stress.

Households with larger holdings are better able to host more livestock. The data show that non-marginalized households hold an average of 5.8 acres (range between households 0–22) whereas marginalized farmers hold on average 2.8 acres (median 1 acre). Marginalized households (all in our sample grew forage as this was part of the sampling frame) grow forage on a relatively larger proportion of their land, but the amount of land they can allocate is smaller in size than for the non-marginalized households since food production for the household must take precedence.

Adoption of CoFS-29 in the study sites

Table 7 provides of adoption by overall caste (marginalized and non-marginalized) and then by caste affiliation within these categories. Across the four village study sites, 51 GC women, 61 OBC women, 31 SC women and 8 ST women had adopted the CoFS-29 forage variety by October 2021. Only a few ST households were members of Mulukanoor Dairy. Of these 8 out of 20 members adopted CoFS 29 forage.

Respondents reported strong increases in milk yield as a consequence of adopting CoFS-29, estimating yield improvements of between 10 and 20% for cows and 5–15% for buffaloes.

We now discuss evidence for empowerment according to the two research questions set out at the beginning of this article.

Research question 1: changes in gender relations at intra-household level

The first question was as follows: *Changes in gender relations at intra-household level.* RQ1a. Are gender dynamics in intra-household dairy management changing? RQ1b. Are there differences in intra-HH gender dynamics by caste? The topics of enquiry are (i) changes in the gender division of labor in dairy, (ii) Milk allocation decisions, and (iii) Milk expenditure decisions.

General findings on gender relations

Marginalized and non-marginalized women are normatively responsible for most tasks associated with livestock care. Although the gender division of labor allocates a substantial burden to women, non-marginalized women argue that, overall, they work less than non-marginalized women because many of them employ laborer's to take care of livestock. Moreover, across caste, men's workloads regarding the care of dairy animals (feeding, grazing, watering, milking and health care) appears to be increasing. This is because livestock are now housed, due to government health regulations aiming to minimize the risk of zoonotic disease, on fields at some distance from the homestead. Mobility norms which restrict women's movements, and their widely recognized responsibility for household tasks, mean that men are under pressure to take on livestock care.

Furthermore, men rather than women interact with market actors and knowledge agents. "Decisions regarding purchase of feed from the market, animal purchase and calling the veterinarian or inseminator are done by men. Cleaning the cow shed, feeding the animals, taking care of the sick animals, and forage cutting is carried out by women" (NMM FGD, V3). This role is not contested.

TABLE 6 Respondent livestock and land holdings by caste.

Characteristics	Non-marginalized caste	Marginalized caste
Average number of household members	4.3	4
Number of households owning only cows (as % of all respondent households)	6 (29%)	9 (39%)
Number of households owning only buffaloes (as % of all respondent households)	5 (24%)	13 (57%)
Number of households owning cows and buffaloes (as % of all respondent households)	10 (48%)	1 (4%)
Number of cows average /HH (range across all respondent households)	1.9 (0–10)	1.7 (0–16)
Number of buffaloes average/HH (range across all respondent households)	1.6 (0–4)	1.4 (0–6)
Land size average acres (range across all respondent households)	5.8 (0–22)	2.8 (0–6)
Land allocated to forage average acres (as % of total land owned by respondent household) (range across all respondent households)	0.33 (5%) (Range 0–1)	0.27 (10%) (Range 0–2)

Authors' elaboration.

One woman explained, "We do not have conflicts about this because he has more knowledge and travels outside" (NMW FGD, V1).

Milk allocation decisions

Across caste gender norms previously stipulated that milk should be provided to men for men's personal consumption or sale. This norm has been transformed. Men no longer participate in decision-making around the allocation of milk between household members, or between how much milk is allocated for consumption and sale. These decisions are now perceived as for women to make.

Today, women provide milk to children and elderly household members before providing milk to adults. Milk is widely understood to promote children's health, and "all girls get equal preference with boys in the families" (NMM FGD, V3). This contrasts with the past when boys were favored. One man reported, *"Twenty years ago my mother gave milk to working men and then to other adults, but now the scenario has changed. Women give milk to children first"* (NMM FGD, V3). Marginalized women used almost the same words and explained that men were previously given milk to drink because milk is thought to build strength, important since marginalized men had to earn money through physical labor. Today, due to reductions in extreme poverty everyone drinks some milk with adults consuming small quantities in tea.

Milk expenditure decisions

Dairy income has allowed some marginalized women to improve household nutrition through enabling them to buy other animal source foods with their own money. Women explained they cannot ask men for money to purchase meat or eggs. One woman reported, "Many households used to eat meat once or twice a year during festivals 25 years ago. Now, some eat meat every weekend because women can decide on household food due to dairy income" (MW FGD, V3).

The findings show significant changes beyond the household. Whereas men normatively take expenditure decisions associated with transactions in public spaces, and women take expenditure decisions associated with the home, the influence of Mulukanoor Dairy is changing—and enlarging—these boundaries for women to grant them more influence over decisions outside the home. Marginalized men explained that "After the women dairy cooperatives came up, women started taking decisions on the purchase of dairy animals to increase dairy income. (To do this) she gets money from her women SHG. Men go to the market and purchase animals." This man added that "Women's contribution within the household is to decide on number of animals to be added, how much milk to keep for household consumption, etc. Decisions related to outside work like feed purchase, animal purchase, getting veterinary help, or breeding are made by men" (MM FGD, V2).

Even though marginalized women are now taking key decisions around spending on dairy livestock, some marginalized men try to defend their continued dominance of key expenditure decisions associated with dairy. This dominance is justified by referring to the low levels of education among marginalized women. One marginalized man said, "My wife does not have any knowledge on breeding or animal health. She does not know anyone who provide these services, so I take all decisions" (MM FGD, V2). A marginalized women explained, "Men are head of household, they often go outside and gain more knowledge so they take all decisions" (MW FGD, V3). These claims are surprising because Mulukanoor Dairy has spent the past two decades offering technical training to women.

Indeed, marginalized women and men shared a perception that non-marginalized caste women are more likely to participate in training and to be listened to at home because the latter have been formally educated. This is believed to have knock-on effects on their ability to absorb the lessons from technical training events. Marginalized women explained that, "Non-marginalized women learn quicker and faster than marginalized women. And their men share

TABLE 7 Overall number of adopters CoFS-29 in the four study communities.

Village	Non-marginalized caste		Marginalized caste		Totals
	GC	OBC	SC	ST	
Village 1	20	15	5	0	40
Village 2	10	22	6	3	41
Village 3	9	11	14	0	34
Village 4	12	13	6	5	36
Total adopters					151
Total adopters by caste	51	61	31	8	
Mulukanoor Dairy membership by caste	269	460	211	20	
Total % of adopters as % of membership	19%	13%	15%	40%	

Authors' elaboration.

more than our men" whilst another marginalized woman added nuance by suggesting that marginalized men "think women are less knowledgeable, so women have to learn for themselves which is not the same in the higher caste. Their women are rich and they get a good education as well" (MW FGD, V3). Marginalized men agreed with this analysis arguing that because non-marginalized women are educated "they have some contribution to make within the home to suggest allocating land for forage." These men added that the very limited size of their lands resulted in a limited range of decisions that needed to be made, unlike with the non-marginalized caste (MM FGD V2).

Some marginalized women, though, contested the claim that men (or non-marginalized women) take important decisions because the latter are better educated. They asserted that marginalized women themselves do not in fact lack the freedom to improve their knowledge. Rather, they are allowing normative assumptions around their level of education to limit their opportunities to learn. These women argued that women themselves must take a lead in becoming more mobile in public spaces and informing themselves. "Women must be self-motivated to learn and get empowered in the community. She should be willing to go for meetings and trainings. If we can get more knowledge, we can also take decisions. If women are willing to grow in community she should go outside in meetings and workshops for learning" (MW FGD, V3).

The findings relating to the ability of non-marginalized women to take important expenditure decisions are markedly different. Although non-marginalized women are expected to inform their husbands about their spending priorities and to provide them with the remaining dairy income this is not necessarily a tense negotiation. One woman explained, "A woman receives money from the dairy center. She takes the money she needs for her expenses and she gives her husband the rest of the money. This was not possible earlier. We had to beg money from our husbands for all expenses" (NMW FGD, V1). Other respondents added, "Earlier women asked money from men for their needs, but now men ask women for some dairy money for their needs" and, "men say 'milk is women's kingdom, we have to ask money from them'" (NMW FGD, V1).

Non-marginalized women added that dairy income has helped to bulk up overall household income thus reducing tensions over "who decides" how money is spent. The fact that women now know precisely how much dairy income has been paid improves their bargaining position. Women also remarked that, compared to crop income, dairy provides a relatively small part of overall household income. Men are not particularly interested in it. However, men retain the right to take more of the dairy income at key points in the agricultural calendar when they need money.

Non-marginalized men attributed women's stronger voice directly to their membership of Mulukanoor Dairy. "Women's capacity to influence decision making has increased over the past 20 years. Money is coming in women's name, so they have more power to spend money. However, it is up to women to give and share money with men for household smooth relations" (NMM FGD, V1). The concept of smooth household relations was widely shared and is the primary reason why women agree to share their milk income with men.

Finally, we turn to credit as a potential game-changer for marginalized women with respect to their caste and also with respect to their relative decision-making power vis-à-vis men. Credit is of particular importance to the marginalized caste, who rarely access loans from banks as they do not have sufficient land to offer as collateral (and women do not own any land). Marginalized women's dairy income, obtained through their membership of Mulukanoor Dairy, assists them to obtain informal credit through relatives and friends. They then typically save this money in SHGs thus creating more funds for themselves. This money is used for repaying SHG loans, school fees, health care expenses and procuring nutritious household food. This in turn provides women with a stronger voice in intra-household negotiations. A man explained the feedback loop as follows: "My wife got 50,000 rupees from her SHG group loan and we bought one more animal. She can influence me on the spending of the dairy income easily" (MM FGD, V2).

Furthermore, marginalized women are able to offer their membership of Mulukanoor Dairy as a form of collateral in their negotiations with their SHGs. This allows them to obtain significant loans from SHGs (up to 100,000 rupees/1 lakh/ approximately 1,220 USD) whereas marginalized men can generally expect to obtain a loan of no more than Rs 20,000 (approximately 245 USD) from the bank. Marginalized men explained, "This is giving some power to the woman within the household. So, we must listen to her suggestions. As she is unable to handle the things outside the household like purchase feed and livestock, she depends on us" (MM FGD, V2). Whilst men appeared anxious to stress that they remain pivotal decision-makers, some SC women seemed to contest this. "Our husbands respect us nowadays. If they say anything against us we do not

share dairy income with them. We help them to get agricultural loans from self-help groups. We share the expenses nowadays" (MM FGD, V3).

Research question 2: changes in caste relations at the village level

The second research question was as follows. *Changes in caste relations at village level*. The research question was: Are caste dynamics among women and men belonging to different castes changing? We decided to elicit this through examining CoFS-29 information exchange between castes.

Over the past 20 years Mulukanoor Dairy has trained women across caste together on the technical aspects of the dairy chain. More recently it has opened up its training programs to men across caste. We hypothesized that co-training across caste would lead to shifts in how people share knowledge – in particular, that they would share knowledge with people of other castes as well as their own castes. We also hypothesized that men and women would share knowledge with each other freely.

To find out, we first asked the respondents (in single sex FGDs) to draw simple knowledge sharing maps. They depicted themselves in the middle of the paper, and then drew lines from themselves to the individuals who had shared knowledge with them—and with whom they had shared their knowledge—with respect to CoFS-29. They were then asked to explain their maps in terms of the gender and caste of the people they depicted. We then aggregated the flows of information to create one knowledge map for men, and one for women. These are depicted below, and discussed.

On the basis of this exercise, we asked respondents to reflect more generally on their relationships with people in other castes. In this section, we first present the knowledge mapping exercise and then turn to the broader reflections.

The colors used on the Figures presented below indicate caste and gender, with blue referring to the non-marginalized caste, yellow to the marginalized caste, with green being caste-free. White is a topic heading. Gender is indicated by the box outline, blue for men and red for women, with a green outline indicating a gender-free domain. The same colors are used to indicate flows of information.

Men's knowledge sharing networks

Figure 2 combines the findings from two men's FGDs. The top row indicates the original source of information. FGD respondents occupy row two, and the people they disseminated to are shown on row three. Along the middle row, the numbers refer to the FGD respondents. All six non-marginalized men FGD respondents received information direct from dairy center staff. However, two marginalized men FGD respondents obtained information from their wife or a female relative, two from the village dairy society, and one man learned about the innovation from another male farmer of his caste. The six non-marginalized men shared their information exclusively with men of their own caste.

Figure 2 indicates important differentials in men's knowledge sharing networks. Non-marginalized men indicated that their wives and women relatives were informed, but when they wanted information, they preferred to go direct to the dairy center secretary. They explained that the secretary—often a man—tells men about the new technology when they come to sell milk, and "then information is passed man to man" (NMM FGD, V3).

The picture for marginalized men is mixed with some relying on the village dairy, some on male relatives and some on women relatives or spouses for their information. One marginalized man indicated that he actively sought out information on CoFS-29, but rather than ask farmers from another caste, he approached the dairy society directly. He explained, "I saw the forage being planted in our village by the non-marginalized caste and I found the stems to be slender and heard it is a good variety. I asked the dairy staff to let us know the seed details, then I planted it in my farm" (MM FGD, V4).

Women's knowledge sharing networks

The women's knowledge sharing map is constructed in the same way as the men's map. The top row indicates the original source of information. FGD respondents occupy row two, and the people they disseminated information to are shown on row three. Figure 3 combines information from two women's FGDs.

The sources of information are more complex than for the men's map. Three non-marginalized women FGD respondents received information from the village dairy society. Non-marginalized women also received information from a local man farmer, a relative of the same caste, and from other Mulukanoor women members of the same caste.

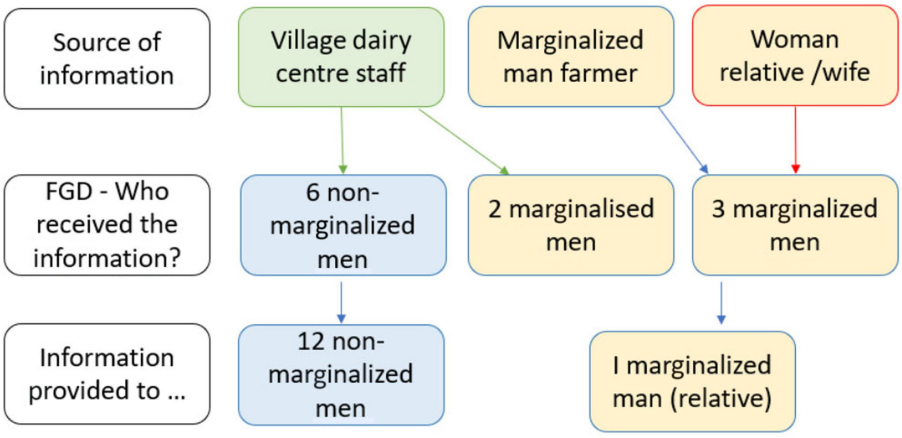

FIGURE 2
Men's knowledge sharing networks. FGDs with men: non-marginalized men (no. 6), and marginalized men (no. 5).

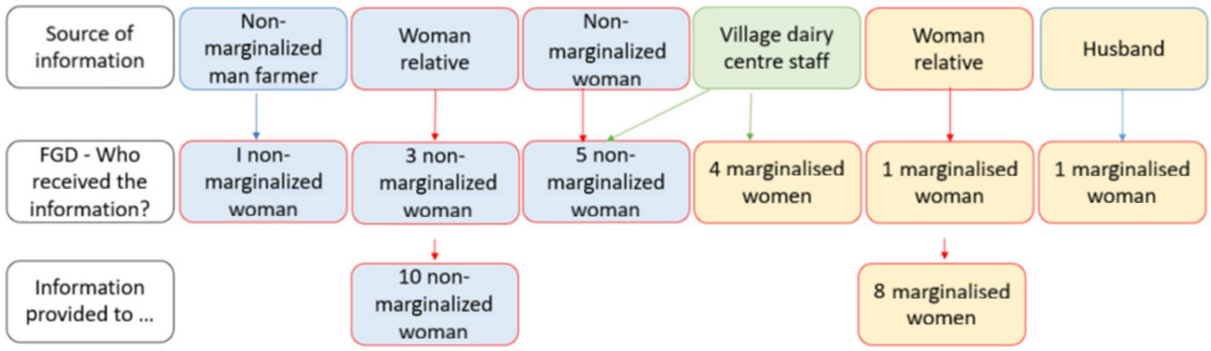

FIGURE 3
Women's knowledge sharing networks. FGDs with women: non-marginalized women (no. 9), and marginalized women (no. 6).

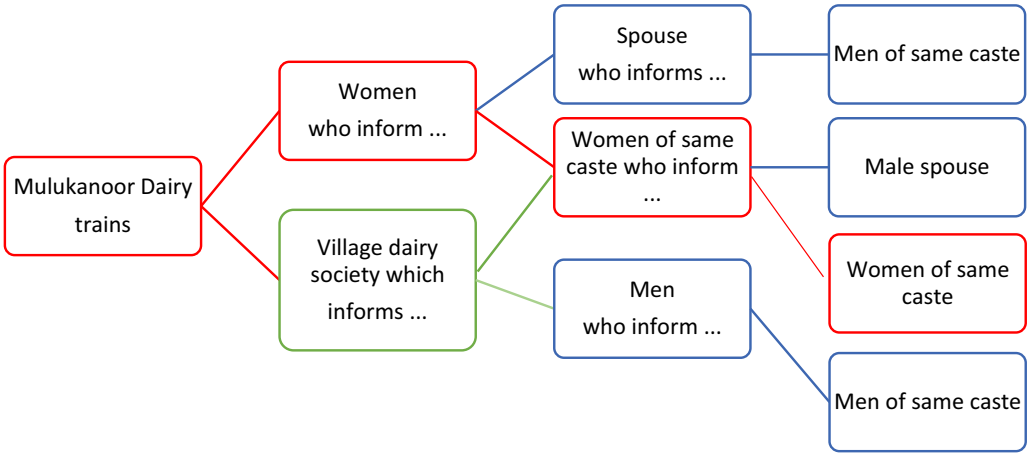

FIGURE 4
Masculinization of the knowledge sharing network on new forage varieties.

Four of the marginalized women FGD respondents obtained information from the dairy center due to direct training in the new forage variety. One obtained information from her husband and another from a woman relative.

Non-marginalized women passed on information to two other women in four cases (in one case, to a sister), to one person in four cases (in two cases sisters). In two cases non-marginalized women did not share their information at all. Among the six marginalized women, two shared with two other women and four shared with one other woman each (in two cases with a relative). Non-marginalized and marginalized women shared only within their caste.

Overall findings on knowledge sharing: towards masculinizing, intra-caste knowledge sharing networks

The overall findings are summarized in Figure 4. The same colors as with the figures above are used to indicate gender: red for women, blue for men, and green for a neutral actor. The lines between actors are colored according to whether the recipient is a woman or a man. Five observations can be drawn from Figure 4. First that knowledge sharing networks begin to masculinize from the source of the information to the end user. Second, this occurs despite women to women sharing within a caste. Third, despite the efforts of Mulukanoor Dairy to train people of different castes together, these efforts have not resulted in inter-caste knowledge sharing networks in the community. Fourth, non-marginalized women and men—and marginalized women—are more likely than marginalized caste men to learn about new forage varieties from the village dairy center. Finally, marginalized men are less likely than anyone else to share information on new forage varieties.

Men-dominated decision-making on field crops lie behind the masculinization of the forage knowledge sharing network. As testified by women and men respondents from all castes, men's decision-making on the utilization of land lies unequivocally within their purview. "Women are trained first, but they inform their husbands. When men understand adoption is faster because men take decisions on which land to allocate and how much to plant" (NMW FGD, Village 2). Marginalized men claimed that women plant forage seeds but otherwise took no decision-making role regarding whether or not to grow forage. These attitudes demotivate many—though not all—marginalized women. They explained that "Anyone can access information but only a few women take the learning further," that "Society thinks men know more than women," and that "Women can learn just like men, but they need to speak up and be bold and confident" (MW FGD, V3). Even so, marginalized women do share information with each other.

Furthermore, the knowledge dissemination system expresses and reinforces caste biases in the dairy business. Non-marginalized castes own better quality—and more—land than marginalized castes. This sets a positive feedback loop in motion, whereby cattle and buffalo owned by non-marginalized castes provide more milk through consuming improved forages. This contributes to higher incomes from milk sales which in turn leads to the purchase of more dairy livestock and thus more income. Furthermore, larger livestock holdings promote livelihood resilience in drought years. "Income from dairy increased after the provision of improved forage. This helped us cope with the agricultural crisis. The forage requires little water which was particularly important in that drought year" (NMM FGD, V3).

Conversely, in marginalized households negative feedback loops operate. The respondents explained that the majority of marginalized men do not plant improved forages because their land is low quality and too small to support forages as well as food crops for their household consumption. This results in a general unwillingness among most marginalized women and men to attend technical training, though it is freely offered to all. Men commented, "Even though there is equal access to information, only a few in our community try to learn about forages" (MM FGD, V4).

General findings on caste relations

Marginalized women expressed their appreciation of being able to mix with non-marginalized women at Mulukanoor Dairy's meeting and training events. Women across caste mix, sit and eat together. This freedom to mix has been extended to some degree to public spaces in the community which are now more open to women of all castes.

Twenty years ago, non-marginalized women were largely restricted to their homes and *a priori* could not mix with other castes. Today, however, non-marginalized women can move freely within the village and visit the local town in company with other women of the same caste. They do not mix, though, with women of marginalized caste.

Changes in a few caste norms appear to be accelerating. Non-marginalized men noted a "very drastic change in education and economic empowerment" over the 5 years prior to the research in 2021. Furthermore, previously "when non-marginalized caste men came to pour milk [at the village dairy society], marginalized castes gave way and showed respect. Nowadays everyone gets the same respect standing in a queue" (NMM FGD, V3). Non-marginalized respondents were clear, though, that this freedom only occurs at the village dairy society (a Mulukanoor space). They do not attend non-marginalized caste festivals, and caste hierarchies and associated behaviors are observed at temples. Taboos preventing eating together are strictly enforced. Non-marginalized women and men do not eat in the homes of marginalized communities. Marginalized communities are provided with a separate tent for their meals when attending functions which non-marginalized members of the community organize, or attend.

Discussion

This article opened through observing that feminists in the Global South were prominent in defining women's empowerment during the 1980s and 1990s, and that their definitions emerged from a background of activism. Some organizations that drew inspiration from this thinking, including Mulukanoor Dairy, exist today. Our research questions were based on the hypothesis that if women members of Mulukanoor Dairy had become empowered over the past 20 years due to the gender and caste empowerment strategies of Mulukanoor Dairy we should be able to see evidence for this today.

Strategies to strengthen women's empowerment in Mulukanoor involved—across caste (i) offering technical training to women, (ii) ensuring board members are (almost) exclusively women with positions open to all, and (iii) paying women directly for milk. Strategies to improve inter-caste relations included (i) mixing and selling milk from all castes, and (ii) seating and eating together at Mulukanoor events. Figures 5, 6 summarize the changes that have resulted, according to our respondents, as a consequence of these strategies.

Strategies to empower women

Our findings show that women across caste benefit directly from technical training courses offered by Mulukanoor Dairy. This strategy has the potential to create a new norm that women (rather than, or as well as men) are knowledgeable and able to act on their knowledge. Broadly speaking, women are indeed now recognized to be knowledgeable. The data show that they are experiencing stronger *power within* now, which is contributing to a new norm privileging women's *power to act* in relation to the allocation of milk and spending of dairy income. This is primarily due to Mulukanoor Dairy' strategy to pay women directly for milk. Paying women rather than men for milk has led directly to the establishment of new norms. First, women are free to allocate milk for household consumption and sale. Whereas men previously drank milk, now children and elderly people are prioritized, and women also drink milk. Second, women's direct access to dairy income enables them to purchase livestock, pay school fees, and other household needs. Their investments in livestock and SHGs has the effect of multiplying women's income from dairy. The virtuous circle thus instigated is recognized, by women and men across caste, to strengthen women's say in intra-household decision-making.

In relation to decision-making around dairy, there is an evident and significant shift in normative power relations away from the *power over* norm that had previously characterized knowledge relations between women and men. However, caste identity nuances these gains, with marginalized women less recognized to be knowledgeable. Surendran-Padmaja et al. (2023) highlight literature focused on caste-gender interactions which suggest that marginalized castes can be subject to sanctions—including violence—when women attempt to challenge gender and caste-based discrimination (see Bidner and Eswaran, 2015; Datta and Satija, 2020; Farnworth et al., 2022). Fear of sanctions may similarly lie behind the efforts of marginalized men in this study to play down their wife's decision-making power, though this is speculation. In their own study in Madhya Pradesh, Surendran-Padmaja et al. (2023) intriguingly find that in some marginalized communities men feared gaining "a bad reputation when women gained financial independence," yet in other marginalized communities marginalized men felt their wives would benefit from becoming more empowered (Surendran-Padmaja et al., 2023, p. 7).

However, women's improved decision-making power appears to be almost hermetically restricted to a specific set of decisions around dairy, including whether to buy new animals—a large decision which

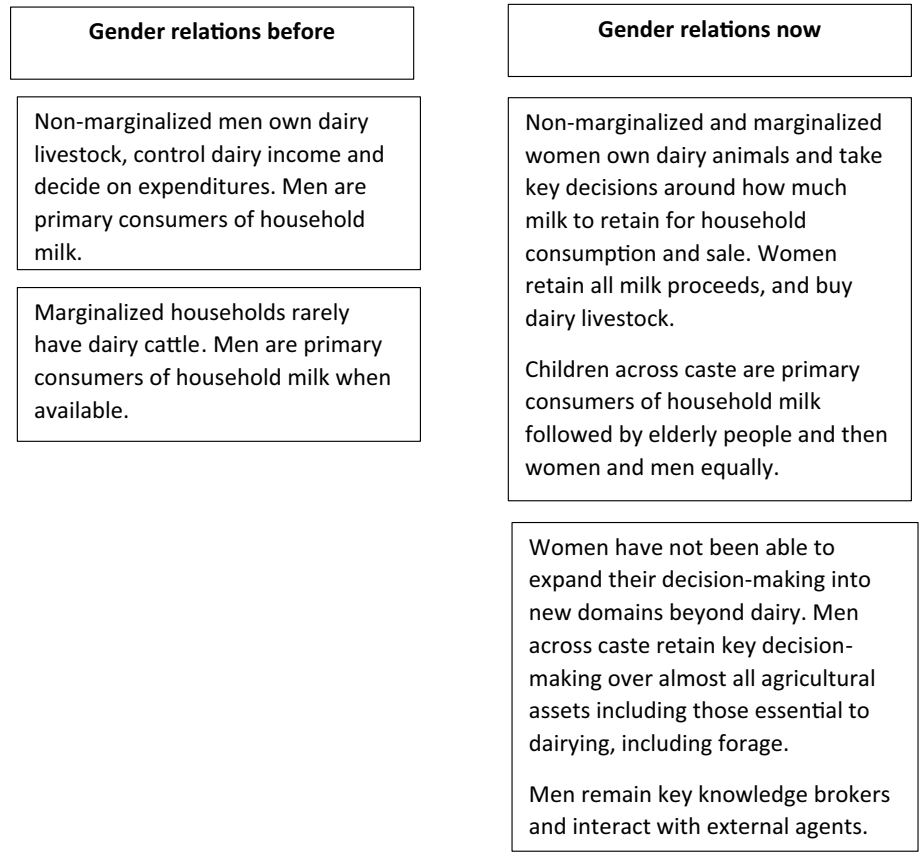

FIGURE 5
Changes in gender relations in the household following Mulukanoor Dairy's interventions.

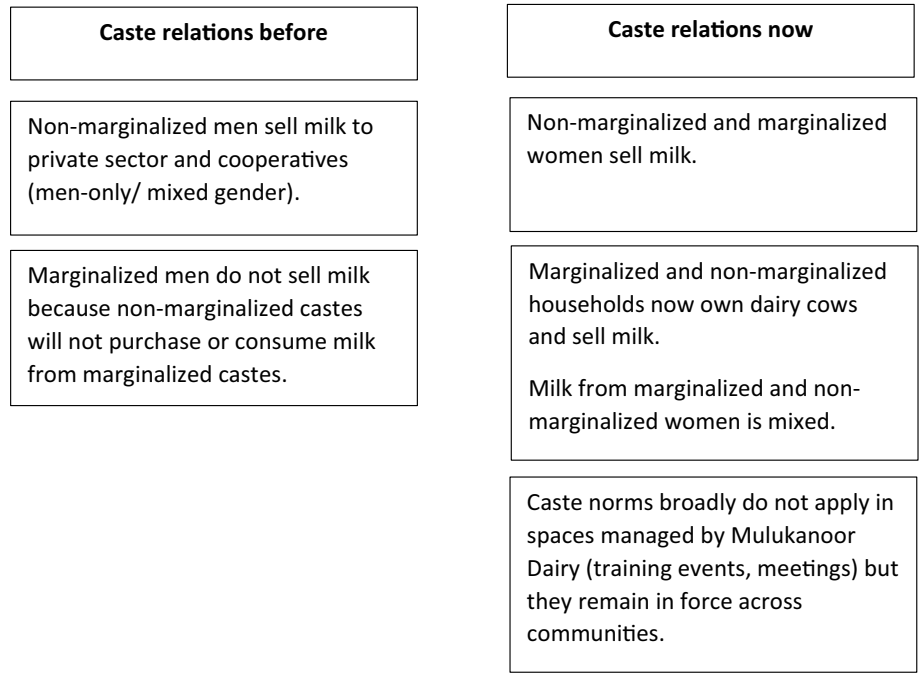

FIGURE 6
Changes in caste relations in the village following Mulukanoor Dairy's interventions.

women finance through their own funds. Yet, generally their decision-making power does not extend to decisions around whether to plant forage because land-related decisions continue to lie within men's normative remit—though the data suggests that a few non-marginalized women have some influence. Farnworth et al. (2022), in a study conducted in a farming community in Madhya Pradesh, find that women across caste conduct fieldwork on their own farms, and as paid day laborers for other farmers, yet very few of these women consider themselves "farmers." Men also refuse to acknowledge them as such. As a consequence, men rarely permit women a say in field decisions, and women never interact with external partners (Farnworth et al., 2022). This finding echoes those of the current study, whereby women members of Mulukanoor Dairy do not interact with extension agents, AI technicians, market agents and other knowledge brokers. Although women are acknowledged to be livestock owners, they are not considered farmers. Much literature has discussed the issue of women's recognition as farmers and its implications (Galiè et al., 2013). As a consequence of the continuing expression of gendered—and caste norms in public spaces, women's abilities to generate and exercise their knowledge are largely limited to the narrow channels provided by Mulukanoor Dairy.

The inability of women to break through into new knowledge networks is reflected in the way Mulukanoor Dairy abandoned its strategy to provide technical training only to women. A decision to throw open its doors to men's participation in training was taken several years ago. This may have appeared to be a necessity given the normative desire of men to retain decision-making power over key capitals required for successful dairying, including natural capital (land and forage) and social capital. However, the outcome is that men once again are primary knowledge holders alongside women. Our tentative findings suggest that information asymmetry is beginning to reassert itself in favor of men. It is too early to say whether this will continue. In Uttar Pradesh, an examination of women's and men's information networks similarly found very little overlap between them, and further found that women's information networks have little influence upon intra-household decision-making around technology adoption (Magnan et al., 2015).

The question thus arises as to whether—had Mulukanoor Dairy continued to support exclusive women's training—this would have, over time, transformed gender norms around 'who is knowledgeable' and whether this might slowly have strengthened women's claim to the productive assets upon which dairying depends—and potentially helped some women to move up the value chain away from production and into new roles in marketing and knowledge broking. It would be valuable to research a situation similar to Mulukanoor Dairy in which women have been exclusively trained in a technology over time to help understand if this has undermined programmatic biases towards strengthening women's knowledge, or rather empowered women to move into new entrepreneurial domains. It is likely, though, that such efforts would need to be embedded within a broader gender-transformative change methodology focused on working with women and men, and partners at a range of levels, to identify and address harmful gender norms across the community (McDougall et al., 2021).

The fact that wider gender norms around the control over productive resources have not changed does not seem to be considered by a respondent to be unjust. It appears to be commonsense to ensure men are well-trained as they own resources, care for livestock, and manage key transactions with resource brokers. There is no evidence for critical scrutiny by the FGD respondents of these deeper *power over* norms, even though they foster gender inequalities and continued expression of gender-inequitable masculinities. This leads the authors to consider whether the concept of doxa applies. Doxa conveys the idea that some norms lie so deep and are so fully naturalized they lie below the level of conscious awareness (Bourdieu, 1977). Farnworth et al. (2021) utilized the concept of doxa as an analytic lens to examine decision-making data from farming communities in four Indian states. Their study found no evidence of doxa: women were fully aware of men's dominant role in decision-making. However, some women—particularly among the non-marginalized caste in some communities, acquiesced in their own silencing. Risseeuw (2005) argues that even acquiescence is a form of resistance, because women are taking a decision even though it is one born out of low power. Perhaps the more disempowered women in the current study engage in a strategy which moves slightly beyond acquiescence. They seem to engage in a non-articulated exchange which acknowledges that women now have important *power over* dairying therefore it seems judicious to allow men *power over* other resources. In any case, it is clear that a unitary model of household decision-making does not apply (Sen, 1990). Further research into how the relative jointness of household making changes over time in cooperatives and other institutional settings would be valuable (Ambler et al., 2017; Seymour and Peterman, 2018; Acosta et al., 2019).

Disaggregation by caste nuances these findings. Non-marginalized caste women express stronger *power within* and *power to act* than do most marginalized women. Non-marginalized women express their views with confidence and claim strong say in intra-household decision-making processes. By way of contrast many, though not all, marginalized caste women are more hesitant in claiming strong decision-making power. Marginalized men generally express a strong version of *power over* women whereas non-marginalized men tend towards a more collegial view. The data suggest this is due to non-marginalized women experiencing a strong form of *power through* (a non-agentic form of power) by virtue of their caste identity. The processes constructing the identities of non-marginalized women result in them obtaining more years of formal education than marginalized women. Higher levels of education command more respect within the community and they contribute to strengthened ability—as individuals and collectively—to practice agency effectively. Interestingly, this contradicts findings by Surendran-Padmaja et al., (2023) who find that non-marginalized men, and men with more land, are more likely to consider that the wider community would frown upon households demonstrating changing gender roles. Sankaran et al. (2017) similarly find that non-marginalized caste violation of social (and gender) norms is likely to result in strong sanctions being applied to the norm violator. In our case, it is plausible to argue that the action of Mulukanoor Dairy to empower women has indeed been extremely successful, to the extent that women speaking out—particularly among the non-marginalized caste, are no longer considered to be violating norms.

Strategies to improve inter-caste relations

Mulukanoor Dairy has used its *power to empower* to implement strategies which encourage women across caste to meet, share ideas and to participate in governance. A major indicator of the success of this

approach is that a new norm has emerged, namely that marginalized women are now active in the dairy industry, and they are also elected to board positions—though the board remains dominated by non-marginalized castes (Ravichandran, 2018). Nevertheless, little of this collegiality translates outside this protected space in the form of more equitable inter-caste community relations. Our findings show that technical knowledge tends to be shared within, rather than between, castes. Village events, though open to everyone, are characterized by caste separation according to caste norms. This said, there is improved acknowledgement of members from different castes in the field, and it is particularly interesting that non-marginalized castes, including men, can no longer queue-jump at the village dairy. This finding suggests that the caste equality practiced by women in Mulukanoor Dairy's spaces has begun to translate into changing men's behaviors within the village albeit in a limited way.

Our findings are echoed by Mudliar and Koontz (2018). They discuss the outcomes of their study into a community organization in Karnataka, India. Here, they argue, the expression of caste is generally—though not entirely—muted. By this they mean that caste norms are not observed in community organization meetings. The community organization has proven successful in instituting collective action across caste for better natural resource management. Yet—just as with Mulukanoor Dairy—caste observance continues in all aspects of village life thereby reproducing caste inequalities. Mudliar and Koontz (2018) further argue that the switching off and switching on of caste identity within and beyond the organizational setting means that marginalized caste group members tend to fall back on caste norms of deference within the organization, not least because they expect to encounter non-marginalized members in everyday village life. It seems likely that similar concerns operate in Mulukanoor Dairy communities. The age-old structures of caste, which have endured for millennia—particularly in rural India (Deshpande, 2010)—and the sanctions associated with contravening caste norms still largely structure and challenge people's ability to form collegial relations.

Conclusion

Mulukanoor Dairy has been largely successful at empowering women across caste, who have seen an improvement in gender relations in their household. Such improved decision-making, however, is mostly limited to decision making specifically around dairy. When it comes to caste relations, Mulukanoor has instituted a new norm that marginalized caste women are dairy farmers. This constitutes a transformative change in local caste arrangements which is nevertheless limited in scope. Mulukanoor Dairy has not developed strategies to change caste norms beyond its doors. This means that the structural disadvantages of women in marginalized castes—which compromise their ability to benefit fully from their membership—remain unaddressed. Mulukanoor Dairy empowers women across caste, but the benefits are not equally distributed because the playing field is already uneven.

In this article we grappled with the complexity of transformative change at the interface of caste and gender and their shaping systems of inequality. Our evidence raises a number of questions on the depth of transformative change. We hope that further research—which is much needed—will continue to shed light on intersectional transformative change and the strategies that may be effective to progress towards both gender and caste equality.

Data availability statement

The datasets presented in this article are not readily available because "The datasets for this article are not publicly available due to concerns regarding participant anonymity. Requests to access the datasets should be directed to the corresponding author." Requests to access the datasets should be directed to: a.galie@cgiar.org.

Ethics statement

The studies involving human participants were reviewed and approved by ILRI ethics committee (Ref: ILRI-IREC2021-46). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. However, oral consent was obtained from each respondent prior to any and every discussion.

Author contributions

AG, CF, and TR contributed to conception and design of the study. TR conducted the empirical field and wrote up the findings. CF analyzed the findings and wrote the first draft of the manuscript. AG provided critical feedback to the article. TR contributed descriptive statistics of the respondents. AG and CF prepared figures. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

References

Acosta, M., van Wessel, M., van Bommel, S., Ampaire, E. L., Twyman, J., Jassogne, L., et al. (2019). What does it mean to make a 'joint' decision? Unpacking intra-household decision making in agriculture: implications for policy and practice. *J. Dev. Stud.* 56, 1210–1229. doi: 10.1080/00220388.2019.1650169

Allen, A. (1999). *The Power of Feminist Theory: Domination, Resistance, Solidarity*. Westview Press, Boulder, CO.

Ambler, K., Doss, C., Kieran, C., and Passarelli, S. (2017). He says, she says: exploring patterns of spousal agreement in Bangladesh. IFPRI discussion paper 01616. IFPRI: Washington DC. Available at: http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/131097/filename/131308.pdf

Basu, P., and Chakraborty, J. (2008). Land, labor, and rural development: analyzing participation in India's village dairy cooperatives. *Prof. Geogr.* 60, 299–313. doi: 10.1080/00330120801985729

Batliwala, S. (2007). Taking the power out of empowerment: an experiential account. *Dev. Pract.* 17, 557–565. doi: 10.1080/09614520701469559

Bidner, C., and Eswaran, M. (2015). A gender-based theory of the origin of the caste system of India. *J. Dev. Econ.* 114, 142–158. doi: 10.1016/j.jdeveco.2014.12.006

Blümmel, M. (2017). *Improved Sorghum and Pearl Millet Forage Cultivars for Intensifying Dairy Systems*. Nairobi, Kenya: ILRI.

Bourdieu, P. (1977). *Outline of a Theory of Practice. Cambridge Studies in Social and Cultural Anthropology*. Cambridge: Cambridge University Press.

CGIAR (2017). CGIAR research program on Fish Agri-food systems, 2017. CGIAR research program on FISH Agri-food systems (FISH): Gender strategy. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems.

Chambers, R. (2006). Transforming power: from zero-sum to win-win? *IDS Bull.* 37, 99–110. doi: 10.1111/j.1759-5436.2006.tb00327.x

Christie, N., and Chebrolu, P. S. (2020). "Creating space for women leadership and participation through innovative strategies: a case of tribal women's dairy cooperatives in Gujarat" in *Cooperatives and Social Innovation*. eds. D. Rajasekhar, R. Manjula and T. Paranjothi (Singapore: Springer)

Cornwall, A. (2016). Women's empowerment: what works? *J. Int. Dev.* 28, 342–359. doi: 10.1002/jid.3210

Cornwall, A., and Rivas, A. M. (2015). From 'gender equality and 'women's empowerment' to global justice: reclaiming a transformative agenda for gender and development. *Third World Q.* 36, 396–415. doi: 10.1080/01436597.2015.1013341

Crouch, M., and McKenzie, H. (2006). The logic of small samples in interview-based qualitative research. *Soc. Sci. Inf.* 45, 483–499. doi: 10.1177/0539018406069584

Datta, A., and Satija, S. (2020). Women, development, caste, and violence in rural Bihar, India. *Asian J. Women's Stud.* 26, 223–244. doi: 10.1080/12259276.2020.1779488

Deshpande, M. S. (2010). *History of the Indian Caste System and its Impact on India Today*. New York, NY: California University Press.

Dohmwirth, C., and Hanisch, M. (2017). Women and collective action: lessons from the Indian dairy cooperative sector. *Commun. Dev. J.* 53, 1–19. doi: 10.1093/cdj/bsx014

Dohmwirth, C., and Liu, Z. (2020). Does cooperative membership matter for women's empowerment? Evidence from south Indian dairy producers. *J. Dev. Eff.* 12, 133–150. doi: 10.1080/19439342.2020.1758749

FAO, IFAD, and WFP. (2022). *Guide to Formulating Gendered Social Norms Indicators in the Context of Food Security and Nutrition*. FAO: Rome.

Farhall, K., and Rickards, L. (2021). The "gender agenda" in agriculture for development and its (lack of) alignment with feminist scholarship. *Front. Sustain. Food Syst.* 5:573424. doi: 10.3389/fsufs.2021.573424

Farnworth, C. R., Bharati, P., Krishna, V. V., Roeven, L., and Badstue, L. B. (2022). Caste-gender intersectionalities in wheat-growing communities in Madhya Pradesh, India. *Gend. Technol. Dev.* 26, 28–57. doi: 10.1080/ 09718524.2022.2034096

Farnworth, C. R., Jafry, T., Bharati, P., Badstue, L., and Yadav, A. (2021). From working in the fields to taking control. Towards a typology of Women's decision-making in wheat in India. *Eur. J. Dev. Res.* 33, 526–552. doi: 10.1057/s41287-020-00281-0

Galiè, A., and Farnworth, C. R. (2019, 2019). Power through: a new concept in the empowerment discourse. *Glob. Food Sec.* 21, 13–17. doi: 10.1016/j.gfs.2019.07.001

Galiè, A., Jiggins, J., and Struik, P. C. (2013). Women's identity as farmers: a case study from ten households in Syria. *NJAS-Wageningen J. Life Sci.* 64-65, 25–33. doi: 10.1016/j.njas.2012.10.001

Gammage, S., Kabeer, N., and van der Meulen Rodgers, Y. (2016). Voice and agency: where are we now? *Fem. Econ.* 22, 1–29. doi: 10.1080/13545701.2015.1101308

Hankivsky, O. (2014). Intersectionality. The Institute for Intersectionality Research & Policy, SFU. Available at: https://www.sfu.ca/iirp/documents/resources/101_Final.pdf

Kabeer, N. (1999). Resources, agency, achievements: reflections on the measurement of women's empowerment. *Dev. Chang.* 30, 435–464. doi: 10.1111/1467-7660.00125

Kabeer, N. (2016). "'Leaving no one behind': the challenge of intersecting inequalities" in *World Social Science Report 2016* (Paris: UNESCO and the ISSC)

Keddie, A., Flood, M., and Hewson-Munro, S. (2022). Intersectionality and social justice in programs for boys and men. *NORMA Int. J. Masculinity Stud.* 17, 148–164. doi: 10.1080/18902138.2022.2026684

Kleiber, D., Cohen, P., Gomese, C., and McDougall, C. (2019). Gender-integrated research for development in Pacific coastal fisheries. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Program Brief: FISH-2019-02.

Lamb, R. (2013). "Madhya Pradesh" in *The Modern Anthropology of India: Ethnography, Themes and Theory*. ed. F. H. Peter Berger (London, New York, NY: Routledge), 157–173.

MacArthur, J., Carrard, N., Davila, F., Grant, M., Megaw, T., Willetts, J., et al. (2022). Gender-transformative approaches in international development: a brief history and five uniting principles. *Women's Stud. Int. Forum* 95:102635. doi: 10.1016/j.wsif.2022.102635

Magnan, N., Spielman, D. J., Gulati, K., and Lybbert, T. J. *Information Networks Among Women and Men and the Demand For An Agricultural Technology in India*. International Food Policy Research Institute (IFPRI), Washington, DC, (2015).

Mahoney, J., and Goertz, G. (2006). A tale of two cultures: contrasting quantitative and qualitative research. *Polit. Anal.* 14, 227–249. doi: 10.1093/pan/mpj017

McDougall, C., Badstue, L., Mulema, A., Fischer, G., Najjar, D., Pyburn, R., et al. (2021). "Toward structural change: gender transformative approaches" in *Advancing Gender Equality Through Agricultural and Environmental Research: Past, Present, and Future*. eds. R. Pyburn and A. Eerdewijk (Washington: International Food Policy Research Institute (IFPRI)), 365–402.

Mudliar, P., and Koontz, T. (2018). The muting and unmuting of caste across inter-linked action arenas: inequality and collective action in a community-based watershed group. *Commons J.* 12, 225–248. doi: 10.18352/ijc.807

Pansardi, P. (2012). Power to and power over: two distinct concepts of power? *J. Polit. Power* 5, 73–89. doi: 10.1080/2158379X.2012.658278

Ravichandran, T. (2018). Comparison of institutional arrangements for inclusive dairy market development in India. Available at: http://opus.uni-hohenheim.de/volltexte/2020/1753/pdf/Thesis_Thanammal_Ravichandran_final.pdf

Ravichandran, T., Farnworth, C. R., and Galiè, A. (2021). Empowering women in dairy cooperatives in Bihar and Telangana, India: a gender and caste analysis. *AgriGender J. Gender Agric. Food Security* 6, 27–42. doi: 10.19268/JGAFS.612021.3

Ravichandran, T., Hall, A., and Blümmel, M.. (2019). Opportunities for small scale green forage enterprise in Mulukanoor women dairy cooperative (MWDC), Kareem Nagar, Telangana. Presented at the forage as cash crop and opportunities for green forage Enterprise development workshop, Kareem Nagar district, India,2019. Nairobi, Kenya: ILRI.

Risseeuw, C. (2005). "Bourdieu, power and resistance: gender transformation in Sri Lanka" in *Sage Masters of Modern Social Thought: Pierre Bourdieu*. ed. D. Robbins (London/New Delhi: Sage Publications), 93–112.

Rowlands, J. (1997). *Questioning Empowerment: Working With Women in Honduras*. Oxford: Oxfam.

Sankaran, S., Sekerdej, M., and von Hecker, U. (2017). The role of Indian caste identity and caste inconsistent norms on status representation. *Front. Psychol.* 8:487. doi: 10.3389/fpsyg.2017.00487

Sen, A. K. (1990). "Gender and cooperative conflicts" in *Persistent Inequalities: Women and World Development*. ed. I. Tinker (New York: Oxford University Press)

Seymour, G., and Peterman, A. (2018). Context and measurement: an analysis of the relationship between intrahousehold decision making and autonomy. *World Dev.* 111, 97–112. doi: 10.1016/j.worlddev.2018.06.027

Singh, D. N., Bohra, J. S., Bohra, J. S., Vishal Tyagi, V., Tyagi, T. S., Singh, T., et al. (2022). A review of India's fodder production status and opportunities. *Grass Forage Sci.* 77, 1–10. doi: 10.1111/gfs.12561

Stuart, G. (2007). Institutional change and Embeddedness: caste and gender in financial cooperatives in rural India. *Int. Public Manag. J.* 10, 415–438. doi: 10.1080/10967490701683727

Sumberg, J., and Okali, C. (2013). Young people, agriculture, and transformation in rural Africa: an "opportunity space" approach. *Innovations* 8, 259–269. doi: 10.1162/INOV_a_00178

Surendran-Padmaja, S., Khed, D. V., and Krishna, V. V. (2023). What would others say? Exploring gendered and caste-based social norms in Central India through vignettes. *Women's Stud. Int. Forum* 97:102692. doi: 10.1016/j.wsif.2023.102692

Swamy, K., Blümmel, M., Cadilhon, J. J., Colverson, K. E., Reddy, Y. R., and Ravichandran, T. (2014). A gendered assessment of the Mulukanoor Women's cooperative dairy value chain, Telangana, India. *Presented at the 8th international conference of Asian Society of Agricultural Economists (ASAE) on viability of small farmers in Asia 2014, saver, Bangladesh,2014*. Nairobi, Kenya: ILRI.

Tavenner, K., Crane, T., Bullock, R., and Galiè, A. (2022). Intersectionality in gender and agriculture: towards an applied research design. *Gend. Technol. Dev.* 26, 385–403. doi: 10.1080/09718524.2022.2140383

Theis, S., Lefore, N., Meinzen-Dick, R., and Bryan, E. (2018). What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana, and Tanzania. *Agric. Hum. Values* 35, 671–684. doi: 10.1007/s10460-018-9862-8

VeneKlasen, L., and Miller, V. (2002) *A New Weave of Power, People and Politics: The Action Guide for Advocacy and Citizen Participation*, Oklahoma City: World Neighbors.

Whitelaw, D. E. (2022). Gender and decolonisation in Zambia: re-examining Women's contributions to the anti-colonial struggle. *J. South. Afr. Stud.* 48, 545–561. doi: 10.1080/03057070.2022.2077578

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Cultural and economic barriers and opportunities for the participation of women in agricultural production systems: a case study in Guatemala

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As in other Latin American countries, agricultural activities in Guatemala contribute with 32% of the total employment (65% in rural areas), but only one in every ten individuals employed in these activities are women. This study examines the cultural and economic barriers and opportunities for the participation of women in agricultural (crop and livestock) production systems. We rely on a qualitative approach involving focus group discussions with 15–20 women in each of the eight communities visited in the departments of Chiquimula (Dry Corridor) and Huehuetenango (Western Highlands) in October 2022. The study provides several interesting findings, which generally hold across locations. First, women do not seem to have a strong preference for crop production activities, except harvesting, and only get involved in specifically assigned tasks. This lack of interest and participation in crop-related activities, which can be related to low empowerment levels and traditional stereotypes in the community about gender roles, persist even in locations with a higher emigration of men, where women could be expected to take over traditionally male crop-related tasks. Second, participants carry out a variety of other unpaid activities, including raising small-scale livestock and maintaining home gardens, which they do not recognize as formal, income-generating occupations despite their more active role. Third, women consider the commercialization of their products a persistent challenge as they do not have access to markets beyond their community, which additionally results in a deterrent to applying for credits due to a generalized fear of defaulting. Despite their day-to-day economic hardship, participants' main aspirations point to generating more income in non-crop-related activities, mainly livestock farming and raising, or, alternatively, emigrating to provide a better future for their children. These findings remark the importance of offering extensive support to women to not only start new activities, as it has been the case of several public and private initiatives in the area, but help them through continuous extension services on production, storage, and commercialization; management and accounting; and financial literacy, as well as on building agency capacity through existing women groups and organizations and enabling the environment for improved access to markets and credit.

KEYWORDS

barriers, opportunities, agriculture, livestock activities, women, rural Guatemala

Introduction

Women make up around 40 percent of the agricultural labor force at the global level, but figures for Latin America and specifically Central America indicate that women's participation in agriculture is significantly lower, only representing 20% (FAO, 2011). In the case of Guatemala, crop and livestock activities contribute to 9.4% of Guatemala's GDP (World Bank national accounts data, OECD National Accounts data files, 2021) and constitute 32% of the total employment in the country (65% in rural areas), and yet only one in every 10 individuals employed in these activities are women (INE, 2019). In contrast, roughly eight out of 10 backyard livestock producers in Guatemala are females (INE, 2003).[1] The contribution of women to their household income is similarly one of the lowest (26%) in the region (Ballara et al., 2010).

The unequal participation of women in agricultural production results in them having less political and institutional support, access to resources, and economic opportunities (Fletschner and Kenney, 2010; Deere et al., 2011; Espinal et al., 2015; Ibáñez and Guerrero, 2022). This could, in turn, have implications on women's empowerment and agency that could limit their participation in certain activities. It can also affect agricultural productivity, poverty, hunger, and economic growth. Women's economic empowerment through credit or access to assets (e.g., land, livestock) positively impacts nutrition and food security (Deutsh et al., 2001; Quisumbing and Meinzen-Dick, 2001; Hendriks, 2019). FAO (2011) further sustains that an equal access to agricultural resources by women could increase farms yield significantly and raise total agricultural output in developing countries.

Several authors also emphasize the importance of livestock as an income source for women. While women in rural households primarily contribute to family care and agriculture as a support role (World Bank Group, 2015; International Labour Organization, 2019), many women own animals and are responsible for managing and caring for them. This is typically small livestock used primarily for household consumption (Herrero et al., 2013; Grassi et al., 2015), but their participation in this activity represents an opportunity to gain empowerment, since they can earn an income from the sub-products (e.g., eggs) without being burdened with additional housework tasks (Rota and Urbani, 2021).

However, when analyzing women's empowerment and agency, it is important to consider additional dimensions. There is a tendency for efforts to focus solely on promoting the participation of women in the labor market and economic activities without taking into consideration cultural and contextual factors (e.g., aspirations, illiteracy) that may contribute to low levels of empowerment (Anderson et al., 2021). Duflo (2012) stresses that economic development alone is not sufficient to deliver significant advancements in aspects such as agency and gender. All in all, the significant gender differences in workforce participation reflect the necessity to better understand the barriers, challenges, and opportunities for women, which may be context specific, to move out of (unpaid) small-scale production for self-consumption and become more involved in (income-generating) agriculture production systems.

Research on gender issues within the context of agricultural production in Latin America is still growing, particularly on livestock activities, and mainly focuses on economic obstacles, such as the lack of access to resources and information. Valdivia (2001) reviews the research on the Small Ruminant Collaborative Research Support Program in different countries, including Bolivia and Peru, and finds that access to livestock differs according to gender and that small ruminants are primarily managed by women. Furthermore, female livestock ownership contributes to household welfare, gender equality, and the empowerment of women. This aligns with Rota and Urbani (2021) who relies on qualitative case studies from Venezuela and other countries and find that women are concentrated in small livestock ownership. Triana and Burkart (2019) review the literature on bovine livestock in Latin America and discuss some cultural barriers faced by women. Besides lack of access to the necessary assets for livestock production, the authors identify cultural resistance to female ownership as well as the perception of the cattle industry as being a male-dominated industry. In Africa and Asia, Herrero et al. (2013) demonstrate that some of the barriers to women owning large livestock include limited access to technology and information, lack of training, long workdays, and literacy problems.

In this context, the main objective of this qualitative study is to broadly examine why women are not more involved in crop production and livestock activities, despite wanting to generate alternative income streams. We pay special attention to cultural and economic barriers that could be preventing women from participating more predominantly in crop and livestock production systems and identify opportunities to promote and increase their participation. We focus both on the Dry Corridor (department of Chiquimula) and Western Highlands (department of Huehuetenango) of Guatemala, which are the two most vulnerable regions in the country. In Huehuetenango, only 6% of the people that work in this sector are women whereas in Chiquimula this percentage is 3% (INE, 2018). However, more than half of backyard producers in both regions are women (INE, 2003). We draw comparisons from two regions sharing poor socioeconomic conditions but different climatic and cultural settings. We explore cultural barriers related to women's expected roles in their household and community as well as their aspirations, beliefs, and social norms, whereas we examine economic barriers linked to limited access to markets and commercialization, lack of credit, and recurrent emigration. Using Chiquimula and Huehuetenango as case studies, we assess similarities and differences in the potential barriers faced by women in two different regions of the country and identify opportunities to increase women's participation in agricultural activities as a means for earning a sustainable income.

The analysis relies on focus group discussions with female participants implemented across eight rural communities in the two departments in October 2022. The study results show that women in both regions do not appear to have a strong preference for crop-related activities. Despite living in areas where there is a high emigration of men, participants do not consider themselves capable of carrying out the complete crop cycle (especially planting, sowing, and tilling) and only opt to participate in specific activities assigned to them. This lack of interest and participation in crop production could be related to low empowerment and agency levels and traditional stereotypes in the community about gender roles and labor activities that women are expected to perform in their communities. Women also do not recognize these secondary activities as economic occupations, as they are generally unpaid. Other unpaid activities include raising and maintaining small-scale livestock for

1 Statistics generally tend to underreport subsistence activities such as domestic work and agricultural backyard production, which are mostly undertaken by women (Beneria and Sen, 1981).

self-consumption. Lack of access to markets outside their community and barriers to commercialization are perceived as important deterrents to acquiring credit or developing businesses by participants. Still, their main desire is to generate more income through non-crop-related activities or to eventually emigrate to provide for their families.

The remainder of the paper is organized as follows. In the next sections, we first describe the background of the areas studied and then outline the study methodology. We then present and extensively discuss the results of the study, including similarities and differences across locations. The final section provides concluding remarks and policy recommendations.

Background

The study focuses on the departments of Chiquimula and Huehuetenango. The two departments, located in the East and West of the country, respectively, concentrate an important number of poor and food insecure populations and were selected to explore potential differences (or similarities) in behaviors, perceptions, and restrictions faced by women toward productive activities in opposite regions of the country, with varying climatic and cultural settings.

Chiquimula is in the Dry Corridor, an area of tropical dry forest or dry area that is highly susceptible to extreme climatic events, such as droughts and heavy rainfall (CGIAR, 2018). Huehuetenango is in the Western Highlands, a region that has been adversely affected by climate change, with more frosts and extreme water shortages (Nerger, 2012). Climate vulnerability is highly relevant since both in Chiquimula and Huehuetenango more than one-half of the rural population works in agriculture activities (INE, 2018).

Crop production in both regions is largely dependent on small farmers who produce maize and beans for their own consumption. In Chiquimula, the livestock industry is predominantly bovine, while in Huehuetenango it is primarily ovine (INE, 2003). Producers generally face numerous challenges because of lack of resources and climate change (Fuentes, 2005; Corado, 2019). Rural women in Huehuetenango are relatively more involved in agricultural activities than in Chiquimula but only represent about 6% of the crop producers (compared to 3% in Chiquimula), while women in both regions represent half of the backyard producers (INE, 2003, 2018). Housework activities are among the main occupations for women in both regions alongside retailing (e.g., selling handcrafts, owning restaurants, and working in food service) and manufacturing (e.g., fabrication of textile and clothing products, preparation of meals).

In terms of socioeconomic conditions, in both departments about seven out of 10 people live below the poverty line and six out of 10 children under five suffer from chronic malnutrition. Both regions are also highly impacted by migration. While Chiquimula has a migration rate of 15 migrants per 10,000 people, Huehuetenango has a migration rate of 55 migrants per 10,000, which is the highest rate in the country (INE, 2015, 2017, 2018). The share of indigenous population, in turn, is very different between the two departments: close to two thirds of the population are indigenous in Huehuetenango versus one fourth in Chiquimula (INE, 2018).

The specific municipalities and communities within the two departments were chosen in collaboration with the Secretariat of Food and Nutritional Security (SESAN) and the Ministry of Agriculture, Livestock, and Food (MAGA), and are part of the areas prioritized by both institutions within the National Great Crusade for Nutrition Initiative 2020–2024, a national program aimed at improving the nutrition of the most vulnerable Guatemalans.[2] All of the selected areas are highly vulnerable, with high levels of poverty, migration, and malnutrition, as described in Supplementary Table 1.

As shown in Figure 1, the four communities in Chiquimula are distributed between the municipalities of San Jacinto (Tizubín and Las Lomas) and San Juan Ermita (Minas Abajo and Tasharjá). About half of the population in both municipalities are involved in agricultural activities as their main economic activity (INE, 2003). However, only 1% of the population in San Jacinto dedicated to this sector are women, while this percentage increases to 3% in San Juan Ermita (INE, 2018). Women are mainly involved in retailing, manufacturing, education, and housework activities (INE, 2018). In the case of Huehuetenango, three communities are in the municipality of Chiantla (El Manzanillo, Siete Pinos, and La Zeta) whereas one is in San Juan Ixcoy (Yulchecán). More than one-half of the population in these areas is employed in agriculture, with women making up only 4 and 2% of this sector in San Juan Ixcoy and Chiantla, respectively (INE, 2003). Women in these municipalities are mostly dedicated to housework and retailing (INE, 2018). Figure 2 maps the eight communities included in the study across the two departments.

Methodology

The methodology of the study consists of the implementation of eight focus groups (one per community) with an average participation of 16 women per focus group, totaling 131 participants overall. Four focus groups were held in Chiquimula and four in Huehuetenango. SESAN pinpointed municipalities, where they, alongside international donors, have carried out interventions and MAGA selected communities that participate in their workshops and events. MAGA then held an open call to all participants from their past interventions and those available to participate were part of the focus groups. The eight communities selected are mainly of subsistence agriculture and are distributed evenly across both departments. The group of women who participated in the focus groups are generally representative of their community population as women in the communities visited typically have the same education level and perform similar roles and occupations based on their age.

An interview guide was developed for the implementation of the focus groups.[3] The interview guide has five key sections with guiding questions meant to elicit deeper conversations on specific topics, including the community setting and local labor dynamics, household decision-making, migration patterns and use of remittances, aspirations and future objectives, among other subjects. The interview guide similarly includes an ethics protocol in which participants were reminded that they can choose to participate or exit the focus group at any point. A summary of the main topics discussed is depicted in Supplementary Figure 1.

2 For more information on the Great Crusade for Nutrition Initiative see: https://portal.siinsan.gob.gt/documentos/gran-cruzada-nacional-por-la-nutricion-2020-2024/ (accessed May 2023).

3 The full interview guide used in the focus groups is included in the Supplementary material.

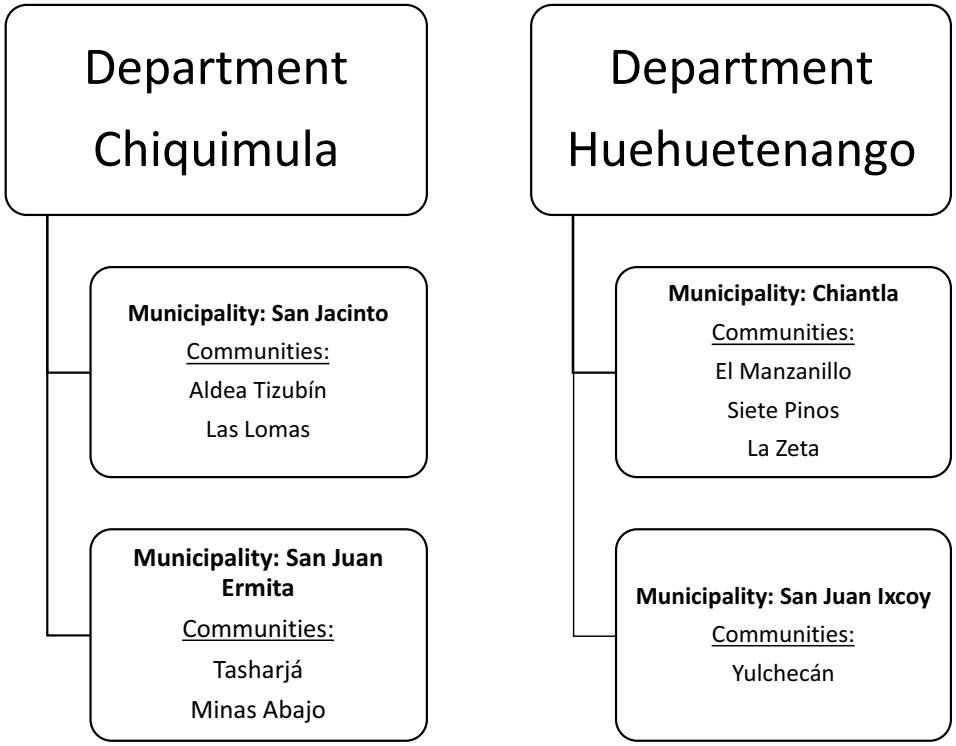

FIGURE 1
Communities selected for focus groups.

The information from the focus groups was captured deploying an extensive methodology that included: two moderators and two note takers per focus group session plus audio recording each session. A theme-based double entry matrix was further elaborated to systemize participants' answers and better organize the findings for subsequent analysis. This matrix systematizes the modules of the focus group interview guide by relevant themes discussed, highlighting three important topics that address our main research question: attitudes, beliefs, and participation in agricultural activities; roles and aspirations; and economic and financial constraints toward commercializing agricultural products.

The focus group sessions were supplemented with post focus group debriefs among researchers per community visited and covering all relevant topics, followed by general discussions analyzing similarities and differences per department once all focus groups for that department were completed. These sessions helped to review all written accounts taken by the notetakers, which were subsequently complemented with the review of the audio recordings that also permitted to capture the most important quotes and testimonies of each focus group.

The descriptive statistics of the studied sample by department are reported in Table 1. The women that participated in the focus groups are roughly equally distributed between Huehuetenango and Chiquimula. Most participants were under 45 years of age, including about three out of 10 being under 30 years of age in Chiquimula and four out of 10 in Huehuetenango. The main occupation self-reported by participants is homemaker. See Supplementary Tables 2, 3 for the composition of the focus groups by municipality and community, respectively.

Results

This section presents the results of the study. First, we present results for Chiquimula, focusing on rural women's attitudes and beliefs toward agricultural activities, their household roles and aspirations, and economic and financial constraints toward commercializing agricultural products. Second, we present results for Huehuetenango on the same topics of interest. These topics inform the cultural and economic barriers to women's participation in both crop and livestock activities.

Chiquimula

Attitudes, beliefs, and participation in agricultural activities

While all communities visited in San Jacinto and San Juan Ermita are traditionally rural, two communities in San Jacinto, Las Lomas and Tizubín, are relatively more developed, particularly the former, in terms of road connectivity, given their closer proximity to the capital of the department.[4] However, all focus group participants across the four communities initially identify their primary occupation as home makers and claim being in charge of their household. Only four

4 Las Lomas is about 45min' drive from the capital of the department and Tizubín is around one hour away, while the other two communities located in San Juan Ermita are more than one hour away.

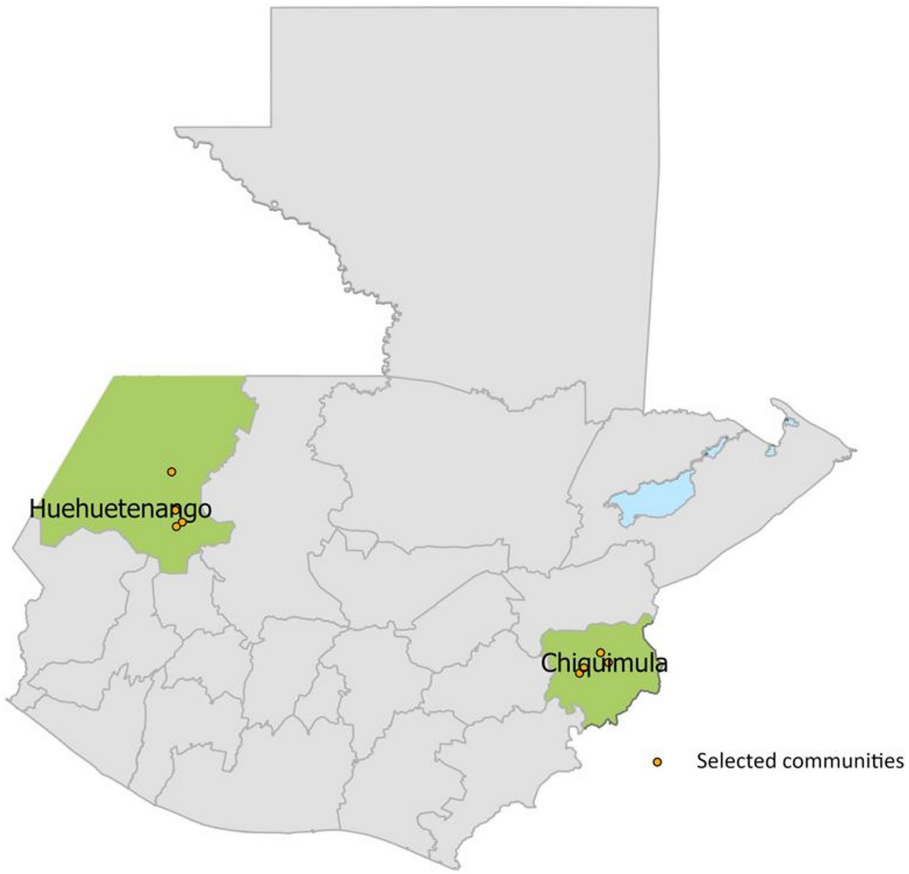

FIGURE 2
Map of communities selected for focus groups.

TABLE 1 Focus group descriptive statistics by department.

Department	N of participants	Age		Main Occupation	
		Range	%	Occupation	%
Chiquimula	64	<30	25	Homemaker	100
		30–45	40.63	Student	0
		>45	34.38	Producer	0
			100	Total	100
Huehuetenango	67	<30	37.88	Homemaker	97.01
		30–45	34.85	Student	1.49
		>45	27.27	Producer	1.49
Total	131		100		100

Producer refers to agricultural producer or individual that works in agricultural-related activities.

participants, out of 64, identify a secondary occupation that include an artisan, community representative, and two agricultural producers. While women overwhelmingly recognize their household as their primary occupation, as the focus group progressed other daily unpaid tasks were recognized as occupations. For example, most of the participants report having free-range hens that they breed, use for self-consumption, and commercialize at a small-scale through the sale of eggs. Participants also allude to occasionally helping in specific crop-related tasks such as maize husking and picking beans; on this regard, a participant in Minas Abajo (San Juan Ermita) noted, *"women have to lend a helping hand when there is not enough money to pay for workers, we usually deal with things that are not heavy, like picking beans."*

Participants note that men in the community often work in crop production as a primary occupation and other temporarily available jobs such as electrician and bricklayer. They indicate that the main crops grown are beans and maize. While women help in specific tasks such as husking maize and picking beans, women do not report actively participating in sowing, planting, and growing activities. Moreover, participants note that there are culturally held beliefs surrounding women's participation in these activities, such as that sowing seeds is a "male dominated" activity and therefore they are not highly interested in participating. In Las Lomas (San Jacinto) a participant stated, "*our husbands work in agriculture, we as women help when there aren't workers available, but I rather stay at home as others typically judge when they see a woman doing a man's job*." Across all four communities (Tizubín, Las Lomas, Minas Abajo, and Tasharjá), participants share the opinion that, only when labor is overtly expensive, they help their partners with limited crop-related interventions such as: extracting maize cobs, fertilizing and collecting crops. It is important to note that participants' partners generally rent the land where their crops grow so they can stop renting if it gets unprofitable to keep operating the land.

In terms of emigration, which is a recurrent phenomenon across several rural areas in the country, participants share their perceptions about the impacts of migration in their communities and households. While participants indicate that they had not experienced high volumes of migration in their nuclear families, they have noticed a significant increase of neighbors migrating over the past 5 years.[5] When asked if there are changes to the role of women who have husbands who have emigrated, participants note that women adopt the roles traditionally assigned to both mothers and fathers, meaning that women must take care of the household as well as become the main income provider for the family. A participant in Tizubín (San Jacinto) mentioned, "*women stay in charge of their family, sometimes they administer the land and crop-related activities, but if there aren't children to help in completing the crop-related tasks then they stop leasing the land and live off of remittances*." Women emphasize that they prefer not to take on the role of crop producer but would rather end the lease on the land their husbands have. Participants also highlight that despite both men and women emigrating, men always migrate first, and women follow when their economies allow for it. However, women in all four communities mention that the increased cost of emigration (i.e., paying a "coyote" about 100,000 Quetzales or over 12,650 US dollars to cross the US border) is inaccessible for them. Ultimately, women perceive that men have more employment opportunities abroad due to their gender and the physical abilities associated with being male, another culturally-held belief.

Roles and aspirations

Participants across communities have very defined primary household roles as caregivers and their aspirations are focused on their children. Participants overwhelmingly have a negative perspective about the future, specifically citing concerns regarding climate change and the external shocks that may affect their partners' crop-related activities considering the recurring natural disasters. A participant in Minas Bajo stated, "*this community is going to go downhill, our crops depend on the climate, and there's always a possibility that climate change will only get worse*."

Another important finding regarding women's aspirations is directly linked to their (negative) gendered self-perception. For example, participants express that they do not have the same physical or mental capabilities as men, who according to them, have more challenging jobs or can develop better entrepreneurship ideas. In Tizubín a participant commented, "*we, as women, do not really know how to do many activities outside our homes, men are the ones who know more*."

When asked about their future regarding becoming involved in income generating activities, participants struggle to visualize and convey their goals or aspirations due to their short-term vision. Still, participants in all four communities state that they would be interested in laying hen and pig farming programs. Only participants in Las Lomas, a more peri-urban community, had previous experience working with local and international organizations on poultry farming and drinkable water projects. These participants expressed interest in participating in more projects raising and selling small-scale livestock but highlight the importance of accessing markets where to sell any potential produce. Specifically, women mention that the poultry farming initiative promoted by the government through the Ministry of Agriculture, Livestock, and Food (MAGA) has been successful at the community level, but ultimately failed at creating them revenue as they do not have any markets outside their own community to sell their eggs and other byproducts. Overall, participants have a looming pessimism about both their household and communities' future, citing challenges such as income generation, continuous increase of food prices, and volatile weather conditions as significant threats.

Economic and financial constraints toward commercializing agricultural products

Across all four communities, participants remark their financial dependence as their most significant constraint. Most participants, except for two crop producers and one artisan, depend financially on their partners' crop production and their limited income generated by this activity is described as a barrier to start or expand any small-scale livestock activities (or emigrate). Participants universally agree on the decision-making dynamics within their households.[6] Women make decisions over family expenses such as food, cleaning products, and children's schooling. One participant in Minas Abajo said, "*while our husband is the provider, women know the necessities of the household; therefore, we decide how the money should be used toward household expenditures*." In terms of home equipment, participants express that while they have discussions together, men have the ultimate say on the items purchased. Finally, when it came to investments for production activities, such as agricultural machinery and equipment, technology, or more livestock, participants agree that

5 It is worth remarking that participants could refer to the neighbors to avoid referring to themselves as emigration can be a sensitive topic.

6 It is important to note that intra-household decisions were discussed without distinguishing between households with or without migrants, but we believe financial decisions are similar regardless of whether the partner has emigrated or not.

the decisions are generally made together. However, if the investment is, for example, on small-scale livestock activities (i.e., a designated "female led" activity), women can eventually have the final decision, while if it concerns an investment for crop-related activities, men will have the final decision. Yet, this type of investments only occurs on rare occasions, given their limited household income.

When asked about the possible use of remittances and credits to overcome economic barriers to invest, for example, in their already existing backyard production activities, participants mention that remittances (when available) are only used to cover household expenses while credits, whether individual or as a group, are negatively perceived. Group lending (where a loan is provided to a group of people and all group members are held liable for repayment) has particularly negative connotations for participants, and they refer to negative experiences with this form of credit. In Tizubín a participant mentioned that a project encouraged women to participate in a group lending pilot project, but the project shut down prematurely due to a member not being able to pay their part of the credit. In Tasharjá (San Juan Ermita), participants also mention having knowledge of group credits and a participant shared her experience were there had been payment defaults that resulted in a higher cost burden for other project members. Both group lending experiences have been carried out with Banrural, the second largest operating bank in Guatemala, and the credits have been used for the purchase of small-scale livestock and crop products. In terms of individual credits, participants across all communities cite high interest rates as the main deterrent for pursuing them. There is an overwhelming collective risk aversion to engaging in individual credits as participants cite fear of missing payments due to the uncertainty and variability of their revenues from crop-related activities. In Las Lomas, a participant said, "*we do not apply for a loan because when you invest in crops, there is always the risk that these can be damaged or ruined due to the uncertainty of the weather, which would make the repayment of the loan impossible*." Another important deterrent cited for applying to individual loans is the requirement of a guarantor by credit agencies, which participants mention creates an additional layer of difficulty in accessing a loan. In addition, participants cite the lack of access to markets as a major economic barrier to seeking any form of credits for investment in secondary occupations such as buying more backyard animals. In Las Lomas a participant mentioned, "*there is no reason to get a credit for a business because we have nowhere to sell our goods; there are few, to none markets within the community and those that are outside are not accessible to us*." All these constraints influence women's attitudes toward investing in income-generating activities (including livestock production) that could allow them to access markets to sell their outputs.

Huehuetenango

Attitudes, beliefs, and participation in agricultural activities

In Huehuetenango, except for La Zeta (Chiantla) that is a walking distance from a main highway (RN-9) and less than 30 min driving distance from the capital of department, the other three communities visited are much more isolated.[7] More than 98% of the participants identify their primary occupation as home makers. Only one participant identified her primary occupation as student, while a second participant identified her main occupation as crop producer. Both participants that did not self-identify as homemakers where from La Zeta. In terms of secondary occupations, five out of 67 women identify themselves as crop producers. As in Chiquimula, women recognize additional tasks that they complete throughout the day of significant importance, which are not necessarily paid. Participants highlight three additional activities: gathering and carrying water from the community watering hole to their households up to three times a day; small-scale livestock farming for household consumption and small-scale commercialization; and managing small home gardens for household consumption. On average, participants indicate that they could spend nine to 12 h per day carrying water to their households as their communities do not have access to water. Except for La Zeta, who have accessible drinking water, the rest of the communities must either visit a river (in the case of Yulchecán in San Juan Ixcoy) or travel to an available water hole (Siete Pinos and El Manzanillo in Chiantla). Farming and raising small-scale backyard animals are important activities for participants across all four communities as most have free range hens, pigs, sheep, goats, cattle, rabbits, and wild turkeys. Women further point out that small-scale backyard production is a woman's role, while crop-related activities are a man's role; yet, when the cost of crop labor is too high, they can help their husbands by performing specific activities such as fertilizing the land, husking maize, and cleaning crops. A participant in El Manzanillo said, "*women help in specific agricultural activities that are considered for women only when there is not enough money to pay for more male workers*." In terms of home garden activities, women grow small herbs that can be used in their daily cooking such as coriander leaves, as well as small vegetables such as cabbages and eggplant.

Participants also mention that the main purpose of raising backyard livestock is for self-consumption that can help cope with their seasonal and volatile crop production. Crop production is seasonal in Huehuetenango as winter is the only time when producers can cultivate their crops; during summer, producers will work and prepare the land, temporally migrate to other departments in search of other crop-related work, or find other occupations such as bricklayer, chauffeur, or bike-driver. The winter period is characterized as a rainy season that lasts from May through October, while summer is a drier period that lasts from November until April. Participants in Huehuetenango heavily rely on their small-scale livestock to keep their families fed all year round. While small-scale livestock is mainly used for self-consumption, participants indicate that they can still commercialize their excess production within their own communities or in neighboring community markets, selling eggs, milk, and cheese, as opposed to Chiquimula where commercialization outside the community is generally infrequent.

Regarding emigration, participants mention that the temporality and uncertainty of the work available in the

7 For reference, the other two communities in Chiantla, El Manzanillo and Siete Pinos, were both over one hour away driving from the department capital. The community visited in San Juan Ixcoy, Yulchecán, was about 2h and 20min away.

communities makes migration an attractive option. However, similarly to participants in Chiquimula, they note that the cost to emigrate to the United States is far too high. Besides the high financial costs, participants allude to the extreme hardship and physical and psychological consequences mothers and children have to suffer in the passage toward crossing the border.[8] "*People risk their lives to migrate, they suffer tremendously during the passage to the border, there is much sadness along the way, but people take on the risk because of necessity, because there aren't any other options to survive*," a participant from El Manzanillo commented. When asked about the role of women who have husbands or close relatives who have emigrated, participants comment that women receive remittances and spend them according to the will of the sender (whether it is their husband or a third-party), supervise crop-related work, and adopt the roles of both mother (household caretaker) and father (income generator). Women, however, did not mention taking on the role of crop producers themselves. In both El Manzanillo and Yulchecán participants said that if the man of the household left, women will either end the lease on the land, or become supervisors of the workers who are left working the land but will not engage themselves in temporal crop-related work. As in Chiquimula, participants in Huehuetenango do not show a preference for carrying out traditional crop-related activities outside of those labeled as "women's work," but rather continue their household duties such as raising small-scale livestock, maintaining home gardens, and managing their household. Overall participants across the four communities agree that emigration has been increasing, and that while men are more likely to migrate, women are starting to follow as well.

Roles and aspirations

As noted above, participants in Huehuetenango have unpaid roles that go beyond caregiving for their children and spouses (e.g., raising backyard livestock, gathering and supplying water to their households, and maintaining home gardens). Despite not being much involved in crop-related activities, participants in all four communities cite climate change as a significant concern. In Siete Pinos a participant stated that, "*every year the climate is worse, there are increasing storms, rain, and wind, which threatens food availability*." Food shortages are a generalized concern as heavy rains and storms threaten the small window for crop production during wintertime, and, in the summer, food must be bought at local stores or markets. Increasing food prices is another major concern as their current income is not sufficient to cover all their basic needs. Participants were more vocal around their aspirations to generate their own income, primarily citing increasing and diversifying their livestock as well as getting help to commercialize their products and reach larger markets as future aspirations.

Women were also outspoken about finding a solution to their water shortage problems. A participant in Siete Pinos stated that they want a water project proposed by the government or an international agency since, "*we spend the entire day carrying water, if we had water tanks, we would not have to spend all of our hours gathering water, but we could do other activities*." In El Manzanillo a participant stated that, "*if we did not have to worry about water, we could work on raising more sheep since they easily produce offspring, and we could generate our own income*." When further discussing their aspirations surrounding income generating activities, participants mention examples on how to maximize the use of their backyard livestock production, how to keep their animals healthy, and how to create entrepreneurship activities to commercialize their existing small-scale livestock byproducts. However, participants' aspirations are tied to activities that they are more familiar with, such as raising small-scale livestock. It is a challenge for them to aspire to anything outside of their lived experiences. In line with what was observed in Chiquimula, women have similarly difficulties envisioning the future of their community and households in 5 years as they live their lives "day to day" (i.e., they exhibit a short-term vision). While participants' main concerns for the future are climate change, water and food shortages, and increasing food prices, they are also worried that if they invest in expanding their backyard production, they might still not be able to commercialize all their produce and recover their investment.

Economic and financial constraints toward commercializing agricultural products

Participants across all four communities cite financial barriers as their most evident limitation regarding expanding their livestock activities and engaging in more formal commercialization. Another main barrier cited is women's role in supplying water to their household, which takes several hours of their day. An additional important barrier mentioned was the irregularity of their husband's work cycle. Given that most men are temporal crop producers, there are periods in which income is significantly reduced, especially during summertime (dry season) when they must travel to other areas for job opportunities. Women prefer to prioritize spending on maintaining their home gardens and ensuring the survival of their small-scale livestock.

Financial decisions regarding the household, home equipment, and investments in production activities is different in Huehuetenango compared to Chiquimula. Whereas women in Chiquimula are the decision makers on day-to-day household expenses, participants across the four communities in Huehuetenango agree that decisions regarding household expenses are made together with their partners. Women report making lists of what is needed for the household and husbands make the purchases depending on whether they have sufficient funds. Regarding home equipment, participants agree that decisions are made in conjunction, except for El Manzanillo were women claim that men make the decision on their own. In terms of crop production activities, participants in La Zeta allude, for example, that men make the decisions about the purchase of crop inputs; "*when spending relates to crops, men decide since they are the ones working the land, they know what needs to be spent in that regard, so they decide by themselves*," stated a participant. Regarding other investments, participants agree that if there is money left over from household and capital good expenditures, decisions are made in conjunction. However, women were emphatic in expressing that if the funds come from backyard production revenue, they are the final decision makers. A participant in Yulchecán noted, "*if the income comes from our animals, then we, the women, decide, because we are the ones who know about raising activities*."

8 According to the Missing Migrants Project of the International Organization for Migration (IOM), around 5,000 people have died or disappeared en route to the United States since 2014; and these are only confirmed cases (Black and Sigman, 2022).

When asked about the use of remittances and credit access to overcome financial barriers, participants mention that when the household has both the homemaker and the husband, remittances are used according to the will of the third-party sender (e.g., sibling, parent, cousin). In El Manzanillo a participant stated, "*whoever sends the money decides how it's going to be used, sometimes the money is used for the children or sometimes for household expenses, it depends*." In La Zeta participants mention that remittances are often invested in construction or home improvements, as renovating their homes is a sign of status in most communities. Participants in El Manzanillo and La Zeta also state that they are aware of group loans but have negative perceptions toward them, whereas in Siete Pinos and Yulchecán participants have not heard about this type of credits. The negative perception is based on bad experiences that neighbors in El Manzanillo and La Zeta have faced but can also be attributed to the overall negative perception toward credits in general. When asked about individual loans, participants in all communities except La Zeta comment that they are fearful of the high interest rates. In Siete Pinos a participant shared her experience saying, "*I asked for a credit from a local financial institution, but I did not have a good experience. I took out the credit to invest in sheep, but because of the hurricane the sheep died, and we could not repay the credit in time, we suffered from the high interest rates*." Participants in La Zeta indicate that they are interested in applying for a credit but, "*interest rates are too high, and no one is helping with any workshops or courses on how to manage credits*." While participants have negative perceptions of both individual and group loans due to their risk adverseness, they still aspire to increase their investment in livestock production and expand their product commercialization. Overall, Table 2 below summarizes the main findings by department and topic.

Discussion

In this section, we discuss the similarities and differences in cultural and economic barriers faced by women to participate in crop production and livestock activities in Chiquimula and Huehuetenango as well as examine opportunities to increase women's participation in livestock production and commercialization activities where they show a more active role (compared to crop-related activities). We discuss cultural barriers in the context of participants' attitudes and beliefs toward agricultural activities and their household roles and aspirations. We then present economic barriers in the context of participants' economic constraints and attitudes toward commercializing crop, livestock, and backyard production goods. Finally, we discuss opportunities for promoting women's participation in agricultural activities, especially livestock production.

Cultural barriers

Participants in Chiquimula and Huehuetenango suffer from lack of social and economic recognition for the tasks they perform in crop and livestock activities. This is consistent with Faria (2009), who finds that the daily work of women in rural areas is underestimated by society as many of their activities do not fit into the categories formally accepted and recognized by community members around the concept of work. Thus, women's work can be considered as a set of activities invisible to society, which go beyond the practices strictly linked to domestic work. The finding also aligns with Grassi et al. (2015), who highlight that women provide much of the labor for livestock tasks and that their role is undervalued by policymakers and underrepresented in statistics (Beneria and Sen, 1981; Gumucio et al., 2015 point this out as well). These authors mention that women take care of their household's animals, which is time-consuming and hindered by lack of water availability, veterinary services, and knowledge of livestock management practices; all of which restricts women's wellbeing and their engagement in remunerative activities. Finally, Howland et al. (2021) state that women are not amply recognized in the agricultural sector and their role is usually stigmatized and concentrated in cultivating small crops for home consumption and supporting their husbands.

Participants in both Chiquimula and Huehuetenango further consider crop-related activities as primarily male dominated tasks. This is in line with Rietveld et al. (2020), who find that women see agriculture (in particular, commercial agriculture) as a male occupation. Further, this perception is associated to the type of activities that women perform in the crop cycle, some of which are perceived as lighter activities that perpetuate gender segregation in agriculture (Paulilo and Silva, 2007; International Labour Organization, 2019). Small livestock farming and raising activities are identified in both departments as a woman's responsibility since they are viewed as part of domestic activities (The World Bank, FAO, and IFAD, 2009; Herrero et al., 2013; Gumucio et al., 2015). Based on the findings above, it seems that national statistics regarding the contribution of women to agriculture are understated. They fail to consider the domestic activities that women perform, especially in the case of small-scale livestock production.

There are also evident differences in women's participation in livestock and crop-related activities between Chiquimula and Huehuetenango. Participants in Chiquimula work exclusively with free range hens (as past government interventions have provided them with hens) and participants in Huehuetenango have a higher diversity of small-scale animals. While participants in Chiquimula prioritize self-consumption, in Huehuetenango they are more market oriented and attempt (to the extent possible) to commercialize part of their livestock products. This is because of two main reasons: first, participants in Chiquimula state that with previous projects, they had not been able to find markets outside their own community; second, people in Huehuetenango are more actively seeking additional income opportunities as the crop cycle is narrower. While participants from both departments express that crop-related activities are a male-led job associated with traditional masculine traits, women in Huehuetenango still express some interest (as opposed to Chiquimula) to receive trainings and workshops on crop-related activities. This is consistent with other studies that emphasize the increasing participation of rural women in crop-related activities, which has been referred to as "the feminization of agriculture" (Deere, 2005; Lastarria-Cornhiel, 2008; World Bank Group, 2015; Baada and Najjar, 2020).

Women in both departments show significant difficulty to project into the future, participants envision themselves as part of a household, and have difficulties verbalizing their personal

TABLE 2 Summary of key findings by department.

Department	Main Findings		
	Attitudes, beliefs, and participation in agricultural activities	Household roles and aspirations	Economic and financial constraints toward commercializing agricultural products
Chiquimula	Participants have free-range hens that they breed, use for self-consumption, and commercialize at a small-scale by selling eggs.	Participants have strict household roles as primary caregivers; their aspirations are focused on their children.	Husbands' agricultural work provides limited income.
	Participants help in specific agricultural tasks such as maize husking and picking beans, when necessary.	Participants have a negative perspective about the future, citing climate change and external shocks such as recurring natural disasters as concerns.	Both individual and group credits are poorly perceived and therefore not utilized by participants.
	Several agricultural activities, such as sowing seeds, are considered "male dominated" activities that women will not engage into.	Women's aspirations are limited to their gendered self-perception.	Group loans are negatively perceived because of prior experiences of missed payments from other group members.
	When husbands emigrate, women will generally not take on the role of agricultural producer but will end the lease on the land their husbands have.	Participants are interested in laying hen and pig farming programs.	Individual loans are negatively perceived because of "high interest rates," requirement of a guarantor, and fear of missing payments due to volatile earnings.
			Lack of access to markets is identified as a major economic barrier to seeking any form of credits for investment in secondary occupations such as buying more backyard animals.
	Attitudes, beliefs, and participation in agricultural activities	*Household roles and aspirations*	*Economic and financial constraints toward commercializing agricultural products*
Huehuetenango	Participants preform three activities: gathering and carrying water 3 times a day; livestock raising for household consumption and small-scale commercialization; managing home gardens for household consumption.	Participants are the households' primary caregivers but also raise backyard livestock and collect water for their homes.	Husbands' temporal agricultural work results in volatile work cycles and limited/reduced income.
	Participants have a wide range of animals including free range hens, pigs, sheep, goats, cattle, rabbits, and wild turkeys.	Climate change, natural disasters, food shortages, and inflation are main concerns.	Constant need to gather water for the household difficult women's ability to generate a secondary income stream.
	Small-scale backyard production is a woman's role, while agriculture is a man's role.	Participants want a solution to their water shortage problems.	Both individual and group loans are poorly perceived and therefore not utilized by participants.
	Women who have husbands who have emigrated, receive remittances (and spend them according to husband or third-party sender's instructions) and supervise agricultural work (if applicable), but do not directly participate in such work.	Participants are interested in programs that could expand their backyard livestock production, keep their animals healthy, and create entrepreneurship activities to increase the commercialization of their small-scale livestock byproducts.	Group credits are negatively perceived because of anecdotal evidence of missed payments from other group members.

ambitions and aspirations. These findings could be related to their day-to-day economic or financial hardship (Dalton et al., 2016), or because they *"aspire to what they know or can imagine"* (Bajema et al., 2002). Rietveld et al. (2020) explain the formation of aspirations through the concept of 'opportunity space,' which *"refers to the constraints and opportunities associated with the socio-institutional and agro-ecological environment of the individual which affect one's agency."* Participants' difficulty to express aspirations for the future could be associated to their lack of agency, determined by their restricted opportunity space. This is a significant barrier to women's ability to see wider possibilities and alternatives to generate income (Kabeer, 2018; Kosec and Song, 2018; DeJaeghere et al., 2022).

For instance, when asked about future investments and potential activities they are interested in learning for income generation, women cite activities they are familiar with and have been involved in, or roles established for them by gender norms in their community. This is aligned with Carter's (2004) findings on the influence of community village-level social norms on intrahousehold behavior. However, Crossland et al. (2021) show that when women receive trainings on empowerment and agriculture, their aspirations to invest in and commercialize their agriculture products grow. This

also suggests that aspirations can grow with the proper changes and incentives.

Overall, these cultural findings highlight the importance of understanding women's internal factors (i.e., personal aspirations, self-perception, preferences for certain activities, gender stereotypes they hold) and external factors (i.e., community norms, time availability, household burden), when designing and implementing development programs oriented to increase women's participation in crop production and livestock activities. Without these considerations, the success of any program could be very limited.

Economic barriers

Participants in Chiquimula and Huehuetenango cite lack of resources as the main barrier for possibly expanding their small-scale livestock activities. Group lending schemes, as a possible mechanism to expand non-agricultural activities, will not be popular or attractive in these communities given the feedback from participants. In terms of individual loans, experiences are mixed. Some groups of women, specifically in communities closer to urban cities, Las Lomas (Chiquimula) and La Zeta (Huehuetenango), are willing to receive trainings and information on this type of financial instrument, while participants in more rural communities show higher risk aversion. These negative perceptions of credits may be related to lack of better tailored financial products for women as well as asymmetry of information on credit markets. Klapper and Parker (2011) find that limited access to finance is one factor that leads to differences between men and women in business performance indicators. This, coupled with other factors such as difficulties completing loan applications, lower financial literacy, and business experience, end up affecting women more than men. Further, as stated by Holland (2014), women's business creation process is influenced by internal factors (women's own hard work and determination and desire to overcome barriers) and external factors (a process of responding to the environment where they operate), highlighting the importance of interventions that will directly target women, but that will also make their environment more inclusive.

Similarly, challenges to access markets outside of their own communities is a clear barrier for participants to commercialize their small-scale livestock products as most of them do not have vehicles, roads are not paved, and larger markets are closer to municipal capitals, which are two to four hours away on foot from their communities. Any development project or program oriented toward increasing investments in crop or livestock production should consider these structural barriers.

While participants in Chiquimula generally face less fluctuations in their household income as crop production is year-round, they show more difficulties in visualizing how to generate additional sources of revenue as they only have home gardens and hens to work with. In Huehuetenango, in contrast, participants show more willingness to invest and create additional revenue streams with their wider range of small-scale livestock and their heightened exposure to markets outside their communities.

All in all, there are multiple economic and financial factors that may limit women's participation in livestock and other income-generating activities. Some of these barriers are structural and may require large investments (e.g., improving roads). Other barriers require the design of programs or projects that address hurdles in a holistic way (e.g., provide affordable credit to increase output for sales, while implementing strategies to increase market access) combined with better-tailored interventions directly supporting women (e.g., technical assistance, financial literacy, flow of marketing information).

