Gender And Resource Extraction Decisions In Common-Pool Resources:A Lab-In-The-Field Experiment Among Pastoralists In Ethiopia

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Gender and Resource Extraction Decisions in Common-Pool Resources: A Lab-in-the-Field Experiment among Pastoralists in Ethiopia

By

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Abstract

This study examines the impact of gender composition on sustainable resource extraction decisions among Borana pastoralists in Southern Ethiopia. Using a common-pool grazing experiment with 225 participants, groups of five participants were randomly assigned varying female representations: two, three, and five females. The all-female groups served as a reference. Participants were tasked to decide on their level of pasture extraction from two hypothetical grazing rangelands under shared access, with varying pasture availability conditions based on their prior aggregate extraction, necessitating trade-offs between short-term self-interest and long-term collective sustainability. The results reveal that the two-female groups consistently outperformed other group compositions in cooperating for the sustainable use of the shared resources across the three resource availability conditions. When pasture was abundant, males in the two-female groups were more cooperative, choosing lower grazing intensity, whereas males in the three-female groups behaved uncooperatively, selecting higher grazing intensity and thus contributing to unsustainable extraction. This suggests that in female-dominated groups, males may resist female dominance by over-extracting resources. In contrast, males in the two-female groups cooperated more, leading to more sustainable outcomes. During relatively pasture-scarce times, cooperation was higher, with two-female groups exhibiting the most sustainable behavior. Under pasture scarcity, males in the two-female groups continued to cooperate more, while males in the three-female groups behaved uncooperatively. The findings emphasize that gender composition affects cooperative dynamics, with mixed-gender groups performing better under resource-scarce conditions. However, female dominance can trigger uncooperative behavior from males, undermining sustainability. For policymakers, the results imply that promoting the participation of women in shared resource management groups is a viable strategy for enhancing sustainability; female dominance, however, can also undermine long-term resource management goals.

Keywords: *Gender, sustainability, common-pool resource, customary institutions*

1. Introduction

The increasing pressures from climate change and population growth in rural Africa have generated debates among researchers and policymakers regarding the ability of indigenous natural resource management institutions to ensure sustainability (Angassa & Oba, 2008; Homann, Rischkowsky, & Steinbach, 2008). However, the issue of gender inclusiveness within these institutions has received little attention. Traditionally, the management of shared natural resources has been dominated by men in many Indigenous communities, resulting in the marginalization of women from decision-making processes (Revollo-Fernández, Aguilar-Ibarra, Micheli, & Sáenz-Arroyo, 2016). For example, among the Borana pastoralists in Eastern Africa, women have been largely excluded from community-based rangeland management, despite the central role of livestock production in the community's livelihood (e.g., Homann, Rischkowsky, Steinbach, Kirk, & Mathias, 2008). This exclusion is particularly concerning given that their Indigenous resource management institutions are facing intensified challenges due to climate change, rising population, and market pressures, all of which undermine their effectiveness in promoting cooperation for sustainable rangeland use (Aklilu & Catley, 2013; Thornton, van de Steeg, Notenbaert, & Herrero, 2009). If the sustainable use of the rangelands needs to be achieved, the institutions need to make adaptive changes in ways that foster more cooperation in the sustainable use of shared natural resources. In this regard, an important pathway can be elevating the role of women in the decision-making process of these institutions. This is because women are more likely to behave cooperatively than men, particularly during periods of resource scarcity. By integrating women into the governance structures of these institutions, the institutions may foster greater cooperation for sustainable resource extraction.

Studies on the link between gender and sustainability have shown that marginalizing women in the management of communal resources has a consequence on the sustainability of the resource. A study by Noguera (2008) showed that females are more interested in the sustainable use of natural resources than men. Revollo-Fernández et al. (2016) show that females are more cooperative in lowering their resource extraction than males if governance institutions are established. Several studies using a field-in-the-lab experiment also indicate that males compared to females tend to be more competitive and overharvested under resource scarcity (Gatiso, Vollan, & Nuppenau, 2015). A meta-analytic review of empirical social dilemma studies on gender differences in cooperation by Balliet et al. (2011) indicates that although males and females may not differ in their overall level of cooperation, females are more cooperative than males in mixed-gender groups and larger groups. In extremely resource-scarce situations, however, males are more cooperative than females in same gender (male-male vs female-female) interactions. These results suggest that gender-mixed groups can potentially elicit higher cooperation to the sustainable resource extraction than purely mono-gender groups.

This study builds on the literature that examines whether individuals' level of cooperation to sustainable resource extractions under a common resource system differs based on the gender composition of resource user groups. The study uses the number of females in the groups as a potential explanation for variations in individuals' behavior toward sustainable resource extraction. Specifically, it examines whether sharing resources with gender-mixed groups will increase the likelihood of individual resource users making sustainable resource extraction decisions. It also examines whether gender differences exist on the level of cooperation depending on the degree of gender composition─ the number of females in the resource user groups.

In examining the issues, the study used the number of females in the group of shared resource users as an explanatory variable for variation in individuals' cooperation in the context of a resource dilemma involving a common pool resource. Resource dilemma experiments have been used to investigate variations in individuals' resource extraction decisions based on gender. These studies, however, used gender as one of the individual characteristics of the participants to explain variation in individuals' resource extraction decisions (Gatiso et al., 2015; Revollo-Fernández et al., 2016). In contexts where females have been neglected in the management of shared resources due to cultural-role differences based on gender, examining the role of gender requires treating gender both as an individual character as well as one of the contextual variables just like the payoff structure, and resource dynamics. This needs to use a resource-dilemma experiment that controls the gender composition of the resource user groups. In this study, the number of females was a treatment that differed across groups and the performance of groups with varying levels of treatment was compared to draw insights into the link between the gender composition of resource user groups and the sustainability of shared resources in a context where there is a higher culture-based role difference by gender.

This study was based on a grazing experiment that was initially developed by Cárdenas, Janssen, and Bousquet (2013) as a common-pool fishery experiment. Later, Prediger, Vollan, and Frolich (2011) use a comparable experimental design to examine the impact of cultural differences on cooperative behavior among Namibian and South African pastoralists. In their study, the experiment was used as a 'within-culture' design to examine the impact of the number of females in the groups on the likelihood that communal farmers will make sustainable pasture-extraction decisions. In the experiment, participants were asked to decide on the pasture harvesting level of two hypothetical grazing rangelands under common access. Depending on the pasture extraction decisions made in previous rounds by each group member, the pasture availability in the rangelands would degrade if certain extraction thresholds were exceeded. The groups would then face different pasture availability conditions, which affect the outcomes of individual members (Prediger et al., 2011).

The grazing experiment was carried out among Borana pastoralists in Southern Ethiopia (see, Fig. 1). Due to differences in cultural roles between males and females, natural resource extraction including pasture and water has been a male activity in the community, and females are typically excluded from the decision-making process. In this

study, variations in the number of females in the groups were a treatment in the experiment. The groups were categorized as control and experimental groups depending on the number of females in a group of five resource users. The control groups included all-female group members, representing the mono-gender groups. The experimental groups included female members at two levels: the *two-female groups*─ 3 males and 2 females; and the t*hree-female groups*─ 3 females and 2 males. To validate the results of this study, the results were compared with a similar study conducted with all-male groups in the study area. Given all the participants shared the same culture, clan origin, and ecological condition, there were no other contextual differences in the experiments, except the gender composition of the groups. By capturing the individual difference variables, among others, age, education status, trust, and level of understanding of markets, the experimental design in this study fits to test the hypothesis that sharing resources with gender-mixed groups promotes individuals to make sustainable resource extractions under a common resource system.

With this study, we make at least two contributions to the existing literature. First, we use the context of pastoralists where gender-based role difference is extremely high, to test the role of gender-inclusive governance in enhancing the sustainability of shared resources. The results provide insights that, during resource-scarce times, the participation of females in the governance of communal resources encourages individual resource users to make more sustainable choices. As the deterioration of communal resources across many parts of Africa and elsewhere is increasing, finding ways to encourage the participation of females in the governance of those resources is essential not only for ensuring gender equity but also for fostering the sustainability of resources. Second, our study shows one of the contexts where males could fight back to maintain the status quo and discourage the participation of females in decision-making. The results show that, during resource-abundant times, the male participants in the female-dominated gender-mixed groups behaved more unsustainably than their counterparts in the male-dominated gender-mixed groups.

The remainder of this article presents the research context of Ethiopian Borana pastoralists, along with their customary communal resource management system in Section 2. This is followed by a discussion of the conceptual framework of the study in Section 3. Section 4 describes the material and methods, while Section 5 discusses the results within the context of previous related studies. The article ends by providing a discussion of the conclusions in Section 6.

2. Research context

The context of this study is the Borana pastoralist community in Southern Ethiopia. The context is an ideal setting for resource dilemma experiments as Borana pastoralists are known for their indigenous self-governance system for managing key natural resources as a communal resource. Their self-governance system is called a Gada system,

having control over the socio-economic life of the society and managing common property regimes (Homann, 2008). The common property regime is used to enable the sustainable use of key natural resources for their livestock-based livelihood, which are grazing rangelands and water sources (Gemedo-Dalle, Isselstein, & Maass, 2006). The management of communal grazing rangelands is done by classifying them into dry-season and wet-season grazing rangelands. For the Borana pastoralists, the rotational use of the commonly held grazing rangelands allows for ensuring the sustainable use of the rangelands. The approach requires the pastoralists to move their livestock to different grazing rangelands across seasons. Mobility is thus an essential element of their traditional rangeland management system (Homann, Rischkowsky, Steinbach, et al., 2008). During dry seasons where natural pasture and water are often scarce, they move their livestock to distant rangelands to take advantage of spatial heterogeneity in pasture availability. The routes of livestock mobility are guided by insights from their traditional ecological knowledge system, which allows them to predict the availability of green pasture and the carrying capacity of rangelands (Gemedo-Dalle et al., 2006).

