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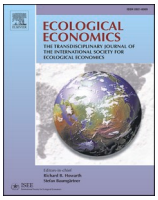

Surveys

Market knowledge as a driver of sustainable use of common-pool resources: A lab-in-the-field study among pastoralists in Ethiopia

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ABSTRACT

Rural communities that depend on common-pool resources for their livelihoods are being increasingly affected by the expanding global market system. Because such market integration is still relatively thin, communities vary in terms of market comprehension. Using a common-pool resource dilemma experiment, this study examines the effect of market knowledge on decisions concerning the use of common-pool resources among Borana pastoralists. Participants chose to use shared grazing rangelands at low or high levels of grazing intensity. Depending on the resource-use decisions in previous rounds, the participants encountered different pasture-availability conditions that required them to make trade-offs between their short-term interests and the long-term sustainability of the shared rangelands. The results indicate that, when resource conditions were good, resource users with more market knowledge are more likely to choose lower grazing intensity. During scarcity, this effect is weaker. The results further show that within-group variance in market knowledge has a negative effect on decisions relating to sustainable-resource use in times of resource scarcity. The results imply that providing an understanding of market functioning is of vital importance to protecting shared natural resources from depletion in communities experiencing increasing impact from the global market economy.

1. Introduction

The ongoing process of globalization is increasingly moving the global market system into remote parts of the globe, including to communities whose subsistence depends on commonly shared natural resources (e.g., grazing lands, forests, fishing areas, and irrigation systems). As markets expand, such resources are increasingly used to supply demands from external markets (Agrawal and Yadama, 1997). While market integration has positive effects on the livelihood of these communities (Keller and Shiue, 2007), it also provides incentives for the overexploitation of natural resources, given that the influence of cash returns on decision-making in the *commons dilemma* (Hardin, 1968). In commons dilemma, individual short-term interests to exploit a scarce shared resource are at odds with the long-term interests of the larger community (Cass and Edney, 1978; Hardin, 1968). To ensure the sustainable management of common-pool resources, communities may manage resources locally by developing a sense of community, trust-based relationships, and institutions that steer decisions toward long-term interests (Acheson, 2006; Ostrom, 1990). The incentives that market integration provides to overexploit resources in the short-term places such relations and institutions under pressure (Agrawal and Yadama, 1997; Pendleton and Howe, 2002). As Acheson (2006) states "new markets can result in growing competition for resources and can motivate people to disobey rules, invade areas of others, or increase their exploitative efforts to the detriment of the resource" (p. 128).

Several recent studies on the impact of markets on common-pool resources support these assertions (Mutenje et al., 2011). In southern Africa, an increase in market integration among forest-fringe dwellers has exacerbated the degradation of forest resources (Mutenje et al., 2011). Common institutions also appear unable to attenuate the effect of market forces on forest degradation in Ecuadorian indigenous communities (Godoy et al., 2005). According to other studies, however, market integration fosters the sustainable usage of common-pool resources by influencing the perceptions of gains and losses associated with resource overexploitation (Oldekop et al., 2013; Vaccaro et al., 2009). In the Gulf of California in northwestern Mexico, small-scale fishers were able to generate stable incomes sustainably by using ecological indicators of the fishing system to guide their fishing decisions (Basurto, 2008). In a

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review of experimental studies, Andersson and Agrawal (2011) report evidence that resource users adjust their common institutions in response to threats from market forces.

In this study, we test a potential explanation for why communities may adopt different approaches to the sustainable use of common-pool resources when integrating with markets. We argue that the understandings that resource users have concerning the functioning and dynamics of markets (market knowledge) affect their decisions concerning the use of common-pool resources (Cecchi and Bulte, 2013). Specifically, we test the hypothesis that market knowledge promotes individual resource users to make sustainable use of common-pool resources.

This study tests this hypothesis by examining market knowledge as an individual-difference variable within the context of a dilemma experiment involving common-pool resources. Such experiments have been used to investigate how the decisions of resource users are sensitive to subtle changes in the context or incentive structure (Anderies et al., 2011). Many of these experiments focus primarily on contextual factors (e.g., payoff structure, resource dynamics, group heterogeneity), as well as on stable individual characteristics (e.g., social motives, gender). Unstable personal characteristics (e.g., market experience, market knowledge) have been largely ignored, however, or used only as contextual features (Anderies et al., 2011).

The grazing experiment used in this study was initially developed by Cardenas et al. (2013) as an experiment in a common-pool fishery. Prediger et al. (2011) use a comparable experimental design to explain the impact of cultural and ecological differences on cooperative behaviors between South African and Namibian communal farmers. Building on their work, we use the experiment as a "within-culture" design to examine the impact of individuals' understanding of markets on the likelihood that communal farmers will make sustainable decisions concerning the use of common-pool resources. In the experiment, participants were required to make decisions concerning grazing intensity, as a proxy for the amount of pasture resources that they preferred to extract from shared grazing rangelands to feed and fatten the livestock they selected for markets. Depending on resource-use decisions made in previous rounds, the rangelands would degrade when certain exploitation thresholds were exceeded. The participants therefore faced different pasture-availability conditions, which lead to different outcomes (Prediger et al., 2011).