Opportunities for promoting women's participation in agricultural activities

While there are significant barriers that limit women's more active or expanded role in agricultural activities, the results and discussion of this study identify a series of opportunities that could help improve their participation, particularly in livestock production, and become more involved in income generating activities. Accessing paid work can have, in turn, a significant improvement in women's agency and empowerment (Kabeer, 2005, 2018).

First, considering participants in Chiquimula and Huehuetenango do not have a strong preference for crop-related activities, mainly due to cultural barriers and social norms that may be difficult to overcome in the short run, projects and programs can start by remarking the importance of generating alternative streams of income among younger women based on their preferences. These initiatives should include a gender-sensitive approach that fully accounts for women's needs and agency within their household dynamics (e.g., in terms of their workload and income decision-making). Understanding intra-household behavior, including individual roles within households and the levels of cooperation, is crucial for the design of policies and interventions (Doss and Quisumbing, 2020).Programs should also follow participatory and hands-on learning methodologies to develop technical livestock knowledge among women and have gender-responsive extension services and trainings (Rota and Urbani, 2021). This is important because gender norms influence the behaviors society expects from men and women; and in the processes of internalization and normalization, they end up generating a patriarchal division of roles, where women are dedicated to caring activities for family members and men to productive activities (Sumberg and Okali, 2013). These norms can certainly threaten the success of any program and should be considered when designing any production- or economic-related initiative for women.

Second, given that women project themselves as a family and not as an individual, which is another cultural barrier, initiatives could consider working on the visualization and identity formation of women before focusing on empowerment and agency development (Bianco et al., 2017; DeJaeghere et al., 2022). Developing a self-identity is an outcome of empowerment and can place women in a better position within their community or inspire other women as role models (Valodia, 2001; Al-Dajani and Marlow, 2013). Dalton et al. (2016) further develop a theoretical framework in which poverty itself can exacerbate women's failure to aspire to their own potential. Visualization and identity formation initiatives can thus aid women to pursue more job opportunities, which could result in an additional income source and alleviate, to some extent, their day to day economic and financial hardship. On this matter, Genicot and Ray (2017) propose a theory about socially determined aspirations, where if an individual's aspirations are slightly above their current livelihood level, these could lead to investments; while if individual aspirations are much higher, they could lead to frustration.

Participants are also generally worried on feeding their families and on becoming more resilient to economic or weather shocks. More programs promoting the creation of home gardens, livestock farming, and commercialization of vegetable patch and livestock byproducts would be helpful to continue securing household's food access and additional income streams (Valdivia, 2001). Promoting programs on financial literacy, specifically designed for homemakers in rural communities, could also help to overcome part of the economic barriers currently faced by participants. While women seem reluctant to engage with group or individual credits, they still show interest in participating in workshops and courses that include modules on financial literacy. In the same vein, the provision of continuous extension services on production, storage, and commercialization as well as on management and accounting could be helpful. Given the vulnerability to climate shocks among the studied population, these extension services should similarly include climate mitigation and adaptation strategies.

Additionally, building agency capacity through existing women groups and organizations and enabling the environment for improved credit and market access is key in this regard. Weak gender institutions can limit the effectiveness of interventions (Howland et al., 2021). The Ministry of Agriculture, Livestock, and Food and international cooperation organizations should consider working more closely with the private sector and existing organizations operating in the areas that could help participants access larger markets. On this matter, Howland et al. (2021) remark that there is a lack of articulation between governmental and international actors in Guatemala, which jeopardizes the effectiveness of interventions. This highlights the importance of stakeholders working closely and in an articulated way focusing on a gendered approach. This would be an opportunity to expand participants' outreach outside their (traditional) community market, encouraging the sustainable expansion of their small-scale livestock and home garden products. These opportunities could increase participation in these activities and consolidate secondary streams of income for women, reducing their perceived (latent) need to emigrate.

Finally, proposing a water project in the three communities in Huehuetenango that are suffering from water shortages would reduce the hours women spend travelling to and from water holes, freeing time to focus and engage in activities related to small-scale livestock farming and production as well as other possible income generating activities.

Conclusion

Cultural and economic barriers play a significant role in the participation of women in crop and livestock production systems. Cultural barriers limit women's roles and activities outside of their household, as they are the primary caretakers for the family unit and adopt secondary unpaid occupations. These are unpaid activities where women must devote a significant amount of their time, which prevent them from engaging in potential income-generating activities. These cultural barriers are also evident in women's role in crop related activities, as participants consider crop production a primarily male-led field. Despite the migration of men into other areas or their involvement in non-agricultural occupations, women do not take over men's crop-related tasks. We similarly find that women's main aspirations are to generate more income either through small-scale livestock activities or other related occupations, or emigrate to improve their livelihoods and seek a better future for their family, despite emigrating being a risky and expensive activity. Women also show significant difficulty projecting into the future, envisioning themselves outside of the household, and verbalizing their personal ambitions and aspirations.

Economic and financial barriers, in turn, limit women's roles and agency outside of their household and their expanded participation in livestock production systems, which ultimately affects their aspirations. Lack of resources is their main barrier for expanding their small-scale livestock activities and commercializing their products, but individual and group loans are negatively perceived, despite being potential solutions. This further raises the question of whether current financial products are sufficiently attractive for women or better tailor-made products for women are needed, combined with information asymmetries. Additionally, lack of access to markets outside their own communities act as another significant economic barrier for the commercialization of their small-scale livestock and home garden byproducts.

Despite the multiple challenges faced by women, we identify and discuss opportunities that may be helpful in promoting women's participation in livestock production activities and achieving their aspirations. Opportunities that include: the promotion of programs that incentivize the creation and sustainability of home gardens, small-scale livestock farming, and commercialization of byproducts offering extensive support to both start new activities and aid through continuous extension services on production (including mitigation and adaptation strategies for climate change); financial literacy training; the promotion of interventions that build agency capacity through existing women groups and organizations; and the promotion of projects that propose community development that could both help women to take on more active roles in other activities as well as encourage people to stay in their communities.

Overall, it is important to promote interventions that can help women start viewing and transforming potential new activities, especially small-scale livestock farming and raising, into profitable and sustainable businesses that can become an important source of income for their families and empower them, reducing their perceived need to emigrate. A closer collaboration and coordination between the public and private sector, including the international cooperation, is necessary depending on the nature of the interventions. This also involves developing programs that can help women project into the future, better envision their potential, and raise their aspirations, which certainly requires additional studies to better understand this topic and provide more tailored recommendations and solutions that consider cultural and contextual factors.

Finally, despite the width of the topics analyzed, it is relevant to outline some potential limitations of the study. First, although several women actively engaged in the focus group discussions, some participants may still have been resistant to fully share their aspirations and (negative) experiences because of the social desirability bias, as participants generally know each other. Second, despite technicians from the Ministry of Agriculture, Livestock, and Food (MAGA) only served as 'entry points' between researchers and communities, their facilitation and prior coordination with community representatives could have affected the nature of the information reported. Looking forward, it will be relevant for future research to hold focus groups with male participants to include and analyze men's perspectives, as well as to expand to other communities in the same departments but

with different socioecological contexts, to discern whether the same or other cultural and economic barriers exist. This study focused, for example, on communities dominated by subsistence agriculture and livestock activities such that a natural expansion would be visiting communities with more market-oriented activities in the same regions.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the International Food Policy Research Institute (IFPRI) Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

MH: led study design and implementation, data analysis, manuscript writing, and paper revision. CA, MB, DL, and DQ: contributed to study design, data collection, literature review, data analysis, manuscript writing, and paper revision. BR: contributed to study design, data analysis, manuscript writing, and paper revision. FO: contributed to study design and implementation. All authors contributed to the article and approved the submitted version.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1185756/full#supplementary-material

References

Al-Dajani, H., and Marlow, S. (2013). Empowerment and entrepreneurship: a theoretical framework. *Int. J. Entrep. Behav. Res.* 19, 503–524. doi: 10.1108/IJEBR-10-2011-0138

Anderson, C. L., Reynolds, T. W., Biscaye, P., Patwardhan, V., and Schmidt, C. (2021). Economic benefits of empowering women in agriculture: assumptions and evidence. *J. Dev. Stud.* 57, 193–208. doi: 10.1080/00220388.2020.1769071

Baada, J. N., and Najjar, D. (2020). A review of the effects of migration on the feminization of agrarian dryland economies. *J. Gender Agric. Food Secur.* 5, 1–12. doi: 10.19268/JGAFS.522020.1

Bajema, D., Miller, W. W., and Williams, D. L. (2002). Aspirations of rural youth. *J. Agric. Educ.* 43, 61–71. doi: 10.5032/jae.2002.03061

Ballara, M., Damianovic, N., and Parada, S. (2010). Aporte de ingreso económico de las mujeres rurales a sus hogares. Fondo de Desarrollo de las Naciones Unidas para la Mujer, UNIFEM, parte de ONU Mujeres.

Beneria, L., and Sen, G. (1981). Accumulation, reproduction, and Women's role in economic development: Boserup revisited. *Signs J. Women Cult. Soc.* 7, 279–298. doi: 10.1086/493882

Bianco, M. E., Lombe, M., and Bolis, M. (2017). Challenging gender norms and practices through women's entrepreneurship. *Int. J. Gend. Entrep.* 9, 338–358. doi: 10.1108/IJGE-10-2017-0060

Black, J., and Sigman, Z. (2022). 50,000 lives lost during migration: analysis of missing migrants project data 2014–2022. IOM GMDAC. Available at: https://missingmigrants.iom.int/sites/g/files/tmzbdl601/files/publication/file/2022%2050k%20deaths.pdf (Accessed June 12, 2023).

Carter, M. W. (2004). Gender and community context: an analysis of Husbands' household Authority in Rural Guatemala. *Sociol. Forum* 19, 633–652. doi: 10.1007/s11206-004-0699-0

CGIAR. (2018). One size does not fit all – Climate change interventions for farmers in Guatemala. available at: https://www.preventionweb.net/news/one-size-does-not-fit-all-climate-change-interventions-farmers-guatemala (Accessed June 12, 2023).

Corado, A. (2019). Caracterización de los sistemas de producción del ganado bovino en el municipio de Chiquimula, departamento de Chiquimula (Tesis). Universidad de San Carlos de Guatemala.

Crossland, M., Paez Valencia, A. M., Pagella, T., Mausch, K., Harris, D., Dilley, L., et al. (2021). Women's changing opportunities and aspirations amid male outmigration: insights from Makueni County, Kenya. *Eur. J. Dev. Res.* 33, 910–932. doi: 10.1057/s41287-021-00362-8

Dalton, P. S., Ghosal, S., and Mani, A. (2016). Poverty and aspirations failure. *Econ. J.* 126, 165–188. doi: 10.1111/ecoj.12210

Deere, C. D. (2005). The feminization of agriculture? Economic restructuring in rural Latin America (No. 1). UNRISD Occasional Paper.

Deere, C. D., Lastarria-Cornhiel, S., Ranaboldo, C., and Costas Monje, P. (2011). Tierra de mujeres: reflexiones sobre el acceso de las mujeres rurales a la tierra en América Latina. Fundacion Tierra. available at: https://www.rimisp.org/wp-content/files_mf/1377805458tierramujeresreflexionesaccesotierraenamericalatina.pdf (Accessed June 12, 2023).

DeJaeghere, J., Wiger, N. P., Le, H., Luong, P., Ngo, N. T. H., Vu, T. T., et al. (2022). Why do aspirations matter for empowerment?: discrepancies between the A-WEAI

domains and aspirations of ethnic minority women in Vietnam. *World Dev.* 159:106057. doi: 10.1016/j.worlddev.2022.106057

Deutsh, R., Duryea, S., and Piras, C. (2001). Empowering, women to achieve food security: labor markets and employment. *Focus* 6, 7–12.

Doss, C. R., and Quisumbing, A. R. (2020). Understanding rural household behavior: beyond Boserup and Becker. *Agric. Econ.* 51, 47–58. doi: 10.1111/agec.12540

Duflo, E. (2012). Women empowerment and economic development. *J. Econ. Lit.* 50, 1051–1079. doi: 10.1257/jel.50.4.1051

Espinal, M., and Witkowski, K.Proyecto EUROCLIMA-IICA, Proyecto Insignia Resiliencia y Gestión Integral de Riesgos en la Agricultura, Proyecto Insignia Resiliencia y Gestión Integral de Riesgos en la Agricultura & Eje Transversal Innovación y Tecnología (ETIT). (2015). Estudio regional sobre género, agricultura y cambio climático. Estado y perspectivas desde la institucionalidad en Latinoamérica. Available at: https://repositorio.iica.int/handle/11324/3043 (Accessed June 12, 2023).

FAO. (2011). The state of food and agriculture 2010–11: Women in agriculture. Closing the gender gap for development. Available at: https://www.fao.org/3/i2050e/i2050e.pdf (Accessed June 12, 2023).

Faria, N. (2009). "Economia feminista e agenda de lutas das mulheres no meio rural" in *(org) Estatísticas Rurais e a Economia Feminista: Um olhar sobre o trabalho das mulheres*. ed. A. Butto (Brasília: MDA)

Fletschner, D., and Kenney, L. (2010). Rural Women's access to financial services: Credit, savings and insurance. Available at: https://www.fao.org/publications/card/en/c/75438ae9-9c1c-5c56-b674-1e1fe52f6c03/ (Accessed June 12, 2023).

Fuentes, J. (2005). Evaluación de dos sub- sistemas de producción ovina, en la meseta de los Cuchumatanes, departamento de Huehuetenango (Thesis). Universidad de San Carlos de Guatemala. Available at: https://core.ac.uk/download/pdf/35294459.pdf (Accessed June 12, 2023).

Genicot, G., and Ray, D. (2017). Aspirations and inequality. *Econometrica* 85, 489–519. doi: 10.3982/ECTA13865

Grassi, F., Landberg, J., and Huyer, S. (2015). *Running out of time: The reduction of women's work burden in agricultural production*. Rome: Food and Agricultural Organization of the United Nations.

Gumucio, T., Mora Benard, M. A., Clavijo, M., Hernández, M. C., Tafur, M., and Twyman, J. (2015). Silvopastoral systems in Latin America: mitigation opportunities for men and women livestock producers. CCAFS policy brief. CGIAR research program on climate change, agriculture and food security (CCAFS), Copenhagen.

Hendriks, S. (2019). The role of financial inclusion in driving women's economic empowerment. *Dev. Pract.* 29, 1029–1038. doi: 10.1080/09614524.2019.1660308

Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., et al. (2013). The roles of livestock in developing countries. *Animal* 7, 3–18. doi: 10.1017/S1751731112001954

Holland, N. (2014). Cultural and socio economic experiences of female entrepreneurs in Brazil and the United States: an exploratorial and empirical analysis. *J. Women Entrepreneursh. Educ.* 1, 3–37.

Howland, F., Acosta, M., Muriel, J., and Le Coq, J. F. (2021). Examining the barriers to gender integration in agriculture, climate change, food security, and nutrition policies: Guatemalan and Honduran perspectives. *Front. Sustain. Food Syst.* 5:664253. doi: 10.3389/fsufs.2021.664253

Ibáñez, M. J., and Guerrero, M. (2022). Women's empowerment and emancipation through entrepreneurship: extending professor Alistair Anderson's contributions. *Entrepreneursh. Region. Dev.* 34, 722–741. doi: 10.1080/08985626.2022.2075038

INE. (2003). IV Censo Nacional Agropecuario. Available at: https://www.ine.gob.gt/sistema/uploads/2014/01/16/cv9H2R2CyhS1n0c1XfKqXVf4pLIxONTg.pdf (Accessed June 12, 2023).

INE. (2015). Republica de Guatemala: Encuesta Nacional de Condiciones de Vida (2014). Available at: https://www.ine.gob.gt/sistema/uploads/2016/02/03/bwc7f6t7asbei4wmuexonr0oscpshkyb.pdf (Accessed June 12, 2023).

INE. (2017). Guatemala VI Encuesta Nacional de Salud Materno Infantil (ENSMI) 2014–2015: Informe Final. Ciudad de Guatemala. Available at: https://www.ine.gob.gt/sistema/uploads/2021/04/27/20210427195413QDinUvuRa9GjopyXaTuNMXc3gd6Jq1Q1.pdf (Accessed June 12, 2023).

INE. (2018). *XII Censo Nacional de Población y VII de Vivienda*. Guatemala: INE.

INE. (2019). Tablero ENEI. Available at: https://www.ine.gob.gt/tablero-enei/ (Accessed June 12, 2023).

International Labour Organization. (2019). Empowering women in the rural economy. ISBN 9789220308028. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_601071.pdf (Accessed June 12, 2023).

Kabeer, N. (2005). Gender equality and women's empowerment: a critical analysis of the third millennium development goal 1. *Gend. Dev.* 13, 13–24. doi: 10.1080/13552070512331332273

Kabeer, N. (2018). Gender, livelihood capabilities and women's economic empowerment. Reviewing evidence over the life course. Gender & Adolescence: Global Evidence (GAGE).

Klapper, L., and Parker, S. (2011). *Gender and the business environment for new firm creation. World Bank research observer*. Geneva: World Bank *26*, 237–257

Kosec, K., and Song, J. (2018). *Aspirations and women's empowerment: evidence from Kyrgyzstan*. Washington: International Food Policy Research Institute (IFPRI).

Lastarria-Cornhiel, S. (2008). Feminización de la agricultura en América Latina y África. Tendencias y fuerzas impulsoras. RIMISP, Centro Latinoamericano para el Desarrollo Rural. Available at: https://rimisp.org/wp-content/files_mf/files_mf/1366830040DTR_No.11_Lastarria.pdf (Accessed June 12, 2023).

Nerger, M. (2012). Getting ahead of climate change in Guatemala's Western highlands. Available at: https://www.rainforest-alliance.org/in-the-field/getting-ahead-climate-change-guatemala-western-highlands/ (Accessed June 12, 2023).

Paulilo, M., and Silva, C. (2007). A luta das mulheres agricultoras: entrevista com Dona Adélia Schmitz. *Revista de Estudos Feministas* 15, 399–417. Florianópolis doi: 10.1590/S0104-026X2007000200007

Quisumbing, A., and Meinzen-Dick, R. (2001). Empowering women to achieve food security: labor markets and employment. *Focus* 6, 1–12.

Rietveld, A. M., van der Burg, M., and Groot, J. C. (2020). Bridging youth and gender studies to analyse rural young women and men's livelihood pathways in Central Uganda. *J. Rural. Stud.* 75, 152–163. doi: 10.1016/j.jrurstud.2020.01.020

Rota, A., and Urbani, I. (2021). IFAD advantage series: the small livestock advantage. A sustainable entry point for addressing SDGs in rural areas (no. 2356–2021-577).

Sumberg, J., and Okali, C. (2013). Young people, agriculture, and transformation in rural Africa: an "opportunity space" approach. *Innovations* 8, 259–269. doi: 10.1162/INOV_a_00178

The World Bank, FAO, and IFAD. (2009). *Agricultura y Desarrollo rural: manual sobre género en agricultura. Agriculture and Rural Development*; Washington, DC: World Bank.

Triana, N, and Burkart, S. (2019). *Gender and the cattle sector in Latin America: recent trends in literature*. Colombia: International Center for Tropical Agriculture (CIAT) Cali, CO. 12.

Valdivia, C. (2001). Gender, livestock assets, resource management, and food security: lessons from the SR-CRSP. *Agric. Hum. Values* 18, 27–39. doi: 10.1023/A:1007613031102

Valodia, I. (2001). Economic policy and Women's informal work in South Africa. *Dev. Chang.* 32, 871–892. doi: 10.1111/1467-7660.00230

World Bank Group. (2015). Women in agriculture: the impact of male out-migration on Women's agency, household welfare, and agricultural productivity. Report no: AUS9147.

World Bank national accounts data, OECD National Accounts data files. (2021). *Agriculture, forestry, and fishing, value added (% of GDP) – Guatemala*. Geneva: WHO

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Small ruminant value chain and empowerment: a gendered baseline study from Ethiopia

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Introduction: Despite growing interest in gender analysis in value chains, comparatively few studies have analyzed gender relations in small ruminant value chains using sex-disaggregated quantitative data in livestock-based systems.

Methods: Drawing on baseline data from the Small Ruminant Value Chain Development Program (SRVD) in Ethiopia, this study aims to address two research questions: what is the gender status along small ruminant value chain stages and the related associations among aspects of empowerment and socio-economic variables? We employed empowerment and value chain frameworks to address these research questions.

Results and conclusion: Our findings reveal that small ruminant market participation, related decisions, and control over income are gender differential. Estimation results identified several variables significantly associated with agency dimensions, achievements, or both, with mixed results. These are age group, context, being married, being men and head of household, participation in breeding stock selection, livestock ownership, contact with extension agents, access to market information, and participation in selling at marketplaces. Participation in a small ruminant value chain may encourage more egalitarian decision-making behaviors but does not guarantee the capacity to make autonomous decision-making, and thus needs to be coupled with interventions on empowerment dimensions. Nevertheless, further investigations are required to establish the mixed results with additional variables on norms.

KEYWORDS

gender, value chain, small ruminants, empowerment, Ethiopia

1. Introduction

Apart from its substantial role in Ethiopia's national GDP, livestock significantly contributes to the economic and social lives of Ethiopian farmers, ranging from smallholder farm households in mixed farming systems to agropastoral and pastoral farming systems (Negassa et al., 2011; Gebreyohanes et al., 2021). In mixed farming systems, livestock provides smallholder farm households with various benefits such as nutritious food, income, traction power, transportation means, source of energy (fuel for cooking), and farm outputs and inputs (Covarrubias et al., 2012; Waithanji et al., 2013a; Galiè et al., 2015; Wodajo et al., 2020; Banda and Tanganyika, 2021; Management Entity, 2021). For livestock keepers in the agropastoral and pastoral systems, livestock offers many important functions. These include the capacity to cope with financial shocks, serving as a safeguard stock to smooth consumption, being a means of income accumulation, and also a store of wealth, thus being a way to build social capital (Negassa et al., 2011; Catley et al., 2021; Bekele et al., 2022; Ozkan et al., 2022). Moreover, livestock is also a source of pride and has symbolic value (Wodajo et al., 2020). In the pastoral system, livestock is the only means that support

and sustain pastoralist livelihoods (Negassa et al., 2011; Headey et al., 2014; Mekuyie et al., 2018). Therefore, improving livestock production and marketing through livestock value chain development is critical to enhancing livelihoods and thus alleviating poverty in developing countries like Ethiopia.

Interventions to develop agricultural value chains (VC)[1] have flourished as instruments for rural transformation and poverty reduction over the last few decades. Nevertheless, scholars argue that it is challenging to achieve development outcomes while making VC interventions empowering women (Minten et al., 2009; Malapit et al., 2020). In the past, the focus has been on the development of tools and methods for analyzing VC efficiency and profitability (GebreMariam et al., 2019). However, although VC analysis with special attention on equity and distributional impacts is a recent phenomenon (Malapit et al., 2020), a growing body of literature now explicitly addresses gender inequalities in value chain analysis (Van den Broeck et al., 2018). Among other things, these studies have exposed and highlighted important insights into unintended gendered consequences of VC participation, mainly through qualitative assessments (Malapit et al., 2020). Such consequences include increased gendered responsibilities and time burden (Lyon et al., 2016), and loss of control over production and marketing (Forsythe et al., 2016). The empowerment dimensions within the livestock VC development assessment efforts are often neglected (Galiè et al., 2019), although livestock VCs are not "socially neutral" in their gendered effects (Nally, 2016: 564 cited in Bain et al., 2020). As a result, much is unknown regarding the context or preconditions for empowerment and the processes by which it is achieved (Mahmud and Tasneem, 2014). Nevertheless, the consideration of empowerment in baseline and end-line impact assessments can increase our understanding of the likely gendered outcomes and what does and does not work beyond the conventional outcomes of development interventions. Doing so has the potential to inform the design and implementation of VC development interventions that would help to achieve better results (Petesch et al., 2005).

The goal of this study is, therefore, to examine patterns of the gendered status of empowerment resources,[2] decision-making (agency), and achievement. This study also investigates the associations that are hypothesized to exist among these aspects of empowerment (empowerment resources, decision-making (agency), and achievement) along the key small ruminant (SR) VC stages. It starts by examining the gendered status of resource ownership, participation status in VC activities, market-related decisions, and achievement in terms of control over income proceeds from SR marketing, and moves on to examine the associations among these factors. To provide context-specific information on gender dynamics related to empowerment within livestock-based systems in Ethiopia, this study seeks to answer the following research questions:

1) What are the gender gaps in empowerment resources, agency (decision-making), and achievement (control over income from small ruminants)? and
2) How are empowerment resources and demographic characteristics related to men's and women's agency and achievement across the key stages of SR VC in livestock-based systems of Ethiopia?

To address these research questions, our case study focused on the Small Ruminant (goats and sheep) Value Chain Development (SRVCD) program in Ethiopia. To transform the current low level of productivity of the indigenous Ethiopian SR breeds under the smallholder production systems, ICARDA,[3] ILRI,[4] and the University of Natural Resources and Life Sciences (BOKU), in partnership with the Ethiopian National Agricultural Research System (NARS), designed and implemented a community-based breeding program in 2007. Up until 2021, about 8,000 households had been enrolled in the project from four potential sheep and goats producing areas, Afar, Bonga, Horro, and Menz (Kangethe et al., 2021). Since the end of the project, the more successful breeding programs have been continued under the CGIAR[5] Research Program on Livestock and Fish by ICARDA, ILRI, and the National Agricultural Research Systems (NARS) in three sites (Menz, Horro, and Bonga). This program also expanded to new potential sheep- and goat-producing areas (Doyogana and Atsbi, and Abergele and Yabello, respectively), with increased numbers of participating sheep- and goat-keeping households (Gutu et al., 2015).

The program, through its research and development partners, has been working to develop and deliver innovations for SR value chain development in an integrated manner to improve impact. The four specific intervention components that the program has been working on since 2012, in an integrated manner across the target sites, include breed improvement through community-based approaches; animal health management; animal feed and nutrition improvement; and market development through collective action. Among the interventions, the breeding improvement interventions were undertaken in potential goat and sheep locations in various parts of the country. Community-based sheep breeding programs have been implemented in Bonga, Horro, Menz, and Doyogena districts, representing sheep-dominated production systems. Goat genetic improvement interventions were undertaken in Abergele and Yabello districts, representing goat-dominated production systems. The intervention on the two species (sheep and goat) was combined by the program and called SRVC transformation.

The remainder of this article is structured into four sections. First, the literature relating to the livestock value chain context, gender and livestock value chain, and a conceptual framework for empowerment and participation in the livestock value chain, are discussed. Next, the methodology section provides information on

1 "A value chain is the sequence of interlinked agents and markets that transforms inputs and services into products with attributes for which consumers are prepared to pay. VC development often involves subsidies or competitive grants, capacity or skills development, inputs or information provision, policy or institutional innovations, and other types of support aimed at different actors or aspects of the enabling environment" (Malapit et al., 2020).

2 Empowerment resources encompass human, economic, material, social, informational, and psychological assets (Alsop et al., 2006).

3 The International Centre for Agricultural Research in the dry areas.

4 The International Livestock Research Institute.

5 CGIAR is The Consultative Group on International Agricultural Research.

sampling procedures, data sources, variables selection, and data analysis techniques used in the study. The third section discusses the major findings of the study, while the final section discusses these findings and presents conclusions.

1.1. Literature on livestock VC and gender

Livestock VCs operate within the opportunity structure—which is defined as the social, economic, political, and institutional (formal and informal institutions) context in which men and women pursue their interests (Alsop et al., 2006; Akter and Chindarkar, 2020). Equitable access to resources, and their accumulation and use, is largely determined by this structure. The interactions among the institutions within the system are what determine the gender outcomes (The World Bank, 2011) and, thus, are responsible for shaping the gender dimensions of livestock VCs. Specifically, how these interactions play out in a given context shape the distribution of resources, how agents can exercise their agency, and more importantly determine the wellbeing outcomes they can achieve through participation in the value chain (Malapit et al., 2020). Here, we define *agency* as the agents' ability to make decisions with freedom from external influences (instrumental agency), their ability to collectively achieve shared interests (collective agency), and their internal sense of freedom, self-confidence, self-efficacy, and self-respect (intrinsic agency; Rowlands, 1997; Alkire et al., 2013; Galiè and Farnworth, 2019).

VCs embedded within the opportunity structures cannot be gender-neutral (Malapit et al., 2020). Although an increasing number of studies (see Dolan and Humphrey, 2000; Kidder and Raworth, 2010; Malapit et al., 2019) have shown the benefits of VCs to women, they have also uncovered its role in exacerbating gender inequalities (Malapit et al., 2020). Yet, VCs can be an instrument for reducing the gender gap and enhancing women's empowerment if implemented intentionally to avoid such pitfalls (Maertens and Verhofstadt, 2013; Van den Broeck et al., 2018). On the other hand, gender roles and time burdens may shift with greater commercialization negatively impacting women's domestic responsibilities (Lyon et al., 2016). Evidence shows that women generally have limited access to empowerment resources; as VC actors, they face several production and market constraints (Forsythe et al., 2016) and simply increasing their involvement in higher nodes of VCs may not automatically result in empowerment (Malapit et al., 2020). In livestock-based systems, women face specific challenges, such as poor access to improved breeds, limited livestock extension services, and inadequate land for forage production (Njuki et al., 2013; Galiè et al., 2017). Although the current extension system being implemented in Ethiopia targets women household heads, based on quota systems, with specific support packages (Mogues et al., 2009), to address the needs of women livestock keepers, empirical evidence consistently shows that there is still a substantial gender gap when it comes to quality services, which is mainly due to the existing biased social norms (Ragasa et al., 2013). Although intra-household gender analysis in livestock-based systems is scarce, existing evidence shows that the problem is more pronounced for women in men-headed households because women and men within the same households do not always share resources or preferences and men often dominate household decision-making processes (see Doss and Kieran, 2014; Kinati et al., 2018; Joshi et al., 2019). Although, in recent years, there is an increased effort to mainstream gender into development efforts in Ethiopia (Mogues et al., 2009) including policies that encourage joint ownership (Kumar and Quisumbing, 2015), women household heads are the target of extension services based on quota systems with specific support packages directed to them (Mogues et al., 2009). Similarly, although women's empowerment is one of the core objectives of most of the development programs by non-governmental organizations, the focus is on women-headed households (Woldu et al., 2013). Thus, the empowerment of women in men-headed households is generally neglected.

In Ethiopia, about 92% of households keep livestock of mainly local breeds and in 78% of these households, the literature suggests that animals are jointly owned (Njuguna-Mungai et al., 2022), although the indicator "joint" ownership is problematic when it comes to empowerment (Kabeer, 2011). Commercialization of agricultural output is one of the country's pillars for development policies (World Bank, 2007). Although livestock is an important asset for women—because they offer a unique opportunity for their economic empowerment—on average, women own fewer herds and control less valuable species, such as poultry, while men control large animals, such as cattle (Kristjanson et al., 2010). Women are prone to lose their traditional resource entitlements when the value of the assets they control improves. Increasingly, evidence shows that this is because men tend to take away ownership and control rights from women when VCs are upgraded and gain higher value through greater commercialization (Ashby et al., 2019; Kinati and Mulema, 2019). These studies shed light on the need to investigate gendered patterns of participation along VC stages and the associated benefits, and also the unintended consequences. Empirical studies investigating gendered VC participation have reported mixed results making it difficult to find general patterns (Malapit et al., 2020). Moreover, empirical evidence within the livestock-based system is generally scarce (Galiè et al., 2019).

Literature on gender roles in livestock is mainly based on headship (Yisehak, 2008; Njuki et al., 2013) and thus tends to mask women's roles. Studies on intra-household gender analysis with regard to small ruminant production are scarcely available in Ethiopia and what is existing shows that both genders play an important role in livestock management and husbandry practices (Kifetew, 2006; Hulela, 2010; Ragasa et al., 2012). However, who does what is not addressed well in these studies. For example, a study conducted by Mulema et al. (2017) in Ethiopia found that livestock management and husbandry practices are generally shared among household members, with men controlling the management of large animals, while women mostly dominate that of small animals. Likewise, studies conducted in the different farming systems of Ethiopia not only have shown that most of the husbandry practices are jointly shared but also revealed that there are gender-based distinct roles—depending on the livestock they keep, women perform roles such as cleaning, gathering feed and feeding, watering, taking care of sick and weak animals, and milking, whereas men mostly do the work of herding, cutting

forage, marketing, and taking sick animals to vet posts (Belete, 2006; Yisehak, 2008; Aklilu et al., 2014; Wegari, 2020). However, in-depth qualitative studies in Ethiopia revealed that women generally carry out all of the husbandry practices while men control the "political" aspects of these roles—making decisions on who should do which activities (Kinati et al., 2018). However, in studying gender relations in agriculture, particularly in livestock, the gender of the informant matters and need to be considered in gender analysis (Kamo, 2000). In our study, we tried to uncover this fact quantitatively by analyzing the gender relations in SRs from the perspectives of both men and women respondents. It is suggested that such sex-disaggregated information is essential to inform and influence interventions in livestock-based systems.

Although the productivity of livestock is low in Ethiopia, on average, it contributes about 37–87% of the household income (Solomon et al., 2003). Quantitative research with sex-disaggregated data on women's participation in livestock and their product marketing is limited (Meinzen-Dick et al., 2011) and is also difficult to generalize as roles vary within and among countries. However, what is apparent from existing studies is that women generally have a low level of involvement in livestock-related marketing as a result of various socio-economic factors (Njuki et al., 2011; Waithanji et al., 2013a; Boogaard et al., 2015; Giziew, 2018; Wegari, 2020). Although women own SRs in most cases, men are responsible for their disposal and thus control decisions related to their sales (FAO, 2011). In this study, decision-making refers to the ability to make one's own decisions without external influences that affect one's own life (Galiè et al., 2019). The most commonly used element in defining women's empowerment in the literature is the concept of women's decision-making power as an indicator of agency (Sell and Minot, 2018; Seymour and Peterman, 2018). Literature on intrahousehold gender dynamics suggests that individuals' asset-holding status influences bargaining power within the household (Quisumbing et al., 2015) whether in production or marketing-related decision-making. Generally, women have little, if any, control over income from small ruminant sales and this is worse among women in male-headed households as compared to households that are headed by women (Boogaard et al., 2015).

If there are gender differentials in livestock production and benefits, gender dynamics will likely influence and potentially hamper the achievement of the SRVCD program. Understanding the gendered status and empowerment dimensions of the livestock VC development in Ethiopia is vital from the perspectives of the reviewed literature. Because what is evident is that the small ruminant VC development is neither gender-neutral nor its empowerment dimension sufficiently studied. Drawing on the SRVC dataset collected as a baseline for the program on SRVC transformation being implemented in Ethiopia, this study contributes to the literature gaps on patterns of the gendered status of empowerment resources, decision-making (agency), achievement, and associations among aspects of empowerment along the key small ruminant (SR) VC stages.

Three types of household surveys are noted in the literature to quantify gender dynamics in agriculture—inter-household surveys (male-headed vs. female-headed households), intra-household surveys (wives vs. husbands), and inter-household level of analysis (male landholders vs. female landholders to explore intra-household questions; Tavenner et al., 2018). This study analyzes data from the third type of survey, whereby respondents were asked a series of questions regarding the intra-household distribution of roles, resources, and decisions regarding small ruminant production and marketing. Although data that captures an intra-household dynamic is widely appreciated (Meinzen-Dick et al., 2011, 2019; Waithanji et al., 2013a; Quisumbing et al., 2015; Wegari, 2020), it is also likely to encounter some level of gender respondent bias that requires caution when interpreting survey results (Tavenner et al., 2018). However, if the gender respondent bias is considered when analyzing and interpreting survey data, men's and women's accounts of participation in the SRVCD program can offer indicative trends useful to inform gender-responsive mitigation interventions in livestock VC development.

1.1.1. The conceptual framework

The framework for the current study draws on empowerment and value chain frameworks. The combination of these frameworks allows the interactive process of empowerment, which enables us to better understand the gendered patterns across empowerment aspects and value chain stages. It helps us to consider how agents utilize empowerment resources to improve their decision-making abilities (agency) which ultimately leads to improved wellbeing outcomes (achievements; Kabeer, 1999; Meinzen-Dick et al., 2019). So, empowerment is understood as a multidimensional contract and a process of change whereby agents obtain the ability to achieve their own choices. It is a complex process and at the same time context-specific, meaning it plays out differently under different contexts (Richardson, 2018a). This implies that not all aspects of empowerment are necessarily considered in the existing studies on gender and agricultural value chains.

Resources enable agents to strategically position themselves with relative power to be effective when bargaining within decision-making processes (Bernard et al., 2020). On the other hand, agents need to have the required agency to access and control empowerment resources (Kabeer, 2011; Choudhary, 2016). This backward and forward interaction between resources and agency gives rise to achievements. In the framework adapted (Figure 1), this process is iterative, meaning achievements can also influence an agent's access to and control over the empowerment resources and their level of decision-making ability (agency). The social and political context in which actors pursue their interests influences all aspects of the empowerment process—the patterns of resources distribution, how agents participate in decision-making processes and exercise their agency, and the economic outcomes that an agent can achieve (Kabeer, 1999; Alsop et al., 2006; Richardson, 2018b).

A large body of literature that attempted to measure empowerment has identified various correlates and determinants of empowerment. However, these analyses have typically focused on empowerment outcomes, with limited or no exploration relating to the process of empowerment (agency), including the pre-conditions (opportunity structure). Table 1 summarizes the correlates and determinants of empowerment and their effects relevant to the current study.

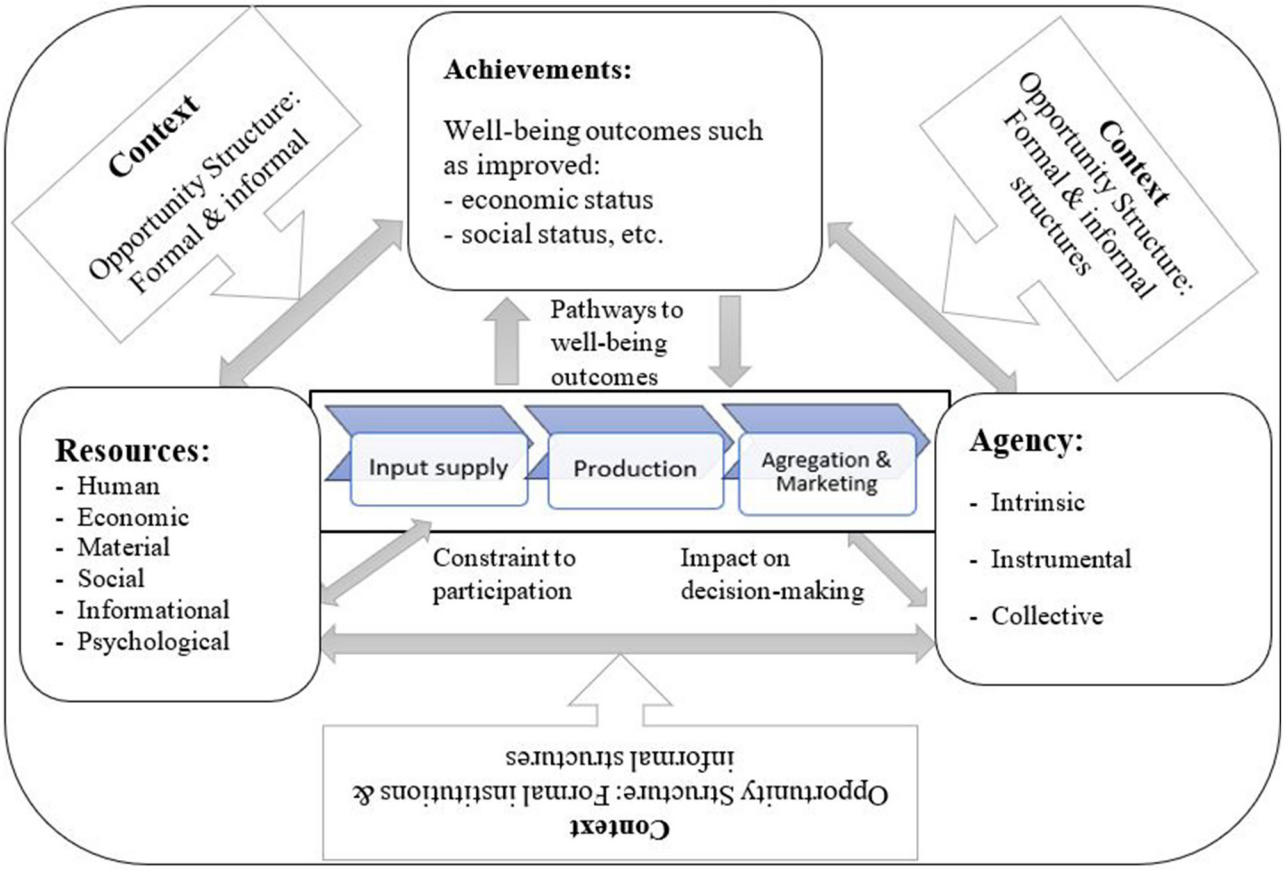

FIGURE 1
Framework for SRVCD and women (men) empowerment. Sources: Adapted from Kabeer (1999), Meinzen-Dick et al. (2019), Bryan and Garner (2020), and Bryan and Lefore (2021).

2. Methodology

2.1. Sampling, data, variables, measurements, and analysis

We relied on baseline data from the International Center for Agricultural Research in the Dry Areas (ICARDA) collected for the SRVCD program. The survey was conducted in 2014 across locations in various parts of the country. The baseline dataset can be taken as a nationally representative survey and covers five of the nine regions across the main agroecological zones of Ethiopia. The survey covered the major SR value chain nodes and used a combination of both purposive and random sampling techniques. Study districts were identified to develop benchmarks for the interventions on SRVCD. After the intervention, Kebeles were selected purposively, which meant that the program identified a list of households in Kebeles based on the health service/taxpayers' roster. Finally, sampled households were identified using a lottery method with recruitment from each district proportional to its population size. The sampled sites initially included nine districts across five regions. In drawing the final sample for the current study, we focused on currently active SRVCD participant districts and limited the sampled sites to six districts for which information regarding gender indicators was available in the baseline dataset. Thus, the final sample used in this study consisted of 723 SR-keeping households from six districts.

Household interviews were conducted in the local language, *Amharic* and *Oromiffa,* and responses were documented in English by well-trained enumerators using a pre-tested VC questionnaire. One person was interviewed from each of the selected households, mostly the head of household or his spouse in the case of male-headed households where the head was not present. Whether it was a man (head of the household) or his spouse who was interviewed, the respondent responded to all the questions including those on the roles of the other household members (intra-household questions). Hence, this enables us to conduct an inter-household level analysis based on the intra-household questions included in the baseline survey. Information related to demographics, access to inputs, ownership, decision-making related to SR market participation, and control over income from SRs were collected. However, no data were collected on structures—norms, social status, and class differences. Nevertheless, the intra-household questions used for the data collection allowed us to carry out intra-household gender analysis in addition to analysis at the household level. Data on agency dimensions and achievement indicators

TABLE 1 Correlates and determinants of women's empowerment and their effects identified in the literature.

Variable	Empowerment aspect measured	Effect	References
Agricultural extension information	Agricultural decision-making; Quantity of maize women sold to the market	+	Lecoutere et al., 2019
Women's empowerment through value chain development	Attitudes to women's economic roles	+	Fuller, 2012
Women's empowerment through value chain development.	Ability to influence decisions in associations	+	Fuller, 2012
Age of men household head	Agricultural decision-making; Quantity of maize women sold to the market	-	Lecoutere et al., 2019
Land rights	Household decision-making	+	Allendorf, 2007
Income and context (being in urban)	Household and financial decisions; empowerment in healthcare and social contacts making	+	Disassa et al., 2016; Akram, 2017
Ownership of asset	Decision-making power	+/-	Lim et al., 2007; Disassa et al., 2016; Akram, 2017
Women's empowerment	Economic, political, social, and psychological capitals	+	Legovini, 2004
Family size	Bargaining power and decision-making	+/-	Lim et al., 2007; Disassa et al., 2016; Akram, 2017; Lecoutere et al., 2019
Involvement in credit programs	Economic security, mobility, making purchases, contribution to family support, political awareness	+	Hashemi et al., 1996
Formal and non-formal education	Use of contraception	+	Al Riyami et al., 2004; Parveen and Leonhäuser, 2004; Gupta and Princy, 2006
Traditional socio-cultural norms (early marriage, dowry and domestic violence)	Resource ownership, contribution to household income and decision-making; Perception on gender awareness	-	Parveen and Leonhäuser, 2004
WDIP program on women's empowerment	Improved dimensions of various resources (economic, social, and psychological assets)	+	Legovini, 2004
Membership in savings and credit groups	Risk of domestic violence	+	Koenig et al., 2003

(dependent variables) were aggregate observations for both sheep and goats.

In the descriptive analysis, we used the intra-household information, gender of the respondent, and location for studying differences in access, ownership, and control over empowerment resources related to SRVC. One of the advantages of the baseline data is that it allows us to identify gendered indicators across aspects of empowerment along the main SR value chain nodes. For example, (1) at the input acquisition stage, the survey asked questions such as "how many sheep/goat do you have?, have you access to extension, credit, training, group membership, etc.?" (2) at the production stage, the survey asked questions such as "Who make breeding stock selection for SRs?, Who sell SRs at market place?" (3) at the marketing stage, the survey asked questions such as "Who define the price of the first goat/sheep? Who decide when to sell goat/sheep? Who kept the sale proceeds of the goat/sheep? Who decides on the goats/sheep sell proceeds?"

Recorded responses for who does what were (1) Head, (2) Spouse, (3) Joint (Head and spouse), (4) Adult male member, (5) Adult female member, (6) Children, and (7) All household members. For further analysis within the regression model, the responses to the questions on agency dimensions and achievement indicators were re-coded into binary. We identified decision-making on defining SR price, when to sell SRs, and controlling the sale proceeds of SRs as our outcome variables, and observations with only head or only spouse to these outcome variables were coded as 1, otherwise 0 (Table 2). However, if they do decide jointly with others, we considered it as not making decisions autonomously because joint decision-making often refers to masked male dominance in the literature (Kabeer, 2011). The identification and measurement of independent and dependent variables are considered for fitting three models in this study. For each of the independent variables, respondents are considered to exercise sole decision-making if they do so alone.

The data analysis for this study was done in two stages. First, mean and frequency tabulation by gender and study areas were computed to summarize basic information on respondents, as well as their responses to empowerment resources, agency dimensions, and achievement indicators. Second, significant variables identified as indicators along the aspects of empowerment and VC stages were further analyzed using logistic regression. Using IBM SPSS Statistics version 26—after cleaning, regrouping, and recoding categorical variables—a binary logistic model (BLM) was applied to describe the relationship of many independent variables to a dichotomous dependent variable (Kleinbaum, 1994) such as: "do you make sole decisions on defining SR price, where to sell, and income from SRs?" The full list of the baseline variables identified along with their meanings, and the descriptive results with the test

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TABLE 2 Brief description of variables used in the binary logistic regression model (valid $N = 343$).

Variables	Description	Code	Categories
Demographics			
Gender	Binary, sex of the respondent	1	Male
		0	Otherwise
District name	Nominal, study areas	1	Abergele
		2	Doyogena
		3	Horro
		4	Menz Gera
		5	Menz Mama
		6	Yabello
Age group	Ordinal, age of the respondent in years	1	≤30 years old
		2	31–40 years old
		3	41–50 years old
		4	51–60 years old
		5	>60 years old
Marital status	Ordinal, marital status of the respondent	1	Married
		2	Single
		3	Divorced
		4	Widowed
Educational status	Binary, education status of the respondent	0	Illiterate
		1	Literate
Family size	Nominal, number of household members	1	<5
		2	6–10
		3	>10
Indicators of empowerment resources			
Land holding	Continuous, size of land (*in Kert*) owned by the household	1	<4
		2	5–10
		3	>10
SR ownership	Ordinal, number of SRs (sheep and goats) owned by the household	1	≤10 heads
		2	11–20 heads
		3	>20 heads
Livestock ownership	Ordinal, total number of livestock owned by the household	1	≤5 heads
		2	6–10 heads
		3	>10 heads
Do you select breeding stock for SRs?	Binary, if the respondent selects breeding stock	1	Yes
		0	Otherwise
Contact with extension agent for advice	Binary, if the respondent has contact with extension agents	1	Yes
		0	Otherwise
Access to credit services	Binary, if the respondent has access to credit services	1	Yes
		0	Otherwise
Market/marketing information	Binary, if the respondent gets market information for SRs	1	Yes
		0	Otherwise
Receive training	Binary, if the respondent receives training on SR production	1	Yes
		0	Otherwise
Membership to groups	Binary, if any of the HH members is membership of group (CBOs)	1	Yes
		0	Otherwise
Participate in selling SRs in the market	Binary, if the respondent participates in selling SRs at market locations	1	Yes
		0	Otherwise
Annual income category from livestock	Continuous, respondent's total annual income from livestock	1	≤5,220.3 (average)
		2	>5,220.3 (average)
Indicators of agency			
Decision-making on defining SR price	Binary, if the respondent makes the sole decision on defining SR price	1	Yes
		0	Otherwise
Decision-making on when to sell SRs	Binary, if the respondent makes the sole decision on when to sell SRs	1	Yes
		0	Otherwise
Indicator of achievement			
Controlling income (decision-making on the sell proceeds) from SRs	Binary, if the respondent control or makes the sole decision on SR sell proceeds	1	Yes
		0	Otherwise

statistics of the differences in means and percentages are reported in Table 3 and under Tables 4–6. BLR results showed an overall percentage predictive correctness of 79.9, 75.8, and 77.1% and a Nagelkerke R^2 of 0.364, 0.338, and 0.355 for defining SRs' price, deciding on when to sell SRs, and controlling the sale proceeds of SRs, respectively (Table 7).

The BLR is robust, including that the independent variables do not require linearity, normality, homoscedasticity, or equal

variance in each group (Hilbe, 2015). Since our outcome variables were dichotomous, they were built as a binary-choice model which assumed that respondents (individual households) were confronted with two alternatives and their choice was contingent on a set of independent variables that were composed of ordinal and categorical variables (Table 2). The logistic regression model is mathematically represented as follows (Gujarati, 1995):

$$\frac{Prob\ (Y_i = 1)}{Prob\ (Y_i = 0)} = \frac{P_i}{1 - P_i} = e^{(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki})} \quad (1)$$

Where P_i is the probability that Y_i takes the value 1 (sole decision-making and membership to group); *1-*P_i is the probability that Y is 0 (no sole decision-making, and no membership to group); e is the exponential constant. Taking the natural log of both sides of Equation 1will give us:

$$L_i = \ln\left(P_i/(1 - P_i)\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} \quad (2)$$

Where,

Li: stands for logit model, which is linear in X_i as well as in β;

i: represents the *i*th observation in the sample;

P: is the probability of the outcome;

β0: is the intercept term; while, $\beta_1 + \beta_2 + \ldots + \beta_k$ are the coefficients associated with each independent variable $X_1, X_2, \ldots, X_k$.

3. Results

3.1. Descriptive analysis

3.1.1. Characteristics of respondents

Table 3 shows the descriptive information on selected demographic and empowerment indicator variables. The majority of the respondents were men (84.8%). While over 88% of the female respondents were widowed or divorced (88.2 and 95.7%, respectively), and only 3% were married, almost all the men (97%) respondents were married. Higher widowed (23.1%) and less married (67.7%) statuses were reported from Menz Gera compared to the other study sites. The average age of respondents was 46.1 years (SD = 14.67). The average family size is about 6 (SD = 2.07), where men-headed households (HH) had slightly higher family sizes, and the highest was reported from Dyogena. More women (65.5%) respondents are illiterate compared to their men (38.5%) counterparts. The proportion of literacy was lowest among Yabello (22.6%) and Abergele (37%) value chain participants. These findings are not surprising as the survey was designed to give preference for the head of household, with wives being interviewed in the event of their husband not being at home during the time of survey completion.

3.1.2. Value chain participation

Systems of ownership of key empowerment resources such as land, SRs, and livestock (mainly cattle) significantly vary across study areas ($p < 0.001$) but do not differ along gender lines except for livestock. On average, respondents own 6.43 (SD = 4.85) kerts of land, and land ownership does not vary by gender. Similarly, SR ownership does not vary by gender. Respondents own about 13 (SD = 12.3) heads of goats and 9 (SD = 8.45) heads of sheep on average and the result is not statistically different between gender. On the other hand, variations in the ownership status of these assets are evident across study sites. The largest owner of these assets, except livestock, was reported from Abergele whereas the opposite was observed in Doyogena and the difference is statistically significant ($p < 0.001$) and consistent with similar studies (Management Entity, 2021; Table 3).

The dataset also provides information on inputs and services. On average, a low proportion of households (22.1%) have access to credit services for investment related to SR production, with significant differences among study sites. Close to half of the respondents from Abergele and Menz Gera reported that they have access to credit services but this is as low as 7.6% for Horo. Most of the respondents (60.9%) generally have contact with extension agents and this does not significantly vary by gender; however, significant variations were observed among study sites. The highest percentage was reported from Menz Gera (84.6%) and Mama (85.2%) study sites. Whereas, a lower proportion (32.9%) of study participants received training, being as low as 13.3% in Abergele study site, which is a common phenomenon in Ethiopia. Engagement in community-based groups is more common in mixed livestock-based systems than in goat-dominated systems. When disaggregated by location, the lowest membership status was reported from Abergele (40%), followed by Yabello (53.5%). Interestingly, in Horo, Menz Gera, and Mama, nearly all of the respondents are members of community-based associations. Nevertheless, the survey data did not provide additional information on the type and purpose of the associations.

The average annual income from livestock for men and women is 5,504.41 (SD = 5,095.38) and 3,583.91 (SD = 3,618.41) birr, respectively, and the difference is statistically significant ($p <$ 001). Interestingly, when disaggregated by study areas, the highest average income from livestock was reported from Menz Mama (7,808.01 birr, SD = 5,789.55) whereas the lowest was reported from Doyogena and Horro which is 3,135.15 birr (SD = 3,608.7) and 3,449.49 birr (SD = 2,918.43) on average, respectively.

3.1.2.1. Input into production and gender status: instrumental agency domains

Gender roles in key activities of small ruminant management and husbandry practices such as breed selection, feeding, monitoring, herding, and marketing were analyzed. The result shows that on average 69.9 and 17.9% of the men and women respondents said that the task of selecting breeding stock for SR production is done only by the head of the household, while the figures were only 0.2 and 38.8% for women, respectively. Similarly, across the study areas, the role of selecting breeding stock is dominated by men except in Horo (<25%) where generally respondents said it is a joint task.

Feeding goats and sheep seems the responsibility of all household members. The majority of respondents agree with this fact, although there is a significant difference between the study sites. As opposed to the study areas in the Amhara region, where all household members take part, the majority of the respondents agree that goat feeding is the work of the head of the household in the rest of the study areas. Whereas, sheep feeding appears the

TABLE 3 HH characteristics, resource ownership, and access to services by gender and study areas, SR VC baseline data, 2014, rural Ethiopia.

Indicators		*N*	Gender of the respondent		Test statistics	Study area						Full sample	Test statistics
			Male	Women		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Household characteristic													
Marital status (%)	Married	610	97	3	500.383**	87	87.5	81.5	67.7	84.4	89.3	84.4	71.965**
	Single	14	78.6	21.4		0	6.6	0	1.5	2.2	0.6	1.9	
	Divorced	23	4.3	95.7		6	0.7	0.6	7.7	7.8	1.9	3.2	
	Widowed	76	11.8	88.2		7	5.3	17.8	23.1	5.6	8.2	10.5	
Sex (%)	Female	110				10.9	16.4	29.1	13.6	11.8	18.2	15.2	9.404
	Male	613				14.4	21.9	20.4	8.2	12.6	22.7	84.8	
Age		722	46.0 (14.9)	46.2 (13.8)	0.017	45.6 (12.1)	44.3 (13.6)	46.5 (15.3)	51.1 (14.2)	46.9 (14.1)	45.1 (16.7)	46.1 (14.7)	2.227
Education (%)	Illiterate	308	38.5	65.5	28.27**	63	25	28.7	24.6	25.6	77.4	42.6	234.632**
	No formal but literate	96	13.9	10		13	5.3	6.4	30.8	8.9	11.9	13.3	
	Completed primary school	220	33	16.4		24	42.8	40.1	32.3	37.8	8.2	30.4	
	Secondary school and above	99	14.7	8.2		0	27	24.8	12.3	7.8	2.5	13.7	
HH size		665	6.4 (2.1)	5.2 (1.8)	27.564**	6.4 (2.1)	6.9 (2.1)	6.1 (2.0)	5.4 (1.8)	5.2 (1.6)	6.4 (2.1)	6.2 (2.1)	10.198**
Ownership of empowerment resources and access to services													
Resource ownership	Land holding (in kert)	695	6.5 (4.8)	6.5 (5.2)	0.010	11.4 (6.2)	3.0 (1.6)	7.5 (5.7)	6.1 (2.8)	5.4 (3.2)	6.5 (3.7)	6.4 (4.9)	49.769**
	Goat	253	13.8 (12.7)	11.0 (9.1)	1.120	20.9 (13.4)	1.4 (0.79)	2.7 (2.38)	0.0	2.5 (2.1)	10.6 (9.7)	13.3 (12.3)	38.331**
	Sheep	600	9.1 (8.43)	9.3 (8.6)	0.055	12.6 (10.3)	3.3 (2.13)	9.0 (6.9)	16.0 (10.1)	13.5 (8.3)	8.0 (7.9)	9.1 (8.5)	41.218**
	Livestock	634	10.9 (8.2)	8.54 (7.1)	6.888*	9.16 (6.6)	7.14 (4.5)	16.55 (10.1)	8.5 (5.3)	8.2 (4.7)	11.6 (9.1)	10.5 (8.1)	25.295**

(Continued)

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TABLE 3 (Continued)

Indicators		N	Gender of the respondent		Test statistics	Study area						Full sample	Test statistics
			Male	Women		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Average annual income from livestock[b]		*553*	*5,504.4 (5,095.4)*	*3,583.9 (3,618.4)*	*11.23***	*5,943.44 (5,024.32)*	*3,135.15 (3,608.7)*	*3,449.49 (2,918.4)*	*6,475.2 (5,222.8)*	*7,808.0 (5,789.6)*	*6,553.7 (5,657.89)*	*5,220.34 (4,949.92)*	*7.30***
Access to credit (%)	Yes	160	22.2	21.8	0.007	48.0	14.5	7.6	35.4	24.4	20.8	22.1	*70.208***
	No	563	77.8	78.2		52.0	85.5	92.4	64.6	75.6	79.2	77.9	
Access to market info.	Yes	*303*	*44.0*	*41.1*	*0.315*	*18.5*	*45.0*	*43.8*	*58.5*	*69.3*	*36.3*	*43.6*	*56.631***
	No	*392*	*56.0*	*58.9*		*81.5*	*55.0*	*56.2*	*41.5*	*30.7*	*63.7*	*56.4*	
Contact with extension (%)	Yes	*423*	*61.9*	*55.1*	*1.739*	*48.9*	*61.4*	*56.9*	*84.6*	*85.2*	*47.8*	*60.9*	*55.186***
	No	272	38.1	44.9		51.1	38.6	43.1	15.4	14.8	52.2	39.1	
Received training (%)	Yes	217	33.0	32.3	0.016	13.3	29.3	40.8	35.5	34.1	37.5	32.9	*21.052***
	No	443	67.0	67.7		86.7	70.7	59.2	64.5	65.9	62.5	67.1	
Membership to group (%)	Yes	563	76.7	84.5	3.355	40.0	86.8	98.1	100.0	96.7	53.5	77.9	219.474***
	No	160	23.3	15.5		60.0	13.2	1.9	0.0	3.3	46.5	22.1	
Who selects Male SR breeding stock for SRs	Husband	323	69.9	17.9	259.899***	76.0	70.8	24.3	66.1	66.7	82.4	63.1	164.414***
	Wife	27	*0.2*	*38.8*		*2.7*	*2.8*	*7.5*	*7.1*	*7.6*	*4.9*	*5.3*	
	Head and wife	*105*	*22.7*	*6.0*		*2.7*	*15.1*	*57.0*	*10.7*	*18.2*	*7.8*	*20.5*	
	Male child	*19*	*1.3*	*19.4*		*10.7*	*2.8*	*2.8*	*1.8*	*3.0*	*2.0*	*3.7*	
	All members	31	*4.7*	*14.9*		*8.0*	*7.5*	*7.5*	*7.1*	*3.0*	*2.9*	*6.1*	
	Others	7	*1.1*	*3.0*		*0.0*	*0.9*	*0.9*	*7.1*	*1.5*	*0.0*	*1.4*	

(Continued)

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TABLE 3 (Continued)

Indicators		N	Gender of the respondent		Test statistics	Study area						Full sample	Test statistics
			Male	Women		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Agency dimensions													
Who defines the price of a goat?	Head	155	*80.2*	*47.4*	*22.054***	*51.4*		*55.6*	*100.0*	*100.0*	*93.7*	*77.1*	*62.698***
	Spouse	2	*1.1*	*0.0*		*0.0*		*0.0*	*0.0*	*0.0*	*1.8*	*1.0*	
	Other member	5	*1.1*	*15.8*		*2.8*		*0.0*	*0.0*	*0.0*	*2.7*	*2.5*	
	Trader	36	*15.9*	*36.8*		*41.7*		*44.4*	*0.0*	*0.0*	*1.8*	*17.9*	
	Other buyers	3	*1.6*	*0.0*		*4.2*		*0.0*	*0.0*	*0.0*	*0.0*	*1.5*	
Who defines the price of sheep?	Head	323	*71.4*	*70.0*	*6.710*	*35.0*	*65.1*	*63.7*	*90.4*	*72.3*	*95.8*	*71.1*	*89.501***
	Spouse	12	*2.3*	*4.3*		*0.0*	*1.2*	*5.6*	*0.0*	*4.8*	*0.0*	*2.6*	
	Other member	10	*1.6*	*5.7*		*2.5*	*2.4*	*2.4*	*1.9*	*2.4*	*1.4*	*2.2*	
	Trader	104	*23.4*	*20.0*		*57.5*	*30.1*	*27.4*	*5.8*	*20.5*	*2.8*	*22.9*	
	All members	4	*1.0*	*0.0*		*5.0*	*1.2*	*0.8*	*0.0*	*0.0*	*0.0*	*0.9*	
	Other buyers	1	*0.3*	*0.0*		*0.0*	*0.0*	*0.0*	*1.9*	*0.0*	*0.0*	*0.2*	
Who decides when to sell goat?	Head	83	*40.1*	*52.6*	*44.162***	*23.6*		*33.3*	*50.0*	*33.3*	*53.2*	*41.3*	*24.902**
	Spouse	3	*1.1*	*5.3*		*2.8*		*0.0*	*0.0*	*0.0*	*0.9*	*1.5*	
	Head and spouse	106	*57.1*	*10.5*		*62.5*		*66.7*	*50.0*	*66.7*	*45.0*	*52.7*	
	All members	9	*1.6*	*31.6*		*11.1*		*0.0*	*0.0*	*0.0*	*0.9*	*4.5*	

(Continued)

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TABLE 3 (Continued)

Indicators		N	Gender of the respondent		Test statistics	Study area						Full sample	Test statistics
			Male	Women		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Who decides when to sell sheep?	Head	163	*29.4*	*71.4*	*67.983***	*20.0*	*38.6*	*29.0*	*50.0*	*26.5*	*54.2*	*35.9*	*53.406***
	Spouse	7	*0.8*	*5.7*		*5.0*	*1.2*	*2.4*	*0.0*	*0.0*	*1.4*	*1.5*	
	Head and spouse	255	*64.1*	*12.9*		*62.5*	*44.6*	*63.7*	*48.1*	*68.7*	*44.4*	*56.2*	
	Other male member	3	*0.5*	*1.4*		*0.0*	*2.4*	*0.8*	*0.0*	*0.0*	*0.0*	*0.7*	
	All members	26	*5.2*	*8.6*		*12.5*	*13.3*	*4.0*	*1.9*	*4.8*	*0.0*	*5.7*	
Achievement indicators													
Who controls the sale proceeds of goats?	Head	70	*32.4*	*57.9*	*43.67***	*23.6*		*33.3*	*50.0*	*33.3*	*41.4*	*34.8*	*19.28*
	Spouse	5	*2.2*	*5.3*		*1.4*		*0.0*	*0.0*	*0.0*	*3.6*	*2.5*	
	Head and spouse	119	*64.3*	*10.5*		*65.3*		*6.7*	*50.0*	*66.7*	*55.0*	*59.2*	
	Other male members	7	*1.1*	*26.3*		*9.7*		*0.0*	*0.0*	*0.0*	*0.0*	*3.5*	
Who controls the sale proceeds of sheep?	Head	152	*26.0*	*74.3*	*80.18***	*22.5*	*41.0*	*32.3*	*42.3*	*20.5*	*41.7*	*33.5*	49.29**
	Spouse	10	*1.8*	*4.3*		*2.5*	*1.2*	*2.4*	*0.0*	*1.2*	*5.6*	*2.2*	
	Head and spouse	265	*67.2*	*10.0*		*60.0*	*43.4*	*62.1*	*51.9*	*75.9*	*52.8*	*58.4*	
	Other male members	3	*0.5*	*1.4*		*2.5*	*2.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	
	All members	24	*4.4*	*10.0*		*12.5*	*12.0*	*3.2*	*5.8*	*2.4*	*0.0*	*5.3*	

Figures in parenthesis are standard deviations.

[a]Data are missing for Doyogena on defining price, decide when to sell, and who controls the sale proceeds of a goat.

[b]Income values are in ETB. There were ~19.65 ETB to the U.S. dollar in 2014.

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

"Kert," a measurement unit locally used to measure land that is roughly equal to 1/4 of a hectare.

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TABLE 4 Gender roles in SR VC activities at production level by study areas, SR VC baseline data, 2014.

SR husbandry and management practices		*N*	HH members						Full sample	Test statistics
		Abergele	Doyogena	Horro	Menz Gera	Menz Mama	Yabello			
Who selects male breeding stock (%)?	HH head only	323	76.0	71.4	24.5	71.2	67.7	82.4	64.0	147.026**
	Spouse only	27	2.7	2.9	7.5	7.7	7.7	4.9	5.3	
	Head and spouse only	105	2.7	15.2	57.5	11.5	18.5	7.8	20.8	
	Sons only	19	10.7	2.9	2.8	1.9	3.1	2.0	3.8	
	All HH members	31	8.0	7.6	7.5	7.7	3.1	2.9	6.1	
Who selects female breeding stock (%)?	HH head only	302	71.6	66.7	22.9	70.4	68.2	80.9	61.3	146.440**
	Spouse only	26	2.7	3.8	6.7	7.4	7.6	4.5	5.3	
	Head and SPOUSE only	114	4.1	21.0	60.0	11.1	18.2	9.0	23.1	
	Sons only	19	13.5	1.9	2.9	1.9	1.5	2.2	3.9	
	All HH members	32	8.1	6.7	7.6	9.3	4.5	3.4	6.5	
Who feeds goats (%)?	HH head only	81	18.9	66.7	41.2	0.0	14.3	36.1	29.7	88.095**
	Spouse only	15	2.1	0.0	5.9	0.0	0.0	8.2	5.5	
	Head and spouse only	55	6.3	0.0	17.6	0.0	14.3	30.6	20.1	
	Daughters only	9	6.3	0.0	0.0	25.0	0.0	1.4	3.3	
	Sons only	5	0.0	0.0	11.8	0.0	0.0	2.0	1.8	
	All HH members	108	66.3	33.3	23.5	75.0	71.4	21.8	39.6	
Who feeds the first sheep (%)?	HH head only	47	7.7	12.5	7.9	6.2	2.3	4.1	7.3	82.482**
	Spouse only	59	1.5	15.8	12.5	3.1	2.3	9.1	9.2	
	Head and spouse only	60	3.1	17.8	9.2	4.6	6.8	6.6	9.3	
	Daughters only	24	7.7	3.3	3.3	3.1	1.1	5.0	3.7	
	Sons only	3	0.0	0.0	0.0	0.0	1.1	1.7	0.5	
	Hired labor only	4	1.5	0.0	2.0	0.0	0.0	0.0	0.6	
	All HH members	446	78.5	50.7	65.1	83.1	86.4	73.6	69.4	
Who monitors breeding goats (%)?	HH head only	80	19.6	66.7	46.7	0.0	14.3	41.3	32.4	94.803**
	Spouse only	9	2.2	0.0	6.7	0.0	0.0	4.8	3.6	
	Head and spouse only	55	6.5	0.0	20.0	0.0	14.3	35.7	22.3	

(Continued)

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TABLE 4 (Continued)

SR husbandry and management practices		*N*	HH members						Full sample	Test statistics
		Abergele	Doyogena	Horro	Menz Gera	Menz Mama	Yabello			
	Daughters only	7	6.5	0.0	0.0	25.0	0.0	0.0	2.8	
	Sons only	3	0.0	0.0	6.7	0.0	0.0	1.6	1.2	
	All HH members	93	65.2	33.3	20.0	75.0	71.4	16.7	37.7	
Who monitors breeding sheep (%)?	HH head only	182	16.9	31.6	28.0	24.6	14.8	43.0	28.4	108.288**
	Spouse only	28	1.5	7.9	6.7	1.5	1.1	2.5	4.4	
	Head and spouse only	104	4.6	25.0	23.3	6.2	9.1	13.2	16.2	
	Daughters only	16	7.7	3.9	1.3	1.5	1.1	0.8	2.5	
	Sons only	1	0.0	0.7	0.0	0.0	0.0	0.0	0.2	
	Hired labor only	1	0.0	0.0	0.7	0.0	0.0	0.0	0.2	
	All HH members	309	69.2	30.9	40.0	66.2	73.9	40.5	48.2	
Who cleans goat house (%)?	HH head only	12	2.2	0.0	6.7	33.3	0.0	5.6	4.6	30.546
	Spouse only	53	15.6	33.3	26.7	0.0	33.3	22.5	20.5	
	Head and spouse only	22	5.6	0.0	6.7	0.0	0.0	11.3	8.5	
	Daughters only	10	1.1	33.3	0.0	0.0	0.0	5.6	3.9	
	Sons only	14	8.9	0.0	6.7	0.0	0.0	3.5	5.4	
	All HH members	148	66.7	33.3	53.3	66.7	66.7	51.4	57.1	
Who cleans sheep house (%)?	HH head only	21	1.5	1.3	7.2	6.2	1.1	1.7	3.3	69.458**
	Spouse only	147	6.2	34.2	28.9	13.8	12.5	22.5	22.9	
	Head and spouse only	16	3.1	1.3	2.0	3.1	4.5	2.5	2.5	
	Daughters only	5	1.5	0.0	0.0	1.5	1.1	1.7	0.8	
	Sons only	26	6.2	7.2	0.7	3.1	3.4	4.2	4.0	
	Hired labor only	2	0.0	0.0	1.3	0.0	0.0	0.0	0.3	
	All HH members	425	81.5	55.9	59.9	72.3	77.3	67.5	66.2	
Who monitors goats health (%)?	HH head only	83	31.5	66.7	40.0	0.0	14.3	32.6	32.0	93.907**
	Spouse only	8	2.2	0.0	0.0	0.0	0.0	4.3	3.1	
	Head and spouse only	77	5.6	0.0	26.7	0.0	28.6	46.8	29.7	

(Continued)

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TABLE 4 (Continued)

SR husbandry and management practices		*N*	HH members						Full sample	Test statistics
		Abergele	Doyogena	Horro	Menz Gera	Menz Mama	Yabello			
	Daughters only	5	4.5	0.0	0.0	25.0	0.0	0.0	1.9	
	Sons only	3	0.0	0.0	6.7	0.0	0.0	1.4	1.2	
	All HH members	83	56.2	33.3	26.7	75.0	57.1	14.9	32.0	
Who monitors sheep health (%)?	HH head only	192	23.4	40.7	29.9	27.0	22.5	40.4	32.3	97.929**
	Spouse only	25	1.6	6.7	5.6	1.6	0.0	5.3	4.2	
	Head and spouse only	102	3.1	25.3	18.8	6.3	10.0	24.5	17.1	
	Daughters only	10	4.7	2.7	1.4	1.6	0.0	0.0	1.7	
	Sons only	1	0.0	0.0	0.0	0.0	0.0	1.1	0.2	
	Hired labor only	1	0.0	0.0	0.7	0.0	0.0	0.0	0.2	
	All HH members	264	67.2	24.7	43.8	63.5	67.5	28.7	44.4	
Who herd the goats around homestead (%)?	HH head only	18	5.8	0.0	21.4	33.3	14.3	5.9	7.2	37.648
	Spouse only	21	8.1	33.3	0.0	0.0	0.0	9.6	8.4	
	Head and spouse only	13	1.2	0.0	7.1	0.0	0.0	8.1	5.2	
	Daughters only	40	29.1	0.0	0.0	0.0	0.0	11.0	16.1	
	Sons only	16	8.1	0.0	7.1	0.0	0.0	5.9	6.4	
	All HH members	141	47.7	66.7	64.3	66.7	85.7	59.6	56.6	
Who herd sheep around homestead (%)?	HH head only	41	6.5	10.2	9.3	4.9	1.2	5.3	7.0	116.722**
	Spouse only	38	3.2	12.9	2.9	0.0	2.4	11.6	6.5	
	Head and spouse only	36	0.0	6.8	7.9	8.2	7.3	4.2	6.1	
	Daughters only	73	24.2	17.7	12.1	3.3	0.0	13.7	12.4	
	Sons only	16	4.8	1.4	2.9	0.0	0.0	7.4	2.7	
	Hired labor only	11	8.1	0.0	4.3	0.0	0.0	0.0	1.9	
	All HH members	372	53.2	51.0	60.7	83.6	89.0	57.9	63.4	
Who herd the goats at distance areas (%)?	HH head only	48	8.1	0.0	40.0	0.0	0.0	30.2	21.0	67.592**
	Spouse only	6	2.3	0.0	0.0	0.0	14.3	2.6	2.6	
	Head and spouse only	9	0.0	0.0	0.0	0.0	28.6	6.0	3.9	

(Continued)

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TABLE 4 (Continued)

SR husbandry and management practices		*N*	HH members						Full sample	Test statistics
		Abergele	Doyogena	Horro	Menz Gera	Menz Mama	Yabello			
	Daughters only	69	51.2	0.0	6.7	33.3	0.0	19.8	30.1	
	Sons only	16	8.1	0.0	0.0	0.0	0.0	7.8	7.0	
	All HH members	81	30.2	100.0	53.3	66.7	57.1	33.6	35.4	
Who herd sheep at distance areas (%)?	HH head only	88	6.3	18.6	14.6	6.7	11.3	32.6	16.1	160.576**
	Spouse only	11	0.0	3.9	0.8	0.0	1.3	4.7	2.0	
	Head and spouse only	33	0.0	3.1	9.2	11.7	12.5	0.0	6.0	
	Daughters only	109	50.8	26.4	14.6	10.0	1.3	19.8	19.9	
	Sons only	8	0.0	0.8	1.5	0.0	0.0	5.8	1.5	
	Hired labor only	14	7.9	0.0	6.2	1.7	0.0	0.0	2.6	
	All HH members	285	34.9	47.3	53.1	70.0	73.8	37.2	52.0	
Who sells goat in the market (%)?	HH head only	177	81.7		77.8	83.3	100.0	93.7	88.5	19.179
	Spouse only	2	0.0		0.0	0.0	0.0	1.8	1.0	
	Head and spouse only	7	4.2		0.0	16.7	0.0	2.7	3.5	
	Sons only	14	14.1		22.2	0.0	0.0	1.8	7.0	
Who sells sheep in the market (%)?	HH head only	368	82.5	81.9	71.0	86.3	83.1	91.7	81.2	47.282**
	Spouse only	24	0.0	3.6	12.1	0.0	7.2	0.0	5.3	
	Head and spouse only	29	0.0	7.2	10.5	5.9	2.4	6.9	6.4	
	Sons only	28	17.5	7.2	5.6	5.9	4.8	1.4	6.2	
	All HH members	4	0.0	0.0	0.8	2.0	2.4	0.0	0.9	

**Significant at 1%.

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TABLE 5 SR market location and channel, SR VC baseline data, 2014.

Variables	*N*	By gender (%)		Test statistics	By study areas (%)						Full sample	Test statistics
		Male	Female		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Did you sell any sheep/goat in the last 12 months?												
Yes	472	65.3	65.5	0.002	53.0	55.9	79.0	80.0	92.2	47.2	65.3	83.580**
No	251	34.7	34.5		47.0	44.1	21.0	20.0	7.8	52.8	34.7	
If you sold goat, marketing channel for first type of goat selling?												
Butchery	1	0.5	0.0	3.135	1.4		0.0	0.0	0.0	0.0	0.5	41.025*
Individual consumers	16	8.2	5.3		15.3		33.3	0.0	33.3	0.9	8.0	
Collectors	25	12.1	15.8		4.2		0.0	0.0	0.0	19.8	12.4	
Traders	148	74.2	68.4		70.8		66.7	83.3	66.7	75.7	73.6	
Retailers/supermarkets	1	0.5	0.0		1.4		0.0	0.0	0.0	0.0	0.5	
Farmers/pastoralists for breeding purposes	8	3.3	10.5		5.6		0.0	16.7	0.0	2.7	4.0	
Other	2	1.1	0.0		1.4		0.0	0.0	0.0	0.9	1.0	
If you sold goat, the place where the first type of goat sold?												
Farm gate	20	9.9	10.5	0.322	6.9		0.0	0.0	0.0	13.5	10.0	5.506
Buyers place	2	1.1	0.0		1.4		0.0	0.0	0.0	0.9	1.0	
On the road to the market	1	0.5	0.0		0.0		0.0	0.0	0.0	0.9	0.5	
In the market	178	88.5	89.5		91.7		100	100	100	84.7	88.6	
If you sold sheep, marketing channel for first type of sheep selling?												
Butchery	2	0.5	0.0	2.057	2.5	0.0	0.0	0.0	1.9	0.0	0.4	86.317**
Individual consumers	30	6.3	8.6		12.5	6.0	6.0	11.3	7.7	2.4	6.6	
Collectors	59	13.3	11.4		2.5	26.5	26.5	14.5	0.0	0.0	13.0	
Traders	339	74.7	74.3		77.5	57.8	57.8	71.8	82.7	91.6	74.7	
Retailers/supermarkets	2	0.3	0.0		0.0	1.2	1.2	0.0	0.0	0.0	0.2	
Farmers/pastoralists for breeding purposes	20	4.2	5.7		5.0	8.4	8.4	0.8	5.8	6.0	4.4	
Other	3	0.8	0.0		0.0	0.0	0.0	1.6	1.9	0.0	0.7	
If you sold sheep, the place where the first type of sheep sold?												
Farm gate	23	5.2	4.3	2.299	7.5	1.2	1.6	3.8	1.2	19.4	5.1	51.542**
Buyers place	2	0.5	0.0		0.0	0.0	0.0	1.9	0.0	1.4	0.4	
On the road to the market	2	0.3	1.4		0.0	0.0	0.0	1.9	0.0	1.4	0.4	
In the market	427	94.0	94.3		92.5	98.8	98.4	92.3	98.8	77.8	94.1	

*,**Significant at 1 and 5%, respectively. Results may not add up to 100 due to rounding.

[a]Data on who sold the first goat are missing for Doyogena in the baseline data.

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TABLE 6 Participation in marketing-related decisions on Small ruminants by gender and study areas, SR VC baseline data, 2014.

Variables		*N*	By Gender (%)		Test statistics	By study sites (%)						Full sample (%)	Test statistics
			Male	Female		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Number of SRs sold in 12 months		525	4.0 (3.218)	3.6 (2.514)	0.864	6.5 (4.129)	1.6 (1.115)	3.0 (1.943)	4.6 (3.647)	4.0 (2.801)	4.5 (2.860)	3.9 (3.123)	28.553**
Who defines the price of goat?	Head	155	80.2	47.4	22.054**	51.4		55.6	100.0	100.0	93.7	77.1	62.698**
	Spouse	2	1.1	0.0		0.0		0.0	0.0	0.0	1.8	1.0	
	Other HH members	5	1.1	15.8		2.8		0.0	0.0	0.0	2.7	2.5	
	Trader	36	15.9	36.8		41.7		44.4	0.0	0.0	1.8	17.9	
	Other buyers	3	1.6	0.0		4.2		0.0	0.0	0.0	0.0	1.5	
Who defines the price of sheep?	Head	323	71.4	70.0	6.710	35.0	65.1	63.7	90.4	72.3	95.8	71.1	89.501**
	Spouse	12	2.3	4.3		0.0	1.2	5.6	0.0	4.8	0.0	2.6	
	Other HH members	10	1.6	5.7		2.5	2.4	2.4	1.9	2.4	1.4	2.2	
	Trader	104	23.4	20.0		57.5	30.1	27.4	5.8	20.5	2.8	22.9	
	All HH members	4	1.0	0.0		5.0	1.2	0.8	0.0	0.0	0.0	0.9	
	Other buyers	1	0.3	0.0		0.0	0.0	0.0	1.9	0.0	0.0	0.2	
Who decides when to sell goat?	Head	83	40.1	52.6	44.162**	23.6		33.3	50.0	33.3	53.2	41.3	24.902*
	Spouse	3	1.1	5.3		2.8		0.0	0.0	0.0	0.9	1.5	
	Head and spouse	106	57.1	10.5		62.5		66.7	50.0	66.7	45.0	52.7	
	All HH members	9	1.6	31.6		11.1		0.0	0.0	0.0	0.9	4.5	
Who decides when to sell sheep?	Head	163	29.4	71.4	67.983**	20.0	38.6	29.0	50.0	26.5	54.2	35.9	53.406**
	Spouse	7	0.8	5.7		5.0	1.2	2.4	0.0	0.0	1.4	1.5	
	Head and spouse	255	64.1	12.9		62.5	44.6	63.7	48.1	68.7	44.4	56.2	
	Other male HH member	3	0.5	1.4		0.0	2.4	0.8	0.0	0.0	0.0	0.7	
	All HH members	26	5.2	8.6		12.5	13.3	4.0	1.9	4.8	0.0	5.7	
Who kept the sale proceeds of goat?	Head	125	59.9	84.2	18.738**	65.3		55.6	50.0	33.3	62.2	62.2	12.651
	Spouse	19	10.4	0.0		9.7		0.0	0.0	33.3	9.9	9.5	
	Head and spouse	54	29.1	5.3		20.8		44.4	50.0	33.3	27.9	26.9	
	Other male HH member	3	0.5	10.5		4.2		0.0	0.0	0.0	0.0	1.5	

(Continued)

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TABLE 6 (Continued)

Variables		*N*	By Gender (%)		Test statistics	By study sites (%)						Full sample (%)	Test statistics
			Male	Female		Abergele	Doyogena[a]	Horo	M. Gera	M. Mama	Yabello		
Who kept the sale proceeds? of sheep?	Head	283	57.0	91.4	33.562**	65.0	78.3	51.6	63.5	57.8	65.3	62.3	50.520**
	Spouse	48	11.7	4.3		7.5	4.8	14.5	5.8	10.8	15.3	10.6	
	Head and spouse	113	29.2	1.4		17.5	12.0	33.1	30.8	30.1	19.4	24.9	
	Other male HH member	8	1.6	2.9		10.0	3.6	0.8	0.0	0.0	0.0	1.8	
	All HH members	2	0.5	0.0		0.0	1.2	0.0	0.0	1.2	0.0	0.4	

*, **Significance at 1 and 5%, respectively.
SD in parenthesis.
[a]Data on who defines the price, who decides when to sell, and who kept the sale proceeds from goats are missing for Doyogena in the baseline data.

work of all household members across the study sites. Monitoring goats and sheep breeding and health in most cases appears to be the role of the household head in Doyogena, Horo, and Yabello. Apart from that, close to 50% of the respondents said that monitoring the health of goats is only done by spouses in Yabello; however, in the remaining sites, all household members participate significantly in these activities. Overall, 66.2% of the respondents said all household members participate in cleaning, while more than 20% of respondents said this work is only done by women spouses. Although the task of herding is accomplished by all household members across the study areas, daughters were found to be the key players in this role both around the homestead and in distant areas.

Less than 45% of respondents have access to market information (input–output market information) and this significantly differed among study areas ($p < 0.001$), but not between genders. Goat-dominating production systems have less market information as compared to sheep-dominating production systems. More than 65% of the respondents sold on average about four heads of SRs during the period covered by the survey (Table 6). The largest proportion of respondents who sold SRs was from Menz Mama (92.2%), followed by Menz Gera (80.0%) and Horo (79%). SR keepers generally sell their animals in the market and use traders as their main market channel, and there are no gender differences in relation to these activities. Interestingly, selling goats and sheep in the market location appeared to be the role of the head of the household or older male family members (Table 5). In Menz Mama, all of the respondents agree that it is only done by the head of the household.

3.1.2.2. Input into marketing decisions: marketing-related decisions and gender status

The responses to the question of the market channel and location for SRs in the baseline data do not demonstrate a variation between genders. The majority of the respondents sell their goats and sheep to traders in the market (Table 5). One of the questions on the agency dimension in the baseline data is who defines the price of SR animals. Although there were significant differences between the gender groups on who defines the price of goats, generally men control defining the price of both goats and sheep across the study areas. The result shows that defining the price of goats is dominated by the head of the household according to the men (80.2%) and women (47.4%) respondents. Across the study sites, except in Abergelle and Horo, defining the price of sheep appears solely the role of men. In Abergelle and Horo, however, traders observed playing a key role in defining the price of SRs. Similarly, decisions on the timing of sale related to goats and sheep were asked in the baseline questionnaire. The result indicated that the gender groups do not agree. According to men respondents (57.1% for goats and 64.1% for sheep), this work was primarily a joint (husband and wife) role. However, the women respondents (52.6% for goats and 71.4% for sheep) believe it is the other way round, suggesting that this role is the job of the head of the household; this difference is statistically significant ($p < 0.001$). This difference in reporting demonstrates the importance of interviewing both husband and wife in future surveys as their perceptions differ around decision-making responsibilities. Across the study areas,

TABLE 7 Binary logistic regression estimates of associations of empowerment (agency and achievements) in the livestock-based systems, SRVC baseline data, 2014, rural Ethiopia.

Variables (demographic and indicators of empowerment resources)		Indicators of agency				Indicator of achievement	
		Define price of SRs		Decide on when to sell SRs		Control income from SRs	
		B	Exp (B)	B	Exp (B)	B	Exp (B)
Age group	≤30	0.427 (0.580)	1.532	−0.494 (0.459)	0.610	−0.444 (0.470)	0.641
	31–40	−0.422 (0.390)	0.656	0.106 (0.340)	1.111	−0.275 (0.350)	0.760
	41–50	0.452 (0.425)	1.572	−0.530 (0.362)	0.589	−0.760 (0.382)	0.468*
	>50 (rf)						
Study areas	Abergele	−3.362 (0.770)	0.035**	−2.466 (0.574)	0.085**	−2.058 (0.596)	0.128**
	Doyogena	−3.623 (0.871)	0.027**	−0.529 (0.538)	0.589	0.283 (0.550)	1.327
	Horro	−2.654 (0.780)	0.070**	−1.340 (0.485)	0.262**	−0.355 (0.481)	0.701
	Menz Gera	−1.135 (0.951)	0.322	−1.170 (0.566)	0.310*	−0.772 (0.604)	0.462
	Menz Mama	−2.444 (0.786)	0.087**	−1.797 (0.500)	0.166**	−1.541 (0.532)	0.214**
	Yabello (rf)						
Gender	Men	1.032 (1.011)	2.808	−0.663 (0.768)	0.516	−1.552 (0.786)	0.212*
	Women (rf)						
Marital status	Married	−0.792 (1.090)	0.453	−1.996 (0.820)	0.136*	−1.722 (0.821)	0.179*
	Single	0.630 (1.702)	1.878	−0.274 (1.203)	0.760	−0.110 (1.251)	0.896
	Divorced	−1.152 (0.980)	0.316	−0.120 (0.898)	0.887	−0.318 (0.896)	0.727
	Widowed (rf)						
Size of livestock owned	≤5	1.370 (0.463)	3.935**	0.989 (0.351)	2.688**	0.869 (0.357)	2.385*
	6–10	0.410 (0.351)	1.507	0.137 (0.324)	1.147	−0.129 (0.339)	0.879
	>10 (rf)						
Select breeding stock	Yes	−0.852 (0.410)	0.427*	0.627 (0.368)	1.871	0.655 (0.379)	1.926
	No (rf)						
Contact with the extension agent	Yes	0.753 (0.359)	2.123*	−0.355 (0.310)	0.701	−0.653 (0.323)	0.521*
	No (rf)						
Get market information on SR	Yes	−0.690 (0.328)	0.501*	0.549 (0.295)	1.732	0.781 (0.308)	2.184*
	No (rf)						
Participate in selling SRs in the market	Yes	−1.563 (0.456)	0.210**	−1.091 (0.491)	0.336*	−0.653 (0.470)	0.521
	No (rf)						

(Continued)

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TABLE 7 (Continued)

Variables (demographic and indicators of empowerment resources)		Indicators of agency				Indicator of achievement	
		Define price of SRs		Decide on when to sell SRs		Control income from SRs	
		B	Exp (B)	B	Exp (B)	B	Exp (B)
Constant		3.016 (1.332)	20.401*	3.248 (1.096)	25.731**	3.791 (1.134)	44.314**
N		*383*		*384*		*384*	
Nagelkerke R square		0.364		0.338		0.355	
Hosmer and Lemeshow Test		Chi-square = 12.388		Chi-square = 6.177		Chi-square = 5.979	
Omnibus Tests of Model Coefficients		Chi-square = 105.801**		Chi-square = 109.775**		Chi-square = 114.042**	
Overall predicted percentage correctness		79.9		75.8		77.1	

S.E. in parenthesis; rf, reference category; HH, Household.
*, **Significant at 1 and 5% level, respectively.
Only covariates with a significant association are shown.
Possible interactions were checked and found insignificant but not shown.

the majority of the respondents agree that the decision on when to sell SRs is a joint role of husband and wife. However, in Yabello and Menz Gera, more than 50% of the respondents suggested that it is mainly the role of the head of the household (Table 6).

3.1.2.3. Achievements and gender status: control over income from SRs

In the empowerment process, the final aspect of empowerment is achievements that an agent needs to realize, which can be manifested in terms of controlling the proceeds from SRs. In the baseline data, it appears that men and women respondents do not agree on the indicators of achievement. While the majority of the women respondents said income from goats and sheep is controlled by the head of the household (57.9 and 74.3%, respectively), the majority of the men believed that it is jointly controlled (64.3 and 67.2%, respectively). When location is considered, it appears that significant proportions of both men and women respondents suggest men's upper hand over control of income from goats, while the task of controlling the sale proceeds of sheep appears a joint task between husband and wife.

3.2. Empirical results

3.2.1. Correlates of agency and achievement

Binary logistic regression analysis was applied to investigate existing associations between the independent variables and dependent variables, as presented in Table 7 along with the statistical results from the analysis. The values of the model chi-square and the Hosmer–Lemeshow statistics are reported at the end of Table 7 indicate that the selected variables fit the model well. Results show that the variables that are significantly associated with agency dimensions include context (represented by study areas), marital status, size of SR and livestock ownership, participation in breeding stock selection, contact with extension agents, market information on SRs, and participation in selling SRs in the market. Similarly, the variables that are significantly associated with the achievement (measured with control over income from SRs) are age, context, gender, marital status, size of livestock ownership, participation in breeding stock selection, contact with extension agents, and access to market information on SRs.

With regard to the age group and its association with empowerment dimensions, the age group between 41 and 50 years is negatively and significantly ($P < 0.05$) associated with one's control over the sale proceeds from SRs compared to older age groups. Considering the study areas, except Menz Gera and Doyogena, it negatively and significantly ($P < 0.01$) influenced agency dimensions (sole decision-making on defining SR prices and when to sell) as compared to Yabello. Gender is negatively and significantly ($P < 0.05$) associated with controlling income from the selling of SRs, implying that men household heads are less likely to make decisions alone on income from SRs compared to women household heads. Being married is negatively and significantly ($P < 0.05$) associated with agency and achievement suggesting that married men and women are less likely to make independent decisions on when to sell and control over income from SRs.

Contact with extension agents and access to market information are significantly ($P < 0.05$) associated with agency and achievement in an opposing manner. The odds ratio shows that respondents who have contact with extension agents and access to market information are 2.1 times more likely to make sole decisions on defining SR prices and 0.5 times less likely to have control over income from SRs, and vice-versa, respectively.

Smaller ownership of livestock (<5 heads) is positively and significantly ($P < 0.05$) associated with agency and achievement. Compared to ownership of more than 10 heads, respondents who own <5 heads of livestock are 3.9, 2.7, and 2.4 times more likely to make independent decisions on defining price, when to sell, and control over income from SRs, respectively. Whereas, participation in SR breeding stock selection is negatively and significantly ($P < 0.05$) associated with agency dimensions. Respondents who took part in breed selection are less likely to make sole decisions on defining the price of SRs. Another variable significantly ($P < 0.05$) associated with agency dimensions is participation in selling SRs in the market. Respondents, who participate in selling SRs in the market are 0.21 and 0.34 times less likely to make sole decisions in defining prices and deciding when to sell, respectively.

4. Discussion

4.1. Input acquisition and gender status: asset ownership and access to services

Systems of ownership of key empowerment resources, such as land, goat, and sheep, significantly vary across study areas but do not differ along gender lines, except for livestock ownership. These findings support the importance of considering context in empowerment interventions as suggested by scholars such as Richardson (2018a). In particular, ownership of small ruminants was less of an obstacle to both men and women across the study areas, except in Doyogena, where the lowest level of ownership was observed. However, men own more livestock as compared to their women counterparts, mainly because gender norms mediate ownership of large and more valuable assets (Ragasa et al., 2013).

The non-significant findings in relation to gender differences in key asset ownership are contrary to existing evidence (Doss et al., 2013; Boogaard et al., 2015; Debela, 2017; Wegari, 2020) because headship status is generally associated with privileges, such as ownership, control, and decision-making on key household assets (Kristjanson et al., 2010). Moreover, for women in male-headed households (and sometimes in women-headed households), ownership does not necessarily translate to control over these owned assets; in most cases, men in the household report rights to decide whether to buy or sell even jointly owned assets (Ahmed et al., 2009), which is influenced by gender norms. The non-significance observed in this study might be attributed to the demographic structure of the sampled HHs. More than 90.9% of the sampled women were the head of their household and women's empowerment is a core objective of most of the non-governmental organizations in Ethiopia targeting these households (Woldu et al., 2013). It is also expected that gender gaps have been narrowed, at least between men- and women-headed households, in the last decade due to an increased effort to mainstream gender equity into development efforts (Mogues et al., 2009). This has included policies encouraging joint ownership, which has led to more equitable divisions of household assets upon divorce, death, or separation (Kumar and Quisumbing, 2015). Nevertheless, when the context was considered, ownership of SRs is higher in lowland areas which is consistent with similar past studies (for example, see Management Entity, 2021). Farmers in lowland areas mainly depend on livestock for their livelihoods, compared to mixed farming systems in the mid and highland areas.