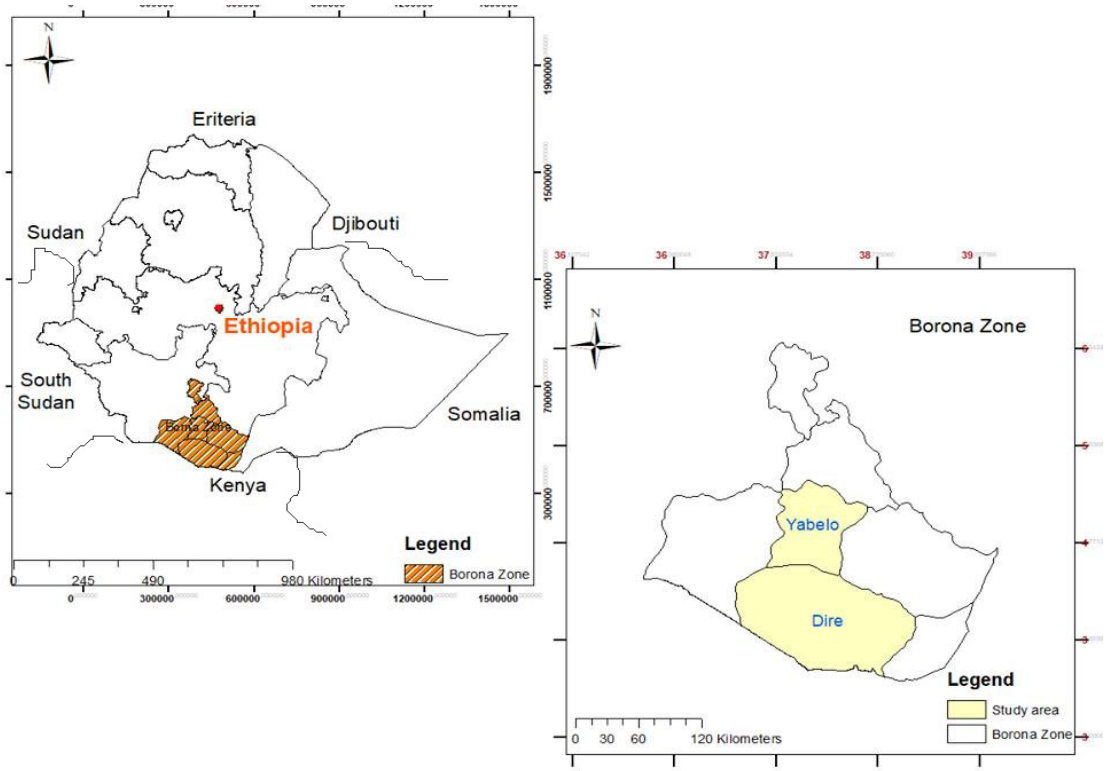


Figure 1: Map of the study area

The context of the Borana Pastoralists possesses essential components for analyzing the sustainability of their communal resource system. According to Ostrom (2007), analyzing the sustainability of a communal resource system requires understanding at three levels: the resource system, the resource units, and the governance system. In the context of this study, natural grazing rangeland, the amount of pasture harvested from the grazing rangelands, and individual pastoralists and their traditional institution represent the three levels, respectively. Like other

indigenous societies, however, the traditional institution is a male-dominated institution, excluding pastoralist women from taking part in the grazing rangeland use and management decisions. This can harm their traditional institution's ability to secure the household and communities' cooperation in the sustainable utilization and maintenance of communal resources, which is of great importance for maximizing livestock production and managing climate-related risks (Homann et al., 2008).

The expansion of market-oriented livestock production in the region is increasing the heterogeneity among individual pastoralists in marketing activities. Recent studies (e.g., Teklehaimanot, Ingenbleek, Tessema, & van Trijp, 2017; Tessema, Ingenbleek, & van Trijp, 2019) have shown that individual pastoralists in the region have significant variations concerning their marketing-related behaviors. Until recently, a subsistence-oriented semi-nomadic lifestyle has been the mainstay for the pastoralists (Aklilu & Catley, 2013). This is, however, changing as the pastoralists are increasingly integrating into local and international markets, leading them to raise livestock for markets and use the communal grazing rangelands to satisfy the requirements of their customers and realize profits. During dry seasons, they encounter difficulty in fulfilling the livestock quality requirements of their customers due to the scarcity of green pasture in their communal grazing rangelands. In effect, some pastoralists have begun to establish private enclosures from the communal grazing rangelands for fatting livestock, which is contrary to the long-standing communal grazing system of the area (Reda, 2016). The increased market integration of pastoralists can pose a challenge to their customary grazing rangeland management system, which was primarily meant to support the subsistence-oriented livestock production system of the pastoralists in the region.

2.1 Gender-Based Role Differences in the Borana Pastoralist Community

The Borana pastoralist community has customary natural resource management institutions, which is a part of their broader endogenous self-governance system called the Gada system (Gemedo-Dalle et al., 2006; Homann, 2005; Reda, 2016). The system organizes the community in a patriarchal framework, where the male elders and clan leaders are entrusted with the authority to make decisions on social, political, and economic issues (Gemedo-Dalle et al., 2006; Homann, 2005; Reda, 2016). The male elders and clan leaders have full control over all key natural resources, including grazing lands and sources of water (Gemedo-Dalle et al., 2006; Homann, 2005; Reda, 2016). The influence of this male-dominated leadership system extends to the division of labor within the community, assigning specific roles to each gender (Flintan, 2011; Kipuri & Ridgewell, 2008). These culture-based gender roles are delineated mostly by the functional needs of the community; men usually address public, political, and economic matters whereas women take on domestic activities (Flintan, 2011; Kipuri & Ridgewell, 2008).

In Ethiopia, women's rights are constitutionally protected and discrimination against women in the use, transfer, administration, and control of land and other essential natural resources such as grazing lands is prohibited under Article 25 and Article 35 of the constitution (Flintan, 2011; Kipuri & Ridgewell, 2008). However, such women's

rights have been mostly enforced only in the highland areas, for example, through land certification programs Mengesha et al. (2022). In the Borana pastoral community, addressing gender equity is largely left to their customary natural resource management institution (Flintan, 2011). Yet, women's position in the community's clan-based institution is largely subservient, marginalized, and disempowered (Flintan, 2011; Reda, 2016; Tache, 2008).

In the Borana community, the male members take the responsibility for managing livestock, negotiating grazing land rights, and managing the communal natural resources, grazing rangelands, and water sources. On the one hand, these responsibilities have major implications for natural resource management, given that decisions about grazing land allocation are taken by male leaders during dry seasons when the resources become scarcer (Flintan, 2011; Reda, 2016; Tache, 2008). On the other hand, women's tasks involve milking, collecting firewood, fetching water, and preparing food. These tasks are essential to the broader operation of the pastoralist system but are seen as subsidiary to the more economically important works of men (Flintan, 2011; Reda, 2016; Tache, 2008). This gender-based role difference implies gendered access to and control over natural resources, particularly grazing rangelands.

In managing the communal grazing rangelands, the community divides the rangelands into wet and dry season grazing lands (Gemedo-Dalle et al., 2006; Homann, 2005; Reda, 2016). The competition over grazing lands is felt stronger during the dry season when the pasture resource is scarcer; leading to strict rules to control the grazing access and use (Gemedo-Dalle et al., 2006; Homann, 2005; Reda, 2016). While decisions on opening and closing of the grazing areas are solely designated to the male elders and clan leaders, women's voices and priorities are largely excluded from these decision-making processes. Yet, women are responsible for livestock-related tasks such as milking cows, and taking care of lactating animals and calves. This makes access to grazing lands by women a matter of discretion by male leaders, which often excludes women's special needs for the small herds. So, women largely relied on men to access key natural resources, grazing rangelands, and water sources (Flintan, 2011; Kipuri & Ridgewell, 2008).

During drought times, the management of grazing lands becomes very critical since the remaining green pasture resources are few. Decisions made by the male elders over which grazing land is accessible for grazing have become a central factor in the survival of livestock. In these contexts, male leaders tend to prioritize larger herds, which are often economically more significant, leaving limited access to the grazing areas for women. This increases women's vulnerability, as their herds are often smaller and less of a priority, as a result, they are more likely to suffer higher livestock losses during drought time (Flintan, 2011; Reda, 2016; Tache, 2008). Moreover, men have relatively greater bargaining power at times of drought, which means they can bargain for better grazing sits, leaving women with limited choice and bargaining power (Reda, 2016; Tache, 2008). The exclusion of women also extends into the rituals and ceremonies that are foundational to the Gada system. These rituals, which are integral to the social fabric of the community, not only maintain social order but also legitimize male leaders' authority. The exclusion of women from

these rituals further consolidates the inequalities between genders and limits women from the networks of power that are so important to enhance their role.

Integrating women's expertise into communal resource governance could enhance decision-making and improve resource management in the Borana pastoralists. Women, though excluded from formal leadership, possess valuable knowledge in livestock care and resource management (Flintan, 2011; Reda, 2016). Including their voices in decision-making, especially during scarcity, could lead to more effective and equitable resource distribution, particularly in times of scarcity, and promote the sustainability of the pastoralist way of life. While involving women in male-dominated institutions is challenging, creating parallel women's forums could promote gender equity (Flintan, 2011). Yet, the understanding of the impacts of women's membership on the sustainable use of natural resources may provide evidence to policymakers and NGOs to promote the idea.

3. Conceptual framework

In explaining the impact of the gender composition of resource user groups on the likelihood of individuals making sustainable resource extraction decisions, the study assumes the individual resource users are rational people, and have *'the desire to engage in fair cooperation as such'* (Gaus, 2008). In social dilemma studies, transforming individual decisions into a certain utility function as if they would always have a ranking of preferences in ways that meet the basic utility axioms is a common erroneous, according to Gaus (2008). Such studies should uphold the assumption of reasonable participants (cf., Ahn, Ostrom, & Walker, 2010; Anderies et al., 2011; Gaus, 2008). As such the studies should not attempt to fit the individual decision patterns into a specific utility model, but rather focus on examining the effects of different attributes of individual participants and socio-ecological contextual variables on individual decision-making (Gaus, 2008).

The empirical strategy for this study is, therefore, based on a reasonable utility function for the participants. A reasonable utility function, which cannot be put in a simple mathematical function, is assumed in contexts where individuals' choice functions and preferences relations are parametrically influenced not only by the decision/choice, but rather by complicated factors including the *identity of the chooser*, the *menu over which the choice is made*, the *relation with the previous act*, and the *relation of the particular act to behavioral social norms that constrain actions* (Chaudhuri, 2016; Gaus, 2008). These features are quite similar to the context of this study, which makes the reasonable utility function appropriate for empirical strategy. Building on the existing theoretical (Anderies et al., 2011; Balliet et al., 2011; Ostrom, 2007) and empirical (Gugissa, Ingenbleek, & van Trijp, 2021; Prediger et al., 2011) studies, Figure 2 below depicts the conceptual framework of the study.

