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Exploration of gender dynamics in the production and marketing of forage technologies in Kenya

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Inadequate and poor-quality feed resources are a key constraining factor in livestock production that compromises the livelihoods of many women and men dependent on livestock, who can be found in most low- and middle-income countries (LMICs). Several forage varieties have been developed, which are targeted to smallholder farmers in developing countries, yet the level of adoption remains low, particularly among women farmers. Adoption of varieties could enhance livelihoods by increasing livestock productivity and also by providing an income from the sale of surplus forage. However, evidence on gendered barriers to and incentives for the adoption of forage varieties is scarce. This study explores the gender dynamics influencing the uptake and commercialization of a forage variety, *Brachiaria* (syn. *Urochloa)*, among women and men farmers in four subcounties in Kenya. Through a mixed-methods approach, 260 individuals (59 women and 201 men) belonging to a household where at least one individual is a member of a dairy cooperative were interviewed. Complementary data from qualitative interviews engaging 16 single-sex focus group discussions (FGDs) and 8 key informant interviews (KIIs) were collected. Results reveal that *Brachiaria* is accessible to both women and men. Dairy cooperatives are important means for women and men to access extension services, useful information, and planting materials, but only a few women are cooperative members. Men face constraints owing to small land areas, rather than the ownership and access problems that constrain women. These challenges privilege men as *de facto* owners of resources while subordinating women and disenfranchising them in terms of adopting this technology. Complex yet important pathways for women's and men's empowerment exist through the sale of planting materials, hay bales, and an increased volume of milk obtained when cows are fed with *Brachiaria*. We conclude that cooperative membership for men should be supported, while at the same time gender norms that reduce women's engagement with cooperatives, and their access to and control over land, should be challenged.

KEYWORDS

forage improvement, gender, Kenya, *Brachiaria*, marketing

1 Introduction

Livestock is an important asset for the livelihood of farmers in low- and middle-income countries (LMICs) and has the potential to empower women through the multiple roles involved in livestock production (Galiè et al., 2015). This is in line with Sustainable Development Goal (SDG) 5 on "Women's Equality and Empowerment" (UN Women, 2019). In the last decade, the discourse on women's empowerment (WE) in livestock production has gained interest among researchers and development partners, and research to establish the link between the two has intensified (Price et al., 2018; Galiè et al., 2019; Baltenweck et al., 2021; Baltenweck et al., 2022). Some of the documented pathways to realize WE through livestock production include women's livestock ownership and management; women's participation in the livestock market and the commercialization of live animals, animal products, and animal inputs; and the opportunity for women to control and make decisions over these products and over the income generated from their sale (Njuki & Sanginga, 2013). For example, women often sell surplus eggs and milk and control the generated revenues, which they can use to meet their own or their household's needs (Njuki and Sanginga, 2013; Tavenner et al., 2021).

This potential is, however, threatened by insufficient and poor-quality feed in LMICs, which limits livestock productivity and the ability of livestock keepers to sell surplus products and earn a living. Quality forages are needed to provide the nutrients and fiber essential for increased livestock production, enhanced body-weight gain, efficient reproduction, and possibly increased income from the sale of livestock and livestock products (Balehegn et al., 2020). Uptake of cultivated forages by farmers is being increasingly promoted by governments and development organizations in collaboration with research institutions (Nguku et al., 2016; Njarui et al., 2016; Maina et al., 2020) as one way of addressing the problem of livestock feed scarcity. *Brachiaria* is a valuable alternative to Napier grass, the dominant forage grass in Kenya (Maass et al., 2015). *Brachiaria* is reputed for its high regeneration potential of up to 7–10 times annually, high biomass, palatability, and drought tolerance. It can enhance the income of smallholder farmers through the sale of both produced milk and excess forage (Maina et al., 2020).

Little is known about women and men farmers' access to and adoption of *Brachiaria*. Research has shown that agricultural technologies, such as plant varieties, are often developed with a focus on enhancing productivity and may fail to cater to the different and gendered needs of various types of farmers (Teklewold et al., 2020; Neway & Zegeye, 2022). Gender-blind plant breeding is unlikely to result in varieties that fully reflect the needs of women farmers or that benefit poor women and men equally (Ragasa, 2012). This is one of the reasons why women farmers are generally less likely to adopt plant varieties than men in their communities (Radović-Marković et al., 2020). Similarly, research shows that forage variety improvement pays little attention to gendered differences in trait needs and priorities, gendered constraints to adoption, the gender dynamics that affect such adoption, and the ability of women to benefit from growing the varieties (Balehegn et al., 2020; Harris-Coble et al., 2022; Njuguna-Mungai et al., 2022).

This study explores the gender dynamics influencing *Brachiaria* uptake and commercialization among women and men farmers and members of dairy cooperatives in four subcounties in Kenya using the framework of empowerment. Specifically, the study (i) assesses the rate of adoption and commercialization of *Brachiaria* among women and men farmers, (ii) analyses the determinants of adopting *Brachiaria* among women and men farmers, (iii) examines the power relations among women and men in the context of feed technology, and (iv) explores how the adoption of feed technologies contributes to women's economic empowerment.

Gender is understood as the characteristics of women, men, boys, and girls that are socially constructed by society (Johnson, 2020)—affected by other individual characteristics such as marital status and ethnic group—and shape an individual's behavior, their access to resources, and opportunities. Gender relations are the social relations and power dynamics between women and men in both private and public spheres (Kabeer, 2009). Gender relations are affected by and, in turn, affect gender norms. Gender norms are the social rules and expectations that govern the behavior of individuals and restrict their gender identities to what is considered to be appropriate (Agarwal, 1997). We define WE as a process of change in terms of the ability of women to make meaningful and strategic life choices and act to reach preferred results (Kabeer, 2009).

The following sections cover the study's method, followed by the study findings, discussion, conclusion, and recommendations. We organize our results starting with the socioeconomic profile of the study participants, then focus on *Brachiaria* establishment and commercialization. This is followed by power relations among women and men farmers in the context of forage technologies, and then by the factors influencing farmers' decision to adopt *Brachiaria*. Finally, we focus on opportunities for and constraints to benefiting from forage technologies. In the discussion section, we expound on how the gender dynamics that affect *Brachiaria* adoption and commercialization relate to empowerment.

2 Materials and methods

2.1 Study area

This study was carried out in four subcounties in Kenya (Figure 1) that were selected owing to their high potential for commercialized dairy production, which is associated with the likelihood of households cultivating forage. Such potential stems from favorable climatic conditions that support crop and livestock production as the primary source of livelihood (County Integrated Development Plan, 2017; National Drought Management Authority, 2020). Each subcounty had some active dairy cooperatives through which a development project, the Accelerated Value Chain Development, implemented by ILRI (Auma et al., 2018), promoted the adoption of *Brachiaria* technology by smallholder farmers. The project supplied the planting materials and piloted a private agricultural extension