Access to agricultural credit market services is generally a challenge for most Ethiopian farmers (Shete and Garcia, 2011). But the higher rate of credit services observed in Abergele and Menz Gera in this study could be related to the presence and services of non-governmental organizations as these areas often experience food shortages. Similarly, the general betterment in terms of contact with extension agents, with no difference between genders, could be partly associated with the current extension system being implemented in the country, which has had an emphasis in recent years on addressing gender gaps, at least at the household level. Women household heads are the target of extension services based on quota systems with specific support packages (Mogues et al., 2009). However, evidence consistently shows that generally women (female heads of households) have limited access to the same quality of services as their male counterparts, mainly due to the existing biased social norms (Ragasa et al., 2013).

4.2. Input into production and gender status: husbandry and management practices

In the face of the introduction of community-based breeding programs across the study areas, the role of breed selection appears to be more important than before for participating in the initiative. Breed improvement through community-based approaches, which involves participatory breeding stock selections, is one of the key components of the program on SRVCD. The breeding stock selection involves participatory breeding goal definition and trait identification, breeding male and female selections, distribution of selected sires along with mating management, and culling of unselected males (Haile et al., 2020). In this study, the significant disagreement between gender groups regarding whose role is this activity has implications. If findings were based on data collected through only talking to men, as the head of the household, this would not only be misleading but also may negatively affect indicators of program performance. Thus, the findings reported here suggest that women (including women spouses) need to be targeted and supported by the SRVCD program as they are also active participants in breeding management activities and may provide different information and viewpoints than men.

The other key activity among SR management and husbandry practices is feeding the animals. It is apparent that on average respondents agree that feeding goats and sheep is the responsibility of all household members including hired labor, although this differed significantly among the study sites, which could be influenced by the differences in farming systems. A similar study investigating gender roles in the same study areas has shown

that all household members participate with varying degrees of involvement in the different practices across the different farming systems. That study, however, found that women dominate in carrying out all of the husbandry-related roles while men control the decision-making aspect of SR husbandry and management practices (Kinati et al., 2018). Thus, although, gender roles in SR appear non-gendered, care should be taken in generalizing, as when these roles are further decomposed into their components, distinct gender roles could be identified (Kinati et al., 2018). Men, for example, tend to control only the decision-making aspects while women and other household members carry out the actual practices (physical work), implying the importance of intrahousehold analyses with in-depth information on gender roles for targeting.

4.3. Market participation and gender status: market-related decisions (instrumental agency)

Households generally sell their SRs in the market and this appeared to be the role of male household members, particularly that of male household heads. This could be because animal marketplaces are often located at a distance and market infrastructures are less developed in the Ethiopian context (Abate et al., 2021), and, in many cases, women do not own or control means of transport to distant marketplaces (Waithanji et al., 2013a). This means that women may face more physical and social barriers to actively participate in SR marketing (Njuki et al., 2011). For example, gender norms in Ethiopia likely prevent women, but not men, from traveling long distances in search of better prices (Mulema et al., 2019). The evidence further suggests that the level of women's market participation diminishes as vertical integration of markets is promoted, when sales move away from farm gates, and when the value chain is more developed and becomes more complex (Njuki et al., 2011). This implies that value chain development, such as the SR transformations program in Ethiopia that is the case for this study, needs to consider women's economic and social conditions when designing SR value chain developments. Moreover, the gender differences may reflect that women face other specific barriers to their market participation, including being more occupied with household chores and thus being less mobile, giving them fewer opportunities to travel and sell animals, as has been suggested by, for example, Waithanji et al. (2013a).

Defining the prices of SRs is controlled by men, which is consistent across locations. However, in some study areas, women also tend to believe that the prices of SRs were defined by traders. Since women do not generally go to the market when animals are sold, they might tend to believe and report what their husbands might have told them. Waithanji et al. (2013b) also reported that, because women's participation in selling SRs in the marketplace was minimal compared to their men counterparts, they rely on their husbands or other male household members for marketing activities. Similarly, decisions on the timing of the sale of goats and sheep and keeping the market proceeds, appear to be controlled by men, although gender groups do not agree. Men tend to report joint decisions while women believe that it was primarily decided by men. This result is consistent with Waithanji et al. (2013a). Importantly, this finding suggests that what men describe as "joint decision-making" may indeed not mean what is commonly referred to as joint decision-making, which warrants surveys to question what joint decision-making means in a specific context and for a specific gender. In Ethiopia, others have reported men, who typically control the productive resources in the household, as the major decision-makers in relation to production, consumption, and sales in the market (Aregu et al., 2011).

4.4. Achievements: control and use of income

There is a disagreement between gender groups regarding who controls income from SRs. Men tend to suggest the task as a joint role whereas women say it is men-dominated. The findings of this study are in concordance with the study conducted by Boogaard et al. (2015) in *Inhassoro* District of Mozambique. He concluded that the income from SR selling was mainly controlled by men or jointly. Meanwhile, women in men-headed households hardly control the income from goats on their own. It has to be noted that, however, the term "joint control of income" can be ambiguous and misleading. It requires a further investigation of what "joint" really means to the respondents, both men and women. At what degree of involvement the term "joint" qualifies was not considered in the baseline study.

Income distribution significantly varies across gender and study sites. The unexpected findings in the income gap from livestock across study areas are contrary to the ownership status reported in Table 3—households with less livestock size ownership reported more income—which might imply differences in production orientation among the study areas. In Ethiopia, while 86% of farmers practice mixed farming (Negassa et al., 2011), two of the sites, Abergele and Yabello, have more livestock-based systems than the rest of the study areas, which would suggest that these two areas would also have a higher level of income from livestock. However, this was not found to be the case, in that the livestock income of Abergele and Yabello was close to that of Horo and less than that of Menz Mama. This could be partly attributed to the fact that, although farmers in Abergele and Yabello keep more animals than crop farmers in the rest of the areas, their participation in marketing is low (Negassa et al., 2011). For example, Negassa et al. (2011) reported that 43 and 50% of Ethiopian smallholder farmers did not participate in the marketing of sheep or goats during the period from 2003 to 2005, respectively. However, for the pastoralists in Yabello, it was about 72 and 66% during the same period, respectively. It is common for pastoralists to sell most of their animals only during shock times, such as drought, in fear of total loss, particularly because animals are also kept for symbolic and social purposes in Ethiopia (Wodajo et al., 2020), and not just for income generation.

4.5. Factors affecting empowerment

This section focuses on exploring the relationship between aspects of empowerment and socioeconomic characteristics along

key SRVC stages in Ethiopia. By strictly limiting our definitions of agency and achievement to the ability to make decisions alone (or autonomously) and having full control over income from SRs, respectively, leaving aside the ambiguous "joint decision-making"—as the term entails masked dominance of men (Kabeer, 2011)—we show that age group, context, marital status, sex of HH head, able to select breeding stock, livestock ownership, contact with extension agent, access to market information, and participation in selling at marketplaces are all factors that are significantly associated with agency dimensions, achievement, or both. These findings agree with several studies (Wayack et al., 2014; Nahayo et al., 2017; Thandar et al., 2020).

The negative relationship of the age category (41–50 years) with one's control over the sale proceeds from SRs, as compared to older age groups, might be related to the demographic status of the study participants. About 42% of the ">50 years old" age group were widowed (descriptive result not reported) and expected to have full control over income as the head of their households, which was a higher proportion than for younger age groups. In the Ethiopian context, and as elsewhere, most women become widowed in their later years and may gain authority in this manner (Wayack et al., 2014). This finding demonstrates the importance of closely examining demographic factors, including age, gender, and marital status, when investigating empowerment and, importantly, the need to be cautious in interpreting results when age is entered as a continuous variable. Context, represented by the study areas, was also found to be an important variable affecting dimensions of agency and achievement in Ethiopia. This could be related to the diverse socio-cultural contexts that exist across the farming systems in the country (Epple and Thubauville, 2012). Hence, further analysis from this perspective is needed to ensure local differences in social norms, spanning from religion and culture, which play vital roles in shaping women's empowerment (Thandar et al., 2020), are not lost when national datasets are compiled and analyzed.

We also found that gender is negatively associated with controlling income from the sale of SRs, suggesting that men household heads are less likely to make decisions alone compared to women household heads. This appears true because the majority of the male respondents (>60%) said income is controlled jointly; however, the women respondents did not agree, which is consistent with evidence from Kabeer (2011) who suggests that joint decision-making is male-masked dominance (Kabeer, 2011). Moreover, researchers noted that male participants behave differently in different research approaches (Jejeebhoy, 2002). In household surveys, male participants tend to display more liberal attitudes toward women's autonomy in decision-making as opposed to in focus group discussions where they appear more conservative because they are with their peers (Jejeebhoy, 2002; Tavenner et al., 2018). Thus, in this study, we assumed it as a non-autonomy indicator. Moreover, married men tend to make decisions in consultation with their spouses, while women household heads do not as they are often widowed, divorced, or do not have adult male members in their household, a finding that is consistent with Aregu et al. (2011). This was also supported by the result that being married is negatively associated with agency and achievement, suggesting that married men and women are less likely to make sole decisions on when to sell and also less likely to have sole control over income from SRs. Respondents in this marital status tend to report joint decision-making.

The positive relationship observed between smaller ownership of livestock (<5 heads) and aspects of empowerment is not consistent with the general trend of decision-making in Ethiopia (Aregu et al., 2011), which suggests that decisions in rich and middle households are male-dominated while it is generally joint in poorer households. Reasons for this conflicting observation might include the following: people tend to be more restrictive and autonomously decide alone when resources are scarce or limited; smaller farms may have an over-representation of female HH heads; smaller farms may have less contact with VCs (both input and markets); smaller farms may be less sensitive to VC-related decisions and thus exhibit joint decision-making behavior; and smaller farms may have recently encountered shocks which reduced their size and influenced what kinds of decisions were made and by whom. All of these possibilities warrant further investigation.

The relationships between participation in VCs activities at the production level (such as breed selection, getting market information, and selling in the market) and agency dimensions were found to be negative, which might imply that participation alone does not generate the capacity to make sole decision-making, but rather may encourage more egalitarian decision-making behaviors (Galiè et al., 2015).

The positive associations observed between contact with extension agents and the ability to define SR prices, and access to market information and control over income, are consistent with other similar studies (Nahayo et al., 2017; Carnegie et al., 2020), implying that access to extension agents and market information improves one's ability to make market-related decisions and exert control over income from SRs. However, the negative associations between contact with extension agents and control over income, access to market information, and ability to define SR market prices are contrary to what is reported from past studies (Carnegie et al., 2020). These differences could be partly attributed to the fact that those individuals who are accustomed to collecting market information on SRs to inform decisions might also tend to consult at home or believe in joint, rather than sole, decision-making, and vice-versa. Similarly, those who often consult with extension agents might become more egalitarian in their attitude and tend to believe in shared control of resources. Again, these are matters requiring further investigation.

By employing existing theory to direct the exploration of the available dataset, this study offers lessons for future research as well as productivity-related program design. Although empowerment indicators are not objectively included in the design of the tools used to collect the baseline data, the dataset allowed us to identify limited but direct measurements of agency and achievement. Nevertheless, some limitations are evident. First, the list of independent variables used missed an important variable related to direct measurements of social norms which is hypothesized as being strongly associated with empowerment. Second, determining the groupings of some of the variables is a complex task due to the existence of heterogeneity among the study locations and thus might affect the reported results. Finally, the baseline data did not collect any qualitative information, and thus interpreting some of the unexpected findings is difficult.

5. Conclusion and implications

This study attempted to generate measures of empowerment and apply them in relation to smallholder livestock systems that are seen as a driver of economic and social development. Using a program conventionally targeted at productivity and efficiency, the study sheds light on other aspects of success for such programs. Empowerment is defined in relation to the decisions surrounding the generation of income—and hence resilience—from livestock. This is one of the first attempts to do this and several lessons have emerged to inform future research. Several explanatory variables have been identified for empowerment, and this informs future program design.

The descriptive analysis highlighted the importance of context with regard to access to major VC imputes, systems of ownership of empowerment resources, and decision-making. At the production stage in the SRVC, although roles in SR appear non-gendered for most of the activities, care should be taken since significant disagreement was observed between gender groups with respect to key activities, such as breed selection, indicating the importance of consulting both men and women. Only talking to men, as the head of the household, may not only generate biased information but also may negatively affect program performance by misunderstanding and undermining the role of women. Market participation, related decisions, and control over income from SRs appear to be under the control of men. Market locations and channels for SR keepers are limited to local marketplaces and traders, respectively, and generally biased against women, mainly because of restrictive norms combined with a lack of market facilities which are often out of the reach of women. However, policymakers need to take into account the trade-off between VC development and gender equality—literature shows that women's market participation diminishes as vertical integration of markets is promoted through value chain development if due consideration is not given to the normative contexts governing resource control rights.

The empirical analysis confirmed the major role of context in determining one's empowerment in terms of making autonomous decisions in SRVC. It provides, thus, additional arguments for further research focusing on the socio-cultural contexts and gender attitudes that make up the opportunity conditions for empowerment across the study areas, which is missing in the current study. The strong associations of gender and marital status with the agency and achievement indicators also affirm the need to give due consideration to women SRVC participants to achieve gender equality for the program. This could be done through various approaches including designing women-targeted interventions. However, to ensure long-lasting gender equality, gender transformational interventions must be in place. The development of national gender policies should focus on transforming the socio-cultural contexts. The strong associations between aspects of empowerment and the various SRVC stages observed asserts the importance of SRs for empowerment. Participation in SRVCs may encourage more egalitarian decision-making behaviors but does not guarantee the capacity for sole decision-making and, thus, the program needs to be coupled with gender-specific interventions to strengthen women's agency. Nevertheless, further investigations are apparent to gain an understanding in relation to the mixed results observed in the livestock-based systems. In particular, those findings which appear to contradict the existing evidence, and where men and women disagreed, need to be further investigated.

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 patients/participants provided their written informed consent to participate in this study.

Author contributions

WK accessed the dataset from ICARDA, conceptualized the idea, and wrote the draft manuscript. ET, DB, and DN reviewed and contributed to the final analysis and write up of the manuscript. All authors agreed on the final appearance of the manuscript after careful review, read, and approved the final manuscript.

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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.

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References

Abate, D., Addis, Y., and González-Redondo, P. (2021). Factors affecting the intensity of market participation of smallholder sheep producers in northern Ethiopia: poisson regression approach. *Cogent Food Agri.* 7, 1874154. doi: 10.1080/23311932.2021.1874154

Ahmed, A., Minten, B., Quisumbing, A. R., Roy, D., Khondkar, M., and Muzareba, A. (2009). *Evaluating the Dairy Value Chain Project in Bangladesh: Baseline Report*. Washington, DC: International Food Policy Research Institute.

Aklilu, N., Hoag, D., and Tigist, A. (2014). Women's workload and role in livestock production in pastoral and agro-pastoral communities of Ethiopia: the case of Afar. *Afri. J. Agri. Econ. Rural Dev*. 2, 138–146.

Akram, N. (2017). Women's empowerment in Pakistan: its dimensions and determinants. *Soc. Indicat. Res.* 140, 755–775. doi: 10.1007/s11205-017-1793-z

Akter, S., and Chindarkar, N. (2020). An empirical examination of sustainability of women's empowerment using panel data from India. *J. Dev. Stud*. 56, 890–906. doi: 10.1080/00220388.2019.1605054

Al Riyami, A., Afifi, M., and Mabry, R. M. (2004). Women's autonomy, education and employment in Oman and their influence on contraceptive use. *Reprod. Health Matt*. 12, 144–154. doi: 10.1016/S0968-8080(04)23113-5

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A., Seymour, G., and Vaz, A. (2013). The women's empowerment in agriculture index. *World Dev*. 52, 71–91. doi: 10.1016/j.worlddev.2013.06.007

Allendorf, K. (2007). Do women's land rights promote empowerment and child health in Nepal? *World Dev*. 35, 1975–1988. doi: 10.1016/j.worlddev.2006.12.005

Alsop, R., Bertelsen, M., and Holland, J. (2006). *Empowerment in Practice: From Analysis to Implementation*. Washington, DC: World Bank.

Aregu, L., Puskur, R., and Bishop-Sambrook, C. (2011). "The role of gender in crop value chain in Ethiopia," in *Paper Presented at the Gender and Market Oriented Agriculture (AgriGender 2011) Workshop, Addis Ababa, Ethiopia, 31 January—2 February 2011*. Nairobi: ILRI.

Ashby, J., Hartl, M., Lambrou, Y., Larson, G., Lubbock, A., Pehu, E., et al. (2019). *Investing in Women as Drivers of Agricultural Growth. ARD Note (2009)*. Washington, DC: World Bank.

Bain, C., Ransom, E., and Halimatusa'diyah, I. (2020). Dairy livestock interventions for food security in Uganda: what are the implications for women's empowerment? *Rural Sociol*. 2020, 12332. doi: 10.1111/ruso.12332

Banda, L. J., and Tanganyika, J. (2021). Livestock provide more than food in smallholder production systems of developing countries. *Anim. Front*. 11, 7–14. doi: 10.1093/af/vfab001

Bekele, A. E., Drabik, D., Dries, L., and Heijman, W. (2022). Resilience of Ethiopian agropastoral households in the presence of large-scale land investments. *Ecol. Econ.* 200, 107543. doi: 10.1016/j.ecolecon.2022.107543

Belete, A. T. (2006). *A Studies on Cattle Milk and Meat Production in Fogera Woreda: Production Systems, Constraints and Opportunities for Development*. (Thesis), Department of Animal and Range Sciences, Awassa College of Agriculture, School of Graduate Studies, Debub University, Awassa, Ethiopia.

Bernard, T., Doss, C., Hidrobo, M., Hoel, J., and Kieran, C. (2020). Ask me why: patterns of intrahousehold decision-making. *World Dev.* 125, 104671. doi: 10.1016/j.worlddev.2019.104671

Boogaard, B. K., Waithanji, E., Poole, E. J., and Cadilhon, J.-J. (2015). Smallholder goat production and marketing: a gendered baseline study from Inhassoro District Mozambique. *NJAS Wageningen J. Life Sci.* 74–75, 51–63. doi: 10.1016/j.njas.2015.09.002

Bryan, E., and Garner, E. (2020). *What does Empowerment Mean to Women in Northern Ghana? Insights from Research Around a Small-Scale Irrigation Intervention. IFPRI Discussion Paper, 1909*. Washington, DC: IFPRI. Available online at: https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/133596/filename/133808.pdf (accessed January 5, 2023).

Bryan, E., and Lefore, N. (2021). *Women and Small-Scale Irrigation: A Review of the Factors Influencing Gendered Patterns of Participation and Benefits. IFPRI Discussion Paper 02025*. Washington, DC: IFPRI. doi: 10.2499/p15738coll2.134425

Carnegie, M., Cornish, P. S., Htwe, K. K., and Htwe, N. N. (2020). Gender, decision-making and farm practice change: an action learning intervention in Myanmar. *J. Rural Stud*. 78, 503–515. doi: 10.1016/j.jrurstud.2020.01.002

Catley, A., Stites, E., Ayele, M., and Arasio, R. L. (2021). Introducing pathways to resilience in the Karamoja Cluster. *Pastoralism* 11, 28. doi: 10.1186/s13570-021-00214-4

Choudhary, N. (2016). Resource access and status versus values and agency: is there a correspondence? *Gender Iss*. 33, 235–257. doi: 10.1007/s12147-016-9150-0

Covarrubias, K., Nsiima, L., and Zezza, A. (2012). *Livestock and Livelihoods in Rural Tanzania: A Descriptive Analysis of the 2009 National Panel Survey*. Washington, DC: World Bank.

Debela, B. (2017). Factors affecting differences in livestock asset ownership between male- and female-headed households in Northern Ethiopia. *Eur. J. Dev. Res.* 29, 328–347. doi: 10.1057/ejdr.2016.9

Disassa, A. A., Degu, N. T., and Toma, A. S. (2016). Determinants of socio-economic empowerment of married women: evidence from Ethiopia. *Human. Soc. Sci.* 4, 66–75. doi: 10.11648/j.hss.20160403.11

Dolan, C., and Humphrey, J. (2000). Governance and trade in fresh vegetables: the impact of UK supermarkets on the African Horticulture Industry. *J. Dev. Stud.* 37, 147–176. doi: 10.1080/713600072

Doss, C., and Kieran, C. (2014). *Standards for Collecting Sex-Disaggregated Data for Gender Analysis: A Guide for CGIAR Researchers. CGIAR Research Program on Policies, Institutions and Markets*. Available online at: https://hdl.handle.net/10947/3072 (accessed January 12, 2023).

Doss, C., Kovarik, C., Peterman, A., Quisumbing, A. R., and van den Bold, M. (2013). *Gender Inequalities in Ownership and Control of Land in Africa: Myths Versus Reality. IFPRI Discussion Paper 1308*. Washington, DC: International Food Policy Research Institute (IFPRI). Available online at: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127957 (accessed October 7, 2022).

Epple, S., and Thubauville, S. (2012). Cultural diversity in Ethiopia: between appreciation and suppression. *Paideuma* 58, 153–166.

FAO (2011). *The State of Food and Agriculture. Women in Agriculture: Closing the Gender Gap for Development*. Rome: FAO. Available online at: http://www.fao.org/docrep/013/i2050e/i2050e.pdf (accessed May 29, 2020).

Forsythe, L., Posthumus, H., and Martin, A. (2016). A crop of one's own? Women's experiences of cassava commercialization in Nigeria and Malawi. *J. Gender Agric. Food Secur*. 1, 110–128. doi: 10.22004/ag.econ.246033

Fuller, R. (2012). *Guatemala Highlands Value Chain Development Alliance: Project Effectiveness Review, Women's Empowerment, Global Outcome Indicator*. Oxford: Oxfam Great Britain.

Galiè, A., Distefano, F., Kangogo, D., Mattioli, R. C., Wieland, B., and Baltenweck, I. (2017). Gendered perspectives on smallholder cattle production and health management in three sites in Tanzania. *J. Gender Agri. Food Secur*. 2, 43–65. doi: 10.19268/JGAFS.232017.3

Galiè, A., and Farnworth, C. R. (2019). Power through: a new concept in the empowerment discourse. *Glob. Food Sec.* 21, 13–17. doi: 10.1016/j.gfs.2019.07.001

Galiè, A., Mulema, A. A., Mora Benard, M. A., Onzere, S. N., and Colverson, K. E. (2015). Exploring gender perceptions of resource ownership and their implications for food security among rural livestock owners in Tanzania, Ethiopia, and Nicaragua. *Agri. Food Secur*. 4, 9. doi: 10.1186/s40066-015-0021-9

Galiè, A., Teufel, N., Korir, L., Baltenweck, I., Webb Girard, A., Dominguez-Salas, P., et al. (2019). The women's empowerment in livestock index. *Soc. Indicat. Res*. 142, 799–825. doi: 10.1007/s11205-018-1934-z

GebreMariam, S., Amare, S., Baker, D., and Solomon, A. (2019). Diagnostic study of live cattle and beef production and marketing: constraints and opportunities for enhancing the system. *Gates Open Res.* 3.

Gebreyohanes, G., Yilma, Z., Moyo, S., and Mwai, O. A. (2021). *Dairy Industry Development in Ethiopia: Current Status, Major Challenges and Potential Interventions for Improvement. ILRI. Position Paper*. Nairobi: ILRI.

Giziew, A. (2018). Determinants of Chicken market participation decisions by smallholder farmers in West Gojam Zone, Ethiopia: a gender perspective. *Ethiop. J. Soc. Sci*. 4, 1–20.

Gujarati, D. N. (1995). *Basic Econometrics*. New York, NY: McGraw-Hill.

Gupta, K., and Princy, P. Y. (2006). Evidence of women's empowerment in India: a study of socio-spatial disparities. *GeoJournal* 65, 365–380. doi: 10.1007/s10708-006-7556-z

Gutu, Z., Haile, A., Rischkowsky, B., Mulema, A. A., Kinati, W., and Kassie, G. T. (2015). *Evaluation of Community-Based Sheep Breeding Programs in Ethiopia*. Addis Ababa: ICARDA.

Haile, A., Getachew, T., Mirkena, T., Duguma, G., Gizaw, S., Wurzinger, M., et al. (2020). Community-based sheep breeding programs generated substantial genetic gains and socioeconomic benefits. *Animal* 14, 1362–1370. doi: 10.1017/S1751731120000269

Hashemi, S. M., Ruth, S. S., and Riley, A. P. (1996). Rural credit programs and women's empowerment in Bangladesh. *World Dev.* 24, 635–653. doi: 10.1016/0305-750X(95)00159-A

Headey, D., Taffesse, A. S., and You, L. (2014). Diversification and development in pastoralist Ethiopia. *World Dev.* 56, 200–213. doi: 10.1016/j.worlddev.2013.10.015

Hilbe, J. (2015). *Practical Guide to Logistic Regression*. New York, NY: CRC Press.

Hulela, K. (2010). The role of women in sheep and goats production in sub-saharan Africa. *Int. J. Sci. Res. Educ.* 3, 177–187.

Jejeebhoy, S. J. (2002). Convergence and divergence in spouses' perspectives on womens autonomy in rural India. *Stud. Fam. Plann.* 33, 299–308. doi: 10.1111/j.1728-4465.2002.00299.x

Joshi, P. K., Khan, M. T., and Kishore, A. (2019). Heterogeneity in male and female farmers' preference for a profit-enhancing and labor-saving technology: The case of Direct-Seeded Rice (DSR) in India. *Can. J. Agri. Econ.* 67, 303–320. doi: 10.1111/cjag.12205

Kabeer, N. (1999). Resources, agency, achievements: reflections on the measurement of women's empowerment. *Dev. Change* 30, 435–464. doi: 10.1111/1467-7660.00125

Kabeer, N. (2011). Between affiliation and autonomy: navigating pathways ofwomen's empowerment and gender justice in rural Bangladesh. *Dev. Change* 42, 499–528. doi: 10.1111/j.1467-7660.2011.01703.x

Kamo, Y. (2000). "He said, she said": assessing discrepancies in husbands' and wives' reports on the division of household labor. *Soc. Sci. Res.* 29, 459–476. doi: 10.1006/ssre.2000.0674

Kangethe, E., Sartas, M., and Dror, I. (2021). *Small Ruminant Value Chain Transformation in Ethiopia Scaling Scan Report*. Nairobi: ILRI.

Kidder, T., and Raworth, K. (2010). 'Good jobs' and hidden costs: women workers documenting the price of precarious employment. *Gender Dev.* 12, 12–21. doi: 10.1080/13552070412331332150

Kifetew, K. (2006). Gender and cross cultural dynamics in Ethiopia: empowering women for gender equity. *Culture* 2006, 122–127.

Kinati, W., and Mulema, A. A. (2019). Gender issues in livestock production systems in Ethiopia: a literature review. *J. Livestock Sci.* 10, 80. doi: 10.33259/JLivestSci.2019.66-80

Kinati, W., Mulema, A. A., Desta, H., Alemu, B., and Wieland, B. (2018). Does participation of household members in small ruminant management activities vary by agro-ecologies and category of respondents? Evidence from Rural Ethiopia. *J. Gender Agri. Food Secur.* 3, 51–73. doi: 10.19268/JGAFS.322018.4

Kleinbaum, D. G. (1994). *Logistic Regression: A Self-learning Text*. New York, NY: Springer.

Koenig, M. A., Ahmed, S., Hossain, M. B., and Mozumder, A. B. M. K. (2003). Women's status and domestic violence in rural Bangladesh: individual- and community-level effects. *Demography* 40, 269–288. doi: 10.1353/dem.2003.0014

Kristjanson, P., Waters-Baye, A., Johnson, N., Tipilda, A., Njuki, J., Baltenweck, I., et al. (2010). *Livestock and Women's Livelihoods: A Review of the Recent Evidence. Discussion Paper No. 20, ILRI*.

Kumar, N., and Quisumbing, A. R. (2015). Policy reform toward gender equality in Ethiopia: little by little the egg begins to walk. *World Dev.* 67, 406–423. doi: 10.1016/j.worlddev.2014.10.029

Lecoutere, E., Spielman, D. J., and Van, B. C. (2019). *Women's Empowerment, Agricultural Extension, and Digitalization Disentangling Information and Role-Model Effects in Rural Uganda, IFPRI Discussion Paper 01889*. Washington, DC: IFPRI. doi: 10.2499/p15738coll2.133523

Legovini, A. (2004). *Measuring Women's Empowerment and the Impact of Ethiopia's Women's Development Initiatives Project*. Washington, DC: Poverty Reduction Group, Poverty Reduction and Economic Management Network, World Bank.

Lim, S. S., Winter-Nelson, A., and Arends-Kuenning, M. (2007). Household bargaining power and agricultural supply response: evidence from Ethiopian coffee growers. *World Dev.* 35, 1204–1220. doi: 10.1016/j.worlddev.2006.09.016

Lyon, S., Mutersbaugh, T., and Worthen, H. (2016). The triple burden: the impact of time poverty on women's participation in coffee producer organizational governance in Mexico. *Agri. Hum. Values* 34, 317–331. doi: 10.1007/s10460-016-9716-1

Maertens, M., and Verhofstadt, E. (2013). Horticultural exports, female wage employment and primary school enrolment: theory and evidence from Senegal. *Food Policy* 43, 118–131. doi: 10.1016/j.foodpol.2013.07.006

Mahmud, S., and Tasneem, S. (2014). Measuring 'empowerment' using quantitative household survey data. *Women's Stud. Int. For.* 45, 90–97. doi: 10.1016/j.wsif.2013.11.009

Malapit, H., Ragasa, C., Martinez, E. M., Rubin, D., Seymour, G., and Quisumbing, A. (2019). *Empowerment in Agricultural Value Chains Mixed Methods Evidence from the Philippines, IFPRI Discussion Paper 01881*. Washington, DC: IFPRI. doi: 10.2499/p15738coll2.133456

Malapit, H., Ragasa, C., Martinez, E. M., Rubin, D., Seymour, G., and Quisumbing, A. (2020). Empowerment in agricultural value chains: Mixed methods evidence from the Philippines. *J. Rural Stud.* 76, 240–253. doi: 10.1016/j.jrurstud.2020.04.003

Management Entity (2021). *Ethiopia's Livestock Systems: Overview and Areas of Inquiry*. Gainesville, FL: Feed the Future Innovation Lab for Livestock Systems. Available online at: https://livestocklab.ifas.ufl.edu/media/livestocklabifasufledu/pdf-/LSIL_Livestock_Systems_Overview_Ethiopia_2021_08.pdf (accessed December 16, 2022).

Meinzen-Dick, R., Johnson, N., Quisumbing, A., Njuki, J., Behrman, J., Rubin, D., et al. (2011). *Gender, Assets, and Agricultural Development Programs: A Conceptual Framework, CAPRi Working Paper No. 99*. Washington, DC: International Food Policy Research Institute.

Meinzen-Dick, R., Rubin, D., Elias, M., Mulema, A. A., and Myers, E. (2019). *Women's Empowerment in Agriculture: Lessons From Qualitative Research, IFPRI Discussion Paper 01797*. Washington, DC: The International Food Policy Research Institute.

Mekuyie, M., Jordaan, A., and Melka, Y. (2018). Understanding resilience of pastoralists to climate change and variability in the Southern Afar Region, Ethiopia. *Climate Risk Manag.* 20, 64–77. doi: 10.1016/j.crm.2018.02.004

Minten, B., Randrianarison, L., and Swinnen, J. F. M. (2009). Global retail chains and poor farmers: evidence from Madagascar. *World Dev.* 37, 1728–1741. doi: 10.1016/j.worlddev.2008.08.024

Mogues, T., Cohen, M. J., Birner, R., Lemma, M., Tadesse, F., and Paulos, Z. (2009). *Agricultural Extension in Ethiopia through a Gender and Governance Lens. ESSP II Working Paper 7*. Addis Ababa: International Food Policy Research Institute/Ethiopia Strategy Support Program II.

Mulema, A., Lemma, M., Kinati, W., Mekonen, M., Demeke, Y., and Weiland, B. (2019). *Community Conversations on Social Structures and Institutions That Shape Women's Control of Livestock, Group Membership and Access to Information in Menz and Doyogena: Field Activity Report*. Nairobi: ILRI.

Mulema, A. A., Farnworth, C. R., and Colverson, K. E. (2017). Gender-based constraints and opportunities to women's participation in the small ruminant value chain in Ethiopia: a community capitals analysis. *Commun. Dev.* 48, 1–19. doi: 10.1080/15575330.2016.1267785

Nahayo, A., Omondi, M. O., Zhang, X. H., Li, L. Q., Pan, G. X., and Joseph, S. (2017). Factors influencing farmers' participation in crop intensification program in Rwanda. *J. Integr. Agri.* 16, 1406–1416. doi: 10.1016/S2095-3119(16)61555-1

Negassa, A., Rashid, S., and Gebremedhin, B. (2011). *Livestock Production and Marketing. Ethiopia Strategy Support Program II, Ethiopia, ESSP II Working Paper 26*. Washington, DC: IFPRI.

Njuguna-Mungai, E., Omondi, I., Galiè, A., Jumba, H., Derseh, M., Paul, B. K., et al. (2022). Gender dynamics around introduction of improved forages in Kenya and Ethiopia. *Agron. J.* 114, 277–295. doi: 10.1002/agj2.20956

Njuki, J., Kaaria, S., Chamunorwa, A., and Chiuri, W. (2011). Linking smallholder farmers to markets, gender and intra-household dynamics: does the choice of commodity matter? *Eur. J. Dev. Res.* 23, 426–443. doi: 10.1057/ejdr.2011.8

Njuki, J., Waithanji, E., Bagalwa, N., and Kariuki, J. (2013). *Guidelines on Integrating Gender in Livestock Projects and Programs. ILRI Project Report 44*. Nairobi: ILRI. Available online at: https://hdl.handle.net/10568/33425 (accessed January 17, 2023).

Ozkan, B., Dube, A. K., and Reed, M. R. (2022). "Role of agricultural extension in building climate resilience of food security in Ethiopia," in *Food Security and Climate-Smart Food Systems*, eds M. Behnassi, M. B., Baig, M. T., Sraïri, A. A. Alsheikh, and A. W. A. Abu Risheh (Cham: Springer), 11.

Parveen, S., and Leonhäuser, I. U. (2004). "Empowerment of rural women in Bangladesh: a household level analysis," in *Conference on Rural Poverty Reduction through Research for Development and Transformation*. Berlin: Deutscher Tropentag.

Petesch, P., Smulovitz, C., and Walton, M. (2005). "Evaluating empowerment: a framework with cases from Latin America," in *Measuring Empowerment: Cross-Disciplinary Perspectives*, ed D. Narayan (Washington, DC: The World Bank), 3.

Quisumbing, A. R., Rubin, D., Manfre, C., Waithanji, E., van den Bold, M., Olney, D., et al. (2015). Gender, assets, and market-oriented agriculture: learning from

high-value crop and livestock projects in Africa and Asia. *Agri. Hum. Val.* 32, 705–725. doi: 10.1007/s10460-015-9587-x

Ragasa, C., Berhane, G., Tadesse, F., and Seyoum, A. T. (2013). Gender differences in access to extension services and agricultural productivity. *J. Agri. Educ. Extens.* 19, 437–468. doi: 10.1080/1389224X.2013.817343

Ragasa, C., Guush, B., Tadesse, F., and Seyoumm, A. T. (2012). *Gender Differences in Access to Extension Services and Agricultural Productivity. ESSP Working Paper 49*. IFPRI. Available online at: https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/127328/filename/127539.pdf (accessed November 20, 2022).

Richardson, R. A. (2018a). Measuring women's empowerment: a need for context and caution. *Lancet Glob. Health* 6, 6. doi: 10.1016/S2214-109X(17)30460-6

Richardson, R. A. (2018b). Measuring women's empowerment: a critical review of current practices and recommendations for researchers. *Soc. Indicat. Res.* 137, 539–557. doi: 10.1007/s11205-017-1622-4

Rowlands, J. (1997). *Questioning Empowerment: Working with Women in Honduras*, Oxford: Oxfam; Atlantic Highlands, NJ: Humanities Press International.

Sell, M., and Minot, N. (2018). What factors explain women's empowerment? Decision-making among small-scale farmers in Uganda. *Women's Stud. Int. For.* 71, 46–55. doi: 10.1016/j.wsif.2018.09.005

Seymour, G., and Peterman, A. (2018). Context and measurement: an analysis of the relationship between intrahousehold decision making and autonomy. *World Dev.* 111, 97–112. doi: 10.1016/j.worlddev.2018.06.027

Shete, M., and Garcia, R. J. (2011). Agricultural credit market participation in Finoteselam town, Ethiopia. *J. Agribus. Develop. Emerg. Econ.* 1, 55–74. doi: 10.1108/20440831111131514

Solomon, A., Workalemahu, A., Jabbar, M. A., Ahmed, M. M., and Hurissa, B. (2003). *Livestock Marketing in Ethiopia: A Review of Structure, Performance and Development Initiatives. ILRI Socio-economic and Policy Research Working Paper 52*. Nairobi: ILRI.

Tavenner, K., Fravel, S., Omondi, I., and Crane, T. A. (2018). Gendered reporting of household dynamics in the Kenyan dairy sector: trends and implications for low emissions dairy development. *Gender Technol. Develop.* 22, 1–19. doi: 10.1080/09718524.2018.1449488

Thandar, M., Moe, H. H., and Naing, W. (2020). Women's empowerment among married women aged 15 to 49 in Myanmar. *Asia-Pacific Sustain. Dev. J.* 26, 57–81. doi: 10.18356/c0408e57-en

The World Bank (2011). *World Development Report 2012*. Washington DC: The World Bank.

Van den Broeck, G., Van Hoyweghen, K., and Maertens, M. (2018). Horticultural exports and food security in Senegal. *Glob. Food Secur.* 17, 162–171. doi: 10.1016/j.gfs.2017.12.002

Waithanji, E., Njuki, J., and Bagalwa, N. (2013a). "Gendered participation in livestock markets. Chapter 4," in *Women, Livestock Ownership and Markets: Bridging the Gender Gap in Eastern and Southern Africa*, eds J. Njuki and P. Sanginga (London; New York, NY: Routledge), 39–59.

Waithanji, E., Njuki, J., and Bagalwa, N. (2013b). *Women's Participation in Livestock Markets. Rsearch Brief, ILR and IDRC*. Available online at: https://cgspace.cgiar.org/bitstream/handle/10568/33738/WomensParticipationLivestockMarkets.pdf?sequence=1&isAllowed=y (accessed January 14, 2023).

Wayack, M. P., Gnoumou, B. T., and Kabore, I. (2014). Relationship between women's socioeconomic status and empowerment in Burkina Faso: a focus on participation in decision-making and experience of domestic violence. *Afri. Popul. Stud.* 28, 1146–1156. doi: 10.11564/28-0-563

Wegari, O. D. (2020). Review on gender roles in livestock value chain in Ethiopia. *Ecol. Evol. Biol.* 5, 14. doi: 10.11648/j.eeb.20200504.14

Wodajo, H. D., Gemeda, B. A., Kinati, W., Mulem, A. A., van Eerdewijk, A., and Wieland, B. (2020). Contribution of small ruminants to food security for Ethiopian smallholder farmers. *Small Ruminant Res.* 184, 106064. doi: 10.1016/j.smallrumres.2020.106064

Woldu, T., Tadesse, F., and Waller, M. K. (2013). *Women's Participation in Agricultural Cooperatives in Ethiopia. ESSP Working Paper 57*. Washington, DC: IFPRI.

World Bank (2007). *Promoting Gender Equality and Women Empowerment in Global Monitoring Report 2007: Confronting the Challenges of Gender Equality and Fragile States, Chapter 3*. Washington, DC: World Bank.

Yisehak, K. (2008). *Gender Responsibility in Smallholder Mixed Crop–Livestock Production Systems of Jimma Zone, South West Ethiopia. Livestock Research for Rural Development. Volume 20, Article #11*. Available online at: http://www.lrrd.org/lrrd20/1/yise20011.htm (accessed August 13, 2020).

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Foresight study on dairy farming systems in Central Kenya and north of Senegal

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Dairy farming activities play important roles in nutrition and health, livelihoods and employment, and culture, in Kenya and Senegal. Faced with various challenges such as climate change, increased populations, insecurity, and conflicts over (water, land, feed) resources, dairy production systems will have to undergo changes in the future that allow them to adapt. This study used a qualitative foresight approach that is mainly based on interviews with technical experts and key stakeholders, including dairy cattle herders, to identify the main evolution trends to be observed in dairy farming in Central Kenya and north of Senegal. It found that (semi)-intensification of production systems and increased settlement of herders who are nomad pastoralists are the prevailing trends. These trends are likely to persist into the future. For both countries, the key drivers of change and their potential environmental and socio-economic impacts were investigated. As dairy systems continue to confront challenges related to livestock feed and water availability, milk quality and safety, production costs, and market access, strategies are needed that can improve resilience of the systems while attaining the right balance between productivity and sustainability.

KEYWORDS

foresight study, dairy systems, Kenya, Senegal, resilience, climate change

1. Introduction

Dairy farming plays a crucial role in many countries in Africa, particularly among pastoralist and agro-pastoralist populations, generating a significant part of the incomes of many households (Diop et al., 2009). Milk is in addition a central component of many local diets, contributing strongly to food and nutritional security (Kibogy, 2019). Demand for dairy products, including milk, has been rising in Africa, reaching a growth rate of 4 % per year recently (ILRI, 2018; Kibogy, 2019). Rising income, population growth, urbanization and changing lifestyles are the main drivers of the increased milk consumption (Ochungo et al., 2016; ILRI, 2018). Kenya is currently one of the countries with the highest rates of *per capita* consumption of milk in sub-Saharan Africa (i.e., around 82 liters in 2019), including cow, sheep, goat, and camel milk, alongside Sudan, Mauritania, and Botswana (Kibogy, 2019; FAO, 2022). Milk consumption *per capita* is lower in Senegal (at around 12 litres in 2019) and has grown at a relatively modest rate of around 1 % annually over the last decade (FAO, 2022). However, milk is an important part of the diet, and its production an important income earner for many in parts of the country.

In Kenya, the annual *per capita* consumption of milk is expected to reach 200 litres by 2030 (Kibogy, 2019). Kenya is the leader in milk production among eastern African countries (ILRI, 2018; Africa-milk, 2019a). It is estimated that Kenya's livestock sector contributes to 12 percent

of national gross domestic product (GDP) (Kimany, 2021) and the dairy sector is the largest agricultural sub-sector in terms of income and employment creation (Bebe et al., 2003; Africa-milk, 2019a). An estimated two million actors derive livelihoods from the dairy value chain in Kenya (Kibogy, 2019; Africa-milk, 2019a).

Agriculture makes a significant contribution to the economy of Senegal, with a share of agriculture in GDP at 17 percent in 2020 (The Global Economy, 2022). Milk production in the country is mainly provided by cattle (followed by goats and sheep), with approximately 3.7 million heads in 2020 (Ministère de l'agriculture, de l'agroalimentaire et de la forêt, 2014; FAOSTAT, 2022). National milk production has increased over the past decade, with the produced milk being consumed mainly within the household and sold on the markets (GRET/APESS, 2016; Africa-milk, 2019b). However, due to a largely unstructured local dairy value chain (Africa-milk, 2019b) as well as the large quantities of milk and milk products being imported annually, only ten tons of milk equivalent are processed yearly in the country's dairies, accounting for less than 10 % of the national milk production (Africa-milk, 2019b).

Faced with various challenges such as climate change and increased demand for milk and other livestock products, dairy systems in Kenya and Senegal are evolving (FAO and GDP, 2018). This raises many research questions which if answered could aid our understanding of how dairy systems are currently evolving and what changes to expect in the future. This study focused on four such questions: (i) how are dairy systems evolving in Kenya and in Senegal? (ii) what factors are driving dairy system evolution in both countries? (iii) what are the potential consequences of these changes, and (iv) how do the ongoing changes enable or limit the resilience of dairy systems in the face of current and emerging challenges (climate change, growing population, insecurity, and conflict)? In this study, these questions have been answered using a series of interviews of herders and dairy sector stakeholders. An inventory was done of their answers, including their interpretations of dairy systems in Kenya and Senegal, and analyzed to provide answers to the specific questions of this research. The specific objectives of the inventory and analysis of stakeholder perspectives carried out in the study were to identify, for dairy farming systems in the study countries, plausible scenarios of system evolution that represent the major tendencies in these countries. This was done without attempting to explore all possibilities of evolution of the dairy systems. This study further sought to identify, also through the interviews, the drivers and potential consequences of scenarios recognized by the dairy system stakeholders, and their implications for resilience of the dairy systems to current and future challenges. A literature review was conducted to initially characterize the dairy systems in Kenya and Senegal. This review provided the context for determining what stakeholders to engage with, where, and how. It also provided a knowledge base against which data emerging from the interviews could be compared.

The next section presents an overview of dairy farming systems in Kenya and Senegal compiled from the literature, followed by a description of the methods used to answer the research questions posed, after which the results of the foresight study are presented and their implications discussed. The discussion on implications allows to put the responses into perspectives while capturing the perspective of interviewees.

According to the literature, dairy farming systems in Kenya can be divided into three general categories: grazing systems, zero grazing systems, and semi-zero grazing systems (van der Lee et al., 2016; Kibogy, 2019) (see Table 1). These systems mainly differ based on their management practices, such as in the choice of cattle feeds, housing, grazing practices, and animal breeds.

Three dairy farming systems are also observed in Senegal: pastoral (also called sylvo-pastoral) systems, agro-pastoral systems, and intensive systems (see Table 2; Dieye et al., 2005; Magrin et al., 2011).

2. Methods

Three research questions, namely (i), (iii), and (iv), were answered using a foresight method called the futures wheel where technical experts and key stakeholders of the dairy systems in Kenya and Senegal were interviewed. Research question (ii) was answered using a combination of the same foresight method and literature review.

Expert and stakeholder knowledge was obtained from individuals representing a diversity of local actors from the dairy value chain in both countries (herders, dairy cooperatives members, consultants, university professors, public and private sector, etc). A foresight tool called the futures wheel was used to conduct interviews of the experts and stakeholders. Along with first-order impacts of a trend or a change (i.e., impacts being a direct consequence of the change), this qualitative foresight method analyses second order impacts (i.e., the consequence of the consequence), and beyond (Inayatullah, 2008) through a structured brainstorming (Glenn, 2009; Bengston, 2016). The futures wheel was invented in 1971 by Glenn (2009) and helps to organize, understand and clarify different future elements and their possible influences (Toivonen and Viitanen, 2016). Despite its simplicity, the futures wheel is seen as an effective method to investigate the future and allows to investigate several possible development paths for the future (Glenn, 2009). The futures wheel method was chosen as it is a method that seeks to outline an issue or a change, and outline its consequences within the context of the longer-term future (Inayatullah, 2008).

The futures wheel method was utilized with all experts and stakeholders interviewed, with little variations in its application to interviews of herders versus non-herders. After gathering information on the production and practices, the following two questions was posed to the herders regarding the future of dairy systems: (1) "What do you wish for you and your children in the future?" and (2) "How do you think dairy activities will change?." The future was here characterized as the coming 10 to 15 years and/or when children become old enough to be herders themselves. For non-herders, the equivalent question posed was « In your opinion, how will dairy activities change in the future, and what would be the consequences of this change?." After obtaining responses to understand how each expert foresees the evolution of dairy farming in their respective country, the futures wheel was then used to investigate perceptions about the consequences of the evolution of dairy farming. This component of the exploration mainly concerned the environment and the economy. Data were collected, aggregated, and analyzed with the use of an online tool (called Klaxoon) to organize the responses from the interviews into emergent scenarios.

The same methodology was applied in Kenya and in Senegal.

TABLE 1 Description of dairy farming systems in Kenya.

Grazing	Short summary	Cattle graze on pastures with or without feed supplementation and low to medium external input levels.
	Breed	Local – Zebu purebred (uncontrolled)[1] or crossbred (controlled)[2]
	Milk production	~2–5 L/cow/day
	Market access	Poor market access, mainly for self-consumption or milk sells directly to consumers
	Land availability	High
	Location	Uncontrolled[1] grazing: Pastoralist areas, Western and Eastern Region Controlled[2] grazing: Central Region, Rift Valley
Semi grazing	Short summary	Cattle are partly confined, mixing grazing during the day and confinement at night with feed supplementation.
	Breed	Exotic – Fressian crossbred or Ayshire crossbred
	Milk production	~6–10 L/cow/day
	Market access	Medium market access, milk sells to consumers or cooperatives
	Land availability	Medium
	Location	Central Rift, Western Region, Eastern Region, South Rift
Zero grazing	Short summary	Cattle are always stall-milked and stall-fed, using cut- and carry fodder as well as concentrates and supplements, with high external input levels and high level of management.
	Breed	Exotic – Fressian or Ayshire crossbred or purebred
	Milk production	~7–12 L/cow/day
	Market access	Market oriented, milk sells to traders or dairy cooperatives
	Land availability	Scarce
	Location	(Peri)-urban areas, Central Region, Central Rift, South Rift

Author's compilation using Bebe et al. (2003), Makoni et al. (2014), van der Lee et al. (2016), Odero-Waitituh (2017), and FAO (2018b).
[1]Uncontrolled grazing: cattle roam on communal lands in search of water and fodder, with unimproved pastures, limited supplementation, and low levels of use of external inputs.
[2]Controlled grazing: cattle graze on private lands, fenced, or divided in paddocks, with use of artificial insemination, possible supplementation, and medium level use of external inputs.

TABLE 2 Description of dairy farming systems in Senegal.

	Pastoral	Agro-pastoral	Intensive
Short summary	Cattle are mobile on long distances (nomad herders), extensive, mostly for self-consumption	Agriculture/livestock integration, mostly multifunctional objective (manure, draught power, production, self-consumption)	Stall-fed and stall-milked with a production objective
Feed	Grass, residues (dry season)	Grass, residues, crop concentrates	Grass (mainly fed as cut-and-carry), residues, crop concentrates, supplements
Breed	Local – Zebu Gobra	Crossbreed – Zebu Gobra, Djakoré, Ndama	Exotic – Montbéliarde, Jersiaise, Holstein, Gir
Milk production	~0.5–2 L/cow/day	~6 L/cow/day	/
Market access	Low	Medium	High
% of national livestock	32%	67%	1%
Location	Ferlo region and around the Senegal river	Other areas of the country	(Peri)-urban – Niayes zone, Dakar, Thiès

Dieye et al. (2005).

3. Results

The study focused on counties from the old Central and Rift Valley provinces of Kenya (specifically, Nyeri, Nyandarua, Murang'a, Nakuru, Bomet, and Kericho counties). In Senegal, the geographical focus of the study was an area in the north of Senegal spanning from the Senegal river to the Ferlo region (specifically, Saint-Louis, Louga, and Matam regions). These areas of Kenya and Senegal are important for dairy farming, having high numbers of dairy cattle (FAO, 2018b), and high milk production potential plus, high demand for milk and dairy products. Milk productivity per cow remains rather low in these regions placing pressure on the dairy production systems to undergo changes such as organization of markets and supply chains as well as re-structuring of production systems to reach their potential.

3.1. Present situation for the foresight study

In total, twenty-eight experts and stakeholders in Kenya and twenty-five in Senegal were interviewed (see Figure 1), with half of them being herders (twenty-six herders in total). Among these

herders, twelve were herders in Kenya coming from Bomet or Nyandarua counties, all belonging to dairy cooperatives, and fourteen herders in Senegal coming from Richard Toll, Saint-Louis and Dahra areas with only four being affiliated to a dairy cooperative. Most herders – 50 percent in Kenya and 78 percent in Senegal – were aged 50 years old or above, as it is common in the study locations of both countries that the household head remains in charge of cattle until his sons inherit the cattle herd. Most of the interviewed herders in Kenya (seven) have adopted grazing systems, three practice semi-grazing, while two herders practice zero-grazing. Ten of the herders in Senegal are agro-pastoralists, three are pastoralists, and one practices intensive production (see Tables 3, 4). Herders interviewed in Kenya own between one and five cows, while the herders included in the study in Senegal possess between 3 and 15 lactating cows in herds of 15 up to 400 cattle. All herders combine dairy production with various other agricultural activities: small ruminant and poultry production mainly, but also fodder production, vegetable gardening, rice growing next to the Senegal river, and cereals, legumes, bananas and tea growing in Central Kenya.

Other experts were interviewed in addition to the herders (see Figure 1), namely, non-academic researchers (three in Kenya and five in Senegal) affiliated with international research organizations, and academic researchers (two in Kenya being also professors and one in Senegal) affiliated with different universities. These researchers had expertise in agricultural economics, smallholder herder systems, livestock feeds, livestock production systems, animal health, and animal breeding. Six technical and advisory consultants were also interviewed in Kenya that had expertise in dairy production, feeds, or milk quality. Interviewed dairy value chain actors included dairy managers and directors, and chairpersons of dairy cooperatives. Finally, experts were interviewed from other institutions in the public sector, the private sector and from herder associations.

Milk production among herders interviewed in Kenya varies between 5 to 13 L/cow/day, with an average of 7.8 L/cow/day, all with crossbreeds cattle (mainly Freisian and Ayrshire). Milk productivity does not seem to correlate with production systems as both the lowest and highest values of milk production were reported in grazing systems (see Table 3). On the other hand, milk production among interviewed herders in Senegal clearly varies among production systems and is associated with differences in cattle breeds (see Table 4). For the local breed in Senegal (Gobra Zebu), milk production varies between 1.5 to 6.5 L/cow/day, with an average of 2.5 L/cow/day. Herders in Senegal possessing crossbreeds (mix between Gobra Zebu and exotic breeds such as Montbeliarde, Holstein, Normande, or Guzerat Zebu) have milk productivity varying between 10 and 20 L/cow/day. The intensive farm, with exotic breeds (mainly Holstein), has a production of 15 L/cow/day. It is also noticeable that the youngest herders in Kenya, i.e., aged between 30 and 40 years old, have the highest milk productivity with 10 L/cow/day on average, compared to the oldest herders, i.e., aged over 60 years old, with the lowest milk productivity of 5 L/cow/day on average (see Table 3).

3.2. Evolution of dairy farming systems

This section answers the research question (i) how are dairy systems evolving in Kenya and in Senegal?

Based on the futures wheel method, three major scenarios were identified and discussed by experts and stakeholders in central regions of Kenya as the important trends that are either happening currently or have potential to dominate in the future (see Table 5). The first evolution scenario identified is the emergence of commercial and intensive zero-grazing systems in which farms own around ten lactating cows, and mainly purchase feeds externally. In that scenario, in the longer term (>15 years), it is envisioned that there will be fewer farms and fewer dairy herders than today, but these farms will have higher productivity and production. Smallholder operations (<5 cows) will slowly decrease in number, without disappearing completely and will serve mainly household own consumption needs. As some experts mentioned, the Rift Valley region still possesses larger

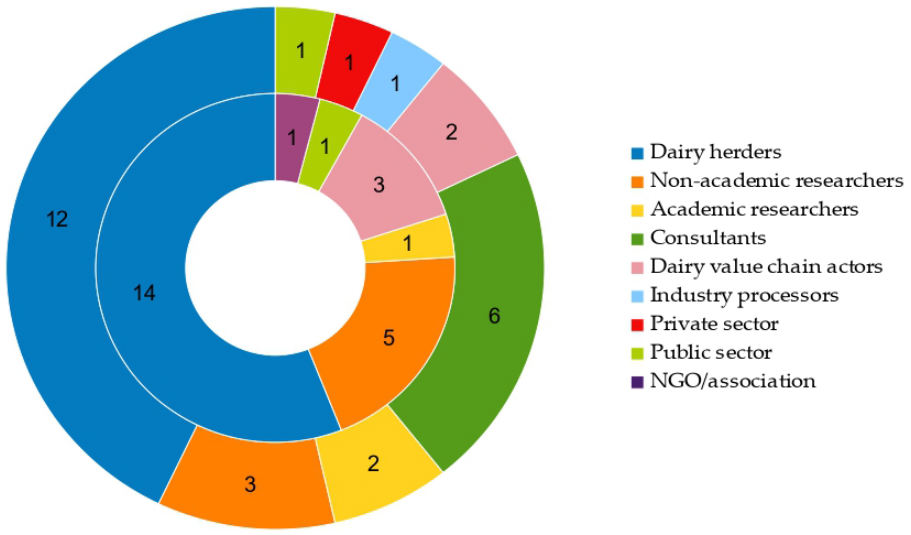

FIGURE 1
Number of interviewed experts and stakeholders in Kenya (outer circle) and Senegal (inner circle) according to their profession during the study (Authors).

TABLE 3 Characteristics of interviewed farmers in Kenya.

Dairy systems	Age group	Number of cows	Milk production (L/cow/day)
Grazing	30–40	2	8
	30–40	2	13
	30–40	5	8
	>60	1	5
	>60	1	5
	>60	2	/
	>60	4	/
Semi-grazing	40–50	3	6
	40–50	2	8
	30–40	4	11
Zero-grazing	50–60	3	8
	50–60	2	6

Authors compilation of information.

TABLE 4 Characteristics of interviewed farmers in Senegal.

Dairy systems	Age group	Total number of cattle (lactating cows)	Milk production (L/cow/day)	
			Local breeds	Crossbreeds/exotic
Agro-pastoralist	>60	400 (10)	2	–
	>60	50 (unknown)	1.5	–
	50–60	50 (10)	1.5	–
	50–60	30 (10)	1.5	–
	>60	20 (5)	1.5	–
	50–60	15 (3)	–	17
	>60	Unknown (6)	–	17
	50–60	Unknown (4)	–	12
	40–50	20 (6)	–	12
	50–60	150 (10)	4	–
Pastoralist	>60	50 (/)	1.5	–
	>60	40 (6)	1.5	–
	40–50	45 (13)	6.5	18
Intensive	<30	50 (15)	–	15 (exotic)

Authors compilation of information.

land size than Central Kenya, implying that the shift toward zero-grazing systems in this region will likely occur at a slower pace.

The second scenario identified in Kenya is the shift from extensive grazing to intensive zero-grazing small-scale dairy farms. In this scenario, most dairy farms will remain as small-scale family managed farms (<5 cows), without an increase in herd size. Most experts agreed that extensive grazing systems would still exist but at a smaller extent. Some argued that small-scale intensive zero-grazing systems are not economically sustainable, as the cultural attachment of people to dairy breeding activities would still be very present, leading to unproductive and non-sustainable activities, therefore mainly maintained for own-consumption purposes.

The third scenario in Kenya envisions the grouping of small-scale herders into cooperative farms with around 30 to 100 cows per cooperative, and herders as the shareholders. Cattle belonging to each herder are kept together on one piece of land and managed together by the cooperative. In this context, herders could then allocate time and land to fodder and food production on their own non-communal land. According to some experts, this scenario is likely not going to happen in areas with larger land sizes, as herders with higher access to land would continue processing milk on their own.

The first two scenarios are seen as most likely by interviewed experts and stakeholders.

In Senegal, using the same method, two evolution scenarios emerged from the discussions with experts and stakeholders (see Table 6). According to interviewed experts and stakeholders, the evolution scenarios will occur more slowly in Senegal than in Kenya in the medium-to-long term (>20 years). This slow pace is attributed to many challenges and uncertainties facing the sector in Senegal. The first identified scenario is the complete settlement of herders, with a

TABLE 5 Evolution scenarios for dairy farming systems in Central Kenya.

	Commercial and intensive scenario	Small-scale intensive scenario	Cooperative scenario
Farming systems	Zero-grazing	Zero-grazing	Zero-grazing
Number of farms (compared to nowadays)	Few	Unchanged	Few
Number of cows per farm	~10	~5	30–100
Feed origin	Off-farm	Off-farm/on-farm	Off-farm
Management	Commercially managed (trained manager)	Family managed	Commercially managed (highly trained manager)

Authors compilation of interview answers.

TABLE 6 Evolution scenarios for dairy farming systems in north of Senegal.

	Full settlement scenario	Partial settlement scenario
Farming system	Agro-pastoralism and intensive	Agro-pastoralism mainly
Number of cows per farm	<30	~5 lactating cows (within a big herd)
Breeds	Crossbreeds or exotic breeds	Crossbreeds
Feed origin	Mainly off-farm and use of crop's by-products	Mainly on-farm and use of residues and crop by-products
Number of farms (compared to nowadays)	Very few	Few
Presence of pastoralism	Reduced	Unchanged

Authors compilation of interview answers.

decrease in herd size (maximum 20–30 crossbreeds or exotic breeds), and the slow disappearance of pastoralism. Due to lack of water and forages during the dry season, pastoralism would evolve toward total settlement of cattle. Under this scenario, animal feeds would either be produced off-farm or will come from by-products of agriculture (sugar cane, rice, straw). This intensification scenario would make multi-objective farms shift to specialized production and would imply a decrease in the total number of farms and herders as these turn to other activities.

The second scenario in Senegal is a partial settlement of some herders that have access to markets and/or directly to consumers. These herders would have a small sedentary production herd (maximum 5 crossbreed lactating cows) situated close to collect centers or consumptions centers while with the rest of the herd (local breeds) will be kept under more extensive and nomadic conditions. The extensive components of the herds would still be able to take advantage of natural dry forages and exploit areas unsuitable for agriculture and would still produce cattle meat, which is important culturally in Senegal. In this second scenario, dairy systems in Senegal would still exist in their current forms, albeit with a higher proportion of agro-pastoralists and intensive farms as well as improved conditions for pastoralists practising semi-intensive systems.

In both scenarios identified in Senegal, integration of livestock with crop agriculture is needed to utilize residues and by-products for cattle feed. Agriculture could continue to be rain-fed or may shift toward irrigation when this is possible (e.g., at locations close to rivers, lakes, or other water sources).

3.3. Drivers of change

The results presented in this section were obtained during interviews with various experts and stakeholders, and from the literature search. The section answers the research question (ii) what factors are driving dairy system evolution in both countries?

3.3.1. Kenya

Central Kenya and the center of the Rift Valley are dominated by "improved" grazing and semi-grazing systems. Since the independence of the country in 1963, a gradual shift toward zero-grazing has largely been observed, especially in some counties of these regions (e.g., Kiambu county, at the periphery of Nairobi). At that period, the government encouraged farming and delivered ownership title and loaning facilities so local farmers could own their private piece of land, especially in Central Kenya and the Rift Valley. In other areas of the country, such as the southern Rift Valley, lands are still owned communally. These rural development policies aimed to improve rural livelihood, including income, education, health and nutrition, reduce inequality, and enhance growth of the rural sector (Kirori, 2003). However, the process of distributing land ownership titles may have led gradually to land division over time. Traditionally, when a farmer dies, his sons inherit the land by dividing it. Average land size has therefore decreased from average 5 acres in 2010–2015 to between 0.5 and 2.5 acres on average today (Kimuge, 2021) and from 2.6 to 5 cows per farm between 1996 and 2020 (IFCN, 2021). Furthermore, high costs and difficulties in acquiring new land provide an incentive in Kenya for individuals to aspire to own their own plot of land, no matter the size (Hlimi, 2013). In addition to land fragmentation, this tradition results in habitat fragmentation, deterioration of land quality, tenure insecurity and conflict, among others (Hlimi, 2013). Zero-grazing systems are therefore seen as a solution to continue dairy farming in the future, even with smaller pieces of land per unit.

One major factor driving the adoption of zero-grazing in Kenya has also been the National Dairy Development Project (NDDP), initiated in the 1980s under the Kenya Ministry of Agriculture, Livestock Development and Marketing. This project has been

promoting establishment of intensive and stall-feeding units by farmers, in combination with adoption of the use of good quality fodder for feed (mainly Napier grass – *Pennisetum purpureum*) (Reynolds et al., 1996). Pilot farms with a zero-grazing model have also been established by international organizations and researchers, where farmers from Kenya, and from other African countries, are trained.

According to the interviewees, the gradual expansion of zero-grazing systems in regions where infrastructure is available is mainly driven by: better access to inputs (feed, artificial insemination, veterinary services), training, growing demand in urban areas, climate change, cultural change (young people are less willing to inherit farms), high cost of labor, and promise of high milk production, productivity, and income.

3.3.2. Senegal

Dairy systems in the north of Senegal are largely dominated by agro-pastoralists and pastoralists. Few intensive farms are also present, with exotic breeds imported mainly from Europe. Sedentary systems – agro-pastoralists and intensive farms – are mainly present close to urban areas and next to the Senegal river and water points. While sedentary systems are inclined toward milk production, traditional pastoralists are more oriented toward production for own-consumption and calf breeding (live animal sales). These systems are facing major challenges related to resource access during the dry season.

Experts and stakeholders in Senegal indicated that the government of Senegal developed irrigated rice agriculture along the Senegal river in the 1960s, which directly affected the traditional patterns of cattle movements. As natural fodder growing close to the river became unavailable, herders and their animals were pushed further south in search for forages. Following some recent difficult years with high cattle mortality and unavailability of forage due to droughts since 2011 (Reliefweb, 2018), evolution of the dairy production seems to be toward restricted animal movements as a climate change adaptation strategy. This is particularly true for herders close to the Senegal river, where feeding from agricultural residues and by-products (rice or sugar cane) is available perennially, and where the location of dairies and urban markets nearby provide ready access to markets (e.g., Laiterie du Berger in Richard Toll and mini-dairies).

In 2018, the Laiterie du Berger introduced "mini-farms" to their supplier herders. These mini-farms allow herders to keep a small number of productive cows (often crossbreeds) under sedentary conditions. According to dairy experts, other than milk production, mini-farms could allow the breeding of high value calves having higher economic value to the herder. This in turn can improve the genetic quality of the herd. Alongside a small, sedentary and productive herd, herders keep a mobile herd that could better utilize available dry forages due to their mobility.

Driven by these changes – closing of nomadic patterns along the river, droughts affecting the availability of natural forages and water, the opening of new markets in form of dairies – the evolution of dairy farming systems in Senegal seems toward (partial) sedentary lifestyle. According to experts, other drivers of change are: economic opportunities that are improving incomes and livelihoods, the growing demand for local milk and dairy products, access to training for herders, and increased school attendance of pastoralists' children (so that they are no longer readily available to care for the family cattle). In addition, increased scarcity of grazing lands, including due to the increase of agricultural and urban land use leads to more intense competition for land which is noted to sometimes lead to conflicts, with, for example, agribusiness establishments located around rivers or production basins cutting off traditional paths for nomadic livestock migration and preventing access to water points.

3.4. Potential consequences of the evolution of dairy systems

This section answers the research question (iii) what are the potential consequences of these changes?

3.4.1. Kenya

Direct and indirect environmental and socio-economical consequences were identified for the three potential scenarios of dairy farming evolution in Kenya (see Figure 2). They were identified by experts and stakeholders using the futures wheel method.

Multiple impacts were identified. The main positive environmental impacts identified by at least four experts for the three scenarios are: minimal dependence of feed production on climatic events due to the increased distribution of production to various regions of the countries, decrease in methane emissions per cow due to better feeding practices and better breeds, increased potential for biogas production, and reduced over-grazing and damage to biodiversity. Negative impacts that were identified include accumulation of waste (manure and feed waste) from increased production, higher nitrogen and phosphorus pollution, and decline in animal health due to increased confinement.

For socio-economic impacts, experts and stakeholders identified the possibility to have better nutrition and food security due to an increase in milk production, and a boost in the country's economy and in herder livelihoods due to increased net incomes. Some experts argued that a transition to zero-grazing is not economically sustainable as production costs (mostly feeds) will remain too high for dairy farming to become profitable, especially for small-scale herders. Without financial support, most herders would not be able to practise zero-grazing, resulting in less farm employment and decreased numbers of smallholders. To other experts, intensive and commercial farms are seen as attractive for employment even though they would only benefit a small number of people as the number of farms is likely to decrease.

3.4.2. Senegal

In Senegal, the futures wheel method identified direct and indirect environmental and socio-economical consequences of two potential scenarios of dairy farming evolution (see Figure 3).

Many of the potential impacts of evolution scenarios in north of Senegal that were identified by experts and stakeholders are like the ones reported from Kenya: livelihood improvements, high production costs, air and water pollution, reduction in over-grazing, increase of manure burden, disease spread, etc. The envisioned increase of milk production and productivity is also explained by use of more productive animal breeds and better cattle feeding explained, which in turn are traced to, in this case, agriculture/livestock integration. This is in contrast with the findings from Kenya, where the use of feeds purchased from external or off-farm sources was identified as the main reason for increased milk production and productivity.

Concerning herd size, at national and farm levels, farm sizes could either decrease due to better milk productivity per cow, or the

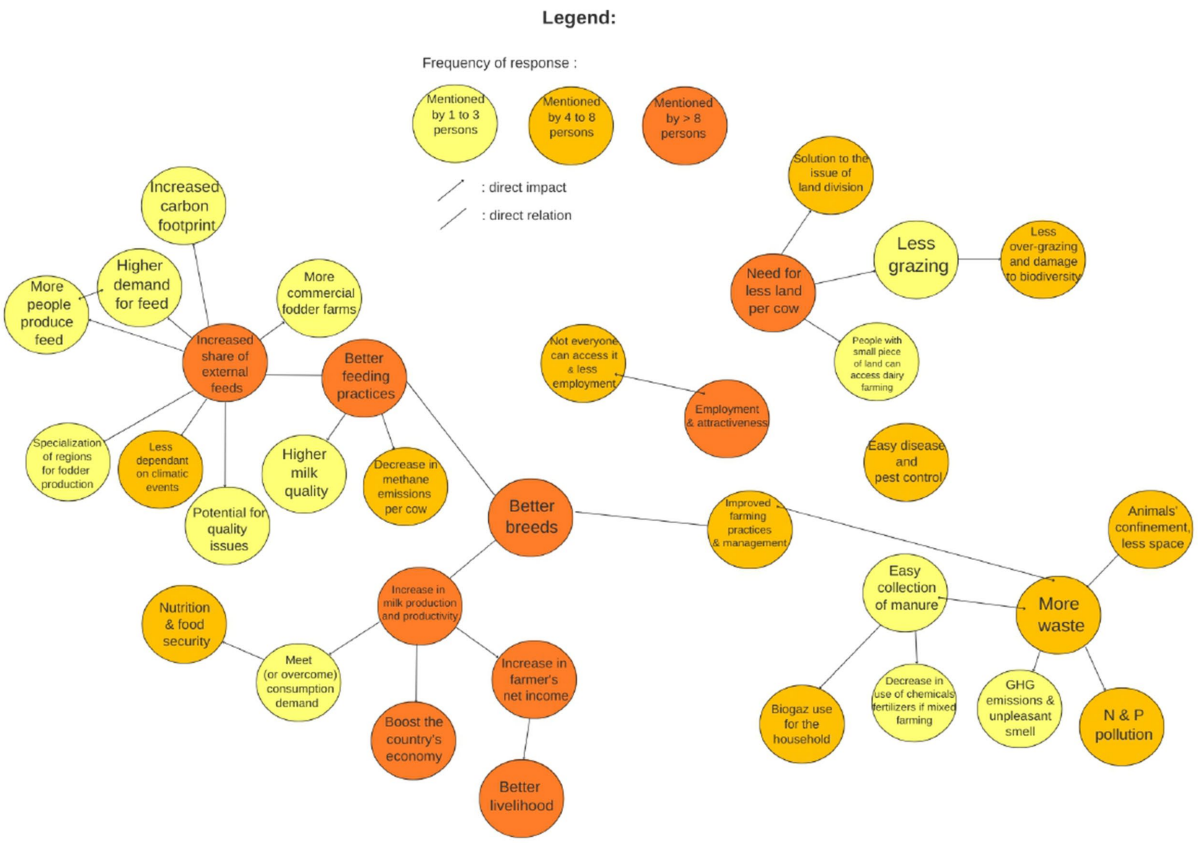

FIGURE 2
Map of the main potential direct and indirect impacts of the three evolution scenarios for dairy farming systems in Central Rift Valley according to the interviewed experts and stakeholders (Authors).

attractiveness of milk production and its income leads to an increase in herd size leading to an increased in environmental impacts and in meat availability.

3.5. Resilience of future dairy systems

This section answers the research question (iv) "how do the ongoing changes enable or limit the resilience of dairy systems in the face of current and emerging challenges (climate change, growing population, insecurity, and conflict)?," and derives from interviews of experts and stakeholders from the dairy value chain.

3.5.1. Resilience to climate change

Intensification or semi-intensification is seen by some experts and stakeholders as a solution for reducing the impacts of dairy farming on climate and the environment and as a mean for these systems to be less strongly impacted by climatic events (e.g., droughts, erratic rains, high temperatures). However, according to other experts as well as based on field observations, it seems that dairy systems will nevertheless have to face several challenges linked to climate change. These include:

1. Feed scarcity, particularly during the dry season, and decline in pasture quality (soil quality, diversity of fodder species);
2. Water shortages and/or difficulty to access water (high price, monopoly of water points by agribusinesses, conflicts over water);
3. Threats to animal well-being (heat stress, lack of movement) and animal health (high mortality rate, reproduction issues, spread of diseases);
4. Milk quality decline due to animal diseases, potential contamination from externally produced feed, unhygienic milking practices, and suboptimal milk storage and transportation.

To address these challenges, future dairy systems will need to adopt a range of climate change adaptation strategies. Results emerging from the futures wheel suggested that the main climate threat to intensive sedentary systems, in both Kenya and Senegal, is the difficulty in supplying cattle with quality feed. Therefore, when land is available in abundance, integration with agriculture to gain sufficiency in fodder production, and not depend on off-farm feed, is needed. On the contrary, when land is largely unavailable, herders must rely on externally produced feed that could be less impacted by adverse climatic events. In this context, various areas producing feeds commercially and unaffected by the adverse events could sustain affected areas. However, externally produced feed is more prone to market price fluctuation related to economic or political events, as well as raise potential feed

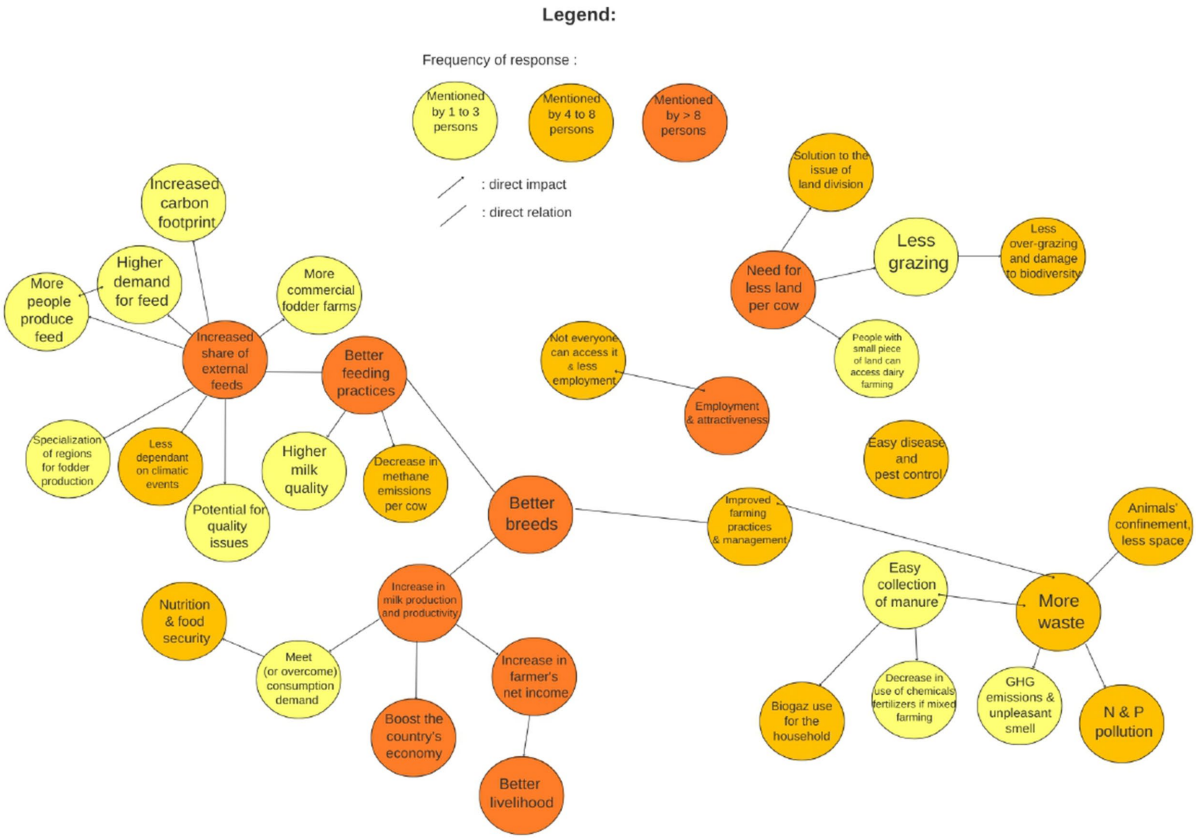

FIGURE 3
Map of the main potential direct and indirect impacts of the two evolution scenarios for dairy farming systems in northern Senegal according to the interviewed experts and stakeholders (Authors).

quality issues that require increased government regulations and/or the enforcing of standards. In either case of land availability, an additional strategy to limit climate impacts is to store fodder when they are available at a lower price (e.g., during the rainy season) which can then be provided to the herd during the dry season.

Finding a balance between productivity and environment protection and adaptation could be the key for sustainable milk production in the future. Practices identified by experts and stakeholders to maintain this balance include the use of locally adapted seeds (e.g., short cycle, highly digestible), and animal breeds (crossbreeds), biodiversity protection and reforestation, soil management and productivity, establishment of protected areas for natural fodder regeneration, integrated fodder production (circulation of nutrients through feed and manure, irrigation), and use of off-farm feeds (fodder conservation and productivity, new technology such as hydroponics).

The expert and stakeholder knowledge, particularly that emerging from the interviews of herders, suggested that the resilience of intensified dairy systems to climate change will also depend on the level of sensitization of herders. Further, focusing solely on strategies that address economic and productivity concerns, without considering sustainability and environmental issues, and the maintaining of equilibrium within production systems, should be avoided. To this end, providing information and training to herders and other dairy value chain actors, about how to manage emerging environmental challenges, will be key for resilience and adaptation. Such training could be implemented by NGOs, associations or cooperatives, while aligned with relevant government policies, but will need to take into account the culture and traditions of herders and others in the dairy systems.

Finally, according to some experts and stakeholders, settlement and intensification of herders might be an issue in the long-term since the herders could lose flexibility and adaptation capacities. In case of extreme climatic events, herders cannot adapt their feeding practices as they used to when they were more mobile. On the other hand, as settlement limits movements of animals in search of feed, it also limits unnecessary energy expenditure, allowing animals to allocate energy more effectively to milk production. However, intensification and settlement might not be the only viable options for the future. For herders who own reasonable tracts of land, (semi-)grazing systems could be a better solution as it address some issues that arise from to the confinement of animals such as poor hygiene of animal facilities, or non-autonomy regarding farmers' cattle feeding options.

To improve sustainability of dairy systems in the future, cooperation, diversity and adaptation of each dairy production system to local constraints and challenges, depending on land availability, agro-climatic context, and market access is the key.

3.5.2. Resilience under growing human population and higher food demand

The populations of Kenya and Senegal grew at the rates of 2.25 percent and 2.7 percent, respectively, in 2020 (The World Bank, 2022). Study interviewees thought that intensive and semi-intensive systems could increase milk production and productivity to supply the increasing demand for milk and dairy products in both countries. According to the expert and stakeholder interviews and observations from the field, dairy farming is facing three main challenges to meet the growing demand in milk and dairy products:

- High production costs (especially in relation to feeds, water management, and cattle reproduction);
- Market access as milk must be collected, transformed, and distributed to consumers – mainly in urban centers. There emerges a strong need for appropriate infrastructure, road networks, and re-organization of the dairy value chains;
- Territorial pressure with the increase of urban and agricultural lands.

From the futures wheel implementation, it emerged that direct sale of milk to consumers by herders or cooperatives could help Kenya better meet the increasing demand for local milk and allows herders to sell milk at a good price. When direct sale is not possible (e.g., when producers are located far from consumption centers), the organization of herders within cooperatives and/or (mini)dairies could help. Having higher numbers of dairies could increase the absorption capacity for locally produced milk and help fight against milk supply instability throughout the year. This can only be possible if the needed resources are available (especially feed – with an association with agriculture residues and by-products), and if producers have good access to markets. For the dairy value chain to be stronger and better organized (in terms of milk collection, transformation, and sales), there is a strong need for policy oriented toward supporting them. One question for the future is therefore to define the desired role, within the economy and territory, of dairy farming in the overall agricultural development of the country.

Milk production and stability throughout the year will likely help to decrease milk price volatility, according to experts, as there are strong differences in milk production quantities between dry and wet seasons. Based on the expert and stakeholder discussions, increase in milk production could also boost the national economy as well as farmers' livelihoods, and decrease imports of milk and other dairy production in the long term.

In Senegal, experts proposed the imposition of taxes on imported milk and dairy products to promote growth of the local dairy industry, at least in the short term. However, this will lead to increases in the prices of imported dairy products, and potentially to negative socio-economic impacts on vulnerable consumers in the short term. In the long-term, restrictions on imports could spur development of the local dairy sector, with potential to help (particularly dairy producer) households move out of poverty, like has been demonstrated previously in Bangladesh (FAO, 2009).

3.5.3. Resilience to insecurity and conflicts

Insecurity and conflicts over resources and land emerged as a common theme in the stakeholder interviews conducted in Senegal. According to experts and dairy system actors, the conflicts arise mainly due to confrontations between herders and farmers as cattle graze on agricultural lands. This phenomenon was less emphasized in the interviews in Kenya. Increased settlement of animals could improve the situation in Senegal as the movements of animals outside of a producer's own land decreases, creating fewer opportunities for conflicts with farmers. Keeping productive cattle enclosed close to the farms or homesteads could also prevent cattle theft even if cattle of high value (e.g., crossbreeds or exotic breeds) would be more prone to theft. However, settlement of herders could also create conflicts with farmers over land and water as herders would prefer to settle down on land with access to water points.

Animal movements may need to be more organized in the future to avoid conflicts with, as proposed by experts, movement calendars agreed within communities/regions, or the establishment of well managed and dedicated places for pastoralism (e.g., Ranch de Dolly in Senegal). Under such arrangements, cattle could in addition benefit from increased ease of veterinary and extension services to extend veterinary health coverage to the animals.

4. Discussion

4.1. A general trend for the evolution of dairy systems in Kenya and Senegal

Dairy sectors in Kenya and Senegal have a wide range of effect on society, contributing to livelihoods, food security and nutrition, while being a major consumer of natural resources, and present public health threats (FAO, 2018a). Dairy farming systems will likely undergo major changes. Potential evolution scenarios in Kenya and Senegal, identified in the result section, can be thought to represent global trends of change without being fully exploratory. Hence, not all possible evolution scenarios are explored in this study, but only those observed during field trips as well as elicited during the interviews of dairy system actors and stakeholders. Scenarios identified for both countries were found to be quite similar, as they are following a current trend.

Intensification seems to be the preferred and foreseen evolution scenario in both countries by the majority of interviewees. However, the pace of evolution will appear to be different in Kenya than in Senegal. Intensification of dairy production is already happening in some parts of Kenya, such as urban and peri-urban areas, due mainly to land unavailability. Further, as they observe increased productivity and higher incomes of other dairy producers, many dairy herders in the country express their desires to experience same. On the contrary, dairy systems are evolving more slowly in north Senegal than observed for Central Kenya, which is a commercially oriented region for dairy production. Many stakeholders expressed during interviews that the study region in north Senegal might not experience major changes within the next few coming decades. This could be due to the specific agro-climatic context of this part of Senegal inducing many challenges such as water and feed availability and could also reflect strong pastoralist culture and tradition.

4.2. Ideas for the main focus areas in dairy research and policy

One focus area to consider by dairy research and policy when intensifying production is the environmental impacts of such growth in production. Even if methane emission can decrease on a per cow basis, for example owing to improvements in the quantity and quality of the animals' diet (Kasyoka, 2020), there is a possibility of higher greenhouse gases (GHG) emissions in overall due to higher input levels and increased numbers of animals. Intensification of dairy production systems also opens new constraints and opportunities regarding manure management. If poorly managed, manure can lead to increased levels of water and air pollution. However, manure could also serve positive functions in the system, for example if used to produce biogas – a combination of methane and carbon monoxide generated during anaerobic digestion of manure (KENPRO, 2022) as witnessed during field visits. Many households in Africa face insufficient energy supply and rely on wood and other non-sustainable fuel sources for cooking, contributing to both increased GHG emissions and deforestation. Biogas could be a solution as an alternative source of energy to deal with issues of GHG emissions and manure disposal (KENPRO, 2022). Manure can also be collected and transformed to be used as organic fertilization in crop production.

Cattle diseases are a major public health issue. Extensive grazing systems have a higher prevalence rate for East Coast Fever and Brucellosis (FAO, 2018a), and many studies observed higher prevalence of nematode gut parasites and liver fluke in these systems (Arnott et al., 2015). In the meanwhile, other health and well-being issues tend to emerge within high confinement systems, such as lameness, mastitis, uterine diseases, and various infectious diseases (Arnott et al., 2015).

Another area to focus on would be market access and the dairy value chain organization. As milk production and productivity are expected to increase with intensification, according to stakeholder opinions, systems with higher capacities for milk to be collected, transformed, and distributed to consumers will be needed. Milk collection and transformation system and dairy systems evolution are mutually influencing each other transforming the dairy value chain to commercialize locally produced milk (Wane et al., 2017). As an example, the Laiterie du Berger in Senegal is a unique collect and milk commercialization firm linking market accessibility with key factors in dairy production systems evolution such as feed access, contracts with herders, and animal settlement (Wane et al., 2017). Market accessibility here solely concerns formal markets. Concerns also raised during some interviews about the evolution of informal markets and their effect on prices paid to herders. Specifically, milk prices paid to farmers could decrease when sold through formal markets, whereas milk price would not change for consumers. On the other hand, deliberate policy and related support to dairy value chain actors will need to be effected to minimize potential for loss of milk quality often associated with an increased role of informal markets in the supply of dairy products (Grace et al., 2020).

Whereas intensifying their use of inputs (such as feeds) could improve herders' livelihoods through higher productivity and production, and increased incomes, the experts and stakeholders interviewed highlighted challenges that herders face, including high production and investment costs. To enable herders in Kenya and Senegal to move to more intensified production, stakeholders identified the need for increased access to credit and other financing mechanisms, as well as access to relevant technical and management training. Interventions that seem to meet these criteria, and which are already being adopted in the study countries include the installation of biogas production units and solar panels, establishment of seed systems for forages and other feeds, creation of serviced mini-farms and use of improved genetics including crossbred cows for dairy production.

4.3. Evolution of Kenya and Senegal within their respective region

During the course of the interviews, stakeholders were also asked about the evolution trend in neighboring countries of Kenya and Senegal and their respective region. Regional trade – in feeds, milk, and live animals – seems to be similar between Kenya and its neighbors in East Africa, and between Senegal and neighboring countries in West Africa. The evolutionary paths of the dairy production systems in both countries may, however, differ.

Even if most countries in East Africa are moving toward zero-grazing, dairy farming systems in Kenya are somewhat different. Zero-grazing systems are currently more evolved in Kenya than in the other countries in the region, with Kenya being ahead in the area of technology adoption. Kenya is also the largest consumer of milk in East Africa with high levels of consumption per person. This high demand stimulates the national dairy sector but also attracts milk imports from neighboring countries. Compared to Kenya, for example, Ethiopia, Tanzania, Uganda, and Rwanda possess low levels of milk production and productivity. However, these countries are also slowly adopting zero-grazing. As they possess larger land size and good climatic conditions for grazing systems, the adoption of zero-grazing is at a slower pace than Kenya. Due to low production costs in Uganda and Tanzania, there is also a possibility that these two countries could become more competitive than Kenya in the future.

Senegal possesses many similarities with other Sahelian countries – especially concerning their agro-climatic and political contexts. However, differences arise in production systems. Even though there is a settlement tendency all over West Africa, Senegal possesses more intensive and semi-intensive systems than other countries in the regional, particularly in the Sahel, where pastoralism remains the dominant system. Moreover Senegal as a coastal country possesses a humid coast and therefore good climatic conditions for dairy farming and agriculture (e.g., Niayes region). Senegal also has high intensification and investment opportunities.

4.4. Potential future opportunities for women and youth

Previous studies have shown that most women in cattle-keeping communities have traditionally taken care of the family's cows, handled feeding and milking activities, and tended to sick animals (ILRI, 2021). Yet most women do not own the cattle, as men are often the owners and managers of the herd. Women in addition usually lack access to essential resources like land, labor, or finance (ILRI, 2021). According to stakeholders, intensification of the sector, if guided to support women, could enable women to be active in dairy farming

and/or benefit from milk production increase, through participating in dairy cooperatives that could improve women's incomes and employment (Staal et al., 2020). Women interviewed in the study often noted that they are dependent on their husband for deriving the benefits from dairy farming activities. Against scenarios of increased intensification and settlement, most women indicated the wish to earn their own money to buy a house and to send their children to school while still taking care of the household. Investments in women-led farms could thus benefit their entire households, communities and nation (ILRI, 2022). It has also been found that increased participation of women in decision-making leads to better management of drought risks and decreases vulnerability to climate change (Grillos, 2018; ILRI, 2022).

According to the experts, youth are likely either turn to commercial dairy farms, shift to more productive crops (e.g., money crops such as avocados or horticulture in Kenya), or engage in other businesses. They will likely think commercial rather than traditional as they have less social attachment to tradition and animals than the elders, and will likely participate in training to obtain skills such as harvesting, making silage, etc. Farmer replacement rates might then slowly decline, making farming activities, including dairy, not a priority for younger generations. Many interviewees also thought that farmers' children will have to take over the farm and animals given limited alternatives in the form of employment and education.

4.5. Strength and weaknesses of the method

The contribution of this study lies mainly in the method used to interview a diverse group of dairy sector actors, experts and stakeholders, allowing participants to think about the future and of the links between the consequences and challenges associated with change (Bengston, 2016). However, it stands to reason that the output of the study is limited to the collective judgments of these experts and stakeholders (Bengston, 2016). There might also be potential biases concerning herders interviewed during the study, as in Kenya they were drawn from a pool participating in a dairy innovation platform close to urban and production centers. Hence, these herders are likely more familiarized with the evolution of dairy farming systems and have been targets already of sensitization and training on improved dairy production practices, making them more likely to include intensifying systems in their anticipation of the systems of the future.

The futures wheel remains, however, an appropriated method for this study and for answering the research questions. Indeed, interviews of experts and key stakeholders allow to identify diversified evolution of dairy systems and cover a multitude of potential consequences. The multitude of interviewees allow us to have various point of views about the research questions.

5. Conclusion

As the dairy sector will undergo changes in the future, and will face challenges such as population growth, climate change and insecurity and conflicts, there is a need for a holistic and integrated approach for future thinking, as well as training and sensitization that builds on the initial conceptualization. Changes in dairy production systems can also affect the autonomy of herders, having consequences on livestock and the society: loss of traditions and knowledge, loss of social links between communities, employment crisis, land use competition, biodiversity issues, etc.

The evolution of dairy systems in Kenya and Senegal seems to go toward intensification with potentially fewer but more productive farms. This evolution is driven by various factors such as land fragmentation in Kenya and government incentives, climate change, and new market opportunities in both countries. This evolution of dairy systems will potentially induce various environmental and socio-economic impacts that will affect the resilience of dairy farms to future challenges. In particular, this study highlights several challenges related to climate change: feed scarcity, water shortages, threats to animal well-being and health, and a decrease in milk quality. Both countries are also facing a growth in population. The challenges associated with the population growth are the difficulty to access markets for some herders, land pressure, and high costs of production. Finally, reduced grazing for cattle on agricultural lands through limited or planned movements of animals could increase the resilience of dairy systems to insecurity and conflicts.

Intensification of dairy cattle production could provide opportunities to women and youth. But these changes will also come with several challenges. For example, increases in productivity and income would potentially benefit only herders capable of accessing intensified systems as production and investment costs are high. Issue on herders' turn-over will also be a challenge as young people tend to abandon agriculture, preferring to migrate to cities to study or start other businesses. Even if GHG emissions per animal could be lower due to an improved diet, manure burden and total GHG emissions would increase, due to high input levels of production and input use. Expansion of agricultural and urban areas might also lead to conflict over land and resources.

Encouraging herders to produce more and better, while being sustainable for the future, is needed. This can be accomplished through climate-smart practices, the design and implementation of appropriate dairy and other policies, efficiency of production, and efficient coordination of contributing activities (e.g., animal breeding and agriculture). Finding a balance between dairy production systems and choosing the most appropriate system depending on the agro-climatic context, land availability, socio-economic context, production objectives as well as local constraints and current and future challenges seems essential to maintain balance and hence, resilience.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by ILRI IREC. The patients/participants provided their written informed consent to participate in this study.

Author contributions

LP and DE contributed to the conception, design of the work, discussing the results, and revising the manuscript. LP participated in the data collection and drafting the manuscript. DE contributed to the supervision of the work. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

References

Africa-milk. (2019a). Kenya. Available at: https://www.africa-milk.org/study-sites/kenya (Accessed February 7, 2022).

Africa-milk. (2019b). Senegal. Available at: https://www.africa-milk.org/fr/study-sites/senegal (Accessed March 3, 2022).

Arnott, G., Ferris, C., and O'Connell, N. (2015). "A comparison of confinement and pasture systems for dairy cows: what does the science say?" in *AgriSearch* (Belfast: Queen's University of Belfast).

Bebe, B. O., Udo, H. M. J., Rowlands, G. J., and Thorpe, W. (2003). Smallholder dairy Systems in the Kenya Highlands: breed preferences and breeding practices. *Livest. Prod. Sci.* 82, 117–127. doi: 10.1016/S0301-6226(03)00029-0

Bengston, D. (2016). The futures wheel: a method for exploring the implications of social– ecological change. *Soc. Nat. Resour.* 29, 374–379. doi: 10.1080/08941920.2015.1054980

Dieye, P. N., Broutin, C., Diao, M. B., Duteurtre, G., and Ly, C. (2005). Synthèse bibliographique sur les filières laitières au Sénégal. *Repol*.

Diop, A. T., Ickowicz, A., Diène, M., and Nzimulinda, J. C. (2009). Production laitière dans la zone sylvopastorale du Sénégal: étude des facteurs de variation et modes de gestion par les populations locales. *Rev. Elev. Med. Vet. Pays Trop.* 62, 39–47. doi: 10.19182/remvt.10092

FAO (2009). "Bangladesh: social gains from dairy development" in *Smallholder dairy development: Lessons learned in Asia*. ed. Food and Agriculture Organization of the United Nations; Regional Office for Asia and the Pacific. (Bangkok, Thailand: Animal Production and Health Commission for Asia and the Pacific).

FAO. *Integrated snapshot – Kenya – cattle and poultry sectors. Africa sustainable livestock 2050*. Rome: Food and Agriculture Organization of the United Nations. (2018a).

FAO. *Livestock production systems spotlight – Kenya – cattle and poultry sectors. Africa sustainable livestock 2050*. Rome: Food and Agriculture Organization of the United Nations. (2018b).