The conceptual framework in Figure 2 suggests that the number of females in share-resource user groups indirectly predicts the likelihood of a sustainable resource extraction decision by influencing the perceived intensity of

competition among group members. Due to culture-based gender role differences, women than males are expected to prioritize collective welfare over individual interests, which typically results in less intense competition for resources; increasing the likelihood of resource users' making sustainable extraction decisions. Culturally, women are responsible for managing household welfare, including food security, while men focus on political and economic affairs that often involve competitive behavior (Flintan, 2011; Kipuri & Ridgewell, 2008). As such, women tend to be less competitive over resources, as their roles center around household well-being, while men are more attuned to resource competition, driven by their responsibilities in managing livestock, pasture, and water resources, and engaging in inter-clan negotiations (Flintan, 2011; Kipuri & Ridgewell, 2008). However, women's increased involvement or leadership in resource management groups could face resistance in the community where the traditional gender norms place men in the dominant role (Flintan, 2011; Kipuri & Ridgewell, 2008). This resistance, from men or women themselves, may manifest in rivalrous behavior, potentially escalating competition over resources. Consequently, while women's participation can reduce the intensity of competition by promoting collective interests, their dominance in the groups could provoke tensions in women-dominated groups. This tension influences the intensity of competition and the overall dynamic of resource management and decision-making, potentially affecting the sustainability of resource use.

As shown in the figure, in estimating how the number of females in such groups predicts the likelihood of individuals making a sustainable resource extraction decision, the model controls for the confounding variables related to the participants in the experiment. Variables related to the socio-demographic and social behavior variables of individual participants as well as one's group characteristic variables are included as confounding variables. The availability of the shared resource (ecological condition), which can be abundant, sufficient, short-term scarce, and long-term scarce, is used as a factor that influences the proposed relationship.

Attributes of individual participants and socio-ecological conditions are important variables in analyzing the effect of gender and the gender composition of communal resource user groups on individuals' decision-making. The social dilemma literature shows that, besides demographic characteristics such as age, gender, education, and access to market centers, individual behaviors of *reciprocity*, *trust towards others*, and *pro-social* behavior play major roles in explaining potential variations in the behavior of individual members decision makings in social dilemma situations (Chaudhuri, 2016; Gaus, 2008). Studies show (Chaudhuri, 2016; Gaus, 2008) that free-riding is often a strategy chosen by only a small fraction of participants, most participants do respond partially to monetary incentives, and most individuals are altruistically willing to refrain from over-harvesting from common-pool resources either because they care about others, want to avert inequality or environmental perspective. In doing so, they also expect less resource exploitation behavior from each other.

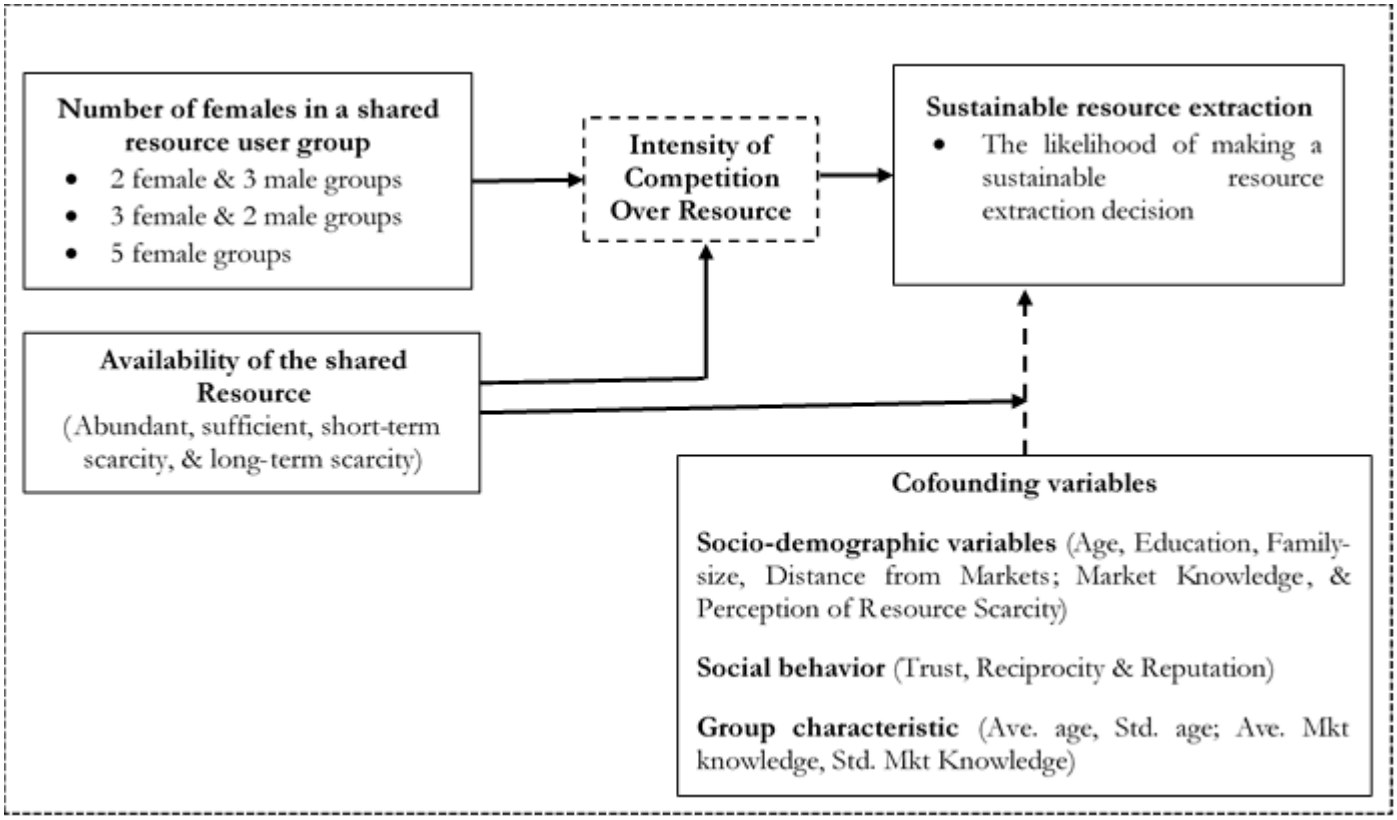


Figure 2: Conceptual framework

Recent empirical studies also show that the understanding that participants have concerning the functioning and dynamics of markets (market knowledge) affects their resource harvesting decisions in a resource dilemma situation (Cecchi & Bulte, 2013; Gugissa et al., 2021). A study by Gugissa et al. (2021) shows that a higher level of market knowledge increases the cooperation of pastoralists in a common dilemma by reducing environmental and social uncertainties while a higher within-group variance in market knowledge does the opposite. Building on prior studies, this study considers individual and group-level market knowledge as well as the within-group variance in market knowledge as explanatory variables for variations in individual decision-making concerning common resource extraction.

The ecological conditions, specifically the availability of a common resource, are also important factors that influence individual decision-making behavior in common dilemmas (Anderies et al., 2011; Balliet et al., 2011). Depending on the availability of resources, individuals often behave differently concerning their resource extraction decisions (Anderies et al., 2011; Balliet et al., 2011). Individuals who would like to avoid the collapse of the common resource are most likely to reduce their resource extraction if they perceive resource scarcity, but if they perceive an abundance of the resource the opposite could happen. These effects, however, can differ based on gender. A metal analysis by Balliet et al. (2011) shows that during resource scarcity rather than abundance, females are more likely to decide to harvest fewer resources than males. For the empirical strategy, the implication is that analyzing the participants' decisions across different ecological conditions, that the participants may encounter during the

experiment, provides deeper insights than the pooled data analysis. Accordingly, in this study depending on the relative resource availability conditions that participants encountered during the experiment, a separate analysis was used to examine the effect of gender and a group's gender composition on the sustainable resource extraction decision of individual resource users.

4. Materials and Methods

4.1 Experimental Design

The experiment involved a social dilemma in which individual interest in grazing at high-intensity clashes with desired group-level outcomes (Cárdenas et al., 2013). Two hypothetical grazing sites were involved: Rangelands A and B, which can have either high or low levels of pasture availability. These sites were held jointly by a group of five participants. An experimental session consisted of 10 rounds. In each round, every member in a group of five chose to graze in either Rangeland A or Rangeland B at a grazing intensity of 0 (no grazing at all), 1 (low grazing intensity), or 2 (high grazing intensity). The higher the grazing intensity, the higher the amount of pasture resource that the participant extracted from the common-grazing rangelands. The decisions were private: the group members were not aware of each other's decisions. A coordinator in the experiment collected all decisions and announced the status of pasture availability for the next round. During the experiment, group members were not allowed to communicate with each other, and there were no rules governing grazing-intensity choices; a non-cooperative experimental game.

As shown in Table 1, the returns on specific grazing decisions depended on the level of grazing intensity and the grazing availability status at the chosen grazing site. The table applies to both grazing sites. Based on the payoff table, a grazing intensity of 2 yielded a return of eight tokens (cf. Prediger et al., 2011) if the grazing availability in the chosen rangeland was high, but only three tokens if grazing availability was low. Before the experimental game, the participants played three trial rounds, in which they were briefed on the amount they would gain depending on their individual and fellow members' grazing-intensity choices, including the possibility of rehabilitating degraded rangeland by refraining from applying the grazing intensity of 2. Participants subsequently played 10 rounds of the experimental game. In the end, participants received the sum of their earnings converted to local currency. On average, each participant earned an amount equivalent to one day of labor.

Table 1: Individual payoff table

	Grazing Intensity		
Grazing quality	*0*	*1*	*2*
High	0	7	8
Low	0	2	3

Source: Cárdenas et al. (2013)

The aggregate grazing intensity in round R_n in a rangeland determines the grazing availability of the rangelands in the next round R_{n+1} (Prediger et al., 2011). At the beginning of the experiment, grazing availability is high in both rangelands. In subsequent rounds, however, if the sum of grazing intensity of the five group members is greater than 4, which is the carrying capacity of the rangelands, the state of grazing availability will become low for the next two rounds. Rangeland with low grazing availability can recover to high grazing availability only if the aggregate grazing intensity applied to that rangeland is 0 or 1 for two consecutive rounds. The maximum grazing intensity that can be chosen to maximize their payoffs is 2. The aggregate grazing intensity for a five-member group can therefore range from 0 to 10 in each rangeland. If all group members behave rationally to maximize their own short-term individual payoffs in any round, all players will choose to graze at the grazing intensity of 2. As a result, the group will encounter low grazing availability in the next round. If this opportunistic behavior continues throughout the game, the group will continue to face low grazing availability in both rangelands for the 9 rounds of the game. At the end of 10 rounds, this opportunistic behavior results in 200 aggregate tokens for the group. If group members refrain from applying the grazing intensity of 2, however, the aggregate payoff for the group can be as high as 382 tokens. This result requires at least two members of a group not to apply the grazing intensity of 2 (Cárdenas et al., 2013)

After the first round, a rangeland's grazing availability can be in a condition of high (H); low with two more rounds needed to recover to the high-availability condition (L_2); or low availability with only one more round needed to recover to the high-availability condition (L_1). A group with two rangelands might therefore face six possible combinations of grazing availability status: HH (both rangelands in high-availability condition), HL_1 (one rangeland in high availability and the other in low availability, with one round required to recover), HL_2 (one rangeland in high availability and the other in low availability, with two rounds required to recover), L_1L_1 (both rangelands in low availability, with one round required to recover), L_1L_2 (both rangelands in low availability, but one requiring one round to recover and the other requiring two rounds), and L_2L_2 (both rangelands in low availability, with two rounds required to recover). In any round of the experiment, if the aggregate grazing intensity in L_1 is higher than 1, its grazing availability status shifts back to L_2.