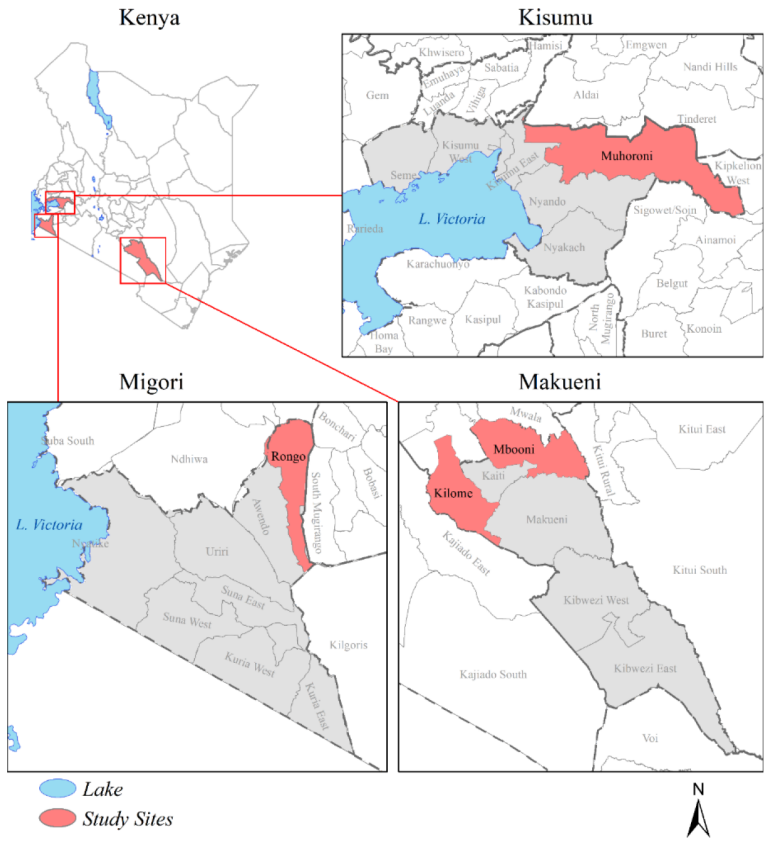

FIGURE 1
Map showing the study site locations in Kenya.

model that uses dairy farmer assistants (DFAs) attached to each dairy cooperative. Under each DFA, community mobilizers were issued with *Brachiaria* seeds for propagation, followed by dissemination to farmers in their respective villages. Anecdotal evidence from the project implementers revealed a disparity in *Brachiaria* adoption levels across the study subcounties (Muhoroni, Rongo, Mbooni, and Kilome), as well as in feed commercialization in Mbooni and Kilome, which have a relatively dry climate.

2.2 Study design and sampling

Gender-sensitive mixed-methods research, with both quantitative and qualitative research designs, was applied to gain a more complete and contextually significant picture of the topic under investigation (Bonis-Profumo et al., 2022). Both study components were conducted concurrently between November/December 2019 and February/March 2020.

2.2.1 Quantitative research method

The quantitative method used in this study is grounded in a positivist paradigm (Alharahsheh and Pius, 2020). We implemented a quantitative survey using a predesigned questionnaire to assess the rate of *Brachiaria* technology adoption and commercialization and to further identify determinants of *Brachiaria* adoption by households in which at least one person (either the household head or the spouse) was a cooperative member. The study employed a multistage sampling technique to select a random sample, guided by the sampling formula provided by Cochran for proportions of large samples with unknown variability (Cochran, 1963). A total of 260 individuals (59 women and 201 men) were randomly selected from a list of all dairy cooperative members, whether men or women, provided by the DFA (Table 1). A questionnaire was administered to the household head; in their absence, an adult woman or man (above 18 years of age) was interviewed.

2.2.2 Qualitative research method

The study adopted an exploratory research design underpinned by a qualitative approach and situated in the interpretivism paradigm (Alharahsheh and Pius, 2020) to obtain in-depth details and new insights on the study topic. Focus group discussions (FGDs) were the primary method of data collection, guided by semistructured interview questionnaires. With the support of DFAs, we purposively selected research respondents following the study selection criteria: (i) women and men from households with membership of a local dairy cooperative and (ii) farmers of *Brachiaria* varieties (whom we call "adopters") or farmers who did not grow any *Brachiaria* variety (whom we call "non-adopters"). By including both *Brachiaria* adopters and non-

TABLE 1 Research questions and tools used.

Research question	Tool used	Respondents			
		Location	Adopters (*n*)	Nonadopters (*n*)	Total (*n*)
Rate of adoption and commercialization of *Brachiaria*	Household survey	Muhoroni	FHH = 8 MHH = 26	FHH = 1 MHH = 22	260
		Rongo	FHH = 9 MHH = 20	FHH = 15 MHH = 22	
		Kilome	FHH = 2 MHH = 18	FHH = 6 MHH = 45	
		Mbooni	FHH = 5 MHH = 21	FHH = 13 MHH = 27	
Analysis of determinants of adopting *Brachiaria*	Household survey	Total of 260 respondents for the four study subcounties as above			
Examination of power relations among women and men	FGDs and KIIs	69 women (34 adopters, 35 non-adopters) and 59 men (23 adopters, 36 non-adopters) for a total of 128 participants			
How the adoption of feed technologies contributes to women's economic empowerment	FGDs and KIIs	69 women (34 adopters, 35 non-adopters) and 59 men (23 adopters, 36 non-adopters) for a total of 128 participants			

adopters, we aimed to compare what influenced and facilitated the adopters to take up *Brachiaria* technology with what barriers non-adopters faced that prevented adoption. We conducted 16 single-sex FGDs: one each with adopting and non-adopting women and one each with adopting and non-adopting men in each study site. Each FGD had between 5 and 15 participants, totaling 69 women (34 adopters, 35 non-adopters) and 59 men (23 adopters, 36 non-adopters) for an overall total of 128 participants. The gender issues explored included activity profiles; perceptions of the attributes of *Brachiaria*; access to and control over resources; and benefits, constraints, and opportunities, and their influence on the decision of whether or not to adopt *Brachiaria*. Our study explored the inter-household gender dynamics and perceptions of female-headed households (FHHs) and male-headed households (MHHs) to understand the gender dynamics surrounding the adoption of *Brachiaria*.

In addition, key informant interviews (KIIs) were conducted with the subcounty livestock production officers, DFAs, and leading farmers in *Brachiaria* production and commercialization to corroborate information gathered from the FGDs and to provide additional nuanced information on social relations and their effects on technology adoption. We conducted a total of eight KIIs with two livestock production officers (one woman and one man), two DFAs (one woman and one man), and four leading *Brachiaria* adopters (four men: there were no leading women *Brachiaria* farmers in any of the study sites). The lead author conducted all the FGDs and KIIs in person, assisted by one temporarily hired and trained research fellow. The number of KIIs was guided by the principle of data saturation (Saunders et al., 2018), and interviewing was stopped when saturation, with no emergent new information, was achieved.

During the study, the confidentiality and anonymity of all study participants was assured. This study received ethical approval from ILRI's Institutional Ethics Committee (Ref. ILRI-IREC 2019-47).

2.3 Data analysis

2.3.1 Quantitative data analysis

To evaluate the determinants of the adoption decision, a logistic regression model was used to assess the association between the binary adoption outcome and factors with the potential to impact it, including demographic, geographic, socioeconomic, institutional, and technology-related attributes. In technology adoption, a farmer's decision to adopt can be described as a binary outcome —to adopt or not adopt. Therefore, the dependent variable, adoption, is a discrete variable that informed the choice of a discrete model. Therefore, a binary logistic model was used in this study, which is popular among other adoption studies (Conteh et al., 2015). A household will adopt *Brachiaria* if the utility derived is higher than that of non-adoption. As we can only observe a household's actual choice and not the derived utility, we therefore specified the logistic model in its linear form as:

$$y(0,1) = \beta_0 + \beta_i x_i + E_i \quad (1)$$

where y is a binary dependent variable taking the value of 1 when a household adopts *Brachiaria* and 0 otherwise, β_0 is the intercept, x_i is a vector of the household's socioeconomic and environmental factors, β_i is a vector of the respective coefficient parameters, and E_i is the error term. The study hypothesized that factors likely to influence adoption decisions include land ownership and access (+); extension support (+); the number of dairy animals owned (+); and respondents' demographic characteristics, such as education (+/–), age (+), gender (+/–), occupation (+/–), sources of income (+/–), and ability to take a decision (+/–) (Melesse, 2018). In parenthesis, we indicate the expected direction of influence, positive (+) or negative (–), based on the literature.