FAO. (2022). Statistics. http://www.fao.org/statistics/en/ (Accessed September, 6 2022).

FAO and GDP. *Climate change and the global dairy cattle sector – The role of the dairy sector in a low-carbon future*. FAO and GDP: Rome. 36, (2018).

FAOSTAT. Food and agriculture Organization of the United Nations. Available at: https://www.fao.org/faostat/en/#home (Accessed June 6, 2022).

Glenn, J. C. (2009). "The futures wheel" in *Futures research methodology – version 3.0, the Millenium project; 3.0 edition*. The Milennium Project for GRET/APESS, 2016: GRET/APESS.

Grace, D., Alonso, S., Bett, B., Lindahl, J., Patel, E., Nguyen-Viet, H., et al. (2020). "Food safety and nutrition" in *The impact of the international livestock research institute*. eds. J. McIntire and D. Grace (Nairobi: ILRI and Wallingford UK, CABI), 338–365.

GRET/APESS. *Promouvoir l'élevage Agropastoral Au Sénégal*. (2016).

Grillos, T. (2018). Women's participation in environmental decision-making: quasi-experimental evidence from northern Kenya. *World Dev.* 108, 115–130. doi: 10.1016/j.worlddev.2018.03.017

Hlimi, T. (2013). Fragmentation and subdivision of land in Kenya. Legal Aid Kenya (blog). Available at: https://legalaidkenya.wordpress.com/2013/06/14/fragmentation-and-subdivision-of-land-in-kenya/

IFCN. *Dairy report 2021 – Helping people in the dairy world to make better decisions*. IFCN: The Dairy Research Network. (2021).

ILRI. *USAID Kenya crops and dairy market systems activity – dairy value chain assessment. Technical Report*. Nairobi: RTI International. (2018).

ILRI (2021). "Women's empowerment leads to healthier people, animals and environments" in *Livestock pathways to 2030: One health* (Nairobi: International Livestock Research Institute)

ILRI (2022). "How does livestock farming support gender equality?" Why livestock matter. Available at: https://whylivestockmatter.org/messages/how-does-livestock-farming-support-gender-equality (Accessed March 11, 2022).

Inayatullah, S. (2008). Six pillars: futures thinking for transforming. *Foresight* 10, 4–21. doi: 10.1108/14636680810855991

Kasyoka, S. (2020) New study finds that severe undernutrition of cattle increases their methane production. Sustainable livestock systems (blog). Available at: https://livestocksystems.ilri.org/2020/05/22/new-study-finds-that-severe-undernutrition-of-cattle-increases-their-methane-production/ (Accessed May, 22 2020).

KENPRO. (2022). An overview of biogas, its benefits and uses. Kenya projects organization KENPRO (blog). Available at: http://www.kenpro.org/an-overview-of-biogas-its-benefits-and-uses/ (Accessed February 21, 2022).

Kibogy, M. R. *Kenya dairy industry: Status and outlook*. Nairobi: Kenyatta International Conference Centre. (2019).

Kimany, J. (2021). The Kenya livestock master plan process initiated to enhance sustainable development and investment in the sector. International livestock research institute (ILRI). Available at: https://www.ilri.org/news/kenya-livestock-master-plan-process-initiated-enhance-sustainable-development-and-investment

Kimuge, S. (2021). Why unchecked land subdivision threatens Kenya's food security. Business daily. Available at: https://www.businessdailyafrica.com/bd/data-hub/why-unchecked-land-subdivision-threatens-kenya-s-food-security-3489164

Kirori, G. *Rural development policies in Kenya: a critical analysis*. Nairobi: University of Nairobi. (2003).

Magrin, G., Ninot, O., and Cesaro, J. D. (2011). L'élevage pastoral au Sénégal entre pression spatiale et mutation commerciale. *M@ppemonde* 103:17.

Makoni, N., Mwai, R., Redda, T., van der Zijpp, A., and van der Lee, J. *White gold: Opportunities for dairy sector development collaboration in East Africa. CDI report CDI-14-006*. Wageningen: Centre for Development Innovation. (2014).

Ministère de l'agriculture, de l'agroalimentaire et de la forêt. *Sénégal. Paris: Les Politiques Agricoles à Travers Le Monde: Quelques Exemples*. (2014).

Ochungo, P., Lindahl, J., Kayano, T., and Sirma, A. J. (2016). Mapping aflatoxin risk from Milk consumption using biophysical and socio-economic data: a case study of Kenya. *African J. Food* 16, 11066–11085. doi: 10.18697/ajfand.75.ILRI08

Odero-Waitituh, J. A. (2017). Smallholder dairy production in Kenya; a review. *Livest. Res. Rural. Dev.* 29

Reliefweb. (2018). Senegal: Third drought in six years leaves 245,000 people food insecure. Reliefweb. Available at: https://reliefweb.int/report/senegal/senegal-third-drought-six-years-leaves-245000-people-food-insecure.

Reynolds, L., Metz, T., and Kiptarus, J. (1996). "Smallholder dairy production in Kenya" in *World animal review 87–1996/2* eds. B. S. Hursey (Rome: Food and Agriculture Organization of the United Nations)

Staal, S., Wanyoike, F., and Ballantyne, P. *Impacts of livestock development investment: Documented positive impacts of livestock-related interventions in Africa, Asia and Latin America*. Nairobi: International Livestock Research Institute (ILRI). (2020).

The Global Economy. (2022). Sénégal: GDP share of agriculture. The global economy. Available at: https://www.theglobaleconomy.com/Senegal/share_of_agriculture/ (Accessed September 6, 2022)

The World Bank. (2022). Population growth (annual %) – Senegal. The World Bank – data. Available at: https://data.worldbank.org/indicator/SP.POP.GROW?locations=SN (Accessed June, 3 2022)

Toivonen, S., and Viitanen, K. (2016). Environmental scanning and futures wheels as tools to analyze the possible future themes of the commercial real estate market. *Land Use Policy* 52, 51–61. doi: 10.1016/j.landusepol.2015.12.011

Lee, J.van der, Bebe, B. O., and Oosting, S. *Sustainable intensification pathways for dairy farming in Kenya. A case study for PROIntensAfrica WP2, deliverable 2.3 997*. Wageningen: Wageningen University & Research. (2016).

Wane, A., Ndiaye, A., Touré, I., and Kane, I. (2017). Marché du lait et (re)structuration de la mobilité pastorale dans un contexte d'incertitudes et d'opportunités. Cas du bassin de collecte de la laiterie du berger (LDB) au Sénégal. *Mobilité Pastorale et développement au Sahel*, 215–237.

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Thematic evidencing of youth-empowering interventions in livestock production systems in Sub-Sahara Africa: a systematic review

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Five to seven in every 10 people in Sub-Saharan Africa (SSA) are youths. They have significantly low employment rates but are unattracted to agriculture. Recently, the sector has witnessed considerable efforts by African governments to promote youth participation. While these efforts have started to bear fruits, salient gender issues remain hard to address and solve promptly. For example, youth empowerment issues—whether mutual or emancipative, asset ownership, taboos and cultural expectations, perceptions against climate change, and use of technology and ICT significantly influence livestock production among pastoralists and agro-pastoralists. While these problems are partly known and being solved, it is to be understood the extent and the salient gender issues that drive youth participation in livestock production. To understand this, we conducted a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to thematically synthesize and evidence the youth-empowering interventions in livestock production systems in Sub-Sahara Africa. Peer-reviewed studies were retrieved from online databases (Scopus, Google Scholar™, and gray literature). The findings show that youth face significant barriers to participating in livestock systems ranging from limited empowerment, limited access to productive assets and land, social-cultural limitations and inadequate youth-focused policy implementation. Despite the hurdles, youths, and other actors are employing various mechanisms to overcome them and enhance their participation in livestock systems. They utilize self-driven approaches such as gifting animals amongst themselves, forming saving groups commonly referred to as merry-go-rounds and belonging to community group formations as a form of social capital to empower themselves mutually. Education is also an empowerment tool for youths in the livestock sector. Emancipative empowerment through participation in political and community-level leadership is taking shape, though still in its infancy. There are opportunities presented by small ruminants and poultry where women and youths are getting a voice in the community by becoming relatively income independent and desisting from waiting for the inheritance of large livestock and assets from men. Opportunities presented by ICT in the field of livestock have been taken advantage of through the use of various apps and internet tools to enhance youth participation in livestock systems.

KEYWORDS

youth, gender, participation, livestock, ICT, empowerment, traditions and culture

1. Introduction

Youths, defined by United Nations and African Union Youth Charter as persons within 15–24 years, 15–35 years, respectively and whose definitions differ by country, such as those between 18–34 years in Kenya, form the largest part of the population in Sub-Sahara Africa (African Union, 2006; Senga and Kiilu, 2022). It is believed that 5 to 7 in 10 persons are under 30 years in Sub-Sahara Africa, thus the "youth bulge" phenomenon NEPAD (NEPAD, 2022; United Nations, 2022). This demographic advantage can be leveraged for the economies of Sub-Sahara African (SSA) countries, as seen in the "East Asian miracle" that has resulted in more than half of the total economic growth in Asia (Bloom et al., 2000). On the other hand, there is also a prevalent narrative of the "ticking time bomb" phenomenon, where an additional billion youths are expected to enter the global job market creating the "angry young men" crisis (Kalliney, 2001; ILRI, 2019). Therefore, there is a pressing requirement for boosting agricultural production to generate a surplus of employment opportunities and lead to over a two-fold rise in the output of industrial and service sectors, facilitated by a shift of labor from off-farm to on-farm sectors (Lipton, 2005).

Interestingly, studies are also finding that since 2000, crop and livestock production has appealed less and less to the youths (Rhiannon et al., 2014; Diogo et al., 2022). On the other hand, there are counterarguments about youth engagement in agriculture as demonstrated in the case of rural Ethiopia and Zambia where introduction of modern farming practices, low-tech solutions like diversification, use of ICTs, draft animals, use of electricity was reported to induce uptake of farming by the youths (Leavy and Hossain, 2014). Reconciling these two juxtapositions require a revisit to well-evidenced youth engagement in agriculture to the extent of challenging the prevailing orthodoxies and assumed policy proposals about youth participation in agriculture in general and livestock sector in particular. Thus, the livestock sector which is dogmatized with gender and youth issues and that reportedly has potential for creating employment through dairy farming, zero grazing, meat provision is pursued in this study. The sector significantly contributes to countries' Gross Domestic Products (GDP) e.g., 10–13% to Kenyan agricultural GDP and 33% to Ethiopian GDP (FAO, 2019). In Uganda, livestock production is valued at around USD 8.7 million per year (Solomon and Assegid, 2003).

To enhance youth participation in the livestock sector, African governments have responded by enacting various policies and developmental programs that would increase production and create employment opportunities for the youths. These efforts are believed to enhance youth empowerment. Youth empowerment can loosely be defined as the process of equipping young people with the right skills, knowledge, and resources with an aim of overcoming developmental barriers (Holden et al., 2004). Some youth empowerment interventions by African governments include: the "Youth in Agribusiness" program in Nigeria which is implemented by the Central Bank of Nigeria and the Federal Ministry of Agriculture and Rural Development and that aims to empower young people to participate in the livestock sector by providing them with training, mentoring and access to finance (Bello et al., 2021). The "African Youth Agripreneurs" program in Ghana implemented by the African Development Bank, is aimed at empowering young people to become agripreneurs in the livestock sector by providing them with training, mentorship, and access to financial services (ADB.AYAF, 2020). The "Youth in Agribusiness" program in Kenya, implemented by the government of Kenya and the International Livestock Research Institute (ILRI), aims to support young people to enter the livestock sector by providing them with training, mentorship, and access to financial services (MOALF, 2018). The "Youth in Livestock Development" program in Ethiopia, implemented by the Ethiopian government and the Food and Agriculture Organization of the United Nations (FAO), aims to support young people to enter the livestock sector by providing them with training, mentorship, and access to resources such as land, feed, and veterinary services (FAO, 2018). While these programs and policies have achieved tremendous success in the recent past, numerous shortcomings have been observed, including lack of government's commitment, lack of proper project management, lack of funding among others (Ika and Saint-Macary, 2014). One factor that is often neglected is the role of gender and youth issues in livestock production as discussed in Kinati and Mulema (2018).

1.1. The gender-youth nexus in livestock production in Sub-Sahara Africa

While revitalization of agriculture in rural areas presents tremendous opportunities for youth employment, gender issues are emerging to be a pain-point to fully maximize these realizations. Indeed, a critical debate is emerging on whether rapid rural transformation efforts through digitalization and "feminization" of agriculture and capacity-building efforts will attract youths to boost livestock production especially the adoption of technology-intensive zero-grazing methods (OECD, 2018). Gender pertains to the expectations and social norms that define the roles and identities attributed to individuals as either male or female within a given society or context. Gender roles can be influenced by a variety of factors such as ideology, religion, ethnicity, economics, and culture, and they have a significant impact on the allocation of responsibilities and resources between men and women either young or old. Gender roles are shaped by social constructs and are therefore fluid and prone to change depending on evolving social norms, circumstances among other factors (Quisumbing et al., 2014). Although gender disparities are inherent in every society, these differences can vary greatly across cultures and can shift drastically over time, either within a single culture or across different ones. A particular case of gender disparities exists within the livestock system.

Specifically, youths in livestock farming in Africa can face a variety of gender-related issues, including: (a) limited access to land, particularly for young women, making it hard for them to establish and operate their own livestock farms (Rabinovich et al., 2020), (b) inadequate education and training opportunities, hindering their ability to acquire the knowledge and skills needed to effectively raise and manage livestock (Scott-Villers et al., 2016), (c) societal norms and expectations, particularly traditional gender roles, that often restrict young women's opportunities in the

livestock sector (Kaba et al., 2013; Moyo, 2014), (d) discrimination and mistreatment due to the perception of being uneducated or "backwards", (e) inadequate access to credit and financial services, making it difficult for them to secure the funding necessary to start and expand their livestock businesses (Opiyo et al., 2016), and (f) limited representation in leadership roles, particularly the underrepresentation in leadership positions in the livestock industry, which can hinder their influence on policies and decisions that impact the sector (Afande et al., 2015). Gender and socially imposed roles, along with traditional customs like female genital mutilation and the unequal distribution of assets and leadership positions among youth, have a disempowering impact, particularly on young women (Vincent, 2022). For example, as seen in many communities that keep livestock, it is common for men and boys to be the sole owners of the herds while women are assigned household tasks, constructing temporary dwellings, and caring for the children (Maru, 2017). Another example could be the issues of patriarchy established in culturally contingent systems that limit realization of rights and justice for young girls (Tavenner and Crane, 2019).

Currently, youth participation in livestock production, is hard to estimate due to minimal age-disaggregated data—and approximated at only 15% (ILRI, 2019). Besides, most livestock keepers are nomadic pastoralists, a few are agro-pastoralists and only a handful practicing zero grazing. In fact, about 50–270 million pastoralists occupy about 40 percent of the entire Africa's land mass; with a poverty rate of between 70–85% (Gueye, 2017). It has been observed that pastoralists, particularly young pastoralists who have a strong feeling of identity with their livelihood and who are frequently referred to as the "heirs of the heritage," are increasingly shunning the tradition and looking for work in towns (Maru, 2017). Due to their lack of education, youth in pastoral villages are also at a disadvantage in the job market and end up working menial occupations in urban areas, as was the situation with Maasai youth in Tanzania (Munishi, 2013). Besides, traditional livestock keeping is threatened by climate change that has exacerbated drought and livestock keepers and mostly pastoralists are now termed as the highly-at-risk group with disrupted livelihoods and shrinking pasturelands that often cause conflicts and deaths to both humans and animals (Akall, 2021). Therefore, modernizing livestock practices and capacity-building the youths who are the heirs-of-the-tradition with ICT knowledge and modern technology-intensive practices would most likely induce their interest in commercial livestock farming and improve commercialization of livestock and livestock products (Leavy and Hossain, 2014).

Together with various issues in livestock systems, this study presents a systematic literature review that is arranged thematically, to highlight the gender-youth nexus in livestock systems with a particular focus on evidence of interventions that are facilitating youth participation in livestock systems. This systematic review delivers a meticulous summary of the available research, making available evidence more accessible in a concise manner, to decision-makers and other researchers working on the same or similar issues. It also highlights constraints and opportunities for particular research questions or research areas. In our case, we are interested in understanding youth participation and engagement beyond livestock production to understand gaps and guide interventions that can intentionally target youths in the livestock value chain within and external to the CGIAR. It delineates from general discussions on the types of livestock kept. It fills the following gaps in literature: Gender equality, youth & social inclusion is one of the impact areas of the CGIAR and the gender impact platform. This is in line with the call for youth inclusion in agriculture and this study contributes to the understanding of the challenges and opportunities in this phenomenon. The interest is to "synthesize and amplify research, fill gaps, build capacity and set directions to enable CGIAR to have maximum impact on gender equality, opportunities for youth and social inclusion in agriculture and food systems. This systematic review responds to this need to gather evidence and understand the opportunities or entry points for youths in the livestock system, a sub-section of the agri-food system. Secondly, youth inclusion and gender issues in livestock farming practices are critical areas that warrant attention, especially in the context of the "youth bulge" and the need to create employment opportunities in the agricultural sector. Therefore, there is a pressing need for an in-depth exploration of the gender-youth nexus in livestock farming, examining themes such as empowerment, education, ownership of assets, societal norms, and adaptation strategies, to address the complexities and opportunities in this area. Evidence gathered and summarized in this review could inform the discourse on the development of policies that target and promote youth participation in livestock production systems in Sub-Sahara Africa. Policy makers can use the evidence to identify salient issues in making agriculture, especially livestock keeping an attractive agribusiness venture that employs the youths.

1.2. Research questions

The main aim of this study is to provide thematically synthesized evidence on gender-empowering and youth-targeted interventions/strategies in livestock production among the youths in Sub-Sahara Africa. It presents the variation across studies in the outcomes that concern broad themes and sub-sets through the following research questions:

a. What are the gender empowerment outcomes for the youth with regards to education achievement, household headship, household decision making, asset ownership e.g., communal land among youth livestock farmers?
b. Do reported differentials in cultural taboos and tradition affect participation in livestock farming for the youth?
c. Do climate change perceptions differ among youth livestock farmers and what adaptation, mitigation and coping strategies youth use?

2. Methods

2.1. Literature search criteria

We carried out literature search in electronic repositories with peer-reviewed articles published in the English language only.

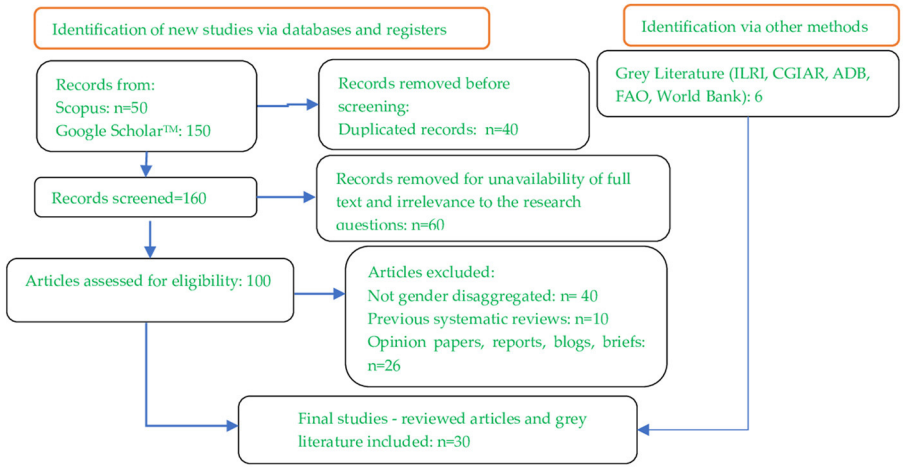

FIGURE 1
Systematic literature review inclusion and exclusion criteria. Source: Author's based on Page et al. (2021) PRISMA guideline.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria was used to assess the relevance of literature to be included (Maru, 2017). The study specifically employed a systematic review rather than meta-analysis due to its qualitative nature and because of the heterogeneity in the aspects reported by each author, due to different settings and study designs. This, therefore, meant that rigorous risk-biases associated with meta-analysis while comparing similar outcomes from different authors was not a problem. Nonetheless, the review authors independently evaluated all the studies to judge if there were certain elements that would warrant assessment of risk of bias for each domain and agreed that non would be of concern to the current paper as discussed in Page et al. (2021). The recommendations of Page et al. (2021), therefore, were followed to the latter (36) as shown in Figure 1. The search was carried out between 15th-16th November, 2022 in the Scopus repository, Google Scholar and additional gray literature (documents produced by organizations with non-commercial publishing) from International Livestock Research Institute (ILRI) and subsidiary CGIAR centers. These institutions carry out large research on livestock across African countries. Limits on the year of publication and the study design were not imposed because of the limited articles that cover the subject on youths with respect to gender issues. Geographical coverage was limited to Sub-Sahara African countries and based on the 2020 survey carried out by Statista (2022).

The search phrases used in the Scopus included "livestock" AND "gender" AND "youth" AND Limit-To (Doctype, "article" Srctype, "j" and interchangeably with OR to join the search string). In Google Scholar^{TM}, the search phrases included allintitle: "livestock" OR "pastoralist" AND "gender" OR "youth" and "[country]." The search was also augmented with the allintext search criteria for in-text keywords to ensure all texts with relevant search phrases weren't excluded. The intext text search was modified to avoid returning only general "livestock" string and synonymous words such as dairy, ruminants, sheep, goats, cows, poultry, chicken, pigs etc. would be used. It was not surprising that this search string always returned the same papers because most authors often start with keyword livestock in their writings. In each successive search, the specific country was iteratively replaced, and the search phrase modified with respect to the theme, e.g., "youth empowerment" OR "education" OR "land ownership" OR "assets" etc. in accordance with the pre-defined thematic areas of interest. The searches in both databases yielded 206 articles. We purposively included a few gray literatures from ILRI and other CGIAR centers to maximize the discussions regarding youth and livestock and to mitigate publication bias in articles as discussed in Gusenbauer and Haddaway (2020).

2.2. Study selection, inclusion, and exclusion criteria

Peer-reviewed journal articles from reputable journals and peer-reviewed reports from NGOs promoting livestock systems in Sub-Sahara Africa were included based on the following criteria: (i) the study reported on youth participation in agriculture with a particular focus on livestock; (ii) the study attempted a disaggregated analysis, preferably by gender; (iii) it was written in English; (iv) not an editorial, expert opinion, review or instructive article, blogs (except gray literature), web pages, opinion pieces, and magazine articles. They were excluded because they lacked scientific rigor. Articles included in our final analysis were 30 i.e., 24 peer reviewed articles and 6 gray literature. Data extracted from each article included author's name, year of publication, study interventions, gender issues addressed, outcomes realized among others. The summarized documents are shown in the section for summary of findings (Tables 1, 2).

3. Results

In this section, the study presents various outputs from each selected paper and the specific gender and youth inclusion

TABLE 1 Summary of peer-reviewed articles on youth and livestock disaggregated by thematic area, authorship, target country and target group.

References	Theme	Country	Target group	Summary of key findings
Mutua et al. (2017)	Relational empowerment	Kenya	Youth pastoralists	Mutual empowerment strategy used by youths through "gifting" of livestock to each other and participating in self-help financials i.e., "merry-go-round" to overcome generational livestock inheritance.
Endris et al. (2022)	Relational empowerment	Ethiopia	Youth pastoralists	Mutual empowerment through system of indigenous mutual support practices (IMSPs) and youth-led initiatives that encourage belonging to Savings Internal Lending Communities (SILC) to overcome limited access to income in the livestock sector.
Tian (2017)	Empowerment through educational achievement	Kenya	Youth pastoralists	Maasai areas in Southern Kenya who had better knowledge of wood species better than boys on their firewood collection duties.
Odhiambo (2013)	Empowerment through educational achievement	Kenya	Youth agro-pastoralists	Government's affirmative action has seen a rise in youths (both girls and boys) enrollment in primary and secondary education among livestock keepers in Kenya.
Ancey et al. (2020)	Educational empowerment	Burkina Faso and Chad	Youth agro-pastoralists	Education is viewed as part of the family's strategy to diversify the household income in Burkina Faso Chad, young migrants from pastoralist communities are often interested in "evening classes" in French, as this helps them overcome cultural shocks associated with traditional livestock keeping.
Misunas et al. (2021)	Empowerment through educational achievement	Burkina Faso	Youth pastoralists	Schooling has seen reduced child marriages as education offers an alternative pathway for girls beyond marriage.
Sulo et al. (2012)	Emancipative empowerment	Kenya	Youth participation in dairy	Young girls and women have opted for less capital-intensive and more accessible options, such as poultry, as a means of generating income instead of waiting to inherit livestock from their fathers
Mueller et al. (2017)	Emancipative empowerment	Ethiopia	Employment in small-ruminant value chains	Young people in Ethiopia are working in wage positions in small-ruminant food chains, bypassing the traditional practice of older generations owning larger animals and as a means of employment
Ruben et al. (2017)	Empowerment	Ethiopia	Producers and consumers	Young, educated, and affluent farmers have embraced an upgrade to production of high quality milk production in place of engaging in traditional milk production methods
Hebo (2014)	Collective agency	Ethiopia	Gender relations in milk marketing cooperative	Exposure or access to emerging markets i.e., cooperatives the markets' mode of operation resulted to increased rights awareness among young men and women in livestock keeping areas has been witnessed among youths participating in registered cooperatives
Ouko et al. (2022)	Land and asset ownership	Kenya	Youth involvement in agripreneurship and employment creation	Internal and external barriers that hinder youth from participating in agripreneurship Youth's unutilized labor capacity is an opportunity as they can be employed in productive agricultural activities.
Afande et al. (2015)	Land and asset ownership	Kenya	Challenges and prospects of youth involvement in agriculture	Inadequate access to land as a barrier to youth involvement in agriculture
Yami et al. (2019)	Land and asset ownership	Malawi. South Africa. Ethiopia	Youth Engagement in Agribusiness:	Strategies aimed at improving young people's access to resources

(Continued)

TABLE 1 (Continued)

References	Theme	Country	Target group	Summary of key findings
Cotula et al. (2004)	Land and asset ownership	Africa	Gender issues and interventions for gender equality in land tenure	Legal instruments that override customary norms, establish community property rights over family land, and grant spouses equal rights in managing family land.
Korir (2018)	Societal norms, culture, and taboos	Kenya	Youth	Mandatory admission, attendance, completion of basic education and 100% transition to secondary schools by all youths in Kenya has resulted in reduced rates of FGM among youths in pastoral/livestock-keeping communities
Wondim and Kefale (2018)	Societal norms, culture and taboos	Ethiopia	Women and girls	Experience-sharing events have been successfully used among livestock-keeping households to overcome traditional practices such as Female Genital Mutilation (FGM)
Besada et al. (2014)	Societal norms, culture and taboos	Chad and Burundi	Women, children, and youth	Targeted interventions for the youths put in place are reducing child marriages through "Well-Being of Community Groups" that protect vulnerable groups
Lwanga-Ntale and Owino (2020)	Societal norms, culture and taboos	Somalia	Youth	Use of alternative sources of income such as remittances from the diaspora and forming youth groups to diversify income and overcome patriarchy-based wealth generation system leading to independence in use of own income to purchase herds of camels and small ruminants
Tavenner and Crane (2019)	Societal norms, culture and taboos	Kenya	Young men	"Sensitizing men" training modules among livestock keepers has resulted in increased recognition of the negative effects of patriarchy among young men
Akilapa et al. (2020)	Use of ICT	Nigeria	Youth	Use of ICT among youth to access real time and customized information to optimize production, access inputs, finance, training and market produce such as milk conveniently
Daum et al. (2022)	Use of ICT	Kenya	Youth	Use of ICT services has enabled youth livestock keepers to relay herd data to experts improving their management practices.
Okello et al. (2020)	Use of ICT	Tanzania	Youth	Use of ICTs has enabled youth to access extension and market information
Eley et al. (2014)	Use of ICT	Benin Cameroon	Youth	Use of ICTs has resulted in transformational agricultural practices and attitudinal change in livestock keeping among the youth.
Opiyo et al. (2016)	Climate change perceptions, climate activism and adaptation strategies	Kenya	Pastoralists	Positive correlation between the age of the household head and the practice of climate change adaptation activities
Bello et al. (2021)	Policies and legal frameworks	Nigeria	Youth	Providing youth with training, mentoring and access to finance to empower them participate in the livestock sector

approaches and policy issues in livestock farming practices it explores. Results are clustered around general thematic areas in the gender-youth nexus. These themes are supported by evidence regarding youth engagement in livestock farming are used to back up the claims. Tables 1, 2 summarizes the literature that was reviewed in terms of the authors, theme covered by the study, the country of the origin of the paper, the population of youth being targeted and the main findings of the paper.

3.1. Youth empowerment

Although the notion of youth empowerment is intricate, vague, and lacks well-defined limits, we adopt the definitions put forward by Úcar et al. (2017) that empowerment is essentially about enabling young people to attain optimal growth by acquiring competencies as they overcome specific challenges. Thus, on the theme of youth empowerment in livestock production, discussions are based on general dimensions

TABLE 2 Summary of *gray literature* on youth and livestock disaggregated by thematic area, authorship, target country and target group.

References	Theme	Country	Target group	Summary of key findings
United Nations (2004)	Societal norms, culture, and taboos	General	Elimination of discrimination against women	Ratification of convention on elimination of all forms of discrimination against women yielding establishment of gender-friendly policies and laws for safeguarding the welfare of girls and women.
ADB.AYAF (2020)	Policies and legal frameworks	Ghana	Youth	Providing young people with training, mentorship and access to financial services to empower them to become agripreneurs in the livestock sector
MOALF (2018)	Policies and legal frameworks	Kenya	Youth	Support young people to enter the livestock sector by providing them with training, mentorship, and access to financial services
FAO (2018)	Policies and legal frameworks	Ethiopia	Youth	Support young people to enter the livestock sector by providing them with training, mentorship, and access to resources such as land, feed, and veterinary services
Maendeleo Ya Wanawake Organisation (2011)	Youth empowerment	Kenya	Peace building in Kenya	Youth in pastoral communities, especially young women are actively engaging in civic education toward increased participation in leadership and political positions

that include: (a) relational empowerment—in which youth engagements in livestock production to a greater degree depend on mutual empowerment among young people themselves, (b) empowerment through educational achievements—in which acquisition of competences with notable indicators of self-efficacity, critical thinking, and participation (Africa Educational Trust, 2011; Maendeleo Ya Wanawake Organisation, 2011; Enns and Bersaglio, 2016; Scott-Villers et al., 2016; African Development Solutions, 2017; Ancey et al., 2020; Yitbarek et al., 2022) and (c) transformative/emancipative empowerment—in which empowerment is integrated within the development of abilities for social change awareness of socio-political hierarchies of power and availability of support structures and those conditions that lead to young people being able to act in their own name and on their own terms instead of being controlled by others (Wagaman, 2011).

We found very few peer-reviewed articles evidencing mutual empowerment in youth-led livestock farming. One study in Kenya by Mutua et al. (2017), explored group membership and "merry-go-round" as strategies for acquisition of livestock by youths and also "gifting" of livestock to each other as a mutual empowerment strategy. While such approaches helped male youths in these communities, gender issues surrounding inheritance were still bold as girls could not inherit livestock or any kind of property—because it encouraged insubordination and reduced chances of getting married among pastoral communities such as the Tugen. Even group membership that would encourage mutual empowerment had limitation as it depended on someone's perceived wealth status in the community (Mutua et al., 2017). On the other hand, while a system of indigenous mutual support practices (IMSPs) exists in Ethiopia among pastoralists, youth-led initiatives that encourage belonging to Savings Internal Lending Communities (SILC) would be a great way for overcoming limited access to income and developing mutually-beneficial social capital to help other youths in the livestock sector (Endris et al., 2022). Most discussions on the mutual empowerment from the gray literature discussed potential but not the actual empowerment in farming among the youths (Maendeleo Ya Wanawake Organisation, 2011; Rhiannon et al., 2014; Scott-Villers et al., 2016; ILRI, 2019).

Educational empowerment with regards to young girls' in nomadic pastoral and agropastoral communities has taken a center stage in most literature and government policies (United Nations, 2004; Maendeleo Ya Wanawake Organisation, 2011; Scott-Villers et al., 2016). It is viewed through the angle of educational attainment among youths in livestock keeping communities. For example, while an enabling policy environment has been created in Ethiopia since 1994, enrollment, retention, and learning attainment remain low in the pastoralist areas for girls (Yitbarek et al., 2022). In Kenya, girls who are educated are prone to losing their "marriageability" (Scott-Villers et al., 2016). Among the Fulani of Nigeria, educating a girl-child should be limited to "preparing her for the roles of mother and wife" (Fareo and Ateequ, 2020). Despite these educational challenges, evidence shows that gender norms and practices contributed to the passing of traditional ecological knowledge from adult to child. This is the case of young girls in Maasai areas in Southern Kenya who had better knowledge of wood species better than boys on their firewood collection duties (Tian, 2017). Evidently, educational empowerment through the governments' affirmative action has also seen rise in youths (both girls and boys) enroll in primary and secondary education among livestock keepers in Kenya (Odhiambo, 2013). In Burkina Faso, schooling has seen reduced child marriages as education offers an alternative pathway for girls beyond marriage (Misunas et al., 2021). In fact, education is viewed as part of the family's strategy to diversify the household income in Burkina Faso and targeted to

youths who can no longer be integrated within the livestock systems (Ancey et al., 2020). In Chad, young migrants from pastoralist are often interested in "evening classes" in French, as this helps them overcome cultural shocks associated with traditional livestock keeping and adapting to town life (Ancey et al., 2020).

Within the domain of transformative/emancipative empowerment, this study provided evidence of youth in livestock production and their engagement in socio-political aspects such as leadership to overcome some gender issues in livestock farming. Breaking free from gender norms requires young people to use empowerment strategies that are not dependent on receiving assets from older generations. For instance, instead of waiting to inherit livestock from their fathers, young girls and women in Kenya have opted for less capital-intensive and more accessible options, such as poultry, as a means of generating income (Sulo et al., 2012; Mutua et al., 2017). Similarly, young people in Ethiopia are taking a similar approach by working in wage positions in small-ruminant food chains, bypassing the traditional practice of older generations owning larger animals and as a means of employment (Mueller et al., 2017). Additionally, young women in Ethiopia can now control income from sale of milk cheese and butter from small ruminants such as sheep and goats (Kinati and Mulema, 2018). Access to livestock can also be strongly gendered. For example, in Kenya, only men can inherit livestock such as cattle, sheep and goats as a customary right, although they can be gifted to both genders. Instead of engaging in traditional milk production methods, evidence from Ethiopia show that a segment of young, educated, and affluent farmers have embraced an upgrade to production of high quality milk production (Ruben et al., 2017).

On the other hand, evidence from gray literature shows that youths in pastoral communities are actively engaging in civic education toward increased participation in leadership and political positions—especially the young women in Kenya (Maendeleo Ya Wanawake Organisation, 2011). In Ethiopia, the increased political interventions and rights awareness among young men and women in livestock keeping areas has been witnessed among youths participating in registered cooperatives (Hebo, 2014). This evidence is also demostrated by Endris et al. (2022) who argue that youth membership in Savings Internal Lending Communities (SILC) has achieved tremendous youth participation in community-based civic education but would even work better if education among the participants was improved.

3.2. Overcoming challenges of ownership of land and assets

Whereas entrepreneurial opportunities exist for youth in livestock systems, barriers including the inadequate access to land hinders success among youths agripreneurs in Kenya (Ouko et al., 2022). Notably, research has found a correlation between low youth participation in agribusiness and inadequate access to land (Njeru and Gichimu, 2014; Afande et al., 2015; Lwanga-Ntale and Owino, 2020). Innovative strategies aimed at improving young people's access to resources have been witnessed to yield positive results. Notably, in Malawi and South Africa, land reform initiatives have enabled youth to gain access to land. In Ethiopia, rehabilitated communal land was allocated to youth groups, opening up opportunities for them to participate in agricultural value chains. Additionally, land rentals and leasing programs have also been effective in expanding access to land. These interventions have shown promising potential to empower youth and promote economic growth in their communities (Yami et al., 2019). In Africa, patrilineal inheritance systems are prevalent, where the male line determines succession and property inheritance, with only sons or other males inheriting land from the family estate. This practice excludes daughters from inheriting family land due to the belief that they become part of another family upon marriage. Despite this, Islamic law recognizes a woman's right to inheritance, but her share is often smaller than a male relative's. To combat this discrimination, several countries have enacted family and succession laws that override customary norms, establish community property rights over family land, and grant spouses' equal rights in managing family land. Examples include Ghana's Intestate Succession Law 1985 and Ethiopia's Revised Family Code 2000, though the implementation of these laws remains low (Cotula et al., 2004).

3.3. Toward overcoming societal norms, expectations, cultural taboos, and traditions

Livestock keeping is dogged with numerous culturally underpinned taboos and traditions among which female genital mutilation, early child marriages, labor division (drudgery) and patriarchy are prominent (Mutua et al., 2017; Daum, 2019). Overcoming these have attracted myriad strategies among which ratification of Convention on Elimination of All forms of Discrimination against Women (CEDAW) has resulted in established gender-friendly policies and laws aimed at safeguarding the welfare of girls and women, including affirmative action for higher education (United Nations, 2004). Deeply ingrained social and cultural practices continue to pose a significant challenge and this is particularly true for pastoralist girls and women (Korir, 2018). However, these practices are changing with affirmative action put in place by governments for the livestock-keeping communities as witnessed in the case of Kenya. Evidently, the mandatory admission, attendance, completion of basic education and 100% transition to secondary schools by all youths in Kenya has resulted in reduced rates of FGM among youths in pastoral/livestock-keeping communities (Korir, 2018). In Ethiopia, overcoming traditional practices such as FGM has witnessed increased use of experience-sharing events among livestock-keeping households to curb the tradition (Wondim and Kefale, 2018). These experience-sharing events can be extended to cases of gender-based and child-based violences in which children or adults experiencing these are often witnessed to seek support from a range of people mostly kin and friends in Ethiopia (Chuta et al., 2019). In Chad and Burundi, early child marriages and FGM have been reported

in various literature, but evidence shows that well-targeted interventions for the youths put in place and based on Social Cohesion and Community Based Protection Mechanisms; are already reducing child marriages through what is called "WellBeing of Community Groups" that protect vulnerable groups (Besada et al., 2014).

While patriarchy and clannism also contribute to youth discrimination in livestock keeping communities, in Somalia, for example, youths overcome such by using alternative sources of income such as remittances from the diaspora and forming youth groups to diversify their income and overcome patriarchy-based wealth generation system (Lwanga-Ntale and Owino, 2020). Evidence shows that this leads to independence in decision and use of own income to purchase herds of camels and small ruminants. In Kenya, the use of "sensitizing men" training modules among livestock keepers and that is targeted to young men has resulted in increased recognition of the negative effects of patriarchy among young men (Tavenner and Crane, 2019). This has resulted into more allocation of resources toward purchasing women produce from small ruminants and poultry in the area, a case of "leading-by-example" to overcoming patriarchy among the youths.

3.4. Use of ICT among the youths in livestock systems

In some cases, youth participation in livestock production has been enhanced through use of modern technologies. For example, overcoming drudgery associated with intensive livestock keeping has witnessed transition to mechanized zero gazing from nomadic pastoralism. In Nigeria, a proposal for use of Information, Communication Technology (ICT) in livestock keeping areas, especially use of real time and customized information to overcome system inefficiencies and optimize production has witnessed youths using apps to access inputs, finance, training and market their produce such as milk conveniently (Akilapa et al., 2020). In Kenya, the use of ICT services especially *DigiCow* Dairy App from Farmingtech Solutions and *SmartCow* have been used to enable youth livestock keepers use ICT services to relay herd data to experts thus improving their management practices (Daum et al., 2022). In Tanzanian youth dairy farmers access the *Shamba-shape* up episodes through the website, radio and TV (Okello et al., 2020). This platform gives youths independence in terms of access to livestock production information. The changing access to information also helps the youth overcome barriers to markets and even pricing of livestock. On the other hand, there are evidence of behavioral change on engagement in agriculture due to use of ICT-enabled platforms as has been witnessed in the Songhai model in Benin, and the AFOP program in Cameroon in which youths engaged in transformational agricultural practices have indicated attitudinal change in livestock keeping especially the startups (Eley et al., 2014). Efforts to increase the use of ICT in agriculture that would, in turn, increase youth participation in the sector are being promoted through the National Agriculture Policy of 2013, which was implemented by the then Ministry of Agriculture and Cooperative in Tanzania, gives credence to integration of ICT in agriculture (Bernard et al., 2019).

3.5. Differentials in climate change perceptions, climate activism, and adaptation strategies

Many references in the literature including IPPC 2018 report highlight that women and youth are more vulnerable to climate change in agriculture and livestock keeping, as they often have less access to information, markets, credit, or insurance in addition to already having heavy workloads in the home. However, many governments and organizations recognize that investing in women is often a better return than in investing in men, possibly because women have stronger family ties and stay at home and depend on livestock more.

Climate change and the resultant environmental stressors as well as environmental degradation often undermine the resilience of livestock production systems. Youth perceptions, responses and mitigation strategies including climate activism with respect to livestock has received little attention in literature (Mugeere et al., 2021). Climate change and the resultant environmental stressors as well as environmental degradation often undermine the resilience of the lives of pastoralists to climate change is necessary for sustainable mitigation and coping strategies (African Union, 2006; Senga and Kiilu, 2022). Perception is very much likely to influence how agripreneurs respond to risks as well as opportunities that come with climate change. Perception will determine the nature, the course of action and the outcomes of the adaptation strategies chosen. In Kenya, there was reported a positive correlation between the age of the household head and the practice of climate change adaptation activities. In other words, older household heads were more likely to engage in activities to cope with the effects of climate change than younger household heads. This suggests that experience and knowledge may play a role in shaping attitudes and behaviors toward climate change adaptation in this particular context (Opiyo et al., 2016). On the contrary, results from studies on the determinants of adaptation to climate change among agro-pastoralists in Botswana and Ethiopia show that in terms of the age of the household head, younger pastoralists are more likely to employ climate change adaptation strategies than their older counterparts. This is explained by the view that older pastoralists are likely to be inclined toward preferring conservative methods of adaptation to climate change as opposed to modern and more relevant strategies. In this study, the perception on climate change was based on an increase in annual temperature and a general decline in the annual rainfall received (Kgosikoma et al., 2018; Gebeyehu et al., 2021).

4. Discussion and conclusion

This study sought to establish thematically synthesized changes on youth participation in livestock production against the backdrop of "youth bulge" and the need to create employment in the agricultural sector to absorb the youths. To assess this, various databases were queried with a realization that limited peer-reviewed articles exist on youth and livestock with respect to Sub-Sahara Africa, a matter that was also raised by Vincent (2022). Even this thin literature seems to concentrate heavily on some countries especially Kenya, Uganda, Nigeria, Chad, and Ethiopia. This has

mostly been attributed to the fact that the search databases are often based on English language (excluding Arabic and Francophone countries) and also on the fact that research is difficult in most areas where livestock keeping is practiced due to conflicts (Mkutu, 2008; Holechek et al., 2017; Gammino et al., 2020). In addition, the literature evidencing youth participation in livestock production is more concentrated among the pastoral communities and only a few concentrates on youth with respect to agropastoral communities and zero grazing. It is our assumption, that perhaps authors prefer to research on the pastoral communities because they are observed to have some of the highest concentrations of gender problems such as early childhood marriages, FGM, inequalities in asset ownership and subjection of women to traditions and taboos that are difficult to change (Maendeleo Ya Wanawake Organisation, 2011). Nonetheless, various gender-youth nexus issues have been observed and evidence of how youths in livestock overcome or cope with them have been reported.

In the case of youth empowerment, it is observed that they utilize self-driven approaches such as gifting of animals amongst themselves, forming saving groups commonly referred to as merry-go-rounds and belonging to community groups formation as a form of social capital to mutually empower themselves (Mutua et al., 2017; Endris et al., 2022). Education is also an empowerment tool for youths in the livestock sector. For example, even under gender-defined roles, young women in livestock-keeping areas seem to be more knowledgeable on some aspects compared to males; and youths in countries such as Chad and Burkina Faso are taking education as a factor for changing their livelihoods and moving from traditionally "acceptable" livelihoods (Odhiambo, 2013; Ancey et al., 2020; Misunas et al., 2021). Evidence shows that emancipative empowerment through participation in political and community-level leadership is taking shape, even though it is still at the infancy. The opportunities presented by small ruminants and poultry is giving women and youths and opportunity to have a voice in the community by encouraging income-based independence and desisting from waiting for inheritance from adult males.

While myriad taboos and traditions still plague progress toward a more harmonized and gender-sensitive community where young women and girls have a voice, evidence shows that youths are using various strategies to overcome them. Use of experience-sharing events and the affirmative action on abolishment of practices such as FGM and early childhood marriage has witnessed increased number of enrolled students and changing livelihoods especially for women. The example of "sensitizing men" in Kenya established through training modules among youth livestock keepers is a behavioral change approach that will increase the recognition of the negative effects of patriarchy and discrimination against women among young men (Tavenner and Crane, 2019).

Besides, the tremendous opportunities presented by ICT in the field of livestock has been taken advantage of through use of various apps and internet tools. Evidence from Kenya suggest that youths can access educational materials through apps. This overcomes the information barrier associated with livestock markets, marketing of products and makes livestock farming attractive. ICT has significantly increased access to modern technologies and already attracting youths in countries such as Zambia and Ethiopia (Osti et al., 2015; ILRI, 2019; Okello et al., 2020; Daum et al., 2022). Perhaps, it will also address the gender issue associated with drudgery among young girls as it will bring in new technologies that solve energy problems such as use of biogas to reduce time taken to fetch firewood by girls in pastoral areas.

This study has successfully identified and analyzed various gender-youth nexus issues in livestock farming practices. The study's contribution to literature is a systematic synthesis of existing research on youth engagement in livestock production systems achieved through aggregating and analyzing findings from diverse sources. It contributes to a comprehensive understanding of the challenges and opportunities faced by youth in this context. The study is valuable to academics, policymakers, development practitioners, and stakeholders interested in opportunities and entry point to youth engagement, gender equity, and sustainable livestock production. It offers evidence-based recommendations and contributes to the broader understanding of youth inclusion in agriculture while aligning with the broader goal of promoting inclusive and sustainable agricultural practices.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

The paper was conceptualized, co-written, and revised by all authors. All authors contributed to the article and approved the submitted version.

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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.

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References

ADB.AYAF (2020). *African Development Bank - Building today, a better Africa tomorrow*. Available online at: https://www.afdb.org/en/african-youth-agripreneurs-forum/ayaf-2020 (accessed January 30, 2023).

Afande, F. O., Maina, W. N., and Maina, M. P. (2015). Youth engagement in agriculture in kenya: challenges and prospects. *J. Cult. Soc. Dev*. 7, 4–19.

Africa Educational Trust (2011). *Vocational Skills for Nomadic Pastoralists*. London: UK: AET, 24.

African Development Solutions (2017). Pastoralist Youth Education Initiative (PYEI) Kenya - Sécheresse info. Nairobi: Kenya. Available online at: http://www.secheresse.info/spip.php?article100451 (accessed December 12, 2022).

African Union (2006). *African Youth Charter African Youth Charter, Eastern Asia University Academic Journal*. Addis Abbaba, Ethiopia: African Union.

Akall, G. (2021). Effects of development interventions on pastoral livelihoods in Turkana County, Kenya. *Pastoralism*. 11, 1–15. doi: 10.1186/s13570-021-00197-2

Akilapa, O., Farayola, C. O., Adebisi, L. O., Akilapa, O., and Gbadamosi, F. Y. (2020). Does innovation enhance youth participation in agriculture: a review of digitalization in developing country? *Int. J. Res. Agric. For*. 7, 7–14.

Ancey, V., Rangé, C., Magnani, S., and Patat, C. (2020). *Pastoralist youth in towns and cities: Supporting the economic and social integration of pastoralist youth Chad and Burkina Faso*. Doctoral dissertation, Food and Agriculture Organization of the United Nations (FAO).

Bello, L. O., Baiyegunhi, L. J. S., Mignouna, D., Adeoti, R., Dontsop-Nguezet, P. M., Abdoulaye, T., et al. (2021). Impact of youth-in-agribusiness program on employment creation in Nigeria. *Sustain*. 13, 1–20. doi: 10.3390/su13147801

Bernard, T., Dercon, S., Orkin, K., and Taffesse, A. S. (2019). Parental aspirations for children's education: is there a "Girl Effect"? Experimental evidence from rural Ethiopia. *AEA Pap. Proceed*. 109, 127132. doi: 10.1257/pandp.20191072

Besada, H., Wheaton, W., Ben, O., and Tok, E. (2014). Phase I Study report : social cohesion and community based protection mechanisms in chad and Burundi. *Res. Rep*. 1, 69.

Bloom, D. E., Canning, D., and Malaney, P. N. (2000). Population dynamics and economic growth in Asia. *Popul. Dev. Rev*. 26, 257–290.

Chuta, N., Morrow, V., Pankhurst, A., and Pells, K. (2019). *Understanding violence affecting children in Ethiopia: a qualitative study*. Working paper.

Cotula, L., Toulmin, C., and Hesse, C. (2004). *Land Tenure and Administration in Africa: Lessons of Experience and Emerging Issues*. London: IIED.

Daum, T. (2019). Of bulls and bulbs: aspirations, opinions and perceptions of rural adolescents and youth in Zambia. *Dev. Pract*. 25, 29. doi: 10.1080/09614524.2019.1646209

Daum, T., Ravichandran, T., Kariuki, J., Chagunda, M., and Birner, R. (2022). Connected cows and cyber chickens? Stocktaking and case studies of digital livestock tools in Kenya and India. *Agric. Syst*. 196, 103353. doi: 10.1016/j.agsy.2021.103353

Diogo, B., Mai, F., Dominique, F., Laurent, K., Loic, L., Pritha, M., et al. (2022). *Climate Change and Chronic Food Insecurity in Sub-Saharan Africa*. Washington, DC, USA: African Department (Series). Report No.: DP/2022/016. doi: 10.5089/9798400218507.087

Eley, M. L., Owens, J. P., and Adjibi, Y. (2014). *Songhaï Centers as Models for Promoting Sustainable Agriculture*. (MEAS Case Study # 10). Report No.: 10.

Endris, G. S., Wordofa, M. G., Aweke, C. S., Hassen, J. Y., Hussien, J. W., Moges, D. K., et al. (2022). A review of the socio-ecological and institutional contexts for youth livelihood transformation in Miesso Woreda, Eastern Ethiopia. *Cogent. Soc. Sci*. 8, 2152210. doi: 10.1080/23311886.2022.2152210

Enns, C., and Bersaglio, B. (2016). Pastoralism in the time of oil: Youth perspectives on the oil industry and the future of pastoralism in Turkana, Kenya. *Extr. Ind. Soc*. 3, 160–170. doi: 10.1016/j.exis.2015.11.003

FAO (2018). *Ethiopia's youth find hope in agricultural entrepreneurship* | FAO Stories | Food and Agriculture Organization of the Unite Nations. Available online at: https://www.fao.org/fao-stories/article/en/c/1132999/ (accessed January 30, 2023).

FAO (2019). *The future of livestock in Uganda: Opportunities and challenges in the face of uncertainty. Africa Sustainable Livestock 2050*. Rome, Italy: FAO, 60. Available online at: https://www.fao.org/documents/card/en/c/ca5464en/ (accessed July 20, 2023).

Fareo, D. O., and Ateequ, W. (2020). Determinants of girl child education among the nomads in Nigeria. *EAS J. Psychol. Behav. Sci*. 2, 138–145. doi: 10.36349/easjpbs.2020.v02i05.006

Gammino, V. M., Diaz, M. R., Pallas, S. W., Greenleaf, A. R., and Kurnit, M. R. (2020). Health services uptake among nomadic pastoralist populations in Africa: A systematic review of the literature. *PLoS Negl. Trop. Dis*. 14, 1–23. doi: 10.1371/journal.pntd.0008474

Gebeyehu, D. T., Bekele, D., Mulate, B., Gugsa, G., and Tintagu, T. (2021). Knowledge, attitude and practice of animal producers towards antimicrobial use and antimicrobial resistance in Oromia zone, north eastern Ethiopia. *PLoS ONE* 16, e0251596. doi: 10.1371/journal.pone.0251596

Gueye, N. (2017). Sustainable pastoralism and rangelands in Africa. *Nat. Faune* 31, 1–63.

Gusenbauer, M., and Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google scholar, PubMed, and 26 other resources. *Res. Syn. Methods* 11, 181217. doi: 10.1002/jrsm.1378

Hebo, M. (2014). Evolving markets, rural livelihoods, and gender relations: the view from a milk-selling cooperative in the Kofale District of West Arsii, Ethiopia. *Afr. Study Monogr*. 48, 5–29. doi: 10.14989/185113

Holden, D. J., Messeri, P., Evans, W. D., Crankshaw, E., and Ben-Davies, M. (2004). Conceptualizing youth empowerment within tobacco control. *Heal. Educ. Behav*. 31, 548–563. doi: 10.1177/1090198104268545

Holechek, J. L., Cibils, A. F., Bengaly, K., and Kinyamario, J. I. (2017). Human population growth, african pastoralism, and rangelands: a perspective. *Rangel. Ecol. Manag*. 70, 273–280. doi: 10.1016/j.rama.2016.09.004

Ika, L., and Saint-Macary, J. (2014). Special issue: why do projects fail in Africa? *J. African. Bus*. 15, 151–155. doi: 10.1080/15228916.2014.956635

ILRI (2019). *CGIAR Research Program on Livestock Youth strategy*. Nairobi, Kenya: ILRI.

Kaba, M., Ame, I., and Mariam, D. H. (2013). Extramarital sexual practices and perceived association with HIV infection among the borana pastoral community. *Ethiop. J. Heal. Dev*. 27, 25–32.

Kalliney, P. (2001). Cities of affluence: masculinity, class, and the angry young men. *MFS Mod. Fict. Stud*. 47, 92–117. doi: 10.1353/mfs.2001.0004

Kgosikoma, K., Lekota, P., and Kgosikoma, O. (2018). Agropastoralists' determinants of adaptation to climate change. *Int. J. Clim. Change Strateg. Manage*. 10, 488500. doi: 10.1108/IJCCSM-02-2017-0039

Kinati, W., and Mulema, A. A. (2018). *Gender Issues in Livestock Production in Ethiopia A Review of Literature to Identify Potential Entry Points for Gender Responsive Research and Development*. Nairobi, Kenya: ILRI. doi: 10.33259/JLivestSci.2019.66-80

Korir, G. K. (2018). Cultural practices contributing to girls' dropout rate in primary schools in kajiado county : a review of literature. *Int. J. Adv. Res. Rev*. 3, 10–15.

Leavy, J., and Hossain, N. (2014). *Who wants to farm? Youth aspirations, opportunities and rising food prices*. IDS Working Papers. doi: 10.1111/j.2040-0209.2014.00439.x

Lipton, M. (2005). *The family farm in a globalizing world: The role of crop science in alleviating poverty*. Discussion Papers 40. International Food Policy Research Institute. Washington, DC.

Lwanga-Ntale, C., and Owino, B. O. (2020). Understanding vulnerability and resilience in Somalia. *Jamba J. Disaster. Risk Stud*. 12, 1–9. doi: 10.4102/jamba.v12i1.856

Maendeleo Ya Wanawake Organisation (2011). *Women and Conflict*. Nairobi, Kenya: Soloh WorldWide Inter-Enterprises Ltd.

Maru, N. (2017). Youth perspectives on pastoralism: opportunities and threats faced by young pastoralists. *Nat. Faune* 31, 22–25.

Misunas, C., Erulkar, A., Apicella, L., Ng,ô, T., and Psaki, S. (2021). What influences girls' age at marriage in Burkina Faso and Tanzania? Exploring the contribution of individual, household, and community level factors. *J. Adolesc. Heal*. 69, S46–56. doi: 10.1016/j.jadohealth.2021.09.015

Mkutu, K. A. (2008). Uganda: pastoral conflict and gender relations. *Rev. Afr. Polit. Econ*. 35, 237–254. doi: 10.1080/03056240802194133

MOALF (2018). *Republic Of Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation Kenya Youth Agribusiness Strategy 2018-2022 Positioning the Youth at the Forefront of Agricultural Growth and Transformation "Vijana Tujijenge na Agribiz"*. Available online at: www.kilimo.go.ke (accessed January 30, 2023).

Moyo, H. (2014). Gendered mourning and grieving rituals amongst the Jahunda people of Zimbabwe as a challenge to the pastoral care ministry of the church. *Black Theol*. 12, 213–229. doi: 10.1179/1476994814Z.00000000036

Mueller, B., Acero, F., and Estruch, E. (2017). *Creating employment potential in small-ruminant value chains in the Ethiopian Highlands. FAO Animal Production and Health*. Rome: FAO (Working Paper). Report No.: 16.

Mugeere, A., Barford, A., and Magimbi, P. (2021). Climate change and young people in Uganda: a literature review. *J. Environ. Dev*. 30, 344–368. doi: 10.1177/10704965211047159

Munishi, E. J. (2013). *Rural-Urban Migration of the Maasai Nomadic Pastoralist Youth and Resilience in Tanzania : Case Studies in Ngorongoro District, Arusha Region and Dar es Salaam City*. Freiburg im Breisgau: Albert-Ludwigs-Universität Freiburg.

Mutua, E., Bukachi, S., Bett, B., Estambale, B., and Nyamongo, I. (2017). Youth participation in smallholder livestock production and marketing. *IDS Bull*. 48, 95–108. doi: 10.19088/1968-2017.129

NEPAD (2022). *AUC and AUDA-NEPAD Second Continental Report on the Implementation of Agenda 2063*. Midrand, SA: NEPAD.

Njeru, L. K., and Gichimu, B. M. (2014). Influence of access to land and finances on Kenyan youth participation in agriculture: a review. *Int. J. Dev. Econ. Sustain*. 2, 1–8.

Odhiambo, M. O. (2013). The ASAL Policy Of Kenya : releasing the full potential of arid and semi-arid lands—an analytical review. *Nomad. People*. 17, 158–165. doi: 10.3167/np.2013.170110

OECD (2018). *The Future of Rural Youth in Developing Countries*. Paris, France: OECD Publishing, 100. Available online at: https://www.oecd-ilibrary.org/development/the-future-of-rural-youth-in-developing-countries_9789264298521-en (accessed November 11, 2022).

Okello, D. O., Feleke, S., Gathungu, E., Owuor, G., and Ayuya, O. I. (2020). Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania. *Cogent. Food Agric*. 6, 1817287. doi: 10.1080/23311932.2020.1817287

Opiyo, F., Wasonga, O. V., Nyangito, M. M., Mureithi, S. M., Obando, J., Munang, R., et al. (2016). Determinants of perceptions of climate change and adaptation among Turkana pastoralists in northwestern Kenya. *Clim. Dev*. 8, 179–189. doi: 10.1080/17565529.2015.1034231

Osti, A., van t Land, J., Magwegwe, D., Peereboom, A., van Oord, J., and Dusart, T. (2015). *The future of youth in agricultural value chains in Ethiopia and Kenya Report*. Available online at: http://agriprofocus.com/agriprofocus#sthash.EnHsicVn.dpuf (accessed July 20, 2023).

Ouko, K. O., Ogola, J. R. O., Ng'on'ga, C. A., and Wairimu, J. R. (2022). Youth involvement in agripreneurship as Nexus for poverty reduction and rural employment in Kenya. *Cogent Soc. Sci*. 8, 2078527. doi: 10.1080/23311886.2022.2078527

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ*. 372, n160. doi: 10.1136/bmj.n160

Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., and Peterman, A. (2014). "Closing the knowledge gap on gender in agriculture," in *Gender in Agriculture,* eds. A. Quisumbing, R. Meinzen-Dick, T. Raney, A. Croppenstedt, J. Behrman, A. Peterman (Dordrecht: Springer). doi: 10.1007/978-94-017-8616-4

Rabinovich, A., Heath, S. C., Zhischenko, V., Mkilema, F., Patrick, A., Nasseri, M., et al. (2020). Protecting the commons: Predictors of willingness to mitigate communal land degradation among Maasai pastoralists. *J. Environ. Psychol*. 72, 101504. doi: 10.1016/j.jenvp.2020.101504

Rhiannon, P., Geneviève, A. B., Sabdiyo, D., and Gabriela, Q. (2014). *Unleashing potential: gender and youth inclusive agri-food chains*. Community workshop session, Guinea Bisseau (KIT working papers). Available online at: http://www.snv.org/ (accessed December 15, 2022).

Ruben, R., Dekeba Bekele, A., and Megersa Lenjiso, B. (2017). Quality upgrading in Ethiopian dairy value chains: dovetailing upstream and downstream perspectives. *Rev. Soc. Econ*. 75, 296–317. doi: 10.1080/00346764.2017.1286032

Scott-Villers, P., Wilson, S., Kabala, N., and Kullu, M. A. (2016). *Study of Education and resilience in Kenya's Arid and Semi-Arid Lands Learning for Peace*. Nairobi, Kenya: UNICEF Eastern and Southern Africa Regional Office.

Senga, M., and Kiilu, R. M. (2022). Understanding the effect of educational attainment and unemployment on youth engagement in conflicts in Machakos County, Kenya. *Afr. Educ. Res. J*. 10, 46–53. doi: 10.30918/AERJ.101.22.003

Solomon, A., and Assegid, W. (2003). *Livestock marketing in Ethiopia : A review of structure, per- formance and development*. Socio-economics and Policy Research Working Paper. Report No.: 52.

Statista (2022). Cattle population in Africa as of 2020 by country. Farming. Available online at: https://www.statista.com/statistics/1290046/cattle-population-in-africa-by-country/ (accessed November 16, 2022).

Sulo, T., Chumo, C., Tuitoek, D., and Lagat, D. (2012). Assessment of youth opportunities in the dairy sector in Uasin Gishu county, Kenya. *J. Emerg. Trends Econ. Manag. Sci*. 3, 332–338.

Tavenner, K., and Crane, T. (2019). "Implementing "gender equity" in livestock interventions," in *Gender, Agriculture and Agrarian Transformations,* ed. C. Sachs (Oxfordshire, UK: Routledge), 147–61. doi: 10.4324/9780429427381-9

Tian, X. (2017). Ethnobotanical knowledge acquisition during daily chores: the firewood collection of pastoral Maasai girls in Southern Kenya. *J. Ethnobiol. Ethnomed*. 13, 1–14. doi: 10.1186/s13002-016-0131-x

Úcar, M. X., Jiménez-Morales, M., Soler Masó, P., and Trilla Bernet, J. (2017). Exploring the conceptualization and research of empowerment in the field of youth. *Int. J. Adolesc. Youth*. 22, 405–418. doi: 10.1080/02673843.2016.1209120

United Nations (2004). *World Youth Report: The Global Situation of Young People*. Rome, Italy: United Nations.

United Nations (2022). *Young People's Potential, the Key to Africa's Sustainable Development | Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.* News. Available online at: https://www.un.org/ohrlls/news/young-people's-potential-key-africa's-sustainable-development (accessed November 9, 2022).

Vincent, K. (2022). A review of gender in agricultural and pastoral livelihoods based on selected countries in west and east Africa. *Front. Sustain. Food Syst*. 6, 908018. doi: 10.3389/fsufs.2022.908018

Wagaman, M. A. (2011). Social empathy as a framework for adolescent empowerment. *J. Soc. Serv. Res*. 37, 278–293. doi: 10.1080/01488376.2011.564045

Wondim, A. K., and Kefale, E. (2018). Gender and youth challenges and opportunities in rural community: the case of Goregora, West Dembia district of North West Ethiopia. *J. Agric. Ext. Rural Dev*. 10, 108–114. doi: 10.5897/JAERD2018.0958

Yami, M., Feleke, S., Abdoulaye, T., Alene, A. D., Bamba, Z., Manyong, V., et al. (2019). African rural youth engagement in agribusiness: achievements, limitations, and lessons. *Sustain*. 11, 1–15. doi: 10.3390/su11010185

Yitbarek, S., Wogasso, Y., Meagher, M., and Strickland, L. (2022). "Life skills education in ethiopia: afar pastoralists' perspectives," in *Life Skills Education for Youth. Young People and Learning Processes in School and Everyday Life,* eds. J. DeJaeghere and E. Murphy-Graham (Cham: Springer) 245–65. doi: 10.1007/978-3-030-85214-6_11

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The hidden end of the value chain: potentials of integrating gender, households, and consumption into agrifood chain analysis

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The aim of this perspective paper is to reinforce the analysis of gender relations in agrifood chain research and integrate the household and the work and consumption taking place there. In the value chain discourse, approaches that integrate households and consumption as an analytical dimension exist, but the last stage often remains hidden. To take a holistic view on value chains integrating the *hidden end*, we apply feminist economic perspectives and gender analysis to agrifood chains. This paper builds on our own research while integrating it with other scholars' empirical work and the theoretical literature concerning gender and value chains. Drawing on empirical examples from both the Global North and South (e.g., on the meat, tomato, seafood, and African Indigenous Vegetables chains), we illustrate the importance of households and consumption to value chain analysis with three examples: Firstly, we demonstrate how commercialization in agrifood chains impacts consumption practices and the food-related care work of women; secondly, we discuss how market-oriented reforms to production in a globalized economy restrict control and access to food for producers; and thirdly, we illustrate that consumer appetite influences working conditions in food production and policies. The examples underscore the fact that households and consumption are not isolated components, but are embedded in a complex agrifood system. In the final part of the paper, we propose an agenda for making this hidden end of the value chain and its links to gender, the household, and consumption more visible.

KEYWORDS

value chains, agrifood chains, feminist commodity chains, food consumption, gender, indigenous food, household

1. Introduction

In this reflection, we aim to shed light on the *hidden end* of global agrifood chains: the household, and the unpaid work and consumption taking place there. We focus on these dimensions of food chains from a gender standpoint, contributing a much-needed perspective on agrifood chains. We argue that neither the household as unit of analysis nor consumption as a social practice have been sufficiently studied and represented in agrifood chain research.

Scholars as well as civil society and political actors have already called for more integrative and interdependent thinking in agrifood studies and politics. Different approaches have been proposed in order to move towards a comprehensive perspective and to challenge the

production-consumption dichotomy; these include nutrition-sensitive value chains (Allen and de Brauw, 2018), post-farmgate agrifood value chains (Maestre et al., 2017), telecoupling effects (Liu et al., 2013), prosumers (Ritzer, 2015), and a focus on meal cultures in value chains (Teherani-Krönner, 2017; Musotsi et al., 2018). While this perspective is thus not new, we see the need to highlight, sort, and reassert this perspective to understand the complexity and inextricability of agrifood chains, specifically by including a perspective on households and consumption.

The purposes of this paper – to strengthen a gender perspective in agrifood chain research in general and to integrate the household and the work and consumption taking place there in particular – are inspired by our own research experiences. The first author conducted research in Kenya on locally produced and consumed vegetables called African Indigenous Vegetables (AIVs)[1], in which the strong relationship between the different nodes in the agrifood chain became evident in various findings. Thus, this paper builds upon our own social scientific research (Brückner, 2020) while integrating it with other scholars' empirical work and the theoretical literature. To build our perspective and to take an integrative view on value chains, we apply feminist views and gender analysis on agrifood chains. This paper is guided by the following questions: Where and how do aspects of households and consumption unfold in the agrifood chain? And how can gender analysis help to make these visible?

In order to reflect these questions, the paper is organized as follows: In the next two sections, we introduce gender as an analytical category for agrifood chain analysis and identify three reasons why household and consumption have played a marginal role in agrifood chain research and discourse. Following this, we draw on selected empirical examples from both the Global North and South to illustrate the many facets of consumption and the roles they play in agrifood chains. Situated at different nodes, these three empirical contexts offer an understanding of the important role of households and consumption in agrifood chains, illustrate the importance of looking at gendered dimensions of value chains, and demonstrate the relevance of the proposed perspective. In the final part of the paper, we propose an agenda on how to make the hidden end of the value chain and its links to gender, the household, and consumption visible.

2. Theoretical backgrounds

2.1. Gender, households, and consumption in agrifood chain research

Gender plays an important role at different nodes of the commodity chain. All over the globe, labor markets are profoundly structured by gender, resulting in considerable horizontal and vertical segmentation as well as pay gaps (ILO, 2018). Gender relations intersect with other categories of social inequality, such as age, ethnicity, race, class, religion, and sexual orientation. We understand gender in this context as a "social ordering principle" (Young, 2010, p. 265), which is neither static nor fixed, but can dynamically change over time.

The food industry in particular has been described as one that exacerbates and reproduces inequalities based on race, class, and gender (Allen, 2016; Haley et al., 2020; Weiler and Grez, 2022). Women make up one third of all agriculture workers globally (Giner et al., 2022) and they are frequently employed on a seasonal or temporary basis (ILO et al., 2007). Women tend to combine formal and informal labor on the farm; thus their flexible labor often sustains agricultural work (Prugl, 2004). In agrifood chain scholarship, gender has also been considered a category that shapes the everyday lives of actors and is deeply entrenched in food politics (e.g., Kaplan, 2011).

Focusing mainly on paid work, much agrifood chain research has overlooked the importance of the household and the unpaid work done there, primarily by women. As a consequence, perspectives that include the area of consumption, such as household practices and decision-making with regard to food, are often missing from the analysis of agrifood chains, and so do food-related care practices. While gender studies in agrifood chains have been widely recognized, approaches that conceptualize and study the household level, the unpaid work done there and the consumption practices in their complexity are not fully incorporated in the value chain discourse. In the next section, we identify three main limitations that have led to the disregarding of household and consumption.

2.2. Three reasons for overlooking the relevance of households and food consumption

The early stages of gender analysis in value chain research were marked by a focus only on women and influenced by development practice and policy. Over time, the research field moved to a more complex gender approach in which women, men, and gender *relations* were addressed. As Dunaway (2013, p. 22) highlights, households are not only important for commodity chains in terms of the added value they provide; rather, "they are the structural end points of commodity chains" (Dunaway, 2013). In recent decades, feminist commodity chain analysis has re-included the household in value chain analysis. Feminist commodity chain analysis, according to Ramamurthy (2013, p. 40) is,

> a method for researchers (1) to pinpoint and investigate the different nodes of a global commodity chain in which women are key agents, (2) to understand how gender and sexual ideologies structure social relations and code value in the production and consumption of commodities, and (3) to track how value is created, extracted, and distributed in commodity circuits so as to accomplish the social reproduction of labor and of capital.

Moreover, a focus on *livelihoods* appeared (Kleiber, 2014), which allowed social, cultural, political, and ecological issues to be considered (Weeratunge et al., 2010) and challenged the narrow focus on employment and income (Krishna, 2012). "[This] approach created a broader understanding of the environmental and social context in which livelihoods are pursued and moved analysis beyond looking at more narrowly defined 'employment'" (Weeratunge et al., 2010). Adopting livelihood approaches also held the potential to include questions of justice, that is, asking who benefits and who loses from

1 About 200 AIV species have been recorded in Kenya (Opiyo, 2014), including the commonly consumed spider plant, African nightshade, and amaranth.

dominating systems, and how livelihoods are impacted by different dimensions of inequality.

Yet the integration of a gender perspective into agrifood value chain analysis was and still is often guided by the goal of including women in agricultural production and empowering them economically. Thus, the first reason why household and consumption have been neglected, we argue, is this productivist framing, which has inevitably led to a focus on economic dimensions and empowerment narratives that fall short of including multiple aspects of life, such as social wellbeing, community cohesion, local and cultural ties, or individual agency and self-determination. Predominant research themes on the subject of agrifood chains have been bargaining and management power. Such approaches are important because they tackle the position and decision-making power of workers in the value chain, yet this focus remains restricted to an economic view. Studies have shown, for example, that the universalist assumption of increasing economic gains or agricultural productivity is not the only desirable goal for workers. Instead, in some cases, community building, education of children or gaining respect are more important (Cook, 2020).

A second reason we identify is the way the household has been conceptualized and addressed in value chain research. Engagements with the household have concentrated largely on poverty alleviation. This poverty-driven take on the household – again based on monetary criteria – has delivered important findings but kept the work and the consumption taking place on the household level invisible. Emphasis has been further placed on decision-making processes at the household level, mainly in relation to access to resources and services. By studying the share of household labor, care work has been implicitly addressed with this approach, although care work has frequently been framed as a burden that leads to time poverty. The knowledge, creativity, and skill needed for this work is often not considered, nor is the life-sustaining and fundamental role of care and domestic work for society.

A third shortcoming that leads specifically to the neglect of consumption and meal cultures in the value chain context is the focus on nutrition security and nutritional outcomes, which are quantifiable and measurable but do not grasp the socio-cultural relevance of food preparation and processing. Taking nutrition as a focal point shifts the focus to aspects of consumption, such as healthy diets, hidden hunger (Kimura, 2013) or recipe development and offers the potential to adopt a broader view on agrifood chains. This "nutritional fix," however, rarely touches upon such topics as the gendered care work that is necessary to implement nutrition-sensitive value chains or the meaning of food.

Against this backdrop, we propose that the procurement, preparation, and consumption of food should be understood, on the one hand, as labor- and knowledge-intensive, and on the other hand, as social and cultural practices that shape individual and group identities. We believe that such a holistic perspective provides opportunities to anchor household and consumption practices into the value chain discourse. While feminist approaches have made a strong contribution by adding the household to the dominant perspectives, the many facets of consumption and the role they play in the value chain, we argue, still need to be included more in agrifood chains. In the following, we illustrate this argument with three empirical examples that show how households and consumption can play a vital role in the agrifood chain.

3. Empirical illustrations

3.1. The impact of food commercialization on consumption and local meal cultures

As described above, agrifood chain scholarship is dominated by studies on production-related aspects. Less attention is given to food's "inside meanings" (Mintz, 1985) and to questions of how food products are culturally and locally bound, for example by practices of food-related care work and consumption. As Collins puts it: "Wherever a global commodity chain touches down, it intersects with local social relations" (Collins, 2013, p. 32). These aspects are particularly relevant from a gender perspective, as these kinds of work and practices are deeply gendered. There have been insightful examples of research that pays attention to these factors (Dowty and Wallace, 2010; Toussaint et al., 2022), but they have not yet been fully adopted by the larger agrifood chain discourse. Therefore, we argue that the symbolic meaning and value of food, as well as the social and cultural practices that shape consumption, are important and fruitful perspectives of agrifood chain analysis.

"Today it's a rich peoples' food!" said one participant in the study on African Indigenous Vegetables in Kenya. Numerous respondents told us that the vegetables, which were formerly produced for household consumption or grown wild, have become more expensive as production becomes commodified, hence influencing consumers' livelihood. As the vegetables are currently becoming more popular, and a lucrative market is developing, especially in urban areas (Henze et al., 2020), consumers fear that the fact that profit can be made from AIVs may have an impact on their quality and accessibility. The commercialization of AIVs has wide-ranging consequences for biodiversity and food sovereignty (Brückner, 2020). It also strongly affects consumption and meal cultures and the ability to eat food that is satisfying, flavorful, and corresponds with culinary preferences. The complex colonial culinary history of Kenya has already shown that local foodways are at risk when power relations in the global agrifood system change (Brückner, 2020). Cases in point include the introduction of new staple foods (e.g., maize) in the sixteenth century and the transformation of agricultural production systems during British colonialism.

The socio-cultural significance of AIVs for everyday consumption in Kenya is fundamental and the consequences of commercialized production systems need to be critically examined. So far, AIVs are mainly sold on domestic markets (Mwema and Crewett, 2019). While new and emerging markets could create economic benefits for farmers, they could also have a profound effect on the everyday foodways and the local population's ability to eat food that is satisfying. This could especially affect those who obtain food on a limited budget, making it financially difficult for low-income households to eat AIVs. Our study (Brückner, 2020) indicated that the price increases forced some consumers to eat so-called exotic leafy vegetables, such as kale and cabbage, which were introduced by colonial rulers, instead of the traditional AIVs. One coping strategy has been to mix exotic and local vegetables in order to preserve the taste as it is known. Another strategy has been to search for markets where the local varieties are less expensive. This change in provisioning has strong gendered implications, as women are mainly responsible for obtaining AIVs, and they need more time to travel to distant markets and more ways

adjust their cooking practices. In summation, the combined process of the increased marketization of AIVs locally and increased recognition of the local vegetables internationally could deny access to traditional and local food, ultimately influencing the social and cultural bonds that communities have created around AIVs.

3.2. Changes in production modes on the value chain and their impacts on food access for producers

The second empirical illustration shows that changes in commodity chains can affect control and access to food on the part of the food workers themselves. As Ferolin (2014) shows in her research on the neoliberal modernization of the fishing industry in the Mindanao region of the Philippines, market-oriented reforms may encompass such areas as production, environmental consequences, the work of the fishers, and their own access to and control of food. The fishing industry on the island of Mindanao has been subject to enormous change: "Within less than two decades, the country's productive systems were transformed into food-extractive enclaves producing cheap consumer commodities for Japan, Western Europe, China, and the United States" (Ferolin, 2014, p. 156).

According to Ferolin (2014), the costs of this transition were externalized both to the environment and to the peasant households in multiple ways, including: (1) The link between aquaculture and damage to nature, including loss of biodiversity and pollution of drinking water: as it is women who do most housework, and housework has become harder as a consequence, women are more affected by these changes; (2) Changes to the gendered structures of work: women remain primarily responsible for unpaid housework, but at the same time have to contribute more in paid work; and (3) The loss of food security: peasants' access to food, both in terms of quality and quantity, deteriorates and malnutrition increases.

As a consequence, in a recent study on Asian fishers, Dunaway and Macabuac (2022, p. 1) poignantly ask: "Why are the Asian peasants who produce and export so much of the world's food the hungriest people in the world?" Their ethnographic research looking at the fishers' livelihoods and including unpaid domestic work reveals "that women's work is central to household provisioning, often generates greater income than that earned by males, and provides visible and hidden inputs into the exports that enter global seafood commodity chains" (Dunaway and Macabuac, 2022, p. 260). Yet, at the same time, women's access to resources and their share of the household pool remains lower than men's.

Regarding the issue of food access, comparable impacts can be observed when it comes to quinoa, a traditional crop of the Andean highlands region that has entered the globalized agrifood market. In Peru, for example, local producers gained purchasing power and were able to buy food and other consumer goods in stores that had been inaccessible before. However, these new foods were less nutritious, and this development influenced their diet negatively (McDonell, 2016). Studies indicate that the consumption of quinoa has declined, having been substituted by wheat products (Hellin and Higman, 2005). These empirical examples illustrate how the consumer end is very relevant when it comes to workers' sovereignty on global agrifood chains: They show how global capitalism changes the systems of production, how this impacts the producers' consumption and domestic work, and how these impacts are gendered.

3.3. Consumer appetite and its impact on employment conditions in the value chain

The third empirical illustration looks at the importance of consumption from yet another angle: In addition to the food cultures among producers and in local households, another aspect that is important to agrifood chains encompasses the consumption cultures and preferences on part of the consumers. Global consumer appetite – that is, increased demand for a specific food product – is influential in shaping the employment conditions of the workers producing the food, and, as we will show, even state policies.

The groundbreaking study on the working and employment conditions of female workers in the transnational tomato food chain by Barndt (1999) illustrated the dynamic relationship between consumption and production. In her ethnography, Barndt maps the journey of tomatoes that are produced and harvested in the Global South on Mexican farms and sold to North America. Barndt's analysis demonstrates that changing consumer preferences to consume tomatoes year-round change the nature of production and shape the working conditions. In this case, transnational agrifood companies flexibilized and feminized the work in order to ensure "just-in-time" production. Indigenous resources such as land became appropriated (Barndt, 1999, p. 67). At the same time, however, consumer appetite can force actors to introduce sustainable standards, as can be seen in the case of organic tea production. Here, consumers' increased appetite for organic tea has given producers the opportunity to work locally and strengthen their networks, although more ambivalent impacts of organic certification can be observed as well (Qiao et al., 2016).

Further examples could be observed during the COVID-19 pandemic. The meat industry in Germany, for instance, saw increased demand during the pandemic. Workers in the industry, many of them migrants, the majority male, faced "multiple precarity" with regard to their employment and living conditions (Birke, 2022, p. 44–45). The different work tasks of slaughtering animals, breaking up the various parts of the meat, and cleaning it are distributed by gender. When there were severe COVID-19 outbreaks in different German slaughterhouses in the spring of 2020, which were partly due to the poor conditions of accommodation and work across the industry, the public reacted strongly (Erol and Schulten, 2021; Birke, 2022). Eventually, the legislation was changed to restrict the use of external labor in the industry (Schulten and Specht, 2021).

Another case in point is harvest work in Germany. The availability of flexible labor in high-income countries in Europe has diminished since the 1990s, among other reasons because many female rural workers turned to other labor markets (Küppers, 2021, p. 10). In Germany, much farm work is done by migrant contract workers from Eastern European countries (Küppers, 2021, p. 1). While these workers were not allowed to cross the border into Germany at the beginning of the pandemic, the fear in the country of what might happen to the harvest, especially the asparagus harvest, led to political changes. Influenced by the agricultural lobby, lockdown restrictions were loosened for these workers in April 2020 and charter flights were organized to transport workers from Romania to Germany (Küppers, 2021, p. 11). It is not by accident that this discussion became particularly prominent at the start of asparagus season, as Küppers (2021) has shown: "As a symbol for German haute cuisine, asparagus is often treated as a national treasure" (Küppers, 2021, p. 11). Thus, the consumer appetite for

asparagus and the value attributed to it eventually changed the policies for harvest workers in Germany during the pandemic.

This set of examples illustrates the impact of food cultures and consumption on the part of the consumers and shows how they impact policies as well as the livelihoods of migrant workers of different genders in precarious labor markets.

4. Discussion: towards a holistic agenda that includes gender, households, and consumption

This perspective paper has argued that households and consumption are important yet often hidden parts of the value chain. By using a gender approach to value chain analysis, we have shown the relevance of the household and the work and consumption taking place there for the value chain empirically by looking at three different facets of consumption. Our first example illustrated how commercialization in agrifood chains impacts the traditional consumption practices, household labor, and food-related care work of women. The second example showed how market-oriented reforms to production in a globalized economy restrict the control of and access to food on the part of those producing it on a local level in gendered ways. The third example, looking at consumption from a different angle, highlighted how consumer appetite influences working conditions in food production and, indeed, policies.

To answer our two guiding questions – where and how do aspects of households and consumption unfold in the agrifood chain and how can gender analysis help to make these visible? – the examples demonstrate that consumption, *the hidden end of the value chain*, can have a variety of effects on different nodes in the agrifood chain. Dynamics and developments in the consumer segment have repercussions in terms of social inequalities. These inequalities stretch from the field to the kitchen, making culturally relevant food inaccessible or increasing the workload for both producers and consumers. By assessing gender as an analytical category and by applying feminist perspectives to agrifood chain analysis, the household, the gendered work being done there, and the consumption happening there can be highlighted.

Based on three points, we would like to suggest a holistic agenda for making the hidden end of the value chain and its links to gender, the household, and consumption more visible. First, consumption has to be conceptualized as an integral part of the agrifood system. A shift is required in how consumption and its place in the chain is conceptualized: Consumption is not an isolated component; rather, it is embedded in a complex agrifood system. A fragmented look at individual nodes in the chain hides social practices and power relations. Moreover, the place where this consumption is embedded – the household – has to be taken seriously, and "lifting the roof off the household" (Seager, 2019) is essential. Therefore, collaborative and transdisciplinary exchanges along the entire value chain promise rich and integrated perspectives for agrifood research. Here, the concept of *livelihoods* (Wichterich, 2004; Weeratunge et al., 2010; Krishna, 2012) can be of help: Looking at the livelihoods of people in the value chain, instead of only paid employment or economic aspects, helps to grasp the broader context of the chain and the *hidden end*.

Second, the application of gender analysis with a broad conception of gender represents a crucial element in the proposed agenda. Gender analysis enables an investigation of how practices and social hierarchies in agrifood chains are gendered. Often, this implies shedding light on the situation of women, who tend to be overlooked in mainstream knowledge production, making it an important task for feminist research. It is vital to consider gender as an analytical category, and gender-disaggregated data needs to be collected (Selva and Janoch, 2022). However, "gender" cannot be equated with "women," and contemporary gender analysis also needs to include men and masculinities, as well as other genders. As examples for future studies, research that adds the concept of "hegemonic masculinity" (Connell, 2005) to the discussion is inspiring. McCarthy et al. (2020), for instance, investigate constructions of masculinity and male power in labor standards and welfare programs in value chains, while Patel-Campillo (2012) looks at gender relations, including women and men, to understand the relationship between production and consumption. Taking up this research can impact future studies, enabling them to address the gendering of agrifood practices while challenging not only constructions of femininity but also of masculinity.

At the same time, researching gender also means going beyond a binary gender construction. Including non-binary concepts of gender can broaden the picture as a supplemental research perspective, taking into account that gender is a fluid and socially constructed category and that the dichotomy of "male" and "female" does not grasp social reality in its entirety. Additionally, social inequalities beyond gender and its intersections have to be incorporated into a holistic agenda.

Third, in order to reach a holistic understanding of agrifood chains, which considers economic as well as cultural and social dimensions, we encourage a stronger exchange between different disciplines. Fruitful cooperation could take place, for example, between economics, sociology, political science, anthropology, geography, and gender studies. In some of these fields, the household, with the unpaid work being done there and the consumption of food happening there, have been extensively studied. Conceptual and empirical insights from these disciplines can build a basis and support a greater understanding of the complexity of the hidden end of the value chain. Unpaid work, such as food-related care work, needs to be recognized an indispensable economic contribution to agrifood chains. At the same time, in order to focus on the socio-cultural experience and preference of food, including the topic of food and the body (Abbots and Lavis, 2016) and the visceral and sensorial encounters with food (Edwards et al., 2021), could be fruitful for agrifood chain research. This focus would allow greater recognition for cooking as a social and political practice that creates a tasty meal. It may also offer the potential to investigate whether value chain interventions – such as new recipe development – correspond with culinary preferences. In addition to important economic and dietary foci, such socio-cultural aspects would further broaden the perspective and create new knowledge relating to agrifood value chains.

On a final note: As we describe specifically in section 3.3 how certain products flourish due to consumer demand, it should not be forgotten that this food is offered and promoted by a powerful capitalist agrifood system. By shifting the focus to consumption, we do not intend to promote the "responsibilization" of consumers; instead, we want to highlight how the global corporations' control over the food system can create food and social inequalities, often in the name of consumer demand. This also needs to be considered in future efforts: Systemic change is needed, rather than change on the individual level.

Data availability statement

Arguments made in this article are based on already analyzed data for other publications. The raw qualitative data presented in this article is highly sensitive. Requests to access these datasets should be directed to the corresponding author.

Author contributions

MB and KS developed the concept for the article together and equally involved in writing the paper. MB conducted and analyzed the research for the quoted empirical case study, and had the lead role in coordinating the submission process and manuscript formatting. All authors contributed to the article and approved the submitted version.

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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.

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References

Abbots, E.-J., and Lavis, A. (2016). *Why we eat, how we eat: contemporary encounters between foods and bodies*. Aldershot: Ashgate.

Allen, P. (2016). In this issue: labor in the food system, from farm to table. *J. Agric. Food Syst. Community Dev.* 6, 1–4. doi: 10.5304/jafscd.2016.062.022

Allen, S., and de Brauw, A. (2018). Nutrition sensitive value chains: theory, progress, and open questions. *Glob. Food Sec.* 16, 22–28. doi: 10.1016/j.gfs.2017.07.002

Barndt, D. (1999). *Women working the NAFTA food chain: women, food & globalization*. Toronto: Second Story Press.

Birke, P. (2022). *Grenzen aus Glas. Arbeit, Rassismus und Kämpfe der Migration in Deutschland*. Wien: Mandelbaum.

Brückner, M. (2020). *Biodiversity in the kitchen. Cooking and caring for African indigenous vegetables in Kenya: a feminist approach to food sovereignty*. München: oekom Verlag.

Collins, J. (2013). "A feminist approach to overcoming the closed boxes of the commodity chain" in *Gendered commodity chains. Seeing women's work and households in global production*. ed. W. A. Dunaway (Stanford: Stanford University Press), 27–37.

Connell, R. W. (2005). *Masculinities*. Cambridge: Polity.

Cook, B. (2020). The problem with empowerment: social reproduction and women's food projects in Jordan. *Ann. Am. Assoc. Geogr.* 111, 52–67. doi: 10.1080/24694452.2020.1747971

Dowty, R. A., and Wallace, W. A. (2010). Implications of organisational culture for supply chain disruption and restoration. *Int. J. Prod. Econ.* 126, 57–65. doi: 10.1016/j.ijpe.2009.10.024

Dunaway, W. A. (2013). "Introduction" in *Gendered commodity chains. Seeing women's work and households in global production*. ed. W. A. Dunaway (Stanford: Stanford University Press), 1–23.

Dunaway, W. A., and Macabuac, M. C. (2022). *Where shrimp eat better than people: globalized fisheries, nutritional unequal exchange and Asian hunger*. Leiden, Boston: Koninklijke Brill NV.

Edwards, F., Gerritsen, R., and Wesser, G. (2021). *Food, senses and the city*. London: Routledge.

Erol, S., and Schulten, T. (2021). *Renewing labour relations in the German meat industry*. WSI Report 61e. Düsseldorf.

Ferolin, M. C. (2014). "Commodity-chained fishing households. Peasant subsidization of exports in a Philippine seafood-extractive enclave" in *Gendered commodity chains. Seeing women's work and households in global production*. ed. W. A. Dunaway (Stanford: Stanford University Press), 156–171.

Giner, C., Hobeika, M., and Fischetti, C. (2022). *Gender and food systems: overcoming evidence gaps, OECD food, agriculture and fisheries papers*, No. 184, OECD Publishing, Paris.

Haley, E., Caxaj, S., George, G., Hennebry, J., Martell, E., and McLaughlin, J. (2020). Migrant farmworkers face heightened vulnerabilities during COVID-19. *J. Agric. Food Syst. Community Dev.* 9, 1–5. doi: 10.5304/jafscd.2020.093.016

Hellin, J., and Higman, S. (2005). Crop diversity and livelihood security in the Andes. *Dev. Pract.* 15, 165–174. doi: 10.1080/09614520500041344

Henze, J., Abukutsa-Onyango, M., and Opiyo, A. (2020). *Production and marketing of African indigenous leafy vegetables – training manual for extension officers and practitioners*. Berlin: SLE Publication.

ILO. (2018). *World employment and social outlook: trends for women 2018 – global snapshot*. Geneva: International Labour Organization, *2018*, 11–27.

ILO, FAO, and IUF. (2007). *Agricultural workers and their contribution to sustainable agriculture and rural development*. Geneva: International Labour Organization.

Kaplan, D. M. (ed.). (2011). *The philosophy of food*. Berkeley: University of California Press.

Kimura, A. H. (2013). *Hidden hunger: gender and the politics of smarter foods*. Ithaca and London: Cornell University Press.

Kleiber, D. (2014). A yawning gender gap. *Yemaya* 45, 6–7.

Krishna, S. (2012). "Redefining sustainable livelihoods' in women reclaiming sustainable livelihoods" in *Spaces lost, spaces gained*. ed. W. Harcourt (London: Palgrave), 12–19.

Küppers, C. (2021). *How to harvest in a pandemic? The German media coverage of migrant workers and harvesting in the context of the Covid-19 crisis in 2020*. Food for Justice Working Paper Series, no. 5. Berlin: Food for Justice: Power, Politics, and Food Inequalities in a Bioeconomy.

Liu, J., Hull, V., Batistella, M., DeFries, R., Dietz, T., Fu, F., et al. (2013). Framing sustainability in a telecoupled world. *Ecol. Soc.* 18:26. doi: 10.5751/ES-05873-180226

Maestre, M., Poole, N., and Henson, S. (2017). Assessing food value chain pathways, linkages and impacts for better nutrition of vulnerable groups. *Food Policy* 68, 31–39. doi: 10.1016/j.foodpol.2016.12.007

McCarthy, L., Soundararajan, V., and Taylor, S. (2020). The hegemony of men in global value chains: why it matters for labour governance. *Hum. Relat.* 1, 2051–2074. doi: 10.1177/0018726720950816

McDonell, E. (2016). Nutrition politics in the quinoa boom: connecting consumer and producer nutrition in the commercialization of traditional foods. *Int. J. Food Nutr. Sci.* 3, 1–7. doi: 10.15436/2377-0619.16.1212

Mintz, S. (1985). *Sweetness and power*. New York: Penguin.

Musotsi, A. A., Brückner, M., Teherani-Krönner, P., and Kingiri, A. (2018). The gender dynamics of provisioning African indigenous vegetables as a meal in Kenya: a meal security perspective. *J. Gend. Agric. Food Secur.* 3, 36–50. doi: 10.22004/ag.econ.293598

Mwema, C., and Crewett, W. (2019). Social networks and commercialisation of African indigenous vegetables in Kenya: a Cragg's double hurdle approach. *Cogent Econ. Finance* 7:1. doi: 10.1080/23322039.2019.1642173

Opiyo, A. M. (2014). *Traditional leafy vegetables: Status and future prospects. HORTINLEA Summer School, presentation*. Kenyatta University, Nairobi.

Patel-Campillo, A. (2012). The gendered production–consumption relation: accounting for employment and socioeconomic hierarchies in the Colombian cut flower global commodity chain. *Sociol. Rural.* 52, 272–293. doi: 10.1111/j.1467-9523.2012.00569.x

Prugl, E. (2004). Gender orders in German agriculture: from the patriarchal welfare state to Liberal environmentalism. *Sociol. Rural.* 44, 349–372. doi: 10.1111/j.1467-9523.2004.00281.x

Qiao, Y., Halberg, N., Vaheesan, S., and Scott, S. (2016). Assessing the social and economic benefits of organic and fair trade tea production for small-scale farmers in Asia: a comparative case study of China and Sri Lanka. *Renew. Agric. Food Syst.* 31, 246–257. doi: 10.1017/S1742170515000162

Ramamurthy, P. (2013). "Feminist commodity chain analysis. A framework to conceptualize value and interpret perplexity" in *Gendered commodity chains: seeing women's work and households in global production*. ed. W. Dunaway (Stanford: Stanford University Press), 38–52.

Ritzer, G. (2015). The "new" world of prosumption: evolution, "return of the same," or revolution? *Sociol. Forum* 30, 1–17. doi: 10.1111/socf.12142

Schulten, T., and Specht, J. (2021). Ein Jahr Arbeitsschutzkontrollgesetz. Grundlegender Wandel in der Fleischindustrie? *APuZ* 71, 51–52.

Seager, J. (2019). *Gender equality and environmental sustainability in the age of crisis, expert paper, sixty-fourth session of the commission on the status of women (CSW 64) "Beijing +25: current context, emerging issues and prospects for gender equality. And Women's rights"*, New York, New York: UN women.

Selva, M., and Janoch, E.. (2022). *Food security and gender equality: a synergistic understudied symphony*. CARE Research Report.

Teherani-Krönner, P. (2017). Meal cultures — a new concept in food security debates on African leafy vegetables in Kenya and East Africa. *Open Access J. Agric. Res.* 2, 1–25.