In the experiment designed by Prediger and colleagues (2011, pp. 1602), participants had difficulty distinguishing between the L_1 and L_2 grazing conditions. So, three pictures were used to easily depict each of the grazing availability conditions (see Figure 3). At the end of each round, the coordinator showed one of the pictures in Figure 2 for each of the grazing sites, as an outcome of the group's grazing decisions. During the experiment, many participants were able to associate the three pictures in Figure 3 with rainy, dry, and drought ecological conditions, respectively. That means, that both the variations in the grazing availability and the pictures used to depict them were good enough in capturing the participants' real-life experiences of grazing variations during periods of rainy, dry, and drought.

Figure 3: Pasture- availability status: H, L_1, and L_2, respectively

4.2 Participants and measurement

This study focuses on the role of gender diversity as a variable in resource-extraction decisions within common-pool resource (CPR) groups in communities where cultural gender role differences are significant. Given the distinct roles and behavioral expectations for male and female participants, the study examines how gender composition affects decision-making and sustainability outcomes in resource-extraction activities. It also compares its findings with those of an earlier experiment conducted with male-only participants (Gugissa et al., 2021).

The participants for this experiment were recruited from the same administrative areas as the earlier study using the same sampling procedure. A total of 225 participants—75 males and 150 females—were selected from four villages in two administrative districts of the Borana Zone: Yabello and Dire (Gugissa et al., 2021). Participants were first briefed on the nature of the experiment. While all male participants agreed to take part, the inclusion of female participants required additional discussions with clan and village leaders due to concerns about culturally accepted gender norms. These discussions clarified the hypothetical nature of the experiment and ensured that the participation of women would not undermine traditional practices.

In line with the field-experiment protocol developed by Cárdenas et al. (2013), participants were randomly assigned to five-member resource-user groups for the entire session. The gender composition within each group varied, with either 2, 3, or 5 females per group. The experiment lasted approximately two hours, including instructions, three trial rounds, ten rounds of the experimental game, and payment distribution.

In this study, variation in the number of females in the group of five resource users was used as a treatment. In the control groups, all five members of the groups were female (hereafter, *all-female groups*). In the experimental groups, however, there were either two or three female members in each group. Based on the number of females in the group, there were two types of experimental groups. The first, experimental groups were mixed-gender groups but male-dominated groups, including three males and two females in the group of five (hereafter, *two-female groups). The*

*second e*xperimental groups were mixed-gender groups but female-dominated groups, having three females and two males (hereafter, *three female groups*). In each group type, there were 75 participants in 15 groups. In total, 225 participants ─75 males and 150 females participated. For details see Table 2.

Table 2: Participants by gender and groups

	No of groups	Gender-composition		Total		Total
		M	F	M	F	
Control groups						
All-female groups	15	5	0	0	75	75
Experimental groups						
Two-female groups	15	3	2	45	30	75
Three-female groups	15	2	3	30	45	75
	45			75	150	225

Cooperation towards the sustainable use of the grazing rangelands was measured using the grazing-intensity choices of individual participants in each round of the experiment. Deciding to apply the grazing intensity of 2 is not a sustainable choice, as it often leads to the degradation of communal grazing rangelands and hinders the group's ability to maximize the aggregate payoffs; it is detrimental to socially optimal outcomes. Because this grazing-intensity choice is not sustainable, individual cooperation in the sustainable use of the grazing rangelands was measured as *refraining from applying a grazing intensity of 2* (i.e., applying grazing intensity of 0 or 1) (Prediger et al., 2011). As an outcome variable, the aggregate token earned in the 10 rounds of the experiment was also used to measure individual total earnings from the use of the grazing rangelands.

Besides the experiment, a survey was administered to collect data on the participants' profiles. The purpose of the survey was to capture the participants' socio-economic profile and their behavior about the use of common-pool resources. The survey was administered three days before the experiment, which is in line with the recommendation to avoid the potential effect of the survey on the experiment (Anderies et al., 2011). Socioeconomic characteristics of the participants; age and family size were measured as a continuous variable, whereas gender (1=Male, otherwise 0) and education level (None, Primary & above, & Adult education) were measured as categorical variables. Additional control variables including market knowledge, cooperation to rules and norms of common-pool resource use, conformity to traditional values and norms, and collectivism were measured using multi-item scales. All items were measured along a five-point Likert scale ranging from 5 (strongly agree) to 1 (strongly disagree). The measure for market knowledge was developed based on a qualitative pre-study and the items were formulated as concretely as possible to make them easily understandable to the respondents (Teklehaimanot, 2017). The items of *market knowledge* tested the extent to which the pastoralists understood how markets function, customer needs, and the influence of competitors' actions. Pastoralists need such knowledge to offer quality livestock based on the requirements of buyers and earn profits (Teklehaimanot, 2017). The measure consisted of seven items as a single-

dimensional scale, which the measure was also checked by examining the item's factor loadings and the average variance extracted for convergent validity (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). All the loadings were higher than the desired .70 loadings and the average variance extracted was also greater than the required .50 for convergent validity (Hair et al., 2014). See *Appendix 1* for details about the constructs, survey measures, and standardized loading for each item.

4.3 Data Analysis

The dependent variable (the grazing-intensity choices of individual participants) is an ordered outcome. An ordered probit model (see Eqn. 1) was therefore used to estimate the effect of gender and a group's gender composition on the grazing-intensity choices of individual participants. Specifically, a heterogeneous ordered probit model was used to estimate the effects (Williams, 2009, 2010). This is because females were expected to have more heterogeneous decision patterns than males as they lacked prior experience in rangeland management decision-making. As a result, for females than males, the residual variance would be higher. A heterogeneous ordered probit model allows capturing this difference in residual variance between the groups (Rohwer, 2015; Williams, 2009, 2010). Specifically, the model depicted below was used to estimate the effects:

$$Y_i^* = \alpha_1 W_1 + \alpha_2 W_2 + \beta_1 W_1 \#Sex + \beta_2 W_2 \#Sex + \gamma X_i + \varepsilon_i \quad (1)$$

$$\text{With} \quad Y_i = \begin{cases} 1 & if\ G_i^* = 0\ or\ G_i^* = 1 \\ 0 & otherwise \end{cases} \quad (2)$$

where Y_i^* was a variable representing a participant i's decision of cooperation; *the likelihood of refraining from choosing the unsustainable grazing intensity —grazing intensity of 2* (Prediger et al., 2011), and G_i^* was a grazing intensity choice of individual participants in each round of the experiment. So, $Y_i^* = 1$ if a participant decides to graze at a grazing intensity of 0 or 1, and 0 otherwise. The two gender-mixed groups were represented by two dummy variables W_1 and W_2 for two-female and three-female groups, respectively. W_1 =1 if a participant was assigned in any of the two-female groups and otherwise 0. Similarly, for W_2 = 1 if a participant was assigned in any of the three-female groups and otherwise 0. To address multicollinearity issues arising from the inclusion of interaction terms between gender and group membership, the gender of the participants was represented by two interaction terms. The dummy variable *Sex* was defined, with *Sex = 1* for male participants and *Sex = 0* for female participants.

The model incorporated two interaction terms: *W1#Sex = 1* for male participants in the two-female group (and 0 otherwise), and *W2#Sex = 1* for male participants in the three-female group (and 0 otherwise). This method effectively included gender in the model while mitigating multicollinearity. *Xi* is the vector of confounding variables, including *age, family size, education level, distance from the village to the market, market knowledge, conformity to*

traditional values and norms, collectivism, and respect for communal resource rules. The later three variables were proxies for individual behavior related to the use of the common pool resources, specifically, trust, reciprocity, and reputation, respectively. The average and within-group variance of age and market knowledge was also included to capture the effects of the within-group heterogeneity. To make up for social learning effects, the *round of the experiment and a one-period lag variable of the grazing intensity decision* were also included in the estimation model. Whereas, α and β were vectors of regression coefficients to be estimated and ε_i is the error term (descriptive statistics provided in Table 3). In the above model, all-female groups were used as baseline groups against which all the experimental groups were compared. And, the residual variances were allowed to differ by the number of female members in the groups. A chi-square contract test indicated that the residual variances were found to differ across groups (Rohwer, 2015).

In addition to gender composition, groups in a resource dilemma experiment may differ based on the average and standard deviation of explanatory variables, which are crucial for understanding group dynamics and decision-making. The average provides insight into the overall behavior of the group, revealing whether participants are more likely to cooperate, over-exploit, or follow other patterns in managing the resource. Meanwhile, the standard deviation highlights the variability or dispersion of individual behaviors within the group, with its coefficients indicating whether diversity among members promotes cooperation or fosters competition in resource use. Building on the study by Gugissa et al. (2021) we included the average and standard deviation of age and market knowledge, as group-level variables in the estimation model.

The marginal effects were reported for the likelihood of applying the maximum grazing intensity (uncooperative behavior), which is a grazing intensity of 2 (Prediger et al., 2011). The marginal effects for the number of females in the groups represent how membership in the groups would impact the individual members' likelihood of applying the maximum grazing intensity. A multiple linear regression model was also used to analyze the effects of females' participation in the resource user groups on the total earnings of the participants.