The study further reports marginal effects on the estimated logistic model to better interpret the model—i.e., using the

probability scale and not the odds scale. In the probability scale, all the effects are non-linear because, conditional on covariate values, the probability must be bound between 0 and 1. The logistic model used in the study is the log-odds, but we interpreted the model in the probability scale. The log-odds are expressed as:

$$log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 x \quad (2)$$

Solving for p to go from log-odds to probability, we get:

$$p = \frac{e^{\beta_0 + \beta_1 x}}{1 + e^{\beta_0 + \beta_1 x}} = \frac{1}{1 + e^{-}(\beta_0 + \beta_1 x)} \quad (3)$$

The logistic regression model was estimated using the Stata® (StataCorp LP, College Station, TX, USA) computer package.

2.3.2 Qualitative data analysis and interpretation

Qualitative data collected were transcribed and translated into English. Coding, based on predetermined and emerging themes, was carried out using QSR International's (Warrington, UK) NVivo 11 software. The findings were then organized and analyzed inductively based on emerging themes. For example, gender norms emerged during the FGDs without the authors having explored them intentionally.

3 Results

The findings from the explanatory study are presented first, then corroborated and integrated with those from the exploratory study. We begin with a characterization of study participants; followed by a characterization of forage production, with a focus on *Brachiaria* adoption in terms of preferences, constraints, and benefits; and lastly, we present the discussion, conclusion, and recommendations.

3.1 Characterization of study participants

Most surveyed respondents came from MHHs (77%), with 23% from FHHs. Sampled households had at least one member registered in the dairy cooperative. Overall, 260 households were surveyed; of them, 109 were adopters of *Brachiaria* (24 FHHs and 85 MHHs) and the rest were non-adopters (35 FHHs and 116 MHHs). Rongo had the highest number (9.2%) of FHHs, whereas only 3.1% of respondents in Kilome were from FHHs (Table 2). The majority (61.2%) of the study respondents were household heads (20% female heads and 41.2% male heads). The other respondents were either spouses (28.1% with 27.7% men and 0.4% women), adult children (7.7% young man/young woman above 18 years of age, the age where adulthood begins in Kenya), or other household members (3.1% either a close relative or a non-relative).

Overall, more MHHs (22% of adopters and 25% of non-adopters) than FHHs (4% of adopters and 6% of non-adopters) engage in non-agricultural activities. Women mostly work on family farms and engage in mixed farming (Figure 2). Food crops, such as maize, beans, green gram, and mung bean, are grown by women, whereas cash crops, such as sugarcane and fruit trees, are grown by men. These results were corroborated by qualitative findings, which indicated that women often engage in on-farm activities for their livelihood. Commonly reared animals are cattle, sheep, goats, and chickens, with the majority (94%) of respondents rearing cows that have calved at least once (96.61% of FHHs and 92.04% of MHHs), with the next most popular livestock being heifers (51% of households; 52.54% of FHHs and 50.25% of MHHs), followed by female calves (40.68% of FHHs and 33.83% of MHHs). Bulls were slightly more popular among MHHs (29.85%), only being raised by 11.86% of FHHs. Forage and food crops were commonly termed as the "women's crops for subsistence", whereas cash crops were for men. Men in Muhoroni and Rongo consider sugarcane as their valued cash crop and more important than any other crop or livestock. Approximately three-quarters of the land

TABLE 2 FHH and MHH households surveyed.

Subcounties		Adopters		Non-adopters		Total number
		Number	Percentage	Number	Percentage	
Muhoroni	FHH	8	23.5	1	4.4	**9**
	MHH	26	76.5	22	95.7	**48**
Rongo	FHH	9	31	15	40.5	**24**
	MHH	20	69	22	59.5	**42**
Kilome	FHH	2	10	6	11.8	**8**
	MHH	18	90	45	88.2	**63**
Mbooni	FHH	5	19.2	13	32.5	**18**
	MHH	21	80.8	27	67.5	**48**
Total	**FHH**	**24**	**40.68**	**35**	**59.32**	**59**
MHH	**85**	**42.29**	**116**	**57.71**	**201**	**260**

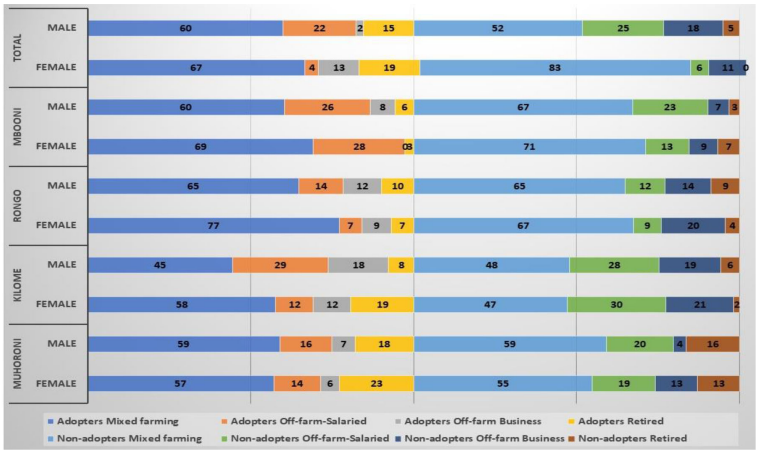

FIGURE 2
Occupation of the study participants.

grows sugarcane, whereas the rest is occupied by the homestead, with little or no space left to grow forage and food crops. In Mbooni and Kilome, mango and orange trees are "crops for men". Regarding marital status, the majority (> 90%) of male and female respondents, as self-identified, were married.

FHHs had less access to extension services than MHHs. More adopters (83.33% of FHHs and 84.71% of MHHs) than non-adopters (54.29% of FHHs and 62.07% of MHHs) had access to extension services (Figure 3), with a chi-squared test further confirming that the differences between the two sets of proportions were statistically significant (chi with one degree of freedom = 20.2836; $p = 0.000$). The qualitative results revealed that both women and men have access to extension services in principle, through which training and information are disseminated.

Cooperatives are important avenues for accessing inputs, credit, information, and a market for products. Overall, dairy cooperative membership comprises 75% men and 25% women, of which 5% are aged between 18 and 35 years. The men, as registered members, commonly attend important cooperative meetings, but for meetings that they deem less important or when they are engaged with other commitments, they ask their spouses, the women, to attend instead.

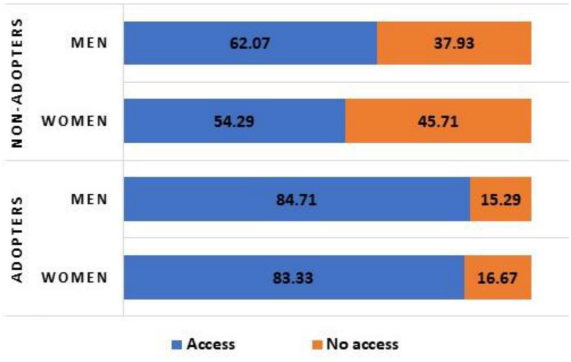

FIGURE 3
Access to extension services.

