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Co-managing common pool resources: Do formal rules have to be adapted to traditional ecological norms?

Björn Vollan, Sebastian Prediger, Markus Frölich

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Contact Address:
University of Innsbruck
Department of Public Finance
Universitaetsstrasse 15
A-6020 Innsbruck
Austria
Tel: + 43 512 507 7171
Fax: + 43 512 507 2970
E-mail: eeecon@uibk.ac.at

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Abstract: We examine the effectiveness of three democratically chosen rules that alleviate the coordination and cooperation problems inherent in collectively managed common-pool resources. In particular we investigate how rule effectiveness and rule compliance depends on the prevailing local norms and ecological values held by resource users. For this purpose, we employ a framed field experiment that is based on a rangeland model for semi-arid regions and carried out with communal farmers in Namibia and South Africa. Participants could vote for three 'best practice' management rules found in many places around the world that are discussed for implementation in the study area: (temporary) private property rights, rotational grazing or limitation of livestock numbers. All rules were designed in a way that facilitated cooperation or coordination of actions. The focus of this study lies on the interactions between these rules and prevalent ecological norms exhibited in the rounds prior to rule implementation. In contrast to previous lab experimental studies, we find that democratic voting of rules is not sufficient for high rule compliance and an overall enhancement in cooperation. Rules turned out to be inefficient if they were in conflict with the prevalent ecological norm.

Keywords: field laboratory experiment, rule compliance, ecological norms, common-pool resource, adaptive co-management, Southern Africa

JEL: C71, C92, D7, Q24

1 Introduction

Over-exploitation of common-pool resources is a major concern worldwide, and the introduction of formal rules is frequently discussed as a means to prevent further degradation. Empirical studies suggest that the acceptance of (and performance under) new rules designed to alleviate collective action problems can be strongly affected by the implementation process. Dietz et al. (2003) for instance, demonstrate that top-down policies that grant resource users only very little autonomy tend to fail in managing inshore fishing grounds. Bardhan (2000) analyses forty-eight irrigation systems in India and finds that the quality of maintenance is lower when farmers have the perception that a local elite had made the rules. By contrast, a positive attitude towards water allocation systems and high rule compliance is reported among those farmers who responded that the rules have been crafted by the community. Sekher (2000) reports similar results for forest management in India and Yoder (1994) and Lam (1998) for irrigation systems designed and governed by farmers in Nepal. In line with these results, laboratory experiments conducted with Western university students demonstrate that rules implemented according to democratic principles are more likely to stimulate cooperative behaviour and rule obedience as compared to the same rule implemented exogenously, i.e. by external agents (see e.g. Ostrom et al., 1992; Decker et al., 2003; Tyran and Feld, 2006; Kroll et al., 2007; Ertan et al., 2009; Dal Bo et al., 2010; Sutter et al., 2010; Walker et al., 2000).