The marginal effects on the likelihood of choosing the maximum grazing intensity were estimated across the different pasture-availability conditions that the groups might face in the experiment. Depending on the level of pasture availability in the two shared grazing rangelands, there were four conditions (cf. Prediger et al., 2011); resource-abundant (HH and HL_1), spatial resource availability (HL_2), short-term resource scarcity (L_1L_1 and L_1L_2), and long-term resource scarcity (L_2L_2). However, the number L_2L_2 condition occurred only 2.33% of the time and was observed in only 15 of the 69 groups in the experiment. The general rule of 10 observations per predictor variable was therefore not satisfied in the L_2L_2 (Vittinghoff and McCulloch, 2007). Because we included 19 predictor variables in our analysis, the 70 observations for the L2L2 resource conditions failed to reach the minimum sample size required. The long-term resource scarcity (L_2L_2) condition has therefore been excluded from the analysis. Thus,

the marginal effects were estimated over three grazing availability conditions: resource-abundant (HH and HL_1), spatial resource availability (HL_2), and short-term resource scarcity (L_1L_1 and L_1L_2),

Table 3: Mean (M), Standard Deviation (SD), and Inter-correlation among variables (N=225)

		1	2	3	4	5	6	7	8	9	10	11
1	Grazing intensity	1.00										
2	Gender	-.03	1.00									
3	Age	.01	.02	1.00								
4	Education	-.05	.26***	-.26***	1.00							
5	Family size	.01	-.05	.57***	-.22***	*1.00*						
6	Distance from market	-.04*	-.08	.06***	-.14***	.17***	1.00					
7	Market knowledge	-.01	.36***	.17***	.06***	.13***	.11***	1.00				
8	Pasture scarcity	-.01	-.02	.03***	.13***	-.06***	-.15***	.10***	1.00			
9	Cooperation to rules	-.02	.07***	-.09***	.20***	-.19***	-.32***	.09***	.31***	1.00		
10	Conformity to norms	.01	.02	-.13***	.21***	-.05**	-.35***	-.02**	-.16***	.23***	1.00	
11	Collectivism	-.04	-.07***	.12***	.19***	.02	-.33***	.03	.23***	.25***	.35***	1.00
	Mean	.97	.33	41.21	.38	7.47	2.33	3.20	4.33	3.93	4.36	4.37
	Standard Deviation	.03	0.01	.22	.01	.06	.02	.01	.01	.01	.01	.01

5. Results

Table 4 shows the grazing intensity decisions of the participants over 10 rounds of the experiment. As indicated in the table, the application of the maximum grazing intensity of 2 was relatively higher in the all-female groups (reference groups), which was 15.6% of the time, whereas it was 10.3, and 11.4 % of the time in the groups with two-female and three-female groups, respectively. A grazing intensity of 1 was applied 65.7% of the time in the all-female groups whilst it was 75.07 and 68.67 % of the time in the two experimental groups, respectively. The application of the lowest grazing intensity of 0 ranged from 1.7% of the time in the groups with two female groups to 18.4% of the time in the reference groups. The same experiment conducted in the study area among all-male participants by Gugissa et al. (2021) showed that the application of the maximum grazing intensity was 21.42%. These results suggest that participants in gender-mixed groups are less likely to apply the application of the maximum grazing intensity.

A participant with cooperation intention to the sustainable use of the shared grazing rangelands would refrain from applying the maximum grazing intensity of 2 as it often leads to the deterioration of the shared grazing rangelands. All female groups acted sustainably 81.6% of the time by refraining from applying the maximum grazing intensity. However, compared to the participants in the experimental groups─ 84.4 and 89.7% of the time, the participants in the all-female groups acted far less sustainably. Similarly, Gugissa et al. (2021) reported that 78.58% of the time participants in all-male groups acted sustainably by refraining from applying the unsustainable grazing intensity of 2; all-female groups acted more sustainably than all-male groups (Gugissa et al., 2021). In a similar experiment by Prediger et al. (2011) among South African and Namibian pastoralists (38.5%), the application of the maximum grazing intensity was lower in both control and experimental groups.

In terms of maintaining high pasture availability in at least one of the shared grazing rangelands, there was no difference between the reference groups and two-female groups, both groups did so about 66.67 % of the time in the experiment. The three female groups, however, were able to maintain slightly higher; 73.73% of the times higher pasture availability in at least one of the shared grazing rangelands. The experiment conducted among all-male groups showed that close to 64% of the time the groups were able to maintain higher pasture availability conditions in at least one of their shared grazing rangelands. These results collectively imply that throughout the experiment the participants, regardless of their group composition, were applying a *'rotation strategy'* in using the rangelands, maintaining one high-pasture availability rangeland to graze while leaving the other rangeland to recover. This result is quite consistent with the findings of prior studies (e.g., Gugissa et al., 2021) as well as their tradition of categorizing rangelands as wet and dry-season grazing rangelands to use them in rotation depending on the season (Homann, Rischkowsky, Steinbach, et al., 2008). None of the participants in any of the groups applied the maximum grazing

intensity when they faced the worst, a long-term pasture scarcity condition (L_2L_2). In this pasture scarcity condition, all participants in gender-mixed groups refrained from grazing, choosing to graze at zero intensity.

Table 4: Grazing intensity choices across different pasture availability conditions

Pasture condition	Reference Group				Experimental Groups							
	All-female groups				Two-female groups				Three-female groups			
	Pasture (%)	Grazing intensity (%)			Pasture (%)	Grazing intensity (%)			Pasture (%)	Grazing intensity (%)		
		0	**1**	**2**		**0**	**1**	**2**		**0**	**1**	**2**
HH	35 (23.3)	0.0	62.8	37.1	35 (23.3)	0.0	70.3	29.7	29 (19.3)	0.0	64.1	35.9
HL_1	20 (13.3)	0.0	80.0	20.0	20 (13.3)	0.7	92.2	7.1	29 (19.3)	0.0	79.3	20.7
HL_2	45 (30.0)	0.0	85.8	14.2	45 (30.0)	1.1	93.6	5.3	52 (34.7)	0.0	90.8	9.2
L_1L_1	4 (2.7)	70.0	30.0	0.0	5 (2.7)	60.0	40.0	0.0	1 (0.7)	60.0	40.0	0.0
L_1L_2	40 (26.7)	51.0	48.0	1.0	40 (26.7)	67.6	32.4	0.0	38 (25.3)	62.6	36.3	1.1
L_2L_2	6 (4.0)	73.3	26.7	0.0	6 (4.0)	100	0.0	0.0	1 (0.7)	100	0.0	0.0
Total	150 (100)	18.4	65.7	15.9	150(100)	14.7	75.1	10.3	150 (100)	16.9	68.8	11.4

Table 5: Gender differences

	Female		Male		t-test (Female -Male)	
	Mean	St.dev	Mean	St.dev	Mean differ	t-value
Grazing intensity	1.36	.48	1.31	.46	.06	0.90
Age	41.06	10.86	41.53	10.3	-.47	0.32
Family size	7.51	2.67	7.41	2.6	.09	0.24
Education	.27	.55	.60	.56	-.32***	4.09
Distance from market	2.35	1.21	2.31	1.17	.05	0.27
Market knowledge	3.06	.38	3.49	.75	-.43***	-4.68
Pasture scarcity	4.34	.39	4.33	.36	.02	0.35
Cooperation to rules	3.90	.56	3.98	.44	-.08	-1.18
Conformity to norms	4.35	.54	4.47	.40	-.02	-0.33
Collectivism	4.35	.58	4.42	.49	-.08	-1.07

Table 5 presents a comparison of the variables between females and males, along with results from independent t-tests assessing gender differences. For most variables, such as grazing intensity, age, family size, distance from the market, pasture scarcity, cooperation with rules, conformity to norms, and collectivism, there are minimal mean differences between the genders, and the t-values indicate no significant statistical differences. However, significant gender disparities are observed in education and market knowledge. Females report lower education levels (mean = 0.27) compared to males (mean = 0.60), with a statistically significant difference (diff = -.32 $p< 0.01$). Additionally, females exhibit lower market knowledge (mean = 3.06) compared to males (mean = 3.49), with a significant negative difference (diff = -.43, $p< 0.01$). These findings suggest that males tend to have higher education levels and better market knowledge than females, while gender does not appear to significantly influence other socio-economic or behavioral characteristics in this sample.

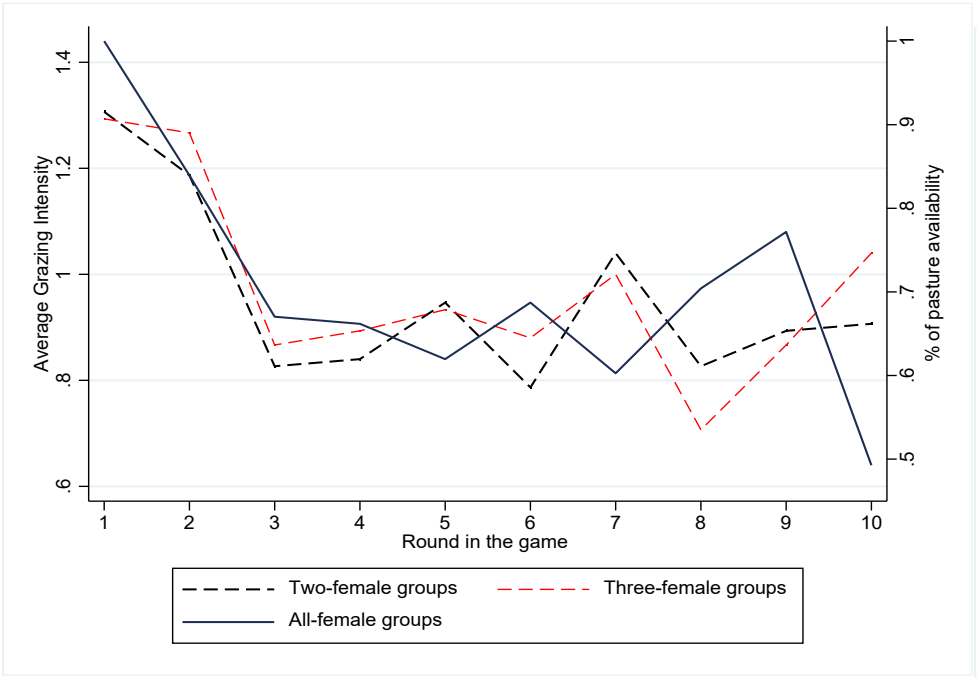
In addition to the t-test on gender differences, comparisons across three distinct groups were also conducted. For most variables, including grazing intensity, age, education level, family size, distance from the market, and collectivism, no statistically significant differences were observed among the groups. However, significant group differences emerged in market knowledge, where the two gender-mixed groups demonstrated higher average scores than the all-female group. Regarding perceptions of pasture scarcity, significant differences were found between the two-female and five-female groups, with the two-female group reporting higher levels of perceived scarcity.

Additionally, in terms of cooperation with pasture use rules and conformity to cultural values and norms, members of the two-female groups exhibited higher levels of adherence compared to those in the three-female group. These findings suggest that while most socio-economic and behavioral characteristics did not vary significantly across groups, notable differences were observed in market knowledge, perceptions of pasture scarcity, cooperation with pasture use rules, and conformity to cultural values and norms.