In our study, we focus on variations in individual resource-use decisions, with market knowledge as an independent variable. The grazing experiment was carried out among Borana pastoralists in Southern Ethiopia (See Fig. 1.). Because all participants shared the same culture, clan origins, and ecological conditions, there were no substantial contextual differences in the experiment. Given the differences identified by prior research within this context with regard to pastoralists' understanding of markets and their subsequent behaviors (e.g., Ingenbleek et al., 2013; Teklehaimanot et al., 2017), we regard this context as suitable for testing our hypothesis that market knowledge promotes users to make sustainable use of common-pool resources.

2. The effect of market knowledge on the sustainable use of common-pool resources

The concept of market knowledge builds on a tradition in the economic literature that relaxed the original assumption of rationality. This tradition includes theories on bounded rationality (e.g., Argote and Greve, 2007) and studies on the effects of market experience on choice behavior (e.g., Cecchi and Bulte, 2013). *Market* knowledge is organized and structured information about customers, competitors, and dynamics in the market environment (De Luca and Atuahene-Gima, 2018). Consistent with the literature from marketing that investigates how businesses can be successful in their market environment (Kotler and

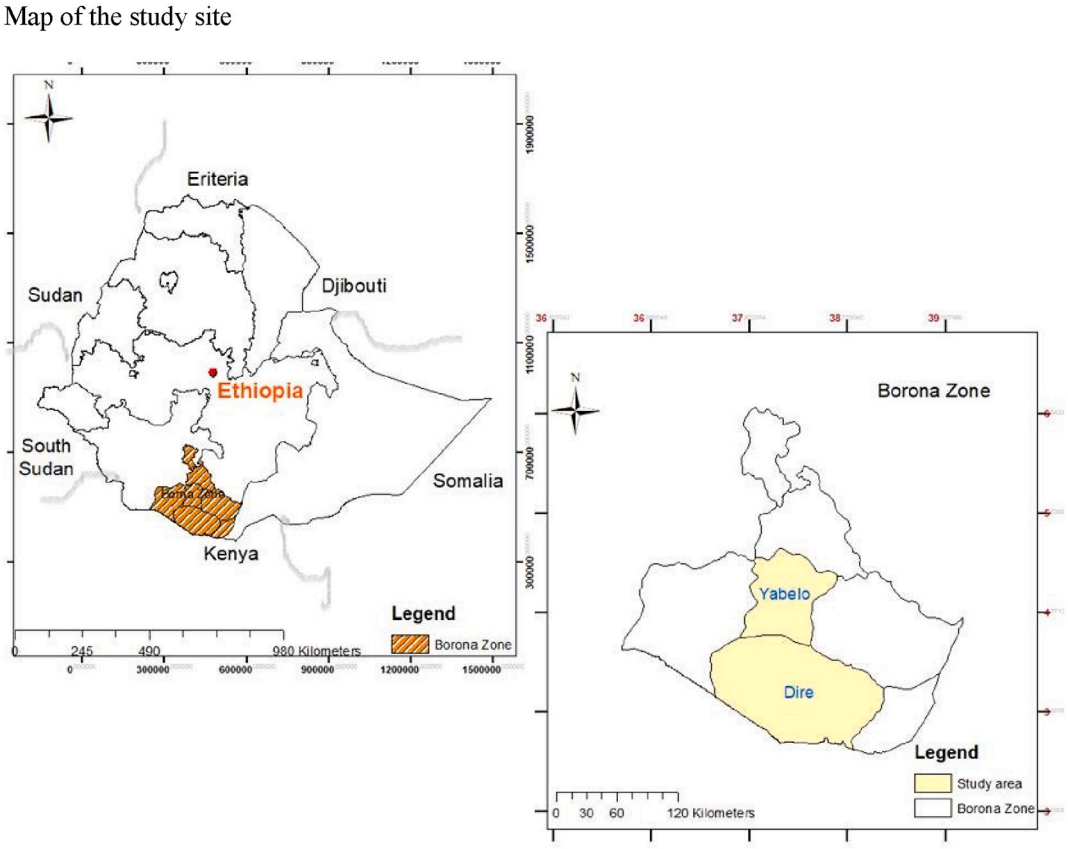

Fig. 1. Map of the study site.

Keller, 2012), market knowledge pertains to the deeper understanding of how markets function, and how buyers and competitors may act and respond to changes in the market. A deeper understanding of these matters helps to understand the direction in which the market develops and how that will affect one's business.

Importantly, knowledge is different from information. While information refers to interpreted data (like buyer preferences, competitor actions, and prices), knowledge pertains to information that is stored in memory (Zins, 2007). Knowledge is obtained through experience or education and creates a cognitive structure in which new information can be categorized, and thus, acts as a filter through which new information is interpreted and given meaning (cf. Zins, 2007). As a consequence, two decision-makers that receive the same information but differ in their knowledge, may draw different inferences, potentially leading one of them to cooperate and the other to behave opportunistically. Consistently, research on common dilemmas has shown that the costs and benefits that resource-users perceive in relation to cooperation in commons dilemmas are affected by the information from prior experiences that they store and process (Anderies et al., 2011; Cárdenas and Ostrom, 2004).

Market knowledge can increase cooperation in a commons dilemma because it reduces uncertainty. In a resource dilemma, resource users face environmental and social uncertainty (Mantilla, 2018; Van Vugt, 2009). *Environmental uncertainty* pertaining to the ecological state of the shared natural resources is at the basis of the dilemma (think for example about climatic forecasts (Marrocoli et al., 2018). Another source of environmental uncertainty pertains to the market value of harvesting the resources (cf. Eppink et al., 2016; Thanassekos and Scheld, 2020). Unpredictably fluctuating prices may stimulate resource-users to harvest more resources than sustainably in order to secure their means of existence (e.g., Thanassekos and Scheld, 2020). *Social uncertainty* pertains to resource usage decisions that other users will make: whether they will cooperate in the resource dilemma or not (Van Vugt, 2009). Coordination between resource-users can reduce such uncertainty, like institutions, incentives, penalties, and socio-cultural norms (Buckley et al., 2018). Janssen, Tyson and Lee (2014) for example find that communication between resource-users removes such uncertainty and increases cooperation.