Women and men with higher education levels have a higher rate of *Brachiaria* adoption. Often men have higher education levels than women, which is reflected in men's slightly higher adoption rate. More adopters (82%) than non-adopters (54%) had attained at least a secondary school level of education. *Brachiaria* adoption rate is low (see below) in study areas where women have low education levels. Adopters in Muhoroni had relatively higher levels of formal education, with 60% of FHHs and 53% of MHHs having at least a college education, in contrast to their counterparts in the other three subcounties. Men in Rongo often had a lower level of education, with 47% of them attaining at most a primary school level of education, compared with 18% of men in Muhoroni. Similarly, most women from Rongo (43%) had at most a primary-level education, and 9% were illiterate (Figure 4). The gender of the respondents and their education level had a statistically significant relationship (chi with degrees of freedom = 26.2573; $p = 0.000$), with men having higher levels of education than women.

3.2 Characterization of forage production

3.2.1 Forage crops cultivated

The study assessed the crops and feed materials grown by households for livestock feeding. Napier grass was most commonly produced (56% of FHHs and 55% of MHHs), followed by *Brachiaria* (41% FHHs and 42% MHHs), which was a recent introduction. There was no significant difference between FHHs and MHHs. These two forage types are grown as "cut and carry" forage. Pasture–ley grasses, forage shrubs, and forage legumes [i.e., greenleaf desmodium (*Desmodium intortum*) and lucerne (*Medicago sativa*)] were produced in only 7% of FHHs and 9% of MHHs (Table 3).

3.2.2 Women and men's roles and responsibilities in forage production

Women in all the study sites are traditionally assigned the roles of forage harvesting, transporting crops home, and feeding the

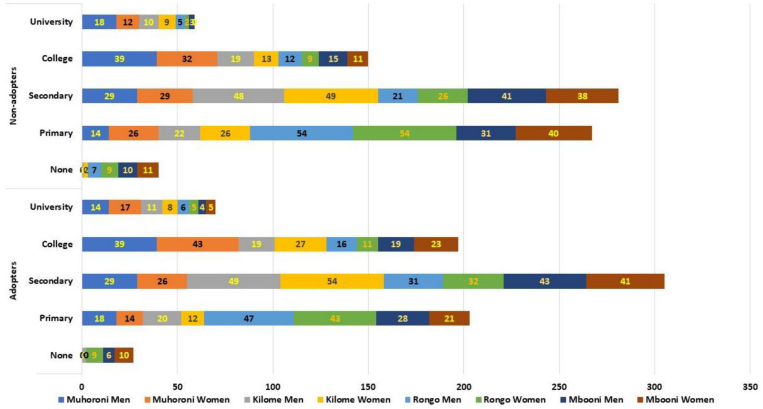

FIGURE 4
Levels of education.

animals. Less than one-third of men, both husbands and workers, in Muhoroni and Rongo harvest and carry forage. Men mostly prepare the land and handle the planting, whereas transplanting, weeding, and forage gathering and its utilization is often assigned to women (Table 4). Women also engage in milking, milk delivery to the dairy cooperative, chicken feeding, and egg collection. During weekends and school holidays, children help with some of the chores. Boys and, in a few instances, girls help the women harvest forage, collect eggs, feed the chickens, and deliver milk to the dairy cooperative. The FGDs revealed some gender stereotypes behind labor patterns. These include men considering women to have strong and flexible backbones, which enable them to bend, and harvest forage and transport it. Women mentioned some gender norms around such labor patterns: men generally find it shameful to transport forage because carrying forage would undermine the image of a man's power in the eyes of his community; also, men do not engage in low-profit activities, such as forage carrying, but prefer high-revenue off-farm activities.

Some of the gender norms discouraging men from carrying forage were expressed by two women in FGDs:

Men like to relax; it is challenging to find a man carrying forage. They view it as a shameful activity. Other men will perceive such a man as weak and one whom his wife oppresses. They think it is not befitting for them to carry forage. (FGD woman, Mbooni subcounty, March 2020)

Older women said that, although it is shameful for men to carry forage, they hire young men to harvest and carry forage because of their physical strength, as explained by one woman KII:

I can say it is culture [that dictates that women carry forage …] but then I can say cutting forage like this Napier grass is heavy. Young men are stronger than me. I must call them to come and help […]. My husband is not involved in this work. I have to make him breakfast because he is still with the government. So, when the young man I hire brings the forage [home], I start feeding the cows; there is no sitting down, and there is no time to go to other homesteads to gossip. You are busy until evening. That is why you need the youth to come and help you to harvest. (KII woman, Rongo subcounty, February 2020)

3.2.3 Focus on *Brachiaria* adoption: preferences, constraints, and benefits

3.2.3.1 Rate of adoption and preferences

The FHHs had a slightly lower rate of adoption (40.7%) than the MHHs (42.3%), with no significant difference in their means (p = 0.6463). The overall adoption rates among the subcounties were significantly different (chi with three degrees of

TABLE 3 Forage crops grown.

Forage crop		Percentage
Napier	FHH	55.9
	MHH	54.7
Brachiaria	FHH	40.8
	MHH	43.1
Pasture–ley grass	FHH	6.8
	MHH	8.5
Other forage	FHH	11.9
	MHH	15.4

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TABLE 4 Participant's activity profile relating to dairy production, forage production, and utilization.

Activity		Who mostly implements the activity				
		Women	Men	Girls/boys (children)	Employee	
					Female	Male
Preparing land		Sometimes	x	Sometimes		x
Planting		x	x	Sometimes	x	x
Weeding		x		Sometimes	x	x
Harvesting forage		x	Sometimes	x	x	x
Carrying harvested forage		x				
Feeding and management of cattle		x	Sometimes	x		
Milking		x	Sometimes			x
Feeding and management of poultry		x	Sometimes	x		x
Selling the produce	Milk	x	x			x
Cattle		x				
Shoats	x	x				
Traditional chicken	x					
Commercial chicken	x	x				
Constructing animal houses			x			x
Collecting milk proceeds from the dairy cooperative		x	Sometimes			

Source: Focus group discussions with study participants.

freedom = 13.1561; p = 0.004); the highest was in Muhoroni (89% for FHHs and 54% for MHHs) and the lowest was in Kilome (25% for FHHs and 29% for MHHs). The adoption rate for FHHs in Rongo and Mbooni was 38% and 28%, respectively (Figure 5).

In general, the surveyed households have small areas of land, with an average of 0.72 acres. The FHHs have smaller land areas (0.46 acres) than MHHs (0.80 acres), which limits their adoption rate. Households in Kilome had the largest properties (1.46 acres), followed by Mbooni (0.65 acres), then Muhoroni (0.52 acres), and, lastly, Rongo (0.49 acres). In all study sites, land allocated to *Brachiaria* cultivation was smaller for FHHs (0.28 acres) than for MHHs (0.43 acres) (Table 5). Overall, few women and men grow forage on a dedicated plot. Commonly it is grown as a hedge or terrace in crop fields along contour lines to conserve soil and water. This limits the ability to increase the quantity of feed produced and compromises year-round feed availability:

I would like to produce [*Brachiaria*], but the limiting factor is land. (FGD woman, Muhoroni subcounty, November 2019).