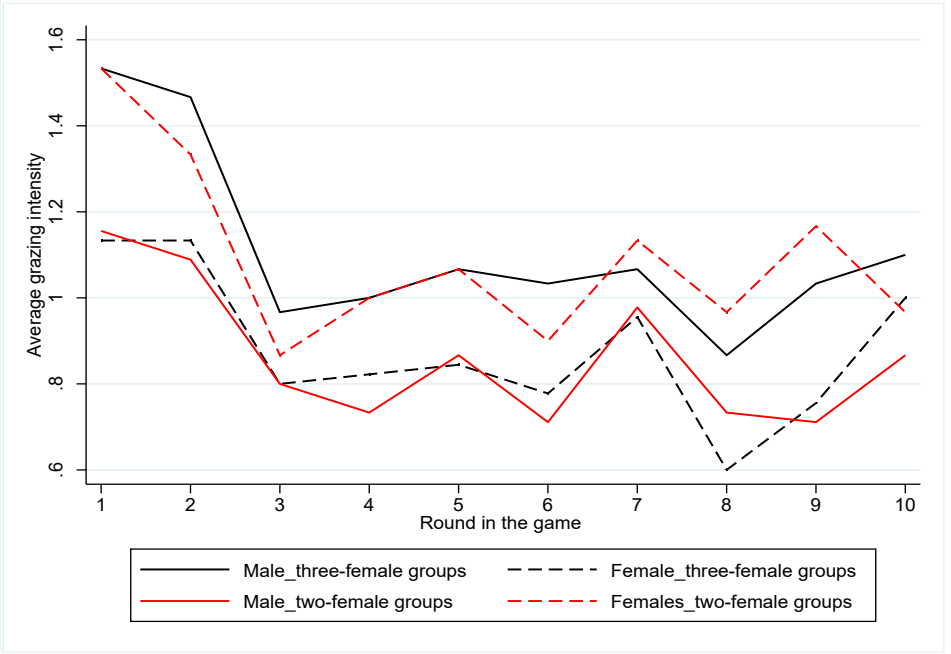
Figures 4A and 4B show the trends of pasture availability and grazing intensity choices over 10 rounds of the experiment. Till the 4th round, there were no clear distinctions among groups in terms of pasture availability and graining intensity application. Starting from the 5th round, however, the groups with gender-mixed members looked relatively better in maintaining stable and higher pasture availability conditions than the mono-gender groups. All-male groups were able to recover their pasture availability conditions while all-female groups faced a decline in pasture availability conditions toward the end of the experiment. Yet, in all the groups the average grazing intensity per round follows a similar pattern with the pasture availability. This implies that throughout the experiment the participants had been adjusting their pattern of grazing-intensity choices depending on the pasture availability conditions (see, Figure 4A).

Figure 4B shows the grazing intensity choice of male and female participants in the gender-mixed-experimental groups. As shown in the figure, in the two female groups' the females exhibited relatively a higher grazing intensity application than the males. Whereas, in the three-female groups, the males had relatively higher grazing intensity application than the females. A t-test with unequal variance showed that the exhibited difference was statistically significant. The result suggests that in gender-mixed groups the gender composition influences which gender type cooperative more, females tend to apply a lower grazing intensity in the three-female groups, while males tend to behave the same in the two-female groups.

In general, the above results suggest that in gender-mixed groups than in mono-gender groups participants were more likely to extract lesser pasture, implying a higher sustainable resource extraction behavior in the gender-mixed groups. Yet, the degree of gender composition of the groups has important implications on which gender would behave more sustainably. In gender-mixed groups, the participants with the dominant gender were more likely to change their behavior toward lesser resource extraction than the participants with the dominant gender.



A



B

Figure 4: Percentage of pasture availability and average grazing intensity choices (A & B) over 10 rounds of the experiment

5.1 The effect of gender composition on individuals' decision to apply the maximum grazing intensity

In the experiment, choosing to apply the maximum grazing intensity of 2 often leads to the depletion of pasture in the shared grazing rangelands. As a result, participants with a cooperative intention to the sustainable use of pasture would refrain from applying the grazing intensity of 2, so they would decide to extract pasture either at 1 or 0 grazing intensity. Table 5 indicates the marginal effects of choosing the maximum grazing intensity. The marginal effects for the number of females in the groups were indicated with dummy variables. The two experimental groups with 2 and 3 number of females in the group of five members were represented by two dummy variables whereas the all-female groups were used as reference groups. The likelihood of choosing to apply the maximum grazing intensity─ uncooperative behavior was estimated across the three pasture-availability conditions: pasture-abundance (HH and HL_1), spatial-pasture availability (HL_2), and pasture scarcity (L_1L_1 and L_1L_2). The long-term pasture-scarcity condition (L_2L_2) was excluded due to limited observations to converge the estimation of the marginal effects. So, marginal effects should be interpreted with caution as it shows how each variable predicts the likelihood of choosing the unsustainable resource-extraction decision.

When pasture was abundantly available, the results indicate that the beta coefficients of the interaction terms for the two-female and three-female groups with gender were significant ($\beta = -0.17$, $p < 0.001$ and $\beta = 0.18$, $p < 0.001$, respectively). These results suggest that males in the two-female groups were less likely to apply the maximum grazing intensity, showing more cooperation. In contrast, male participants in the three-female groups were more likely to choose higher grazing intensity, signaling less cooperation. This could reflect a competitive response, where males may resist female dominance and attempt to assert control over resource use. As a result, they behave more uncooperatively than females. The findings suggest that when females dominate the group, males may act more competitively, undermining sustainability even when resources are abundant. However, the group dummy variables for gender-mixed groups were not significant, suggesting that the gender composition of the group did not necessarily foster cooperation among all members. In general, compared to participants in all-female groups, male participants in the two-female groups exhibited a higher level of cooperation for the sustainable use of grazing resources, while males in the three-female groups displayed less cooperation. This underscores the complexity of gender dynamics in resource management, where female dominance may trigger uncooperative behavior from males, potentially compromising the sustainability of the shared resource when the resource is abundantly available.

Furthermore, the results suggest that the higher average age of the group positively predicted the likelihood of applying the maximum grazing intensity─ $\beta = .12 (p < 0.01)$. Deciding to apply the maximum grazing intensity in the prior round (Lag_Gi1) also positively predicted making the same uncooperative decision: $\beta = .13$ ($p < 0.01$). A higher score in cooperation with the common rules and norms scale and higher average market knowledge of the group negatively predicted the likelihood of making the uncooperative decision; $\beta = -.05$ ($p < 0.05$), and $\beta = -.04$ (p

< 0.10), respectively. Additionally, factors like education (specifically secondary education, $\beta = -0.12$, $p < 0.1$) and distance from the market ($\beta = -0.03$, $p < 0.1$) are associated with more sustainable behavior, highlighting that participants with greater education or those farther from markets may be more inclined toward lower grazing intensity, possibly due to different perceptions of resource management or access to external markets.

In the spatial-pasture availability condition (HL2), the participants faced one rangeland with a high-pasture availability condition while the other rangeland in an extremely low-pasture availability condition. In this pasture availability condition, the participants in the two-female and three-female groups were more likely to cooperate for the sustainable use of the shared pasture by refraining from choosing the maximum grazing intensity: $\beta = -.17$ ($p < 0.01$) and $\beta = -.23$ ($p < 0.01$), respectively. These results suggest that when pasture is spatially distributed and may require more complex management (e.g., managing grazing across different areas), the dynamics of cooperation are altered. This change could reflect the need for more strategic, less aggressive decisions when pasture resources are dispersed, as opposed to when they are abundant and readily available in one area. As a result, the participants in the two gender-mixed groups behaved more sustainable than the participants in all-female groups. However, the gender dynamics in cooperative behavior remain the same; the males in the two-female groups behave more cooperatively ($\beta = -0.10$, $p < 0.001$) while they behaved uncooperatively ($\beta = 0.32$, $p < 0.001$) in the three-female groups.

Hypotheses testing for equality of the beta coefficients showed that the participants in the two-female groups had a significantly higher likelihood of making the sustainable choice than in the three-female groups. So, when pasture was spatially available the participants in the two-female groups outperformed all the other groups in eliciting higher cooperation for the sustainable use of the shared resource. In general, the results showed that the participants in the gender-mixed groups were more likely to choose lower grazing intensity than the participants in the all-female groups when pasture was relatively scarce; and spatially scarce.

During spatial-pasture availability, besides refraining from applying the maximum grazing intensity, participants with cooperative intentions could also decide to graze at a grazing site where pasture is scarcely available, allowing the good pasture site to be maintained. The results in Table 7 indicated that membership in any of the group types affected the likelihood of individuals' cooperation in choosing the pasture-scarce grazing site. The male participants in the two female groups were more likely to show such cooperative behavior: $\beta = .11$ ($p < 0.10$) while they exhibited the opposite behavior in the three-female groups: $\beta = -.07$ ($p < 0.01$). Participants with high school education were less likely to show such cooperation behavior: $\beta = -.06$ ($p < 0.01$). Higher within a group variance in age and market knowledge, and rounds in the experiment negatively predicted the likelihood of such cooperation behavior: $\beta = -.01$ ($p < 0.01$), $\beta = -.12$ ($p < 0.01$), and $\beta = -.02$ ($p < 0.05$), respectively. A higher understanding of markets among group members; and higher average market knowledge, positively predicted the likelihood of the cooperation behavior by choosing a pasture-scarce grazing site: $\beta = .05$ ($p < 0.01$) (see Table 7).

In the resource-scarce condition (L_1L_1 and L_1L_2), pasture availability is scarce in both grazing rangelands while there is a hope that the pasture condition in at least one of the rangelands would be recovered to a higher pasture condition in the next round. To this end, the group members that faced this resource condition should choose to apply the lowest grazing intensity (0 grazing intensity, but one or two of the members could still apply 1 grazing intensity). This decision pattern would allow the recovery of degraded rangelands to high pasture conditions. The results indicated that participants in the two female groups were more likely to refrain from applying the maximum grazing intensity: $\beta = -.02$ ($p < 0.05$). So, the two female groups performed more sustainably than the control groups during pasture scarcity times.

The results further indicated that participants with high levels of conformity behavior were more likely to refrain from applying the maximum grazing intensity during pasture-scarcity times: $\beta = -.01$ ($p < 0.10$). In terms of the gender dynamics in cooperation behavior, the males in the two-female groups were more cooperative ($\beta = -0.01$, $p < 0.05$), while in the three-female groups, they behaved uncooperatively ($\beta = 0.04$, $p < 0.05$). This implies that scarcity is acknowledged in the gender-mixed groups, leading to more cooperative behavior during resource scarcity conditions. However, the competitive dynamics between males and females in the three female groups still influence the decisions of male participants, leading to less cooperative behavior even in a resource-scarce context. This behavior underlines the complex nature of gender dynamics, where even in conditions of resource scarcity, competition and resistance to female dominance may persist.