Toussaint, M., Cabanelas, P., and Muñoz-Dueñas, P. (2022). Social sustainability in the food value chain: what is and how to adopt an integrative approach? *Qual. Quant.* 56, 2477–2500. doi: 10.1007/s11135-021-01236-1

Weeratunge, N., Snyder, K. A., and Sze, C. P. (2010). Gleaner, fisher, trader, processor: understanding gendered employment in fisheries and aquaculture: gendered employment in fisheries. *Fish Fish.* 11, 405–420. doi: 10.1111/j.1467-2979.2010.00368.x

Weiler, A. M., and Grez, E. E. (2022). Rotten asparagus and just-in-time workers: Canadian agricultural industry framing of farm labour and food security during the COVID-19 pandemic. *Can. Food Stud. / La Revue Canadienne Des études Sur l'alimentation.* 9, 38–52. doi: 10.15353/cfs-rcea.v9i2.521

Wichterich, C. (2004). *Überlebenssicherung, Gender und Globalisierung. Soziale Reproduktion und Livelihood-Rechte in der neoliberalen Globalisierung*. Wuppertal: Wuppertal Papers Wuppertal Institut für Klima, Umwelt, Energie, 1–57.

Young, B. (2010). "The gendered dimension of money, finance, and the subprime crisis" in *Gender and economics*. eds. C. Bauhardt and G. Çağlar (Wiesbaden: VS Verlag für Sozialwissenschaften), 258–277.

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Young women's and men's climate adaptation practices and capacities in Kenya livestock production systems

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Climate change adaptation strategies must be identified and tailored to diverse locations and livestock production systems to be effective. Social factors such as gender, wealth, age and education levels generate differentiated abilities and capacities to cope with climate shocks. In this study we draw upon 48 sex disaggregated focus group discussions with youth to understand young people's engagement in the livestock sector and their livestock adaptation strategies. We first explore whether gender and locational differences exist in young women's and men's engagement in the livestock sector, specifically which livestock species young women and men rear. Next, we describe young women's and men's livestock adaptation strategies in mixed crop and livestock and agropastoral systems. Lastly, we share insights about relationships that shape young women's and men's engagement in livestock during their transitions to adulthood. Youth rear certain species more than others, such as chickens and dairy cows. Livestock adaptation practices are generally low. Gendered practices during transitions to adulthood differ for young women and men and household relationships mediate young women's and men's livestock production engagement. Intergenerational transfers are gendered, however, are changing in all locations. Women's opportunities to inherit or acquire land, for instance, have expanded. Transitions into new households, however, often reinforce gendered access to resources and women's labor. Recommendations on how to better develop inclusive and sustainable policies that provide support to youth in livestock and strengthen their adaptation capacities are provided.

KEYWORDS

youth, gender, livestock, adaptation, Kenya

Introduction

Climate change has risen in Kenya's policy agenda over the last decade. Frequent and increasing severity of drought threaten agricultural livelihoods, especially those who depend on livestock in arid and semi-arid lands (Njeru, 2017; Marty et al., 2022). Climate change adaptation strategies specific to the livestock sector must be identified and tailored to diverse locations and livestock production systems to be effective (Thornton and Herrero, 2014; Rojas-Downing et al., 2017). Climate impacts upon livestock include decreased availability of water and forage and subsequent lower production and losses associated with increased incidence of disease (Rojas-Downing et al., 2017). Adaptation practices include production and management system modifications, such as changes in breeding practices and choices of breeds that are tolerant to

heat stress and disease; intensification in production, livelihood diversification and shifting out of livestock production altogether (Bennett et al., 2014).

Multiple policies specific to climate and youth exist, however the integration of youth specific issues and their abilities to implement adaptation practices in livestock production is not clearly elaborated. Kenya has prioritized mainstreaming climate adaptation in national and county level development planning (Kenya NAP, 2015–2030) and demonstrates consistent policy focus on strengthening climate adaptation (Ashley, 2019). The Climate Change Act of 2016 is the main legislation guiding Kenya's climate response and informed the *National Climate Change Action Plan (NCCAP) 2018–2022* in which agriculture features as a priority sector. The *Kenya Climate Smart Agriculture Strategy (KCSAS) 2017–2026,* includes a strategic goal to empower women, youth, and vulnerable groups through improved participation in CSA activities, including some that are specific to livestock.

Concerns about the significantly large, and mostly unemployed youth population in Sub-Saharan Africa have raised the visibility of youth in international and national level policy discourse (Sumberg et al., 2019). The potential of the agricultural sector to support youth, defined by the Kenya Constitution as those between 18 and 34, is recognized (see Kenya Youth Development Policy, 2019; National Policy on Gender and Development, 2019). However, such policies seldom identify the linkages between youth and livestock (e.g., National Agricultural Policy, 2019). While the National Livestock Policy (2019) highlights the sector's vulnerability to climate change, youth specific approaches or the identification of youth specific climate adaptation strategies are largely absent.

Social dynamics in livestock and adaptation

Inequalities based on gender, race, class, ethnicity, and other axes of power interact and shape social dynamics, such as who may own specific types of livestock, how livestock are managed, whose labor is used and how labor is distributed in livestock production. This study spans three counties and diverse ethnic groups therein, the Kalenjin in Nakuru, Kikuyu in Kiambu, and the Maasai in Kajiado. Gender roles and practices within these cultural groups, to varying extents, influence social dynamics in livestock production and, consequently, livestock adaptation practices. Gender roles, however, are dynamic and changing under the pressures of emerging economic and climatic circumstances (Doss, 1999) and, in some cases, creating opportunities for women to exercise agency in ways that counter conservative and restrictive norms about what women should and should not do (see Petesch et al., 2018; Bullock and Tegbaru, 2019). Studying social change in communities and households during these times of rapid change provides a lens on societal shifts in norms and practices in agricultural systems more generally.

In East Africa, livestock species often are culturally valued, which tends to underpin gendered practices in livestock systems that are well documented, but more recently may be in flux under current economic and climate pressures, for instance. Women often own livestock species of lower economic value relative to men. Men typically own larger livestock, such as cattle, while women own chickens and goats (Njuki and Mburu, 2013; Tavenner and Crane, 2019; Odhiambo, 2020; Garsow et al., 2022). Kalenjin men's legitimacy as men, for example, is in part shaped by ownership of cows (Tavenner and Crane, 2019). Cows are imbued with gendered meaning and Kalenjin masculinity is embedded in localized practices, especially between husbands and wives (Tavenner and Crane, 2019, p. 706). While women may acquire livestock through purchase, gifts, and inheritance, they may not have the decision-making power over livestock or access to resources like land for the livestock (Njuki and Mburu, 2013; Mutua et al., 2017). Purchasing livestock may require permission from the household head and young women may not inherit livestock due to cultural practices (Mutua et al., 2017). In pastoral settings cultural customs may also restrict women's rights to own livestock assets (Omolo et al., 2017) and though women receive livestock through marriage, their rights of access and control may be limited (Rao, 2019).

The division of labor is often gendered in livestock production. Women often carry out most of the daily labor tasks in intensive and semi-intensive dairy production (Tavenner and Crane, 2019) and small ruminant production (Ogolla et al., 2022) such as feeding, watering, and cleaning housing structures. In agropastoral and pastoral systems mobility in animal husbandry is gendered. Men and boys migrate with livestock and leave women and girls at home with weaker or lactating animals, in some cases requiring women to assume more control in management and decision-making over livestock in the homestead (Bullock et al., 2021). Gender dynamics in livestock systems underpin socially differentiated adaptation capacities and capabilities.

Social factors such as gender, wealth, age and education levels generate differentiated abilities and capacities to cope with climate shocks (Omolo and Mafongoya, 2019; Ng'ang'a and Crane, 2020). Among the Maasai gender intersects with age, education, and wealth to shape socially differentiated adaptation pathways and diversification outcomes (Marty et al., 2022). Adaptation practices are shaped by, and themselves shape, beliefs, values, norms, practices, and livelihoods in communities confronted by uncertainty and contextually specific climatic events (Adger et al., 2009; Fazey et al., 2016; Marks et al., 2022), that necessitates the development of "highly situated climate adaptation strategies" (Neef et al., 2018). Adaptation actions influence social relations, and the distribution of resources in any given population or place (Eriksen et al., 2015). For example, in semi-arid northern Kenya, differential adaptation in pastoral and agro-pastoral contexts affect gender and generational relations, with implications for changing household structures (Rao, 2019).

In this study we draw upon sex disaggregated focus group discussions with youth to understand young people's engagement in the livestock sector and their livestock adaptation strategies. We first explore whether gender and locational differences exist in young women's and men's engagement in the livestock sector, specifically which livestock species young women and men rear. Next, we go on to describe young women's and men's climate livestock adaptation strategies in mixed crop and livestock and agropastoral systems. Lastly, we share insights about specific relationships in different household arrangements that shape young women's and men's engagement in livestock during their transitions to adulthood.

Materials and methods

Site description

Kenya spans multiple and diverse agro-climatic zones and livestock production systems are similarly diverse. Commonly owned

livestock in Kenya include cattle, goats, and poultry (Njarui et al., 2016; Odhiambo, 2020). Regions with high mean annual rainfall and fertile soils support mixed crop and livestock systems in which crops and livestock are integrated on the same farm. Production in such systems may be intensified through commercialization practices such as high rates of productivity and inputs, often in smaller spaces when compared to livestock practices in arid and semi-arid lands (ASALs), that occupy a substantial land area in Kenya and where extensive practices are more common, e.g., grazing and mobile husbandry (Kogo et al., 2021). Mixed crop and livestock and pastoral based systems are vulnerable to the effects of climate change, manifested through increasing frequency and intensity of extreme events. Drought has been particularly severe in ASALs in Kenya in recent years (Kalele et al., 2021).

Data collection

Qualitative data was collected in Kiambu, Nakuru, and Kajiado counties (Figure 1). Site selection was based on diversity sampling. The counties differ in terms of ethnic composition and livestock production systems. Ethnic groups differ across the 3 counties. The majority group in Kiambu are the Kikuyu, Kalenjin in Nakuru and Maasai in Kajiado. Dairying is especially common in Kiambu and Nakuru. In the livestock sector dairying is the leading enterprise, with nearly 70% of households keeping an average of 2–3 cows in intensive zero-grazing systems (Kiambu County Integrated Development Plan, 2018). Livestock trade and livestock products in Kajiado include beef, milk, and hides and are a main source of livelihood to most households in the county (Kajiado County Integrated Development Plan, 2018).

The field team consisted of 4 enumerators composed of 2 men and 2 women who underwent a 2-day training. The principal author led the training that entailed a review of the Focus Group Discussion (FGD) guide, translation of the instruments from English to Swahili, and practicing interviews. Data collection was carried out in May 2021 and a total of 48 sex disaggregated FGDs were conducted (Table 1).

Participant selection criteria included age (8–34 years), engagement in agricultural and livestock production and residence in the location for at least 5 years to ensure participants had adequate familiarity with local contexts. Each FGD comprised 5–6 participants and took approximately 2 h. Topics discussed included youth engagement in agriculture, experiences of climate impacts and adaptive capacities and strategies.

Ethical approval was obtained through the ethics board of the International Livestock Research Institute (ILRI-IREC2020-25). Informed consent was read to participants prior to starting the group discussion and signatures were obtained. FGDs were conducted by a facilitator with a note-taker of the same sex. All discussions were recorded, and notes were taken during the sessions. Transcription was carried out by the facilitators in coordination with notetakers, who worked remotely and separately due to COVID. Transcription teams worked jointly in online shared files that were crosschecked by both teams to ensure inter-transcriber reliability, e.g., listening to the audios and checking the transcripts.

Transcripts were translated from Swahili to English and imported into NVivo, a qualitative data analysis software (NVivo 13) (Lumivero, 2022). Iterative deductive and inductive approaches were used (Figure 2). Deductive coding refers to a provisional list of codes that was determined beforehand to explore the study's research questions while inductive approaches refer to identification of emergent, data driven coding (Saldaña, 2021; Bingham, 2023). Coding was conducted by the authors and intercoder consistency was supported through frequent discussions until agreement was reached (O'Connor and Joffe, 2020). Through this process multiple rounds and revisions of the codebook were made. Cross tab coding queries were run to identify gender and location-based trends that were reported in graphs in the Results section.

Results

This section is composed of three sub-sections. First, we describe the livestock species young women and men produce. Then we provide more details about the main species-specific adaptation practices those young women and men implement for chickens, dairy cows and cattle. We report overall trends and gender-specific trends within each location. Percentages of the FGDs, disaggregated by sex per location, were generated to describe key trends. The final sub-section focuses on relationships and the ways that key relations, namely parents and spouses influence youth in livestock production.

Youth engagement in livestock production

Youth rear chickens, dairy cows, small ruminants and pigs and often rear multiple combinations of species (Figure 3). Livestock diversification was described as a strategy to offset fluctuations and irregular income from livestock products.

> "A lot of youths in the area are involved in chicken farming, rabbit and pig farming since you find that if you depend on crop farming too much sometimes the harvests are insufficient. So with keeping those animals you are able to sell eggs, rabbits and pigs for meat." (Men's Group, Nakuru)

Livestock production functions as both a primary and secondary source of income, more commonly referred to as a "side hustle," or a part time enterprise. Dairy, cattle, and small ruminants were reported common primary activities that require more labor than species that were reported to be secondary sources of income: pigs, chickens, and rabbits. Youth engagement in livestock production, and the role of livestock as either primary or secondary sources of emerging income, often changes over the course of the year and depends upon emerging opportunities, such as finding a job or other activities such as attending school.

Poultry production, specifically chicken, is the most common livestock activity and is practiced in both mixed and agropastoral systems (92% of all FGDs). Chicken rearing requires relatively low capital, labor and space requirements. However, this is irregular over the course of the year. Chicken and egg production is flexible, and, should another opportunity arise, like a salaried job, a young person may opt out of livestock activities.

> 'Mine is part time since if I get something else to do, I don't know if I will continue. After school, I have not gotten anything to do that is permanent, so, I have been doing this but it has been part

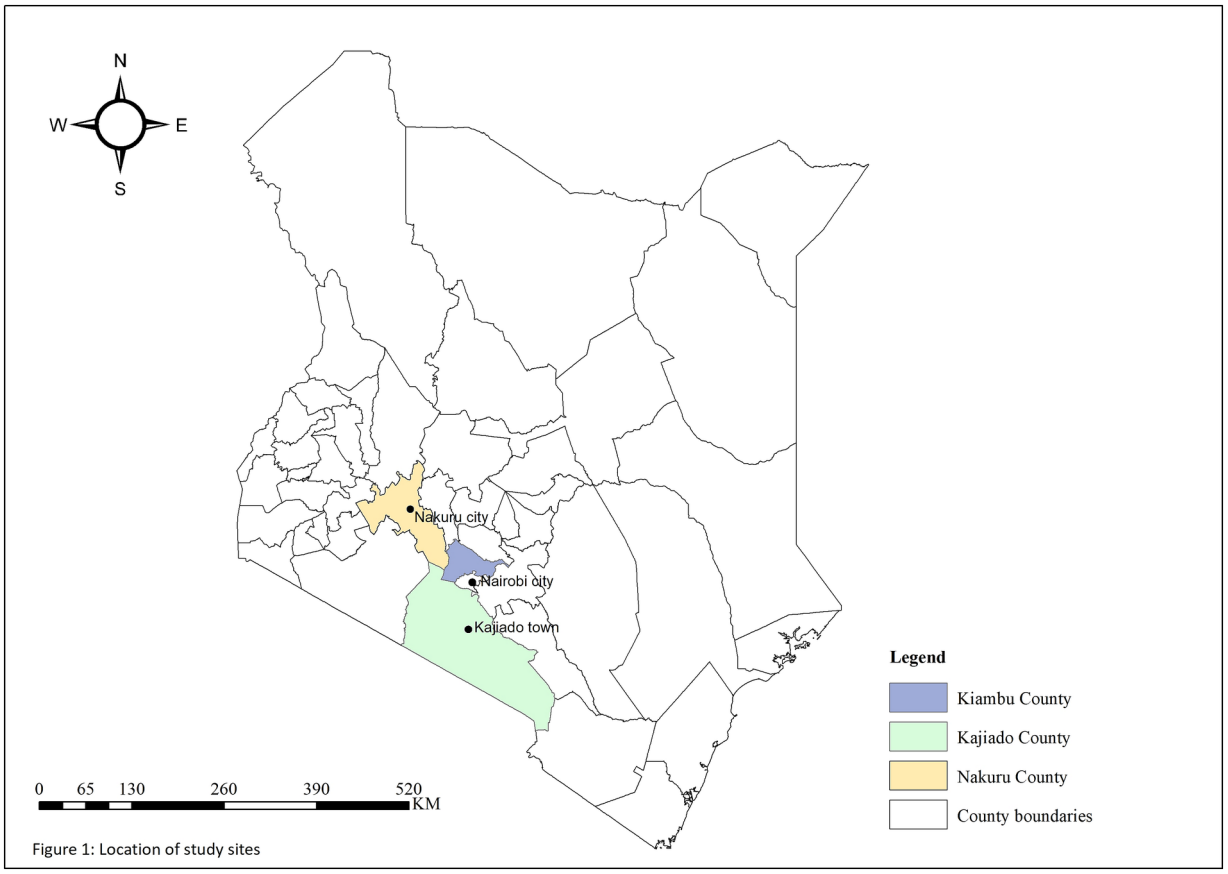

FIGURE 1
Map of study sites.

TABLE 1 Summary of FGDs.

	Women	Men	Sublocation totals	County totals
Kiambu				16
Gatundu North	4	4	8	
Uthiru	2	2	4	
Gitaru	2	2	4	
Nakuru				16
Bahati	4	4	8	
Keringet	4		4	
Kuresoi South		4	4	
Kajiado				16
Bisil	4	4	8	
Matasia	4	4	8	
Total				48

> time … the eggs, they are not sold daily because the chicken reduced in number. So, the eggs are not that many you can find that in a week you sell 2 crates twice or 4 crates at most.' (Women's group, Kajiado)

Dairy cow production (75%), that was reported more often as a full-time activity, is valued for generating daily income and supporting household nutrition needs. It also requires substantially more labor when practicing intensive zero grazing.

> "Personally, I do it full time because since I graduated I have never been employed and I have to farm for a living, so I plant potatoes, peas and keep dairy cows in order to sell milk. These activities keep me occupied full time." (Men's group, Nakuru)

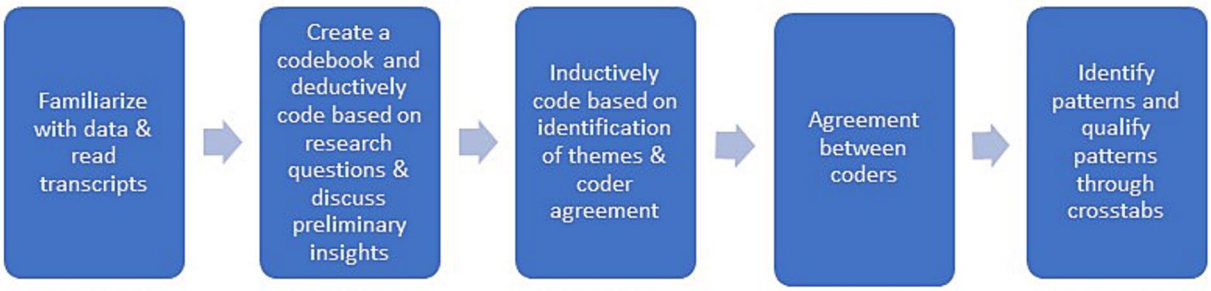

FIGURE 2
Methodological process.

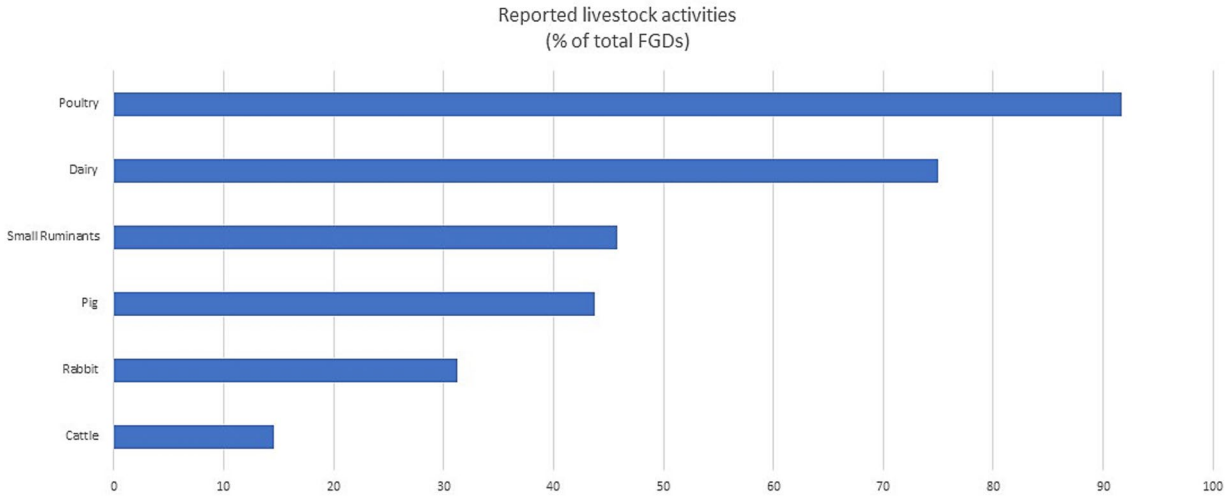

FIGURE 3
Livestock activities based on FGD reporting.

Women and men often reported rearing similar types of livestock but at different rates (Figure 4). More men report livestock production activities than women. An exceptional and location specific trend was found in Kiambu where women and men report similar levels of production in chicken, pigs, and rabbits. Women and men's groups reiterated that raising pigs is done by both women and men. In Kajiado, women and men reported similar rates of rabbit production. Men in Kajiado reported higher levels of cattle production relative to other groups in other locations. Fifty percent of men's FGDs reported engaging in cattle production, compared to only 13% of women's groups.

Climate impacts and adaptation practices

Reported climate events included drought, variable and unpredictable rainfall, flooding, and cold spells. Costs associated with climate include decreased production and availability of resources that sustain livestock, such as feed and water. Reported livestock specific practices were generally low: less than half of the focus groups reported livestock specific adaptation practices. Men reported more practices than women. Across the dataset adaptation for chicken was the highest reported set of practices (45% of the groups), followed by cattle (40%) and dairy practices (25%) (Figure 5).

In mixed livestock systems, the primary adaptation practices are related to chicken and dairy. In Nakuru, men report more practices than women and at higher rates than women in most cases. Women did not report any dairy adaptation practices. In Kiambu, men also report more adaptation practices across livestock species compared to women. Women's reporting of chicken-related adaptation practices is lower than men. In Kajiado, the agropastoral system, cattle—specific practice are reported by women and men at similar rates (75%). Chicken follows and men report at higher rates than women. Women and men reported small ruminant practices at similar rates (Figure 6).

In the following two sub-sections we provide more details about common livestock specific practices, namely chicken, dairy and cattle.

Chicken practices

Climate stressors that affect chicken production include cold and frost that lead to increased mortality and incidence of disease and a decrease in egg production. Practices reported include heating enclosures, treating diseases, destocking or selling off chickens, and

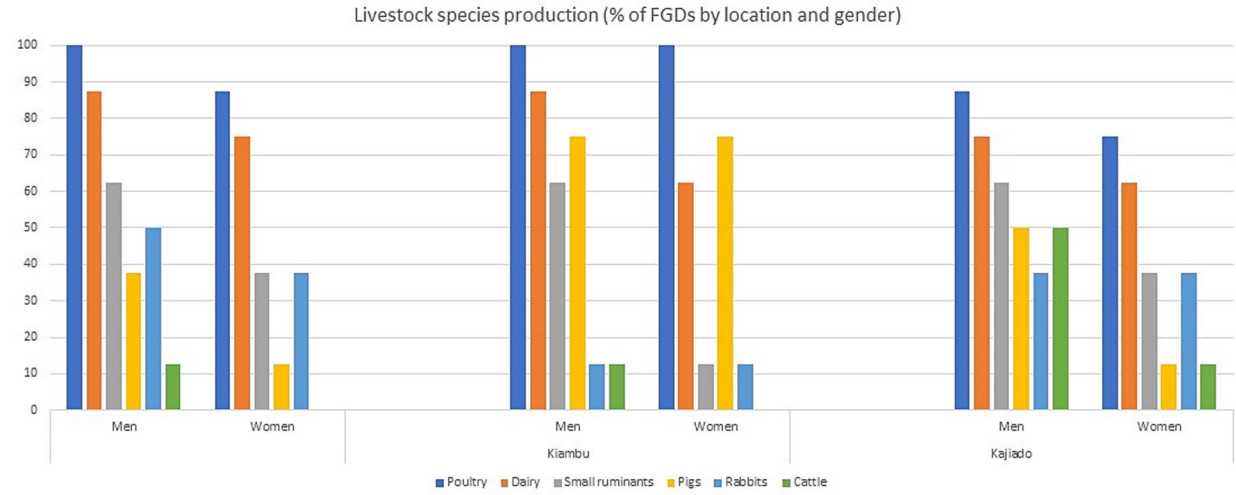

FIGURE 4
Livestock species production (% of FGDs by location and gender).

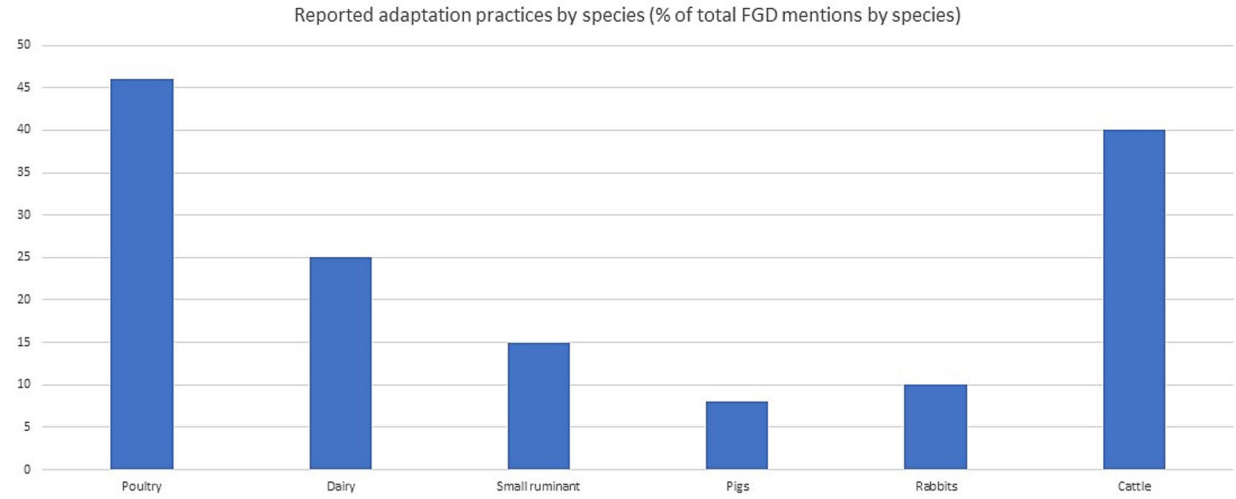

FIGURE 5
Reported adaptation practices by species (% of total mentions by species).

managing reproduction. Women and men often employ multiple practices. Heating techniques and sources for heating include spreading sawdust, sacks, and dry grass in enclosures, using charcoal and braziers, and placing chicken coops and rabbit hutches in areas protected by the wind. Electrical devices like heating bulbs and lamps, which are more expensive, are used and more common in commercial enterprises (Figure 7).

Men utilize more diverse practices than women, however the reporting rates of women's and men's practices differ. Women reported treatment such as vaccines at higher rates than men in Nakuru and Kajiado.

> "I vaccinate my chicken from diseases. Also when I know that there is an outbreak that may kill my chicken, I sell all of them before it gets to them and use the money to restock once the outbreak is over." (Women's group, Nakuru)

Women also reported using heating implements in Nakuru, while men did not. In Kiambu, women reported heating elements in shelters more often than men while men reported more practices than women, including destocking and managing reproduction. Women only reported using heating and at a higher rate than men.

In Kajiado, men reported more practices than women and heat was the most common practice used. Men reported higher rates of destocking or selling than women.

> 'In the past I could let the chicken raise their chicks until they had become established but these days I have to brood the chicks and warm their coops for them to survive.' (Men's group, Kajiado)

Women did not report managing breeding, or reproduction. Women and men report similar rates of using heating implements in the hutches. Women reported higher rates of treatment than men.

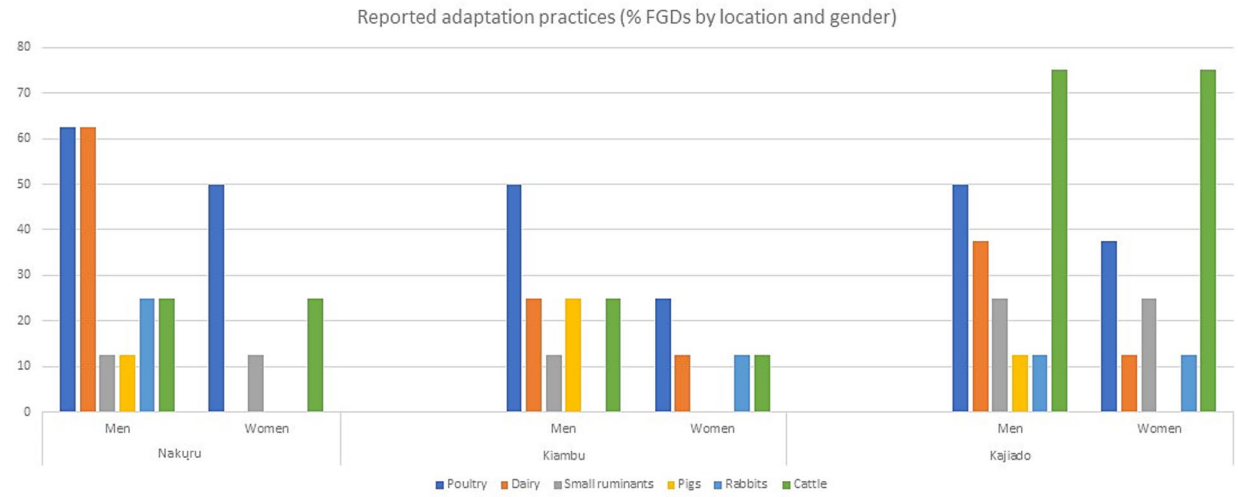

FIGURE 6
Reported adaptation practices by species (% FGDs mentions by location and gender).

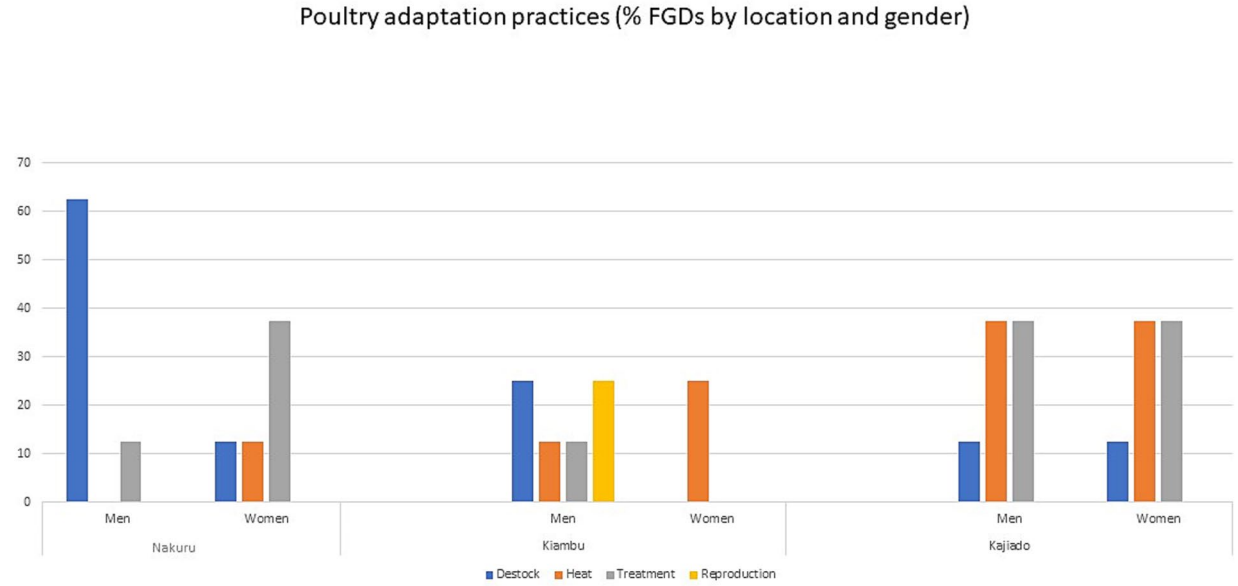

FIGURE 7
Poultry adaptation practices (%FGDs by location and gender).

Cattle and dairy cow practices

Reported dairy cow and cattle specific adaptation practices were combined and analyzed together. Dairy cows and cattle are the same livestock species, but are often different breeds and managed differently. Dairy cattle are bred to produce milk while cattle are bred for beef. Climate stressors to cattle and dairy cows include drought, and consequent impacts include water and feed shortages. Adaptation practices are similar and include feed and fodder practices, destocking and harvesting water. Feed and fodder practices were reported by all groups and the highest reporting was by women and men in Kajiado, followed by men in Nakuru. Destocking and managing reproduction is a risk management strategy and motivated by interests to offset costs in feeding and animal losses due to inadequate feed availability (Figure 8).

In Nakuru, men and women report different practices and men report feeding practices at higher rates than women. Women report medical treatments such as use of vaccines while men do not. In Kiambu, men report more practices than women and overall reporting of feeding practices was lower for Kiambu than other locations. In Kajiado, both women and men report the same number of practices and report feeding at the same rate. Men destock at higher rates than women, women reported higher rates of vaccines treatment than men.

Feed practices

Feed and fodder practices include purchasing feed, paddocking, utilizing and processing crop residues. In mixed crop and livestock systems, purchasing feeds and silage preparation is more common while in agropastoral areas like Kajiado, mobile systems of livestock

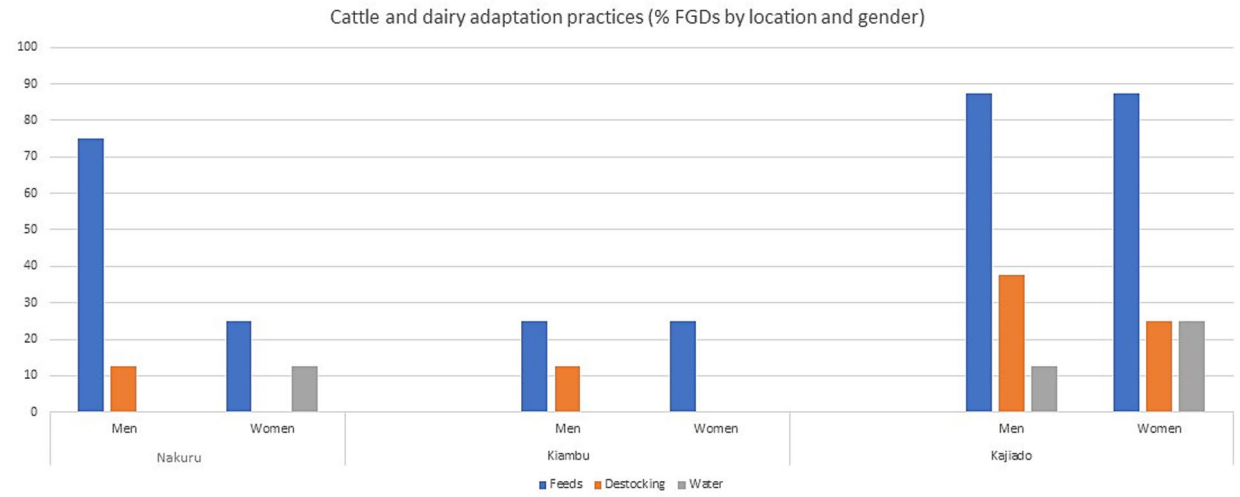

FIGURE 8
Cattle and dairy adaptation practices (% FGDs by location and gender).

husbandry, such as pastoral migration are common adaptation practices. However, pressures to change these practices exist and include limited land and drought-induced fodder scarcity.

> "Sometimes moving to a better area helps your animals get grass to eat but that was in the past when you could take your cows up to Loitoktok. What happens these days is you keep your cows in one place and go and buy grass and bring it to them although this needs money to be able to do. This can cost you anything from 70,000/= to 100,000/= for a small patch of grass, maybe a few acres." (Men's group, Kajiado)

Purchasing feed was reported more often by women. Young women as part of collectives and groups save money from milk sales to then use during drought. In Kajiado, collective community support was explained.

> "If you know that there will be drought next month, anybody with goats or cattle will come as a community and make sure that there is enough … Let's say I have a borehole … they should be given so that those cattle don't lack water. They also buy grass (hay) and store to feed them." (Women's group, Kajiado)

Women and men both described using fencing and paddocking in both mixed and agropastoral systems. Subdividing and fencing the land for paddocking is most common in Kajiado, as reported by both women's and men's groups, so that "cattle can have food to eat to for a short while" (Men's group, Kajiado). Paddocking and planting grass is less common in Kiambu, where land constraints exist.

> 'Mostly due to small land sizes the youths cannot practice in tea and coffee farming since big land parcels still belong to the older generation hence the youths rely mostly on dairy and poultry farming that require small land.' (Men's group, Kiambu)

In Nakuru only men reported making silage, while both women and men reported making silage in other locations. Crop residues are also sourced as feed for livestock. Planting maize and grasses such as Napier and selling fodder is a source of income in Nakuru and Kiambu. Collecting maize cobs and stalks in anticipation of droughts and selling of crop harvests as fodder are reported more often by men in Nakuru than by women, who spoke at generally lower rates than men about feeds.

> 'For my livestock which I value very much, I stock up on silage if I know that year there is a drought expected by going to farmers and collecting maize cobs and stalks and grind these up and store as silage. I stock up on silage enough for even up to one and a half years depending on how the drought comes. This is what I do to prevent my animals from going hungry.' (Men's group, Nakuru)

Certain practices are specific to Kajiado, such as mobile husbandry. Young men migrate with herds, often cattle, goats and sheep, in search of water and pasture, mainly in anticipation of approaching drought, "while the animals still have strength to move" (Men's group Kajiado). Migrating with weak and hungry cows is challenging because weak animal's immunity is lower, and they are more likely to contract diseases and die.

> 'We move cattle to areas with more grass. We move as a group during drought to areas that received more rainfall and still have adequate grass that the cattle can graze on. We move as a group to keep the cattle safe too.' (Men's group, Kajiado)

Resorting to extreme measures like cutting and feeding drought-tolerant cacti to the cows is practiced occasionally.

Herd management: destocking

Destocking or selling off is primarily motivated by resource constraints, namely feed and water. After feed and fodder practices destocking practices were reported as a way to avoid losses. Destocking rates were highest in Kajiado.

> 'Most cattle owners sell. Moving is hard because the family is left alone and the cost of the land for fodder is never cheap. The land is also getting smaller to move anyhow. To leave the family behind might mean more suffering.' (Men's group, Kajiado)

Men sell cows based on rainfall predictions because, "If the drought finds you with too many animals automatically some will die" (Men's group, Kajiado). Men also sell some cattle to then buy hay for remaining animals.

Women in Kajiado described practices to manage breeding, specifically preventing conception to avoid risks associated with livestock pregnancy and birth during drought, when milk supply may be low due to feed shortages. Managing reproduction is also a mechanism to support overall herd health.

> 'When dry season is about to come, you won't let the cows out to prevent mating with a bull. When it is dry, the cow won't get a lot of grass and it won't have a lot of energy to carry the calf so there is high chance of this cow and calf inside dying. So, it is better to prevent this bull from mingling with the cow so that the cow gets its own energy until when it rains.' (Women's group, Kajiado)

Different roles of relationships in mediating adaptation

Young people navigate multiple transitions and uncertainties through the age period of 18–35. For many in our sample, livestock production features as an important source of income during those times in which there may be increased uncertainty over income. Livestock production is practiced by youth who are living with their parents, those who are starting families in separate households and, in some cases, living alone or independently. Gendered practices in these life stages may differ for young women and men because household relationships mediate young women's and men's livestock production engagement and capacities to adapt. In the following sub-section we describe primary relationships in our dataset: parents and spouses. Intergenerational support from parents can provide youth with more opportunities to adapt, namely through resources such as land, capital, and knowledge. Livestock production in married households tends to reproduce gender-based norms and practices and has important implications upon women's labor and mobility.

Intergenerational transfers of resources

Parents provide multiple resources that enable youth to engage, or limit, their activities in livestock production while living at home. Parents provide resources, such as land, knowledge, and labor for instance. Youth often learn about livestock keeping in their parents' home or while they are growing up.

> 'Growing up seeing our parents doing those jobs as part time therefore, you develop passion and you start doing whatever they are doing maybe in another way. My mum is doing dairy farming and I do poultry because I love it.' (Women's group, Kiambu)

Land is frequently passed from parents to sons based on culture and customary practices and women may be urged to marry to gain access to land through their husbands. However, women in all locations reported that they can get land from parents. In Kiambu, women reported that they may ask for and receive land. 'Because we have resources such as enough land, parents give us land to do agriculture when we ask them' (Women's group, Kiambu). The possibility for women, does however, depend upon family dynamics and the presence of sons in the family.

> 'Most of them here have sold their land, the more you keep more cattle and while you don't have land enough for the cattle, you will have to reduce the amount of cattle. Many men have land while many women don't own land and this one really affects them in going to agriculture. Women are not given land; nowadays it depends with your parent. Let's say in your home there are 2 men and you are the only girl, your dad can decide to give you land but if there are 3 men and 3 women, women may not be given.' (Women's group, Kajiado)

Parents and children may also engage in livestock production as a joint and mutually supportive enterprise, in which case they may share space, labor and profits. Parents may also offer space in backyards, and in more intensive management, such as keeping dairy cows, not much space may be needed. Frequent reference to small space requirements for keeping chickens and pigs was mentioned in all locations. In Nakuru, one young woman explained how her cow is kept by her mother, where space is adequate.

> 'There are women keeping goats and even doing dairy farming. You go work, buy a cow and leave it to your mother to manage it for you. That is what I have done, I have a cow and I sell 7 litres every morning at 40 shillings. The cow is mine but I leave it to my mother to manage since I can go to Nairobi and other places and I won't move around with it and while I haven't constructed my own house. I have a group where I take the money to and I also give my mother something small.' (Women's group, Nakuru)

This arrangement frees up her time and enables her to search for work in urban locations and save up to build her own household. Livestock, specifically income from milk, functions as a regular source of income.

Young women and men in married households

Setting up one's own household and starting a new family is a new and often challenging transition. The provision of livestock as a gift in newly married households is a cultural tradition in all study locations. However, men are often given livestock, not women. Women, who may not own the livestock, may assume responsibility of caring for the livestock. This is in part, because labor in households and, by extension in some case livestock production, is gendered.

Furthermore, when starting a new home, women's new responsibilities of assuming more domestic roles and especially childcare responsibilities, often increase. Frequent references were made, by women and men across

the dataset, about women's roles in home-based livestock production activities. Specific characteristics of livestock, such as keeping chicken in backyards are 'convenient' for women because they are home. On one hand, production may be an opportunity, however, additional livestock and home-based responsibilities may also limit women's mobility and create additional labor.

Women's roles in households, that include carrying out household chores and caring for children, often are coupled with 'backyard businesses' that oftentimes include chicken production. Meanwhile, men are looking for source of income to support the household. Gender roles in marriage thus influence women's mobility, labor and potential to control income from livestock sales.

> 'Women are more fulltime farmers since they are left at home dealing with the domestic chores and cannot be expected to do these and go out and do jobs like construction work. So, if there are chickens in the homestead these become her fulltime work where she might get money from eggs while the husband is out working. Women have the time and patience to do agriculture unlike us men. Men are out doing fulltime jobs and providing another source of money that allows women to do their farming activities.' (Men's group, Kiambu)

While both women and men reported chicken production, data across locations frequently described why chicken production is especially important for young married women. Chicken, relative to other livestock species, require lower labor inputs, and are easy for women to maintain along with other activities, because women are at home.

> "Women do it mostly because it is easy to maintain, once you feed them in the morning, you can leave do other things and then feed them again in the evening." (Women's group, Kiambu)

> "Poultry farming is done by mostly women since they mostly stay at home and they like rearing them; they are more concerned about them." (Women's group, Nakuru)

Young women's time spent in supporting and maintaining mixed crop and livestock systems is substantial. As explained by a young woman in Kajiado:

> 'Full time since when you have chicken, they should be fed every day, check the water, when manure increases, you remove so that they don't feel cold and you pour saw dust, if there is any that wants to sit on the eggs, you have to make a place for them; you know when it is time for them to sit on the eggs, they do it at once and you find like 4 of them want to sit on the eggs so that they increase in number. So, let's say it is full time. I also have a farm and after visiting the chicken, instead of being idle, I go to the farm; I have vegetables there. The manure I collect from the chicken house I go pour in the farm and there are ducks which have a lot of work; you have to place a pool of water for them to swim, you have to trim their wings so that they don't fly and get lost. So you see there is no day you will lack work to do.' (Women's group, Kajiado)

Spouses also manage different species together. For instance, as reported by a focus group participant from Nakuru:

> 'As a youth from this area I focus on goat and chicken farming. These are the activities most youths are involved in because they say it brings in more income than crop farming. This is also because if you have a family, you can have your wife tend to the chicken while you tend to the goats and if an urgent need for cash arises you can take some eggs or one animal and sell to get cash.' (Men's group)

Diversification of livestock species can buffer from climate shocks. The prospect of additional and quick income can also foster cooperative relations within households. However, the question of *who* in the household decides *when* to sell *which* animal, while relevant, was not systematically explored in data collection.

Discussion

Empirical insights

In this paper we set out to understand how youth in Kenya engage in livestock production and how their adaptive practices and capacities differ by gender, location, and livestock species. Livestock production is attractive to youth as an alternative to crop production for multiple reasons, that include greater resilience to climate change, lower capital investments, and the potential for quick returns and flexibility. Clear and consistent gender trends are not evident when comparing mixed crop and livestock and pastoral systems.

Youth rear certain species more than others, such as chickens and dairy cows. Chicken production is the most common livestock activity in both mixed and agropastoral systems. Women and men often reported rearing similar types of livestock but at different rates. More men report livestock production activities than women except in Kiambu where women and men report similar levels of production in chicken, pigs, and rabbits.

Major climate events that affect livestock include drought and cold spells. Livestock adaptation is generally low, less than half of the focus groups reported livestock specific adaptation practices. Men reported more practices than women. Chicken was the highest reported set of practices, followed by cattle and dairy. Men utilize more diverse practices than women, however the reporting rates of women's and men's practices differ. Women reported treatment such as vaccines at higher rates than men in Nakuru and Kajiado. Women also reported using heating implements in Nakuru and Kiambu more than men. In Kajiado, men reported more practices than women and heat was the most common practice used. Men reported higher rates of destocking or selling than women. Feed and fodder practices were reported by all groups and the highest reporting was by women and men in Kajiado, followed by men in Nakuru. Specific practices such as purchasing feed and making silage were gender specific. Mobile husbandry was specific to Kajiado.

Gendered practices during transitions to adulthood also differ for young women and men and household relationships mediate young women's and men's livestock production engagement. Data suggest that intergenerational transfers are gendered, however, are changing in all locations. Women's opportunities to inherit or acquire land, for instance, have expanded. Transitions into new households, however, often reinforce gendered access to resources and women's labor. In summary gender differences in livestock production and adaptation practices exist. While young men often try more diverse practices and

at higher rates than young women, occasionally women report practices different and at higher rates than men, such as using vaccines.

Our empirical insights inform recommendations on how to better develop inclusive and sustainable policies that provide support to youth in livestock and strengthen their adaptation capacities.

Recommendations

Young people engage in livestock and are finding ways to adapt to climate change, often while navigating complex life transitions. Climate change undermines the ways that livestock support youth transitions, especially income generation from regular sales of livestock products. Halting production through destocking and selling off is not optimal. Efforts to sustain youth engagement in livestock production through policy support in adaptation could improve the sector's potential to ease uncertainty in young women's and men's transitions. Policy investments that enable young people to sustain their activities through climate events and shocks are recommended to maintain their participation in the sector and ensure equitable income and nutrition benefits.

The *Kenya Climate Smart Agriculture Strategy (KCSAS) 2017–2026* focus on the livestock sub-sector and emphasis upon equity and inclusion of women, youth, and vulnerable groups provides a valuable entry point youth inclusive and to generate tailored, practical, context-specific approaches that are youth inclusive and co-developed with local communities. Further efforts include:

1 Engage young women and men in policy creation through forums in which they share their experiences, constraints, and capacities by location, and specific to livestock systems.
2 Tailor interventions to mixed and pastoral systems and consider gendered differences and equitable approaches to support both women and men.
3 Develop socio technical bundling to offset potential social and economic tradeoffs associated with certain livestock and livestock practices.
4 Identify crop and livestock synergies in mixed and agropastoral contexts, e.g., crop residues as livestock feed.

Conclusion

Adaptive actions are shaped through the interaction of physical events with social, political, and cultural systems. Social differences shape livelihoods and climate adaptation (Djoudi et al., 2016; Carr, 2020). Our empirical study similarly confirms that age and gender interact and influence livestock engagement and adaptation in ways that vary across contexts and systems. Activities, technologies and practices are influenced by relationships, depending upon where young people are in transitions, e.g., living at home or starting their own independent households.

Evidence should inform new initiatives supporting climate change adaptation, e.g., National and County Climate Change Funds. That being said, more evidence about socially differentiated practices and capacities, many of which are species or livestock system specific, is needed. Putting evidence to work and finding out what works for whom will enable more targeted and relevant efforts to scale existing practices. Additional support in building skills and capacity is recommended to improve upon what people are doing and support more diverse opportunities. Tailored approaches that recognize the unique position of youth in transitions are recommended. Livestock function in important ways, namely by providing steady income or quick sales covering unplanned emergencies. Livestock support youth transitions, that are often dynamic, by generating income and potentially reducing uncertainty associated with income volatility to some extent, however climate change threatens and undermines this potential livestock.

Youth engagement in the livestock sector is diverse and often gendered. National policies and donor supported programs and interventions may inadvertently reinforce inequitable power relations that exacerbate climate related vulnerabilities of certain groups of livestock keepers. Awareness and sensitivity to the ways in which adaptive practices may influence gender relations, specifically young women's labor, mobility, and control over income and livestock products, will be critical to develop sustainable and socially inclusive pathways for livestock systems in the face of climatic change.

Data availability statement

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

Ethics statement

The studies involving humans were approved by ILRI Institutional Review Board (ILRI-IREC 2020-25). The studies were conducted in accordance with the local legislation and institutional requirements, e.g., NACOSTI. The participants provided their written informed consent to participate in this study.

Author contributions

RB developed the proposal, research design, and methodologies, supervised data collection activities and guided analysis, and led in the organization of the manuscript and final edits. PM and TD carried out analysis and supported write up of the manuscript including literature review. All authors contributed to the article and approved the submitted version.

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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.

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References

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., et al. (2009). Are there social limits to adaptation to climate change? *Clim. Chang.* 93, 335–354. doi: 10.1007/s10584-008-9520-z

Ashley, L. (2019). *Climate and livestock policy coherence analysis in Kenya, Ethiopia and Uganda*. CCAFS Working Paper No. 268. Wageningen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available at: www.ccafs.cgiar.org

Bennett, N. J., Dearden, P., Murray, G., and Kadfak, A. (2014). The capacity to adapt? Communities in a changing climate, environment, and economy on the northern Andaman coast of Thailand. *Ecol. Soc.* 19:5. doi: 10.5751/ES-06315-190205

Bingham, A. J. (2023). From data management to actionable findings: a five-phase process of qualitative data analysis. *Int. J. Qual. Methods* 22:16094069231183620. doi: 10.1177/16094069231183

Bullock, R. M., Huyer, S., Shai, T., and Nyasimi, M. (2021). *The CCAFS youth and climate-smart agriculture (CSA) strategy*. Working Paper. CGIAR Research Program on Climate Change, Agriculture and Food Security. Available at: https://cgspace.cgiar.org/handle/10568/110552 (Accessed February 24, 2023).

Bullock, R., and Tegbaru, A. (2019). Women's agency in changing contexts: a case study of innovation processes in Western Kenya. *Geoforum* 105, 78–88. doi: 10.1016/j.geoforum.2019.07.007

Carr, E. R. (2020). Resilient livelihoods in an era of global transformation. *Glob. Environ. Chang.* 64:102155. doi: 10.1016/j.gloenvcha.2020.102155

Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., and Basnett Sijapati, B. (2016). Beyond dichotomies: gender and intersecting inequalities in climate change studies. *Ambio* 45, 248–262. doi: 10.1007/s13280-016-0825-2

Doss, C. R. (1999). *Twenty-five years of research on women farmers in Africa: lessons and implications for agricultural research institutions*. CIMMYT economics program paper no. 99–02. Mexico.

Eriksen, S. H., Nightingale, A. J., and Eakin, H. (2015). Reframing adaptation: the political nature of climate change adaptation. *Glob. Environ. Chang.* 35, 523–533. doi: 10.1016/j.gloenvcha.2015.09.014

Fazey, I., Wise, R. M., Lyon, C., Câmpeanu, C., Moug, P., and Davies, T. E. (2016). Past and future adaptation pathways. *Clim. Dev.* 8, 26–44. doi: 10.1080/17565529.2014.989192

Garsow, A. V., Kim, E. G., Colverson, K. E., Ilic, S., Kunyanga, C., Bainah, A., et al. (2022). A review of the roles of men, women, and youth in ensuring food safety in the smallholder poultry value chain in Kenya. *Front. Sustain. Food Syst.* 6:1041472. doi: 10.3389/fsufs.2022.1041472

Kajiado County Integrated Development Plan. (2018). *Kajiado County integrated development plan 2018–2022*. Kenya, Kajiado.

Kalele, D. N., Ogara, W. O., Oludhe, C., and Onono, J. O. (2021). Climate change impacts and relevance of smallholder farmers' response in arid and semi-arid lands in Kenya. *Sci. Afr.* 12:e00814. doi: 10.1016/j.sciaf.2021.e00814

Kenya Youth Development Policy (2019). *Empowered youth for sustainable development*. Nairobi: Ministry of ICT, Innovation and Youth Affairs.

Kiambu County Integrated Development Plan. (2018). *Kiambu County integrated development plan 2018–2022*. Kiambu Kajiado, Kenya.

Kogo, B. K., Kumar, L., and Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environ. Dev. Sustain.* 23, 23–43. doi: 10.1007/s10668-020-00589-1

Lumivero. (2022). *NVivo* (Version 13). Available at: www.lumivero.com

Marks, D., Bayrak, M. M., Jahangir, S., Henig, D., and Bailey, A. (2022). Towards a cultural lens for adaptation pathways to climate change. *Reg. Environ. Chang.* 22:22. doi: 10.1007/s10113-022-01884-5

Marty, E., Bullock, R., Cashmore, M., Crane, T., and Eriksen, S. (2022). Adapting to climate change among transitioning Maasai pastoralists in southern Kenya: an intersectional analysis of differentiated abilities to benefit from diversification processes. *J. Peasant Stud.* 50, 136–161. doi: 10.1080/03066150.2022.2121918

Mutua, E., Bukachi, S., Bett, B., Estambale, B., and Nyamongo, I. (2017). *Youth participation in smallholder livestock production and marketing, in fifty years of research on pastoralism and development* Institute of Development Studies (IDS bulletin 51A) Available at: https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/15335.

National Agricultural Policy (2019). *Ministry of Agriculture livestock fisheries and cooperatives*. Nairobi: Republic of Kenya.

National Livestock Policy (2019). *Ministry of Agriculture livestock fisheries and cooperatives*. Nairobi Republic of Kenya.

National Policy on Gender and Development (2019): *Towards creating a just, fair and transformed society free from gender-based discrimination in all spheres of life*. Ministry of Public Service, Youth and Gender: Nairobi.

Neef, A., Benge, L., Boruff, B., Pauli, N., Weber, E., and Varea, R. (2018). Climate adaptation strategies in Fiji: the role of social norms and cultural values. *World Dev.* 107, 125–137. doi: 10.1016/j.worlddev.2018.02.029

Ng'ang'a, T. W., and Crane, T. A. (2020). Social differentiation in climate change adaptation: one community, multiple pathways in transitioning Kenyan pastoralism. *Environ. Sci. Pol.* 114, 478–485. doi: 10.1016/j.envsci.2020.08.010

Njarui, D., Gichangi, E., Gatheru, M., Nyambati, E., Ondiko, C., Njunie, M., et al. (2016). A comparative analysis of livestock farming in smallholder mixed crop-livestock systems in Kenya: 1. Livestock inventory and management. *Livestock Res. Rural Dev.* 28:66

Njeru, L. K. (2017). Climate change vulnerability and response measures for enhancing coping strategies by marginalized groups in Meru County, Kenya. *Greener J. Agric. Sci.* 10, 275–281. doi: 10.15580/GJAS.2017.10.110217162

Njuki, J., and Mburu, S. (2013). "Gender and ownership of livestock assets" in *Women, livestock ownership and markets: bridging the gender gap in eastern and southern Africa*. London, United Kingdom: Routledge. 21–38.

O'Connor, C., and Joffe, H. (2020). Intercoder reliability in qualitative research: debates and practical guidelines. *Int J Qual Methods* 19:1609406919899220. doi: 10.1177/1609406919899220

Odhiambo, G. (2020). *Hatching Hope: gender and youth analysis report*. Heifer International, Kenya.

Ogolla, K. O., Chemuliti, J. K., Ngutu, M., Kimani, W. W., Anyona, D. N., Nyamongo, I. K., et al. (2022). Women's empowerment and intra-household gender dynamics and practices around sheep and goat production in south East Kenya. *PLoS One* 17:e0269243. doi: 10.1371/journal.pone.0269243

Omolo, N., and Mafongoya, P. L. (2019). Gender, social capital and adaptive capacity to climate variability: a case of pastoralists in arid and semi-arid regions in Kenya. *Int. J. Clim. Change Strat. Manag.* 11, 744–758. doi: 10.1108/IJCCSM-01-2018-0009

Omolo, N., Mafongoya, P., and Ngesa, O. (2017). Gender and resilience to climate variability in pastoralists livelihoods system: two case studies in Kenya. *J. Sustainab. Dev.* 10:218. doi: 10.5539/jsd.v10n2p218

Petesch, P., Bullock, R. M., Feldman, S., Badstue, L. B., Rietveld, A. M., Bauchspies, W., et al. (2018). Local normative climate shaping agency and agricultural livelihoods in sub-Saharan Africa. *J. Gender Agric. Food Secur.* 3, 108–130. doi: 10.22004/ag.econ.293590

Rao, N. (2019). From abandonment to autonomy: gendered strategies for coping with climate change, Isiolo County, Kenya. *Geoforum* 102, 27–37. doi: 10.1016/j.geoforum.2019.03.017

Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., and Woznicki, S. A. (2017). Climate change and livestock: impacts, adaptation, and mitigation. *Clim. Risk Manag.* 16, 145–163. doi: 10.1016/j.crm.2017.02.001

Saldaña, J. (2021). *The coding manual for qualitative researchers*. London, United Kingdom: Sage.

Sumberg, J., Chamberlin, J., Flynn, J., Glover, D., and Johnson, V. (2019). *IFAD research series 47 landscapes of rural youth opportunity papers of the 2019 rural development report (no. 2165–2020-025)*. International Fund for Agricultural Development (IFAD). Rome, Italy.

Tavenner, K., and Crane, T. A. (2019). Beyond "women and youth": applying intersectionality in agricultural research for development. *Outlook Agric.* 48, 316–325. doi: 10.1177/0030727019884334

Thornton, P. K., and Herrero, M. (2014). Climate change adaptation in mixed crop–livestock systems in developing countries. *Glob. Food Sec.* 3, 99–107. doi: 10.1016/j.gfs.2014.02.002

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Integrating social dynamics in the participatory modeling of small-scale cattle farmers' perceptions and responses to climate variability in the Yucatan Peninsula, Mexico

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Climate variability poses multifaceted challenges for livestock production. Rising temperatures and shifting rainfall patterns impact crop and pasture yields, reduce water availability, and contribute to livestock diseases, particularly affecting small-scale cattle producers dependent on climate-sensitive resources. Sustainable livestock farming promotes integrating best practices to enhance productivity while responsibly managing natural resources, but often overlooks relevant social dynamics. Social factors are excluded when promoting and studying the adoption of practices for sustainable cattle farming. This study aims to understand the factors and interactions between the social, animal and ecological systems within the small-scale cattle socioecosystems in the southern region of the Yucatan Peninsula, exploring cattle farmers' perspectives on climate change, as well as their strategies and responses to extreme events like drought. Using fuzzy cognitive maps and scenario development as participatory and reflection methodologies, we found a conceptual gap between climate change and drought, indicating a lack of sustainable adaptive thinking toward these challenges. Interestingly, we found that local social organization, cultural dynamics, and spiritual practices are equally significant factors than technical and environment-oriented changes to the management of ranches in shaping an optimal cattle farming scenario. Our findings reveal that the management of cattle farms involves complex interplay among technical, environmental, social, political, and cultural elements, highlighting the inherent need to consider social values and preferences as fundamental components of sustainability. This study establishes the initial groundwork for employing participatory modeling with social actors engaged in the small-scale cattle context in Yucatan. The goal is to emphasize the importance of the social dimension in the general management of the small-scale cattle socioecosystem, thus in promoting sustainable cattle farming.

KEYWORDS

social dynamics, small-scale cattle famers, drought, climate variability, fuzzy cognitive maps, Yucatan Peninsula

1 Introduction

The Yucatán Peninsula, located in the south eastern region of Mexico, is comprised of three states: Campeche, Yucatán, and Quintana Roo. Projected decreases in average annual rainfall and increased frequency and intensity of droughts makes this region highly vulnerable to the adverse consequences of climate change (Márdero et al., 2012; de la Barreda et al., 2020). For the broader Maya region, an increase in average temperature (2–3.5°C) by 2090 is expected (Magrin et al., 2007). For the Yucatán Peninsula, projections indicate a significant reduction in annual precipitation (10–15%) and even up to 30% during dry and rainy seasons compared to the average for 1980–1999 (Bárcena et al., 2010). In 2020, Yucatan state experienced a severe drought followed by a nearly 2 months longer than usual rainy season, resulting in the rainiest year since 1941 (CONAGUA, 2020). Considering that in both the Mexican tropics and Yucatan state, extensive grazing of cattle is the predominant form of livestock farming (Bacab et al., 2013), these decreases in rainfall poses threats, including more severe droughts, reduced agricultural productivity, a decline in food production, and an increased risk of forest fires (Galindo, 2007).

Livestock farming, particularly cattle farming for meat production, faces a paradox. Notwithstanding suffering the negative effects and consequences of climate change, it is one of the main productive activities that contributes to this phenomenon, therefore it has the potential to mitigate it (Ibrahim et al., 2010; Gerber et al., 2013; Mottet et al., 2016). This type of production model involves greenhouse gas emissions, land-use change from forests and jungles to pasturelands, loss of biodiversity, poor animal health and welfare, low animal productivity, soil degradation, pesticide pollution, and socioeconomic polarization (Gerber et al., 2013; Palma, 2014; Cheng et al., 2022). However, through sustainable livestock production systems, we could potentially establish an environmentally, socially, economically, and culturally appropriate strategy that conserves ecosystems and promotes the well-being of people.

This is the case for Yucatán where slightly over one-third of the Yucatán territory is occupied by cattle farming. Due to the geographical and climatic characteristics of Yucatán, the most common production model in the region is extensive grazing based on monocultures of low-productivity pastures, which have a high environmental impact (Bacab et al., 2013; Zepeda Cancino et al., 2021). Although most cattle farming is carried out by small-scale producers who rely solely on forage and native vegetation as the food base (Gamboa-Mena et al., 2005), the majority of Yucatán's cattle herd is concentrated in the eastern region of the state in units with higher technical and productive capacity. Small-scale producers are considered one of the most vulnerable groups in the face of climate change (Donatti et al., 2019). These producers heavily depend on agriculture and livestock for their food security and income, but they often encounter resource limitations and tend to reside in remote areas. Climate change poses an additional threat to small-scale producers, exacerbating the already insecure conditions in which they live.

Under the tropical geographical, climatic, and productive conditions of the Yucatan Peninsula, increasing temperatures and changes in rainfall patterns affect crop and pasture yields, reduce water supply and quality, and contribute to the emergence and/or reemergence of diseases in livestock (PAECC, 2014; Cheng et al., 2022). While the projected climate change effects might not pose an evident threat to Mexican livestock farming as a whole (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación y Organización de las Naciones Unidas para la Agricultura y la Alimentación, 2014), the occurrence of extreme climate events does indeed endanger the livestock system as Murray-Tortarolo and Jaramillo (2019) report drought impact over a million of affected animals in 2011. These extreme events represent long-term costs (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación y Organización de las Naciones Unidas para la Agricultura y la Alimentación, 2014), in particular for small-scale producers, whose economic, environmental, and social stability largely depends on rainfall patterns and climate-sensitive resources (Berlanga, 2013; Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación y Organización de las Naciones Unidas para la Agricultura y la Alimentación, 2014; Faisal et al., 2021).

The Mexican government is working to design and promote initiatives in different states and regions with the aim of transitioning toward a sustainable livestock farming. These initiatives have focused on strategies to support and technology adoption to define goals regarding greenhouse gas emissions reduction and enhance livestock productivity. However, these are still early actions and need to be scaled up and implemented to address the specific needs of each territory (IICA, 2020). However, the historical context shows that the Mexican field has benefited from welfare measures that have failed to change the poverty situation of farmers, as they have prioritized the efficiency of agricultural and livestock processes and increasing productivity. As the expansion of agricultural frontiers, the increased use of agrochemicals, and the dependency on external inputs continue, the negative impact on ecosystems and increased pressure on them, paradoxically results in increased vulnerability of those with fewer resources and diminished development opportunities (Garcia-Frapolli et al., 2013). Most government programs that support cattle producers focus on the technical aspects that, while relevant to the livestock sector, these measures do not consider sustainability aspects and are often built on the idea that one strategy fits all, ignoring the particularities present when examining a local-scale context.

In response to the need for climate change mitigation and adaptation programs, alternative models to conventional cattle production have been proposed. Livestock sustainability has been proposed as technologies and good production practices that contribute to improving the productivity, profitability, and competitiveness of the livestock subsector without affecting ecosystems, while preserving the raw materials and natural resources

used in production. It aims to reduce greenhouse gas emissions, protect and restore soil, capture carbon, conserve biodiversity, and recharge aquifers – essential elements in the fight against the adverse effects of climate change (IICA, 2020).

Silvopastoral systems (SPS) being an example of an cattle production alternative model since they have proved to increase productivity, profitability, and competitiveness while delivering environmental positive effects (Bacab et al., 2013; Broom et al., 2013; Mancera et al., 2018; Pérez-Lombardini et al., 2021; Zepeda Cancino et al., 2021). Despite the scientific evidence of their economic and environmental benefits, their adoption is still very low in southern Mexico and Central America (Dagang and Nair, 2003; Zepeda-Cancino et al., 2016; Cosío Ruiz, 2020). Institutionally, barriers to transitioning to sustainable cattle production include inadequate coordination, lack of awareness, technical, and environmental capabilities in the value chain, and absence of appropriate financing schemes (IICA, 2020). Meanwhile, producers face challenges due to limited knowledge, lack of implementation support, initial capital needs, and high labor requirements (Dagang and Nair, 2003; Zepeda-Cancino et al., 2016; Cosío Ruiz, 2020).

It is common for problems associated with natural resources and their management to stem from a lack of recognition that social systems and ecosystems are complexly interconnected (Folke et al., 2010). Efforts made for mitigation and adaptation to the challenges faced by livestock farming through technological innovations and good practices may overlook aspects of equity, distribution, power, and politics, underestimating the role they play in transformation processes and the potential of individuals as agents of change (O'Brien, 2018) rather than as individuals subject to change. Along with the challenges that small-scale cattle farmers face, the transformation of their production systems represents an adaptive challenge that requires a new way of perceiving the problem and solutions.

Adaptation can be understood as the process of adjustment to actual or expected climate and its effects (IPCC, 2014). While the concept of adaptability encompasses technical aspects, it also recognizes the importance of beliefs, values, and worldviews in how problems and solutions are perceived and addressed (O'Brien, 2018). By generating new approaches where the internal dimensions of individuals are considered as potential triggers of broader cultural changes capable of achieving a transformation toward sustainability (Wamsler and Osberg, 2022), this work contributes to identifying the direction in which actions can be oriented toward cattle production sustainability.

Understanding the role of values in transformations toward sustainability requires exploring values as dynamic components within the evolution of socio-ecosystems (Rosenberg, 2022). Therefore, in this work, we study animal production systems as socio-ecosystems with high uncertainty, whose management and functioning are not only conditioned by technical innovations and evidence-based science but also by the social dimension and values of the involved producers (Funtowicz and Ravetz, 1994; Stirling, 2015). We use fuzzy cognitive maps (FCMs) as a tool for participatory modeling and collective reflection to gain a better understanding of the vision, knowledge, and management of ten small-scale cattle producers regarding their production systems.

The framework of the three spheres of transformation by O'Brien and Sygna (2013) (see Figure 1) represents the interaction of different components that comprise a system and interact within the realms of practice, politics, and personal spheres to promote or constrain sustainability. The cosmologies, values, and beliefs present and past are located in the personal sphere; the middle field represents the political sphere where social, political, cultural, and ecological structures and systems enable or constrain the changes in the practical sphere, which is located at the core where we find actions, technical solutions, and measurable and monitorable behavioral changes. This interaction among spheres is dynamic and nonlinear, and its understanding it is essential to recognize users as part of the system they manage. This framework has been applied for studying the influence of knowledge in climate change in the behavior of people traveling by air by exploring personal and political/societal incentives and barriers to air travel reduction (Jacobson et al., 2020), and as well as for understanding the transformation from conventional to organic farming in the UK (James and Brown, 2018). In this study the operationalization of the framework of the three spheres of transformation through the reflection on FCMs constructed by the producers allowed an insight to the context of the local cattle farming socio-ecosystem and to understand how, why, and where the relationships between the three spheres are taking place.

This study aims to contribute to the understanding of shifts toward sustainable cattle farming by exploring *How are small-scale cattle farmers responding to climate variability?*; taking into account the values that influence the vision and decision-making of producers at the personal, cultural, organizational, and institutional levels (Fairweather, 2010; Voinov et al., 2014). So far, sustainable livestock farming has mostly been addressed from a technical-environmental perspective, and the well-being of the producer has been understood mostly in terms of increased productivity and profitability of the system (Ibrahim et al., 2010; Murgueitio et al., 2011, 2013; Nahed-Toral et al., 2013). The article proceeds by describing the use of FCM for participatory modeling of the small-scale cattle farms' management as a primary data collection. Subsequently, the results describe the producers' perception of the identified issues, along with the strategies implemented to address them. The development of an ideal livestock scenario is presented, interpreted in the context of the three spheres of transformation. Finally, the discussion is organized around the practical, political, and personal spheres, concluding with reflections on integrating the social dimension into processes of transitioning toward sustainable livestock practices.

2 Methods

2.1 Study area

The state of Yucatán is characterized by a predominant vegetation of low deciduous jungle, and in the southern zone, there are higher, more humid, and floodable jungles. The prevailing climate is warm sub-humid with concentrated rainfall during the summer and a high percentage of winter rain. Additionally, in most parts of the peninsula, two dry periods are experienced: the pre-summer or spring drought, which lasts from 2 to 4 months, and the intra-summer or *canícula*, which extends from late July to September (Estrada-Medina and Cobos-Gasca, 2014; Orellana et al., 2019).

Unlike the central and northern parts of the state, the southern zone features high karstic hills known as interior valleys. Although these hills represent only 1% of the state's surface area, they have poor

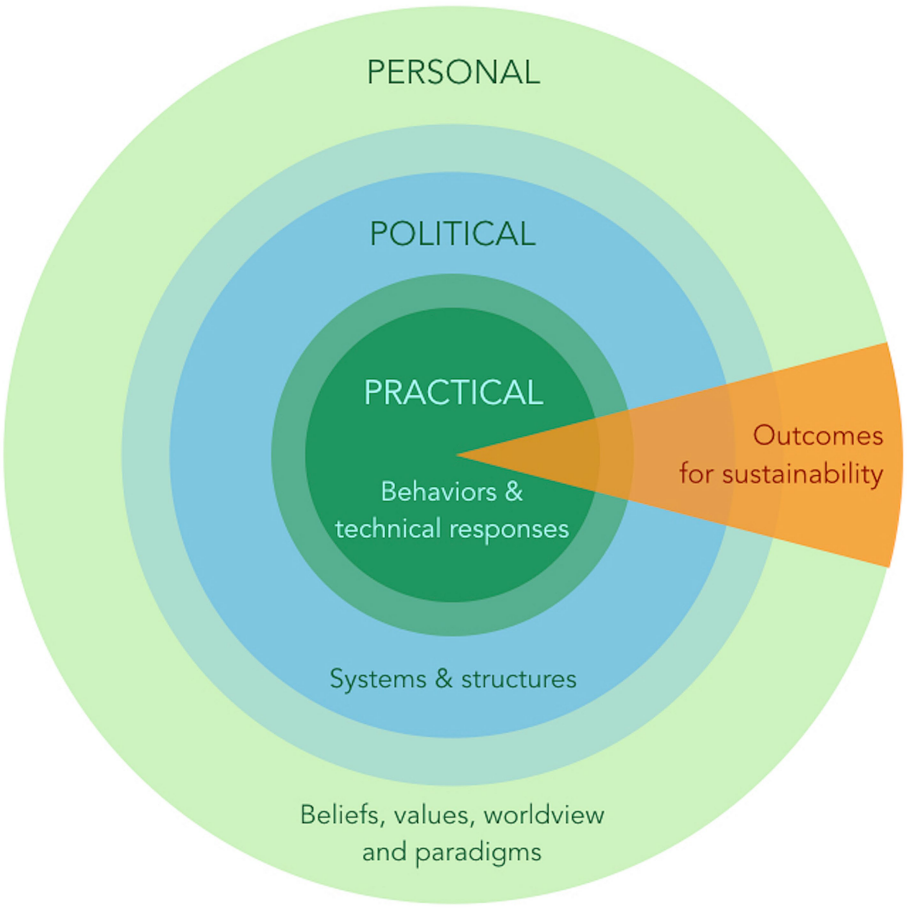

FIGURE 1
Three spheres of transformation. Adapted from O'Brien and Sygna (2013), same diagram but with different colors from the original.

internal drainage, making them highly susceptible to flooding during the rainy season, storms, and hurricanes (Bautista et al., 2010). The study was conducted in the southern part of Tzucacab (see Figure 2), which is one of the 17 municipalities that make up the southern region of Yucatán, Mexico, specifically in the locality of Corral. Corral is an *ejido* (communal land) founded approximately 75 years ago mainly by *chicleros* (rubber tappers) and farmers. Its population is approximately 400 people, of which 82.7% are Mayan speakers (INEGI, 2020). Similar to most of the state, the municipality of Tzucacab does not have surface water streams, so groundwater is the main source for consumption, agricultural and industrial activities (Delgado et al., 2010). Additionally, this region has natural or artificial formations of rainwater reservoirs known as *aguadas*. These are utilized by cattle farmers as watering holes for their animals and play a vital role in supporting wildlife and mitigating floods.

2.2 Small-scale cattle farmers

The recruiting of the participants was done through the local cattle association in an assembly where the project was presented and producers were invited to participate in themes of cattle farming and management practices. The participants in this study are the producers that were willing to take part of this work, all of them small-scale producers, predominantly from the locality of Corral and neighboring villages. When working in participatory processes, often used in qualitative research involving exploration of complex systems, it does not always require large sample sizes as in quantitative research. Small sample sizes allows the research to focus on the depth and richness of information gathered from the 10 participating cattle-farmers.

According to the typology used by the Ministry of Agriculture and Rural Development of the Mexican government, a small-scale cattle producer is considered someone who has 35 animal units or their equivalent in another species. According to Robles Berlanga (2018), a small-scale producer is someone whose family plays a central role in the production, where a variable portion of their income comes from agricultural work, either in kind or money, and their livelihood involves crop cultivation and animal husbandry.

Despite having varying herd sizes and land extents, all participants engage in cattle farming and consider themselves small-scale producers. The participants' primary activity is cattle farming, aimed at producing and selling calves of approximately 6 months of age for subsequent fattening and sale in the eastern part of the state or the northern region of the country. However, they have diverse profiles in terms of age, language, sources of income, herd size, land area, and geographical location within the community (see Table 1 and consult in Supplementary material).

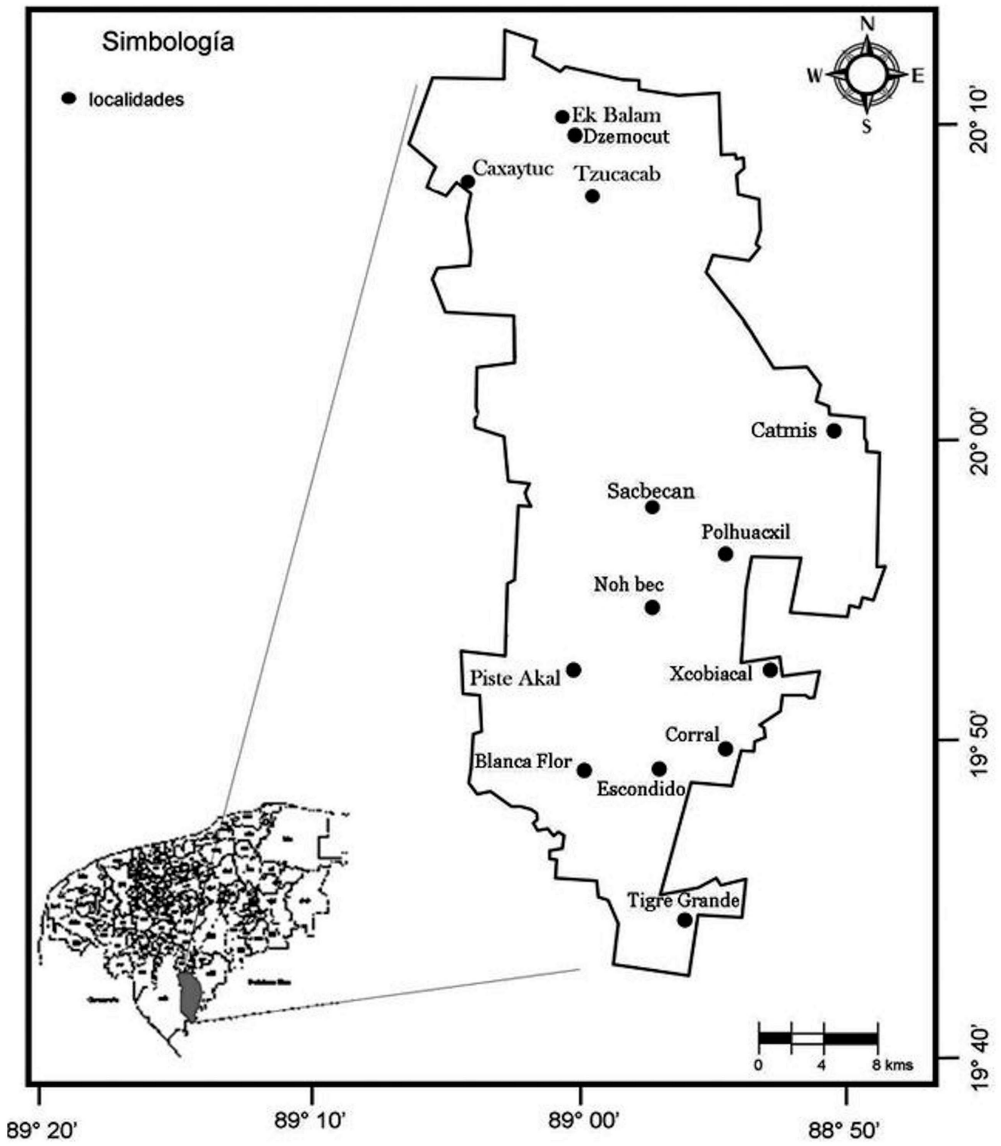

FIGURE 2
Map of Corral, Tzucacab. Source: Zamora-Crescencio et al. (2009): Flora útil y su manejo en el cono sur del estado de Yucatán, México.

2.3 Data collection

The fieldwork was conducted during the periods between January and March 2020 and December 2020 and March 2022. During the field visits, a mix of informal conversations and four semi-structured interviews (consult in Supplementary material) were conducted as a general scope to understand and explore the perspectives of the producers regarding their ranch management, the local livestock situation, and the environmental context. A questionnaire (consult in Supplementary material) was also administered to 28 cattle farmers during a meeting at the Local Livestock Association of Tzucacab to gather information on the impact of drought and rainfall and the strategies they implement to mitigate them and their associated costs. Based on the information obtained from the questionnaire, interviews, and observations during the field visits, a preliminary list of 44 concepts was defined for the construction of Fuzzy Cognitive Maps (FCMs) (consult in Supplementary material). Due to the COVID-19 pandemic, some follow-up interviews were conducted via telephone, and although informed consent was obtained, not all of them could be audio-recorded. The producers verbally consented to the use of the information collected, as well as the use of the models and pictures obtained during the participatory processes.

Fuzzy Cognitive Maps (FCMs) are a modeling technique that, through graphical representations, reflect causal reasoning to explain complex phenomena. They originated from cognitive maps proposed by Axelrod (1976) and were further developed by Kosko (1986) as a semiquantitative and dynamic method to structure expert knowledge (Gray et al., 2015). These representations reflect different ways of conceptualizing and understanding the same reality based on diverse knowledge derived from various contexts (Fairweather, 2010). The person constructing the FCM is considered an expert who determines the important variables that affect the system, whether they are

TABLE 1 Producers' characteristics.

ID	Age	Language	Education level	Cattle farming experience (years)	No. Animals	Land area (ha)	Location	Income sources
CAR-1	65	Spanish, Mayan	Primary	30	25	36	High	1. Ranch, 2. Sale of fodder, 3. Agriculture
CRE-2	50	Spanish, Mayan	Primary	21	50	100	High	1. Ranch, 2. Sale of other products, 3. Agriculture, 4. Government
FEL-3	70	Spanish, Mayan	None	40	17	27	Low	1. Ranch and 2. Family
FER-4	46	Spanish	Primary	15	13	34	Low	1. Ranch, 2. Agriculture, 3. Government
FID-5	75	Spanish, Mayan	None	40	15	32	Low	1. Ranch
JIL-6	42	Spanish, Mayan	Secondary	8	18	22	High	1. Ranch, 2. Sale of other products, 3. Agriculture, 4. Government
MAN-7	47	Spanish, Mayan	Primary	30	40	39	High	1. Ranch 2. Off-ranch work
MOI-8	47	Spanish	Secondary	30	15	28	High	1. Ranch, 2. Sale of fodder, 3. Sale of other products, 4. Off-ranch work
ROQ-9	79	Spanish, Mayan	None	50	11	20	High	1. Ranch, 2. Family, 3. Off-ranch work
VIC-10	62	Spanish, Mayan	None	40	20	27	Low	1. Ranch, 2. Agriculture, 3. Family

In Location, "high" refers to highlands, and "low" refers to flood-prone areas. In Income sources "ranch" refers to livestock sale; "sale of fodder" refers to cut fodder produced by themselves; "agriculture" refers to sale of corn; "government" refers to support programs; "sale of other products" refers mainly to citrus fruits and honey, and to a lesser extent citrus grafts, avocados, sheep and pigs; "off-ranch work" refers to working in other ranch or masonry.

concepts, quantities, processes, actions, or abstract ideas (Özesmi and Özesmi, 2004), and links the variables (Gray et al., 2015) with the strength of each relationship (Özesmi and Özesmi, 2004).

Two workshops were organized, one for the construction of the FCMs and another one for discussing them and developing an alternative scenario. During the first workshop, the objective of the activity was shared with the participants, the process of constructing FCMs was explained, and ten individual FCMs were constructed using the guiding question: "How do you manage your ranch in scenarios of climatic uncertainty: rainfall and drought?" (see Figures 3A–C). Different colors were used to denote positive and negative causal relationships, and three different sticker colors were used to represent the strength of the connections, with each color corresponding to a different intensity level (low, medium, high).

During the second workshop, a Group Map (GM) (see following section for detailed information) was presented as a shared model to validate, add, or modify concepts and links that the producers considered relevant, as well as to collectively develop an ideal scenario. Scenario building is a narrative-based method that describes possible and multiple future versions of a system, from which assumptions are generated regarding a variable or group of variables that can shape a change in the future system (Hichert et al., 2022). The development of the ideal scenario unfolded through discussing the GM and by taking note of the changes, obstacles, and desirable elements that producers identified in their activity as cattle farmers (see Figure 3D).

2.4 Analysis

2.4.1 Group map

To graphically represent the overall structure of the production system management, a Group Map (GM) was generated by performing arithmetic operations on the adjacency matrices of the individual FCMs. The weight of the connections between components is the number of actors who mentioned that relationship in their map (Vanwindekens et al., 2013). The relationships mentioned by two or more individuals, with a weight greater than or equal to 2, were selected for analysis. The central nodes based on betweenness centrality were visualized for further analysis.

2.4.2 Visualization and analysis of FCMs

The FCMs were analyzed as directed networks. The modeling software Mental Modeler (Gray et al., 2013) was used for digitization and obtaining adjacency matrices. Subsequently, they were analyzed using the open-source software platform Cytoscape v3.7.1 (Shannon et al., 2003), which allows for the visualization and formatting of complex networks using the following network analysis metrics: betweenness centrality, degree centrality, in-degree centrality, and out-degree centrality. We used different measures of centrality to identify and understand which elements have the greatest influence or weight in the FCMs of the 10 producers. Betweenness centrality measures the frequency with which a node lies on the shortest paths between pairs of nodes, so it can be said that these are the components that have the greatest influence on the overall management of a

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FIGURE 3
FCM construction workshop in the community Corral, Tzucacab, Yucatan. **(A)** Producers could choose the cards with the components they considered most important in their systems and drew the connections with different colors to refer to positive or negative links. **(B)** Facilitation on the construction of the FCM to a producer while others watched and assisted the process. **(C)** Part of the process of construction where producers started building their maps by themselves. **(D)** GM with the interventions made during the second workshop; in green post-its he added components, in orange post-its ideas generated by the ideal scenario development.

system. Despite being directed networks, we also considered overall degree centrality (total number of connections) to determine which components are more generally connected in each FCM. Finally, we considered the in-degree centrality, considering that the centrality of these nodes is given by other nodes, unlike out-degree centrality, which is determined by the node itself.

2.4.3 Ideal scenario and three spheres of transformation model interpretation

The three spheres of transformation model of O'Brien and Sygna's (2013) was adapted and enriched with the FCMs and the information generated during the ideal scenario development. In the practical sphere: management practices considered responsible for changes in climate conditions and land quality. In the political sphere: aspects related to the social and political organization of the producers and within government support programs. In the personal sphere: religious aspects and social values. The effects, results and consequences of the former aspects were considered as an adaptation of the sustainability outcomes presented in the original model.

3 Results

3.1 Centrality of FCMs

The 10 FCMs can be seen in a bigger format in Supplementary materials. Based on betweenness centrality, the central nodes followed by the number of FCMs in which they appear (in parenthesis) are: grass (4), cattle (3), money (2), and drought (1). According to betweenness centrality, these components have the greatest influence on the overall management of systems in the face of climate variability events. The components that are more generally connected in each FCM (overall degree centrality), were the following: money (5), grass (2), cut fodder (2), herbicide (1), drought (1). Finally, the central nodes by in-degree centrality are: money (7), grass (4), and cattle (1). In cases where more than 10 central nodes are mentioned, it is because there were FCMs with more than one central component (see examples of four FCM in Figure 4 and centrality results in Table 2).

3.2 Perception of the problem

Based on the questionnaires and FCMs, we identified that drought is the problem affecting all producers every year, regardless of whether it occurs regularly or with varying duration or intensity. Drought can be defined as a prolonged period of reduced or absence of rainfall, which impacts human activities. From the questionnaire administered to 28 producers, 27% mentioned that drought affects them little, and very few are partially or not affected at all. For the rest of the producers, drought has a strong impact, mainly on the economic aspects and the well-being of the animals. 59% of the producers mentioned that the main obstacle to dealing with drought is the difficulty in accessing water due to various reasons: (1) they do not have a well; (2) they have a well, but: (a) it does not work, (b) it does not provide enough water, (c) the cost of fuel for pumping water is too high. For 41%, access to water is not a problem because they have one or more wells, irrigation systems, and, in the particular case of one producer, a rainwater harvesting system.

3.3 Interpretation of the FCMs

3.3.1 Individual FCMs

60% of the producers identified changes over time as the cause of variability in rainfall (CAR1, JIL6, MOI8, ROQ9), drought (JIL6, MAN7, MOI8), and flooding (JIL6, VIC10). Of the four ranches located in low-lying and/or flood-prone areas, three included the flooding component in their FCMs (FER4, FID5, VIC10). FEL3 did not include flooding as a component in their map, despite being one of the producers most affected by prolonged flooding on their land. In all FCMs, drought was identified as the cause for using at least one form of supplementary feed with exception of one producer who did not represent any form of supplementation but mentioned renting a paddock to feed their cattle. The feeding strategies are presented next followed by the frequency with which it was mentioned (in parentheses): cut fodder (5), poultry manure (4), stubble or low-quality forage (3), grazing in areas with conserved vegetation or woodland (1). As a result of drought, only 3 producers have and use an irrigation system (CRE2, MAN7, ROQ9), 2 haul water for their cattle, and another producer relies on natural water sources on their land.

Regarding the social values and preferences mentioned in the FCMs, we found that 60% of the producers associated their love for the ranch with their motivation for carrying out their work, and in one case, it was linked to social organization. Another producer (FEL3) positively linked prevention and order with money, and camaraderie with a greater possibility of accessing programs and support. In terms of emotions mentioned, the same producer (FEL3) associated programs and support with despair, and another producer (ROQ10) associated corn with the well-being of the family, happiness, and tranquility. Finally, only one producer (CRE2) performs a ritual or ceremony, a thanksgiving mass, aimed at obtaining good harvests.

3.3.2 Group map

During the workshop, the following components were added to the GM: pasture rental, corn, water source, cow manure, citrus, pigs, bees, and woodland (see Figure 5). The components with the highest betweenness centrality in the GM are: money, clearing land, grass, and cattle. The component with the highest number of connections (degree centrality) is money, and the central components in terms of incoming and outgoing connections are drought and money, respectively.

In a simplified way, the flow of the GM can be read from left to right, interpreting the effects of climatic variability on the system. When rainfall occurs, grass experiences a positive impact, resulting in increased cattle production and economic remuneration. Likewise, rainfall leads to increased weed growth, which requires measures to control it and ensure better grass growth. These additional actions generate economic expenses and require more work. On the other hand, during periods of drought, a series of actions are implemented to compensate for the scarcity of forage. These actions include cut fodder, supplementing with poultry manure, using lower-quality forage such as corn stubble, or irrigating pastures. All these measures also entail economic costs, while the surplus of cut fodder is the only element that generates economic income in addition to cattle. Additionally, the practice of clearing land (manually cutting weeds) to improve grass growth is the only action that, in some cases, is considered an economic investment.

3.4 Responses and strategies for drought

Based on the questionnaires and FCMs, we identified that small-scale cattle farmers employ various strategies during drought. These strategies include supplementing feed with cut fodder and poultry manure, grazing in woodland areas, and supplementing with low-quality forage bales or corn stubble. Some farmers reduce their herd size through cattle sales and use irrigation systems to maintain grass supply. Less common strategies include sowing new pasture, land clearing for maintenance or establishing new paddocks, renting pastures, and supplementing with silage.

Regarding the economic implications of these strategies (see Figure 6), the questionnaires revealed that in 75% of the cases, farmers produce their own cut fodder, and among those who supplement with cut fodder according to the FCMs, 66% do not incur additional expenses since the farmers produce the fodder in their own farms. On the other hand, 63% of farmers who supplement with "maloa" or corn stubble, do have to buy it and therefore have associated costs. Concentrated feed always represents an economic expense as it is an external industrial input. The costs of irrigation vary for farmers with shared or individual systems and depend on whether solar panels or conventional power are used. As for land clearing for weed control, although it incurs labor costs, few farmers perceive it as an investment.

3.5 Socialization and projection of an ideal cattle-farming scenario

The interpretation of the following results into the three spheres model is shown in Figure 7. For the ideal scenario, the producers expressed their desire for timely rainfall and a reduction in drought. They observed that excessive deforestation negatively affects the humidity and freshness of the wooded areas. Additionally, the low fertility of mechanized lands poses a challenge as it results in low yields of commercial corn unless chemical fertilizers are used. The producers expressed their interest in reviving the rituals of *Ch'a' ch'aak*

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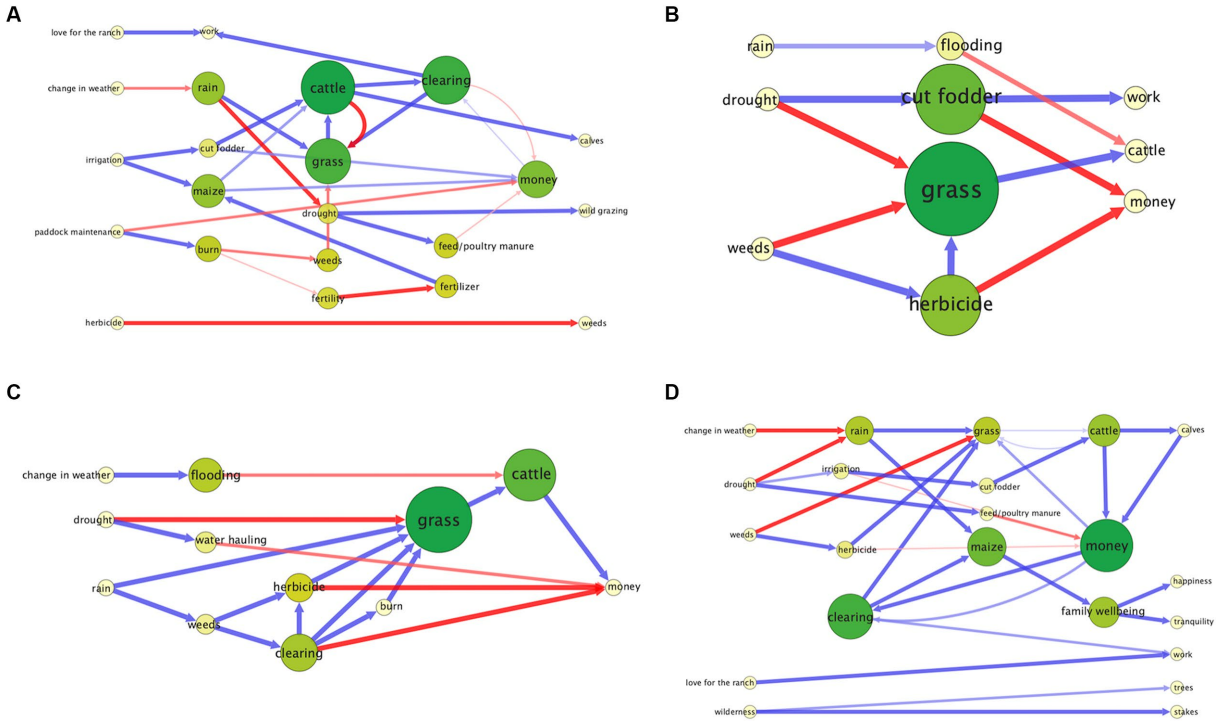

FIGURE 4
Examples of betweenness centrality in individual FCMs: **(A)** FCM with cattle as central node (upper left); **(B)** FCM with grass as central node (upper right); **(C)** FCM grass as central node (lower left); **(D)** FCM with money as central node (lower right). The size and color of the nodes correspond to their betweenness centrality; larger size and darker color indicate higher centrality. Connections that represent a positive causal relationship are shown in blue, indicating that as one node increases, the linked node also increases (+A → +B). Connections that represent a negative causal relationship are shown in red, indicating that as one node increases, the linked node decreases (+A → −B). The thickness and opacity of the connections correspond to the weight of the causal relationship, with thicker and stronger connections representing stronger intensity. Nodes connected with money under a negative link represent an economic expense, while when the link is positive, it signifies an economic income. When money is positively linked, it represents an investment. In the case of work, the weight of the links refers to the amount of effort required to carry out an activity. In the case of "grass," it refers to grass, and when the links associated with this component are positive, they signify practices or strategies that increase the quantity or availability of "grass," while negative relationships indicate higher consumption of "grass" and, therefore, a lower quantity of this resource or an impact leading to a decrease in the resource. "Clearing" is used as manual weed control.