The market knowledge of an individual resource user can reduce *environmental uncertainty* pertaining to the market value of resources. Two mechanisms may contribute to this expectation. First, literature in marketing suggests that market knowledge helps resource users to perform better and are more capable to influence the directions of development within their market (e.g., Kim and Atuahene-Gima, 2010; Liu and Atuahene-Gima, 2018). Such knowledge therefore generates more confidence in the future, which in turn affects perceptions of the gains and losses associated with overexploitation. Recent research on Ethiopian pastoralists indeed shows that pastoralists who integrate into markets with a higher level of market knowledge have a better notion of which livestock they should sell, when, and to whom, thus generating higher income than do those making transactions without such knowledge (cf. Ingenbleek et al., 2013; Tessema et al., 2019). Because those resource-users have more confidence in and feel more control over their long-term earnings from livestock sales, their perceived gains from overexploitation will be smaller and the perceived losses larger (Oldekop et al., 2013). The logical consequence is that resource users equipped with high levels of market knowledge will try to protect natural resources for the future and cooperate in the common resource dilemma.

Second, the marketing literature implies another mechanism that reduces environmental uncertainty. The marketing literature suggests that market knowledge is at the basis of market-oriented behavior, including the development of relationships with buyers, and extra efforts of collecting market information about current and potential buyers and the factors affecting them (Day, 1994; Slater et al., 2012). Such behaviors contribute to an even deeper understanding of buyers and thus, help to assess their sensitivity to quality. In the context of common resource dilemmas, it may help to make inferences about the causal chain starting with resource degradation which influences the health and fitness of livestock, followed by the perceived quality by potential buyers of that livestock, and their willingness to buy and pay. According to recent qualitative evidence, Ethiopian pastoralists indeed receive market feedback on the quality of the livestock they sell from their buyers and brokers or/and in the form of the price they receive for their livestock (Tessema et al., 2019). These insights obtained through such feedback will further contribute to cooperative behaviors in the common resource dilemma because higher market knowledge leads to a more precise assessment of the consequences of resource degradation (and with that a reduction of environmental uncertainty).

Market knowledge also can reduce *social uncertainty*, because the levels of market knowledge held by other group members reduce the perceived behavioral uncertainty for all resource users facing a common resource dilemma. Again, two mechanisms are contributing to this assertion. First, if other group members are perceived to have a comparable level of market knowledge as the decision-maker, the decision-maker will expect that his/her peers will reason in the same way, come to the same conclusions, and make similar decisions. Thus, a higher *average level of market knowledge* in the group will reduce social uncertainty, thereby increasing the likelihood that an individual resource-user decides to cooperate (Varughese and Ostrom, 2001; Vona and Patriarca, 2011). Comparably, within-group differences in market knowledge increase social uncertainty. Larger differences between the resource users with the highest and lowest level of market knowledge (higher *within-group variance in market knowledge*) increase the social uncertainty and therefore decreases the chance of cooperation by resource users. Similarly, other studies have shown that differences in perceptions concerning actual resource use and lack of trust within a group of resource users are detrimental to cooperation (e.g., Varughese and Ostrom, 2001; Vona and Patriarca, 2011). Second, research on common resource dilemmas has shown that resource users also imitate each other's behavior (cf. Ostrom, 1998). Given that the level and distribution of market knowledge in the group is associated with cooperation, it is therefore likely that the cooperative and defective behaviors are reciprocated by other members of the group. This further reinforces the effects of the average levels of market knowledge and the within-group variance.

3. Materials and methods

3.1. Research context

We conducted the experiment among Borana pastoralists. Pastoralists in this region are known for their indigenous ecological knowledge system, which allows them to manage commonly held grazing rangelands sustainably (Gemedo-Dalle and Maass, 2006). Their indigenous self-governance institutions exercise control over the socio-economic life of the society, including the use of grazing rangelands. Classifying the communal grazing rangelands into dry-season and wet-season grazing units is the main strategy that Borana pastoralists use to ensure the sustainable management of communal rangelands (Gemedo-Dalle and Maass, 2006). Like other pastoralists, mobility is also part of the traditional rangeland-management strategy (Homann et al., 2008). During resource-scarce times, they move their livestock to distant rangelands, thereby taking advantage of spatial heterogeneity in pasture availability. The route of livestock mobility depends on the availability of pastures and the carrying capacity of rangelands (Gemedo-Dalle and Maass, 2006). Based on our knowledge of the study area, the pastoralists largely possess what Ostrom (2007) regards as essential components for analyzing the sustainability of common resource systems: the resource system (e.g., grazing rangeland), the resource units (e.g., pasture), the users, and the governance system (e.g., traditional institutions). Studies have nevertheless revealed significant variations among individual pastoralists in the region with regard to marketing activities and

livelihood performance (e.g., Teklehaimanot et al., 2017; Tessema et al., 2019).