Unlike the earlier results, the hypotheses testing for equality of the beta coefficients showed that the participants in the two-female groups had a significantly higher likelihood of making the sustainable choice than in the three-female groups. All gender-wise differences, collectively, suggest that the differences in the likelihood of making the sustainability choice between males and females diminish as the availability of the shared resource gets scarce.

Table 6: Marginal effects after using heteroskedastic ordered probit models

Y: Grazing intensity (Gi)	*HH and HL1: Abundant pasture*		*HL2: Spatial-pasture*		*L1L1 and L1L2: Pasture-scarcity*	
	Beta	Z-value	Beta	Z-value	Beta	Z-value
All_female groups[1]						
Two-female group	-.01	-0.45	-.17***	-7.82	-.02**	-2.36
Three-female groups	.08	1.19	-.23***	-9.46	-.01*	1.91
Socio-demographics						
Two-female group # Sex (Male=1 & 0 otherwise)	-.17***	-3.64	-.10***	-5.76	-.01***	-2.01
Three-female group # Sex (Male=1 & 0 otherwise	.18***	3.17	.32***	10.08	.04**	1.71
Age	-.01	-0.28	.00	0.05	.01	1.20
Education						
Primary	-.06*	-1.76	-.07***	-2.74	-.01*	-1.79
Secondary	-.12*	-1.87	-.05*	-1.87	-.01**	-2.25
Family size	-.01	-0.37	-.02	-1.37	-.00	-1.07
Distance from market	-.03*	-1.84	-.01	-0.86	.00	0.53
Market Knowledge (MK)	-.01	-0.64	-.02**	-1.87	-.01**	-2.51
Perception of pasture scarcity	.01	0.63	-.01	-0.60	-.00	-0.18
Collective action						
Cooperation with common rules	-.05***	-2.30	-.02**	-1.69	-.00	-0.13
Conformity to norms & values	-.01*	-0.95	.01	0.74	-.01**	-1.52
Collectivism	.00	0.11	.00	0.47	.00	0.31
Group Variable						
Average Age	.12***	4.13	.01	0.80	-.01	-1.04
Std Age	-.01	-0.29	.00	0.15	.00	0.89
Average MK	-.04*	-1.85	-.01	-0.39	-.01**	-1.63
Std MK	.03	0.32	.20**	1.77	.01	0.42
Round	.02	1.04	.00	0.17	-.01	-0.90

[1] Two-female and three-female groups were presented with the dummy variables while all-female groups were used as base/reference groups. Two-female group # Sex is a dummy variable representing males in the two-female group and Three-female group # Sex is a dummy variable representing males in the three-female group.

Lag_Gi1	.13***	7.28	.01*	1.49	.01**	1.83
Observations	670		750		565	
Chi-square	151.65**		72.89***		102.53***	
Pseudo R^2	0.21		0.15		0.13	
Log Likelihood	-290		-246		-349	

Table 7: Marginal effects after logit estimation for choosing a good grazing quality site

Y: Grazing intensity (Gi)	*HL_2: Spatial-resource availability*	
	Beta	Z-value
All_female groups		
Two-female groups	-.05	-1.14
Three-female groups	-.01	-0.48
Socio-demographics		
Two-female group # Sex (Male=1 & 0 otherwise)	.11*	1.77
Three-female group # Sex (Male=1 & 0 otherwise	-.07***	-7.36
Age	-.02	-0.93
Education		
Primary	.01	0.59
Secondary	-.06***	-5.41
Family size	.01	0.98
Distance from market	.00	0.46
Market Knowledge (MK)	-.01	-0.75
Perception of pasture scarcity	-.00	-0.08
Collective action		
Cooperation with common rules	-.01	-0.83
Conformity to norms & values	.04**	2.29
Collectivism	-.01	-1.11
Group Variable		
Average Age	.00	0.18
Std Age	-.01***	-2.74
Average MK	.05***	2.96
Std MK	-.12**	-2.34
Round	-.02**	-1.84
Lag_Gi1	-.01*	-1.42
Observations	750	
Chi-square	73.55***	
Pseudo R^2	0.20	
Log Likelihood	-204	

5.2 The effect of gender composition on individual and group earnings

Table 8 shows the summary of the total individual and group-level earnings at the end of the experiment. It also showed differences in individual earnings across groups as well as between male and female participants in gender-mixed groups. The mean total individual earnings ranged from 49.9 tokens for the control groups to 56.2 tokens for the two-female groups and 53.8 tokens for the three-female groups. Compared to the participants in the control group, the t-test results indicated that participants in the two-female groups earned 6.30 higher tokens while the three-female groups earned 3.90 higher tokens. All the differences are statistically significant. However, between the participants in the two-female and three-female groups, there was no significant difference (2.40 tokens) in their token earnings.

The results in Table 8 also showed that in the two gender-mixed groups, there were statistically significant differences in earnings between male and female participants. In the two female groups, female participants earned 5.7 higher tokens compared to their male teammates. In the three-female groups, however, males managed to earn 4.9 higher tokens compared to their female teammates. These results suggested that, within the groups, there are statistically significant differences between male and female participants depending on the group's gender composition. On average, male participants earned higher payoff in the two-female groups while the reverse is true in the three-female groups. The results imply that participants with the minority gender earned higher payoff in the gender-mixed groups. The total aggregate earnings of the groups from 243.4 tokens for the all-male groups to 281.1 tokens for the two-female groups.

The results in Table 9 reveal important variables influencing the total individual payoff of the participants. In terms of group composition, the participants in the two-female groups earned higher individual payoffs $\beta = .38$ ($p < 0.001$), due to more effective cooperation and resource management by the group, while the participants in the three-female groups showed no significant effect; suggesting challenges in cooperative decision-making. Gender dynamics also play a significant role; in two-female groups, males ($\beta = -0.29$, $p < 0.001$) earn significantly lower payoffs, while in three-female groups, males earn higher ($\beta = 0.21$, $p < 0.001$). This is in line with cooperative behavior, cooperating more reduces individual payoff. Perception of pasture scarcity negatively impacts earnings ($\beta = -0.11$, $p < 0.05$), highlighting that perceived resource shortages may increase cooperation to refrain from self-interest maximizing behavior and thereby, reducing individual payoff. Scoring higher on the collectivism and conformance to group norm scales had opposite effects on individual earnings: $\beta = .28$ ($p < 0.001$) and $\beta = .02$ ($p < 0.05$), respectively. In terms of group-level variables, higher within-group age differences, and higher average market knowledge had negative and positive effects on individual earnings: $\beta = -.38$ ($p < 0.01$) and $\beta = .21$($p < 0.001$), respectively. The finding on the effect of market knowledge is consistent with the findings of Gugissa et al. (2021); they find that groups with greater average market knowledge tend to cooperate more, and that helps group members to develop trust in their future cooperation with the rest of the group members. Whereas, greater within-group variance in ages

has the opposite effect, leading to higher variance within group grazing decisions, thereby reducing the trust of group members.

Table 8: Individual and group payoffs and t-test on mean payoff differences across groups

Groups	Individual payoff			Group payoff	Individual payoff (mean difference)		
	Pooled	Male	Female		Two-female	Three-female	Male vs Female
	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean (Std. Dev)	Mean Diff	Mean Diff	Mean Diff
Control Groups							
All-female groups	49.9 (7.2)	np	49.9 (7.2)	249.7 (27.8)	-6.30***	-3.90**	
Experimental Groups							
Two-female groups	56.2 (8.9)	53.9 (8.5)	59.7 (8.1)	281.1 (37.9)		2.40	- 5.73***
Three-female groups	53.8 (7.7)	56.7 (7.2)	51.8 (7.4)	268.8 (30.6)			4.95***

Table 9: Total individual payoffs and the number of females in the group

Y: Total earnings (Individual)	*Beta*	*t-value*
All-female groups		
Two-female groups	.38***	3.60
Three-female groups	-.03	-0.38
Socio-demographics		
Two-female group # Sex (Male=1 & 0 otherwise)	-.29***	-3.34
Three-female group # Sex (Male=1 & 0 otherwise	.21***	2.86
Age	.01	0.21
Education		
Primary	-.04	-0.66
Secondary	.05	0.74
Family size	.08	1.21
Distance from market	-.01	-0.20
Market Knowledge (MK)	.03	0.51
Perception of pasture scarcity	-.11*	-1.78
Collective action		
Cooperation with common rules	-.02	-0.33
Conformity to norms & values	-.15*	-1.92
Collectivism	.28***	3.56
Group Variable		
Average Age	-.01	-0.15
Std Age	-.38***	-5.22
Average MK	.21***	2.76
Std MK	-.01	-0.18
Observations	225	
F-statistics(df)	(18, 206) 6.19***	
R^2 (adj. R^2)	0.35 (0.29)	

6. Discussion

This study examines the role of the gender composition of common-pool resource user groups in promoting the sustainable use of the shared resource under different resource availability conditions within the context of pastoralists in Ethiopia. The results provide empirical evidence that gender-mixed groups are more likely to make sustainable resource extractions; implying that encouraging females to take part in the management of shared natural resources is key for the sustainable use of shared natural resources and the maximization of long-term returns for the communities. The most likely explanation for these findings is that individuals are more cooperative in opposite-gender than same-gender interactions. In particular, males are found to be more cooperative in mixed-gender groups that encourage cooperation and reciprocity among the resource users (Agarwal, 2009; Balliet et al., 2011).

When the resource is abundant, the results provide no evidence that male-dominated mixed-gender groups (two-female groups) performed better in the sustainable extraction of the resource compared to groups with three-female and all-female. Compared with a prior experiment conducted in the same context with all-male groups, however, groups with all female members performed far less than mixed-gender groups as well as all-male groups; the likelihood of individuals making the unsustainable resource extraction decision was higher in all-female groups. This finding is contrary to the initial expectation as well as the findings of other similar studies (e.g., Agarwal, 2009; Balliet et al., 2011). This could be due to females' lack of experience in decisions concerning resource management in the context of this study.

Within-group gender-wise comparison showed that males than females in the groups with three have a higher likelihood of making the unsustainable resource extraction decision during resource-abundant conditions. However, in the groups with two female members, only females have relatively a higher likelihood of choosing the unsustainable resource extraction option. The results together suggested that a higher proportion of females decreases the male members' cooperation towards the sustainable extraction of the shared resource. This implies that the proportion of females in the decision-making group is essential in determining whether the participation of females leads to more sustainable or unsustainable outcomes.