Little attention in the empirical research on the impact of rules designed to alleviate collective problems, however, has been paid to the interactions between formal rules and prevalent local norms. Since most (if not all) rules can be understood as incomplete contracts that are imperfectly enforced, prevalent norms play a crucial role for compliance. Ellickson (1994) showed that dispute resolution, rule formation, and enforcement among cattle breeder and grain growers are provided by norms instead of the external institutions of the county government. Ellickson points out that people face transaction costs of learning the law such that there is little use in governments issuing new laws, and actors will ignore them anyway. Another viewpoint is put forward by Hayek (1974) who argued that a central planner does not have the relevant knowledge in order to purposefully decide and plan what is best for the actors (Hayek called the constructivist temptation to create governmental laws, "the pretension of knowledge"). Both Ellickson's and Hayek's analysis thus emphasize the strength of local norms and decentralized solutions vis-à-vis centralized legislations. One prominent example where homegrown norms and external institutions often clash is the planning of institutional interventions both in the context of government policy making as well as of development projects. For example in aid programs donors require “best practice” procedures to be implemented by the recipients without adapting these “best practices” to the homegrown norms and institutions in the recipient country. In many cases the donor hopes that the best practice rule or procedure will later become the norm. However, this planning of interventions often is not successful. As Easterly (2006) points out “searchers”, both economic and political, who explore solutions by trial and error, get feedback on the solutions that work, and then expand the ones that work, all of this in an unplanned, spontaneous way. Similar “best practice” blueprints also exist for the co-management of common-pool resources. Co-management is different from purely ‘top-down’ and ‘self-organized’ management approaches and combines the comparative advantages of communities and the government. Enforcement of the rules as well as technical and financial support is typically provided by the government while resource users democratically decide on the policies or set of rules they want to have implemented. In this paper we analyse how democratically elected blueprints rules interact with traditional ecological norms of real life common-pool resource (CPR) users.[1] According to the norm-activation theory in psychology (Schwartz, 1977), an important precursor to pro-environmental behavior is the activation of a personal moral norm. This activation takes place in our setting when the individual is aware of environmental problems and values nature per se, other humans’ well-being or his own well-being. In particular, we address the following questions: Given imperfect rule enforcement of the government, is democratic rule choice itself sufficient to enhance cooperation and high rule compliance among users? Are democratically implemented rules effective in all environments or is their effectiveness dependent on local (ecological) norms?

Our experiments were conducted in villages in southern Namibia (Berseba constituency in the Karas region) and northern South Africa (Namaqualand in the Northern Cape province) where the majority of residents depend on livestock production on communal rangelands

[1] We define an ecological norm as a personal norm based on one’s own moral obligation to protect the threatened environment. The personal ecological norm builds on both ecocentric and anthropocentric environmental values. Ecocentric values represent the belief that the ecosystem should be protected for its intrinsic value, while anthropocentric values represent the belief that the environment needs protection because of its contribution to human welfare. Our ecological norm is distinct from these pro-environmental values as the latter are not sufficient to form pro-environmental behavior (Pieters et al., 1998). One reason may be that the choice between acting in a pro-environmental way and not doing so often involves a conflict between immediate individual and long-term collective interests..

managed under common-property regimes. The population belongs to the Nama ethnicity. The experimental design is adopted from Janssen and Anderies (2011) and framed according to the ecological conditions of rangelands in semi-arid areas.[2] Framing the decision situation as a rangeland management problem can be important in order to stimulate norm driven daily-life behaviour within the experiment. The design and payoff structure of the experiment reflects typical ecological features of the study sites, such as path-dependence of previous use, non-linearity of payoffs and spatial resource variability. In contrast to most other CPR experiments, which typically use a context-free design and focus on extraction decision and hence cooperation problems only, our design allows us to study resource users' willingness to cooperate as well as their ability to coordinate actions. That cooperation is not the only underlying motivational factor for CPR users was shown by Fehr and Leibbrandt (2011), who disentangled social preferences and time preferences as two independent predictors of real world behaviour of commons users. However, because there is no policy that can "increase" the share of people with pro-social or time preferences, experiments designed to measure preferences can only be the first step in order to design institutions for real life CPR problems.[3] The functioning of institutions and rules crucially hinges on aspects of group dynamics (status seeking, reputation, peer pressure, etc.) and context information transmitted through framing (which 'activates' the ecological norm) that are deliberately excluded from the design of standard experiments that measure generalizable social preferences. Our study also distinguishes from previous ones regarding the kind of rules that are employed. In contrast to related experimental studies that examine the impact of rather abstract institutions for norm enforcement, like peer-punishment,[4] we consider three management rules (*lottery*, *rotation*, *quota*) that have been applied in real life in various countries around the world to govern common pool resources.

As a measure for local (ecological) norms, we analyze the behavioral patterns exhibited in the rounds prior to rule introduction and assume that people who tend to forgo profits in order to

[2] The original experiments of Janssen and Anderies (2011) are fishery games conducted with fishermen from Colombia and Thailand. Some of their results are also reported in Castillo et al. (2011).