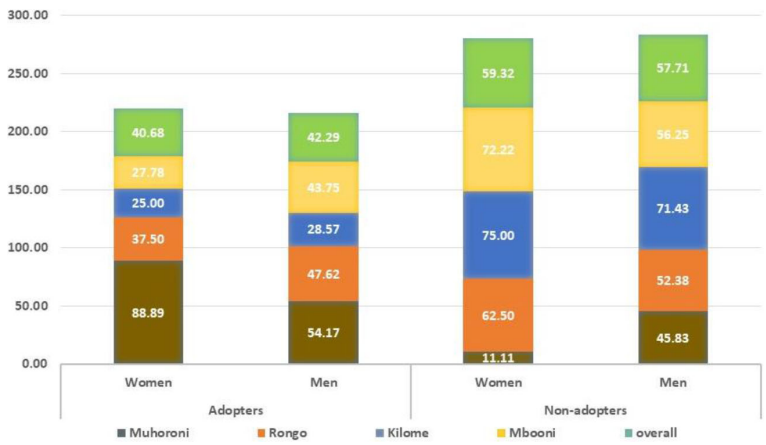

FIGURE 5
Rate of *Brachiaria* adoption.

TABLE 5 Average area of *Brachiaria* in the surveyed households.

Gender of household head	Mean area in subcounty (acres)				
	Muhoroni	Kilome	Rongo	Mbooni	Overall
FHH	0.52	0.15	0.18	0.12	0.28
MHH	0.48	0.58	0.29	0.38	0.43

We have planted *Brachiaria* on small portions of land since we have a challenge with land. (FGD man, Muhoroni subcounty, November 2019)

We enquired about gendered preferences for forage crops through the FGDs. *Brachiaria* is preferred by both women and men adopters, and it is much more frequently traded than other forage crops (67% FHHs and 56% MHHs) (Table 6). It was also evident among the KII traders that there is high demand for processed *Brachiaria* (in the form of hay) rather than silage because of its preservability and ease of transportation. Through the FGDs in Kilome and Mbooni, we also identified a preference for *Brachiaria* by both women and men adopters over food crops. Maize, beans, and vegetables were being replaced with *Brachiaria* because "milk has higher income", which can be used to purchase the grains and pulses. However, men prioritize cash crops over *Brachiaria*.

We further explored *Brachiaria* characteristics liked and disliked by women and men farmers. The women and men farmers mentioned their preferred characteristics according to their experience using the grass or what they had heard from neighbors, friends, and relatives. *Brachiaria* was assessed positively by both women and men in all the study subcounties because of (i) low labor intensity, (ii) high productivity, (iii) high palatability, (iv) resistance to drought and disease, and (v) ease of storage. However, respondents from Kilome, which is relatively drier, said that it is not drought tolerant. Low labor requirements were particularly important to women in all sites because *Brachiaria* suppresses weeds, so in turn women's traditional work of weeding was reduced. *Brachiaria* is preferred to other grasses because of its productivity: it is high yielding and increases milk production. *Brachiaria* is more palatable to cattle, which translates to higher productivity, as animals eat more. Farmers mentioned that it is resistant to pests and diseases and has high regeneration potential even with little rainfall. Finally, *Brachiaria* is easy to bale and store. In the words of two FGD respondents:

It [*Brachiaria*] kills the indigenous weeds, reducing our [women's] work. (FGD woman, Kilome subcounty, November 2019)

The roots are deep, so no other grass can grow … it is drought resistant, it regenerates quickly after harvesting, and it helps in soil conservation by preventing soil erosion. (FGD man, Mbooni subcounty, March 2020)

Additional attributes preferred by most women respondents include the lack of hairiness and non-stemminess, making it easier to harvest and transport. These characteristics were also mentioned by only a few men as being important. Some women FGD respondents argued that the *Brachiaria* variety they were growing had these characteristics, whereas less than one-quarter of the respondents said *Brachiaria* was hairy and stemmy. Women and men clearly expressed preferences for characteristics associated with the roles they played in managing the crop. Some had the right variety for their preferences, and some did not:

I know *Brachiaria* Basilisk, Mulatto, but I do not know where they came from. There is one that is smooth, and the other is hairy … I think [Basilisk] is the one that is hairy. I have planted both: one bench has Basilisk and the other bench has the other one. I only know this grass is *Brachiaria*. We have not been able to monitor … the first, *Brachiaria*, is a bit tough; one has to chop it for cows to be able to feed on it well. (FGD man, Mbooni subcounty, March 2020)

TABLE 6 Commercialization of *Brachiaria*.

		FHH percentage	MHH percentage	Overall percentage
Forage trading—main business		100	17	14
Source of traded forage	Self-produced	100	100	100
Forage type sold	Ley grass	33	17	10
	Napier	0	17	14
	Brachiaria	67	56	52
	Other	0	11	9
Forage business ownership	Sole ownership	100	78	
	Partnership	0	6	
	Group activity	0	11	
	Other	0	6	

In terms of the characteristics that respondents did not like about *Brachiaria*, although environmental resilience (*Brachiaria* does not dry completely and regenerates very fast even with little rainfall) was one of the positive attributes of *Brachiaria*, the poor growth rate was highlighted, particularly by respondents from Kilome and Mbooni, which are areas that experience dry and salty/saline environmental conditions. These conditions do not favor growth for most crops, including *Brachiaria*:

I planted *Brachiaria* splits and seedlings, but they dried off. The few that grew were retarded because of the salty water prevalent in our environment. (FGD woman, Kilome subcounty, December 2019)

The high demand for manure by the grass was also a concern for both women and men.

3.2.3.2 Factors that influence the adoption of *Brachiaria*

The study quantitatively evaluated the factors that influence women's and men's decisions to adopt the production of *Brachiaria* forage. Two models were estimated—one for FHHs and another for MHHs. Multicollinearity was tested before the estimation by evaluating the partial correlation coefficients between pairs of explanatory variables in the model. One of the variables was dropped when the partial correlation coefficients were too high (> 0.6 or< –0.6) between the two variables. Table 7 shows the results of the econometric model. The likelihood ratio (LR) chi-squared test (LR χ^2 = 46.70 for women and 90.19 for men, degrees of freedom = 12; p = 0.0000) for both models was statistically significant, indicating the suitability of the model for explaining adoption. Logistic results for FHHs and MHHs revealed a slight difference in some of the factors that influence the adoption decision.

For both women and men, four main factors were positively and significantly associated with the probability of adopting *Brachiaria* forage, but mostly at varying significance levels. These factors were ownership and access to resources (including land, lactating animals, and forage technology); access to services (including extension services); access to education; and low labor demand (e.g., method of land preparation). Other factors uniquely influenced either men's or women's adoption decisions. For example, how adopters got the planting materials and the sale of forage influenced MHHs only. Group membership positively and significantly influenced the FHHs' adoption decision. The significant variables (factors) are explained in detail below.