TABLE 2 FCM components by different types of centrality: betweenness centrality (number of shortest paths between any given pair of nodes that pass through a node in a graph) that tells us the amount of influence the node has over the flow of the system; degree centrality (total number of edges), outdegree (number of edges that the node directs to others) and indegree centrality (number of ties directed to the node).

ID	Betweenness centrality	Degree centrality	Outdegree centrality	Indegree centrality
CAR-1	Cattle	Money	Cattle, weeding	Money
CRE-2	Money	Money	Drought	Money
FEL-3	Cattle	Grass	Herbicide, burn	Money, grass
FER-4	Grass	Cut fodder	Herbicide	Money, cattle
FID-5	Grass	Cut fodder, herbicide	Herbicide, weeds, cut fodder, drought	Grass
JIL-6	Cattle	Money	Rain, change in weather	Money
MAN-7	Drought	Drought	Drought	Money
MOI-8	Grass	Money	Change in weather, drought, water well, rain	Money
ROQ-9	Money	Money	Drought, cattle, money, weeding	Grass
VIC-10	Grass	Grass	Weeding	Grass
Most frequent	Grass	Money	Drought	Money

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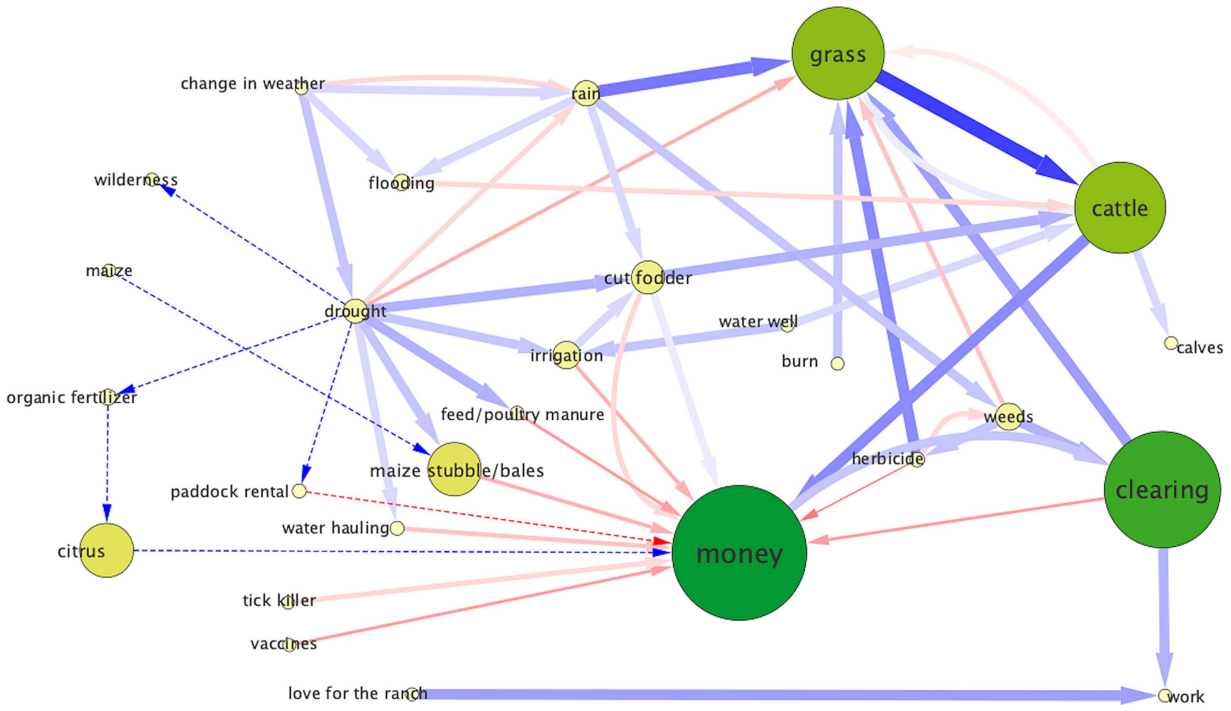

FIGURE 5
Group map (GM). Colorless nodes connected by a dashed line correspond to the concepts added by producers during the workshop.

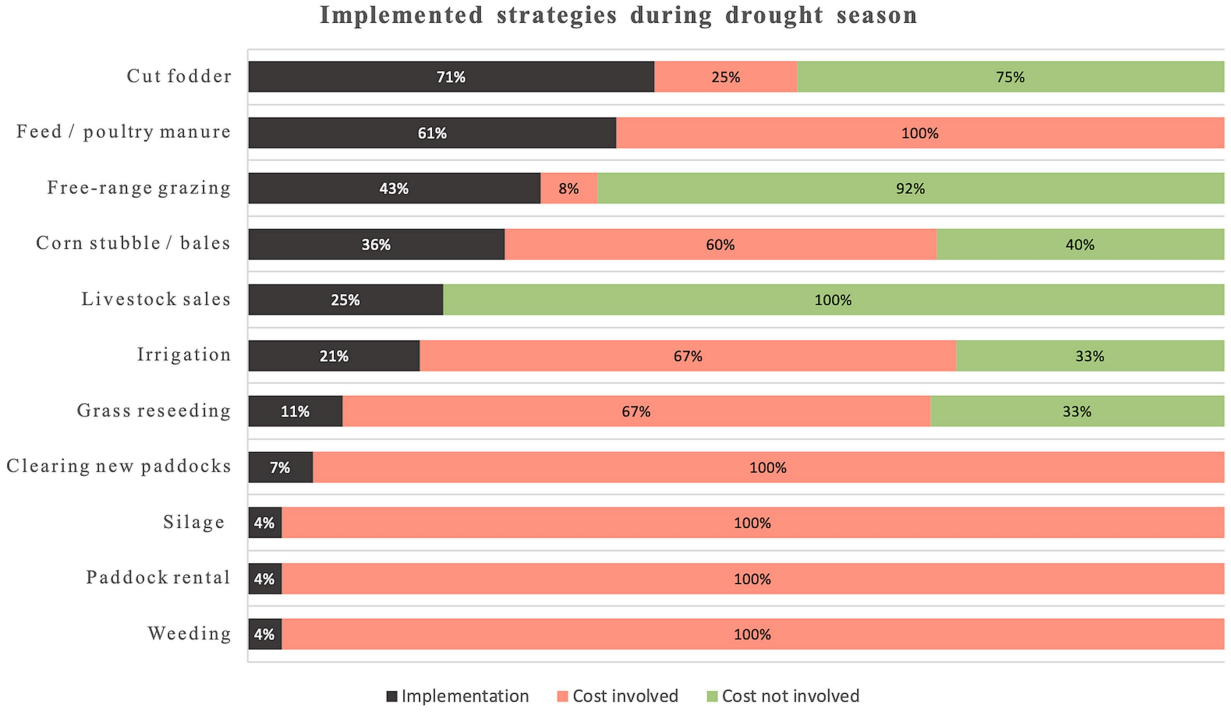

FIGURE 6
Implemented strategies during drought season and their economic implications (questionnaire data). In black the implementation percentage according to frequency. In colors we can see the proportion in which the strategy involves or does not involve a cost.

(rain god) and *Jaanlil kool* as offerings to the land and crops. However, they noted that these traditions are declining due to the influence of emerging religions.

The identified obstacles include the management and implementation of government support programs. The producers criticize the uneven allocation of these programs, which primarily

benefit large producers in the eastern livestock zone of the state. Their wish would be to receive economic support, cattle, cattle insurance, and agricultural implements, as well as training in silage techniques. Lack of efficiency in the management of government support, corruption at the local and regional levels, delays in the delivery of assistance, and the lack of attention to small producers in remote areas were also mentioned. Lastly, the producers emphasize the importance of collective work but identified obstacles such as individualism, land fragmentation, lack of organization, and migration.

4 Discussion

4.1 Perceptions and responses to climate variability – practical sphere

In the present study, drought, although in some cases associated with "changes in the weather," is interpreted as a technical inability to access and properly manage water. In other words, when discussing drought as the main problem that farmers face, instead of questioning and directing the attention toward analyzing its origin and finding a root solution, producers seek ways to address the consequences generated by the technical incapability that the lack of water access represents. Meanwhile, in two studies conducted in the same region, other producers do attribute the decrease in rainfall and changes in seasonal patterns directly to climate change (Márdero et al., 2014; Metcalfe et al., 2020). Although we found similarities in the perception of increased ambient temperature as a consequence of regional deforestation, as reported in the study by Márdero et al. (2014), even within the same region or municipality, it is possible to obtain different results among neighboring localities or within the same community, as the construction of perceptions and responses to the same phenomenon such as climate change can vary (Fierros-González and López-Feldman, 2021).

As seen in Figure 6, climate variability, manifested in more intense and/or prolonged drought seasons, economically destabilizes small-scale production units. The apparent mechanism for cattle farmers to compensate for the low availability of water and therefore of feed is through strategies that involve higher economic costs, such as feed supplementation or maintaining pasture through irrigation. Producing and supplementing feed with cut fodder proves to be a common strategy used during drought (Idrissou et al., 2020; Sánchez-Romero et al., 2021). While some producers mentioned supplementing feed with self-cultivated cut fodder or maize stubble, the majority resort to purchasing feed (poultry manure) from the local livestock association, which partially subsidizes the feed from government entities.

A similar case in South Africa, addressing drought strategies, suggests that producer participation in networks or cooperatives enhances resilience. The results indicate a need for increased

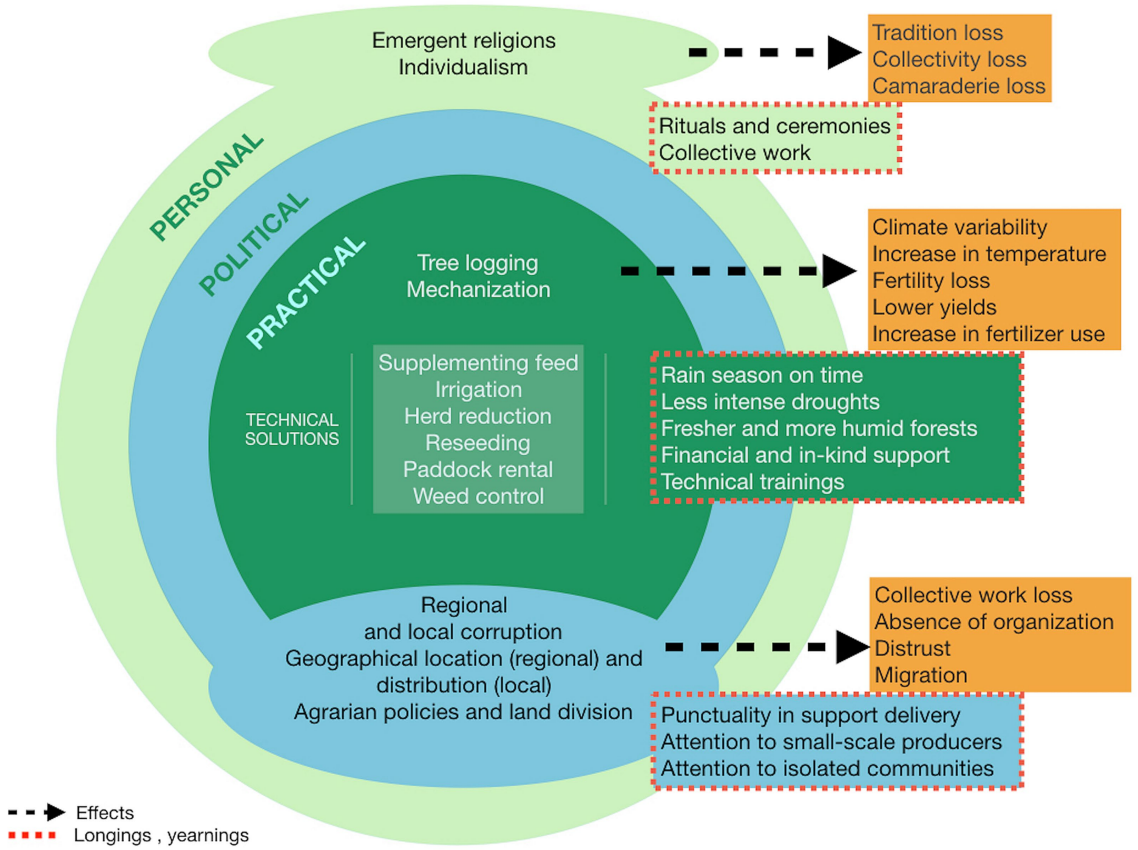

FIGURE 7
Adaptation of the three spheres of transformation diagram. Black dashed arrows show the effects of the referred aspects. In red dashed boxes are the desired things or aspects that producers long for.

government support, particularly in providing credits and promoting involvement in collaborative networks (Bahta and Myeki, 2021). Similarly, Idrissou et al. (2020) mention transhumance as an adaptation strategy to drought in tropical zones in West Africa, whereas in Corral, few cattle farmers utilize their forested areas for grazing. The use of forests as an alternative feeding method during droughts is a strategy that could be promoted as a more sustainable form of silvopasture to avoid establishing new pastures. Despite being a model that is environmentally and socially sustainable (Pérez-Lombardini et al., 2021), for the farmers, secondary vegetation, or what is called "monte," is seen as a hindrance to cattle (Sánchez-Romero et al., 2021), rather than a resource that can be used as year-round forage.

There is no clear trend toward implementing adaptation or mitigation strategies; actions are taken in a way that allows immediate coping with the situation without anticipating a future crisis. The type of support available for cattle farmers, primarily through technical solutions, aims to provide temporary rather than medium or long-term resolutions by analyzing structural causes. This enables them to resolve immediate issues, but not to address climate variability through adaptation strategies or to transform their production methods. This approach puts small-scale producers in a highly vulnerable situation because it promotes dependence on external inputs or support without encouraging them to look beyond the immediate context.

We identified a causal disconnection between climate change and drought, as drought is perceived by producers as an immediate and temporary problem. By not perceiving climate change as something that directly affects them, there are no indications that farmers are responding to drought through adaptation measures. Despite recognizing the increase in temperature and the uncertainty in seasonality, there is a conceptual gap, as farmers do not have a clear understanding of climate change and its effects. The issue is seen as a technical problem, and solutions are contracted to address short-term needs.

4.2 Social organization and responsiveness – political sphere

The collective actions that shape the field or space in which responses occur in the practical sphere are generally systems or structures created and managed through political processes (O'Brien, 2018). In this study, we observed that processes and management within the political sphere have had an effect on social organization at both the individual and community levels.

The categorization of producers based on the number of animals and land area determines whether a producer is small, medium, or large. However, this approach ends up homogenizing other characteristics that confer different capacities and characterize the specific conditions of each producer. These characteristics either facilitate or constrain their possibilities for responding to climate variability. If we understand the capacities of producers as the possibility of doing something rather than as an ability to do it (Boltvinik, 2006), we find that producers, exhibit different coping strategies in their FCMs in response to water stress. Their responses can vary depending on their geographic distribution, level of technological advancement, and access to resources (Table 1).

In this sense, the possession of an asset such as an irrigation system is not determinant of a better response to drought, as it does not guarantee that the producer can effectively use the asset. If the equipment is not functional and does not fulfill its irrigation characteristic, the producer loses the ability to maintain forage in their pasture. The same applies to the location of each producer's land; after a flood, low-lying areas do not recover in time to produce the grass, which is the foundational resource of the system. This disadvantage implies not only higher expenses but also the fact that these lands are not suitable for producing other types of products. Additionally, the majority of producers do not have government support as an extra source of income (Table 1). While monetary support is often a fundamental component of producers' livelihoods, it should be accompanied by sustainable changes in infrastructure and management practices. Also, income diversification constitutes a crucial sustainable form of adaptation to climate variability and other social conditions (O'Brien and Sygna, 2013; Márdero et al., 2014).

At the level of the social organization of producers, we notice that the processes of agricultural production automation have had an impact on social dynamics. In contrast to inclusive innovation, whose main purpose is to generate social benefits and address the needs of a specific group (Amaro-Rosales and de Gortari-Rabiela, 2016; Sampedro and Díaz, 2016), from a standpoint guided by macroeconomics and the well-being of businesses, technological innovation is defined as the application and use of new ideas, concepts, products, services, or practices to achieve higher productivity (Amaro-Rosales and de Gortari-Rabiela, 2016). In the evolution of the agricultural sector, there is a pursuit of production automation to achieve better capital profitability, but little attention is paid to the impacts of technification on other domains of life and the community of producers. The collective organization and communal work that producers mentioned they had in the past in order to carry out arduous tasks such as clearing pastures have been replaced by more individualistic ways of controlling weeds through agrochemicals. Beyond the efficiency that one form or another may bring to the activity, collective work suited in the personal sphere (Figure 7), meant establishing interactions and generating relationships governed by values such as camaraderie, solidarity, and joy, which have been lost in the present day.

Simultaneously, in the political structure that governs small-scale cattle farming of the participating producers (Figure 7), we observe a dependence on government programs and a distrust generated by regional corruption. Instead of triggering social movements or alliances to fight against injustice (O'Brien, 2018), the political organization has led to conflicts and corruption at the local level. The concentration of government support on larger-scale and more capable producers (Gómez and Tacuba, 2017; Robles Berlanga, 2018; Cosío Ruiz, 2020) determines the possibilities of change for smaller-scale producers in isolated regions, and it also reduces the potential for response through non-homogeneous and poorly focused adaptation measures. Eriksen et al. (2015) argue that adaptation should be seen beyond a technical adjustment to a biophysical change; it should be seen as a socio-political process linked to livelihood activities and people's ambitions.

Policies should be focused on the doing and being based on the capacities (developed through programs and support generated by these policies) related to the possessed assets and the services each one obtains from these assets. Alternatives to conventional cattle farming

through sustainable practices and agroforestry are effective (Ibrahim et al., 2010; Murgueitio et al., 2011; Bacab et al., 2013; Broom et al., 2013; Murgueitio et al., 2013; Nahed-Toral et al., 2013). However, their implementation has been sought through the transformation of the production model without considering all the elements that make up the system. (Dagang and Nair, 2003; Cosío Ruiz, 2020) In this regard, considering livestock units as socio-ecosystems is useful for identifying the social processes. When viewed as mutually dependent and interconnected part of the entire system, these processes can be taken into account along with technical solutions for animal and pasture management, and therefore, become part of the solutions that may contribute to shifting toward a more sustainable production model.

4.3 Scenario projection and ideal cattle-farming identity – personal sphere

Cattle farmers expressed aspects of their worldview through the descriptions of ceremonies and rituals and their influence on their perceptions and interpretation of the changes on weather and on the rainfall patterns. According to the study conducted by Metcalfe et al. (2020), these rituals and prayers are shared with cattle farmers in the northeastern region of the Yucatán coast. In the past, these rituals were performed because they were believed to have an effect on their world, such as providing essential elements like rain, bringing good harvests and blessings to the cattle and ranches (Metcalfe et al., 2020; Camacho-Villa et al., 2021). However, currently, although the producers consider these spiritual aspects desirable for a more productive system and a more pleasant environment, they have stopped performing them.

The idea of individualism constructed from and reinforced by other spheres has also led to the loss of tradition. As O'Brien (2018) states, the personal sphere defines what is imaginable, desirable, viable, and achievable individually and collectively, based on different understandings of causality and future awareness. In this study, producers assign significant value to the interpretation of tradition and its implications for community and camaraderie as part of the ideal imaginary of managing their productive systems. It is important to consider the relationship between perceptions, behavior, and climatic phenomena as they participate in the cognitive processes of individuals when observing, constructing meanings, and making decisions regarding social and environmental changes (Eguavoen et al., 2013). According to the producers' perception, the ideal scenario is not a silvopastoral system (considering that producers may not always be familiar with the concept and the type of production model) (Zepeda-Cancino et al., 2016), but rather a scenario similar to the one they used to live in, with elements that have been lost over time.

Rosenberg (2022) discusses the influence of values on how humans relate to their environment and on transformations of socio-ecosystems toward sustainability. In socio-ecosystems with well-defined cultural identities and beliefs, processes of adaptation and transformation are not easy and usually require a perceived crisis to recognize the need for change (Folke et al., 2010). However, the values involved in the human-environment relationship are dynamic and can change from generation to generation or within the same generation (Shrivastava et al., 2020). Furthermore, Rosenberg (2022) shows that values can be deliberately chosen in the intentional pursuit of unity as the primary driver of enactive action toward sustainability. Despite the knowledge gap regarding the current scenario surrounding climate change, the recovery of social values and desirable aspects from the past can incentivize producers to adopt new practices to steer livestock farming toward sustainability.

Understanding what would be a desirable scenario for the actors directly involved in the system allows for a more successful approach, knowing which changes are feasible and achievable within a certain timeframe. Focusing strategies on adaptation is the way to "guarantee" a scenario of greater social benefit and lower environmental impact. In the face of limited specific institutional support, the government's assistance promotes dependence on external inputs, lower adaptive capacity, and ultimately, lower resilience. Therefore, we consider it relevant and necessary for public policies to consider local contexts and the social and cultural factors that influence small-scale cattle management in order to move toward a transformation in livestock farming toward more sustainable management strategies.

4.4 The cattle-farming socio-ecosystem – the three spheres

The operationalization and articulation of the three-sphere model have allowed us to gain greater knowledge and understanding of the cattle production socio-ecosystem of the producers in Corral. Regarding the perception and response to climate variability, we have observed that the practical sphere has a predominant influence over the other spheres. It is evident how the interplay between these three spheres impacts the sustainability of the systems, especially in relation to development values and technified production models.

Moreover, we recognize the significance of cultural and spiritual values in comprehending the perception of the environment, along with the role that worldviews play in interpreting the environment, its components, and its intricate processes. As a result, cultural values shape the farmers' perspectives of climatic events like drought, influencing both their perception of causality and their subsequent responses to these events. By acknowledging these interactions and the influence of the three spheres at both the social organizational level and in practical implementation, we consider that addressing sustainable livestock farming from an exclusively technical-economic perspective is insufficient to achieve greater adoption of sustainable practices.

The social dimension is often underestimated and less understood (Stirling, 2015) as social values and preferences are considered fixed and independent of the ecological context. However, quite the opposite, they are susceptible to change over time (Voinov et al., 2014) and dependent on social and environmental conditions (Halbrendt et al., 2014). By not taking into account the preferences and values that influence decision-making, certain strategies may lack effectiveness (Voinov et al., 2014), which is reflected in low levels of adoption, as is the case with silvopastoral systems (Zepeda-Cancino et al., 2016; Cosío Ruiz, 2020).

Livestock farming represents a significant source of subsistence for a substantial portion of the human population. As noted by Shaffer and Naiene (2011), local mental models of climate change represent the community's conception and knowledge of climate, based on observations and experiences of past and present climate variability. Although integrating local knowledge and beliefs into climate change

adaptation strategies is challenging due to their social nature, it is crucial for farmers to be involved in decision-making processes regarding the adoption of strategies and the integration of local knowledge in adapting to climate variability (Audefroy and Sánchez, 2017).

We acknowledge the limitations within the scope of this study and believe that conducting such research involving a wider range of participants, as well as a diversity of cattle producers including small, medium, and large-scale ones, would be highly valuable in gaining insights from various production scales. However, from the simplified representations that integrate local-level complexity of the 10 participating producers, we were able to grasp the regional reality with its particularities gaining a better understanding of the small-scale cattle socioecosystem in the Yucatan Peninsula. Acknowledging social values and preferences as fundamental components of sustainability itself and for sustainable livestock farming, contributes to identifying the scales where socially and culturally pertinent transformations can be pursued. In this matter, participatory processes were useful for addressing challenges from multiple perspectives and therefore, for recognizing the needs of particular contexts within a regional policy making.

5 Conclusion

The tacit knowledge from which the FCMs are built is composed of complex relationships and associations that cannot be directly translated into a pre-established model like O'Brien and Sygna's (2013) spheres of transformation. However, FCMs, along with the reflective process, triggered a coherent articulation of the three spheres with the practical actions, the organizational and political context, and personal realm of the cattle farmers. Participatory modeling places special emphasis on the modeling process itself rather than solely on the model (Voinov et al., 2014). Through discussion and reflection during the development of FCMs, trust was fostered, and a common understanding was developed that incorporated information that might otherwise be excluded from scientific assessments (Gray et al., 2015). Although participatory modeling processes do not aim to directly intervene in the decision-making of cattle farmers or predict the future state of their systems, they do significantly contribute to understanding a complex problem. This paves the way for successful transitions from conventional cattle farming to a more sustainable one. The focus of this work extends beyond collectively identifying problems and obstacles, it also promotes spaces for understanding and reflexive thinking that ultimately aim to contribute to support better social organization mechanisms and the adoption of sustainable practices to tackle climate change challenges.

The small-scale cattle farmers who participated in this study demonstrate an coping capacity to droughts each year. They implement various strategies such as feed complementation, irrigation practices, reducing herd and government support, that differ in terms of sustainability. However, despite their coping capacity, responses may not always achieve positive outcomes in reducing vulnerability to climate variability. Adaptation must also occur at sociocultural levels, as perceptions of climate change influence decisions and may determine the adoption of sustainable adaptation measures. Being based on the legitimacy of the producers themselves describing the current reality and expressing their aspirations and desired changes, this work plays a fundamental role in establishing a methodological foundation that promotes participation, discussion, and reflection. It is essential for these participatory approaches to include small-scale producers, who are directly involved in the management of the production systems, to ensure that project objectives align with different perspectives and that expected outcomes benefit all stakeholders involved.

It is important to recognize that livestock farming represents a significant source of subsistence for a substantial portion of the human population. We acknowledge the limitations within the scope of this study and believe that conducting such research involving a wider range of participants, as well as a diversity of producers including small, medium, and large-scale ones, would be highly valuable in gaining insights from various production scales. As we gain a better understanding of the livestock socioecosystem, we can address challenges from multiple perspectives toward more sustainable states.

Data availability statement

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

Author contributions

FP-L: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. JS-G: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – review & editing. FS-S: Resources, Supervision, Validation, Writing – review & editing. FG: Conceptualization, Funding acquisition, Investigation, Supervision, Validation, Writing – review & editing.

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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.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1321252/full#supplementary-material

References

Amaro-Rosales, M., and de Gortari-Rabiela, R. (2016). Innovación inclusiva en el sector agrícola mexicano: los productores de café en Veracruz. *Economía Informa* 400, 86–104. doi: 10.1016/j.ecin.2016.09.006

Audefroy, J. F., and Sánchez, B. N. C. (2017). Integrating local knowledge for climate change adaptation in Yucatán, Mexico. *Int. J. Sustain. Built Environ.* 6, 228–237. doi: 10.1016/j.ijsbe.2017.03.007

Axelrod, R., (1976). *Structure of decision: The cognitive maps of political elites*. Princeton University Press: Princeton, NJ.

Bacab, H. M., Madera, N. B., Solorio, F. J., Vera, F., and Marrufo, D. F. (2013). Los sistemas silvopastoriles intensivos con *Leucaena leucocephala*: una opción para la ganadería tropical (The intensive silvopastoril systems with *Leucaena leucocephala*: tropical livestock option). *Avances En Investigación Agropecuaria* 17, 67–81.

Bahta, Y. T., and Myeki, V. A. (2021). Adaptation, coping strategies and resilience of agricultural drought in South Africa: implication for the sustainability of livestock sector. *Heliyon* 7, 1–9. doi: 10.1016/j.heliyon.2021.e08280

Bárcena, A., Prado, A., Beteta, H., Samaniego, J. L., and Lennox, J. (2010). "La economía del Cambio Climático en Centroamérica: Síntesis 2010" *Comisión Económica para América Latina y el Caribe (CEPAL)*.

Bautista, F., Frausto, O., Ihl, T., and Aguilar, Y. (2010). "El Relieve" in *Biodiversidad y Desarrollo Humano en Yucatán, México*. eds. R. Durán and M. Méndez (Merida, Yucatan, Mexico: CICY, PPD-FMAM, CONABIO, SEDUMA), 7–9.

Berlanga, M.R. (2013). *Los pequeños productores y la política pública*. Páginas Subsidios al Campo. México

Boltvinik, J. (2006). Evaluación crítica del enfoque de 'capabilities' de Amartya Sen (Primera parte). *Mundo Siglo* 53, 424–426.

Broom, D. M., Galindo, F. A., and Murgueitio, E. (2013). Sustainable, efficient livestock production with high biodiversity and good welfare for animals. *Proc. R. Soc. B Biol. Sci.* 280:20132025. doi: 10.1098/rspb.2013.2025

Camacho-Villa, T., Martinez-Cruz, T. E., Ramírez-López, A., Hoil-Tzuc, M., and Terán-Contreras, S. (2021). Mayan traditional knowledge on weather forecasting: who contributes to whom in coping with climate change? *Front. Sustain. Food Syst.* 5:618463. doi: 10.3389/fsufs.2021.618453

Cheng, M., McCarl, B., and Fei, C. (2022). Climate change and livestock production: a literature review. *Atmos* 13, 1–20. doi: 10.3390/atmos13010140

CONAGUA. (2020). Reporte del clima en México. Reporte anual 2020. México. Comisión Nacional del Agua.

Cosío Ruiz, C. (2020). Sistema silvopastoril en la Unidad Doméstica de Producción Agropecuaria. Enfoque estratégico y regionalización, Península de Yucatán. *Int. Soc. Sci. Rev.* 9, 163–179. doi: 10.37467/gka-revsocial.v9.2519

Dagang, A. B. K., and Nair, P. K. R. (2003). Silvopastoral research and adoption in Central America: recent findings and recommendations for future directions. *Agrofor. Syst.* 59, 149–155. doi: 10.1023/A:1026394019808

De la Barreda, B., Metcalfe, S. E., and Boyd, D. S. (2020). Precipitation regionalization, anomalies and drought occurrence in the Yucatan Peninsula, Mexico. *Int. J. Climatol.* 40, 4541–4555. doi: 10.1002/joc.6474

Delgado, C., Pacheco, J., Cabrera, A., Batllori, E., Orellana, R., and Bautista, F. (2010). Quality of groundwater for irrigation in tropical karst environment: the case of Yucatán, Mexico. *Agric. Water Manage.* 97, 1423–1433. doi: 10.1016/j.agwat.2010.04.006

Donatti, C. I., Harvey, C. A., Martinez-Rodriguez, M. R., Vignola, R., and Rodriguez, C. M. (2019). Vulnerability of smallholder farmers to climate change in Central America and Mexico: current knowledge and research gaps. *Clim. Dev.* 11, 264–286. doi: 10.1080/17565529.2018.1442796

Eguavoen, I., Schulz, K., de Wit, S., Weisser, F., and Müller-Mahn, D. (2013). Political dimensions of climate change adaption: Conceptual reflections and African examples = Dimensions politiques de l'adaptation au changement climatique. *ZEF Working Paper Series* 120, 1–29.

Eriksen, S. H., Nightingale, A. J., and Eakin, H. (2015). Reframing adaptation: the political nature of climate change adaptation. *Glob. Environ. Chang.* 35, 523–533. doi: 10.1016/j.gloenvcha.2015.09.014

Estrada-Medina, H., and Cobos-Gasca, V. (2014). *Programa de Medidas Preventivas y de Mitigación de la Sequía del Consejo de Cuenca Península de Yucatán*. Merida, Yucatan, Mexico: PMPMS-CCPY, 294.

Fairweather, J. (2010). Farmer models of socio-ecologic systems: application of causal mapping across multiple locations. *Ecol. Model.* 221, 555–562. doi: 10.1016/j.ecolmodel.2009.10.026

Faisal, M., Abbas, A., Xia, C., Haseeb-Raza, M., Akhtar, S., Ajmal, M. A., et al. (2021). Assessing small livestock herders' adaptation to climate variability and its impact on livestock losses and poverty. *Clim. Risk Manag.* 34, 2212–0963. doi: 10.1016/j.crm.2021.100358

Fierros-González, I., and López-Feldman, A. (2021). Farmers' perception of climate change: a review of the literature for Latin America. *Front. Environ. Sci.* 9, 1–7. doi: 10.3389/fenvs.2021.672399

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., and Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecol. Soc.* 15:20.

Funtowicz, S., and Ravetz, J. (1994). Uncertainty, complexity and post-normal science. *Environ. Toxicol. Chem.* 13, 1881–1885.

Galindo, L. M. (2007), *Economía del Cambio Climático en México*, Informe Galindo, Síntesis, Gobierno Federal, SEMARNAT: México

Gamboa-Mena, J. V., Magaña-Magaña, M. A., Rejón-Ávila, M., and Pech Martínez, V. C. (2005). Eficiencia económica de los sistemas de producción de carne bovina en el municipio de Tizimín, Yucatán, México. *Tropical Subtropical Agroecosyst.* 5, 79–84.

Garcia-Frapolli, E., Garcia-Contreras, R., Balderas, U. J., González-Cruz, G., Astorga-de Ita, D., Cohen-Salgado, D., et al. (2013). Fostering traditional Yucatec Maya Management of natural resources through microcredits: a community case study. *Soc. Nat. Resour.* 26, 1351–1364. doi: 10.1080/08941920.2013.791902

Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., et al. (2013). Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. *Food Agric. Organ. United Nations*. 1–139.

Gómez, L. O., and Tacuba, S. A. (2017). La política de desarrollo rural en México. *J. Econ. Lit.* 14, 93–117. doi: 10.1016/j.eunam.2017.09.004

Gray, S.A., Gray, S., Cox, L.J., and Henly-Shepard, S. (2013). Mental modeler: a fuzzy-logic cognitive mapping modeling tool for adaptive environmental management. In Proceedings of the Annual Hawaii International Conference on System Sciences, 965–973.

Gray, S. A., Gray, S., de Kok, J. L., Helfgott, A. E. R., O'Dwyer, B., Jordan, R., et al. (2015). Using fuzzy cognitive mapping as a participatory approach to analyze change, preferred states, and perceived resilience of social-ecological systems. *Ecol. Soc.* 20, 1–14. doi: 10.5751/ES-07396-200211

Halbrendt, J., Gray, S. A., Crow, S., Radovich, T., Kimura, A. H., and Tamang, B. B. (2014). Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture. *Glob. Environ. Chang.* 28, 50–62. doi: 10.1016/j.gloenvcha.2014.05.001

Hichert, T., Biggs, R., de Vos, A., and Peterson, G. (2022). ""Scenario development" in *The Routledge handbook of research methods for social-ecological systems*. eds. R. Biggs, A. Vos, R. Preiser, H. Clements, K. Maciejewski and M. Schlüter (New York: Routledge international handbooks), 527.

Ibrahim, M., Guerra, L., Casasola, F., and Neely, C. (2010). Importance of silvopastoral systems for mitigation of climate change and harnessing of environmental benefits in grassland carbon sequestration: management, policy and economics. In Proceedings of the Workshop on the role of grassland carbon sequestration in the mitigation of climate change (Food and Agriculture Organization of the United Antions) 11, 189–196

Idrissou, Y., Assani, A. S., Baco, M. N., Yabi, A. J., and Alkoiret Traoré, I. (2020). Adaptation strategies of cattle farmers in the dry and sub-humid tropical zones of Benin in the context of climate change. *Heliyon* 6, 1–9. doi: 10.1016/j.heliyon.2020.e04373

IICA. (2020). Hacia una ganadería sustentable y de bajas emisiones en México. *Propuesta de implementación de una acción nacionalmente apropiada de mitigación para transitar hacia la ganadería bovina extensiva sustentable*. Instituto Interamericano de Cooperación para la Agricultura: México.

INEGI. (2020). *Censo de población y vivienda*. México: Instituto Nacional de Estadística y Geografía

IPCC (2014). "Annex II: Glossary" in *climate change 2014: Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change*. eds. R. K. Pachauri and L. A. Meyer (Geneva, Switzerland: IPCC), 40.

Jacobson, L., Akerman, J., Giusti, M., and Bhowmik, A. K. (2020). Tipping to staying on the ground: internalized knowledge of climate change crucial for transformed air travel behavior. *Sustainability* 12, 1–18. doi: 10.3390/su12051994

James, T., and Brown, K. (2018). Muck and magic: a resilience Lens on organic conversions as transformation. *Soc. Nat. Resour.* 32, 133–149. doi: 10.1080/08941920.2018.1506069

Kosko, B. (1986). Fuzzy cognitive maps. *Int. J. Man–Machine Stud* 1, 65–75.

Magrin, G. O., Travasso, M. L., Grondona, M. O., and Rodríguez, G. R. (2007). *Variabilidad climática, cambio climático y sector agropecuario*. Encuentro Internacional sobre cambio climático en America Latina: Quito, Ecuador.

Mancera, K. F., Zarza, H., de Buen, L. L., García, A. A. C., Palacios, F. M., and Galindo, F. (2018). Integrating links between tree coverage and cattle welfare in silvopastoral systems evaluation. *Agron. Sustain. Dev.* 38, 1–9. doi: 10.1007/s13593-018-0497-3

Márdero, S., Nickl, E., Schmook, B., Schneider, L., Rogan, J., Christman, Z., et al. (2012). Sequías en el sur de la península de Yucatán: análisis de la variabilidad anual y estacional de la precipitación. *Investigaciones Geográficas* 78:19. doi: 10.14350/rig.32466

Márdero, S., Schmook, B., Christman, Z., Nickl, E., Schneider, L., Rogan, J., et al. (2014). "Precipitation variability and adaptation strategies in the southern Yucatán peninsula, México: integrating local knowledge with quantitative analysis" in *International perspectives on climate change. Latin America and beyond*. eds. F. Walter Leal, F. Alves, S. Caeiro and U. M. Azeiteiro (Switzerland: Climate Change Management), 189–202.

Metcalfe, S. E., Schmook, B., Boyd, D. S., De la Barreda-Bautista, B., Endfield, G. E., Mardero, S., et al. (2020). Community perception, adaptation and resilience to extreme weather in the Yucatan peninsula, Mexico. *Reg. Environ. Chang.* 20, 1–15. doi: 10.1007/s10113-020-01586-w

Mottet, A., Henderson, B., Opio, C., Falcucci, G., Silvestri, S., Chesterman, S., et al. (2016). Climate change mitigation and productivity gains in livestock supply chains: insights from regional case studies. *Reg. Environ. Change.* 17, 129–141. doi: 10.1007/s10113-016-0986-3

Murgueitio, E., Calle, Z., Uribe, F., Calle, A., and Solorio, B. (2011). Native trees and shrubs for the productive rehabilitation of tropical cattle farming lands. *For. Ecol. Manag.* 261, 1654–1663. doi: 10.1016/j.foreco.2010.09.027

Murgueitio, E., Chará, J. D., Solarte, A. J., Uribe, F., Zapata, C., and Rivera, J. E. (2013). Agroforestería Pecuaria y sistemas silvopastoriles intensivos (SSPi) para la adaptación ganadera al cambio climático con sostenibilidad. *Rev Colombiana Ciencias Pecuarias* 26, 313–316.

Murray-Tortarolo, G. N., and Jaramillo, V. J. (2019). The impact of extreme weather events on livestock populations: the case of the 2011 drought in Mexico. *Clim. Change.* 153, 79–89. doi: 10.1007/s10584-019-02373-1

Nahed-Toral, J., Valdivieso-Pérez, A., Aguilar-Jiménez, R., Cámara-Cordova, J., and Grande-Cano, D. (2013). Silvopastoral systems with traditional management in southeastern Mexico: a prototype of livestock agroforestry for cleaner production. *J. Clean. Prod.* 57, 266–279. doi: 10.1016/j.jclepro.2013.06.020

O'Brien, K. (2018). Is the 1.5°C target possible? Exploring the three spheres of transformation. *Curr. Opin. Environ. Sustain.* 31, 153–160. doi: 10.1016/j.cosust.2018.04.010

O'Brien, K, and Sygna, L. (2013). Responding to climate change: the three spheres of transformation. In Proceedings of transformation in a changing climate, 19-21 June 2013, Oslo, Norway. University of Oslo 16–23.

Orellana, R. (2019). Precipitación pluvial anual. Estrategia de Cambio Climático para la Península de Yucatán. Available at: http://www.ccpy.gob.mx/agenda-regional/escenarios-cambio-climatico/atlas/precipitacion-total.php (Accessed June 15, 2023).

Özesmi, U., and Özesmi, S. L. (2004). Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. *Ecol. Model.* 176, 43–64. doi: 10.1016/j.ecolmodel.2003.10.027

PAECC. (2014). Programa Especial de Acción ante el Cambio Climático del Estado de Yucatán. Diario Oficial Del Gobierno Del Estado de Yucatán (DOGEY). Available at: http://www.yucatan.gob.mx/docs/transparencia/general/indice_transparencia_disponibilidad/III_Marco_Programatico_Presupuestal/III_MPP_ProgramaEspdeAccinateelCambioClimtico20140426_1.pdf (Accessed June 15, 2023)

Palma, J. M. (2014). Escenarios de sistemas de producción de carne de bovino en México. *Avances Investigación Agropecuaria* 18, 53–62.

Pérez-Lombardini, F., Mancera, K. F., Suzán, G., Campo, J., Solorio, J., and Galindo, F. (2021). Assessing sustainability in cattle Silvopastoral Systems in the Mexican Tropics Using the SAFA framework. *Animals* 11, 1–21. doi: 10.3390/ANI11010109

Robles Berlanga, H. M. (2018). *La organización económica de los pequeños y medianos productores. Serie documento de trabajo N° 232*. Rimisp: Mexico.

Rosenberg, M. N. (2022). What matters? The role of values in transformations toward sustainability: a case study of coffee production in Burundi. *Sustain. Sci.* 17, 507–518. doi: 10.1007/s11625-021-00974-3

Sampedro, J. L., and Díaz, C. (2016). Innovación para el desarrollo inclusivo: Una propuesta para su análisis. *Economía Informa*. 396, 34–48. doi: 10.1016/j.ecin.2016.01.002

Sánchez-Romero, R., Balvanera, P., Castillo, A., Mora, F., García-Barrios, L. E., and González-Esquivel, C. E. (2021). Management strategies, silvopastoral practices and socioecological drivers in traditional livestock systems in tropical dry forests: an integrated analysis. *For. Ecol. Manag.* 479:118506. doi: 10.1016/j.foreco.2020.118506

Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación y Organización de las Naciones Unidas para la Agricultura y la Alimentación (2014). *México: el sector agropecuario ante el desafío del cambio climático*. Mexico: Forestry Economics and Policy Division, FAO.

Shaffer, L. J., and Naiene, L. (2011). Why analyze mental models of local climate change? A case from southern Mozambique. *Weather Climate Soc* 3, 223–237. doi: 10.1175/WCAS-D-10-05004.1

Shannon, P., Markiel, A., Ozier, O., Baliga, N. S., Wang, J. T., Ramage, D., et al. (2003). Cytoscape: a software environment for integrated models. *Genome Res.* 13:426. doi: 10.1101/gr.1239303.metabolite

Shrivastava, P., Smith, M. S., O'Brien, K., and Zsolnai, L. (2020). Transforming sustainability science to generate positive social and environmen- tal change globally. *One Earth* 2, 329–340. doi: 10.1016/j.oneear.2020.04.010

Stirling, A. (2015). Developing 'Nexus capabilities': towards transdisciplinary methodologies. *Nexus Network*. 1–38. doi: 10.13140/RG.2.1.2834.9920

Vanwindekens, F. M., Stilmant, D., and Baret, P. V. (2013). Development of a broadened cognitive mapping approach for analysing systems of practices in social-ecological systems. *Ecol. Model.* 250, 352–362. doi: 10.1016/j.ecolmodel.2012.11.023

Voinov, A., Seppelt, R., Reis, S., Nabel, J. E. M. S., and Shokravi, S. (2014). Values in socio-environmental modelling: persuasion for action or excuse for inaction. *Environ. Model. Softw.* 53, 207–212. doi: 10.1016/j.envsoft.2013.12.005

Wamsler, C., and Osberg, G. (2022). Transformative climate policy mainstreaming - engaging the political and the personal. *Global Sustain.* 5, 1–12. doi: 10.1017/sus.2022.11

Zamora-Crescencio, P., Flores-Guido, J. S., and Ruenes-Morales, M. Del R. (2009). Flora útil y su manejo en el cono sur del estado de Yucatán, México. *Polibotánica* 28, 227–250.

Zepeda Cancino, R. M., Nahed Toral, J., and Velasco Zebadua, M. E. (2021). Evaluación de unidades ganaderas e índice de desarrollo de sistemas silvopastoriles en el municipio de Mezcalapa, Chiapas. *Avances Investigacion Agropecuaria* 25, 57–74.

Zepeda-Cancino, R. M., Velasco-Zebadua, M. E., Nahed-Toral, J., Hernández-Garay, A., and Martínez-Tinajero, J. J. (2016). Adopción de sistemas silvopastoriles y contexto sociocultural de los productores: Apoyos y limitantes [adoption of silvopastoral systems and the sociocultural context of producers: support and limitations]. *Revista Mexicana Ciencias Pecuarias* 7, 471–488. doi: 10.22319/rmcp.v7i4.4282

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Communally established cattle feedlots as a sustainable livelihood option for climate change resilience and food security in sub-Saharan Africa: a systematic review

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Climate change poses a significant threat to agriculture and livestock production in sub-Saharan Africa, a region heavily reliant on livestock for smallholder farmers' livelihoods. This systematic review investigates the potential of communally established cattle feedlots as a sustainable strategy to address the interconnected challenges of climate change resilience and food security in the area. The review focuses on the intensification of climate change, marked by rising temperatures and altered precipitation patterns, posing a direct threat to the livelihoods of millions in the region. Conducting a systematic literature review, we meticulously analyzed 72 articles that centered on communally established cattle feedlots in sub-Saharan Africa. The inclusion criteria considered studies within the context of climate change resilience and food security, utilizing both qualitative and quantitative methodologies. Published articles, grey literature, and relevant reports were systematically sourced from academic databases such as PubMed, Scopus, Google Scholar and Web of Science, complemented by manual searches of journals, conference proceedings, and organizational websites. The synthesis of findings reveals a nuanced landscape of successes and challenges associated with communal feedlots. Through a narrative synthesis, studies were categorized based on key themes, unraveling the impact of communal feedlots on livestock health, economic viability, and socio-economic dynamics. The review highlights the role of communal feedlots in mitigating climate-related shocks, enhancing livestock productivity, and fostering economic opportunities for smallholder farmers. However, challenges related to land tenure, community engagement, and resource allocation emerged as critical considerations. In conclusion, communally established cattle feedlots offer a holistic and sustainable approach to address climate change challenges in sub-Saharan Africa.

KEYWORDS

cattle feedlots, climate-induced challenges, resource-poor countries, smallholder farmers, sustainable livestock production

1 Introduction

Climate change poses a critical threat to global agriculture and food security, with far-reaching consequences for ecosystems and the millions who rely on agriculture for their livelihoods (Archer et al., 2021; Zhou et al., 2022). Sub-Saharan Africa, where agriculture is integral to the economy and social well-being, is particularly vulnerable to these disruptive impacts (Oduniyi et al., 2020; Slayi et al., 2023c). Urgent action is needed to develop innovative and sustainable adaptation strategies that address both climate change resilience and food security in this region (Amamou et al., 2018; Slayi et al., 2023b). This paper focuses on one such strategy—communally established cattle feedlots—tailored to the unique circumstances of developing countries. Climate change, as outlined by the Intergovernmental Panel on Climate Change (IPCC), manifests through rising temperatures, altered precipitation patterns, and increased extreme weather events, impacting agricultural systems at various levels (Popoola et al., 2020; Slayi et al., 2023a). Livestock, crucial to the livelihoods of smallholder farmers, are especially vulnerable, posing a significant barrier to food security (Musemwa et al., 2012; Ntshangase et al., 2018).

Developing countries in the sub-Saharan Africa, home to a substantial proportion of the world's smallholder farmers, face disproportionate impacts due to limited adaptive capacity and resources (Boomiraj et al., 2010; Costa Junior et al., 2015). Trapped in a cycle of poverty and vulnerability, these farmers grapple with the dual challenge of adapting to climate change while ensuring food security (Iglesias et al., 2012; Taruvinga et al., 2013). Communally established cattle feedlots offer an innovative adaptation strategy with the potential to mitigate climate change impacts and enhance food security. This systematic review comprehensively explores the concept, dissecting its structural organization, management practices, and socioeconomic implications. Drawing on empirical evidence and literature from different countries in the sub-Saharan Africa, it highlights the advantages of communal feedlots and their potential to address climate-related shocks, enhance livestock productivity, and create economic opportunities for smallholder farmers. While contributing to mitigating greenhouse gas emissions, successful implementation requires addressing challenges such as land tenure, community engagement, and resource allocation, emphasizing the need for supportive policy frameworks and institutional mechanisms. This study aims to provide a thorough understanding of the potential of communally established cattle feedlots in addressing climate change resilience and food security challenges in sub-Saharan Africa, contributing to the discourse on climate-resilient agricultural practices.

2 Methodology

This literature survey employed a systematic review approach, chosen for its ability to ensure transparency, accuracy, and replicability, as illustrated in Figure 1. The methodology adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Cooper, 2010; Monroe et al., 2017), a framework well-established in climate science-related systematic reviews (Barth and Thomas, 2012; Berrang-ford et al., 2015). The data gathering process encompassed two primary approaches: (1) literature search and selection, and (2) data management, coding, and analysis. This methodological choice enhances the robustness and reliability of the survey findings.

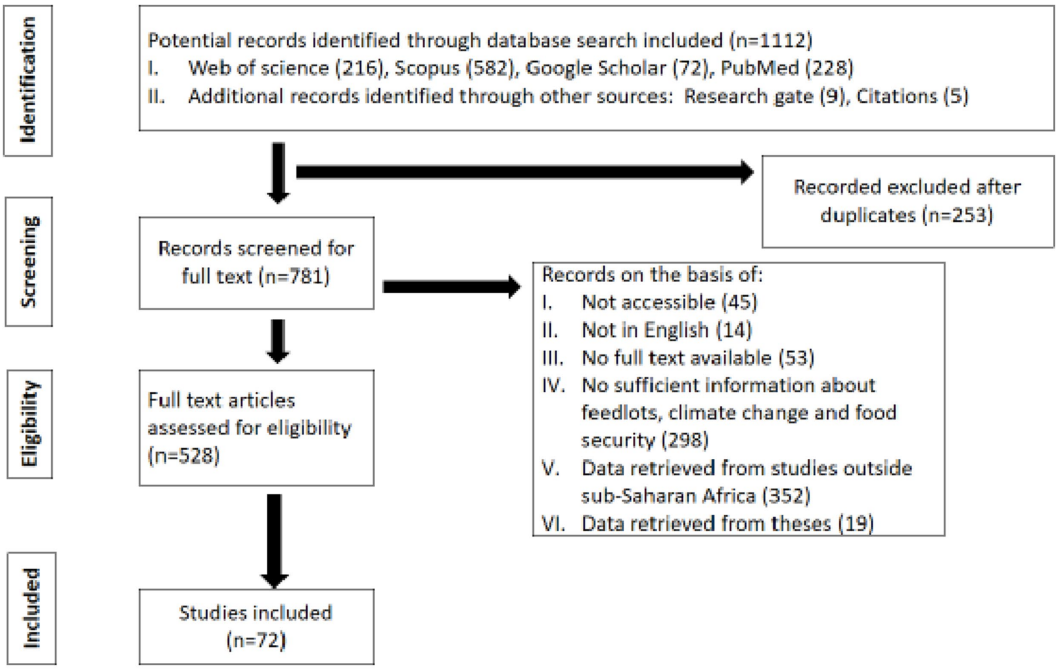

FIGURE 1
PRISMA flow diagram showing the process of identifying relevant studies for the review.

2.1 Inclusion criteria for studies

The research comprised studies that specifically concentrated on communally established cattle feedlots in sub-Saharan Africa. It encompassed investigations conducted within the context of climate change resilience and food security. The selected studies employed a range of methodologies, both qualitative and quantitative. The sources considered for this research included published articles, grey literature, and relevant reports.

2.2 Exclusion criteria for studies

The research excluded studies that were not directly pertinent to the topic of communally established cattle feedlots. It did not incorporate research conducted outside the geographical scope of sub-Saharan Africa. Studies lacking relevance to either climate change resilience or food security were not considered. Additionally, articles not available in English were excluded from the research.

2.3 Search strategy for literature retrieval

The research employed academic databases, including PubMed, Scopus, Google Scholar, and Web of Science, alongside grey literature repositories. It utilized a comprehensive search strategy involving the combination of keywords such as "communal feedlots," "livelihood," "climate change resilience," and "food security." Additionally, relevant journals, conference proceedings, and organizational websites were hand-searched to ensure a thorough exploration of the topic.

2.4 Data extraction and synthesis methods

A standardized data extraction form was created to systematically capture essential information, including study details such as author, publication year, and title. The form included fields for documenting the geographical location and characteristics of communally established cattle feedlots. It further encompassed aspects such as livelihood and economic impacts, sustainable livestock management practices, socio-economic and institutional considerations, as well as climate change resilience and food security outcomes. This structured approach ensured comprehensive and organized data collection for analysis.

2.5 Data analysis

The research undertook a narrative synthesis of findings, organizing studies based on key themes to provide a coherent and comprehensive overview. Additionally, the synthesis process included the development of summary tables to effectively present and communicate key results, enhancing the clarity and accessibility of the research findings.

3 Results and discussion

The synthesis of findings from the systematic review of communally established cattle feedlots in sub-Saharan Africa unravels a complex tapestry of insights that holds profound implications for climate change resilience and food security in the region. A meticulous analysis of 72 articles, employing a diverse range of methodologies and drawing from various sources, has laid the foundation for a comprehensive understanding of the challenges and potentials associated with this innovative adaptation strategy. As we delve into the results and discussion section, we navigate through the intricate dynamics of communal feedlots, exploring their impact on livestock health, economic viability, and the broader socio-economic landscape. This section scrutinizes the nuanced interplay of factors that shape the success and challenges of communal feedlots, shedding light on their role in mitigating climate change-induced shocks and enhancing the resilience of smallholder farmers. Through an evidence-based discussion, this paper aims to distill key insights that can inform policies, practices, and future research directions, contributing to the ongoing dialog on sustainable agricultural solutions in the face of a changing climate.

3.1 Climate change impacts on livestock and agriculture in sub-Saharan Africa

Climate change stands as a paramount global challenge, profoundly impacting agriculture and livestock production, as extensively outlined in existing literature (Escarcha et al., 2018; Talanow et al., 2021). The escalating intensification of climate change manifests through rising global temperatures, altered precipitation patterns, heightened frequency, and severity of extreme weather events, alongside shifts in the distribution of pests and diseases (Popoola et al., 2019; Oduniyi et al., 2020). The gravity of these changes reverberates worldwide, with particular repercussions for agricultural systems, especially in developing nations where agriculture predominantly relies on rain-fed practices, is resource-dependent, and serves as the cornerstone of rural livelihoods (Beauchemin and McGinn, 2005; Anderson et al., 2016; Bareki and Antwi, 2017; Tibesigwa et al., 2017). Existing research, including the compilation presented in Table 1, comprehensively highlights the multifaceted implications of climate change on global agricultural systems, shedding light on its effects on temperature and precipitation patterns that directly impact crop yields (Ntshangase et al., 2018). The identified threats, such as extreme heat and prolonged droughts, pose substantial risks to food security by diminishing crop productivity, particularly in developing nations where subsistence farming prevails, amplifying the vulnerability of local populations (Muthelo et al., 2019; Zwane, 2019; Popoola et al., 2020; Tesfuhuney and Mbeletshie, 2020).

Furthermore, the susceptibility of livestock, integral to the livelihoods of millions in sub-Saharan countries, is extensively documented in the literature (Zhou et al., 2022; Slayi et al., 2023a). Rising temperatures induce heat stress in animals, resulting in reduced productivity and increased mortality rates, a critical concern for smallholder farmers' livelihoods and the global food supply chains they contribute to (Hristov et al., 2017; Lottering et al., 2020a; Archer et al., 2021). The intricate relationship between climate change and water scarcity is also thoroughly explored, emphasizing its repercussions on agriculture and livestock (Derner et al., 2018; Oduniyi et al., 2020; Lottering et al., 2020b). Reduced water availability compromises food production by impeding crop irrigation and limiting drinking water access. Moreover, alterations in the geographic

TABLE 1 Key findings of climate change impacts, adaptive strategies and policy and investment needs on livestock and agriculture.

Category	Impacts of climate change	Adaptive strategies	Policy and investment needs	References
Reduced crop yields and food insecurity	Changes in temperature and precipitation patterns can lead to reduced crop yields, posing threats to food security.	Farmers adapt through changes in planting, diversification, and drought-resistant crop varieties.	Supportive policies, investments, and access to resources are crucial for resilience in agriculture.	Ntshangase et al. (2018); Popoola et al. (2020); Serote et al. (2023); Zwane (2019)
Livestock health and productivity	Rising temperatures can lead to heat stress in animals, reducing productivity and increasing mortality rates.	Livestock farmers adjust management practices to mitigate heat stress and disease risks.	Policies and investments in research and technology are needed to address livestock health challenges.	Zhou et al. (2022); Tibesigwa et al. (2017); Slayi et al. (2023a)
Water scarcity	Climate change exacerbates water scarcity, compromising irrigation and access to drinking water for agriculture and livestock.	Adaptive strategies may include water-efficient irrigation techniques.	Policies promoting water management and conservation are essential.	Derner et al. (2018); Slayi et al. (2023a); Archer et al. (2021); Lottering et al. (2021)
Changing pest and disease dynamics	Climate change alters the distribution of pests and diseases, affecting crop and livestock health.	Farmers adapt to changing disease dynamics through pest control measures and disease management.	Investments in research and disease surveillance, along with policy support, are necessary.	Ndiritu (2020);Tesfuhuney and Mbeletshie (2020); Theusme et al. (2020); Zhou et al. (2022)
Extreme weather events	The increasing frequency and severity of extreme weather events pose immediate risks to agriculture and livestock.	Communities and farmers may implement disaster preparedness measures and infrastructure improvements.	Policies and investments in disaster resilience and risk reduction are critical.	Lottering et al. (2020a,b); Oduniyi et al. (2020); Talanow et al. (2021)
Adaptive strategies	Farmers and communities have developed various adaptive strategies, such as changing planting dates and crop diversification.	These strategies help mitigate climate change impacts and enhance agricultural resilience.	Policies supporting farmer adaptation and knowledge sharing are important.	Taruvinga et al. (2013); Popoola et al. (2019); Ndiritu (2020); Vetter et al. (2020)
Policy and investment needs	Effective adaptation requires supportive policies, investments in research and technology, and improved access to resources.	National and international efforts are crucial for enhancing resilience and ensuring food security.	Coordinated policies, funding, and capacity-building are essential for climate adaptation.	Iglesias et al. (2012); Chatrchyan et al. (2017); Popoola et al. (2020)

distribution of pests and diseases due to climate change are identified as significant factors affecting crop and livestock health (Musemwa et al., 2012; Zhou et al., 2022). Despite the wealth of information presented, the existing literature remains silent on critical aspects. Notably, it falls short in providing a comprehensive identification of research gaps and a thorough critique of the current state of knowledge, limiting our ability to fully grasp the nuances of climate change impacts on agriculture and livestock in sub-Saharan Africa.

In response to the multifaceted challenges posed by climate change, farmers and communities in developing nations have devised various adaptive strategies. These strategies encompass alterations in planting dates, crop diversification, and the adoption of drought-resistant crop varieties (Boomiraj et al., 2010; Henry et al., 2018; Galyean and Hales, 2023). Similarly, livestock farmers may adjust their management practices to mitigate the adverse effects of heat stress and changing disease risks (Zhou et al., 2022; Slayi et al., 2023a). However, the existing literature lacks a comprehensive critique of the effectiveness of these adaptive strategies and their widespread implementation. Effective adaptation to climate change in agriculture and livestock is contingent on the formulation and implementation of supportive policies, investments in research and technology, and improved access to resources and markets (Popoola et al., 2020; Terry et al., 2020; Ridoutt et al., 2022; Ruwanza et al., 2022). Yet, there is a notable gap in the literature regarding the evaluation of the policy frameworks and the adequacy of investments and support mechanisms in facilitating successful adaptation strategies.

Recognizing the significance of national and international collaboration is crucial for enhancing resilience in agriculture and ensuring food security amidst climate change (Loerch and Fluharty, 1999; Joyce et al., 2013; Briske et al., 2015). However, the existing body of literature lacks a thorough analysis of the effectiveness of these collaborative efforts and their impact on smallholder farmers in diverse geographical and socio-economic contexts. The multifaceted and complex nature of climate change's impact on agriculture and livestock production in developing nations, as outlined by Amamou et al. (2018); Marco et al., (2018); Malusi et al. (2021), necessitates a more nuanced understanding. The identified impacts, including reduced crop yields, livestock health issues, water scarcity, changing disease dynamics, and extreme weather events, highlight the urgency of addressing these challenges through comprehensive and

context-specific approaches. Therefore, there is a notable research gap in the literature concerning the development and evaluation of holistic strategies that integrate scientific research, policy development, and community engagement to enhance resilience and ensure food security in the dynamically changing climate.

3.2 Smallholder livestock farming and vulnerability in sub-Saharan Africa

Smallholder farmers, heavily reliant on livestock as a key asset, play a pivotal role in the agriculture of many developing nations (Taruvinga et al., 2013). However, their vulnerability to the impacts of climate change is a growing concern, given their limited access to resources, technology, and adaptive capacity (Musemwa et al., 2012). This literature review scrutinizes the unique challenges faced by smallholder livestock farmers within the context of climate change, emphasizing their implications for food security. Operating on restricted land holdings and lacking access to modern farming technologies and practices, smallholders face constraints in adapting to changing climate conditions and managing climate-related shocks in sub-Saharan Africa (Escarcha et al., 2018; Archer et al., 2021). Climate variability, affecting traditional livestock management practices, poses a significant threat to smallholders (Muller and Shackleton, 2014; Dabasso et al., 2018; Nganga and Crane, 2020).

Precipitation pattern shifts leading to water scarcity and changing forage availability impact animal nutrition and health, intensifying the vulnerability of smallholder livestock farmers (Zhou et al., 2022). Given that livestock constitutes a crucial source of income and nutrition for smallholder households, climate-induced livestock losses can have severe consequences, exacerbating poverty and food insecurity (Slayi et al., 2023a). Moreover, the gender dimension in smallholder livestock farming is substantial, with women often assuming responsibility for livestock care and management (Maltitz and Bahta, 2021). Climate change, by causing livestock health issues and altering resource availability, may further amplify gender inequalities, placing an increased workload on women (Muthelo et al., 2019). The changing climate landscape also elevates the risk of livestock diseases through the altered distribution of disease vectors and pathogens (Escarcha et al., 2018). Smallholder farmers, especially those with limited access to veterinary services, face heightened vulnerability to disease outbreaks (Bocquier and González-García, 2010). Despite these challenges, smallholder livestock farmers employ adaptive strategies, including changes in grazing patterns, the introduction of drought-tolerant livestock breeds, and diversification of income sources (Zhou et al., 2022). However, the existing literature lacks a comprehensive evaluation of the effectiveness and limitations of these adaptive strategies, presenting a notable research gap. Additionally, the gender-specific impacts of climate change on smallholder livestock farming warrant further exploration and analysis in the existing literature.

Smallholder farmers often encounter barriers in accessing markets and value chains for their livestock products (Nyhodo et al., 2014). The economic prospects of these farmers are further complicated by market volatility and disruptions induced by climate change (Harrington and Lu, 2002). It is crucial for governments and development agencies to provide effective support to enhance the resilience of smallholder livestock farming (Popoola et al., 2020). Policies promoting sustainable livestock practices, facilitating access to climate information, and strengthening veterinary services can significantly reduce vulnerability (Archer et al., 2021; Zhou et al., 2022). However, the existing literature lacks a comprehensive assessment of the effectiveness of these policy interventions and their practical implications for smallholder farmers. In conclusion, smallholder livestock farmers in developing nations grapple with a myriad of challenges exacerbated by climate change. Their limited resources, reliance on livestock for income and food security, and susceptibility to climate-induced shocks underscore the pressing need for targeted interventions. While the literature acknowledges the importance of supportive policies, there is a gap in understanding the specific impacts and outcomes of these policies on smallholder livestock farming. Policymakers and development organizations must recognize the unique circumstances of smallholders and tailor climate adaptation and mitigation strategies to address their specific needs. Additionally, further research is warranted to critically evaluate the effectiveness of existing policies and identify areas for improvement. Mitigating the impacts of climate change on smallholder livestock farming is not only vital for their livelihoods but also imperative for global food security and poverty reduction efforts (Table 2).

3.3 Top of form

3.3.1 The emergence of communally established cattle feedlots

In response to the challenges posed by climate change and the vulnerability of smallholder livestock farmers in sun-Saharan Africa, communally established cattle feedlots have emerged as an innovative and context-specific adaptation strategy (Slayi et al., 2023b). This literature review critically examines the concept, development, and potential benefits of communal feedlots as an adaptation option. Communally established cattle feedlots are community-managed facilities designed to optimize cattle management and improve livestock health and productivity (Sotsha et al., 2018). In contrast to traditional extensive grazing systems, these feedlots provide controlled environments for feeding and management (Slayi et al., 2023c). However, existing research lacks a comprehensive evaluation of the effectiveness and practical implications of communal feedlots, creating a notable research gap.

The emergence of communal feedlots can be traced back to the need to address climate change impacts on livestock farming (Marandure et al., 2020). Rising temperatures, reduced forage availability, and water scarcity have prompted a reevaluation of traditional livestock management practices (Escarcha et al., 2018). Feedlots offer a way to adapt to changing conditions while maintaining livestock health and productivity (McAllister et al., 2020). Despite their potential benefits, the existing literature falls short in providing a thorough critique of communal feedlots' strengths and limitations, leaving room for further investigation. Communal feedlots, which vary in size and organization, are typically managed by community members who collectively oversee cattle feeding, health care, and record-keeping (Nyhodo et al., 2014). The infrastructure may include feeding areas, water sources, and shelter (Novelli et al., 2022). While empirical evidence from various developing nations highlights several advantages of communal feedlots, such as improved livestock health

TABLE 2 Summary of the key findings on vulnerability of smallholder farming as well as adaptive strategies and policy and institutional needs in livestock.

Category	Challenges	Adaptive strategies employed	Policy and institutional support needs	Reference
Limited resources and adaptive capacity	Smallholder farmers have limited access to land and modern farming technologies, constraining their ability to adapt to climate change.	Farmers employ adaptive strategies like resource diversification, seeking external support, and knowledge sharing	Policies should focus on resource access, technology transfer, and capacity building for smallholder livestock farmers.	Slayi et al. (2023b); Lottering et al. (2020b)
Climate variability and livestock management	Climate variability disrupts traditional livestock management practices.	Adaptive strategies include changing grazing patterns, adjusting feeding practices, and improving water resource management.	Policies should support climate-resilient livestock management practices and provide access to climate information.	Ntshangase et al. (2018); Archer et al. (2021)
Income and food security	Climate-induced livestock losses can push smallholder households deeper into poverty and food insecurity.	Diversification of income sources, crop-livestock integration, and the use of resilient livestock breeds are common adaptive strategies.	Policies should aim to protect smallholders from income shocks, enhance food security, and promote livestock resilience.	Oduniyi et al. (2020); Tibesigwa et al. (2017)
Gender dynamics	Women often play a significant role in livestock care and management. Climate change can exacerbate gender inequalities in workload and resource access.	Gender-sensitive adaptation strategies, such as providing women access to resources and climate information, help address these disparities.	Policies should integrate gender considerations and support women's empowerment in livestock farming.	Maltitz and Bahta (2021); Muthelo et al. (2019), Briske et al. (2015)
Livestock disease risks	Climate change can increase the risk of livestock diseases, particularly for smallholders with limited access to veterinary services.	Farmers employ disease prevention and management strategies, such as improved biosecurity measures and vaccination programs.	Policies should strengthen veterinary services, disease surveillance, and livestock health support for smallholders.	Zhou et al. (2022); Escarcha et al. (2018)
Market access and value chains	Smallholders often face challenges in accessing markets and value chains for their livestock products.	Adaptive strategies include participating in farmer cooperatives, building market linkages, and improving post-harvest handling practices.	Policies should support smallholders in accessing markets, enhancing value addition, and mitigating market risks.	Nyhodo et al. (2014); Harrington and Lu (2002)
Policy support	Effective support from governments and development agencies is essential for enhancing smallholder livestock farming resilience.	Policies should focus on promoting sustainable livestock practices, climate information access, and strengthening veterinary services.	Institutional support is vital to facilitate policy implementation, capacity building, and knowledge sharing among smallholder livestock farmers.	Popoola et al. (2020); Chatrchyan et al. (2017)

and weight gain, controlled feeding, and reduced exposure to climate-related stressors, the lack of a comprehensive synthesis impedes a nuanced understanding of their broader implications.

Establishing communal feedlots can create economic opportunities for smallholder farmers (Slayi et al., 2023b). By improving the growth and marketability of cattle, these feedlots enhance income generation potential and contribute to poverty reduction (Harrington and Lu, 2002; Bevans et al., 2005). However, the literature fails to provide a holistic examination of the economic impacts, leaving unexplored avenues for understanding the socio-economic dynamics associated with communal feedlots. In addition to their role in climate adaptation, communal feedlots can contribute to mitigating greenhouse gas emissions. Improved cattle management reduces methane emissions associated with enteric fermentation (Costa Junior et al., 2015). While this aligns with global efforts to reduce the environmental footprint of livestock production, a comprehensive analysis of the environmental implications of communal feedlots remains underexplored in the existing literature.

Despite their potential benefits, the establishment and successful operation of communal feedlots are not without challenges. Issues related to land tenure, resource allocation, and community participation can hinder their adoption (Sotsha et al., 2018). Additionally, the sustainability of these feedlots depends on effective management practices and ongoing support (Slayi et al., 2023c). Existing research lacks an in-depth exploration of the challenges associated with communal feedlots, making it imperative to address these gaps for a more nuanced understanding of their implementation challenges. Governments and development organizations play a crucial role in promoting the adoption of

communal feedlots (Marandure et al., 2021). However, the literature does not critically examine the policy frameworks, financial incentives, and technical support required for the successful implementation of communal feedlots, presenting a notable gap in the current understanding. In concluding this point, communally established cattle feedlots offer a promising adaptation strategy for smallholder livestock farmers in the face of climate change. Their potential to improve livestock health, increase economic opportunities, and contribute to climate mitigation makes them a compelling option. However, addressing challenges related to land tenure, resource allocation, and community engagement is essential to ensure the successful implementation and sustainability of these feedlots. Policymakers and development practitioners should consider these factors when designing strategies to enhance climate resilience and food security in developing nations. The existing literature, while providing valuable insights, leaves critical research gaps that warrant further exploration and analysis to inform effective policy and implementation strategies.

3.4 Sustainable livestock management in communal cattle feedlots

As previously discussed, communal feedlots have garnered recognition as a sustainable adaptation strategy for smallholder livestock farming within the context of climate change resilience and food security. This literature review critically examines the application of sustainable livestock management principles within communal feedlots, focusing on their contributions to environmental sustainability, animal welfare, and economic viability. Despite the growing acknowledgment of communal feedlots, the existing literature lacks a comprehensive analysis of the potential drawbacks and limitations associated with the integration of sustainable practices, highlighting a notable research gap. Communal feedlots incorporate sustainable livestock management practices into their operational framework, encompassing controlled feeding, efficient resource utilization, and waste management (Slayi et al., 2023c). While the literature acknowledges the importance of adopting sustainable principles for maximizing the benefits of communal feedlots (Nyhodo et al., 2014), it falls short in providing a nuanced critique of the practical challenges and potential trade-offs associated with their implementation.

One of the primary objectives of communal feedlots is to optimize the utilization of available resources, including feed, water, and land. Sustainable practices within these feedlots aim to ensure efficient resource use, minimize waste, and conserve natural resources (Barbero et al., 2017). While the literature highlights the positive aspects of sustainable resource management, it overlooks potential conflicts or unintended consequences that may arise, such as increased workload or conflicts over resource allocation, representing a gap in the current understanding. Sustainable livestock management principles within communal feedlots prioritize the well-being of animals, contributing to reduced stress, disease prevention, and enhanced productivity (Marandure et al., 2020). However, the literature lacks an in-depth examination of potential challenges or trade-offs associated with implementing these practices, such as the economic costs and logistical complexities of adopting improved animal health and welfare measures, presenting an avenue for further research.

Communal feedlots, often integrated with other agricultural activities, contribute to resource use efficiency and income diversification for smallholder farmers (Slayi et al., 2023b). While the literature recognizes these benefits, it fails to explore potential conflicts or challenges arising from the integration of livestock with other farming practices, such as competition for resources or increased complexity in managing integrated systems. The economic viability of communal feedlots is highlighted in the literature, emphasizing improved livestock health, increased weight gain, and higher marketability of cattle leading to increased income for smallholders (Gwiriri et al., 2019; Marandure et al., 2021). However, the existing research lacks a comprehensive economic analysis, including potential costs and risks associated with implementing sustainable livestock management practices, presenting a critical research gap. The successful implementation of sustainable livestock management in communal feedlots may require training and capacity-building for community members (Slayi et al., 2023b). Despite this acknowledgment, the literature falls short in providing a detailed analysis of the challenges related to knowledge transfer, traditional practices, and resource constraints, hindering a comprehensive understanding of the practical barriers to adoption.

Policymakers play a pivotal role in promoting sustainable livestock management in communal feedlots (Nyhodo et al., 2014). While the literature recognizes the importance of supportive policies, it lacks a critical analysis of the potential policy challenges, conflicts, or unintended consequences that may arise, presenting a research gap in the current understanding. Global initiatives, such as the Global Agenda for Sustainable Livestock, acknowledge the importance of communal feedlots in broader efforts to promote sustainability in livestock production (Rivera-Ferre et al., 2016). However, the literature does not delve into potential tensions or conflicts between global sustainability goals and local implementation challenges, leaving a gap in the assessment of the broader implications of these initiatives. In summary, while sustainable livestock management practices within communal feedlots are deemed essential for enhancing the resilience of smallholder livestock farming in the face of climate change and food security challenges, the existing literature falls short in providing a comprehensive critique and analysis. By integrating principles that prioritize environmental sustainability, animal welfare, and economic viability, communal feedlots offer a holistic approach to sustainable livestock production. Policymakers, development organizations, and local communities must collaborate to ensure the successful implementation of these practices and maximize their benefits for both farmers and the environment. However, addressing the identified research gaps is crucial for a more nuanced and informed approach to the integration of sustainable practices within communal feedlots. Future research should focus on these gaps to provide a more comprehensive understanding of the challenges and opportunities associated with sustainable livestock management in communal feedlots.

3.5 Socio-economic and institutional considerations in communal cattle feedlots

The successful establishment and operation of communal feedlots involve a nuanced interplay of socio-economic and institutional factors (Costa Junior et al., 2015). This literature review critically examines key considerations in communal feedlots, encompassing issues related to land tenure, community participation, gender dynamics, and the policy and institutional framework. Despite the

existing body of literature, several research gaps and areas for improvement within the discourse on communal feedlots are identified. Land tenure emerges as a critical factor in the establishment of communal feedlots (Nyhodo et al., 2014). However, the literature lacks a comprehensive analysis of the potential complexities arising from unclear tenure arrangements in communal lands (Marandure et al., 2021). This absence of nuanced exploration hinders a detailed understanding of the challenges and conflicts associated with land use in the context of communal feedlots, presenting a notable research gap.

Community engagement is vital for the success of communal feedlots (Gwiriri et al., 2019), with community members often playing key roles in management and decision-making processes (Slayi et al., 2023c). However, the literature falls short in providing a nuanced critique of the potential challenges and conflicts that may arise in ensuring active community involvement and ownership of feedlot initiatives, representing a research gap in the understanding of communal dynamics. Gender dynamics within communal feedlots are acknowledged, emphasizing the significant role of women in livestock management (Maltitz and Bahta, 2021). However, the literature lacks an in-depth examination of existing gender inequalities and potential barriers to women's equal access to resources, training, and decision-making opportunities within the context of communal feedlots, presenting an area for further research. Efficient resource allocation is crucial for the sustainability of communal feedlots, requiring careful planning and management (Mader et al., 2002). While the literature recognizes the importance of resource optimization, it lacks a detailed analysis of the decision-making processes regarding feed procurement, water resource allocation, and budgeting within communal feedlots, representing a gap in the current understanding.

Effective local governance structures are deemed essential for resolving conflicts and enforcing rules within communal feedlots (Slayi et al., 2023b). However, the literature lacks a critical analysis of potential challenges or conflicts that may arise in establishing and maintaining these governance structures, presenting a gap in the understanding of the practical aspects of communal feedlot management. Adequate institutional support is crucial for the establishment and success of communal feedlots, including technical assistance, training, and access to financial resources (Slayi et al., 2023c). While the literature acknowledges the importance of institutional support, it lacks a detailed exploration of potential challenges or conflicts in providing such support, hindering a comprehensive understanding of the dynamics involved in institutional backing for communal feedlots. National and regional policy frameworks are recognized as instrumental in promoting and sustaining communal feedlots (Tavirimirwa et al., 2019). However, the literature lacks an in-depth analysis of the potential tensions or conflicts between overarching policy goals and local implementation challenges, representing a research gap in the assessment of the broader implications of policy frameworks.

Access to necessary infrastructure and services is deemed essential for the economic viability of communal feedlots (Teklebrhan and Urge, 2013). While the literature recognizes the importance of improving infrastructure, it lacks a detailed analysis of potential challenges or conflicts associated with enhancing accessibility and marketability of livestock products, presenting a research gap in the understanding of economic dynamics. Training and capacity-building initiatives are considered critical for effective feedlot management (Slayi et al., 2023c). However, the literature falls short in providing a nuanced analysis of potential challenges or conflicts related to knowledge transfer and capacity-building within communal feedlots, presenting a research gap in the practical aspects of community empowerment. Robust monitoring and evaluation mechanisms are acknowledged as necessary for assessing the performance of communal feedlots (Dabasso et al., 2018). However, the literature lacks a comprehensive analysis of the practical challenges or conflicts that may arise in implementing effective monitoring and evaluation, presenting a research gap in understanding the continuous improvement processes.

In summing up, while the socio-economic and institutional aspects of communal feedlots are deemed pivotal for their sustainability and effectiveness as adaptation strategies, the existing literature falls short in providing a comprehensive critique and analysis. By addressing the identified research gaps, communal feedlots can contribute not only to climate resilience and food security but also to community empowerment and sustainable development in rural areas. Future research should focus on these gaps to provide a more nuanced and informed approach to the socio-economic and institutional considerations of communal feedlot development.

3.6 Case studies and empirical evidence of communal cattle feedlots in sub-Saharan Africa

The adoption and impact of communal cattle feedlots have been extensively examined through diverse case studies and empirical research in various developing nations (Tavirimirwa et al., 2019; Slayi et al., 2023b). While these studies contribute valuable insights into the practical application of communal feedlots as a sustainable adaptation strategy, a critical evaluation reveals areas of improvement and research gaps within the existing literature. Table 3 provides a comprehensive summary of the successes and challenges associated with the establishment of communal cattle feedlots in developing countries, drawing from a range of studies. Examining specific cases, such as Zimbabwe, reveals notable successes, including improvements in cattle health, weight gain, and increased marketability leading to enhanced income for smallholder farmers (Tavirimirwa et al., 2019). However, challenges persist, such as limited access to veterinary services and the need for sustained support and training, emphasizing the necessity for further research on effective strategies to address these issues (Dube et al., 2021).

Similar success stories are observed in Ethiopia, South Africa, Kenya, and Sudan, where communal feedlots have positively influenced cattle management practices, livestock productivity, and economic outcomes for smallholder farmers. Challenges, however, vary across regions, encompassing resource allocation, land tenure issues, access to markets, and community engagement (Babiker et al., 2009; Alemayehu and Leta, 2014; Banerjee et al., 2014; Dabasso et al., 2018; Marandure et al., 2020). The existing literature underscores the importance of addressing these challenges to maximize the benefits of communal feedlots in specific contexts. While the case studies collectively highlight the potential of communal cattle feedlots as a strategy for improving livestock health, increasing income, and enhancing resilience to climate-related challenges, a closer examination reveals certain research gaps. The literature would benefit from more in-depth analyses of the factors contributing to both the successes and challenges identified. For instance, understanding the mechanisms behind successful resource management, effective

TABLE 3 Successes and limitations of establishing communal cattle feedlots in developing countries.

Country	Success story	Challenges	References
Zimbabwe	Communal feedlots have demonstrated the potential to enhance cattle health and weight gain, thereby increasing the marketability of livestock. This has translated into improved income for smallholder farmers.	Challenges include limited access to veterinary services and the need for sustained support and training to maintain feedlot operations	Tavirimirwa et al. (2019); Dube et al. (2021); Ncube et al. (2014)
Ethiopia	Communal feedlots in Ethiopia have proven effective in improving cattle fattening practices, increasing livestock productivity, and enhancing smallholder income.	Challenges include resource allocation, land tenure issues, and access to markets. Effective resource management and market access remain key areas of concern	Teklebrhan and Urge (2013); Alemayehu and Leta (2014); Banerjee et al. (2014)
South Africa	Communal feedlots have been successful in reducing livestock vulnerability to climate variability and improving cattle growth rates	Limited access to finance and technical support for feedlot development have been identified as challenges. Collaborative efforts with government agencies and non-governmental organizations have helped address some of these challenges	Slayi et al. (2023b); Marandure et al. (2021); Sotsha et al. (2018); Marandure et al. (2020); Gwiriri et al. (2019); Nyhodo et al. (2014)
Kenya	Communal cattle feedlots in Kenya have contributed to better cattle health management and reduced exposure to climate-related stressors	Challenges include the need for continuous training and community mobilization. Ensuring community participation and adherence to sustainable practices remains an ongoing effort	Dabasso et al. (2018); Kahi et al. (2006)
Sudan	Sudan has witnessed the successful establishment of communal feedlots that have increased livestock productivity and improved the livelihoods of smallholder farmers	Resource allocation and community engagement have been challenges. Addressing resource inequities and ensuring broad community involvement are critical	Babiker et al. (2012); Babiker et al. (2009)

community mobilization, and collaborative efforts involving government agencies would provide valuable insights for tailored interventions.

Moreover, there is a need for comparative studies across multiple developing nations to elucidate the adaptability of communal feedlots in different local contexts. Climate conditions, available resources, and community dynamics play crucial roles in determining the success of communal feedlots (Dabasso et al., 2018; Gwiriri et al., 2019; Tavirimirwa et al., 2019). Examining these factors systematically across diverse regions would contribute to a more nuanced understanding of the contextual variations and inform context-specific interventions. In conclusion, while the existing literature on communal cattle feedlots provides significant insights, addressing research gaps related to the specific factors influencing successes and challenges, as well as conducting more comparative studies across diverse regions, will enhance our understanding of communal feedlots as a sustainable adaptation strategy. Policymakers, development practitioners, and communities can leverage these insights to implement effective and tailored approaches to overcome challenges and maximize the benefits of communal feedlots in diverse developing nation settings.

3.7 Conclusion and further research suggestions

This systematic review highlights the multifaceted potential of communally established cattle feedlots as a sustainable livelihood option for enhancing climate change resilience and food security in sub-Saharan Africa. The synthesis of literature reveals the significant strides made in understanding the benefits and challenges associated with these communal feedlots. Sustainable livestock management practices, economic impacts, and their role in bolstering climate resilience and food security are evident themes. The review highlights the importance of socio-economic and institutional considerations in shaping the success of such initiatives. Despite the promising aspects, challenges such as land tenure, community engagement, and resource allocation necessitate attention for successful implementation. This review emphasizes the critical need for supportive policies and institutional frameworks to address these challenges and ensure the sustained success of communally established cattle feedlots. Building on the insights gained from this systematic review, avenues for further research are identified:

I Longitudinal Studies: Conduct longitudinal studies to track the long-term impacts of communally established cattle feedlots on climate resilience and food security. This would provide a deeper understanding of their sustained effectiveness.

II Comparative Analyses: Undertake comparative analyses between different regions within sub-Saharan Africa to discern contextual variations in the outcomes of communal feedlots, accounting for diverse ecological, socio-economic, and institutional factors.

III In-Depth Socio-Economic Studies: Delve into more in-depth socio-economic studies to explore the nuanced dynamics of community engagement, gender roles, and the economic implications on individual households.

IV Policy Analysis: Evaluate existing policies and assess their effectiveness in supporting the establishment and maintenance of communal feedlots. Propose policy recommendations that can enhance their impact on climate resilience and food security.

V Climate Change Modeling: Integrate climate change modeling to forecast the future effectiveness of communally established

cattle feedlots under different climate scenarios, providing insights into their adaptive capacity.

VI Community Participation Studies: Conduct studies focused on community participation dynamics, exploring strategies to enhance local involvement and ownership in the management of communal feedlots.

In pursuing these avenues, researchers can contribute to a more comprehensive understanding of the potential and challenges associated with communally established cattle feedlots, further informing sustainable strategies for climate adaptation and food security in sub-Saharan Africa.

Author contributions

MS: Data curation, Methodology, Writing – original draft, Writing – review & editing. LZ: Conceptualization, Funding acquisition, Supervision, Writing – review & editing. PN: Writing – review & editing. IJ: Conceptualization, Methodology, Supervision, Writing – review & editing.

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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.

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References

Alemayehu, G., and Leta, S. (2014). Biosecurity practices in central Ethiopian cattle feedlots: its implication for live cattle export. *Int. J. Livestock Product.* 5, 181–187.

Amamou, H., Ben Sassi, M., Aouadi, H., Khemiri, H., Mahouachi, M., Beckers, Y., et al. (2018). Climate change-related risks and adaptation strategies as perceived in dairy cattle farming systems in Tunisia. *Clim. Risk Manag.* 20, 38–49. doi: 10.1016/j.crm.2018.03.004

Anderson, C. L., Schneider, C., Erickson, G. E., MacDonald, J. C., and Fernando, S. C. (2016). Rumen bacterial communities can be acclimated faster to high concentrate diets than currently implemented feedlot programs. *J. Appl. Microbiol.* 120, 588–599. doi: 10.1111/jam.13039

Archer, E. R. M., Landman, W. A., Malherbe, J., Maluleke, P., and Weepener, H. (2021). Managing climate risk in livestock production in South Africa: how might improved tailored forecasting contribute? *Clim. Risk.* 32:100312. doi: 10.1016/j.crm.2021.100312

Babiker, A. A., Amir, M. S., and Khidir, O. A. (2009). Feedlot performance of Sudan Baggara bulls fed pelleted and Unpelleted Baggase based diets. *Pak. J. Nutr.* 8, 384–387. doi: 10.3923/pjn.2009.384.387

Babiker, A. A., Babiker, I. A., Abdelhadi, O. M. A., Elemam, M. B., and Salih, A. M. (2012). Feedlot performance and carcass characteristics of Sudan Baggara bulls fed varying levels of pelleted sorghum straw. *Online J. Anim. Feed Res.* 2, 422–426.

Banerjee, S., Ahmed, M., and Tefere, G. (2014). Studies on morphometrical traits of Boran bulls reared on two feedlots in southern Ethiopia. *Animal Genetic Resour.* 54, 53–63. doi: 10.1017/S2078633614000095

Barbero, R. P., Malheiros, E. B., Nave, R. L., Mulliniks, J. T., Delevatti, L. M., Koscheck, J. F., et al. (2017). Influence of post-weaning management system during the finishing phase on grasslands or feedlot on aiming to improvement of the beef cattle production. *Agric. Syst.* 153, 23–31. doi: 10.1016/j.agsy.2017.01.015

Bareki, N. P., and Antwi, M. A. (2017). Drought preparedness status of farmers in the Nguni cattle development project and the sire subsidy scheme in north West Province, South Africa. *Appl. Ecol. Environ. Res.* 15, 589–603. doi: 10.15666/aeer/1504_589603

Barth, M., and Thomas, I. (2012). Synthesising case-study research—ready for the next step? *Environ. Educ. Res.* 18, 751–764. doi: 10.1080/13504622.2012.665849

Beauchemin, K. A., and McGinn, S. M. (2005). Methane emissions from feedlot cattle fed barley or corn diets1. *J. Anim. Sci.* 83, 653–661. doi: 10.2527/2005.833653x

Berrang-ford, L., Pearce, T., and Ford, J. D. (2015). Systematic review approaches for climate change adaptation research. *Reg. Envir. Ch.* 15, 755–769. doi: 10.1007/s10113-014-0708-7

Bevans, D. W., Beauchemin, K. A., Schwartzkopf-Genswein, K. S., McKinnon, J. J., and McAllister, T. A. (2005). Effect of rapid or gradual grain adaptation on subacute acidosis and feed intake by feedlot cattle. *J. Anim. Sci.* 83, 1116–1132. doi: 10.2527/2005.8351116x

Bocquier, F., and González-García, E. (2010). Sustainability of ruminant agriculture in the new context: feeding strategies and features of animal adaptability into the necessary holistic approach. *Animal* 4, 1258–1273. doi: 10.1017/s1751731110001023

Boomiraj, K., Wani, S. P., Aggarwal, P. K., and Palanisami, K. (2010). Climate change adaptation strategies for agro-ecosystem—a review. *J. Agrometeorol.* 12, 145–160. doi: 10.54386/jam.v12i2.1297

Briske, D. D., Joyce, A. L., Polley, H. W., Brown, J. R., Wolter, K., Morgan, A. J., et al. (2015). Climate-change adaptation on rangelands: linking regional exposure with diverse adaptive capacity. *Front. Ecol. Environ.* 13, 249–256. doi: 10.1890/140266

Chatrchyan, A. M., Erlebacher, R. C., Chaopricha, N. T., Chan, J., Tobin, D., and Allred, S. B. (2017). United States agricultural stakeholder views and decisions on climate change. *WIREs Clim. Chang.* 8:469. doi: 10.1002/wcc.469

Cooper, H. M. (2010). *Research synthesis and Meta-analysis: A step-by-step approach* (Thousand Oaks: Sage).

Costa Junior, C., Cerri, C. E. P., Dorich, C. D., Maia, S. M. F., Bernoux, M., and Cerri, C. C. (2015). Towards a representative assessment of methane and nitrous oxide emissions and mitigation options from manure management of beef cattle feedlots in Brazil. *Mitig. Adapt. Strateg. Glob. Chang.* 20, 425–438. doi: 10.1007/s11027-013-9499-2

Dabasso, B. H., Wasonga, O. V., Irungu, P., and Kaufmann, B. (2018). Stratified cattle production in pastoral areas of Kenya: existing forms, driving factors and management practices. *Applied Animal Husbandry and Rural Develop.* 11, 22–31.

Derner, J., Briske, D., Reeves, M., Brown-Brandl, T., Meehan, M., Blumenthal, D., et al. (2018). Vulnerability of grazing and confined livestock in the northern Great Plains to projected mid-and late-twenty-first century climate. *Clim. Chang.* 146, 19–32. doi: 10.1007/s10584-017-2029-6

Dube, T., Sibanda, S., and Chiwara, P. (2021). Adapting peri-urban agriculture to climate change in Bulawayo, Zimbabwe: a qualitative assessment. *Cogent Soc. Sci.* 7:486. doi: 10.1080/23311886.2021.1944486

Escarcha, J. F., Lassa, J. A., and Zander, K. K. (2018). Livestock under climate change: a systematic review of impacts and adaptation. *Climate* 6:54. doi: 10.3390/cli6030054

Galyean, M. L., and Hales, K. E. (2023). Feeding management strategies to mitigate methane and improve production efficiency in feedlot cattle. *Animals* 13:758. doi: 10.3390/ani13040758

Gwiriri, L. C., Bennett, J., Mapiye, C., Marandure, T., and Burbi, S. (2019). Constraints to the sustainability of a 'systematized' approach to livestock marketing amongst smallholder cattle producers in South Africa. *Int. J. Agric. Sustain.* 17, 189–204. doi: 10.1080/14735903.2019.1591658

Harrington, L. M., and Lu, M. (2002). Beef feedlots in southwestern Kansas: local change, perceptions, and the global change context. *Glob. Environ. Chang.* 12, 273–282. doi: 10.1016/s0959-3780(02)00041-9

Henry, B. K., Eckard, R. J., and Beauchemin, K. A. (2018). Review: adaptation of ruminant livestock production systems to climate changes. *Animal* 12, s445–s456. doi: 10.1017/s1751731118001301

Hristov, A. N., Degaetano, A. T., Rotz, C. A., Hoberg, E., Skinner, R. H., Felix, T., et al. (2017). Climate change effects on livestock in the northeast US and strategies for adaptation. *Clim. Chang.* 146, 33–45. doi: 10.1007/s10584-017-2023-z

Iglesias, A., Quiroga, S., Moneo, M., and Garrote, L. (2012). From climate change impacts to the development of adaptation strategies: challenges for agriculture in Europe. *Clim. Chang.* 112, 143–168. doi: 10.1007/s10584-011-0344-x

Joyce, L. A., Briske, D. D., Brown, J. R., Polley, H. W., McCarl, B. A., and Bailey, D. W. (2013). Climate change and north American rangelands: assessment of mitigation and adaptation strategies. *Rangel. Ecol. Manag.* 66, 512–528. doi: 10.2111/REM-D-12-00142.1

Kahi, A. K., Wasike, C. B., and Rewe, T. O. (2006). Beef production in the arid and semi-arid lands of Kenya: constraints and prospects for research and development. *Outlook on AGRICULTURE* 35, 217–225. doi: 10.5367/000000006778536800

Loerch, S. C., and Fluharty, F. L. (1999). Physiological changes and digestive capabilities of newly received feedlot cattle. *J. Anim. Sci.* 77, 1113–1119. doi: 10.2527/1999.7751113x

Lottering, S., Mafongoya, P., and Lottering, R. (2020a). Drought and its impacts on small-scale farmers in sub-Saharan Africa: a review. *South Afr. Geogr. J.* 103, 319–341. doi: 10.1080/03736245.2020.1795914

Lottering, S., Mafongoya, P., and Lottering, P. (2020b). Detecting and mapping drought severity using multi-temporal Landsat data in the uMsinga region of KwaZulu-Natal, South Africa. *Geo. Int.* 37, 1574–1586. doi: 10.1080/10106049.2020.1783580

Lottering, S., Mafongoya, P., and Lottering, P. (2021). The impacts of drought and the adaptive strategies of small-scale farmers in Umsinga, KwaZulu-Natal, South Africa. *J. Agric. Afr. Stud.* 56, 267–289. doi: 10.1177/0021909620916898

Mader, T. L., Holt, S. M., Hahn, G. L., Davis, M. S., and Spiers, D. E. (2002). Feeding strategies for managing heat load in feedlot cattle. *J. Anim. Sci.* 80, 2373–2382.