Many Borana pastoralists have long led a subsistence-oriented seminomadic lifestyle (Aklilu and Catley, 2013). In recent decades, however, they have been increasingly integrating into local and export markets, which has required them to raise livestock and use the shared grazing rangelands to satisfy market requirements and realize profits (Aklilu and Catley, 2013). In their efforts to produce livestock for the market, pastoralists often encounter natural-resource scarcity due to the area's arid climate (Luseno et al., 2003). The traditional common-resource management system is being affected by both the increased market integration of pastoralists and the depletion of natural resources. For example, in contrast to long-standing tradition, pastoralists in the region have begun to build fences and establish private enclosures for fattening and farming purposes (Reda, 2016).

3.2. Experimental design

The experiment involved a social dilemma in which individual interest in high-intensity grazing clashes with desired group-level outcomes (Cardenas et al., 2013). Two hypothetical grazing sites were involved: Rangelands A and B, which can have either high or low levels of pasture availability. The sites were held jointly by a group of five participants. An experimental session consisted of 10 rounds. In each round, every member of a group 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 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 no rules were governing grazing-intensity choices.

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 (the currency in the game (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 we briefed them on the amount they would gain depending on their individual and fellow members' grazing-intensity choices, including the possibility of rehabilitating degraded rangeland through no grazing or low grazing intensity. 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.

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, pasture 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. A 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 players can choose to maximize their individual 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, all players will choose to graze at maximum intensity. As a result, the group will encounter low grazing availability in the next round. If this opportunistic behavior continues, the group will continue to face low grazing availability in both rangelands for the remaining 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 maximum grazing intensity, 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 maximum grazing intensity (Cardenas et al., 2013).

Table 1
Individual payoff table.

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

Source: Cardenas 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 game, 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 et al. (2011, p. 1602), participants had difficulty distinguishing between the L_1 and L_2 grazing conditions. We therefore used pictures to present the three pasture availability conditions (see Fig. 2). At the end of each round, the coordinator showed one of the pictures in Fig. 2 for each of the grazing sites, as an outcome of the group's grazing decisions. Before conducting the experiment, we showed the pictures to three local experts and ten pastoralists and they confirmed that the three pictures in Fig. 2 with rainy, dry, and drought conditions, were perceived as realistically depicting the real-life variations in pasture availability.

3.3. Participants and measurement

Our study focuses on market knowledge as an individual difference variable in communities where trade connections with the outside world were intensified only recently. Because participants may have relatively little experience with markets, we searched for a context that would likely offer us sufficient variance in market knowledge between participants. We therefore recruited participants from an earlier project that conducted an experimental training program on market knowledge in October 2015 with 60 pastoralists who were compared to a control group of the same size (Teklehaimanot, 2017). The participants had been selected using a multi-stage sampling procedure. Four villages from two administrative districts from the region—Yabello and Dire—were used as sampling units for the selection of 120 participants. Our grazing experiment was conducted in August 2018, using the same participants. In the three years since the training took place, the training effects were expected to have faded for some participants, further developed for others, and spilled over to pastoralists that had not been trained, thus creating a setting that provides sufficient variance in market knowledge between participants. A two-sample *t*-test confirmed that there is no statistically significant difference in the score of market knowledge between the two groups ($M_{\text{experimental group}} = 3.44$, $M_{\text{control group}} = 3.52$, $t = -0.63$, $p > 0.10$). To minimize the chance that participants would make a connection between the market knowledge

Grazing-quality status: H, L_1, and L_2, respectively.

Fig. 2. Grazing-quality status: H, L_1, and L_2, respectively.

training and the current study, we didn't inform them about the recruitment criteria and procedure. All 120 pastoralists accepted the invitation to take part in the experiment. Consistent with the field-experiment protocol developed by Cardenas et al. (2013), the participants in each village were randomly assigned to one of 24 five-member groups for the entire duration. The experiment took about two hours, including the instructions, three trial rounds, 10 rounds of the experimental game, and payments.

We used the grazing-intensity choices of individual participants in each round of the experiment to measure individual cooperation. In the experimental game, a grazing intensity of 2 is not a sustainable decision, as it often leads to the degradation of communal grazing rangelands and hinders the group's ability to maximize the aggregate payoffs. Because this grazing-intensity choice is not sustainable, we measured individual cooperation in the sustainable use of the rangelands as refraining from applying a grazing intensity of 2 (i.e., applying grazing intensity 0 or 1) (Prediger et al., 2011). Another outcome variable, individual total earnings, was measured as the aggregate token earned in 10 rounds of the experiment.

To collect data on the participants' profiles, a survey was administered three days before the experiment (Anderies et al., 2011). Multi-item scales were used to measure market knowledge, along with a set of control variables including cooperation with rules for the use of common-pool resources, conformity to traditional values and norms, and collectivism. For validation purposes, the survey also included a measure of customer orientation (which are the behaviors that stem from market knowledge). All items of these measures are provided in Table 2. All items were measured along a five-point Likert scale ranging from 5 (strongly agree) to 1 (strongly disagree). The items were developed based on a qualitative pre-study and formulated as concretely as possible to make them easily understandable to the respondents (Teklehaimanot, 2017).