[3] It is also neglected that not all studies using simple experiments have high external validity (Voors, 2012) especially without interpreting the data within the context of local norms and traditions (Tracer (2003) or Vollan (2012)).

[4] An exception is the study by Casari and Plott (2003), who test the efficiency of a punishment institution that was employed for centuries by CPR users in the Alps.

maintain grazing availability have strong ecological norms.[5] We observe strong differences among individuals and groups regarding their willingness to forgo profits. These differences become particularly apparent in situations of asymmetric resource availability, which constitute critical points in our experiment because groups face the threat of getting trapped in a situation of low resource availability for several future rounds. Groups characterized by a large fraction of members being willing to forgo profits in these situations are called *high sustainability groups*, whereas groups in which selfish short-term profit considerations seem to predominate are called *low sustainability* groups. The distinction between *high* and *low sustainability* groups is used to investigate the interactions between rules and prevalent ecological norms on group level.

To summarize our results, we find that democratically implemented rules do not per-se enhance cooperation and social efficiency. Only the quota rule has a significant positive impact on resource availability in both *high* and in *low sustainability* groups. By contrast, the rotation rule only works well for *low sustainability* groups, which suffered from cooperation and coordination problems in the rounds prior to rule implementation. *High sustainability* groups, on the other hand, frequently violate the rule and eventually fail in improving their performance. Our analysis suggests that the high occurrence of rule disobedience in these groups is largely due to a conflict between the behavioural patterns prescribed by the rotation rule and prevalent ecological norms. Thus, the effectiveness of formal rules, even if democratically elected, can strongly depend on its reconcilability with ecological norms held by CPR users.

2 The experiment

2.1 Experimental design

An experimental session consisted of five players and was subdivided into two stages, each lasting ten rounds. The group composition remained unchanged through the session (*fixed matching*). In the no-rule stage, i.e. the first ten rounds, no rules were in place. After the end of round 10, the participants had to vote for one of three different rules that were to be implemented for the final ten rounds: a quota rule, a lottery rule, and a rotation rule.

[5] Using revealed behaviour as a measure for the prevalence of ecological norms has the advantage that we do not exclusively need to rely on hypothetical interviews or questionnaire items about attitudes and motives, degree of 'oughtness' or cognitive beliefs.

In each round, similar to a grazing season, each participant decides whether to graze either on area A or on area B. In addition to the area choice, participants choose the grazing intensity 1 or 2. Alternatively, one may choose not to graze at all (= intensity 0). According to the payoff table below (Table 1), returns to grazing depend not only on individual intensities but also on the grazing quality, which can be good or bad. For example, an intensity of 1 leads to a payoff of seven tokens when the chosen grazing land is in good condition, but only two tokens when the grazing quality is low.[6]

The aggregate *group intensity* on an area (i.e., the sum of the grazing intensities of all players who had decided to graze on that area) in round *t* determines the grazing condition in the next round *t*+1. (Since the maximum intensity each player can choose is 2, the aggregate intensity ranges between 0 and 10, for each area.) If the aggregate group intensity exceeds 4 units in round *t*, the grazing area switches to bad condition in round *t*+1. A grazing area of bad quality recovers to good quality only if for two *successive* rounds the group grazing intensity is less than or equal to 1 (in each round).

<Table 1 here>

The design implies that each grazing area (A and B) can either be in a good quality (H), or in bad quality with two more rounds needed to recover (L_2) or in bad quality but with only one more round needed to recover (L_1, i.e., this area already has recovered one round). Thus, there are six possible situations a group might face at the beginning of each round: HH (both areas are of high quality), HL_1 (one area high quality, the other area low quality but already recovered one round), HL_2 (one area high quality, the other low quality with two rounds needed to recover), L_1L_1 (both areas low quality and each needs one more round to recover), L_1L_2 (both areas low quality, but one needs only one round to recover whereas the other needs two rounds) and the worst situation L_2L_2 (both areas low quality and each needs two rounds to recover). The initial resource situation in each session is HH.