Maltitz, L. V., and Bahta, Y. T. (2021). Empowerment of smallholder female livestock farmers and its potential impacts to their resilience to agricultural drought. *AIMS Agric. Food* 6, 603–630. doi: 10.3934/agrfood.2021036

Malusi, N., Falowo, A. B., and Idamokoro, E. M. (2021). Herd dynamics, production and marketing constraints in the commercialization of cattle across Nguni cattle project beneficiaries in eastern cape, South Africa. *Res. Policy and Pract.* 11, 1–12. doi: 10.1186/s13570-020-00186-x

Marandure, T., Bennett, J., Dzama, K., Bennet, J. E., and Mapiye, C. (2021). Drivers of low-input farmers' perceptions of sustainable ruminant farming practices in the eastern Cape Province, South Africa. *Environ. Dev. Sustain.* 23, 8405–8432. doi: 10.1007/s10668-020-00973-x

Marandure, T., Bennett, J., Dzama, K., Makombe, G., Gwiriri, L., and Mapiye, C. (2020). Advancing a holistic systems approach for sustainable cattle development programmes in South Africa: insights from sustainability assessments. *Agroecol. Sustain. Food Syst.* 44, 827–858. doi: 10.1080/21683565.2020.1716130

Marco, I., Padró, R., Cattaneo, C., Caravaca, J., and Tello, E. (2018). From vineyards to feedlots: a fund-flow scanning of sociometabolic transition in the Vallès County (Catalonia) 1860–1956–1999. *Reg. Environ. Chang.* 18, 981–993. doi: 10.1007/s10113-017-1172-y

McAllister, T. A., Stanford, K., Chaves, A. V., Evans, P. R., de Souza Figueiredo, E. E., and Ribeiro, G. (2020). "Nutrition, feeding and management of beef cattle in intensive and extensive production systems" in *Animal Agriculture*. Eds. F. W. Bazer, G. Cliff, and G. Wu (Cambridge, MA, USA: Academic Press), 75–98.

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., and Chaves, W. A. (2017). Identifying effective climate change education strategies: a systematic review of the research. *Environ. Educ. Res.* 25, 791–812. doi: 10.1080/13504622.2017.1360842

Muller, C., and Shackleton, S. (2014). Perceptions of climate change and barriers to adaptation amongst commonage and commercial livestock farmers in the semi-arid eastern Cape Karoo. *African J. Rang. For. Sci.* 31, 1–12. doi: 10.2989/10220119.2013.845606

Musemwa, L., Muchenje, V., Mushunje, A., and Zhou, L. (2012). The impact of climate change on livestock production amongst the resource-poor farmers of the third world countries: a review. *Asian J. Rural Dev.* 2, 621–631. doi: 10.22004/ag.econ.198008

Muthelo, D., Owusu-Sekyere, E., and Ogundeji, A. A. (2019). Small-holder farmers' adaptation to drought: identifying effective adaptive strategies and measures. *WaterSA* 11:2069. doi: 10.3390/w11102069

Ncube, S., Ndlovu, L. R., Tavirimirwa, B., Tambo, G., Mwembe, R., and Nyamushamba, G. B. (2014). Growth performance of ruminants fed different proportions of maize and sorghum grain. *Livest. Res. Rural. Dev.* 26:166.

Ndiritu, S. W. (2020). Beef value chain analysis and climate change adaptation and investment options in the semi-arid lands of northern Kenya. *J. Arid Environ.* 181:104216. doi: 10.1016/j.jaridenv.2020.104216

Nganga, T. W., and Crane, T. A. (2020). Social differentiation in climate change adaptation: one community, multiple pathways in transitioning Kenyan pastoralism. *Environ. Sci. Pol.* 114, 478–485. doi: 10.1016/j.envsci.2020.08.010

Novelli, T. I., Bium, B. F., Biffi, C. H. C., Picharillo, M. E., de Souza, N. S., de Medeiros, S. R., et al. (2022). Consumption, productivity and cost: three dimensions of water and their relationship with the supply of artificial shading for beef cattle in feedlots. *J. Clean. Prod.* 376:134088. doi: 10.1016/j.jclepro.2022.134088

Ntshangase, N. L., Muroyiwa, B., and Sibanda, M. (2018). Farmers' perceptions and factors influencing the adoption of no-till conservation agriculture by small-scale farmers in Zashuke, KwaZulu-Natal Province. *Sustain. For.* 10:555. doi: 10.3390/su10020555

Nyhodo, B., Mmbengwa, V. M., Balarane, A., and Ngetu, X. (2014). Formulating the least cost feeding strategy of a custom feeding programme: a linear programming approach. *Int. J. Sustain. Dev.* 7, 85–92.

Oduniyi, O. S., Rubhara, T. T., and Antwi, M. A. (2020). Sustainability of livestock farming in South Africa. Outlook on production constraints, climate-related events, and upshot on adaptive capacity. *Sustain. For.* 12:2582. doi: 10.3390/su12072582

Popoola, O. O., Yusuf, S. F. G., and Monde, N. (2019). Perception and adaptation responses to climate change: an assessment of small-holder livestock farmers in Amathole District municipality, eastern Cape Province. *S. Afr. J. Agric. Ext.* 47, 46–57. doi: 10.17159/2413-3221/2019/v47n2a502

Popoola, O. O., Yusuf, S. F. G., and Monde, N. (2020). South African National Climate Change Response Policy Sensitization: an assessment of small-holder farmers in Amathole District municipality, Eastern Cape Province. *Sustainability* 12:2616. doi: 10.3390/su12072616

Ridoutt, B., Lehnert, S. A., Denman, S., Charmley, E., Kinley, R., and Dominik, S. (2022). Potential GHG emission benefits of *Asparagopsis taxiformis* feed supplement in Australian beef cattle feedlots. *J. Clean. Prod.* 337:130499. doi: 10.1016/j.jclepro.2022.130499

Rivera-Ferre, M. G., López-i-Gelats, F., Howden, M., Smith, P., Morton, J. F., and Herrero, M. (2016). Re-framing the climate change debate in the livestock sector: mitigation and adaptation options. *Wiley Interdiscip. Rev. Clim. Chang.* 7, 869–892. doi: 10.1002/wcc.421

Ruwanza, S., Thondhlana, G., and Falayi, M. (2022). Research progress and conceptual insights on drought impacts and responses among small-holder farmers in South Africa: a review. *Landscape* 11, 159–167. doi: 10.3390/land11020159

Serote, B., Mokgehle, S., Senyolo, G., du Plooy, C., Hlophe-Ginindza, S., Mpandeli, S., et al. (2023). Exploring the barriers to the adoption of climate-smart irrigation Technologies for Sustainable Crop Productivity by smallholder farmers: evidence from South Africa. *Agriculture* 13:246. doi: 10.3390/agriculture13020246

Slayi, M., Zhou, L., and Jaja, I. F. (2023a). Constraints inhibiting farmers' adoption of cattle feedlots as a climate-smart practice in rural communities of the eastern cape, South Africa: An In-Depth Examination. *Sustain. For.* 15:14813. doi: 10.3390/su152014813

Slayi, M., Zhou, L., and Jaja, I. F. (2023b). Smallholder farmers' adoption and perception of communally established cattle feedlots for climate change resilience in the eastern cape, South Africa. *Front. Sustain. Food Syst.* 7:1239766. doi: 10.3389/fsufs.2023.1239766

Slayi, M., Zhou, L., and Jaja, I. F. (2023c). Exploring farmers' perceptions and willingness to tackle drought-related issues in small-holder cattle production systems: a case of rural communities in the eastern cape, South Africa. *Appl. Sci.* 13:7524. doi: 10.3390/app13137524

Sotsha, K., Fakudze, B., Khoza, T., Mmbengwa, V., Ngqangweni, S., Lubinga, M. H., et al. (2018). Factors influencing communal livestock farmers' participation into the National red Meat Development Programme (NRMDP) in South Africa: the case of the eastern Cape Province. *OIDA Int. J. Sustain. Dev.* 11, 73–80.

Talanow, K., Topp, E. N., Loos, J., and Martin-Lopez, B. (2021). Farmers' perceptions of climate change and adaptation strategies in South Africa's Western cape. *J. Rural. Stud.* 81, 203–219. doi: 10.1016/j.jrurstud.2020.10.026

Taruvinga, A., Muchenje, V., and Mushunje, A. (2013). Climate change impacts and adaptations on small-scale livestock production. *Int. J. Dev. Sustain.* 2, 664–685.

Tavirimirwa, B., Manzungu, E., Washaya, S., Ncube, S., Ncube, S., Mudzengi, C., et al. (2019). Efforts to improve Zimbabwe communal grazing areas: a review. *African J. Range & Forage Sci.* 36, 73–83. doi: 10.2989/10220119.2019.1602566

Teklebrhan, T., and Urge, M. (2013). Assessment of commercial feedlot finishing practices at eastern Shoa, Ethiopia. *Open J. Animal Sci.* 3, 273–280. doi: 10.4236/ojas.2013.34041

Terry, S. A., Basarab, J. A., Guan, L. L., and McAllister, T. A. (2020). Strategies to improve the efficiency of beef cattle production. *Can. J. Anim. Sci.* 101, 1–19. doi: 10.1139/cjas-2020-0022

Tesfuhuney, W. A., and Mbeletshie, E. H. (2020). Place-based perceptions, resilience and adaptation to climate change by small-holder farmers in rural South Africa. *Int. J. Agric. Res. Innov. Technol.* 10, 116–127. doi: 10.3329/ijarit.v10i2.51585

Theusme, C., Avendaño-Reyes, L., Macías-Cruz, U., Correa-Calderón, A., García-Cueto, R., Mellado, M., et al. (2020). Climate change vulnerability of confined livestock systems predicted using bioclimatic indexes in an arid region of México. *Sci. Total Environ.* 751:141779. doi: 10.1016/j.scitotenv.2020.141779

Tibesigwa, B., Visser, M., and Turpie, J. (2017). Climate change and South Africa's commercial farms: an assessment of impacts on specialised horticulture, crop, live-stock and mixed farming systems. *Environ. Dev. Sustain.* 19, 607–636. doi: 10.1007/s10668-015-9755-6

Vetter, S., Goodall, V. L., and Alcock, R. (2020). Effect of drought on communal livestock farmers in KwaZulu-Natal, South Africa. *Afr. J. Ran. For. Sci.* 37, 93–106. doi: 10.2989/10220119.2020.1738552

Zhou, L., Slayi, M., Ngarava, S., Jaja, I. F., and Musemwa, L. (2022). A systematic review of climate change risks to communal livestock production and response strategies in South Africa. *Front. Anim. Sci.* 3:868468. doi: 10.3389/fanim.2022.868468

Zwane, E. M. (2019). Impact of climate change on primary agriculture, water sources and food security in Western cape, South Africa. *J. Disast. Risk Stud.* 11:7. doi: 10.4102/jamba.v11i1.562

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Understanding the drivers of rural household scaling up of integrated crop-livestock-forestry systems. A systematic review and bibliometric analysis

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This literature review focuses on the drivers of Integrated Crop-Livestock-Forestry Systems (ICLFS) adoption by small farmers. It has enabled us to identify current trends and analyze the various drivers of adoption and knowledge gaps. According to the PRISMA literature review protocol, 1,352 scientific publications have been selected and analyzed after a Scopus database search. Data analysis was carried out in two steps. A systematic review was performed with the metadata of scientific publications using the Biblioshiny package of R 4.3.1 software. Then, the 42 most relevant publications were used for a brief narrative synthesis. The results showed that between 2003 and 2023, publications were made in 587 different sources. 73% of publications were scientific articles. 91% of publications were written by an average of 05 co-authors. The effectiveness of Integrated Crop-Livestock-Forestry Systems (ICLFS) practices, the production of organic matter and the effects on farmers' livelihoods are the research topics considered. Five categories of factors were identified to facilitate the adoption of ICLFS by small farmers: (i) farmer profile, (ii) farm characteristics, (iii) economic factors, (iv) institutional factors and (v) biophysical factors. Policy orientations are the most decisive of all the factors identified, followed by the establishment of extension systems and social networks between farmers. This paper makes three main recommendations. Firstly, it recommends the implementation of collaborative research frameworks between West African researchers and those from East Africa, Asia and South America, who have more experience in this area. In addition, this study suggests that future research on the adoption of ICLFS should take into account herd mobility issues in the adoption process. Finally, it suggests that ICLFS should be taken into account in development policies and implemented through action research projects, mostly in West Africa.

KEYWORDS

integrated crop-livestock-forestry system, adoption, scaling up, smallholders, literature review

Introduction

Challenges around food security are growing ever more urgent for humanity. According to Global Report on Food Crises 2023, which draws upon data from 58 countries/territories, more than a quarter of people were affected by extreme food insecurity in 2022 (FSIN and GNAFC, 2023). Farming systems are under enormous constraints due to their inability to satisfy food needs of the world's population. Technological advances, the use of genetic improvements, fertilizers and heavy mechanization have more destroyed the environment and human health than satisfy food needs (Ramankutty et al., 2018; Willett et al., 2019). An alarming observation made by Borrelli et al. (2017) is that this form of agricultural intensification has contributed to the depletion of land nutrients. Indeed, several environmental, social and economic factors explain this fear of the adaptability of crop, forestry and livestock systems to satisfy food needs (Pörtner et al., 2022). As well as the various factors listed in Table 1, production systems are also exposed to the impacts of COVID 19 and the world's wars (Béné, 2020; Nasir et al., 2022).

In order to address this crisis, many scientists agree that we need to reinvent production systems by promoting agroecological systems (Kremsa, 2021; Côte et al., 2022). One of the promoted agroecological approaches is the Integrated Crop-Livestock-Forestry Systems (ICLFS). ICLFS is an integrated approach that provides options for the sustainable production of goods and services (Matos et al., 2022). This farming system, also referred to as the Mixed Farming and Agroforestry System (MIFAS), is described by Martin et al. (2016) as an integration of farming and agroforestry operations that promotes the creation of opportunities for synergistic resource transfers in time and space. Its main focus is the sustainability of production systems by integrating the scientific concepts of the disciplines of agriculture, ecology, sociology and economy (Moraine et al., 2016; Wezel et al., 2020).

Many authors have studied the socio-economic and environmental benefits of ICLFS. Research carried by Low et al. (2023) in the developed economies of Europe, North America, Australia and East Asia has shown that ICLFS can potentially reduce supply chains through the trading, processing and sale of ICLFS-derived (by)products and enable farmers increase profitability. Other research focused on improving soil quality with the implementation of ICLFS (Valani et al., 2021; Rodrigues et al., 2023). However, the various reviews give little consideration to the factors driving the adoption of ICLS on small farms. This review examines the state of the art in scaling up ICLFS to the smallholder farming. Three research questions are addressed in this paper: (i) What is known about research on smallholder adoption of the ICLFS? (ii) What are the knowledge gaps and the trends in research on the adoption of ICLFS by smallholders? (iii) What are the drivers for the adoption of ICLFS by smallholders?

Adoption of sustainable farming systems

Farming systems refer to the combination of productive activities and their production resources (Grantham et al., 1998). In 2001, the FAO and the World Bank define farming systems as a presentation of the way farmers think and decide. These definitions show that farming systems bring together all the production factors (land, labor, capital) used to make a crop and/or animal production specific to a farm.

Farming systems were soon confronted with the issue of sustainability, with the emergence of several types of system. Sustainable agriculture refers to "*a range of strategies for addressing many problems that effect agriculture. Such problems include loss of soil productivity from excessive soil erosion and associated plant nutrient losses, surface and ground water pollution from pesticides, fertilizers and sediments, impending shortages of non- renewable resources, and low farm income from depressed commodity prices and high production costs. Furthermore, "Sustainable" implies a time dimension and the capacity of*

TABLE 1 Ecological, social and economic factors affecting the production system.

Production system	Ecological factors	Social factors	Economics factors	References
Forestry systems	- Deforestation - Extensive agriculture - Overgrazing - Loss of natural habitats - Recurrence of natural disasters - Climate change	- Poor resource governance - Bushfires - High dependence of local populations on resources - Heavy urbanization	- Pressure on Non-Timber Forest Products - Development of timber markets - Sale of arable land	Burgess et al. (2012), Pörtner et al. (2022), and Zhang et al. (2020)
Livestock systems	- Extreme weather events (drought, heavy rainfall, etc.) - Water quality - Contribution to greenhouse gas emissions - Diseases	- Little modernization of farming practices - Conflict between farmers and breeders	- Access to uncompetitive markets - High cost of feed and healthcare products	Amadou and Magnani (2020), Sejian et al. (2015), and Vries and Marcondes (2020)
Crop systems	- Extreme weather conditions (drought, excess rainfall, severe hailstorms, frost, floods) - Invasion of predators/pests - Soil erosion	- Unavailability of labor - Lack of farming professionalization - Weak stakeholder organization	- Inflation in the cost of specific inputs - Poor credit access	Adnan et al. (2019), Li et al. (2020), and Marie et al. (2020)

a farming system to endure indefinitely. "(Rao et al., 2010, p. 9). In other words, sustainable production systems involve integrating the environmental, social and economic dimensions of sustainable development, as defined at the 1992 Rio de Janeiro conference, into farming systems. In the implementation of sustainability strategies for agricultural systems, the promotion of agroecological practices such as ICLFS holds a key place (Gil et al., 2016).

Many authors provide insights into the adoption of agricultural innovation systems. While Rogers (1962) views adoption as a process of "acceptance" of a product, an idea, etc., by an entity within a given social system, Robertson (1971) expands on this concept, stressing that adoption is not a trial, but a commitment to the further use of a product. In 2015, Beaudry defines adoption as the behavior of an agent (an individual) who decides to adopt a technology or innovation at a specific point in time. The adoption of a new practice by farmers depends on several factors. Curry et al. (2021) identified some factors such as gender, experiences in agriculture and others factors.

Methodology

To meet the study's objectives, a review of scientific publications addressing the drivers of ICLFS adoption by smallholders was conducted. The PRISMA protocol[1] conceptualized by Moher et al. (2015) was used to select scientific publications that discuss ICLFS adoption. The methodology adopted can be summarized around three important points (Figure 1): Search, Selection and data analysis. Methodological steps are described below:

Search

The literature search was carried out on the Scopus citation database, which is one of the most extensive databases of scientific citations and references (Singh et al., 2021). Publications were considered up until July 07, 2023. Using the various English keywords identified, search equations were drawn up. The search equation used is as follows:

Once this search had been completed, 1,582 scientific publications were recorded and submitted for screening. The database was not updated after this stage.

Screening of publications

The first step of the screening process consists in removing duplicates. Following this phase, a relevance analysis was carried out based on the titles and abstracts of the scientific publications identified, and then a check was carried out to ensure that all articles were retrievable. The scientific publications identified were subjected to previously established inclusion criteria. These inclusion criteria are that the publications (1) focus on an initiative to scale up an ICLFS, (2) must be published in English, (3) are published between 2003 and 2023 and (4) are articles, reviews, conference papers, conference reviews, books or book chapters. The choice to consider articles in English is justified by the fact that most of the resources on the topic are in English. After this rigorous screening process, 1,353 documents were selected for the data analysis phase. Metadata were exported in BibTeX and csv formats. The exported metadata includes:

- Citation information (authors, document title, year, source title, volume, issue, page, number of citations, source and document title, publication stage, DOI)
- Bibliographic information (affiliations, series identifiers, publishers, source short title)
- Abstract and keywords (abstract, author's keywords, index keywords)
- Funding details (sponsor, funding text)
- Other information (Include references)

Data analysis

The extracted metadata were then analyzed in two separate steps. Bibliometric analysis was performed using R 4.3.1 software. The Bibliometrix package and the Biblioshiny web interface were used for the performed analyses (Aria and Cuccurullo, 2017). To review the state of the art on knowledge linked to the ICFLS adoption, several analyses were carried out. After a brief description of data collection, an analysis of the evolution of publications over time was carried out. The analysis took three key parameters into account: the number of scientific publications per year, the total number of citations per article and the total number of citations per year. The average number of citations per article is assessed by aggregating the cumulative count of occurrences where the articles of an author, or related to a specific theme, have been cited. This total is then divided by the total number of written articles, providing an indication of the average level of citations attributed to each publication. Concurrently, the average number of citations per year is determined by dividing the total number of citations by the number of years during which the authors have published in the field. This measure proves particularly valuable for assessing the annual impact of research on a theme, thus offering an enlightened perspective on the evolution of their influence over time. The number of articles provides information on the quantity of publications in the collection for each year (Moral-Muñoz et al., 2020).

Publication sources were examined using statistics on the 30 most influential sources in the collection and the 10 most influential sources cited locally. Local citation measures the number of citations a document receives from other articles within the collection, contrasting with global citation that counts citations an article in the collection receives from all publications indexed in the source (Batista-Canino et al., 2023). To assess the contribution of authors to the evolution of research topics, further analyses were carried out. Trends on the top 10 most important authors and top 10 most locally cited authors were generated. This analysis was complemented by an overview of publication trends for the top 10 authors over the last 20 years (Waltman, 2016). Keyword analysis was carried out through word cloud and Trends topics evolution. The literature confirms that analyzing the evolution of topics enables us to understand changes in topics over

1 http://www.prisma-statement.org/

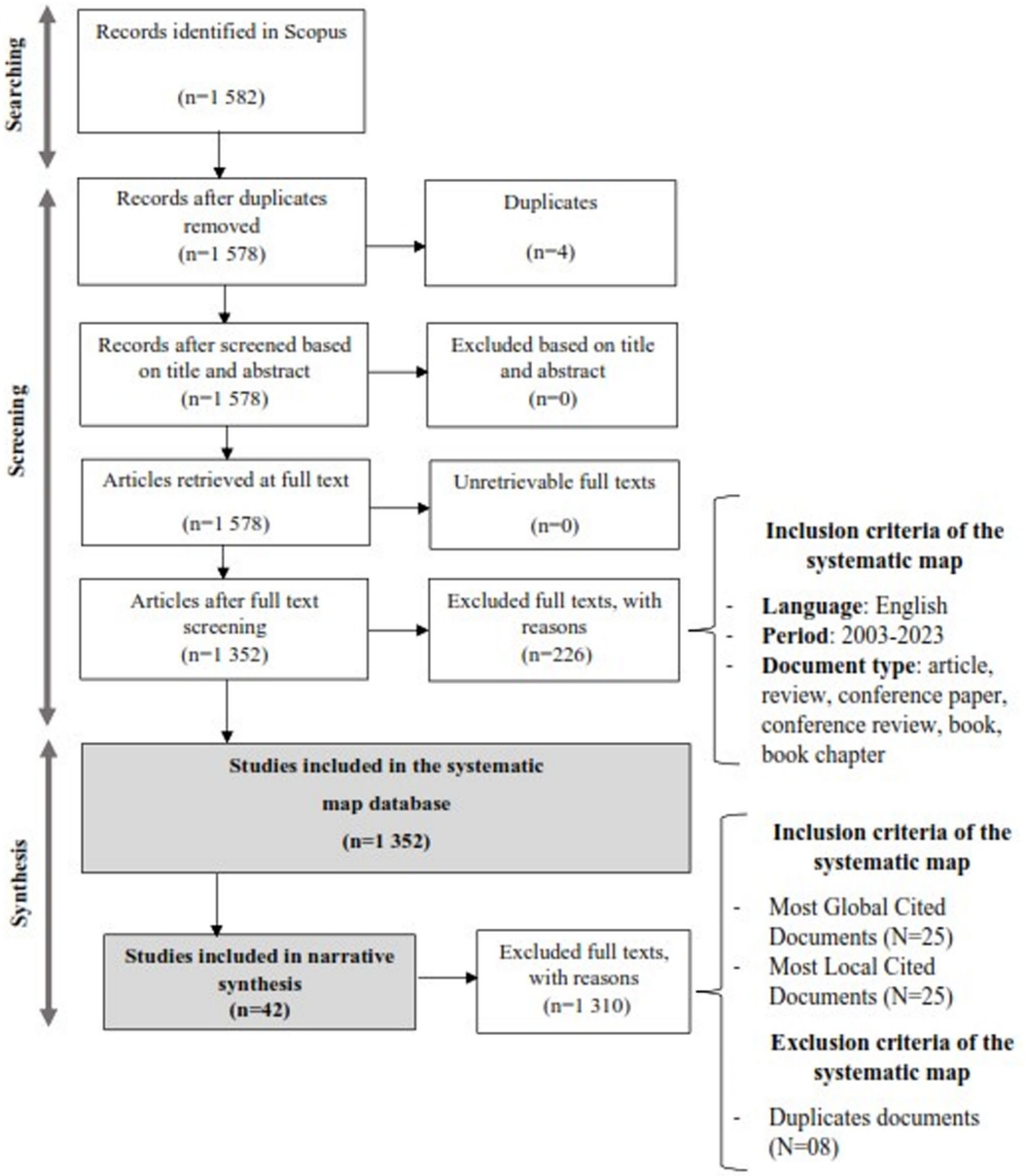

FIGURE 1
Schematic overview of the method used to the literature review, According to PRISMA guidelines.

time and to identify topical and most relevant search themes (Glänzel and Thijs, 2012). A word cloud was created from the 100 keywords most frequently used by authors in the collection. The occurrence of keywords is assessed by their thickness. The most frequently used words are thicker, while the least frequent are thinner. In addition, keywords such as article, which have no impact on the topic, have been eliminated. Synonyms were also merged (e.g.: smallholder farmers, smallholder, smallholders). The thematic evolution was plotted in a graph that shows the evolution of keywords and the frequency of their use through time. The above analyses were complemented by a Bibliographic Coupling Analysis (BCA) to provide a more in-depth analysis of current research areas in the adoption of ICLFS. The BCA was developed by Kessler (1963) for the purpose of comparative analysis of references cited in a collection of scientific publications. It is based on the assumption that if two documents cite the same literature, they cover the same research topics, perspectives and positioning (Maucuer and Renaud, 2019).

The second stage of data analysis was the narrative synthesis, which identified the levers for scaling up ICLFS among smallholders. This analysis took into account the 25 Most Global Cited Documents and the 25 Most Local Cited Documents (Abiola et al., 2023). After removing duplicates (08), 42 publications were submitted to the narrative analysis to determine the drivers of ICLFS adoption by smallholders. The 42 publications were scanned to highlight ICLFS adoption factors. Descriptive statistics were used to determine the occurrence of the different factors in the chosen publications.

Results and discussions

Descriptive overview of the literature review

The Table 2 shows an overview of the research carried out on the ICLFS adoption by smallholders. Over a 20-year period from 2003 to 2023, 1,352 scientific works have been published in 587 different sources. The number of documents cited by the scientific publications identified is equal to 68,720 references. Publications are cited an average of about 23.58 times. These statistics show that the information contained in these documents is of great interest for the scientific research. During the 20 years covered by this review, 5,075 authors have published on the thematic. Nine out of 10 papers (91.20%) were co-authored by an average of 05 authors (4.55) per document. Collaboration between authors at international level is estimated at 39%. Regarding document type, around three-quarters of published scientific documents (73%) are articles, 9.32% are book chapters and 7.40% are journal articles. The summary keyword analysis shows a high degree of consistency between the keywords used by the authors and those generated automatically based on references. Four hundred and fifty-nine additional keywords were detected in the references compared with the keywords generated from the data collections. The keywords used by the authors reflect and are more informative about trends in ICLFS research.

Scientific publication trends

An analysis of the evolution of publications over time has been carried out and is presented in Figure 2. It shows the evolution of parameters such as the number of articles published per year, the average number of total citations per article and the average number of total citations per year. Overall, the trend in publications on the ICFLS adoption has two important periods. There is an ascending phase from 2003 to 2021, with 1,152 publications, and a descending phase from 2021 to 2023. During the latter phase, 200 articles were published. The upward phase of publications took place during the period of the United Nations Decade for Biodiversity from 2011 to 2020 when the Integrated Resource Management Strategy was adopted for the implementation of the Convention on Biological Diversity (UNEP, 2012). The drop in research spending over last 2 years (2021–2023) can be attributed to a stabilization in thematic research. In 2021, the number of publications peaked at an estimated 187. This coincides with the 2nd World Congress on Integrated Crop-Livestock-Forestry Systems. Variations in the average number of citations per year and per article show a decrease in the number of citations per article and per year from 2014 onwards. However, in 2006, the increase in the number of citations per year (8.16) matched the number of citations per article (146.83), with a total of 29 scientific publications.

Sources of research publications

Table 3 shows the top 30 most influential sources of publications concerned with scaling up ICLFS in rural households. The parameters presented in the table are the H-index, the G-index, the M-index, the total number of citations and the number of publications. The scientific publications were made in 468 different sources. This table shows that 20% of publication sources began publishing in 2003. Throughout the entire period, 2003 saw the greatest number of scientific publications. These results provide further evidence that 2003 was a key year in the development of ICLFS research. FAO put in place political strategies and institutional measures in 2003, which were incorporated into national plans, to ensure that farming systems were adaptable to food needs through the promotion of integrated farming systems (FAO, 2004). The analyses also showed the 10 most cited sources locally (Figure 3). "Agricultural Systems and Agriculture" and "Ecosystems & Environment" are the most cited sources, with, respectively, 737 and 596 local citations.

TABLE 2 Main information about the collection.

N°	Description	Results	N°	Description	Results
1	*Main information*		4	*Document types*	
1.1	Timespan	2003:2023	4.1	Article	988
1.2	Sources (Journals, Books, etc)	587	4.2	Book	8
1.3	Documents	1,352	4.3	Book chapter	126
1.4	Annual Growth Rate %	6.58	4.4	Conference paper	124
1.5	Document Average Age	6.64	4.5	Conference review	6
1.6	Average citations per doc	23.58	4.6	Review	100
1.7	References	68,720	5	*Document contents*	
2	*Authors*		5.1	Keywords Plus (ID)	4,395
2.1	Authors	5,075	5.2	Author's Keywords (DE)	3,936
2.2	Authors of single-authored docs	102			
3	Authors collaboration				
3.1	Single-authored docs	119			
3.2	Co-Authors per Doc	4.55			
3.3	International co-authorships %	39.05			

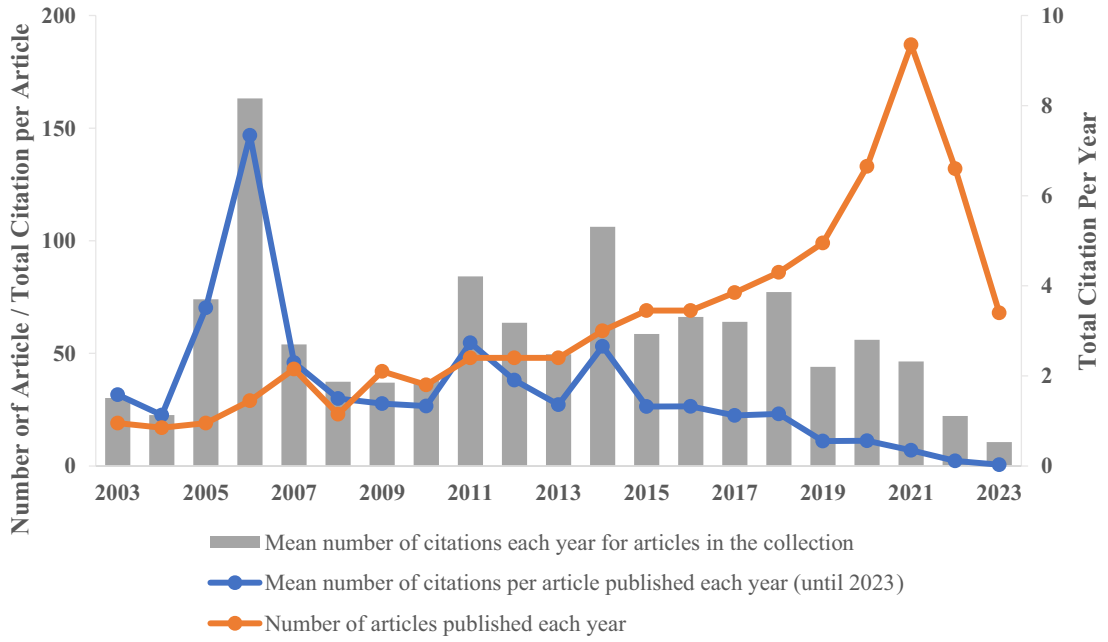

FIGURE 2
Trends of publications on ICLFS adoption.

Most impactful authors

Figure 4 shows the top 10 authors with the most publications. It provides an index of the authors' productivity. Analysis of this figure shows that Kumar S. and Herrero M. have each published 13 scientific articles. Three authors have the same number of scientific publications (08). These authors are Zhang W., Rufino MC. and Moraine M. The top 10 authors with the most local citations are shown in Figure 5. Kumar S. has 32 local citations, followed by Singh JM. and Horo A. with 31 local citations each. Closing the ranking is Paramesh V. with 20 local citations. Figure 6 provides some details on the scientific production per year. By author, it gives the number of articles and citations per year. The size of the bulbs provides information on the number of publications, while the intensity of the bulb color provides information on the number of citations per year. The results show that Kumar S. has published the most publications and is also the most cited author on the subject. It should be noted that these indicators only measure the activity of different researchers on the topic and provide limited information about their actual impact.

Keywords' analysis and trends topics

Figure 7 shows the cloud of the 100 keywords most used by the authors. According to the frequencies of occurrence of key words in the word cloud, ICLFS studies are gradually being integrated into smallholder farmers' climate change adaptation strategies. Food security and the sustainability of farming systems are also among the topics addressed. However, ICLFS adoption in African countries has received little attention. Also, women's contribution to the scaling-up of ICLFS is little explored. The trends in ICLFS research presented in Figure 8 show the emergence of new research topics. Over the past 2 years, research has focused on ICFLS efficiency, manure production, fruit production, livelihoods and the socio-economic effects of ICFLS. This trend in research is sufficient proof of the importance of scaling up ICLFS with farmers. These studies will provide theoretical evidence to facilitate the adoption process.

Bibliometric coupling of documents

A scientific map was drawn up to determine the impact of scientific publications and the linkages between documents. The documents represent the unit of analysis. The analysis was based on the 250 most influential publications in the collection, representing 18.49% of all publications. Minimum frequency of grouped links was measured at around 10%. Taking impact and centrality into account, five clusters were identified. These clusters are presented below (the color within brackets indicate the color of the cluster in Figure 9):

1 *Mixed farming practices in farmers' adaptation to climate change (pink)*: located between the upper left and lower left quarters, this cluster is characterized by a centrality of 0.33 with an impact of 1.95. It includes 84 documents. The topic addressed in the cluster is related to the use of mixed farming practices in farmers' adaptation to climate change. Behera and France's (2016) paper makes a strong contribution to the topic with 5.23 normalized local citations. This paper was followed by Asante et al. (2018) with 2.99 local normalized citations and Takahashi et al. (2020) with 2.7 local normalized citations.
2 *Relationship between integrated systems and livestock farming (Blue)*: This cluster is characterized by a centrality of 0.535, an impact of 4.64 and 54 documents. It is located in the upper

TABLE 3 Impact of the 30 most influential publication sources.

N°	Element	h_index	g_index	m_index	TC	NP	PY_start
1	Agricultural Systems	33	57	1.571	3,416	78	2003
2	Agriculture, Ecosystems and Environment	17	25	0.81	1,409	25	2003
3	Field Crops Research	17	23	0.81	1,124	23	2003
4	Land Use Policy	12	19	0.857	501	19	2010
5	Renewable Agriculture and Food Systems	11	21	0.55	688	21	2004
6	Sustainability (Switzerland)	11	19	1.1	404	33	2014
7	Agroforestry Systems	10	19	0.5	373	20	2004
8	Agronomy for Sustainable Development	10	17	0.588	824	17	2007
9	International Journal of Agricultural Sustainability	10	18	0.5	351	18	2004
10	Journal of Environmental Management	9	11	0.474	271	11	2005
11	Nutrient Cycling in Agroecosystems	9	10	0.429	296	10	2003
12	Crop and Pasture Science	8	12	0.533	294	12	2009
13	Journal of Cleaner Production	8	9	1.143	264	9	2017
14	Animal Production Science	7	9	0.467	174	9	2009
15	PLoS One	7	9	0.538	263	9	2011
16	Crop Protection	6	6	0.333	179	6	2006
17	Ecological Indicators	6	7	0.4	187	7	2009
18	European Journal of Agronomy	6	8	0.286	484	8	2003
19	Heliyon	6	7	1.2	157	7	2019
20	Journal of Sustainable Agriculture	6	7	0.286	172	7	2003
21	Livestock Science	6	7	0.333	227	7	2006
22	Tropical Animal Health and Production	6	7	0.462	162	7	2011
23	Advances in Agronomy	5	5	0.278	502	5	2006
24	Agricultural Economics (United Kingdom)	5	5	0.714	166	5	2017
25	Agriculture and Food Security	5	6	0.417	316	6	2012
26	Agroecology and Sustainable Food Systems	5	9	0.455	87	11	2013
27	Agronomy	5	9	0.714	87	9	2017
28	Animal	5	5	0.5	218	5	2014
29	Food Security	5	7	0.556	70	7	2015
30	Frontiers in Plant Science	5	8	0.625	148	8	2016

right-hand quadrant and mainly addresses the relationship between integrated systems and livestock farming. Bell and Moore's (2012) article is the most influential document in this cluster with a score of 13.44 normalized local citations. It is followed by the articles written by Russelle et al. (2007) and Martin et al. (2016), which have a score of 13.33 and 11.5 local normalized citations, respectively.

3 *Crop yields in relation to integrated practice (Green)*: the third cluster is positioned at the center of the graph and focuses on crop yields in relation to integrated practice. With 50 documents, this cluster has a centrality of 0.41 and an estimated impact of 2.45. The three papers that contribute strongly to this cluster are those by Gil et al. (2015, 2016) and Chen et al. (2011). These papers have a normalized local citation score of 6.61, 5.75 and 5.29, respectively.

4 *Climate change perceptions and adaptation strategies (Orange)*: This focuses on perceptions and adaptation strategies around climate change issues. 19 publications were identified in this cluster, with a centrality of 0.33 and an impact of 1.16. The most influential article in this cluster is by Kgosikoma et al. (2018) with a local normalized citation of 1.5. Gebre et al. (2023) and Jena et al. (2023) each have one normalized local citation. It is located in the top left-hand quadrant.

5 *Agricultural production with mixed farming practices (Purple)*: This cluster is located in the lower left-hand quadrant and comprises 41 documents. It has a centrality of 0.37 and an impact of 3.26. The publication of Valbuena et al. (2015) is the most influenced in the network with 8.16 normalized local citations. It is followed by the publication of Rufino et al. (2011) with a normalized local citation score of 5.29 and that by Giller et al. (2011) which has 4.88 normalized local citations. This cluster focuses on agricultural production by small farmers based on mixed farming practices.

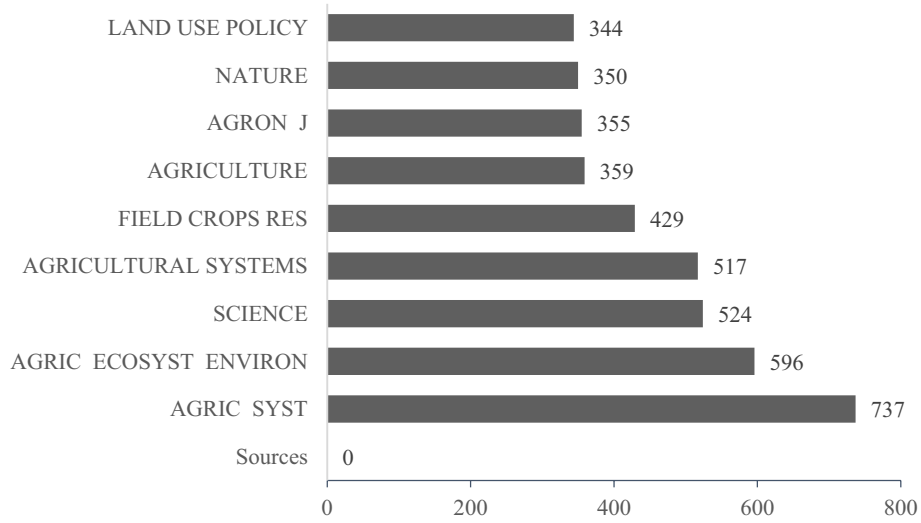

FIGURE 3
Top 10 of most locally cited sources on integrated crop-livestock-forest systems adoption.

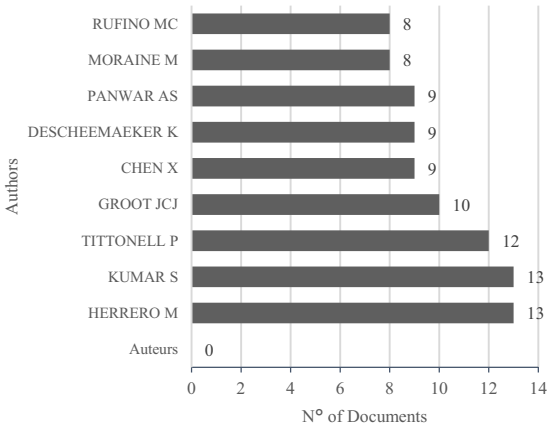

FIGURE 4
Most relevant authors on ICLFS adoption.

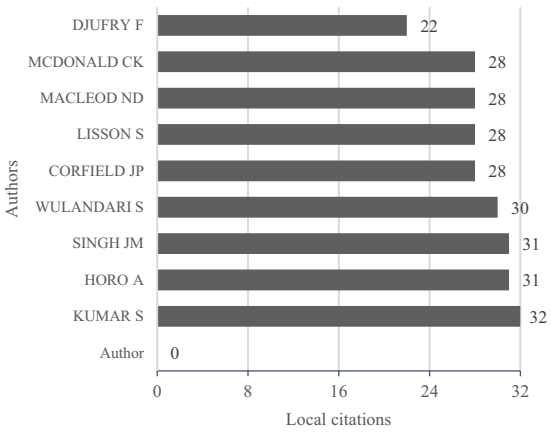

FIGURE 5
Most local cited authors on ICLFS adoption.

ICLS adoption drivers based on literature review

The analysis of ICLFS adoption drivers was based on the 42 scientific publications identified after the selection process. Several factors affect the adoption of ICLFS by farmers. On the basis of the literature, a number of factors have been identified (Figure 10). Five categories of factors were distinguished. These are factors linked to the farmer's profile, farm characteristics, economic factors, institutional factors and biophysical factors. An analysis of the results shows the key role of institutional factors in the ICLFS adoption process. The implementation of environmental policies that encourage the development and scaling-up of ICLFS appears to be the most important factor. Indeed, Garrett et al. (2017) and Asai et al. (2018) argue that environmental policy orientations must accompany the ICLFS adoption process. This factor is followed by others such as access to extension services and the establishment of stakeholder networks for the dissemination of ICLFS practices (Behera and France, 2016; Tesema, 2021). Access to credit or subsidies is a significant contributing factor in promoting also the adoption of policies that favor the ICLFS (Devendra, 2007; Mariano et al., 2012; Moraine et al., 2017). Other market-related economic factors have been highlighted by Lal et al. (2007), Udo et al. (2011), and Tesema (2021), and many other authors. Biophysical factors such as experience with farming practices (Bolliger et al., 2006), the presence of pathogens (Oerke, 2006), soil type (Lisson et al., 2010), access to climatic information (Mzoughi, 2011), topography (Gil et al., 2016) and variability of crop yields (De Moraes et al., 2014) also determine the ICLFS adoption. Other factors linked to the farmer and his/her farm also explain the ICLFS adoption. Indeed, the size of the farm and livestock held, level of education, gender, income level, availability of labor, age... are factors that influence the ICLFS adoption. For example, Widadie and Agustono's (2015) research showed that education level, income as well as family size positively influence farmers' adoption of agriculture-livestock integration technologies.

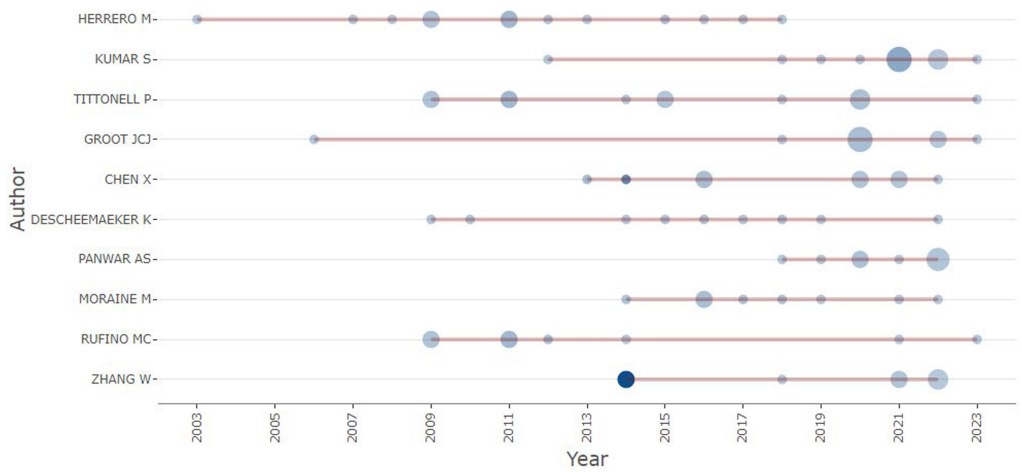

FIGURE 6
Top 10 authors' production over time on ICFLS adoption.

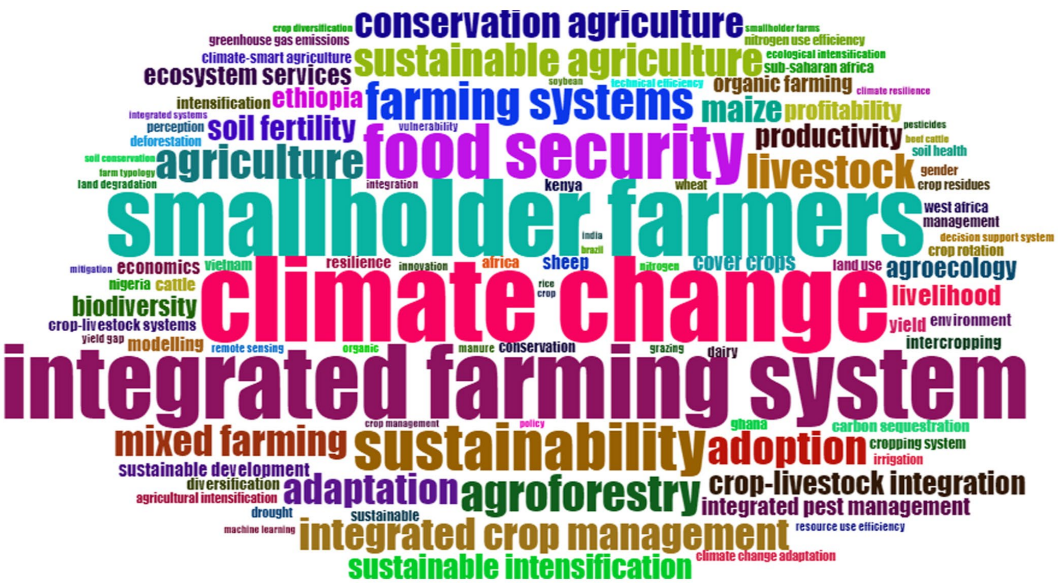

FIGURE 7
Word cloud of the top 100 most frequents author's keywords on ICLFS adoption.

Tesema (2021) proved that age, gender, farm size and herd size affect the ICLFS adoption.

Knowledge gaps and orientations for future research

This study has provided an understanding of research trends related to the adoption of ICLFS by smallholders. Among the key findings was the paucity of data on ICLFS scaling-up initiatives in Sub-Saharan Africa. Given the urgent need to adapt to climate change, adaptation options such as ICLFS need to be scaled up and reported in this area to ensure the sustainability of food production. Although livestock holding parameters are major indicators for the adoption of ICLFS, it is vital that future thinking integrates livestock rearing methods into the scaling-up of these practices. For example, we need to consider how to scale up ICFLS in a context characterized by high herd mobility. Finally, politicians need to take ownership of ICLFS in order to provide technical and financial support for their implementation. It would be very interesting for countries promoting reduced livestock mobility to think about developing more policies along these lines, not only to encourage communities to live together, but also to develop safe alternatives for sustainable land management and food production. Given research experience in East Africa, Asia and South America, research and experience-sharing partnerships with West African

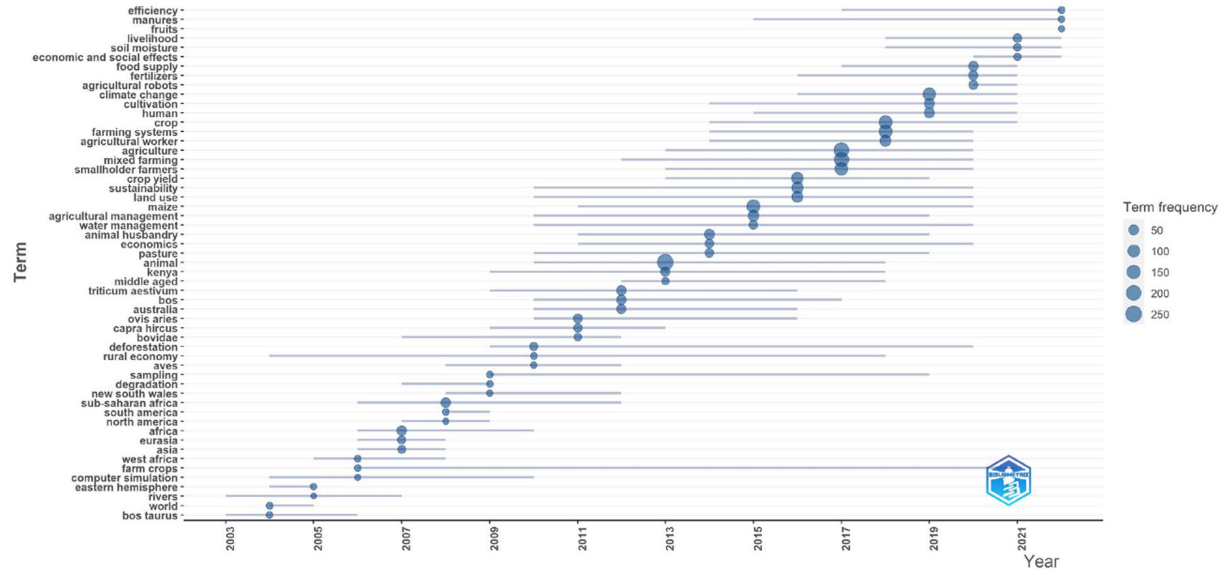

FIGURE 8
Trends topics on ICLF adoption.

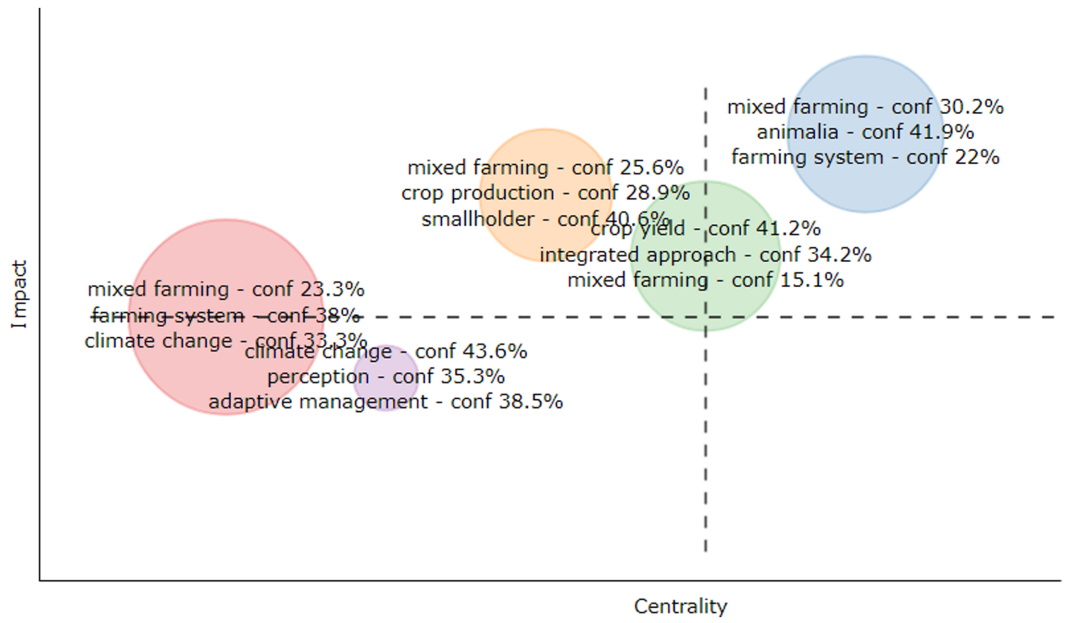

FIGURE 9
Clusters by documents coupling on ICLFS adoption.

regions would be highly beneficial for promoting ICLFS and advancing toward SDGs 1, 2, 5, 13, and 15.

Conclusion

ICLFS is a sustainable way of producing food that will help reduce the harm caused by climate change and meet the needs of people. This research emphasizes that the crucial element in achieving sustainable food production is the establishment of clear, effective environmental policies that promote the integration of different systems. These green policies must be supported by practical and financial actions for expansion, connecting farmers and funding farming activities. Nations such as Benin, which promote stationary livestock farming through its law, should try out this method. Last but not least, this study promotes research cooperation on this issue, especially to help West African countries. Future studies should focus on how to design agro-forestry-pastoral innovations together with development actors

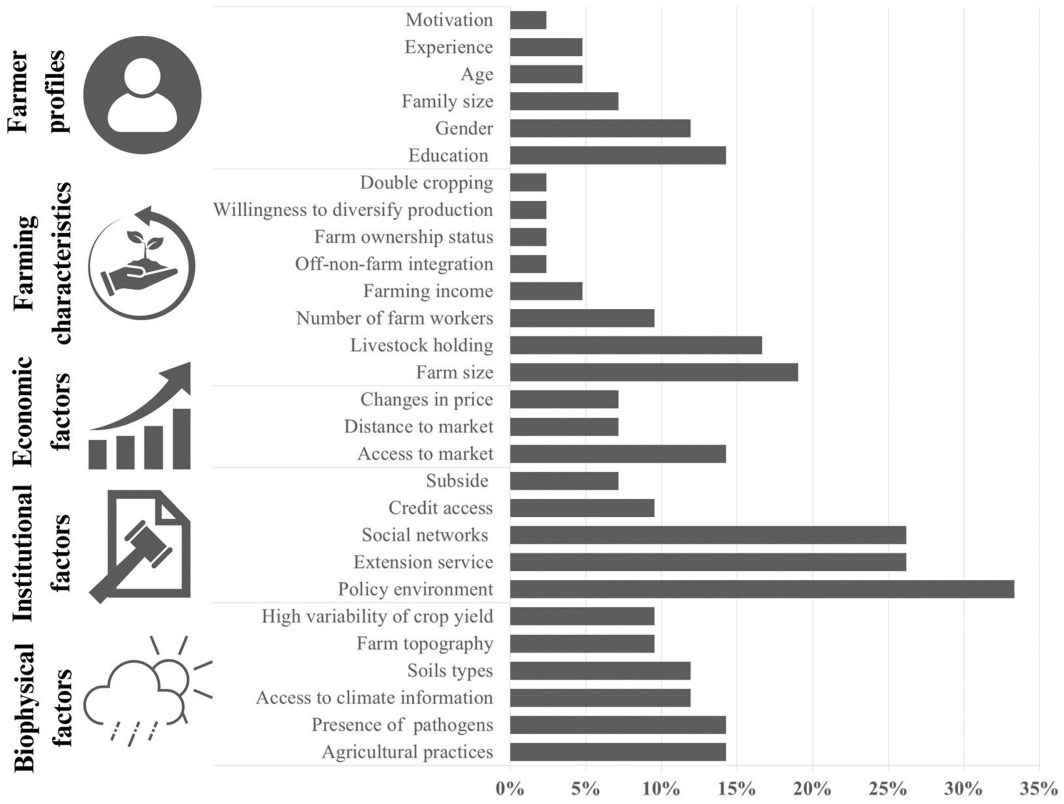

FIGURE 10
Drivers of ICLFS adoption.

and producers, so that they can be more easily adopted by rural communities.

Author contributions

MK: Conceptualization, Methodology, Writing – original draft, Investigation. JE: Conceptualization, Methodology, Writing – review & editing. SD: Writing – review & editing. MB: Supervision, Writing – review & editing.

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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.

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References

Abiola, W. A., Diogo, R. V. C., Tovihoudji, P. G., Mien, A. K., and Schalla, A. (2023). Research trends on biochar-based smart fertilizers as an option for the sustainable agricultural land management: bibliometric analysis and review. *Front. Soil Sci.* 3:1136327. doi: 10.3389/fsoil.2023.1136327

Adnan, N., Nordin, S. M., Bahruddin, M. A., and Tareq, A. H. (2019). A state-of-the-art review on facilitating sustainable agriculture through green fertilizer technology adoption: assessing farmers behavior. *Trends Food Sci. Technol.* 86, 439–452. doi: 10.1016/j.tifs.2019.02.040

Amadou, H., and Magnani, S. D. (2020). *Améliorer l'accès des éleveurs à une alimentation du bétail de qualité pour augmenter la production laitière dans les Pays sahéliens d'Afrique de l'Ouest, No. 21.*

Aria, M., and Cuccurullo, C. (2017). Bibliometrix: an R-tool for comprehensive science mapping analysis. *J. Informet.* 11, 959–975. doi: 10.1016/j.joi.2017.08.007

Asai, M., Moraine, M., Ryschawy, J., De Wit, J., Hoshide, A. K., and Martin, G. (2018). Critical factors for crop-livestock integration beyond the farm level: a cross-analysis of worldwide case studies. *Land Use Policy* 73, 184–194. doi: 10.1016/j.landusepol.2017.12.010

Asante, B. O., Villano, R. A., Patrick, I. W., and Battese, G. E. (2018). Determinants of farm diversification in integrated crop–livestock farming systems in Ghana. *Renew. Agric. Food Syst.* 33, 131–149. doi: 10.1017/S1742170516000545

Batista-Canino, R. M., Santana-Hernández, L., and Medina-Brito, P. (2023). A scientometric analysis on entrepreneurial intention literature: delving deeper into local citation. *Heliyon* 9:e13046. doi: 10.1016/j.heliyon.2023.e13046

Behera, U. K., and France, J. (2016). Integrated farming systems and the livelihood security of small and marginal farmers in India and other developing countries. *Adv. Agron.* 138, 235–282. doi: 10.1016/bs.agron.2016.04.001

Bell, L. W., and Moore, A. D. (2012). Integrated crop–livestock systems in Australian agriculture: trends, drivers and implications. *Agric. Syst.* 111, 1–12. doi: 10.1016/j.agsy.2012.04.003

Béné, C. (2020). Resilience of local food systems and links to food security – a review of some important concepts in the context of COVID-19 and other shocks. *Food Secur.* 12, 805–822. doi: 10.1007/s12571-020-01076-1

Bolliger, A., Magid, J., Amado, J. C. T., Skóra Neto, F., Ribeiro, M. D. F. D. S., Calegari, A., et al. (2006). Taking stock of the Brazilian "zero-till revolution": a review of landmark research and farmers' practice. *Adv. Agron.* 91, 47–110. doi: 10.1016/S0065-2113(06)91002-5

Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., et al. (2017). An assessment of the global impact of 21st century land use change on soil erosion. *Nat. Commun.* 8:2013. doi: 10.1038/s41467-017-02142-7

Burgess, R., Hansen, M., Olken, B. A., Potapov, P., and Sieber, S. (2012). The political economy of deforestation in the tropics. *Q. J. Econ.* 127, 1707–1754. doi: 10.1093/qje/qjs034

Chen, X.-P., Cui, Z.-L., Vitousek, P. M., Cassman, K. G., Matson, P. A., Bai, J.-S., et al. (2011). Integrated soil–crop system management for food security. *Proc. Natl. Acad. Sci.* 108, 6399–6404. doi: 10.1073/pnas.1101419108

Côte, F. X., Rapidel, B., Sourisseau, J. M., Affholder, F., Andrieu, N., Bessou, C., et al. (2022). Levers for the agroecological transition of tropical agriculture. *Agron. Sustain. Dev.* 42:67. doi: 10.1007/s13593-022-00799-z

Curry, G. N., Nake, S., Koczberski, G., Oswald, M., Rafflegeau, S., Lummani, J., et al. (2021). Disruptive innovation in agriculture: socio-cultural factors in technology adoption in the developing world. *J. Rural. Stud.* 88, 422–431. doi: 10.1016/j.jrurstud.2021.07.022

De Moraes, A., Carvalho, P. C. D. F., Anghinoni, I., Lustosa, S. B. C., Costa, S. E. V. G. D. A., and Kunrath, T. R. (2014). Integrated crop–livestock systems in the Brazilian subtropics. *Eur. J. Agron.* 57, 4–9. doi: 10.1016/j.eja.2013.10.004

Devendra, C. (2007). Small farm systems to feed hungry Asia. *Outlook Agric.* 36, 7–20. doi: 10.5367/000000007780223641

FAO. (2004). *Programme Implementation Report 2002–2003*. Rome, Italy: FAO.

FSIN and GNAFC. (2023). *Global report on food crises 2023: Joint analysis for better decisions*. FSIN and GNAFC.

Garrett, R. D., Niles, M. T., Gil, J. D. B., Gaudin, A., Chaplin-Kramer, R., Assmann, A., et al. (2017). Social and ecological analysis of commercial integrated crop livestock systems: current knowledge and remaining uncertainty. *Agric. Syst.* 155, 136–146. doi: 10.1016/j.agsy.2017.05.003

Gebre, G. G., Amekawa, Y., Fikadu, A. A., and Rahut, D. B. (2023). Do climate change adaptation strategies improve farmers' food security in Tanzania? *Food Secur.* 15, 629–647. doi: 10.1007/s12571-023-01348-6

Gil, J., Garrett, R., and Berger, T. (2016). Determinants of crop-livestock integration in Brazil: evidence from the household and regional levels. *Land Use Policy* 59, 557–568. doi: 10.1016/j.landusepol.2016.09.022

Gil, J., Siebold, M., and Berger, T. (2015). Adoption and development of integrated crop–livestock–forestry systems in Mato Grosso, Brazil. *Agric. Ecosyst. Environ.* 199, 394–406. doi: 10.1016/j.agee.2014.10.008

Giller, K. E., Tittonell, P., Rufino, M. C., Van Wijk, M. T., Zingore, S., Mapfumo, P., et al. (2011). Communicating complexity: integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. *Agric. Syst.* 104, 191–203. doi: 10.1016/j.agsy.2010.07.002

Glänzel, W., and Thijs, B. (2012). Using 'core documents' for detecting and labelling new emerging topics. *Scientometrics* 91, 399–416. doi: 10.1007/s11192-011-0591-7

Grantham, G. W., Postel-Vinay, G., Mazoyer, M., and Roudard, L. (1998). *Histoire des agricultures du monde. Du néolithique à la crise contemporaine, 1997*. Revue d'Études en Agriculture et Environnement, 48, pp. 129–131.

Jena, P. R., Tanti, P. C., and Maharjan, K. L. (2023). Determinants of adoption of climate resilient practices and their impact on yield and household income. *J. Agric. Food Res.* 14:100659. doi: 10.1016/j.jafr.2023.100659

Kessler, M. M. (1963). Bibliographic coupling between scientific papers. *American Documentation* 14, 10–25. doi: 10.1002/asi.5090140103

Kgosikoma, K. R., Lekota, P. C., and Kgosikoma, O. E. (2018). Agro-pastoralists' determinants of adaptation to climate change. *Int. J. Clim. Change Strat. Manage.* 10, 488–500. doi: 10.1108/IJCCSM-02-2017-0039

Kremsa, V. Š. (2021). "Sustainable management of agricultural resources (agricultural crops and animals)" in *Sustainable Resource Management*. eds. C. M. Hussain and J. F. Velasco-Muñoz (Amsterdam, Netherlands: Elsevier), 99–145.

Lal, R., Follett, R. F., Stewart, B. A., and Kimble, J. M. (2007). Soil carbon sequestration to mitigate climate change and advance food security. *Soil Sci.* 172, 943–956. doi: 10.1097/ss.0b013e31815cc498

Li, M., Wang, J., Zhao, P., Chen, K., and Wu, L. (2020). Factors affecting the willingness of agricultural green production from the perspective of farmers' perceptions. *Sci. Total Environ.* 738:140289. doi: 10.1016/j.scitotenv.2020.140289

Lisson, S., MacLeod, N., McDonald, C., Corfield, J., Pengelly, B., Wirajaswadi, L., et al. (2010). A participatory, farming systems approach to improving Bali cattle production in the smallholder crop–livestock systems of eastern Indonesia. *Agric. Syst.* 103, 486–497. doi: 10.1016/j.agsy.2010.05.002

Low, G., Dalhaus, T., and Meuwissen, M. P. M. (2023). Mixed farming and agroforestry systems: a systematic review on value chain implications. *Agric. Syst.* 206:103606. doi: 10.1016/j.agsy.2023.103606

Mariano, M. J., Villano, R., and Fleming, E. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agric. Syst.* 110, 41–53. doi: 10.1016/j.agsy.2012.03.010

Marie, M., Yirga, F., Haile, M., and Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon* 6:e03867. doi: 10.1016/j.heliyon.2020.e03867

Martin, G., Moraine, M., Ryschawy, J., Magne, M.-A., Asai, M., Sarthou, J.-P., et al. (2016). Crop–livestock integration beyond the farm level: a review. *Agron. Sustain. Dev.* 36:53. doi: 10.1007/s13593-016-0390-x

Matos, A. M. S., Bonini, C. S. B., Moreira, B. R. A., Andreotti, M., Heinrichs, R., Da Silva, D. T., et al. (2022). Long-term integrated crop–livestock–forestry systems recover the structural quality of Ultisol soil. *Agronomy* 12:2961. doi: 10.3390/agronomy12122961

Maucuer, R., and Renaud, A. (2019). Business model research: a bibliometric analysis of origins and trends. *M@n@gement* 22:176. doi: 10.3917/mana.222.0176

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., et al. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst. Rev.* 4:1. doi: 10.1186/2046-4053-4-1

Moraine, M., Duru, M., and Therond, O. (2017). A social-ecological framework for analyzing and designing integrated crop–livestock systems from farm to territory levels. *Renew. Agric. Food Syst.* 32, 43–56. doi: 10.1017/S1742170515000526

Moraine, M., Grimaldi, J., Murgue, C., Duru, M., and Therond, O. (2016). Co-design and assessment of cropping systems for developing crop-livestock integration at the territory level. *Agric. Syst.* 147, 87–97. doi: 10.1016/j.agsy.2016.06.002

Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., and Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: an up-to-date review. *Prof. Inf.* 29:3. doi: 10.3145/epi.2020.ene.03

Mzoughi, N. (2011). Farmers adoption of integrated crop protection and organic farming: do moral and social concerns matter? *Ecol. Econ.* 70, 1536–1545. doi: 10.1016/j.ecolecon.2011.03.016

Nasir, M. A., Nugroho, A. D., and Lakner, Z. (2022). Impact of the Russian–Ukrainian conflict on global food crops. *Foods* 11:2979. doi: 10.3390/foods11192979

Oerke, E.-C. (2006). Crop losses to pests. *J. Agric. Sci.* 144, 31–43. doi: 10.1017/S0021859605005708

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., et al. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Switzerland: IPCC Geneva.

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., et al. (2018). Trends in global agricultural land use: implications for environmental health and food security. *Annu. Rev. Plant Biol.* 69, 789–815. doi: 10.1146/annurev-arplant-042817-040256

Rao, V. P., Veeraraghavaiah, R., Hemalatha, S., and Joseph, B. (2010). *Farming systems and sustainable agriculture*. Jodhpur: Agrobios.

Robertson, T. S. (1971). *Innovative behavior and communication*. Available at: https://cir.nii.ac.jp/crid/1130000794546025088.

Rodrigues, R. A. R., Ferreira, I. G. M., Da Silveira, J. G., Da Silva, J. J. N., Santos, F. M., and Da Conceição, M. C. G. (2023). "Crop-livestock-Forest integration systems as a sustainable production strategy in Brazil" in *Sustainability challenges of Brazilian agriculture: Governance, inclusion, and innovation*. eds. N. Søndergaard, C. D. de Sá and A. F. Barros-Platiau (Berlin: Springer International Publishing), 165–182.

Rogers, E. (1962). *Adoption and diffusion of innovations*. New York: The Free.

Rufino, M. C., Dury, J., Tittonell, P., Van Wijk, M. T., Herrero, M., Zingore, S., et al. (2011). Competing use of organic resources, village-level interactions between farm types and climate variability in a communal area of NE Zimbabwe. *Agric. Syst.* 104, 175–190. doi: 10.1016/j.agsy.2010.06.001

Russelle, M. P., Entz, M. H., and Franzluebbers, A. J. (2007). Reconsidering integrated crop–livestock Systems in North America. *Agron. J.* 99, 325–334. doi: 10.2134/agronj2006.0139

Sejian, V., Bhatta, R., Soren, N. M., Malik, P. K., Ravindra, J. P., Prasad, C. S., et al. (2015). "Introduction to concepts of climate change impact on livestock and its adaptation and mitigation" in *Climate change impact on livestock: adaptation and mitigation*. eds. V. Sejian, J. Gaughan, L. Baumgard and C. Prasad (Berlin: Springer India), 1–23.

Singh, V. K., Singh, P., Karmakar, M., Leta, J., and Mayr, P. (2021). The journal coverage of web of science, Scopus and dimensions: a comparative analysis. *Scientometrics* 126, 5113–5142. doi: 10.1007/s11192-021-03948-5

Takahashi, K., Muraoka, R., and Otsuka, K. (2020). Technology adoption, impact, and extension in developing countries' agriculture: a review of the recent literature. *Agric. Econ.* 51, 31–45. doi: 10.1111/agec.12539

Tesema, T. (2021). Determinants of allocative and economic efficiency in crop-livestock integration in western part of Ethiopia evidence from Horro district: data envelopment approach. *Heliyon* 7:e07390. doi: 10.1016/j.heliyon.2021.e07390

Udo, H. M. J., Aklilu, H. A., Phong, L. T., Bosma, R. H., Budisatria, I. G. S., Patil, B. R., et al. (2011). Impact of intensification of different types of livestock production in smallholder crop-livestock systems. *Livest. Sci.* 139, 22–29. doi: 10.1016/j.livsci.2011.03.020

UNEP. (2012). *United Nations decade on biodiversity 2011–2020*. p. 11. United Nations. Available at: https://www.cbd.int/undb/home/undb-strategy-en.pdf.

Valani, G. P., Martíni, A. F., Silva, L. F. S., Bovi, R. C., and Cooper, M. (2021). Soil quality assessments in integrated crop–livestock–forest systems: a review. *Soil Use Manag.* 37, 22–36. doi: 10.1111/sum.12667

Valbuena, D., Tui, S. H.-K., Erenstein, O., Teufel, N., Duncan, A., Abdoulaye, T., et al. (2015). Identifying determinants, pressures and trade-offs of crop residue use in mixed smallholder farms in sub-Saharan Africa and South Asia. *Agric. Syst.* 134, 107–118. doi: 10.1016/j.agsy.2014.05.013

Vries, A. D., and Marcondes, M. I. (2020). Review: overview of factors affecting productive lifespan of dairy cows. *Animal* 14, s155–s164. doi: 10.1017/S1751731119003264

Waltman, L. (2016). A review of the literature on citation impact indicators. *J. Informet.* 10, 365–391. doi: 10.1016/j.joi.2016.02.007

Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., and Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agron. Sustain. Dev.* 40:40. doi: 10.1007/s13593-020-00646-z

Widadie, F., and Agustono, A. (2015). Comparison of integrated crop-livestock and non-integrated farming systems for financial feasibility, technical efficiency and adoption (case of farmers in Gunung Kidul regency, Yogyakarta, Indonesia). *J. Int. Soc. Southeast Asian Agric. Sci.* 21, 31–45.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., et al. (2019). Food in the Anthropocene: the EAT–lancet commission on healthy diets from sustainable food systems. *Lancet* 393, 447–492. doi: 10.1016/S0140-6736(18)31788-4

Zhang, Z., Liu, Y., Wang, Y., Liu, Y., Zhang, Y., and Zhang, Y. (2020). What factors affect the synergy and tradeoff between ecosystem services, and how, from a geospatial perspective? *J. Clean. Prod.* 257:120454. doi: 10.1016/j.jclepro.2020.120454

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Women's seed entrepreneurship in aquaculture, maize, and poultry value chains in Ghana, Kenya, and Tanzania

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Seed systems are essential to bring good genetic material to farmers. Women farmers, however, have benefited less than men farmers from seed systems in low and middle income countries. We identify factors that inhibit and promote women's success in seed businesses through three case studies of women's and men's entrepreneurship across seed-related value chains and country contexts: tilapia seed production in Ghana, marketing and trading of improved maize and sorghum seeds in Kenya, and chicken seed dissemination in Tanzania. Applying a gender lens, we use key informant interviews and focus group discussions to analyze women's and men's motivations to engage in seed businesses, the challenges they confront to start and build their enterprises, and prospects for sustainability and continued success. We use quantitative data to characterize the levels of empowerment of the agripreneurs sampled. For women, the results show that the social normative context of the sector is critical. Time flexibility and profitability are important considerations for women's engagement. Furthermore, across all three country cases, family and external support are frequently key to women's participation and success in seed agripreneurship. The article discusses the importance of government bodies, NGOs, and donors in challenging the normative context around gender resource gaps, as well as provide technical packages and training to develop business acumen. Supporting change of restrictive gender norms in non-threatening ways - such as ICTs - is key.

KEYWORDS

gender, agripreneurship, fish seed systems, poultry seed systems, maize seed systems

1 Introduction

All agricultural production starts with seeds: plant seeds (botanical seeds, crop seeds, tubers, cuttings, and so on), animal seed stock (eggs, semen, young animals, and birds), and fish seed or fingerlings. Development actors including governments, donors, private sector, and research organizations are investing heavily in breeding improved varieties and breeds for smallholder producers to enhance farm productivity, support livelihoods, strengthen food and nutrition security, and, in some cases, to work explicitly toward gender equality, youth, and social inclusion. To ensure smallholder farmers' adoption of these improved genetic materials, efforts to strengthen the formal and informal seed systems through which high-quality seed of improved varieties and breeds can be disseminated are intensifying (Louwaars et al., 2013; Donovan et al., 2021). Efforts to enhance seed systems—the sets of activities that contribute to seed development, production, use and dissemination—include

improving infrastructure, value chains, and business models to strengthen the availability, accessibility, use, and control over quality seed among smallholder farmers (McGuire and Sperling, 2011).

Since improved seed systems have reached and benefited fewer women farmers than men farmers, particularly in remote areas, some research is being directed toward strengthening the gender-responsiveness of seed systems (Kramer and Trachtman, 2023). Women's access to and adoption of improved seed, and their control over the benefits generated through this seed—for example through seed entrepreneurship—have the potential to enhance women's empowerment, thereby contributing to Sustainable Development Goal (SDG) 5 (Galiè, 2013). Women's adoption of improved seed is expected to strengthen farm productivity, thereby contributing to SDGs 1 and 2. Women with better access to productive resources and information, and with more control over income and mobility, are more likely to know about the availability of improved seed, access it, control its use, and contribute to variety or breed development (Galiè, 2013).

In this article, we are particularly interested in the potential of women's involvement in seed entrepreneurship for increasing incomes and empowering them. Dias et al. (2019) note the variety of terms related to agricultural entrepreneurship (agrientrepreneur, agricultural entrepreneur, farmer-entrepreneur, and so on), suggesting that the research area is still consolidating. We use the term agripreneur in preference to other terminology in this article. Currently, women's involvement in seed agripreneurship in low- and middle-income countries is limited, and evidence on the mechanisms that support or hinder women from engaging in it, or on how seed agripreneurship may contribute to women's empowerment, is meager (Puskur et al., 2021). In this article, we posit that such evidence is necessary to develop more functional, effective, and equitable seed systems that support the empowerment of all farmers and actors along seed value chains (Kramer and Galiè, 2020; Puskur et al., 2021; Kramer and Trachtman, 2023). Through case studies, we aim to deepen the evidence base on the challenges women seed actors face and suggest ways forward.

Our hypothesis is that *enhancing women's seed agripreneurship without simultaneously changing norms toward more gender equality does not empower women*. To investigate this hypothesis, we pose the following research questions:

1. How are women's empowerment, gender norms and agripreneurship interrelated?
2. How important is it to address local gender norms in the seed sector to facilitate women's ability to start seed entrepreneurship and stay in the seed sector over time?
3. How and in what form can external support help women agripreneurs overcome normative gender constraints?

We address these research questions by analyzing quantitative and qualitative data obtained from three case studies on seed agripreneurship across different value chains and countries: tilapia (fish) seed production in Ghana, marketing and trading of improved maize and sorghum seeds in Kenya, and dissemination of chicken seed (28-day-old, improved chicken breeds) in Tanzania.

Section 2 presents our conceptual framework and literature review. Section 3 discusses methodology. Section 4 presents the quantitative and qualitive findings, and Section 5 discusses the results and recommendations for promoting women's agripreneurship in seed systems.

2 Conceptual framework

FAO et al. (2023a) and Njuki et al. (2023) present the conceptual framework we used to analyze the factors that facilitate or inhibit women's agripreneurship and empowerment in the three selected seed systems.

Women need livelihood capital and resources (financial capital, human resources and skills, social capital, land and water, and physical assets) to engage in agribusiness. Yet the interplay of gender dimensions at the household, community, and macro and organizational levels can (detrimentally) affect women's access to capital and resources, which in turn affect their empowerment and agripreneurship ability. FAO et al. (2023a) and Njuki et al. (2023) highlight the following dimensions (depicted in column 1, Figure 1).

1. The enabling environment for women's agripreneurship, including the gender-responsiveness of policies and organizational support.
2. Gender norms affecting social acceptability, aspirations, mobility, and choices of activities by women and men.
3. The gender division of labor across market and non-market activities and trade-offs in time use and development outcomes.
4. Intra-household power dynamics affecting access to and control over resources, assets, and income, and strategic livelihood decisions.

As shown in Figure 1, these dimensions act and interact across nested scales, from the household level through the community level to the macro and organizational level. The intermediate outcomes of these systemic interactions affect the ability of women to access the various types of capital (financial, social, etc.) they need to become successful agripreneurs. The ways in which gendered dynamics across nested scales play out determine whether the final desired systemic outcomes are reached. In our case, they are (i) equitable gender opportunities in seed entrepreneurship, and (ii) women's empowerment in the seed system. Self-evidently, the various factors highlighted in Figure 1 are interrelated, dynamic and multi-directional. Changes in outcomes in terms of women's agripreneurship and empowerment in seed systems feed back into, influence, and reshape, these dimensions in continual and highly complex systemic processes.

This article focuses on women—and to a lesser extent—men agripreneurs attempting to start up, develop, and maintain their seed businesses in challenging rural environments. Entrepreneurship involves taking risks, innovating, identifying opportunities, making decisions, allocating resources, obtaining resources, and maximizing their use in order to create products and services that meet consumer needs (Mukhtar et al., 2018; Baliyan et al., 2020). Successful agripreneurship generates employment opportunities, develops income, reduces poverty, and helps create sustainable livelihoods (Wongnaa et al., 2019). Although some agriculture takes place in peri-urban and urban environments, agripreneurs in low and middle-income countries (LMIC) generally operate in rural environments (Korsgaard et al., 2015). These are generally, though not exclusively, characterized by low

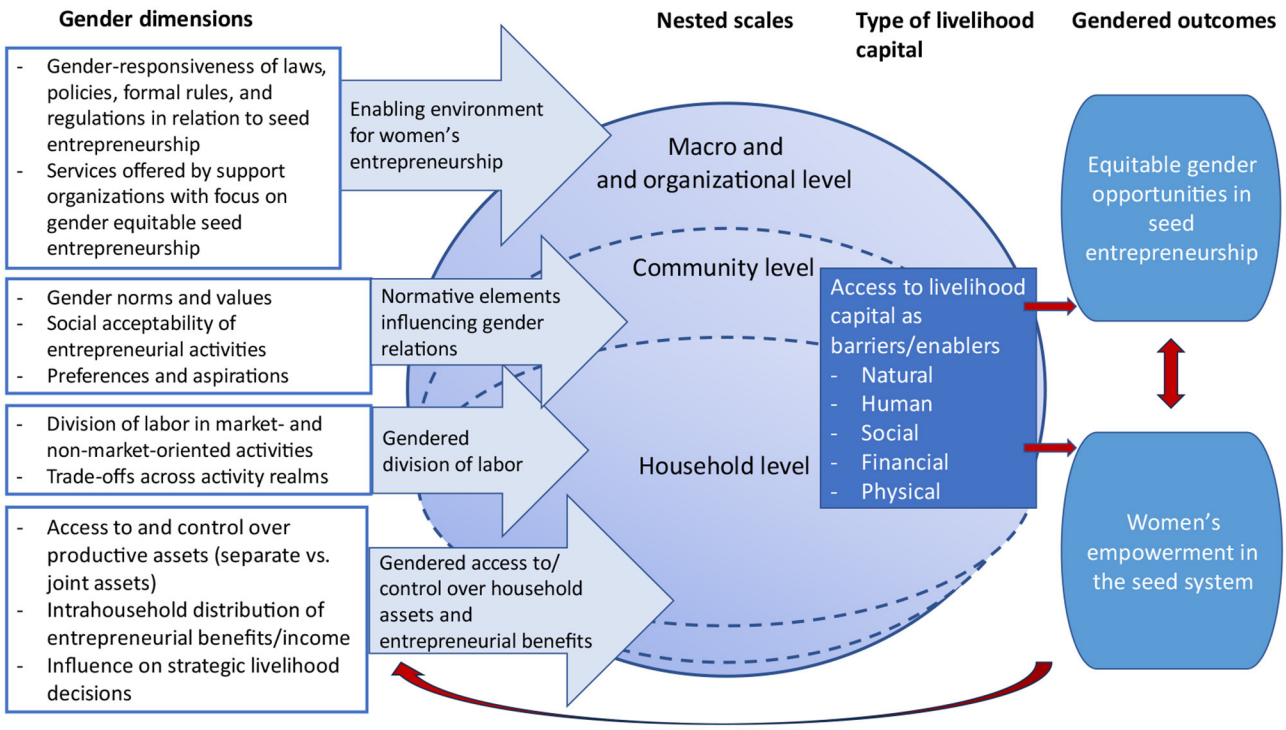

FIGURE 1
Conceptual framework of factors affecting women's agripreneurship and empowerment in the seed system. Large, light blue arrows represent the gender dimensions that affect women's access to livelihood capital. Thin red arrows denote the direction of influence. Gender dimensions affect livelihood capital, which affects women's agripreneurship and empowerment.

levels of human and financial capital, relatively small markets, and poor communications infrastructure. These pose significant challenges to the efficacy of value chain development and the development of effective entrepreneurial behaviors (Dias et al., 2019). Input and output markets, including seed markets, are frequently weakly commercialized and in some contexts may need to be created.

The conceptual framework posits that women's empowerment is both an expected outcome and a means of women's agripreneurship in the seed system. Women's empowerment is "about the process by which those who have been denied the ability to make strategic life choices acquire such an ability" (Kabeer, 1999, p. 435). Kabeer (1999) contends that the process of empowerment involves interactions between agency, resources, and achievements. For women agripreneurs, this process involves agency (the ability to access, control and benefit from) over the essential resources needed to successfully develop their business, including land, water, finance, technology, labor, and information. However, women do not exercise agency in a vacuum. Rather, they are knitted into normative structures that pose a range of gendered barriers which inhibit the ability of women to act freely in entrepreneurial ways (Alkire et al., 2013; Galiè et al., 2018; Malapit et al., 2019).

Gender norms, ideologies and power relations shape the ways in which women and men participate in value chains, and the benefits they accrue (Ihalainen et al., 2021). They frequently construct men as breadwinners and women as supportive actors to men's efforts with women being primarily tasked to take care of the home and the people within it (Bernard et al., 2019; OECD, 2021). In line with man's breadwinner role, gender norms widely establish men as the primary owners of productive resources and as key decision-makers (OECD, 2021; Rietveld et al., 2023). As a consequence, women frequently have less access than men to the resources needed for engaging in seed businesses (Nyantakyi-Frimpong, 2019). Gender norms frequently undermine women's efforts to establish themselves as agripreneurs (Achandi et al., 2023). For instance, financial institutions rarely see women as agripreneurs, making it challenging for women to obtain loan, even when they can provide loan collateral. In addition, women are rarely targeted by business training bodies and may not be treated as professionals by male agripreneurs or customers (Galiè et al., 2022). Gender norms around women's roles in domestic work and care affect workload and women's valuation of opportunities and trade-offs around entrepreneurship (Ragasa et al., 2023). Local environment, harassment, and norms around women's mobility also affect women's entrepreneurship, especially younger women (Malapit et al., 2023).

3 Methods

3.1 Study context

This paper explores the interlinkages between gender dynamics in seed agripreneurship, empowerment, and gender norms using mixed research methods. Data were collected by this paper's

authors and their research colleagues in three countries, from women and men who participated in three different projects: the Women-in-Business (WiB) project for chicken seed dissemination in Tanzania; an aquaculture value chain and tilapia project in Ghana; and a project promoting stress-tolerant maize and sorghum varieties in Kenya.

3.1.1 Tanzania

The WiB project supported young women veterinary graduates and para veterinarians (we call them "vendors") in starting a chicken business to reach women farmers from remote areas with good breeds, animal inputs and advice, and access to markets. The vendors went through a business incubation process which provided them with training and mentoring in business and chicken brooding skills.[1] This women-led small-scale business model aimed to leverage and enhance the knowledge and skills of the graduates in order to provide them with a route to economic empowerment. In terms of seed, the WiB project was used as a vehicle to disseminate the improved Kuroiler chicken breed alongside well-performing local breeds.[2] Access to improved breeds, inputs and markets was expected to enhance also the empowerment of the women farmers. Overall, the aim was to provide a women-led agripreneurial model to improving household food and nutrition security among remote rural communities in. The WiB project strategically utilized social media to challenge restrictive gender norms around women's agripreneurship in order to create a conducive environment for young women taking up chicken vending to effectively run their businesses.

The project, developed and co-implemented by the International Livestock Research Institute (ILRI) with public and private partners in Tanzania, ran from January 2019 to October 2022. It was implemented in the Kilimanjaro region (Hai and Siha districts) in northeastern Tanzania, where most of the rural population depends on livestock and crop farming as its main source of income, and in the Lindi region (Mtama and Ruangwa districts) on Tanzania's southern coast, where farming and fishing are among the main economic activities. The interventions initiated under the WiB project are currently being scaled through the SAPLING Initiative.[3]

3.1.2 Ghana

The Ghana Tilapia Seed Project aimed to promote agripreneurship in the aquaculture value chain. Aquaculture is among the fastest-growing food value chains globally and surpasses capture fisheries in fish production (FAO, 2018). In Sub-Saharan Africa, aquaculture is growing almost twice as fast as in the rest of the world, largely because of rapid growth in tilapia and catfish production (Ragasa et al., 2022a). Ghana, the largest producer of tilapia in the subcontinent, is experiencing tremendous growth led mainly by large-scale commercial cage operators (Ragasa et al., 2022b). Small-scale pond farming, however, generally exhibits greater backward and forward linkages and a larger multiplier effect on local economic growth and poverty reduction than commercial cage farming (Kassam and Dorward, 2017). Aiming to ensure inclusive sustainable growth, the Government of Ghana and its partners are targeting small-scale rural aquaculture agripreneurs, especially youth and women (Ragasa et al., 2022b).

The aquaculture project in Ghana aimed to address challenges faced by different actors of the fish seed chain, starting with breeders and broodstock multipliers, hatchery and nursery operators, and grow-out farmers.[4] It also aimed to increase participation of women and youth along the chain (Ragasa et al., 2022b). Interventions included monitoring seed quality, providing technical support and training to different actors in the value chain, setting up broodstock multiplication centers and nurseries in strategic locations, piloting digital tools for various actors along the value chain, and supporting inclusive and sustainable hatchery, nursery, and feed production business models. The project studied the barriers to and enablers of women's and young people's effective participation along the seed value chain. The project interventions and research focused on six major producing regions (Ashanti, Ahafo, Bono, Bono East, Eastern, and Volta) that together account for about 95 percent of the country's aquaculture production.

The project was implemented in Ghana between February 2019 and December 2022 by a consortium led by the International Food Policy Research Institute (IFPRI), the Water Research Institute of the Council for Scientific and Industrial Research (CSIR-WRI), KIT Royal Tropical Institute in the Netherlands, WorldFish, Ghana Fisheries Commission (a government institution), and two private hatcheries (S-HOINT Ltd. and Crystal Lake Ltd.).

3.1.3 Kenya

A third project trained agripreneurs to promote the adoption of stress-tolerant varieties of maize and sorghum as well as crop insurance in seven counties in Kenya (Bungoma and Busia in the western region; Machakos and Makueni in the lower eastern region; and Embu, Meru, and Tharaka Nithi in the upper eastern region). Maize is a key crop grown by 90 percent of farmers in project locations. Hybrid varieties from past breeding efforts to improve maize productivity are widely adopted. However, although extension programs and seed companies ensure seeds of these varieties are widely available, popular varieties are becoming unsustainable due to climate change—particularly with respect to increasing uncertainty about the timing of rainfall and their water requirements. Crops such as sorghum and drought-tolerant maize varieties offer promising pathways to improve farmer resilience.

1 See https://www.ilri.org/research/projects/women-in-business for more information on the WiB project.

2 An earlier project had identified the Kuroiler breed, characterized by high productivity under low input requirements, as the breed most preferred by women and men farmers in Tanzania.

3 See https://www.cgiar.org/initiative/sustainable-animal-productivity/ for more information on SAPLING.

4 The life cycle of fish in aquaculture starts with hatcheries receiving broodstock: spawning adult fish which produce eggs that are hatched and conditioned into fish fry (1–10 grams weight). Nurseries use the fry to produce fingerlings (10–30 grams weight). Grow-out farmers receive fingerlings and grow them into table-size tilapia.

Yet adoption of new drought-tolerant crops and varieties remains low (Fisher and Carr, 2015; Cairns and Prasanna, 2018) due to inadequate information outreach and high seed prices (Fisher and Carr, 2015), failure to properly adopt suitable farming practices, and the risks of crop failure posed by pests and disease.

To address these constraints, the Kenyan project promoted sorghum and drought-tolerant maize through a network of 181 agripreneurs called "champion farmers", 60 percent of whom were women. Recruitment criteria included demonstrating an agripreneurial mindset and social influence in their communities. Champion agripreneurs received training to market and deliver seeds of improved varieties, crop insurance to protect farmers' investments in more expensive seeds, and agricultural advice. They also received a monthly incentive payment to mobilize farmers within their community and a commission per bag of seed or insurance policy sold.

The project was implemented between April 2019 and December 2022 by an IFPRI-led consortium including ACRE Africa, which is an insurance service provider operating in Kenya and other parts of East Africa, Kenya's Agricultural and Livestock Research Organization (KALRO), and Wageningen University. A diverse group of local seed companies partnered with the consortium to promote their new varieties through the champion farmers.

3.2 Qualitative research component

Using focus group discussions (FGDs) and individual key informant interviews (KIIs), we collected qualitative data from women and men who had participated in the three projects. The qualitative interview guides varied by project because of differing project goals and contexts, but they explored four similar topics across all three projects: (i) women's and men's motivations for taking on an agripreneurial role related to seed supply within their value chain; (ii) gender-based opportunities and the constraints women (and, in the Ghana and Kenya case, also men) face in running their businesses, and strategies for managing these challenges; (iii) respondent' recommendations for changes or additional support needed to help them develop their businesses and become more successful, and to assist them to identify prospects for sustainability and continued success; and (iv) the relevance of the seed businesses to the respondents' overall livelihood strategies (which researchers determined by inquiring into respondents' other livelihood activities). In Kenya, because of the high visibility of ACRE Africa's support for champion agripreneurs, the KII guide additionally included questions on how this support had been helpful to them.

Table 1 summarizes the KIIs and FGDs samples by country. With respect to KIIs, we interviewed women and men agripreneurs participating in the projects in Ghana and Kenya. However, in Tanzania, only women agripreneurs were targeted and interviewed. We conducted a total of 38 KIIs with women respondents: 23 poultry agripreneurs in Tanzania; 11 agripreneurs (three hatchery operators, two pilot nursery operators, and six grow-out farmers) in Ghana; and six women agripreneurs in Kenya (where we also interviewed six male agripreneurs).[5] We opted for interviewing agripreneurs through KIIs instead of FGDs because of their small numbers and physical remoteness from one another.

TABLE 1 Overview of respondents by country and qualitative research method.

Method		Sample		
		Tanzania	Ghana	Kenya
KII	Women	23	11	6
	Men			6
FGD	Women		4/[a]	1/[a]
	Men		2/[a]	1/[a]
	Mixed		1/[a]	

[a]Carried out with non-seed agripreneurs.

An important determinant of the success of agripreneurs is their potential clients. We therefore also collected data from non-agripreneurs, specifically, through FGDs with farmers in the communities where agripreneurs were operating, given that these farmers are their potential clients or potential agripreneurs. In Ghana, we organized four women-only, two men-only, and one mixed-gender FGDs with seven non-agripreneurs per FGD (for a total of 49 women and men respondents) to understand the aspirations of women and young men, and to gain insights into their motivation for engaging in aquaculture. In Kenya, we administered one women-only and one men-only FGD with 8–10 non-agripreneurs per FGD to document farmers' perception of male and female champion agripreneurs and to ascertain gender norms that could inhibit agripreneurs from reaching their aspirations.[6] We used FGDs instead of KIIs for non-agripreneurs because of their larger numbers, physical proximity to one another, and the value of having a group discussion around perceptions and norms held by potential clients of agripreneurs.

We used Nvivo (a qualitative computer-supported data management program) to inductively analyze KII and FGD data for the Kenya and Tanzania cases. Microsoft Excel was used for the Ghana case. Emerging patterns were identified using predetermined codes agreed among the three research teams. New codes were included as they emerged from the interviews from each country.