Market knowledge was measured as a latent variable with seven items. The scale measures the pastoralists' level of understanding of fundamental market knowledge based on marketing textbook knowledge (e.g., Kotler and Keller, 2012) contextualized to the pastoralist context. While the items are fully contextual they reflect founding ideas of marketing, namely that customers should come first, that customer satisfaction is the main driver of profitability, that competitors are determined from the alternatives that buyers consider, that prices follow the value that buyers experience, but if the perceived quality is high negotiation may be necessary to arrive at such prices with buyers (Teklehaimanot, 2017). We also used 5-point Likert-type scales for this measure, examining their agreement with statements about the market. The advantage of formulating these items as Likert-type items is that respondents are not put in the position of a student that completes an exam, but rather in the role of an expert whose opinions and ideas matter to the interviewer. The pastoralists are therefore likely to respond in terms of their conceptualization of a market as they use it in day-to-day decisions in breeding, fattening, and selling livestock. The measure was adopted from Teklehaimanot (2017) who developed the measure based on a qualitative pre-study and extensively pre-tested and validated it. The items are shown in Table 2.

The scale measures one dimension of market knowledge varying between high and low knowledge. We checked the unidimensionality with a test for convergent validity, examining the construct's item loadings and average variance extracted (Hair et al., 2014). The results confirm that the measure was unidimensional. To check the distribution, we examined the histogram and normal probability plots of the variable market knowledge and within-group variance in market knowledge (Hazelton, 2003). The plots suggest a normal distribution of the variable market knowledge. As 64.5% of the respondents scored above the scale middle of 3, the data have substantial variance in terms of market knowledge. The within-group variance in market knowledge was computed for each group by calculating the squared deviation of the five group members' market knowledge scores from the mean market knowledge value of the group and therefore ranges from 0 to 1. The plots for the variable within-group variance in market knowledge also suggest a normal distribution. The plots are shown in Web Appendix 1.

3.4. Data analysis

Because our dependent variable (the grazing-intensity choices of individual participants) is an ordered outcome, we used an ordered probit model to estimate the effect of market knowledge (Daykin and Moffatt, 2002). We then report the marginal effect of market knowledge for the likelihood of applying the maximum grazing intensity (Prediger et al., 2011). We used a multiple linear regression model to analyze the effect of market knowledge on the total earnings of the participants.

The marginal effect of market knowledge on the likelihood of choosing the maximum grazing intensity was estimated across the different pasture-availability conditions that groups might face in the experiment. We used four conditions, based on the level of the pasture-availability in the two grazing rangelands: 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) (Prediger et al., 2011). We included control variables for age, family size, education level, and distance from the village to the market, as well as for conformity to traditional values and norms, collectivism, and respect for rules regarding the use of common-pool resources (descriptive statistics provided in Table 3). The last three variables function as proxies for trust, reciprocity, and reputation, respectively. We also added a one-period lag in the grazing-intensity decisions of individual participants as a control variable to account for the effect of learning from decisions in previous rounds. With regard to group composition, we controlled for average age and the average and within-group variance of market knowledge.

4. Results

As indicated in Table 4, the maximum grazing intensity of 2 was applied 21.42% of the time, whereas grazing intensities of 0 and 1 were

Table 2
Model constructs, Survey Measures, and standardized loading for each item.

	Market knowledge (Teklehaimanot, 2017) alpha = 0.93; eigenvalue = 4.5	*Loadings*
	A pastoralist who wants to sell his livestock:	
1	Has no option other than selling his livestock at a marketplace such as Dubuluq. (R)	Dropped
2	Will benefit more if he finds a buyer who seeks ways in which both the buyer and the pastoralist selling	Dropped
3	Should know that climate and export markets influence prices for livestock.	Dropped
4	Should be aware of changes in the buyers' livestock preferences.	0.82
5	Will benefit more if his livestock-raising practices center on satisfying the needs of buyers.	0.84
6	Will benefit more if he searches for better breeds that livestock traders are looking for.	0.8
7	Will receive lower prices if he sells livestock of a lower quality than that sold by highland farmers.	0.8
8	Should know the specific activities required to raise high-quality livestock.	0.84
9	Should be able to explain the quality of his livestock to livestock buyers.	0.71
10	Should accept the first price that the buyers offer for his livestock. (R)	0.78
	Customer-orientation (Ingenbleek et al., 2013) alpha = 0.94; eigenvalue = 4.26	
1	I increase the quality of the livestock that I am planning to sell.	0.88
2	I do nothing to increase the quality of the livestock that I want to sell.	0.82
3	I breed with livestock that will give me the quality traders are looking for.	0.83
4	I always prefer to keep the best livestock for ourselves.	Dropped
5	I sell my livestock only when I cannot generate income from other sources.	0.74
6	I raise livestock that the market wants.	0.87
7	I always search for better breeds to satisfy livestock traders and exporters.	0.92
	Cooperation to Common Rules alpha = 0.91; eigenvalue = 4.11	
1	I always graze my livestock in the grazing areas distant from my village (Arda).	*0.8*
2	I prefer to graze my livestock near my village (Arda). (R)	*0.77*
3	When pasture is very scarce, I always sell some of my livestock.	*Dropped*
4	I always fence the enclosed rangeland for calves (Kalo).	*0.8*
5	When I water my livestock in a pond, I always put Meerii.	*0.81*
6	During rainy seasons, I graze all of my livestock in Worralands. (R)	*0.71*
7	I sometimes graze my dry livestock in Worralands. (R)	*Dropped*
8	I always herd my dry and lactating livestock separately in both wet and dry seasons.	*0.73*
9	I care more about the well-being of my livestock than I do about the overgrazing of our rangeland. (R)	*0.74*
10	My livestock is more important to me than the communal rangeland is. (R)	*Dropped*
	Conformity to Traditional Values and Norms (Teklehaimanot, 2017) alpha = 0.94; eigenvalue =3.75	
1	I strongly respect our traditions.	*0.83*
2	It is important for us to stick to our traditions and experience.	*0.84*
3	I am devoted to transferring our traditions to my children.	*0.91*
4	Only our existing traditions and knowledge can make us successful.	*Dropped*
5	I want to preserve our ancestors' tradition of livestock-raising practices.	*Dropped*
6	I aim to inherit more livestock to my children.	*Dropped*
7	I adhere to our norms to avoid any deeds that would endanger the preservation of our traditions.	*0.9*
8	I conform to our norms.	*0.85*
	Collectivism (Teklehaimanot, 2017) alpha = 0.92; eigenvalue =2.93	
1	I consider it important to contribute livestock to my clan members.	*0.85*
2	I assign priority to the survival and protection of our community	*0.83*
3	I am loyal to the collective well-being of my clan members.	*0.85*
4	I feel pride in contributing to my clan members.	*0.9*
5	I consider it important to save money for my own future.	*Dropped*