When analyzing ownership and access to resources, a woman's or man's land tenure status and ownership of lactating cows were considered independent variables for the logistic model. In general, married women lack access to and control over productive resources such as land, which constrains their rate of adoption. Land tenure (private, non-private leased, or communal) was positively associated with adoption (p< 0.05 for FHHs and p< 0.01 for MHHs). When a woman or a man privately owns the land, the probability of adopting *Brachiaria* increases by 36.10%. However, FGD respondents from all sites revealed gendered inequalities in land ownership, land management, and the right to sell land. Land ownership is considered to be for men in all the subcounties. Less than one-quarter of the women respondents owned land with the title deed in their names. FGD results revealed that land inheritance is a common means of owning land; traditionally, men and boys inherited property. Unmarried, separated, divorced, or widowed women (i.e., unmarried women) can acquire land with their income only, as explained by some men respondents:

TABLE 7 Factors influencing the decision to adopt *Brachiaria*.

Explanatory variables	Odds ratio		Standard error		*z*-value		Marginal effects
	MHH	FHH	MHH	FHH	MHH	FHH	
Main occupation (1 = mixed farming; 0 = otherwise)	1.34	0.13	0.59	0.18	0.67	−1.50	0.0693
Extension contact (access = 1; 0 = otherwise)	2.38	12.11	1.17	14.73	1.76*	2.05**	0.1932
Number of lactating cows	1.43	5.08	0.25	4.67	2.07**	1.77*	0.0839
Grow Napier grass	12.09	184.44	5.83	407.89	5.16***	2.36**	0.5245
Schooling years	1.17	1.57	0.07	0.30	2.59***	2.35**	0.0368
Household's land tenure (1 = private; 0 = otherwise)	11.13	44.84	11.27	93.61	2.38**	1.82*	0.3610
Method of land preparation (1 = manual; 0 = otherwise)	0.36	0.01	0.22	0.03	−1.66*	−1.88*	0.2486
Source of labor for land preparation (1 = family; 0 = otherwise)	0.83	0.21	0.36	0.22	0.42	-1.49	0.0431
Source of planting materials (1 = dairy cooperative; 0 = otherwise)	9.17	7.23	5.09	12.04	3.99***	1.19	0.5033
Group membership (1 = member; 0 = otherwise)	1.38	47.33	0.69	100.78	0.64	1.81*	0.0743
Engagement in sale of forage (1 = sell forage; 0 = otherwise)	6.90	108.87	7.01	2024.76	1.90**	0.25	0.4388
Constant	0.00	8.22	0.00	4.24	−4.47***	−2.72***	
Men: observations = 180, χ^2 = 0.0000; pseudo-R^2 = 0.3485. Women: observations = 58, χ^2 = 0.0000; pseudo-R^2 = 0.5837.							

*, **, and *** are significance levels: *p< 0.05, **p< 0.01, ***p< 0.001.

… men own ancestral land, but if a woman works hard and buys her own land, then she is the rightful owner of the land. (FGD man, Mbooni subcounty, March 2020)

Culturally land is owned by men. Upon marriage, women surrender land they might have owned before getting married to the man. There is no land owned by women, a woman might have bought land before you married her, but with time, she must transfer to your name … all the woman's property becomes mine once we get married. (FGD man, Kilome subcounty, December 2019)

The study further assessed the patterns of individual livestock ownership among FHHs and MHHs. This revealed the intra-household dynamics that have significant implications for the decision to adopt *Brachiaria*, a critical resource for livestock production. The rate of adoption for both FHHs and MHHs increases with an increase in the number of lactating animals, probably due to increased livestock resources and the subsequent high demand for feed. An increase in the number of lactating animals increases the probability of adopting *Brachiaria* for FHHs ($p< 0.05$) and for MHHs ($p< 0.01$) by 8.39%. The women FGD respondents added that an increase in lactating animals means more demand for feed/forage and, also, more work for the women who collect forages, as stated below:

The men have left everything to be done by women … it is like a donkey in the house. (FGD woman, Kilome subcounty, December 2019)

Although men are the owners of land and cattle, women own indigenous chickens, which are perceived to be of low economic value. The high cost of purchasing an animal (specifically a cow) was blamed for limiting women's ownership. Even with limited ownership rights, as it is a woman's responsibility to mostly fetch forage and feed the animals, women expressed the desire to grow forage grass. This would reduce the work of traveling far to fetch forage from community land or collect forage purchased from neighbors.

Access to services, such as extension services, social capital (such as group membership), and access to education and markets were assessed as valuable channels for accessing relevant information and influencing adoption decisions. Contact with extension services ($p< 0.01$) and group membership ($p<0.05$) positively and significantly influenced the decision to adopt *Brachiaria*. For men, only access to extension services was significant ($p< 0.05$). The probability of participating in *Brachiaria* production increases with access to extension services by 19.32% (for both women and men). In comparison, group membership increases the adoption decision for women by 7.43%.

When analyzing how labor affects adoption decisions, the model result shows that the manual land preparation method had adverse and significant effects on the adoption decision for women and men ($p< 0.05$). The probability of adoption increases by 24.86% with a shift from manual to mechanized or chemical land preparation methods. This is probably due to reduced workload, particularly for women who are overburdened with numerous other activities (both paid and unpaid, as discussed above). Most FHHs (85%) and MHHs (83%) prepare land manually; only a few have mechanized land preparation (15% of FHHs and 17% of MHHs), and only 0.38% of the respondents use herbicides as a land preparation method. FGD respondents indicated that dependence on family labor or both family labor and hired labor combined is common for land preparation. Most FHHs (51%) are dependent on family labor for land preparation, compared with 40% of MHHs, whereas 42% of FHHs and 50% of MHHs depend on hired labor (women and men employees). The others depend on a combination of hired labor and family labor.

We qualitatively explored the constraints the respondent farmers faced when wanting to adopt *Brachiaria*. Results from the FGDs revealed that both the women and the men are faced with land constraints: women lack land ownership, whereas men complained about the small area of land they owned. Persistent gender norms in the study communities restrict women from owning or renting land as men do. Men, on the other hand, complained that their ability to grow more *Brachiaria* and its commercialization are constrained by the small area of the land they own and the different uses of the land that compete for space. For example, most men in Muhoroni engage in sugarcane production, which occupies most of the family land. In three-quarters of the households, men have prioritized their crops, mainly the cash crops, and the rest of the land is occupied by the homestead, with little or no land left for women's crops, which are mostly the food crops. Men can afford to hire land, whereas women cannot, especially given that they do not seem to have cash crops as men do.

Overall, men make major decisions, and they must be consulted by women when decisions are made. The decision to adopt *Brachiaria* is subject to the existent decision-making patterns:

I went somewhere to a meeting and took *Brachiaria*, I did not consult my wife, I did not consult my mother, I just came and planted. But in case it is the woman who went to that meeting and heard the benefits of *Brachiaria*, she must convince me [her husband] that it is good before we collectively choose a place to plant it. (FGD man, Rongo subcounty, February 2020)

FGD respondents clarified that another challenge to the adoption of *Brachiaria* relates to access to the planting materials by women and men farmers. The commonly used planting materials were seeds, splits, and seedlings. Approximately one-quarter (25%) of *Brachiaria* adopters, mostly men, received *Brachiaria* planting materials directly through the dairy cooperatives, whereas women mostly sourced splits or seedlings from fellow farmers, owing to their group membership. However, it was highlighted that access to *Brachiaria* planting materials was a challenge, particularly among non-adopters who said, "for non-cooperative members, it is difficult to access *Brachiaria* seeds":

I started with *Brachiaria* in 2017 when ILRI and Heifer International brought seeds to a group where I was a member. We were 30 [members] but only four were given the seeds, I was not among them. I borrowed some seeds from the other members, and I was given *Brachiaria* 'Xaraes' [one of the varieties]. (KII woman, Rongo subcounty, February 2020)