5 In Tanzania, we interviewed all 23 young women veterinary or animal health graduates who directly benefited from the WiB interventions. Because Ghana has few hatcheries and first pilot nursery operators, we sought to interview all of them, though a small number declined participation. In Ghana, from the list of women grow-out agripreneurs, we randomly selected 1–2 women per focus region. In Kenya, the qualitative research focused on Bungoma County because agripreneurs in this county had advanced more than in other counties. Participants were selected via random sampling, using a list from a previously conducted quantitative survey, and champion farmers represented a range of different villages.

6 In Ghana, we selected one fish-producing community in each focus region. In Kenya, the FGD focuses on Bungoma County, where agripreneurs had advanced more than in other counties.

3.3 Quantitative research component

We collected quantitative data on sociodemographic characteristics and empowerment status for targeted women (and men as well in the case of Ghana and Kenya) agripreneurs through computer-aided personal (face-to-face) interviews. To measure empowerment, all three projects used a version of the survey-based Women's Empowerment in Agriculture Index: WEAI (IFPRI, 2021). A first subindex of WEAI assesses the degree to which respondents are empowered in several domains in agriculture, including decisions about agricultural production, access to and decision-making power about productive resources, control over the use of income, community leadership, and time allocation (Alkire et al., 2013). A second subindex, the Gender Parity Index (GPI), measures the percentage of women who are empowered, or whose achievements are at least as high as those of the men in their households. In households not achieving gender parity, the GPI shows the empowerment gap that needs to be closed for women to reach the same level of empowerment as men in their households (Alkire et al., 2013; Quisumbing et al., 2023).

Because of modifications to WEAI over time in response to user needs, we used different versions in the three projects (Table 2). In Ghana, we implemented A-WEAI, an abbreviated version. The key domains of empowerment under A-WEAI reflect the content and coverage of WEAI. However, the tool is shorter and collects data for the five domains of empowerment through six indicators (Malapit et al., 2019). The interviewee in sampled households was either the manager or owner (if different) of the farm/firm, or the person who made most decisions on fingerlings and inputs, and thus would be most likely to attend a production training. The survey also interviewed the primary decision-maker of the opposite gender (often the spouse of the interviewee) to document gender-based constraints or opportunities and intrahousehold dynamics, and to measure gender parity. We interviewed a total of 567 agripreneur households. For these, 266 second respondents were interviewed as well.

In Kenya, we used the Project-Level WEAI (Pro-WEAI). This is an extension of A-WEAI similarly designed to measure the impact of agricultural development projects on women's empowerment. It includes, however, additional indicators to measure program impacts. Its indicators are grouped into three domains: instrumental agency, intrinsic agency, and collective agency (Table 2). Pro-WEAI data were collected from all 126 female and 61 male-agripreneurs in the project, as well as their spouses if available and willing to participate in the survey (thus yielding an additional 56 male and 49 female respondents). Whilst the qualitative research focused on Bungoma county, the Pro-WEAI survey was completed with agripreneurs across all seven counties where the project was active.

In Tanzania, we used the Women's Empowerment in Livestock Business Index (WELBI), an index that builds on the Women's Empowerment in Livestock Index (WELI) and focuses on agripreneurs in livestock value chains (Galiè et al., 2018). WELBI uses the same domains and indicators as Pro-WEAI (Table 2) but differs from it by focusing on livestock and integrating both business (economic) and household spheres of livelihood.[7] WELBI data were collected from 23 women chicken agripreneurs, essentially a census of all women agripreneurs engaged in the WiB project. Because a composite score requires non-missing responses across all modules, we were able to calculate WELBI scores for a final sample of 18 women chicken agripreneurs.

We followed Alkire et al. (2013) and Malapit et al. (2019) to construct the A-WEAI, Pro-WEAI and WELI indices. We constructed a measure of gender parity by tallying the proportion of households in which the woman either achieves empowerment or has an empowerment score equal to, or greater than, the man's empowerment score. Since we interviewed agripreneurs and their spouses in Ghana and Kenya, we can construct gender parity metrics for these two case studies. It is not possible to construct a GPI for the Tanzania sample because we did not interview male household members of women agripreneurs.

4 Results

The following subsections present our results: descriptive statistics of survey respondents/agripreneurs; quantitative results regarding the empowerment status of women and men agripreneurs; and qualitative results related to agripreneurs' motivation for starting seed businesses, challenges—and some opportunities—to starting up and continuing seed businesses, and agripreneurs' recommendations for creating an enabling environment.

4.1 Descriptive statistics of survey respondents

Table 3 presents basic demographic information about the agripreneurs respondents. Women and men agripreneurs in Ghana and Kenya are relatively older, with average ages of 49 and 48 years (Ghana) and 41 and 43 years (Kenya), respectively, compared to women in Tanzania, who have an average age of 29 years, as the project in Tanzania is focused on empowering newly qualified women veterinary/animal health graduates/paravets. A similar trend is observed in terms of marital status: most (above 62 percent) women and men respondents in Ghana and Kenya are married, with a substantial proportion of women in Ghana (26 percent) and some in Kenya (9 percent) divorced or widowed. In Tanzania, most (62 percent) of the women agripreneurs are unmarried.

Regarding formal education, the sample of women agripreneurs in Tanzania substantially differs from the samples of women and men agripreneurs in Ghana and Kenya. In Ghana and Kenya some respondents reported having completed postsecondary education, whereas all the young women agripreneurs in Tanzania had completed postsecondary education. In Kenya, a higher proportion of men (42 percent) than women (26 percent) reported having completed postsecondary education. In Ghana, however, a higher proportion of women (21 percent) than men (7 percent)

7 Both Pro-WEAI and WELBI are also similar to A-WEAI. The main difference is that, unlike Pro-WEAI and WELBI, A-WEAI does not include intrinsic agency.

TABLE 2 Overview of quantitative research methods.

Country	Tool	Key domains researched	Indicators	No. of women respondents	No. of men respondents
Ghana	A-WEAI	Production	Input in productive decisions	266	567
		Resources	Ownership of land and other assets. Access to and decisions on credit		
		Income	Control over use of income		
		Leadership	Group membership		
		Time	Work balance		
Kenya	Pro-WEAI	Intrinsic agency	Autonomy in income, self-efficacy, and attitudes toward domestic violence	126	117
		Instrumental agency	Input in productive decisions, ownership of land and other assets, access to and decisions on credit, control over use of income, work balance, and visiting important locations		
		Collective agency	Group membership		
Tanzania	WELBI	Intrinsic agency	Autonomy in income, self-efficacy, attitudes toward domestic violence, and respect among household members	18	n/a
		Instrumental agency	Input in productive decisions, ownership of land and other assets, access to and decisions on credit, control over use of income, work balance, and visiting important locations		
		Collective agency	Group membership and membership in influential groups		

TABLE 3 Demographic statistics of seed agripreneurs, by country (in % except for age).

Variables	Kenya		Ghana		Tanzania
	Women	Men	Women	Men	Women
Age in years (mean)	41.32	43.23	49.46	47.67	29.19
Marital status					
Never married	13	9	12	12	62
Married	77	89	62	86	38
Divorced/separated/widowed	9	2	26	2	0
Formal education					
Primary education not completed	4	3	21	7	0
Primary education completed	29	15	46	50	0
Secondary education completed	42	40	10	21	0
Postsecondary education completed	26	42	23	22	100
Number of observations	94	65	43	575	21

Source: IFPRI/CSIR-WRI household survey (2019), IFPRI/ACRE Africa/IPA household survey (2021), and ILRI survey (2021).

reported having zero years of formal education or not completing primary education.

4.2 Quantitative results: empowerment status of women and men agripreneurs

Table 4 presents summary statistics on empowerment for the three case studies, focusing on agripreneurs and their spouses.[8] We found substantial variation in the rates of achieving empowerment across the three case studies. Men agripreneurs in Kenya are the most empowered, with 72 percent achieving empowerment. Ghanaian men (58 percent), Ghanaian women (58 percent) and Kenyan women (57%) follow.

8 Note that there are slight differences in the indicators contributing to the overall indexes for the three empowerment tools (A-WEAI, PRO-WEAI, and WELBI), as discussed above and outlined in Table 2.

Tanzanian women agripreneurs are the least empowered group (28%).

We further computed gender parity gaps for Ghana and Kenya to identify agripreneur's empowerment relative to their spouse (Tanzania had no data on men, so we could not calculate gender parity). The results on gender parity show some commonality and substantial variation across the two contexts.

Households with a male agripreneur and female spouse achieve relatively low gender parity compared to households with a female agripreneur and male spouse. In the former households, male agripreneurs are relatively more empowered than their female spouses. This variation is particularly pronounced in the Ghanaian sample: only 34 percent of households with a male agripreneur and female spouse achieve gender parity, which could be attributed to the finding that only 22 percent of wives in households with a male agripreneur achieve empowerment in the Ghanaian sample. Some female spouses are helpers in the fish farm, while the majority are housewives or not involved in any entrepreneurship. However, all (100 percent) households in Ghana with a female agripreneur with a male spouse achieve gender parity. In these households, the female agripreneurs are as empowered as male spouses. This compares with 78 percent of households with a female agripreneur and male spouse in Kenya.

Figure 2 illustrates the contribution of each domain to men's and women's disempowerment in Ghana, decomposing total disempowerment (the total length of a bar) into disempowerment stemming from each domain (the total length of a colored section of a bar). Longer sections contribute more in absolute terms to disempowerment. A lack of group membership is the greatest contributor to the disempowerment of women and men agripreneurs. Moreover, limited or lack of control over income from agripreneurial activities, and lack of input into production decisions, are top contributors to men's disempowerment. For women agripreneurs, a lack of work balance and control over the use of income are the second and third largest contributors. Spouses show a similar trend, with lack of group membership and of decision-making regarding control and use of income contributing to disempowerment, particularly among female spouses.

In Kenya (Figure 3), Pro-WEAI results show that the major contributors to disempowerment do not differ as much across the type of respondent (agripreneur vs. spouse) or the respondent's gender (male or female) compared to the Ghana sample. However, in Kenya, women agripreneurs, and the female spouses of male agripreneurs, are less empowered than their male counterparts. Key indicators contributing to disempowerment among Kenyan women and men agripreneurs, as well as their male and female spouses are: a high workload; lack of control over the use of income; and lack of autonomy in decision-making. Unlike men agripreneurs and male spouses of women agripreneurs, however, women agripreneurs and female spouses of men agripreneurs tolerate gender-based violence (negatively influencing Pro-WEAI's attitudes toward domestic violence indicator). This greatly contributes to their higher disempowerment scores.

Figure 4 shows that a lack of work balance, tolerance of domestic violence, inability to visit important places, and lack of control over and use of income are the main contributors to the disempowerment of women agripreneurs in Tanzania. Unlike in

TABLE 4 PRO-WEAI, WEAI, and WELBI results.

	Kenya				Ghana				Tanzania agripreneurs[c]	
	Agripreneurs[a]		Spouses		Agripreneurs[b]		Spouses			
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
Achieved empowerment	57%	72%	59%	54%	58%	58%	22%	69%	28%	
Achieved gender parity	78%	73%	73%	78%	100%	34%	34%	100%	n/a	
Average empowerment gap	0.11	0.14	0.14	0.11	0.0	0.56	0.56	0.0	n/a	
Number of observations	77	61	49	56	34	550	232	17	18	

[a]In Kenya, women and men farmers selected as seed agripreneurs (champion farmers) were evaluated using pro-WEAI.
[b]In Ghana, fry, fingerling, or table-size tilapia women and men agripreneurs were evaluated using modified A-WEAI.
[c]In Tanzania, women chicken seed agripreneurs were evaluated using WELBI.
Source: Baseline data from IFPRI/CSIR-WRI Ghana household survey (2019), baseline data from IFPRI/ACRE Africa/IPA Kenya household survey (2021), and baseline WiB Tanzania household survey (2020).

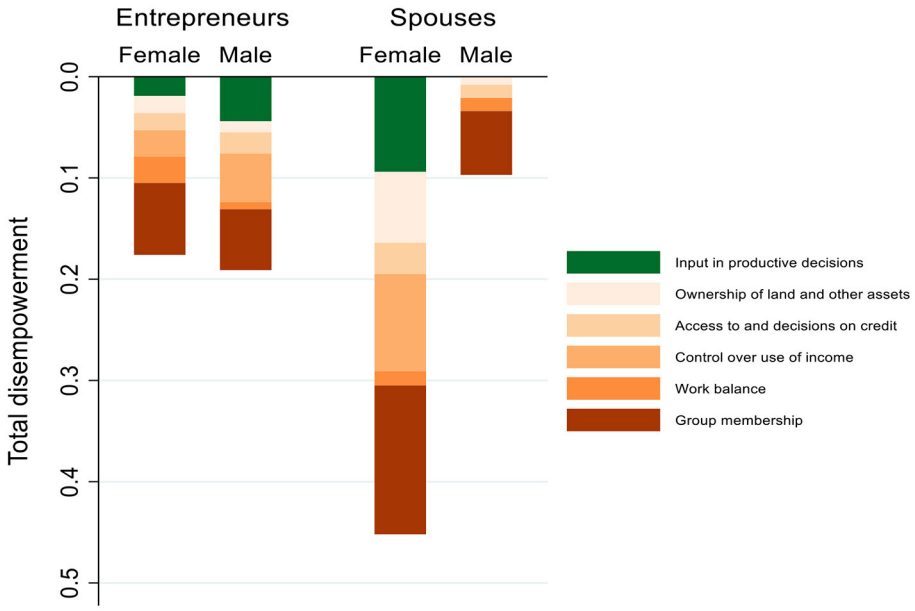

FIGURE 2
Contribution of each indicator to disempowerment of women and men agripreneurs in Ghana. Source: IFPRI/CSIR-WRI household survey (2019).

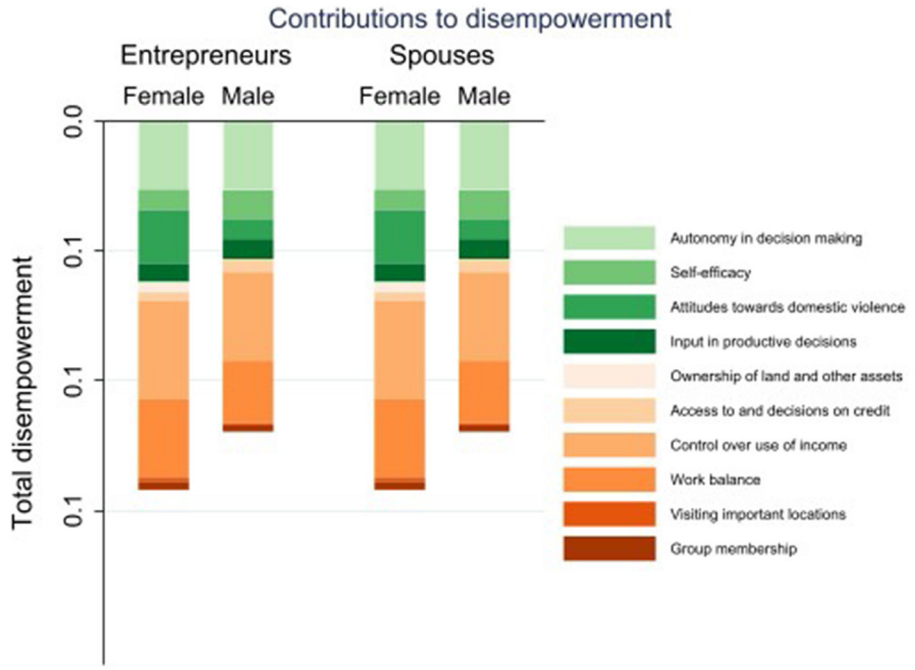

FIGURE 3
Contribution of each indicator to disempowerment of women and men agripreneurs in Kenya. Source: IFPRI/ACRE Africa/IPA household survey (2021).

Ghana, but like the case of Kenya, a lack of group membership has only a small contribution to disempowerment among Tanzanian women agripreneurs.

In summary, across all three countries, a lack of control over the use of income is an important contributor to disempowerment for agripreneurs and their spouses across genders. A lack of work balance and tolerance of domestic violence contribute to disempowerment of female agripreneurs in Kenya and Tanzania. In Ghana, although A-WEAI did not capture attitudes toward domestic violence, it did capture workload, finding that this indicator is not a major contributor to disempowerment. Instead, in the Ghana case, a lack of group

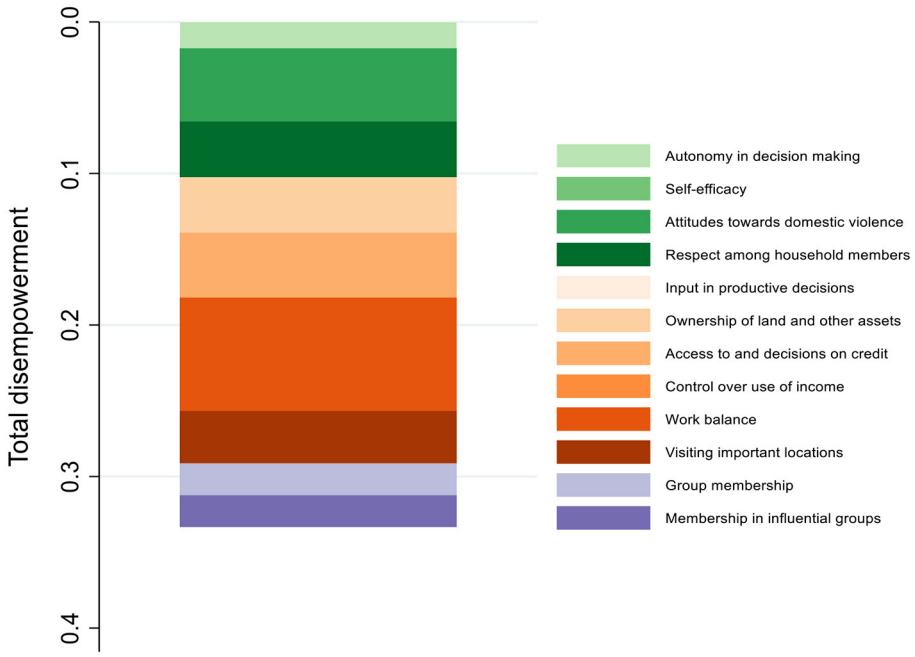

FIGURE 4
Contribution of each indicator to disempowerment of women agripreneurs in Tanzania. Source: ILRI survey (2021).

membership is the most important contributor to disempowerment of agripreneurs.

4.3 Qualitative results (1): motivations for starting seed business

In each country, we asked participants about their reasons for entering the seed business in order to understand the opportunities and challenges offered by the sector. Figure 5 summarizes the main pull factors that encouraged agripreneurs to enter the business across the three countries, marking pull factors reported by women only in green, and those reported by both women and men in blue.

4.3.1 Lack of alterative opportunities to work in their field

In Tanzania, most women seed agripreneurs who trained as veterinarians or animal health specialists ventured into selling chickens as a form of self-employment. Beyond self-employment, the chicken vending business gives seed agripreneurs a chance to practice the skills acquired through their veterinary and animal health courses in college. Before taking up chicken vending in the WiB project, many seed agripreneurs had engaged in volunteer or internship roles at Tanzania District extension offices, yet the majority asserted that they nevertheless failed to secure better-paying jobs in their chosen careers. Due to local gender norms, respondents argued, most farmers prefer to work with male livestock health specialists and veterinarians, who they believe to be more knowledgeable. They added that gender norms characterize men as stronger than women and thus better suited to veterinary work since this may involve restraining animals. Another gender norm suggests that women who travel widely in the course of their veterinary work are considered morally dubious because they travel in public spaces and enter client homes.

4.3.2 Strong market demand

In Ghana, women hatchery and grow-out farmers entered the sector because they believed the activity was good business and would provide better income than other livelihood activities. In Kenya, women and men noted that project incentives and commissions from seed sales motivated their involvement. In Tanzania, most seed agripreneurs were attracted to chicken vending because of the high demand for brooded chickens of improved breeds. Across the study sites, female smallholders commonly raise chickens, but low productivity means they cannot meet demand for improved breeds (in terms of egg production and improved weight), especially during festivals.

4.3.3 Low levels of bureaucracy

In Tanzania, seed agripreneurs reported lack of bureaucracy as attractive. All respondents have a brooding and vending capacity of <500 birds; taking their business to a larger scale would require them to obtain a license. They therefore can practice their business at home without the need for a business license. In contrast, veterinary service provision—regardless of scale—requires approval from the veterinary council of Tanzania and a license.

FIGURE 5
Summary of motivation for entry into seed business across the three projects. Green (blue) denotes motivations reported by women only (by women and men).

4.3.4 Capacity development courses

Ghanaian and Kenyan respondents expected to advance their careers through developing their knowledge and experience on seed businesses. Some Ghanaian women hatchery owners and managers hoped that doing so would help them eventually obtain jobs in aquaculture consulting and international agricultural organizations. Kenyan women and men agripreneurs associated their involvement with training provided by ACRE Africa. This offers capacity development courses on good farming practices, smartphone usage, and training of trainers to help promote dissemination. Without the impetus provided by ACRE Africa, most respondents considered they would not have become involved. Tanzanian women agripreneurs were similarly attracted by the training courses offered through the WiB project. This included good agricultural practices in relation to poultry care and specifically brooding, marketing, and networking skills.

4.3.5 Altruism

In Ghana, women respondents indicated that they were motivated by altruism, for example by a desire to provide employment opportunities to young people. In Kenya, women and men agripreneurs felt that they were addressing farmers' needs by providing them certified, good-quality seeds. Men emphasized that their capacity to facilitate easier access to seed and associated products and to provide a specific variety required by the farmer motivated their involvement. Respondents in Tanzania expressed similar thoughts. Some agripreneurs spend time helping their clients find markets for chicken eggs and mature chickens. Being able to provide improved breeds is also motivating. One agripreneur said, "I have a friend who now has around 300 improved chickens, Kuroiler, which she bought from me. Before, it was difficult for her to access the desired chicken breeds."

4.3.6 Recognition

In Ghana, women hatchery and grow-out farmers highlighted that a notable benefit of initiating their businesses is the self-confidence they have gained, coupled with the respect and recognition from community members who now view them as knowledgeable individuals. In Kenya, women champion farmers expressed motivation stemming from the opportunity to interact with farmers as customers, as trainees, and during project meetings.

4.3.7 Flexibility in time use

In Tanzania, the majority of women agripreneurs were attracted by the belief that chicken brooding is not particularly time-consuming, thus permitting them to pursue other forms of income generation, including providing veterinary services or running an agrovet shop, alongside brooding and selling their chicks. Yet respondents noted that intermittent peaks in labor demand in relation to poultry care impinges on their other income-generation activities. For instance, maintaining the warmth required for chicks under 14 days involves frequent monitoring and adjustment of room temperature, especially during the cold season. As the chicks

grow older, women have more time available for other income-generating activities. Similarly, women hatchery owners in Ghana find that their fish farming businesses provides them a form of relaxation and aligns with their interests in nature and being active in the field.

4.3.8 Prior experience

Prior experience and skills, together with resources, motivated women across the case studies to start seed businesses. In Tanzania, agripreneurs cited their life-long experience with poultry. Most were raised in livestock-keeping households, and they benefited at an early age from livestock sales. For example, some parents paid for their daughter's education in this way. Consequently, they have always viewed livestock, and particularly poultry, as a business. Having completed their studies in animal health or veterinary courses, they find it easier to brood and sell the chicks successfully. In Ghana, most women hatchery owners already had good financial resources, access to land or water resources, and access to skilled labor. Some women inherited their business from a father or husband who passed away or migrated. Women noted that possessing technical knowledge and resources important for hatchery and grow-out farming motivated them to start their businesses. They had previously obtained technical knowledge and assistance from other farmers and hatchery operators in the local area, from extension agents, and through information and communication technology tools. In Kenya, several women agripreneurs highlighted that their prior experiences in agricultural development projects and their previously developed customer base motivated them to engage with ACRE Africa.

4.3.9 Family support

Encouragement from family members is an important motivating factor for many Ghanaian and Tanzanian women to become involved in hatchery businesses.

4.4 Qualitative results (2): challenges- to starting up and continuing seed businesses

This section highlights the qualitative results related to challenges (Figure 6).

4.4.1 Family support

Across all countries, some single women (as well as women without a spouse, such as those divorced or widowed) require the permission of male household members to engage in a household business. In Ghana, there is a widely held perception that aquaculture is a man's business, and taboos around the menstrual cycle can limit women from engaging in cage fish farming. Similarly in Tanzania, business more broadly is considered a man's domain and women are often discouraged from engaging. As a result, agripreneurs in Ghana and Tanzania frequently contend with problems in the home stemming from a lack of acceptance of their work by husbands and other male family members. Some women seed distributors in Kenya associated their constrained mobility with difficulties in securing their spouse's agreement to their business activities. They must inform or, in some cases, seek their husbands' permission to attend meetings or engage in marketing activities beyond the home. Family can also provide support in carrying out the business. Although women agripreneurs in Kenya did not note help from husbands, they did mention that relatives assist with advertising. Their wives are also engaged in financing, advertising, and selling seed.

4.4.2 Insufficient experience

In Tanzania, many chicken seed agripreneurs complained about losing large numbers of chicks from their first batch (between 15 and 160 chicks from the first brooding batch of 200 donated to them by the local project partner; AKM Glitters). Despite receiving training about temperature control and how to administer vaccines, many women lost birds due to overheating in the brooder house and other failures. To resolve these issues themselves, they drew upon the information provided through the WiB training and their own knowledge. Women shared information between themselves, often using WhatsApp, to create informal self-help groups. One respondent explained, "After talking to friends and consulting suppliers, I found out that the brooding temperature varies according to area and weather in each place [Once I had learned this, this] resulted in a significant reduction in mortality rates of the brooded chicks."

4.4.3 Managing market demand

In Ghana, the provision of technical assistance, guidance and direction from veterinary services and aquaculture groups, visits and WhatsApp groups, have helped aquaculture farmers to remain in business. Even so, locating buyers remains an important challenge, particularly for women hatchery owners.

In Kenya, the challenge of maintaining a customer base is minimal for many respondents because they have prior experience and networks. They leverage their existing know-how on the best ways to market agricultural products and on how best to provide capacity building to farmers. To market seed and insurance products, they mobilize established social networks, including farmer organizations and agricultural and livestock development organizations, local markets, or religious institutions like the church. In several cases, agripreneurs save time and effort by advertising their products at meetings concerned with other initiatives they are engaged in. Male agripreneurs use their community contacts to advertise their products to others and conversely to be informed about farmer requests for seed. Women agripreneurs frequently help each other and share customers.

Both women and men agripreneurs in Kenya emphasized that communication and good marketing skills—"knowing how to talk to people"—contributes to their success in convincing farmers to purchase insurance alongside seed; although a married woman explained that she has better communication skills than most men and is more successful at convincing farmers to purchase her products. This skill also helps men and women manage difficult discussions, for example when seed does not arrive on time. Even so, managing competition poses a

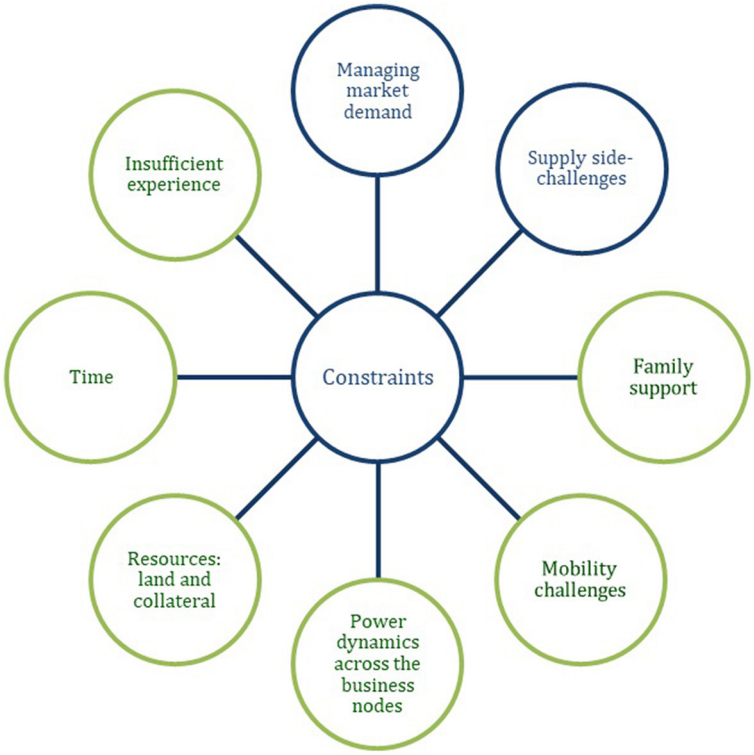

FIGURE 6
Challenges to entering the seed business across the three projects. Green (blue) denotes challenges reported by women only (by women and men).

significant challenge for agripreneurs in Kenya. The smallholder farmers targeted by these agripreneurs are in a powerful position. They often expect price reductions or permission to purchase seeds on credit, to which the agripreneurs feel bound to accede given competition from other vendors. Predicting smallholder demand for seeds of specific varieties poses another challenge.[9]

On a more positive note, women and men agripreneurs in Kenya benefited from ACRE Africa's support. Seed trial samples from ACRE Africa created good publicity for the sales services for both women and men. Seeds were of good quality and helped farmers trust the company and the agripreneurs. This in turn made it simpler to convince farmers that the insurance products were trustworthy. ACRE Africa's provision of seeds also helped establish market demand and the incentives for agripreneurs provided them with financial support to carry out their operations. Women reported that providing T-shirts branded with ACRE Africa's company name and logo was particularly advantageous, because T-shirts gave them publicity and made smallholders take them seriously.

9 Selling insurance can be a major headache. Some farmers expect to be given free items (seeds, other inputs) when they purchase insurance. Since farmers may not have a clear understanding of how agricultural insurance functions, they may expect (potentially substantial) compensation for any loss or argue that the insurance premium is too high. Discouraged insurance purchasers can become distrustful of the product itself as well as the agripreneur. This hampers the marketing of insurance and seed.

4.4.4 Time

Household and care responsibilities limit women's rather than men's time. In Ghana, some women are forced to neglect their businesses, whereas women who allocate more time to their businesses may face escalated household tensions. Married women can find work on their fish business particularly onerous. The timing and duration of their daily responsibilities in the home often overlap with the time of hatching, thereby inhibiting women's full engagement in the hatchery. One married woman who owns a hatchery and grow-out farm, and processes catfish, explained:

> "The time of the hatching is the major barrier hindering most women from being in the hatcheries. I have been taken through training on how to hatch the catfish, but I am not able to practice it because I need to be at the farm very early in the morning and the distance from my home to the farm is far. By the time I get there the worker has finished the hatching. When selling the fingerlings, the counting sometimes starts very late in the evening just at the time I have to go home, or very early in the morning when I have not yet got to the farm."

However, some women hatchery managers and owners manage their time constraints by ensuring that their fish farming activities are strictly scheduled and compatible with their household responsibilities. Some women managers and owners manage their time across fish farming and home care by training and hiring more labor to help in the farm. One woman who owns a hatchery and grow-out farm and processes catfish explained how she organizes

her time among multiple livelihood activities over the week: "With respect to household chores, I stay with my stepchild, after school she takes over. On Sunday, I work at home. I go to work on Monday, Wednesday, and Friday. I use the weekends to plait hair. I have been in the hair dressing business for 20 years now."

In Kenya, women and men recognize that women are more time-constrained in comparison to men. One single young woman explained:

> "A man will just wake up and leave but a woman has to do household chores before leaving for work. In the evening, a woman has to think about what people will eat for supper whilst a man works without distraction. The time that a woman spends in the business is less compared to the man."

Overall, women rarely spoke of hiring others to help them with their business or with their farm work. They argued that women do not have enough time to spend on mobilizing farmers and building networks despite recognizing the importance of these activities for marketing their seeds and (as applicable) insurance products. Another young single woman explained that she markets and sells her products whilst carrying out other livelihood activities.

4.4.5 Supply-side challenges

In Tanzania, most seed agripreneurs reported facing initial difficulties in accessing inputs such as feeds, vaccines, and drugs. The rural location of their business makes it difficult to access quality chicken feed from the smaller agrovets located within their area of operation. Some seed agripreneurs claimed that poultry feed purchased from local markets or agrovets is low quality, resulting in high levels of stunted growth and poor health among poultry. Two agripreneurs noted that some feeds caused health issues, such as severe bloating, and even death. They have resolved this by purchasing day-old chicks and quality feed directly from the hatcheries. In Lindi region, particularly Ruangwa, the main hatchery has established an agent that sells chicks and chicken feeds. In Ghana, many challenges, including rising feed prices and having to maintain water quality and biosecurity measures, affect women and men equally. Fish disease and mortality, particularly the low survival rate of catfish fryers, likewise contribute to increased production costs for both women and men hatchery owners. Respondents in Kenya likewise face supply-side challenges. Late arrival of project-procured seeds has made it difficult to sell seeds in time for farmers' seasonal planting requirements. If distributors do not have seeds available, customers source seed from competitors.

4.4.6 Power dynamics across the business nodes

In Tanzania, women face challenges associated with hired labor and lack of land ownership. Some women seed agripreneurs—when busy with other economic activities, such as marketing, providing veterinary services or attending a training course—use hired labor or family members to help them take care of the brooders. However, hired laborers frequently lack experience and may make mistakes adjusting the temperature in the brooder house. Unsuitable temperatures increase chick fatalities. Jealously can impact on the ability of agripreneurs to keep control over land they rent. When they become successful, landlords frequently argue that they are making money from the landlords' resources and increase rental prices or claim their land back. Some women agripreneurs complained about sexual harassment when visiting male farmers in their households. They argued that male farmers fail to see them as professional chicken agripreneurs and assume that women's visits to the farmers' houses show their interest in sexual interactions. Women respondents also reported being harassed when publicizing their business through leaflets that include their telephone number. Men call them assuming they are selling sexual services.

In Ghana, a lack of skilled and trustworthy workers affects both women and men hatchery agripreneurs. Youth disinterest in aquaculture reduces the pool of potential workers. Furthermore, even when agripreneurs find employees, informal norms that assign leadership roles to men over women make it difficult for male employees to accept supervision by a woman hatchery manager. This challenge particularly affects younger women and, to a more limited degree, young men. Management is also difficult for owners who tend to be absent from their farms (which is often the case for women due to their home and caring roles). To help enforce their decision-making power, Ghanaian women seed agripreneurs typically employ workers on short-term contractual arrangements rather than committing to long-term salaried contracts. This practice weakens men's ability to resist supervision by women, and generally is considered to promote worker efficiency. Some women hatchery owners address challenges related to their personal gaps in knowledge on hatcheries by hiring skilled employees to manage their farms for them. Another strategy is to employ young high school graduates or dropouts with no prior knowledge, provide them with on-the-job training, and support their additional training in hatcheries.

4.4.7 Mobility challenges

In Tanzania, seed agripreneurs generally cannot source day-old chicks locally and instead must transport chicks sourced further afield using public transportation. However, some chicks usually die on the way and transportation costs are high. Some agripreneurs transport fewer day-old chicks per trip to avoid losses. In Kenya, women and men agripreneurs often ask agrodealers with shops to store their seeds and advertise them. Doing so allows the agripreneurs to circumvent the challenge of transporting seed to farmers themselves, which is important especially for women agripreneurs, who reported feeling frustrated with the costly but necessary expense of transporting seeds via a hired bodaboda (motorbike), since driving a bodaboda is widely considered a man's activity and inappropriate for women.[10] In contrast, men agripreneurs commonly own a bodaboda and use it for seed delivery and other business-related tasks. Even so, they remarked on the high costs of fuel and motorbike repair. Agripreneurs therefore prefer to encourage client farmers to obtain seed directly from the agrodealer shop. In a few cases, women and men use

10 Although seed agripreneurs explained that this norm is weakening, it nevertheless remains prevalent and restricts women from driving bodabodas themselves.

their agrodealer contacts to source alternative seeds to sell when project-procured seeds are delayed.

4.4.8 Resources: land and collateral

In Tanzania, many agripreneurs are not native to the regions where they practice their businesses, and even when living closer to their parents, most ethnic communities allow only sons to inherit land, and daughters are not permitted to use family land for their own businesses. As such, most agripreneurs must rent land that is expensive and insecure for the construction of brooder houses. They may be forced to move their brooder houses when landowners raise rent or decide to use the land differently. In some cases, poultry units are forbidden. One agripreneur recalled that she had "rented a house where the owner did not allow the building of a poultry unit due to the noise and the air pollution caused by chicken keeping." Another agripreneur noted that, because she cannot find a location for her business, she shares a brooder house with a smallholder woman client. During the farming season, the client focuses on farming, letting the agripreneur use the brooder house. However, at the end of the season, the client takes over the brooder house to raise poultry herself, preventing the agripreneur from realizing her brooding and expansion plans. Overall, the land challenge is rather intractable. Women respondents explained that, because they cannot inherit, the only way to own land is to purchase it, but it is difficult for women to earn sufficient income to buy land. Securing sufficient business finance is another challenge. Some women agripreneurs draw on their limited savings and the per diems they received for attending the WiB seminars and workshops to renovate the brooder houses they rent. Other agripreneurs depend on men (close family adult male members and adult male friends or neighbors) to help them construct brooder houses. Culturally, women are not supposed to engage in any activities that involve construction, and those who do are stigmatized by the community.

4.5 Qualitative results (3): recommendations for creating an enabling environment

KII respondents (all men and women agripreneurs) were asked to identify measures that could help them scale their businesses and level the playing field. Figure 7 summarizes the topics they highlighted.

4.5.1 Subsidies and loans

In Tanzania, women highlighted a role for financial institutions to facilitate their access to capital and loans. For example, they want to be able to access loan products without having to use their husbands' names and want loans without onerous lending constraints. Respondents in Ghana suggested that dialogue with feed sellers on prices and feed support could help facilitate feed subsidies for their hatchery businesses. The provision of, or financial assistance to acquire, ponds and cages and fish feed would be valuable. Agripreneurs could pay back in installments until they complete repayment and take ownership of the ponds or cages. This would help address challenges faced specifically by women, who tend to have less access to land than men, as well as by young women and men, who often do not have the collateral needed to access bank loans. Kenyan respondents noted the importance of access to an agrodealer that could store seed as well as facilitate sales. Some agripreneurs have benefited from their existing access, and others argued that this access could improve their enabling environment. Agripreneurs also emphasized the need for financial assistance or ACRE Africa support to provide inputs along with seeds, provide seeds on credit, acquire a license to formalize their seed selling, and fund their transportation for marketing activities.

4.5.2 Value chain group membership

Lack of group membership contributes significantly to disempowerment of women agripreneurs in Ghana. Women argue that forming groups would enhance the collective power of women fish farmers concerning customers and facilitate negotiations for a standardized price for their fish. In some instances, Tanzanian women agripreneurs organized themselves in groups to help pool the resources needed to start their businesses. However, in other cases this was not possible. Respondents—who were largely unmarried—argued that marriage customs (patrilocal marriage) oblige women to relocate to their husband's home and community, making it difficult to set up a group. If a woman is likely to relocate, her reliability as a group member diminishes.

4.5.3 Training and capacity development

Agripreneurs in Ghana and Kenya highlighted that external support for capacity building on themes related to their businesses would help ensure success and innovation in their businesses moving forward. Women hatchery owners and managers specifically noted the need for knowledge on water quality management. Agripreneurs involved in hatcheries and grow-out farms emphasized the need for leadership skills training. Ghanaian respondents highlighted that young women and men could address challenges related to lack of capital by first acquiring knowledge on hatcheries. This would facilitate their employment as hatchery managers, thereby enabling them to earn income, and thus raise capital to start their own farms. Men agripreneurs in Kenya noted the need for training on marketing and on how to expand their customer bases. In comparison, women agripreneurs noted that they would benefit from agricultural trainings, to help them sell their products and support farmers better. Agripreneurs in Ghana also highlighted that sponsoring women and youth to visit hatcheries in countries with more successful fish farming sectors than their own would be an important area of support.

4.5.4 Land

Agripreneurs across countries emphasized the need for access to land. Those in Ghana noted that land and financial resources are key to starting a hatchery business. Similarly, Tanzanian women mentioned land as a key resource because of the need for land to rear birds. Women's inability to inherit land puts them at

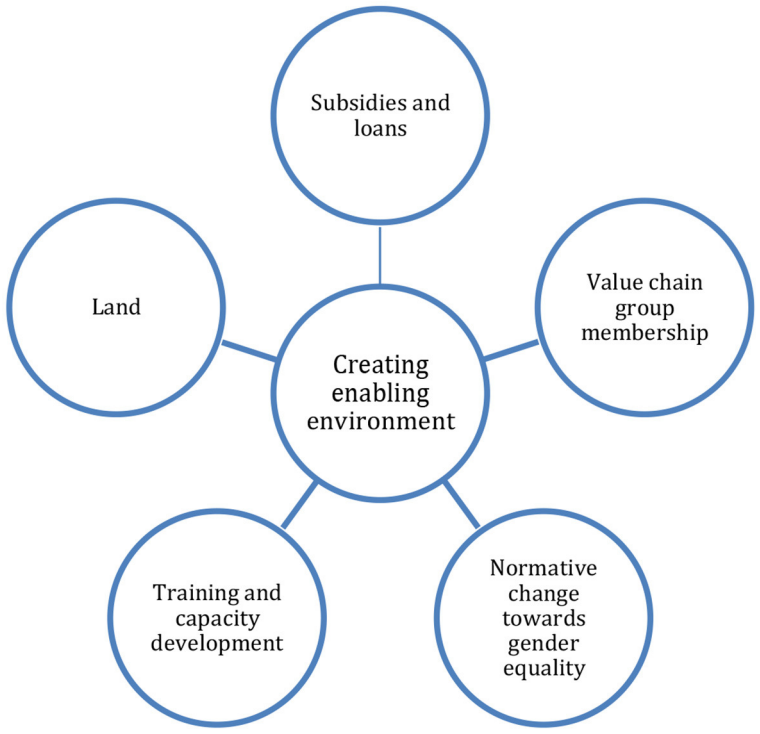

FIGURE 7
Creating an enabling environment for seed businesses.

a disadvantage to their male peers (see "Resources: Land and collateral" in the previous section).

4.5.5 Securing normative change toward gender equality

Agripreneurs in Ghana mentioned that raising awareness about the issues of women's involvement in hatcheries and fish farming in general would address important gender-related challenges to women's entry and success in the business. They suggested, for example, community-level gender awareness campaigns. Agripreneurs engaged in grow-out farming also mentioned that women's empowerment programs specifically targeted to the sector would help; and that leaders in the aquaculture sector can play an important role in addressing young women's and young men's disinterest and lack of skilled and trusted workers for hatchery and grow-out farming by making the sector more attractive to youth. Women and men agripreneurs in Kenya emphasized that donors, government, nongovernmental organizations (NGOs), and private sector players could all play important roles in raising awareness and educating farmers on the utility of certified seed, the various varieties, and the importance of insurance. Trust-building measures like these would help to improve their ability to successfully market seeds and insurance. Furthermore, they emphasized the need for the government to refrain from small business harassment created by costly regulations and required documentation; they also called for civil society mobilization to lobby the government to refrain.

5 Discussion and conclusion

Our cross-country study aimed to identify the main factors that inhibit and promote women's success in seed businesses, and to determine the roles played by gender norms and women's empowerment. Recapping our three research questions, we draw out key learning points.

5.1 Research question 1: how are women's empowerment, gender norms and agripreneurship interrelated?

First, it appears that access to resources and capital, training and information, and family support are key to women starting agricultural business. While gender norms around women's role in domestic chores and men's role in agripreneurship were strong disablers for women entrepreneurship in the study cases, the agripreneurs were able to deviate from and work through these norms. They were "deviants" from the norms and had to work extra hard to prove themselves. This indicates that some level of empowerment or specific empowerment domains relevant to the specific situation are important to the ability of women to

start an agricultural business. In the Ghanaian case study, for example, the comparative equality between women and men in some households can be correlated with the support these women receive from men in their household to start their hatchery businesses (causality cannot be established). In Kenya, women agripreneurs experience lower levels of empowerment compared to male Kenyan agripreneurs, and female and male Ghanaiain agripreneurs. However, women agripreneurs draw upon existing social capital in the form of group membership and social networks. They have important community contacts and, prior to project contact, were already social influencers in their villages. ACRE Africa's support through capacity building on insurance and marketing, and through branding women (alongside men) agripreneurs with T-shirts and badges, assists women to become effective agripreneurs. This finding shows that understanding which particular combination of empowerment domains, within a particular seed systems context, support women's agripreneurship can help to determine the most appropriate interventions.

Second, the findings raise the issue of how gender dynamics affect the significance of women's and men's empowerment scores in relation to their actual engagement in business. Achieving gender parity, with women and men having similar empowerment scores, may be insufficient to guarantee that women and men agripreneurs benefit equally from their business, given that empowered women will still face challenges in operating their business due to the existence of strong gender norms that disadvantage them. This issue is particularly important considering our finding that women agripreneurs do not only face common constraints faced by both men and women, but also additional gendered constraints, such as a lack of family support, limited mobility, high workloads, and limited access to land. Women, therefore, may need extra support in specific domains of empowerment associated with the success of their business to achieve a level playing field with their male colleagues and ensure comparable outcomes in their business. For instance, improving women's access to affordable and secure land, or challenging the perception that a woman cannot ride her own motorbike, could help address the factors that challenge women in specific empowerment domains. This conclusion is in line with the evidence on milk businesses led by women and men in Kenya and Tanzania (Galiè et al., 2022).

Third, based on additional findings not reported above, many women agripreneurs initially overestimated the ease of entering the business, and they did not necessarily recognize the salience of factors determining the success of their business, that later became critical. A notable example is family support. Women appear to have assumed that this would be forthcoming. In reality, gender norms around male breadwinning and the necessity of drawing upon household resources at start-up emerged to confound this expectation. Nevertheless, some women managed to win their families over. To manage expectations when encouraging young women and men to take on a role as agripreneur, capacity development and business incubation short courses could play a vital role. These programs could assist individuals in better assessing constraints and opportunities when establishing their businesses.

5.2 Research question 2. How important is it to address the normative gender context of the seed sector to facilitate women's agripreneurship over time?

The local gender normative context evidently influences women's capacities to continue as effective managers of their seed businesses. As the Ghana hatcheries and Tanzania chicken agripreneur cases show, ingrained norms concerning which gender ought to work in a sector limit the ability of women to fully develop business opportunities. When programs fail to achieve a change in gender norms, women risk losing control over their agricultural business as well as their place in the value chain, particularly when production and productivity increase (Omondi et al., 2014; Achandi et al., 2023).

The Tanzania case highlights how harmful gender norms contribute to systemic feedback loops which compound disadvantage upon disadvantage making it very difficult for women to act. In the cultural communities described in the case study, women cannot inherit land and as a consequence cannot use family land to rear their chickens (probably because the exercise of usufruct rights could potentially translate into ownership rights over the longer term). Renting land is also challenging as landowners can at any time wrest control over the land away from the agripreneur. The only way for women to own land is to purchase it. However, it is very difficult for women to earn sufficient money since, normatively, their businesses should remain small and be scarcely financially viable. This is because—as noted in the conceptual framework—higher level gender norms, in particular the norm that men are primary breadwinners, needs to be supported by male control over key productive assets, and over intra-household decisions regarding how to deploy assets and income (OECD, 2021; Achandi et al., 2023). While Tanzanian women agripreneurs recognize the importance of acquiring land for their chicken business, prevailing gender norms, especially those affecting single women, hinder the realization of this ambition. The women in question are typically young and unmarried. Although they could potentially benefit from participating in savings groups to pool resources for purchasing land, the influence of patrilocal marital gender norms presents a significant barrier. According to these norms, women are expected to relocate to their husband's community upon marriage. This expectation discourages young women from investing time and money into forming groups, as the likelihood of relocation diminishes their commitment and reliability as group members.

Finally, the culturally laden significance of the male breadwinner role means that women are not expected to become significant agripreneurs. Achandi et al. (2023) examined the interactions between gender norms and women's livestock businesses in Tanzania. They found that normative sanctions—such as insulting name calling and social marginalization—are applied to women who are perceived to be moving beyond acceptable gender norms in their efforts to develop dairy-related livelihoods.

Overall, our findings indicate that women agripreneurs often respond to harmful gender norms which penalize women with larger businesses through going "wide rather than deep" (see Pyburn and van Eerdewijk, 2021; Galiè et al., 2022 for further

evidence of this strategy). Rather than specializing in one node of the value chain, or a single commodity, many women prefer to engage in more limited ways in several businesses. This pluralistic strategy has a number of benefits. First, it allows them to spread risk. Second, the amount of income obtained by each small business is inevitably limited. This helps to ensure that women do not overtly challenge gender norms privileging men's income generation role whilst still enabling women to generate monies in their own name. Third, women (most likely) accrue a higher sum of money through their diverse businesses than may be apparent to their spouses and families. These are small wins, though. The downside is that this accommodative strategy leaves gender norms unchallenged and thus prevents women from investing their time and money in overtly lucrative ways. Diversification fragments women's involvement in each value chain—thus hampering their efforts to scale their involvement, improve their bargaining power, and obtain more income (Galiè et al., 2022). They are forced to spend considerable time and effort in developing and managing multiple income streams. Women may invest in crops and livestock that offer low returns, or invest in portfolios associated with women because the barriers to entry and continuing presence in these chains are less prohibitive (Okello, 2020; Ihalainen et al., 2021).

Overall, however, going wide rather than deep can increase women's time use and workloads without ensuring commensurate recompense in the form of increased income or status within the household and community (Stoian et al., 2018; Hirvonen et al., 2020; Mayoux, 2020; Ambler et al., 2021). Furthermore—and critically—would-be women agripreneurs are prevented from developing and exhibiting truly entrepreneurial behaviors. Instead, they shape their businesses around the exigencies of gender norms. In a time of climate change and other associated challenges, the inability of entrepreneurially-minded women to effectively exercise their agency in response to such challenges is likely to pose severe costs upon agrarian economies (Rietveld et al., 2023).

5.3 Research question 3. How and in what form can external support help women agripreneurs overcome gender-related constraints?

Women agripreneurs in the study received varying degrees of support to start and continue operating their seed-related businesses. Although women agripreneurs in the Kenyan case demonstrated strong existing social capital, our results suggest that women particularly appreciated ACRE Africa's support to formally recognize them as agripreneurs. This recognition facilitated their sales activities in their communities. The two other case studies indicate that women still struggled with securing community level acceptance as agripreneurs in aquaculture and chicken. Increased explicit recognition and support by external actors may have facilitated this process. The necessity of recognizing women in their roles as farmers, and agripreneurs, is widely noted in the literature (Safilios-Rothschild, 1985; Galiè et al., 2013; Haney and Knowles, 2021).

In response to such situations an initial entry point for external actors is frequently to design accommodative gender strategies which support women in their careful negotiation around, and manipulation of, gender norms. However, over time, strategies aimed at challenging and modifying harmful gender norms could be introduced with the overall aim of enabling women to go deep rather than wide (or as well as) in their businesses. It is essential that women be facilitated to build and exercise a suite of effective entrepreneurial behaviors.

Gender awareness campaigns, in association with technical support, could help guide normative change processes provided they engage with the long-term nature of the support required. Government bodies, NGOs, and donors can play a valuable support role in challenging the normative context around gender resource gaps, as well as provide technical packages and training to develop business acumen.

Challenging men's traditional role as breadwinners without creating win-win situations can lead to increase gender-based violence, potentially break up relationships, and marginalize women agripreneurs within the community (Coles and Mitchell, 2010; Farnworth et al., 2018a; FAO et al., 2023b). To help manage this conundrum, a number of behavioral strategies specifically designed to support gender-normative change in non-threatening ways have been developed and could be deployed at the community level and with value chain actors (Farnworth et al., 2018b, 2022, 2023; Ambler et al., 2021; Lecoutere and Van Campenhout, 2023). These can be complemented by making best use of information and communication technologies. In two of the case studies, WhatsApp was identified as an important source of information and social capital for the women. Television (TV) programs also serve as a powerful channel for promoting gender-normative change, embedding gender messaging within popular dramas and other TV programs, including those providing agricultural information. For example, "Shamba Shape Up," a popular farm makeover reality TV show in Kenya, broadcasted a drama in which it challenged the widespread tolerance of violence toward women taking on a proactive role in agriculture (Aju et al., 2022). This drama was informed partly by the findings from our research with men and women agripreneurs.

In conclusion, our conceptual framework examined how to create (i) equitable gender opportunities in seed entrepreneurship, and (ii) women's empowerment in the seed system. The findings show that harmful gender norms remain powerful in all three case studies and are particularly challenging in Ghana and Tanzania. In Ghana, the normative challenge appears to rest primarily on women entering a male-dominated value chain. In Tanzania, the normative challenge is even more fundamental. The very concept of women agripreneurs is questioned at a very deep level. In Kenya, by way of contrast, women agripreneurs appear to face fewer challenges due to their longer-term presence in the value chains studied.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by International Livestock Research Institute Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

AG, CR, and BK contributed to the conception and design of the study. HJ organized the data and statistical analyses. TG with support from BK, CR, and AG wrote the first draft of the manuscript. TG, HJ, BK, and CR provided material for sections of the manuscript. CF wrote the second draft of the manuscript. All authors contributed to revising, reading, improving, and approving the submitted version and contributed equally to the manuscript and names are listed alphabetically in recognition of this.

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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.

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References

Achandi, E. L., Farnworth, C. R., Galiè, A., Omore, A., and Jeremiah, A. (2023). How do local gender norms interact with local conceptualisations of empowerment to shape women's engagement in local dairy value chains in Tanzania? *Front. Sustain. Food Syst.* 7, 1–15. doi: 10.3389/fsufs.2023.1198181

Aju, S., Kramer, B., and Waithaka, L. (2022). "Edutainment, gender and intra-household decision-making in agriculture: a field experiment in Kenya," in *Promoting Stress-Tolerant Varieties at Scale - Kenya*. Available online at: https://econpapers.repec.org/paper/fprprnote/december2022.htm (accessed February 14, 2024).

Alkire, S., Meinzen-Dick, R., Peterman, A., Quisumbing, A., Seymour, G., and Vaz, A. (2013). The women's empowerment in agriculture index. *World Dev.* 52, 71–91. doi: 10.1016/j.worlddev.2013.06.007

Ambler, K., Jones, K., and O'Sullivan, M. (2021). Facilitating women's access to an economic empowerment initiative: evidence from Uganda. *World Dev.* 138, 1–13. doi: 10.1016/j.worlddev.2020.105224

Baliyan, S. P., Mosia, P. A., and Baliyan, P. S. (2020). Gender differences in entrepreneurial attitudes and constraints: do the constraints predict university agriculture graduates' attitudes towards entrepreneurship? *Int. J. High. Educ.* 9, 259–273. doi: 10.5430/ijhe.v9n5p259

Bernard, T., Hidrobo, M., Le Port, A., and Rawat, R. (2019). Nutrition-based incentives in dairy contract farming in Northern Senegal. *Am. J. Agric. Econ.* 101, 404–435. doi: 10.1093/ajae/aay036

Cairns, J. E., and Prasanna, B. M. (2018). Developing and deploying climate-resilient maize varieties in the developing world. *Curr. Opin. Plant Biol.* 45, 226–230. doi: 10.1016/j.pbi.2018.05.004

Coles, C., and Mitchell, J. (2010). "Gender and agricultural value chains and practice and their policy implications. A review of current knowledge and practice and their policy implications," in *ESA Working Paper (Issues 11–05)*. Rome, Italy: FAO. Available online at: http://www.fao.org/publications/sofa/en/ (accessed February 14, 2024).

Dias, C. S. L., Rodrigues, R. G., and Ferreira, J. J. (2019). What's new in the research on agricultural entrepreneurship? *J. Rural Stud.* 65, 99–115. doi: 10.1016/j.jrurstud.2018.11.003

Donovan, J., Rutsaert, P., Spielman, D., Shikuku, K. M., and Demont, M. (2021). Seed value chain development in the Global South: key issues and new directions for public breeding programs. *Outlook Agric.* 50, 366–377. doi: 10.1177/00307270211059551

FAO (2018). *The State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals*. Rome, Italy: FAO. Available online at: https://www.fao.org/3/CA0191EN/CA0191EN.pdf (accessed February 14, 2024).

FAO, ILRI, IFAD, and CGIAR GENDER Impact Platform (2023b). *Guidelines for Measuring Gender Transformative Change in the Context of Food Security, Nutrition and Sustainable Agriculture*. Rome, Italy, FAO.

FAO, ILRI, IFAD, and World Bank (2023a). *A Framework for Gender-Responsive Livestock Development: Contributing to a World Free From Hunger, Malnutrition, Poverty and Inequality*. Rome, Italy: FAO.

Farnworth, C. R., Fischer, G., Chinyophiro, A., Swai, E., Said, Z., Rugalabam, J., et al. (2022). *Gender-transformative decision-making on agricultural technologies: Participatory tools*. Ibadan, Nigeria: IITA. Available online at: https://hdl.handle.net/10568/127692 (accessed February 14, 2024).

Farnworth, C. R., Fischer, G., Rugalabam, J., and Islahi, Z. S. (2023). Gender-transformative agricultural experimentation and decision-making: Piloting GALS tools in Tanzania. *Womens. Stud. Int. Forum* 101, 102836. doi: 10.1016/j.wsif.2023.102836

Farnworth, C. R., López, D. E., Badstue, L., Hailemariam, M., and Abeyo, B. G. (2018a). Gender and agricultural innovation in Oromia region, Ethiopia: from innovator to tempered radical. *Gend. Technol. Dev.* 22, 222–245. doi: 10.1080/09718524.2018.1557315

Farnworth, C. R., Stirling, C. M., Chinyophiro, A., Namakhoma, A., and Morahan, R. (2018b). Exploring the potential of household methodologies to strengthen gender equality and improve smallholder livelihoods: Research in Malawi in maize-based systems. *J. Arid Environ.* 149, 53–61. doi: 10.1016/j.jaridenv.2017.10.009

Fisher, M., and Carr, E. R. (2015). The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: the case of drought-tolerant maize seed in eastern Uganda. *Glob. Environ. Chang.* 35, 82–92. doi: 10.1016/j.gloenvcha.2015.08.009

Galiè, A. (2013). Empowering women farmers: the case of participatory plant breeding in ten syrian households. *Frontiers (Boulder).* 34, 58–92. doi: 10.1353/fro.2013.a503836

Galiè, A., Jiggins, J., and Struik, P. C. (2013). Women's identity as farmers: a case study from ten households in Syria. *NJAS - Wageningen J. Life Sci.* 64–65. doi: 10.1016/j.njas.2012.10.001

Galiè, A., Njiru, N., Heckert, J., Myers, E., and Alonso, S. (2022). Gendered barriers and opportunities in Kenya's informal dairy sector: enhancing gender-equity in urban markets. *Gend. Technol. Dev.* 26, 214–237. doi: 10.1080/09718524.2022.2084491

Galiè, A., Teufel, N., Korir, L., Baltenweck, I., Webb Girard, A., Dominguez-Salas, P., et al. (2018). The women's empowerment in livestock index. *Soc. Indic. Res.* 142, 799–825. doi: 10.1007/s11205-018-1934-z

Gumucio, T., Kramer, B., Ragasa, C., Pyburn, R., Galiè A., Aredo, S. D., et al. (2021). "Gender and seed entrepreneurism: case studies in Ethiopia, Ghana, Kenya and Tanzania," in *CCAFS Working Paper no. 412*. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: https://hdl.handle.net/10568/117469 (accessed February 14, 2024).

Haney, W. G., and Knowles, J. B. (2021). "Introduction: making "The Invisible Farmer" visible," in *Women and Farming, 1st Edn*, ed. W. G. Haney (New York, NY).

Hirvonen, K., Baye, K., Headey, D. D., and Hoddinott, J. F. (2020). *Value Chains for Nutritious Food: Analysis of the Egg Value Chain in the Tigray Region of Ethiopia*. Washington, DC: IFPRI.

IFPRI (2021). *WEAI Versions. Weai.ifpri.info. R*. Available online at: https://weai.ifpri.info/versions/ (accessed December 31, 2021).

Ihalainen, M., Shaikh, S., Mujawamariya, G., Mayanja, S., Adetonah, S., Tavenner, K., et al. (2021). "Promise and contradiction: value chain participation and women's empowerm," in *Advancing Gender Equality Through Agricultural and Environmental Research: Past, Present and Future*, eds. R. Pyburn and A. van Eerdewijk (Washington, DC: IFPRI), 147–188.

Kabeer, N. (1999). Resources, agency, achievements: reflections on the measurement of women's empowerment. *Dev. Change* 30, 435–464. doi: 10.1111/1467-7660.00125

Kassam, L., and Dorward, A. (2017). A comparative assessment of the poverty impacts of pond and cage aquaculture in Ghana. *Aquaculture* 470, 110–122. doi: 10.1016/j.aquaculture.2016.12.017

Korsgaard, S., Ferguson, R., and Gaddefors, J. (2015). The best of both worlds: how rural entrepreneurs use placial embeddedness and strategic networks to create opportunities. *Entrep. Reg. Dev.* 27, 574–598. doi: 10.1080/08985626.2015.1085100

Kramer, B., and Galiè, A. (2020). *Gender Dynamics in Seed Systems Development. PIM Synthesis Brief.* Washington D.C.: IFPRI.

Kramer, B., and Trachtman, C. (2023). Gender dynamics in seed systems: an integrative review of seed promotion interventions in Africa. *Food Secur.* 16, 19–45. doi: 10.1007/s12571-023-01403-2

Lecoutere, E., and Van Campenhout, B. (2023). Joint forces: the impact of intrahousehold cooperation on welfare in east african agricultural households. *Fem. Econ.* 29. doi: 10.1080/13545701.2022.2120206

Louwaars, N. P., de Boef, W. S., and Edeme, J. (2013). Integrated seed sector development in africa: a basis for seed policy and law. *J. Crop Improv.* 27, 186–214. doi: 10.1080/15427528.2012.751472

Malapit, H., Heckert, J., Adegbola, Y. P., Crinot, G. F., Eissler, S., Faas, S., et al. (2023). *Measuring Empowerment across the Value Chain: The Evolution of the Project-Level Women's Empowerment Index for Market Inclusion (pro-WEAI+MI)*. Washington D.C.: IFPRI.

Malapit, H., Quisumbing, A., Meinzen-Dick, R., Seymour, G., Martinez, E. M., Heckert, J., et al. (2019). Development of the project-level Women's Empowerment in Agriculture Index (pro-WEAI). *World Dev.* 122, 675–692. doi: 10.1016/j.worlddev.2019.06.018

Mayoux, L. (2020). "Gender mainstreaming in value chain development: Experience with Gender Action Learning System in Uganda," in *Value Chain Development and the Poor*, eds. J. Donovan, D. Stoian, and J. Hellin (Warwickshire, UK: Practical Action Publishing).

McGuire, S., and Sperling, L. (2011). Les liens entre la sécurité alimentaire et la sécurité des semences: Faits et fiction qui orientent la riposte. *Dev. Pract.* 21, 493–508. doi: 10.1080/09614524.2011.562485

Mukhtar, S., Gwazawa, U., and Jega, A. (2018). Entrepreneurship development for diversification of nigerian economy. *J. Econ. Manag. Trade* 21, 1–11. doi: 10.9734/JEMT/2018/41679

Njuki, J., Eissler, S., Malapit, H., Meinzen-Dick, R., Bryan, E., and Quisumbing, A. (2023). A review of evidence on gender equality, women's empowerment, and food systems. *Sci. Innov. Food Syst. Transform.* 33, 165–189. doi: 10.1007/978-3-031-15703-5_9

Nyantakyi-Frimpong, H. (2019). Visualizing politics: A feminist political ecology and participatory GIS approach to understanding smallholder farming, climate change vulnerability, and seed bank failures in Northern Ghana. *Geoforum* 105, 109–121. doi: 10.1016/j.geoforum.2019.05.014

OECD (2021). *Man Enough? Measuring Masculine Norms to Promote Women's Empowerment, Social Institutions and Gender Index*. Paris, France: OECD Publishing

Okello, D. (2020). Gender effect of entrepreneurial orientation on dairy farming career resilience in Kenya. *Cogent Food Agric.* 6, 1–16. doi: 10.1080/23311932.2020.1863565

Omondi, I., Zander, K., Bauer, S., and Baltenweck, I. (2014). "Using dairy hubs to improve farmers access to milk markets in Kenya: Gender and its implications," in *A Paper Presented at the Tropentag 2014: Bridging the Gap Between Increasing Knowledge and Decreasing Resources Workshop, Prague, Czech Republic*. Available online at: https://hdl.handle.net/10568/69348 (accessed February 14, 2024).

Puskur, R., Mudege, N. N., Njuguna-Mungai, E., Nchanji, E., Vernooy, R., Galiè, A., et al. (2021). "Moving Beyond Reaching Women in Seed Systems Development," in *Advancing Gender Equality through Agricultural and Environmental Research: Past, Present, and Future*, eds. R. Pyburn and A. van Eerdewijk (Washington, D.C.: IFPRI), 113–145.

Pyburn, R., and van Eerdewijk, A. (2021). "CGIAR research through and equality and empowerment lens," in *Advancing Gender Equality Through Agricultural and Environmental Research: Past, Present, and Future*, eds. R. Pyburn and A. van Eerdewijk (Washington, DC: IFPRI), 1–75.

Quisumbing, A., Meinzen-Dick, R., and Malapit, H. (2023). "Measuring women's empowerment and gender equality through the lens of induced innovation BT - agricultural development in Asia and Africa: essays in honor of Keijiro Otsuka," in *Agricultural Development in Asia and Africa: Essays in Honor of Keijiro Otsuka,* eds. J. P. Estudillo, Y. Kijima, and T. Sonobe (Singapore: Springer Nature Singapore), 343–355.

Ragasa, C., Agyakwah, S. K., Asmah, R., Mensah, E. T. D., Amewu, S., and Oyih, M. (2022a). Accelerating pond aquaculture development and resilience beyond COVID: ensuring food and jobs in Ghana. *Aquaculture* 547, 1–14. doi: 10.1016/j.aquaculture.2021.737476

Ragasa, C., Charo-Karisa, H., Rurangwa, E., Tran, N., and Shikuku, K. M. (2022b). Sustainable aquaculture development in sub-Saharan Africa. *Nat. Food* 3, 92–94. doi: 10.1038/s43016-022-00467-1

Ragasa, C., Torbi, E., Kruijssen, F., and Amewu, S. (2023). "Women and youth participation and empowerment in aquaculture: Mixed-methods evidence from Ghana," in *A Paper Presented During the CGIAR GENDER Platform International Conference, New Delhi, India.* Available online at: https://hdl.handle.net/10568/135615 (accessed February 14, 2024).

Rietveld, A. M., Farnworth, C. R., Shijagurumayum, M., Meentzen, A., Voss, R., Morahan, R., et al. (2023). *An evidence Synthesis of Gender Norms in Agrifood Systems: Pathways Towards Improved Women's Economic Resilience to Climate Change*. Rome, Italy: Bioversity International. Available online at: https://hdl.handle.net/10568/136053 (accessed February 14, 2024).

Safilios-Rothschild, C. (1985). The persistence of women's invisibility in agriculture: theoretical and policy lessons from Lesotho and Sierra Leone. *Econ. Dev. Cult. Chang.* 33. doi: 10.1086/451462

Stoian, D., Donovan, J., Elias, M., and Blare, T. (2018). Fit for purpose? A review of guides for gender-equitable value chain development. *Dev. Pract.* 28, 494–509. doi: 10.1080/09614524.2018.1447550

Wongnaa, C. A., Adams, F., Bannor, R. K., Awunyo-Vitor, D., Mahama, I., Osei, B. A., et al. (2019). Job creation and improved consumer health through commercialisation of tiger nut yoghurt: a willingness to pay analysis. *J. Glob. Entrep. Res.* 9, 1–22. doi: 10.1186/s40497-018-0139-x

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Gender-based approaches for improving milk safety, value addition, and marketing among smallholder livestock farmers

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In the context of Uganda, this study delves into gender-based strategies aimed at enhancing women's engagement in milk safety, value addition, and marketing within smallholder livestock farming. The objectives were two-fold: first, to document the current practices of women in milk safety, value addition, and marketing channels; second, to examine the constraints, opportunities, and strategies related to the production of safe milk and milk products, along with accessing sustainable markets. Conducted in four sub-counties of the Kiruhura district, this research employed both qualitative participatory methods and structured questionnaires, including 12 focused group discussions and 20 key informant interviews with both women and men. Notably, 217 structured questionnaires were administered. The findings illuminate that women played a central role in milk processing, water provisioning, sanitation, and hygiene practices and were the primary contributors to milk value addition, particularly in the production of butter and ghee. Despite their active involvement, women face challenges in accessing adequate milk quantities, employ traditional labor-intensive procedures, and encounter difficulties in marketing their processed products. Men, often the household heads, held decision-making authority over milk consumption and controlled the selling of milk, contributing to gender disparities. Addressing these challenges necessitates comprehensive support, including training and capacity-building initiatives for both men and women in milk value addition, credit access, and market entry. The study underscores the potential for improved women's access to milk quantities, particularly for butter and ghee production, to strengthen rural livelihoods and boost dairy production in Uganda.

KEYWORDS

decision-making, gender, food safety, milk, value addition

Background of the study

Many would argue that there is a need to improve women's entry and participation points in livestock ownership in Sub-Saharan Africa. Specifically, access to markets and value chains in relation to the existing laws, policies, regulations, and institutional practices; access to and control over assets and resources; and gender roles, responsibilities, cultures, norms, and

patterns of power and decision-making require more work (Raney, 2011; Grace et al., 2015; Quisumbing et al., 2015, 2021). Rural women perform different roles in livestock farming besides multitasking and performing reproductive, productive, and community roles. Their roles in livestock sub-sectors vary by region, country, and community based on their particular economic status and social and cultural contexts (Naz et al., 2022; Sennuga et al., 2022).

In Uganda, women play a significant role in activities related to animal husbandry, especially in dairy production. Their participation is commonly concentrated at the handling level and less in profitable activities such as marketing (SPRING, 2014; Katothya, 2017). They are often involved in roles that range from washing milking utensils, cleaning milking areas, and making milk products such as butter and ghee, among others. In contrast, men are engaged in grazing, milking, and marketing of milk. Women often lack knowledge on how to produce and maintain safe milk products along the milk value chains. They also lack information and knowledge on how to increase the value of their milk products, including access to sustainable markets. Local milk collection centers do not have adequate cooling and chilling facilities to accommodate all the milk produced. The excess milk is often wasted due to having limited options for prolonged storage of the milk. Excess milk is usually thrown away or sold at very low prices during wet seasons (Monitor, 2020). Value addition can increase the shelf life of excess milk during the wet season since milk is always plenty during these periods. Common value-added products include ghee and butter. Ghee-making has been demonstrated as a major economic activity undertaken by women in western Uganda (Katimbo et al., 2017). Usually, women are rationed milk by their husbands to make butter and ghee, which are mainly processed using traditional methods that may not always guarantee product safety and quality. Women involved in these activities use water from different sources whose quality may not be ascertained. Furthermore, the cleanliness of utensils used in the process, such as calabashes, gourds, buckets, and saucepans, may pose a risk to meeting food safety standards.

Generally, there was a lack of gender-specific data related to the practices of women in the production of safe milk and milk products, value addition, and access to lucrative markets in Uganda. There was a dearth of gender analysis on the role of women in ensuring the production of safe milk and milk products, value addition, and access to lucrative milk market value chains. There remained some work to be undertaken to ensure that women achieve the capacity to address value addition and milk food safety. It was against this background that this study was designed to identify the current practices and constraints faced by especially women in the production of safe milk and milk products, value addition, and accessing marketing channels among smallholder livestock farmers in Western Uganda, Kiruhura district (Njuki and Sanginga, 2013; Katothya, 2017).

Methodology

In this cross-sectional study, both qualitative and quantitative research tools were used to collect data from four sub-counties that were purposively selected. The four sub-counties were selected during a reconnaissance visit and meetings held with the district and local government extension staff. Mapping of the selected study sites was based on access to the relevant women groups where the extension staff were aware of the existence of women livestock farmers.

Qualitative data were collected using participatory methods. Quantitative data were collected using a structured questionnaire. The information captured during the discussion and administration of questionnaires was on current practices, constraints faced, and opportunities that exist in the production of safe milk and milk products, milk value addition, and access to milk and milk product markets and credit facilities by women. All these interviews were conducted in the local Runyakole language and guided by extension staff. All tools were translated into the local Runyakole language. This was a requirement of the Research Ethics Committee for approval of the research proposal.

Participatory methods involved carrying out Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) with the aid of a checklist of questions. Twelve FGDs were carried out: three per sub-county. In each sub-county, two FGDs for women and one for men were carried out. Each FGD consisted of a minimum of eight and a maximum of 12 participants. The key informants included opinion leaders, sub-county veterinary extension staff, district production officers, district veterinary officers, community-based development officers, women livestock farmer groups and associations, dairy milk associations, milk processors, milk collectors, milk vendors, and milk value addition actors.

A semi-structured questionnaire was administered to verify the information obtained from participatory methods by conducting a detailed and quantitative inquiry on individual perceptions of the research variables stated above. A sub-county was taken as the administrative sampling unit for the administration of a structured questionnaire.

A minimum sample size of 30 households per sub-county was determined using the equation adopted from Dohoo et al. (2003):

$$n = Z^2 PQ / D^2$$

Where n = minimum sample size.

Z = 1.96 at 95% confidence interval.

P = estimated percentage of households owning cattle to be 98%.

Q = 100−P.

D = acceptable error of 0.05.

However, to increase the reliability, questionnaires were administered to 54 households per sub-county, totaling 217 households in the district.

Qualitative data collected from KIIs and FGDs were organized and analyzed into themes. The themes were reviewed, defined, and refined through thematic maps to answer the research questions. Following data collection, the research team members would compare field notes daily upon return from the field. Qualitative content analysis was used to have an in-depth understanding of the phenomenon from the perspective of those involved. Inductive content analysis was enlisted in coding categories that were derived directly from the raw data, and this contributed to figuring out possible categories, patterns, and themes. For quantitative data, descriptive statistical analysis was undertaken. The chi-square test was used to test the significant difference in gender participation in carrying out routine household roles involving cattle keeping.

TABLE 1 Mean daily liters of household milk production and use dynamics ($n = 217$).

Season	Production	Home consumption (% of total production used for home consumption)	Milk used by women for value addition (% of total milk production used by women for value addition)	Milk sold (% of total milk production sold)
Wet	56.8 ± 4.3	6.5 ± 0.2 (11.4)	5 (8.8)	45.3 (79.8)
Dry	37.7 ± 3.3	5.1 ± 0.18 (13.5)	5 (13.3)	27.6 (73.2)

TABLE 2 Livestock-keeping households in which specific genders were participating in certain roles on a dairy farm ($n = 217$).

Roles	Gender (%)						
	Men	Women	Workers	Boys	Girls	X^2	*p* value
Feeding of cattle	6.9	0.9	91.7	0.9	0	302	0.0000
Fetching water	8.3	0	92.6	0	0	321.3	0.0000
Milking	8.3	0	84.3	2.3	0	263.2	0.0000
Farm cleaning episodes	6.0	20.3	63.6	0	6.9	33	0.0000
Tick control	12.9	0	92.6	3.2	0	321.3	0.0000
Marketing	81.6	3.7	10.1	2.3	0	99	0.0000
Farm maintenance	91.7	3.7	0	2.3	0	30.2	0.0000
Financial transactions	89.4	0.5	10.1	2.3	0	269.2	0.0000

This study obtained ethical approval from Makerere University, School of Veterinary Medicine and Animal Resources, Research Ethics Committee (MAKSVAR REC) under protocol number #SVAR-IACUC/99/2021. Information regarding the role of each participant was explained, and consent forms were signed after a detailed explanation of the study and the rights to participate or not to participate. The researchers ensured that the study participants remained anonymous and confidentiality was observed through coding and restricting access to all the data.

Results

There were 217 respondents in total, of which 81.6% were women and 12.6% were female household heads. Out of these, 79% were married and 11.7% were widowed. A majority (86.8%) of the farmers had over 11 years of experience in dairy farming. The dynamics of household milk production are shown in Table 1.

The details of how household gender roles were shared in the daily running of the dairy farm are shown in Table 2.

Women were solely responsible for maintaining the hygiene of milking utensils and boiling milk. Details of hygienic practices used for milking utensils are shown in Table 3. A majority (87.2%) of households boiled milk before consumption and 83.2% made sour milk from boiled milk.

In the FGDs, both men and women described and clearly differentiated the specific gender roles in milk processing in the community. Both men and women noted that men and boys were solely responsible for milking cows. Both men and women FDGs confirmed the prevailing norm and cultural belief that women and girls were not supposed to milk cows because it was taboo. Some of the taboos attached to milking by women included the belief that it would lead to the death of cattle and that girls would not get married. In most households, male workers were hired under the supervision of the head of the household to milk the cattle. Men also supervised the quality and quantity of milk produced at the farm on a daily basis. Workers were also employed to feed cattle, fetch water, and clean farm implements.

TABLE 3 Households employing hygienic practices for milking utensils, quality including sources of water used for cleaning milking utensils in Kiruhura district ($n = 217$).

Variable	*N* (%)
Hygiene of milking utensils	
Cleaning milking utensils before milking	195 (91.1)
Drying of milking utensils before milking	176 (82,2)
Sanitizing milking utensils before milking	105 (49.1)
Immediately cleaning milking utensils after milking	138 (64.5)
Water quality used for cleaning	
Very clean	116 (54.2)
Clean	181 (84.6)
Unclean	6 (2.8)
Water sources	
Dam	40 (18.7)
Well	120 (56.1)
Protected spring	2 (0.9)
Tap water	5 (2.3)

> *We believe that once women and girls milk the cows, our cattle will die and our girls will not get married. Why should a woman or girl squat (okurotama) under the udder of cattle? (Interview from Male FGD).*

Some men acknowledged that it was their responsibility to wash the udders and tits of cows before milking. However, their female counterparts were in charge of cleaning both the conventional and indigenous utensils used for milk storage. Women cleaned and smoked milk pots and gourds, tidied up the milk shade, and swept the home yards.

Boys and girls in this community performed the same duties as their fathers and/or mothers, respectively in the production of milk. Children aged 3–10 years took care of the calves and chased away flies while milking was done.

In total, 36.4% ($n = 78$) of the households were engaged in milk value addition. Details of milk value-addition activities are shown in Table 4. Women were involved in value addition as traditional roles for household consumption, and this provided them a business opportunity to earn income. Details of reasons for involvement in value addition are shown in Table 5.

All these milk value-added processes were conducted in all four sub-counties of the study area except jelly processing. Indigenous jelly processing was only practiced in the Kikatsi Sub-county in 0.9% of the households ($n = 2$).

Interestingly, milk value addition was solely undertaken by women. Culturally, butter/ghee-making was a women's activity and was clearly defined within the community. In a cultural context of male dominance, a woman's task, such as butter-making, was perceived to be an inferior task only for women and girls. Women used traditional knowledge and experience to produce dairy products such as yogurt, ghee/butter, and jelly. However, the women lacked preservation techniques that could further improve the shelf-life of their products. They also had inadequate information and knowledge on proper packaging and labeling.

TABLE 4 Households producing milk and types of value-added products in Kiruhura district ($n = 217$).

Value-added milk product	*N* (%)
Yogurt	18 (8.4)
Sour milk (*amacuunda*)	35 (16.4)
Ice cream	3 (1.4)
Butter	28 (13.1)
Indigenous jelly processing	2 (0.9)

TABLE 5 Livestock keeping households and their reasons for participating in the milk value addition in Kiruhura district.

Reason	*n* (%)
Improve marketability of milk and its products	78 (36.4)
Create a business opportunity	66 (30.8)
Improve financial sustainability	70 (32.7)
Career change	26 (12.2)
Passion for producing dairy products	78 (36.4)

Critically, the women lacked certification of their products by the Uganda Bureau of Standards.

> *As women, we are also interested in the value addition, but some of us still have many challenges in accessing milk because it is controlled by our husbands. Some of us can buy milk from our spouses once in a while but we often do not have the money to buy it (Interview with a female-dominated FGD).*

Overall, decision-making about the money from milk marketing was deemed a man's responsibility. Women also explained that they faced problems accessing milk for value-added products. Some women explained that their obtaining of milk depended on their husbands' mood. *If he is not happy, there will be no milk*. According to women, a husband's happiness depended on various factors such as good sex, good food, respect, maintaining a clean homestead, and providing a warm reception to his relatives. According to men, they did not give women all the milk they needed because the proceeds from the sale of valued-added milk products were spent solely by women without involving them. However, after dialoguing with men and women on this issue, women agreed to share the proceeds. Women also faced the challenge of their spouses consuming their value-added products freely without payment, while still expecting the women to buy milk from them. A common challenge that women reported was the traditional processing (churning) of butter, which was very tiresome and time-consuming.

> *Culturally, women have more opportunities to engage in value addition, especially in butter/ghee processing, sour milk, creams, lotion, jelly, and oils. This is because men in this community have been nurtured and trained that it is solely a female-dominated responsibility. In fact, you will never ever find a man/boy in this community churning milk for ghee. This is solely due to the clear demarcation of the gender-specific roles (interview with the sub-county officials, a key informant).*

The women complained of chest pains and fatigue due to the handling of big volumes of milk when churning the milk into butter or ghee. Processes from value-added products were completely under the control of women. Men complained that women did not give them any share of the money earned from value-added milk products. That was the reason why they were reluctant to give women the milk for value addition. In a week, from 35 L of milk given to them costing approximately Ug Shs 35,000, women can produce 5 kg of ghee that could sell at Ug Shs 100,000, making a gross margin of Ug Shs. 65,000.

In total, 42.5% ($n = 92$) of the households complained that they had a poor market for milk, especially during the rainy season. Prices of milk per liter fell 87% from Ug Shs 1,500 during the dry season to Ug Shs 200 during the wet season. This was the time when women had the opportunity to buy more milk for value addition, especially for ghee-making. In addition, any access to loans or credit required the husbands' approval. However, the women lacked marketing strategies and networks for their products. They only marketed their value-added milk products through social networks. Women also had difficulties penetrating the market space and promoting the sale of their products. They also lacked linkages to private partners for marketing milk products.

Discussion

This study showed that different genders play distinct roles in household dairy farming, milk processing, and value-adding activities. We demonstrated that men were solely responsible for milking and the women for cleaning up milking utensils and churning milk. However, this differs from the Masai communities in Kenya and Tanzania, where women were allowed to milk the cattle (Parsons and Lombard, 2017; Yurco, 2022). In Uganda, the Karamoja women were solely responsible for milking (Stites and Mitchard, 2011). In these identified communities, women were the milk managers and were responsible for providing it to their households. They were the right to sell any surplus milk. Unlike in this study community, men were solely responsible for the use of milk within their households, and they apportioned milk use. Most of the household milk produced was for sale. Approximately 79.7 and 73.2% of the milk produced was sold during wet and dry seasons, respectively. In most Eastern African pastoral communities, men were the lone decision-makers in terms of milk use allocation (Parsons and Lombard, 2017; Yurco, 2022). In addition, among the Bihar community in India, women actively got involved in tasks related to milking, collecting cow manure, caring for ill animals, preparing feed, feeding the animals, and cleaning the animal shades (Kumar et al., 2021; Manisha and Satpathy, 2022).

In this study area, it was entirely women's responsibility to clean and sanitize milking utensils. Both conventional and traditional utensils were used for milk handling and storage. Milking utensils were sanitized by smoking using local herbs. Similar findings were also reported in Ethiopia (Mossie, 2019; Abera and Mideksa, 2020; Amenu et al., 2020), where traditional methods were used for handling and processing dairy products by women. The washing of traditional milking utensils comprised using traditional herbs/plants and smoking.

Our study showed that women played a limited role in financial transactions in the sale of milk despite having more options for value addition (Table 2). The men were in charge of marketing and managing financial receipts from milk sales. This is similar to studies in Bihar, India, where men were in charge of managing funds and selling milk and milk products (Kumar et al., 2021; Manisha and Satpathy, 2022). This would imply that women could not actively participate in the marketing and financial management of milk proceeds. Therefore, women played a limited role in decision-making in households. In the study communities, where there were widowed-headed households, the sons took over this responsibility, thus marginalizing their decision-making powers.

Our findings strongly suggest and support women taking the lead in milk value addition in the study area. They were involved in making butter, ghee, yogurt, and jelly. This finding was similar to what was found in Ethiopia, where traditional butter-making, known as *kibe,* was mainly processed by women (Mossie, 2019). In addition, women in the Boran pastoral community in Ethiopia sold traditionally made fermented yogurt to enhance their household incomes. In our study, women were allocated 5 L daily for milk value addition. Ghee/butter production was a profitable enterprise with a return on investment of 1.9. However, the amount of milk given was not enough for women to meet the value-addition efforts. To increase access to milk, women need to continue dialoguing with their spouses to allocate more milk to them and to share proceeds accrued from value addition used as a household income. Alternatively, women could identify ways such as working together in groups or seeking financial support, such as accessing credit, to enable them to buy more milk. However, this also requires men to provide them with security so they can access loans from financial lending institutions readily available in the area. The ghee/butter value addition has a high potential for becoming a sustainable and profitable household enterprise among communities in the study area.

In the study area, there was no clear, well-established milk marketing system for women to sell their products. Their access to markets was limited. Women only sold their products through social networks. A similar finding was observed in Ethiopian pastoral communities in the Hamaraya District (Eshetu et al., 2019), where the marketing systems were not well-developed. Marketing of the milk products was mainly done by women who organized themselves into traditional milk association groups called *Faraqa Annanni.* To overcome these challenges, there is a need to identify, lobby, and link women to private partners to market their value-added milk products. Similarly, in our study area, one way to overcome these challenges would be to organize the women into groups. Studies show that where patriarchal norms interfere with or limit women's entrepreneurship, especially in rural areas, groups could provide an option (Semkunde et al., 2022). However, the men in the study area were found to be against forming these associations. Exploring these issues through participatory dialogues could be a way of addressing some of these negative cultural norms hindering a gender-aware milk value chain. Considering the amount of money or rewards women earn from the production of ghee, butter, and jelly, explaining these opportunity costs and sharing benefits may make men more willing to work together with women.

In summary, there were a number of limitations constraining women's participation in milk value chains in the study area. Women did not have access to enough milk for value addition. On the other hand, men concluded that women did not share the benefits of the sale of ghee and butter despite purchasing milk from them. The effort toward value addition, such as churning, was limited due to the tedious, laborious traditional technology available. Churning was done to separate butter fat using simple gourds. Women handling big milk volumes complained of chest pains and fatigue due to the energy required during the churning process. Seldom occupational hazards are included in the discussions on gender and milk value addition. There is a need to design and introduce appropriate household labor-saving technology for churning in this area.

Conclusion

The presented findings underscore the central role of women and girls in crucial aspects of the milk production process, encompassing milk processing, water provision, sanitation, hygiene practices, and value addition. Conversely, men primarily focused on milking cows and held decision-making authority regarding milk consumption within households, with the selling of milk under their control. Despite women's pivotal involvement, challenges arise from limited support, insufficient information, and knowledge, particularly in appreciating the significance of value addition. The absence of energy-efficient technology poses occupational hazards, particularly for women.

The implications call for targeted support initiatives, emphasizing training, capacity building in milk value addition, credit access, and financial assistance. Such interventions could enhance negotiating skills among women and foster constructive dialogues with men. The acknowledgment and positive engagement of men in supporting and marketing women-produced milk could potentially lead to increased ghee and butter production, contributing to elevated household incomes. Future ethnographic studies are recommended to delve deeper into socio-cultural contextual factors, paving the way for informed interventions and a more comprehensive understanding of the dynamics at play.

Data availability statement

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

Ethics statement

This study obtained ethical approval from Makerere University, School of Veterinary Medicine and Animal Resources, Research Ethics Committee (MAKSVAR REC) under the protocol number #SVAR-IACUC/99/2021.

Author contributions

JN: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. MO: Supervision, Writing – review & editing. ER: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Writing – review & editing. AA: Conceptualization, Formal analysis, Methodology, Writing – review & editing. LC-K: Conceptualization, Formal analysis, Methodology, Writing – review & editing.

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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.

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References

Abera, H., and Mideksa, T. (2020). Tradition processing, handling and mitigation systems of milk and milk products in the Nekemte milk shed of Ethiopia. *Glob. Vet.* 22, 149–159. doi: doi: 10.5829/idosi.gv.2020.149.159

Amenu, K., Agga, G. E., Kumbe, A., Shibiru, A., Desta, H., Tiki, W., et al. (2020). Milk symposium review: community-tailored training to improve the knowledge, attitudes, and practices of women regarding hygienic milk production and handling in Borana pastoral area of southern Ethiopia. *J. Dairy Sci.* 103, 9748–9757. doi: 10.3168/jds.2020-18292

Dohoo, I. R., Martin, W., and Stryhn, H. (2003). Veterinary epidemiologic research. Charlottetown, PE: Canada.

Eshetu, M., Seyoum, M., and Mummed, Y. Y. (2019). Milk production, marketing practices and qualities along milk supply chains of Haramaya District, Ethiopia. *Afr. J. Agric. Res.* 14, 1990–2005. doi: 10.5897/AJAR2019.14087

Grace, D., Roesel, K., Kanggethe, E., Bonfoh, B., and Theis, S. (2015). Gender roles and food safety in 20 informal livestock and fish value chains (Vol. 1489): Social Science Electronic Publishing presents Social Science Research Network Available at: https://www.ifpri.org/publication/gender-roles-and-food-safety-20-informal-livestock-and-fish-value-chains.

Katimbo, A., Sempiira, J. E., Mugisa, D. J., and Kisaalita, W. S. (2017). Ghee consumption in Uganda. *Afr. J. Food Agric. Nutr. Dev.* 17, 11771–11786.

Katothya, G. (2017). Gender assessment of dairy value chains: evidence from Kenya. Gender assessment of dairy value chains: Evidence from Kenya. Rome: FAO.

Kumar, R., Devi, I., Meena, R. L., and Kumar, A. (2021). Role of farm women in animal husbandry of semi-arid Rajasthan. *Indian J. Small Rumin.* 27, 118–122. doi: 10.5958/0973-9718.2021.00015.5

Manisha, M., and Satpathy, B. (2022). Participation of farm women in dairy keeping-a case study of Bihar. *Vigyan Varta* 3, 31–33. Available at: https://www.vigyanvarta.com/adminpanel/upload_doc/VV_1022_09.pdf

Monitor (2020). Dairy farmers struggle to find market for their milk. Special Report, March 17, 2020. Available at: https://www.monitor.co.ug/uganda/special-reports/dairy-farmers-struggle-to-find-market-for-their-milk-1880968.

Mossie, H. (2019). Review on traditional handling, processing and marketing of milk and its derivative in Ethiopia. *Dairy Vet. Sci. J.* 13:555874. doi: 10.19080/JDVS.2019.13.555874

Naz, S., Arif, M., and Ali, A. (2022). Women's participation and its determinants in livestock management across the developing world: a systematic review. *Sarhad J. Agric.* 38, 383–396. doi: 10.17582/journal.sja/2022/38.5.383.396

Njuki, J., and Sanginga, P. (2013). "Gender and livestock: key issues, challenges and opportunities" in Women, livestock ownership and markets. Eds. N. Jemimah and C. P. Sanginga (London: Routledge), 21–28.

Parsons, I., and Lombard, M. (2017). The power of women in dairying communities of eastern and southern Africa. *Azania Archaeol. Res. Afr.* 52, 33–48. doi: 10.1080/0067270X.2016.1249589

Quisumbing, A., Heckert, J., Faas, S., Ramani, G., Raghunathan, K., and Malapit, H. (2021). Women's empowerment and gender equality in agricultural value chains: evidence from four countries in Asia and Africa. *Food Secur.* 13, 1101–1124. doi: 10.1007/s12571-021-01193-5

Quisumbing, A., Rubin, D., Manfre, C., Waithanji, E., van den Bold, M., Olney, D., et al. (2015). Gender, assets, and market-oriented agriculture: learning from high-value agriculture and livestock projects in Africa and Asia. *Agric. Hum. Values* 32, 705–725. doi: 10.1007/s10460-015-9587-x

Raney, T. (2011). The state of food and agriculture. *Women in agriculture: Closing the gap for development*, *2*. Rome: FAO Available at: https://www.fao.org/uploads/media/Raney_SOFA.pdf.

Semkunde, M. A., Elly, T., Charles, G., Gaddefors, J., and Chiwona-Karltun, L. (2022). Rural entrepreneurship and the context: navigating contextual barriers through women's groups. *Int. J. Gend. Entrep.* 14, 213–234. doi: 10.1108/IJGE-01-2021-0013

Sennuga, S. O., Lai-Solarin, W. I., Adeoye, W. A., and Alabuja, F. O. (2022). Extension's role in improving livestock production: information needs, institutions and opportunities. *Int. J. Agric. Nutr.* 4, 43–51. doi: 10.33545/26646064.2022.v4.i2a.80

SPRING (2014). "Strengthening partnerships, results, and innovations in nutrition globally" in *Understanding the Women's empowerment pathway.* Brief 4. Improving nutrition through agriculture technical brief series (Arlington, VA, US: USAID/SPRING).

Stites, E., and Mitchard, E. (2011). Milk matters in Karamoja: Milk in children diet and household livelihoods. Feinstein International Centre: Tufts University Available at: https://fic.tufts.edu/assets/Milk-Matters-in-Karamoja.pdf.

Yurco, K. (2022). Pastoralist milking spaces as multispecies sites of gendered control and resistance in Kenya. *Gend. Place Cult.* 30, 1–22. doi: 10.1080/0966369X.2022.2067522

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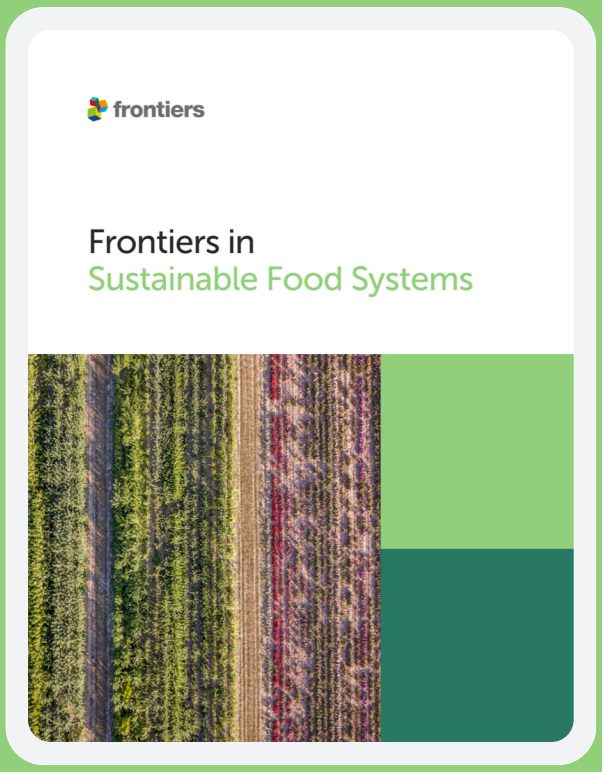

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