If subjects are purely selfish and rational as assumed by the homo oeconomicus model, they will always choose an intensity of 2 units in each round, irrespective of the resource situation. Following this argumentation, we would expect the degradation of one grazing area immediately after the initial round, leading to a situation with one good area and one bad area

[6] The tokens were converted to South African Rand (ZAR) or Namibian Dollar (NAD), respectively. Both currencies are accepted means of payment in Namibia and are pegged at a 1:1 exchange ratio. One token was worth ZAR/NAD 0.25.

(HL_2) in the beginning of the second period. In the next round, all players will choose the remaining area in good quality, resulting in a situation where both grazing areas are bad (L_1L_2) at the beginning of the third round. In that situation, both pastures yield the same return, but one grazing area (L_1) will require only one more round to recover. If subjects do not distinguish between L_1 and L_2, or if they are myopic, they most likely get stuck in a situation where both grazing areas are degraded for all remaining rounds. Then, the group return will be at most 200 in the first stage (i.e., rounds 1 to 10).

Thus, the design of our experiment captures the social dilemma which is characteristic for common-pool resources: individual payoff maximisation causes resource degradation and consequently lower payoffs to all resource users in the long-run. If, on the other hand, participants were able to coordinate their actions in such a way as to retain two high quality grazing areas, a group return of 380 would be possible. This requires that at least some players choose an intensity of less than 2.[7]

2.2 Rules for election

After ten rounds individuals vote one of the rules described below, which are similar to grazing management rules that have been applied in different countries across the world. In our study area there are clear signs of desertification (Kuiper and Meadows, 2002; Visser et al., 2004) and the introduction of formal rules is increasingly discussed by politicians as a possible solution to prevent further degradation. Formal rules that have been considered in the context of grazing management in the study sites are either those that limit individual stock numbers (Kössler, 2001)or that facilitate coordination, such as the rotation of livestock between different "camps" or the assignment of temporary private property rights (see e.g. the economic units described in Cousins (1996)). In our experiment, at the end of round 10, a "community election" was held, where participants had to choose one of these three rules for the remaining ten rounds. All rules were explained aloud to the participants and everyone

[7] The highest total payoff is received if two players play an intensity of 2 on one grazing area and the other three players choose an intensity of 2, 1 and 1, respectively, on the other grazing area. Thereby, the total intensity on each grazing area is 4, such that both areas remain of good quality. This optimal solution is only possible if players coordinate their area choices. Since players were not able to communicate during the game, full coordination is not possible. Therefore, the optimal solution is nearly infeasible. Nevertheless, the only way to avoid degradation of the grazing areas or to let bad grazing areas recover is via choosing an intensity of 0 or 1. A choice of 0 shows the most graceful and cooperative behaviour but results in zero payoff. A choice of 1 leads to a positive payoff, but increases the probability of resource degradation. For example, if all subjects applied an intensity of one unit in a situation where both areas are of high quality, resource degradation would happen if all players coincidentally choose the same grazing area. However, the probability that all players happen to choose the same area is only 6.25%, provided each player is indifferent between choosing grazing area A or B.

received a written explanation. Participants were not allowed to communicate about the rules or the prior game. The rules were imperfectly enforced, and rule deviation was possible. Yet rule violators faced the risk of being detected and having to pay back the tokens earned in that round. The monitoring probability was one-sixth for each rule.

Rotation rule: In many areas of the world, people form rotating credit groups, short-term groups that work on each other's rice fields in rotation or gain access to water by rotation rules. Also, traditional grazing systems that grant herders access to available pastures are based on rotation schemes and have been reported for example in Mali in the Niger river delta (Lawry, 1989, p.4) , in Chad (Tubiana and Tubiana, 1977) and in Mongolia (Sneath, 1998). In his study, Sneath (1998) demonstrates via satellite images that this rotational system is an appropriate land use strategy to avoid degradation. A rotation system was also traditionally practiced by the Nama people in the study areas in Namibia and South Africa, before they were forced into sedentariness. Nowadays, the vast majority of farmers independently from other farmers 'rotate' their animals around their homesteads (82%, n=120) at a small radius, if fodder becomes scarce. In our rotation treatment, in each round, one area is banned from grazing: Area A for rounds 11 and 12, B for 13 and 14, etc.. This use pattern allows the recovery of the resource. The rotation rule was explained in the following way (See full protocol in the appendix): "Rotation rule: Only one area is allowed to be grazed in each round. There is a rotation of a ban where you are not allowed to harvest. E.g. in the eleventh round you are not allowed to graze in area A. When you graze, but are not allowed to, the throwing of a dice determines whether you need to pay a penalty. If we throw a six, the penalty is to return back the earning of this round."