applied 15.92% and 62.67% of the time, respectively. The participants thus decided to act sustainably 78.58% of the time by refraining from applying the maximum grazing intensity of 2. Compared to the results from the experiment conducted by Prediger et al. (2011) among South African and Namibian pastoralists (38.5%), the Borana pastoralists in our experiment applied the maximum grazing intensity at a lower rate (15.92%) (see also Homann et al., 2008).

Throughout 10 rounds, the groups maintained high grazing availability in at least one of their grazing rangelands 64.17% of the time (Table 4). This suggests that groups applied a "rotation strategy," in which they would have one high-availability rangeland in which to graze in each round while leaving the other rangeland to recover. Examining developments after 10 rounds, the number of high-availability rangelands and the average grazing-intensity choices per round exhibited the same patterns (see Fig. 3). The participants had apparently adjusted the pattern of their grazing-intensity choices based on the availability of resources. As also demonstrated in Table 4, none of the participants applied the maximum grazing intensity in the worst resource-availability conditions, and they increasingly applied the lowest grazing intensity as resource scarcity increased.

4.1. The effect of market knowledge on grazing-intensity choices

The results presented in Table 5 indicate the marginal effects of market knowledge on the likelihood of choosing the maximum grazing intensity across three resource-availability scenarios. The L_2L_2 condition occurred only 4.58% of the time and was observed in only 8 of the 24 groups in the experiment. The popular rule of 10 observations per predictor variable was therefore not satisfied in the long-term resource-scarcity condition (Vittinghoff and McCulloch, 2007). Because we included 12 predictor variables in our analysis, the 55 observations for the L_2L_2 resource conditions failed to reach the minimum sample size required. We therefore excluded this resource-availability condition from our analysis.

The results indicate that individual market knowledge was a negative predictor of the likelihood of choosing maximum grazing intensity when pasture resources were abundantly and spatially available: $\beta = -0.13$ ($p < 0.01$) and $\beta = -0.12$ ($p < 0.01$), respectively. In these conditions, individuals with more market knowledge were more likely to refrain from applying maximum grazing intensity. Average market knowledge and variance in the level of market knowledge among group members were not significant. In the HL_2 resource-availability condition, we further examined the rangeland choices of the participants (H or L_2). Individual market knowledge had no significant effect on a grazing-site selection (Web Appendix 1).

When a group is facing resource-scarce conditions, its members should choose the lowest grazing intensity to allow the degraded rangelands to recover to high pasture availability. An individual may nevertheless decide to apply the grazing intensity of 1 and hope all other group members will choose the grazing intensity of 0. In a resource-scarcity condition (L_1L_1 and L_1L_2), pasture resources are scarcer, however, there is a hope that the grazing availability of at least one of the rangelands will be able to recover in the next round. As indicated by the results displayed in Table 5, under conditions of resource scarcity, market knowledge at the individual level negatively predicts the likelihood of applying maximum grazing, with marginal effects of $\beta = -0.02$ ($p < 0.05$). The results further reveal a highly significant (1% level) positive marginal effect of individual market knowledge on the likelihood of choosing minimum grazing intensity (see Web Appendix 1 for the marginal effects for intensities of 1 and 0). The marginal effect of market knowledge is weaker for these conditions than for the resource-abundant and spatial resource-availability conditions. This result is likely due to the traditional tendency of Borana pastoralists to act sustainably when resource scarcity is more acute (Davies, 2008; Kihiu, 2016). Group-level average market knowledge did not affect grazing decisions. In line with our expectations, however, variance in the level of

Table 3
Row mean (M), Standard deviation (SD) and Inter-correlation among variables ($N = 120$).

		1	2	3	4	5	6	7	8	9	10	11	12
1	Grazing intensity	1.00											
2	Market knowledge	−0.19	1.00										
3	Group average market knowledge	0.07	0.33	1.00									
4	Group variance market knowledge	−0.03	−11	−0.32	1.00								
5	Cooperation with common rules	−0.12	0.50	0.13	−0.08	1.00							
6	Conformity to norms and values	−0.01	0.04	0.02	−0.14	0.22	1.00						
7	Collectivism	0.03	0.04	0.07	−0.13	0.25	0.82	1.00					
8	Age	−0.01	−0.05	−0.07	0.07	−0.08	0.36	0.31	1.00				
9	Average Age	−0.05	−0.06	−0.18	0.19	−0.06	0.08	0.09	0.38	1.00			
10	Family size	0.02	0.16	0.16	−0.01	−0.05	0.30	0.24	0.53	0.10	1.00		
11	Education	−0.01	0.04	−0.04	−0.06	0.24	−0.12	−0.12	−0.31	0.07	−0.24	1.00	
12	Distance from market	−0.03	0.09	0.18	−0.18	0.13	−0.07	0.03	0.05	−0.17	0.15	−0.11	1.00
	Mean	1.06	3.47	3.47	0.52	3.66	4.42	4.39	51.5	51.55	8.29	0.33	2.71
	Standard Deviation	0.61	0.75	0.25	0.22	0.67	0.81	0.82	12.8	4.9	4.4	0.74	1.01

Table 4
Summary of resource conditions faced by the groups and grazing-intensity choices for different resource-availability conditions.