In times of spatial-resource and short-term resource scarcities, the two mixed groups are significantly different from the all-female groups in eliciting a higher level of cooperation toward the sustainable extraction of the resource. The predicted probability of applying the unsustainable resource extraction level is lower for the participants in the mixed-gender groups in all resource-availability conditions. The results from individual total payoffs show that membership in the two female groups earned higher payoffs at the end of the experiment. On the other hand, the three-female and all-female groups are significantly different from the all-male groups in encouraging a higher level of cooperation toward the sustainable extraction of the resource. Membership in these groups does not predict earning higher individual total payoffs at the end of the experiment. At the group level, however, the groups have significantly

higher earnings. These findings suggest that, although female participation could help pastoralists to foster the sustainable use of pasture, a higher proportion of females in the pasture management institution could also lead to more competition and uncooperative behavior of males. As a result, there should be a way to encourage female pastoralists to take part in the customary rangeland management institution. However, the level of female participation needs caution as it is equally important to maintain the leading role of male pastoralists.

The gender dynamics observed in the two-female and three-female groups reveal complex interactions that significantly influence cooperation and resource management. In the two female groups, males were more cooperative, exhibiting lower grazing intensities and demonstrating a willingness to contribute to sustainable resource use. This cooperative behavior likely stemmed from the minority status of males, which may have led them to align with the group's cooperative norms, avoiding conflict and over-extraction. In contrast, males in the three female groups behaved less cooperatively, often choosing higher grazing intensities, which could be interpreted as a competitive response to female dominance. This suggests that males in female-dominated groups may resist perceived control, undermining sustainability efforts. As a result, the overall group performance in the two-female groups was superior in terms of sustainability, as males were less inclined to engage in the unsustainable behavior observed in the three-female groups. These findings highlight the intricate relationship between gender composition and cooperative behavior, with the balance of power within the group influencing individuals' decisions. Policymakers must recognize these gender dynamics when designing interventions for resource management, as they can shape the long-term sustainability of shared resources.

In terms of the characteristics of individual participants, the results provide empirical evidence that a higher level of education and an understanding of what markets are and how these markets function within the context of pastoralists helps to promote the sustainable extraction of pasture among pastoralists. This finding further enforces the findings of a similar study by Gugissa et al. (2021). A higher average age of the groups, however, decreases the groups' ability to elicit cooperation toward the sustainable use of the shared grazing rangelands among the pastoralists. Similarly, the results on the payoffs indicate that higher average age, within-group variance in age, and market knowledge at the group level help the pastoralists maximize their long-term return from the use of the shared grazing rangelands. Furthermore, pastoralists with higher cooperation to common rules and conformity to norms and values of the pastoralists are important in promoting cooperation behavior among other pastoralists toward the sustainable use of the shared grazing rangelands.

In general, the results are consistent with other studies that provide empirical evidence ─ females than males are more cooperative in resource-dilemma situations (e.g., Agarwal, 2009; Balliet et al., 2011). In practice, however, the sustainable choice stimulated by females' participation in the customary common resource management institutions is unlikely to lead to the sustainable use of the shared resources. The gender composition and the availability of

resources are important factors that influence the impact of females' participation in the sustainable use of resources. This study shows that, for instance, when the availability of the resource is abundant the participation of females leads to more unsustainable use of the resource, leading to the deterioration of the resource. And, a higher proportion of females than males in the groups is also counterproductive to the sustainable use of the resource. Future research should therefore further explore the issue in other study contexts. This study provides limited insights into the contextual differences in the role of females in the sustainable use of shared resources. So, future studies should examine the number of females in the group of shared resource users under different resource availability conditions using multiple study contexts with different cultural backgrounds.

Due to limited observations on long-term resource scarcity conditions, the study provides limited insights into how the participants' choice behavior in this resource condition. This partly happened due to the strong collective culture that the participants come from; Borana pastoralists have a very strong collective culture that could help them promote collective interest over self-interest. As a result, during the experiment, the majority of the resource user groups avoided the worst-case scenario; long-term resource scarcity condition (where the groups faced with highly degraded pasture conditions in both grazing rangelands & both rangelands required longer rounds to recover to good pasture condition). However, understanding the participants' choice behavior in this resource scarcity condition is very insightful about how individuals behave to enable highly degraded rangelands to recover into good conditions. So, future studies can extend the findings of this study by examining the long-term resource scarcity condition by artificially imposing the long-term resource scarcity conditions in the experiment in the same study context or by doing the same experiment in different contexts where participants could come with relatively weaker collective cultural values.

6.1 Policy Implications

The results of the study imply that policymakers should actively promote the formation of mixed-gender groups for communal resource management initiatives. Evidence from this study indicates that diverse gender representation enhances cooperation and fosters more sustainable resource use. However, promoting gender inclusiveness within customary natural resource management institutions requires careful consideration, as it may conflict with established norms in many Indigenous communities. Maintaining the current norm, which often marginalizes women, also limits both women's opportunities and the community's potential for sustainable resource use. The policy contributions of this study can be summarized in four key areas:

1. **Stimulating Dialogues on Mixed-Gender Resource Management Groups**: Policymakers should facilitate dialogues on the benefits of mixed-gender resource management groups. Highlighting successful case studies can demonstrate how such groups achieve better sustainability outcomes. Organizing community dialogues that allow both men and women to share their experiences is essential. In pastoralist communities, engaging clan

leaders and influential males can help shift perceptions and promote broader acceptance of women's roles in the management of communal resources.

2. **Identifying Culturally Sensitive Approaches**: After raising awareness, it is crucial to determine how women can participate in resource management in culturally appropriate ways. The study warns that if men feel dominated, they may respond with unsustainable behaviors. Therefore, integrating women into these institutions must be context-specific. Collaborating with research and academic institutions to explore effective strategies for promoting women's participation in culturally appropriate ways is vital.
3. **Consider Gender Dynamics in Group Composition for Sustainability Programs:** The competitive behavior observed among males in three female groups highlights the importance of considering gender dynamics when organizing groups for resource management programs. Policymakers should assess the potential for gender-based competition and tailor interventions to address these dynamics, ensuring that cooperation is maximized and not undermined by gendered power struggles.
4. **Enhance Education and Market Knowledge for Women:** The study revealed that females had lower levels of market knowledge and education compared to males. The findings show that all-female groups behave more competitively than all-male groups, this could be attributed to their lower level of market knowledge and education. To level the playing field, policies should focus on providing targeted education and training programs for women in resource management and market knowledge. Empowering women through education could lead to more informed decision-making and enhance their ability to contribute to cooperative, sustainable outcomes.
5. **Encourage Cooperation Through Education and Market Access:** Policies that promote education and increase market access could improve cooperation in resource management. The study suggests that individuals with higher levels of education or those near markets tend to engage in more sustainable behavior. Policymakers should implement programs that enhance market knowledge and education, which could help participants make more cooperative and sustainable decisions.
6. **Facilitate Collaborative Platforms for Knowledge Exchange:** To overcome gaps in market knowledge, education, and resource management knowledge, policymakers should support platforms that encourage knowledge sharing and collaboration between different gender groups. Creating spaces for women and men to share experiences, learn from each other, and collaborate on resource management could help overcome disparities in knowledge and foster more effective, cooperative decision-making.

6.3 Conclusion

This study shows that the sustainability performance of Indigenous common-pool resource management institutions in rural communities can be improved by promoting gender inclusiveness. The empirical findings in this study suggest that male-dominated, gender-mixed groups increase the likelihood of individuals adopting more sustainable behaviors in the extraction of communal resources, thereby maximizing the long-term return from the use of shared

natural resources for rural communities. The findings also suggest that resource scarcity enhances the positive effects of gender inclusiveness on sustainable resource extraction behaviors. For policymakers, this highlights that gender inclusiveness is crucial not only for rural women but also for the entire community, including rural men, as it fosters the sustainable use of common-pool natural resources. By encouraging gender-inclusiveness in Indigenous natural resource management institutions policymakers could achieve multiple objectives: improving livelihoods and enhancing climate-change resilience through sustainable resource use, while empowering women and addressing the marginalization of women in key resource management roles. This approach not only promotes equitable participation but also strengthens the overall resilience and sustainability of rural communities.

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Appendix 1: Model constructs, Survey Measures, and standardized loading for each item

	Market knowledge (Teklehaimanot, 2017) alpha = .91; eigenvalue = 4.48	*Loadings*
	A pastoralist who wants to sell his livestock:	
1	Should be aware of changes in the buyers' livestock preferences.	0.73
2	Will benefit more if his livestock-raising practices center on satisfying the needs of buyers.	0.85
3	Will benefit more if he searches for better breeds that livestock traders are looking for.	0.79
4	Will receive lower prices if he sells livestock of a lower quality than that sold by highland farmers.	0.82
5	Should know the specific activities required to raise high-quality livestock.	0.83
6	Should be able to explain the quality of his livestock-to-livestock buyers.	0.77
7	Should accept the first price that the buyers offer for his livestock. (R)	0.81
	Perceived pasture scarcity (Gugissa, 2020) alpha = .62; eigenvalue = 1.72	
1	In the last five years, the availability of palatable grasses is decreasing	0.62
2	In the last five years, our grazing areas have been covered by unpalatable grass species.	0.67
3	In the last five years, our rangeland has been enough to graze our livestock. (R)	0.71
4	In the last five years, woody plant encroachment is increasing.	0.78
	Cooperation to Common Rules (Gugissa, 2020) alpha = .82; eigenvalue = 3.82	
1	I always graze my livestock in the grazing areas distant from my village (Arda).	*0.79*
2	I prefer to graze my livestock near my village (Arda). (R)	*0.76*
3	I always fence the enclosed rangeland for calves (Kalo).	*0.75*
4	When I water my livestock in a pond, I always put Meerii.	*0.70*
5	During rainy seasons, I graze all of my livestock in the Worralands. (R)	*0.72*
6	I always herd my dry and lactating livestock separately in both wet and dry seasons.	*0.76*
7	I care more about the well-being of my livestock than I do about the overgrazing of our rangeland. (R)	*0.71*

	Conformity to Traditional Values and Norms (Teklehaimanot, 2017); alpha = .85; eigenvalue =3.12	
1	I strongly respect our traditions.	*0.79*
2	We need to stick to our traditions and experience.	*0.79*
3	I am devoted to transferring our traditions to my children.	*0.83*
4	I adhere to our norms to avoid any deeds that would endanger the preservation of our traditions.	*0.77*
5	I conform to our norms.	*0.76*
	Collectivism (Teklehaimanot, 2017); alpha = .85; eigenvalue =2.78	
1	I consider it important to contribute livestock to my clan members.	*0.80*
2	I assign priority to the survival and protection of our community	*0.86*
3	I am loyal to the collective well-being of my clan members.	*0.81*
4	I feel pride in contributing to my clan members.	*0.86*

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