3.2.3.3 Benefiting from *Brachiaria*

We sought to understand the potential benefits that can accrue from the uptake of *Brachiaria* technology for a woman and a man, because this might influence the adoption decision. An increase in milk production was a benefit reported by women and men FGD respondents when an animal was fed with this grass. Farmers mixed *Brachiaria* with other feed (either Napier grass, wild grasses, or concentrates), making it difficult to determine the effects of *Brachiaria* on milk production. However, more than three-quarters of the FGD and all the KII respondents reported an increase in produced milk by approximately 2–8 L of milk (an approximately 40% to 80% increase) when *Brachiaria* was part of the dairy cattle diet:

Generally, this grass is good, you get a bumper harvest, and it increases milk production. It also makes you feel proud … when you have a lot of grass, everyone with dairy cows will look for you … it is resistant to termites, common during the dry spell … milk production has increased and the cost of dairy meal reduced by half … I have transformed my farm to a registered forage model farm where I charge access and training fee to individuals and groups who visit to learn about *Brachiaria* production. (KII male farmer, Makueni County, December 2019)

Another benefit highlighted by participants, which they noticed when animals were fed on *Brachiaria*, was the expediated expression of heat signs (estrus) and improved body condition (smooth skin).

Increased income and reduced cost of production (in terms of labor needed to weed the grass and the cost of buying concentrates) were highlighted by women and men as benefits reaped from the production of *Brachiaria*. The quantity of concentrates fed to an animal (lactating animal) reduces by half when an animal is fed *Brachiaria*, yet an increase in milk production is evident.

Respondents said that the production of *Brachiaria* could offer an opportunity for a woman or a man to become an entrepreneur. Approximately three-quarters of women include the sale of milk as a source of income from *Brachiaria*, whereas approximately one-quarter of men said they received income from selling *Brachiaria* seedlings and splits. The cost of splits was approximately US$10 for a 90-kg bag, whereas the retail price of a seedling is approximately US $0.05. Survey results revealed, however, a modest sale of the grass in the form of seedlings or splits. Overall, only 21 (8.08%) out of 260 participants sell forage of any type. Among *Brachiaria* adopters, only two (8.33%) FHHs and 15 (17.65%) MHHs sell forage (Figure 6). However, the difference in the proportion of forage traders between FHHs and MHHs is not statistically significant.

The potential earnings from the sale of *Brachiaria* seedlings and splits were explained by a man involved in a KII:

One day my son wanted school fees, so I decided to sell. I got 25 bales of *Brachiaria* 'Xaraes' and sold them for US$170. I realized *Brachiaria* had money, so I decided to expand … It has been giving me approximately US$250 per month … I grow seedlings and sell them. I have earned US$400 from that … this has made me do away with cereals. I sell forage and buy grains, and I can still pay school fees … Seeds are not locally available. (KII man, Rongo subcounty, February 2020)

All FHHs and 78% of MHHs that sell *Brachiaria* operate their forage business on their own or are solely assisted by their spouse, a family member, or a hired worker (who are often men).

Another business opportunity that *Brachiaria* can provide for farmers is, according to FGD respondents, the ability to train other farmers about the grass, as was the case with one man from Makueni county, who has commercialized *Brachiaria* production and engaged in all three activities i.e., production of brachiaria for own use, sale, and training of other farmers.

The study further explored the power dynamics surrounding produced milk and how this influenced the benefits of growing *Brachiaria*. The results show that a woman or a man can deliver milk to dairy cooperatives where at least one of them is a member. Although the men constitute the majority of registered members of the cooperatives, women mostly collected the milk proceeds from the dairy cooperatives. Often, the woman remits the money from milk and forage sales to her husband, for him to direct its use, either solely or jointly. In a few instances, the woman keeps the money, but often she is required to purchase food, pay children's school fees, or buy clothes (roles "traditionally" assigned to a man). Even though a man directs the use of income from the sale of milk/forage, women's access to it is a motivation for the woman to continue taking care of the cow:

… there are some [husbands] who just want a little money so I can just keep the income from milk if it is little. But when such

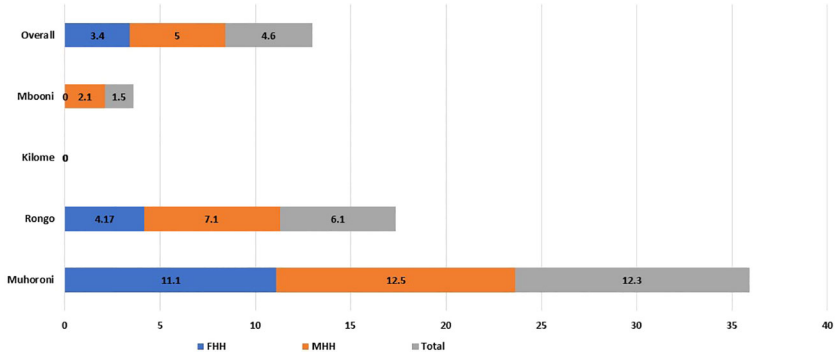

FIGURE 6
Commercialization of *Brachiaria* (percentage of adopters selling).

income is a lot, then he must know about it, and when I get the money, I must show him and tell him to take some while I remain with the rest. (KII Woman, Rongo subcounty, February 2020).

Remitting the milk money to my husband is a sign of respect for him. (FGD woman, Kilome subcounty, December 2019)

In our culture, we leave some activities to women, like selling milk. A man does not sell milk, so they [the women] know that if they get milk and sell it, then they will get the money. That is why women like milking because they will milk and sell. I will not ask my wife how many liters the cow produced because, normally, that is little money that women can use in the household. (FGD man, Kilome subcounty, November 2019)

4 Discussion

We explored the gender dynamics influencing *Brachiaria* technology uptake and commercialization among women and men farmers. These results can inform future breeding and development efforts to enhance the benefits that women and men can reap from such agricultural technologies. This section summarizes and interprets the key findings, guided by the research questions. The implications of the results and the study's limitations and recommendations are also discussed.

This study assessed several components of *Brachiaria* production among women and men farmers. We specifically focused on the rate of *Brachiaria* adoption, forage characteristic preferences, *Brachiaria* establishment and commercialization, and perceptions about *Brachiaria*. These components are important, and they potentially reveal the opportunities and limitations for women and men farmers that might either enhance or hinder forage production. *Brachiaria* has attributes liked by both women and men. In addition, women had preferences related to their role as forage providers. This shows that, although women may not be the official owners of the cattle, the intra-household gender division of labor may affect forage variety preferences. Breeding programs may therefore need to provide forage solutions by involving household members engaged in various forage-related tasks. This is in line with the literature on gender-responsive plant breeding (Ceccarelli et al., 2013).

It is important that women and men farmers receive information on what varieties are available and what varieties reflect their needs so that the adoption of new *Brachiaria* varieties is increased, in turn enhancing farmers' livelihoods. We also found that FHHs have adopted *Brachiaria* to a slightly lesser extent than MHHs in three out of four subcounties. The reason for the slightly higher adoption rate among MHHs is possibly related to the fact that dairy cooperatives were found to be an important means of accessing extension services, useful information about the production, and forage planting materials. However, mostly men and only a few women are cooperative members. Female heads of households from three sites said they accessed *Brachiaria* planting materials through women's groups. This arguably limits women's access to new technologies and advice, as also discussed by Farnworth and Colverson (2015) and Lamontagne-Godwin et al. (2019). This is in line with Wossen et al. (2017), who posit that access to extension services by a household exposes them to new technologies and trains them on best agricultural practices. Our findings support the evidence from the literature pointing to the importance of integrating gender-sensitive approaches into extension services in order to reach female and male farmers with agricultural innovations.