Resource-availability conditions	Total	Percent	Cumulative	Grazing intensity		
				0	1	2
HH	42	17.50	17.50	0	117	93
HL_1	28	11.67	29.17	1	93	46
HL_2	84	35.00	64.17	1	315	104
L_1L_1	7	2.92	67.09	19	14	2
L_1L_2	68	28.33	95.42	142	186	12
L_2L_2	11	4.58	100	28	27	0
Total	240	100		191	752	257

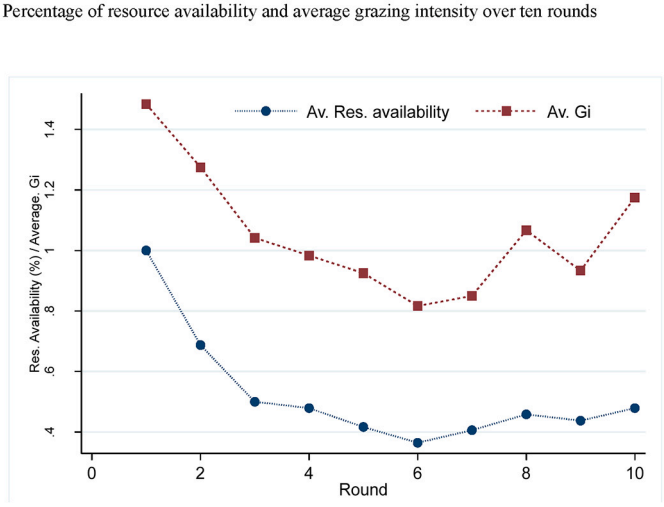

Fig. 3. Percentage of resource availability and average grazing intensity over ten rounds.

market knowledge positively predicted the probability of choosing maximum grazing intensity, with the marginal effect of $\beta = 0.02$ ($p < 0.05$).

As also indicated by the results presented in Table 5, an individual's level of cooperation in respecting rules regarding the use of common-pool resources negatively predicted the likelihood of choosing maximum grazing intensity, with the marginal effect of $\beta = -0.06$ ($p < 0.10$), $\beta = -0.05$ ($p < 0.05$), $\beta = -0.02$ ($p < 0.05$) in the abundance, spatial, and scarce resource-availability conditions, respectively. These results highlight the importance of institutional common resource use rules in the sustainability of common-pool resources.

We performed additional analyses to assess the robustness of our results. First, to examine whether the results were influenced by the market-knowledge measure, we replaced the market-knowledge variable with customer orientation. Rather than measuring actual market knowledge, the customer-orientation scale measures a set of behaviors associated with such knowledge (Ingenbleek et al., 2013). Because we found no substantial differences between the effects of market knowledge and those of customer orientation on grazing-intensity decisions, it is unlikely that the results were affected by issues of validity with regard to the market-knowledge measure. Second, we replaced the within-group variance in market knowledge with the difference between the highest and lowest level of market knowledge in the group. The results revealed no substantial differences as compared to those using the variance measure.

4.2. The effect of market knowledge on individual and group earnings

We observed substantial variation in both individual and group-level total earnings. Individual total earnings ranged from 26 to 68 tokens, with a mean of 48.56. Group earnings ranged from 155 to 322 tokens, with a mean of 242.79. As indicated by the regression results presented in Table 6, individual market knowledge has a negative marginal effect on individual total earnings: $\beta = -0.17$ ($p < 0.10$). Group-average market knowledge had a positive effect—$\beta = 0.27$ ($p < 0.01$)—on individual earnings, and within-group variance in market knowledge had a negative effect: $\beta = -0.24$ ($p < 0.01$). The most likely explanations for these findings are that groups with greater average market knowledge tend to cooperate more and that these decisions subsequently create trust in their future cooperation with the rest of the group, thereby further stimulating cooperative decisions within the group. The difference between the effect sizes of individual market knowledge ($\beta = -0.17$*) and group-average market knowledge ($\beta = 0.27$***) suggests that individuals with greater market knowledge were the victim of free riding by others who have less market knowledge. They didn't free ride themselves however since the effect size of group average outweighs the individual market knowledge. Greater within-group variance in market knowledge has an opposite effect, given the higher level of variation in the cognitive basis of the group's members and, the members vary more in their grazing decisions, thereby reducing the trust of group members in future cooperation.

5. Discussion

This study examines the role of market knowledge in promoting the sustainable use of common-pool resources under various conditions of resource availability within the context of Ethiopian pastoralists. The results provide empirical evidence that a greater understanding of market functioning makes resource users more likely to make sustainable decisions, thereby leading to the preservation of those resources and the maximization of long-term returns for the communities. The

Table 5
Marginal effects after ordered probit estimation for the probability of choosing the maximum grazing intensity of 2.

Y: Grazing intensity (Gi)	HH and HL_1: Resource abundance[a]		HL_2: Spatial-resource availability		L_1L_1 and L_1L_2: Resource scarcity	
	Beta	Z-value	Beta	Z-value	Beta	Z-value
MK	−0.13***	−3.80	−0.12***	−5.37	−0.01**	−2.10
Average MK (Group)	0.03	1.17	0.02	0.89	0.01	1.30
MK variance (Group)	0.01	0.37	−0.02	−0.94	0.02**	2.41
Average MK * MK variance	0.01	0.19	0.04*	1.81	0.01	0.65
Socio-demographics						
Age	−0.03	−0.86	−0.01	−0.36	−0.00	−0.63
Family size	0.05*	1.68	−0.03	−0.97	0.01	0.99
Education	0.00	0.08	−0.04	−1.62	0.01	1.59
Distance from market	−0.00	−0.07	−0.03	−1.64	0.01	1.09
Collective action						
Cooperation with common rules	−0.06*	−1.74	−0.05**	−2.10	−0.02**	−2.15
Conformity to norms & values	−0.04	−0.78	−0.02	−0.52	−0.01	−1.42
Collectivism	0.08	1.44	0.04	1.15	0.02**	2.00
Group Variable						
Average age	0.03	0.78	0.06**	2.41	−0.01	−0.81
Round	0.00	0.02	0.01	1.58	0.00	1.13
Lag_Gi	−0.01	−0.20	0.03	0.72	0.02*	1.68
Observations	230		420		375	
Chi-square	34.53***		89.52***		44.75***	
Pseudo R^2	0.11		0.19		0.07	
Log Likelihood	−138		−197		−286	

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.
[a] Due to the inclusion of Lag_Gi in the estimation model, the first round of the experiment is not included in the estimation.

Table 6
Effect of market knowledge on total earnings.

Variables	Total earnings (Individual)	
	Beta	t-value
MK	*−0.17***	*−1.76*
Average MK (group)	*0.27***	*2.98*
MK variance (group)	*−0.24***	*−2.74*
Average MK * MK variance	−0.16*	−1.70
Socio-demographics		
Age	−0.02	−0.21
Family size	0.01	0.09
Education	0.15	1.64
Distance from market	−0.06	−0.62
Collective action		
Cooperation with common rules	−0.05	−0.44
Conformity to norms & values	0.11	0.73
Collectivism	−0.00	−0.00
Group Variable		
Average age	−0.28***	−2.92
Constant	−0.05	−0.61
Observations	120	
F-statistics(df)	(12,107), 4.53***	
R^2 (adj. R^2)	0.33 (0.26)	

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

most likely explanation for these findings is that markets enhance the extent to which users of common-pool resources understand gains and losses in association with the degradation of these resources (Oldekop et al., 2013). For users with market knowledge, therefore, market integration provides incentives for more making sustainable use of common-pool resources.

At the group level, the results provide no evidence that a group's average market knowledge has any significant effect on individual grazing decisions. This does not necessarily imply, however, that greater market knowledge at the group level does not affect group-level outcomes. The results for group payoffs show that groups with relatively higher levels of average market knowledge earned higher payoffs at the end of the experiment, thus indicating that groups with higher average levels of market knowledge are better at making sustainable use of grazing rangelands. Within-group variance in market knowledge among group members reduced payoffs. This finding suggests that, although greater market knowledge could help pastoralists to maximize their long-term returns from livestock production, the learning process about the market should be inclusive. The finding that users with more market knowledge are more capable of making sustainable use of common-pool resources underscores the importance of providing marketing training to all decision-makers in rural communities in order to enhance their level of market integration while improving their performance in the sustainable use of common-pool resources.

Our results are consistent with the theory formulated at the start of this article. In practice, however, the sustainable choices stimulated by market knowledge are unlikely to lead directly to the sustainable management of common-pool resources at the community level. The literature on commons dilemmas has drawn attention to the role of common institutions in this process (e.g., Agrawal, 2001; Andersson and Agrawal, 2011). It is therefore likely that market knowledge will also affect the institutions developing within communities in response to the decisions, expectations, and trust that resource users develop over time. Future research should therefore explore the influence of market knowledge on the development of common institutions within communities.

This study is intended primarily to explain individual differences in decisions concerning the sustainable use of common-pool resources. All of the participants in this study shared a common cultural background and clan origin, and there were no substantial differences between the groups. The results thus provide only limited insight into group-level of contextual differences in decisions concerning the sustainable use of common resources. Future studies should therefore test the theory further, using multiple groups with differing levels of market knowledge.

6. Conclusion

In this study, we show that the capacity to use common-pool resources sustainably depends on the understanding of what markets are and how they function within the context of rural communities and that such knowledge subsequently influences the long-term returns for

individual livelihoods, which depend on the use of these resources. Our empirical findings suggest that a greater understanding of the market leads to more sustainable choices at the individual level and that average market knowledge maximizes group-level earnings from the use of common-pool resources. Within-group variance in market knowledge impedes the sustainable use of common-pool resources. Our findings also suggest that resource scarcity diminishes the effects of market knowledge on individual sustainable choices. Policymakers could thus achieve multiple objectives by enhancing the market knowledge of entire communities of resource users, including livelihood improvement and the sustainable use of common-pool resources within rural communities while promoting the production of food for the growing population and increasing the export earnings of their countries.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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