In the Muhoroni subcounty only, FHHs adopted *Brachiaria* to a greater extent than their male counterparts. This is possibly related to women's higher education levels in this subcounty: our quantitative analysis across all sites shows that higher education levels correspond to higher rates of *Brachiaria* adoption, regardless of the gender of the head of the household. This is in line with findings from Melesse (2018), who posits that an educated farmer can obtain, process, and efficiently use information that supports the adoption of new technologies. Although qualitative analysis could have shed light on the ways in which the respondents thought higher education related to variety adoption, our qualitative study was undertaken at the same time as the quantitative study. Consequently, we were not able to explore in depth our quantitative findings through qualitative interviews. We therefore agree with Galiè et al. (2019) that qualitative and quantitative analysis can be best used complementarily: qualitative analysis can be best undertaken before quantitative to contextualize the quantitative component; another round of qualitative work can then also be undertaken after the completion of the quantitative survey to both validate and explain the quantitative results.

Another methodological consideration relates to our aggregation of quantitative results according to household headship, that is, as either FHHs or MHHs. Such an approach does not allow for intra-household exploration of the topics the study focused on. An exploration of intra-household dynamics can present a more complete and unbiased assessment of who is likely to be constrained, the extent of constraint, and why they are constrained. For this to happen, we recommend that questions asked to individual household members do not focus on the household but highlight the respondent's own perception, in line with the recommendation by Doss and Kieran (2014).

One of the main constraints to growing *Brachiaria* (and, therefore, commercializing it) mentioned by both women and men was the availability of land. However, a gender dimension emerged in such land-related constraints. Men are limited by small land areas coupled with competing uses for land, where cash crops are prioritized over *Brachiaria*. Women, on the other hand, are limited by a lack of formal ownership of, access to, and control over land. As such, whereas men complained about small land areas, women complained about a lack of land altogether. Those interested in intensifying their *Brachiaria* production are left with the option to rent land. Even then, women are still limited by a lack of capital to pay land rent. These findings are consistent with results from the literature, where gender norms are shown to limit women's ability to accumulate and retain control over assets [see, e.g., Herrero et al. (2013) and Quisumbing et al. (2015)].

Among both adopter and non-adopter respondents, women seemed more frustrated about the inability to grow *Brachiaria* (or expand its cultivation) than men. This can be explained by the fact

that, in all sites, women control income from milk, and women are therefore interested in growing *Brachiaria* to produce more milk for sale; however, they have no say on the use of land. Interestingly, men showed a keen interest in growing more *Brachiaria* in sites where they had adopted it because they had seen the contribution of *Brachiaria* to household expenses and food security: men traditionally are in charge of providing food and money to the household. On these bases, we recommend that in order to support adoption of forage grasses such as *Brachiaria*, women need to be supported in their control over land and men need to be sensitized to the benefits of forage grasses. Interventions that challenge the gender norms that limit women's access and control over land can enhance the adoption of forage technology by women. This may result in increased women's income from milk sales. Such interventions could also support the enforcement of the existing land ownership policies in Kenya, which recognize spouses as equal property owners and protect women's rights to land ownership during marriage, divorce, and separation. In addition, sensitization of male farmers to the importance of forages, including *Brachiaria*, and the possible benefits to household income and nutrition would contribute to nutrition security and also align men's and women's crop interests. Aligning men's and women's interest in growing forages could also satisfy women's preference for forage crops owing to their normative role as weeders and forage providers.

Overall, our findings indicate three main potential pathways offered by *Brachiaria*—and, possibly, other forage varieties—toward the economic empowerment of the respondents. These pathways concern (i) the sale of *Brachiaria* planting materials and hay bales, (ii) the sale of the increased volume of milk obtained when cows are fed with *Brachiaria* (which is particularly effective for women who control milk income), and (iii) the training of other farmers as another, more limited way of generating revenue from *Brachiaria*. For men to be able to enjoy such progress toward empowerment through *Brachiaria*, it is important that their cooperative membership continues to be supported, which enhances access to information and extension services. For women to also progress toward economic empowerment through *Brachiaria*, their control over milk revenues needs to continue to be supported together with their access to and control over land. Norms reducing women's engagement with cooperatives and meetings need to be addressed for women to access good forage-planting materials.

The fact that gender norms emerged from our discussion as strongly affecting the ability of women and men to learn about, adopt, grow, and benefit from *Brachiaria* is an important finding in itself. Our findings also show that these gender-based norms are flexible. Although older men cannot be seen carrying forage or risk losing power in the eyes of the community, young men can be hired as daily laborers to do such work. This speaks to how gender and age intersect to shape individuals' access to opportunities (such as working as a daily laborer to carry forage). Wealth may also be another intersectional component, as young men may be allowed to engage in such work when in need of money. Also, the findings seem to show how gender-based power dynamics are relational: married men, unlike young men, may be seen as losing power to their wives when carrying forage because a married man "should" have the power to get his wife to do the work.

5 Conclusions and recommendations

This study explored the gender dynamics influencing *Brachiaria* uptake and commercialization among dairy cooperative FHHs and MHHs. More MHHs than FHHs often engage in non-agricultural activities, whereas women mostly work on family farms and engage in mixed farming. Food crops are grown by women, whereas cash crops are grown by men, with little land left for forage production. Dairy cooperatives are important means to access information and forage-planting materials. There exists land-holding differences between women and men. Women are disenfranchised by an inability to own, access, and control land use, whereas men are limited by small land areas. Women's land ownership and access is subject to traditions that dictate who can inherit and own land. The same culture assigns the roles of forage harvesting, transportation, and feeding of animals to women. Education emerged from the quantitative analysis as important to the adoption process.

In this regard, our study recommends the need for holistic efforts to address the identified barriers often faced by women farmers. The barriers regarding land tenure, decision-making, and control rights function in favor of men. Hence, challenging the social structures that produce, and reproduce, such inequalities between women and men is necessary. Enforcement of existing land ownership law in Kenya that recognizes spouses as equal property owners is needed. Gender-sensitive approaches to extension services are essential, as extension services have not successfully reached women and men equally, meaning women are often not reached by technologies and related information received by their men counterparts. The systematic implementation of qualitative studies, followed by quantitative studies, then another qualitative exploration and validation of the results yielded in the first two phases, is recommended. Such holistic efforts can contribute to the ongoing momentum of women's mobility out of poverty and advancing equality in the study areas.

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's Institutional Ethics Committee (Ref. ILRI-IREC 2019-47). The patients/participants provided their written informed consent to participate in this study.

Author contributions

Conceptualization: NN, MT, BB, and JB. Methodology: NN, FW, MT, and AG. Software: NN. Validation: NN, FW, AG, IB, BB,

and JB. Formal analysis: NN. Investigation: NN and MT. Resources: IB. Data curation: NN. Writing—original draft preparation: NN. Writing—review and editing: NN, FW, AG, IB, MT, BB, JB, and EN-M. Supervision: AG, IB, BB, JB, EN-M, and CJ. Project administration: IB. Funding acquisition: IB. 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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