Lottery rule: Lotteries to temporarily grant a property right for resource allocation were frequently used for example in English medieval manorial system, in Ethiopia by the Abdawuha to allocate high quality land, for forest resources in Japan (McKean, 1986, p.556 7) and access to fisheries in Turkey (Berkes, 1992). Although formal private property rights to rangelands are currently not in place in our study area, there have been attempts to do so in the Namaquland (Cousins, 1996) and recent resettlement processes in both countries also go in this direction. Apart from that, most farmers in the study sites perceive the grazing area they use as their property and sometimes defend it physically against 'intruders'. In our experiments, the lottery rule assigns temporary private use rights. Its design is as follows: At the beginning of each round, for each participant the area where she or he is allowed to graze is randomly determined by the throw of a dice. The allocation is publicly revealed.

Quota rule: The quota rule limits individual stocking rates and is quite common in resource management. In contrast to lottery and rotation, the quota does not solve the coordination problem but aims to ease the cooperation problem. In the South African study region there is a limitation of livestock per person on the commonly owned grazing land.[8] In our experiments, the quota rule restricts individual intensities to a maximum of 1 unit. Subjects who apply an intensity of 2 face the risk of being detected and having to pay back the tokens earned in that round.

2.3 Participants and study site

The experiments were carried out in two different regions which, during the former apartheid regime, were either homelands or so-called “coloured reserves”, where the non-white population lived and was allowed to farm: in the Berseba constituency in the Karas Region of southern Namibia and in some of the coloured reserves of the Namaqualand in South Africa. Both areas are populated by descendants of the same Nama tribe, i.e. have the same ethnic and cultural origin, at least until colonialisation.

Detailed information on the procedures, the socio-demographic characteristics of the participants and a map of the study area can be found in the supplementary material (see Table A.1 and Figure A.1). The experiments were conducted in the community hall of five settlements in the communal lands of Namibia and South Africa. Altogether 24 experimental sessions were conducted, 12 in each country. The instructions for the experiments were presented orally (in Afrikaans) by the same experimenter in all 24 sessions. Individual earnings ranged between 21.25 and 40.75 South African Rand (ZAR), with an average of 28 ZAR, including a show-up fee of 10 ZAR.[9]

[8] The total number varies between municipalities. It is 200 in the Nama Khoi but 350 in Concordia (where no experiments were conducted). Regulations in four municipalities of Namaqualand were established based on the land reform process TRANCRAA (The Transformation of Certain Rural Areas Act, Act 94 of 1998) involving a thorough consultation process between farmers, an NGO called Surplus People Project, the Department of Land Affairs, the Department of Agriculture, and the Legal Resources Centre. The regulations are public contracts and are adopted, amended or repealed by public notice, confirmation by the municipal council and publication in the provincial gazette – in the same manner that national and provincial laws are made.

[9] ZAR is an excepted means of payment in both countries. Daily wage rates for low skilled labour, like fencing or construction work, ranged from 30 to 50 ZAR in 2007, when the experiments were conducted. The average exchange rate was 7.153 ZAR/$ at that time.

3. Results

The results section consists of three parts. We start with the analysis of behaviour in the ten rounds prior to voting (no-rule stage). Based on behavioural variations across groups, we will separate our sample into groups that attach high importance to preventing degradation (*high sustainability* groups) and those, in which profit considerations seem to dominate over sustainability considerations (*low sustainability* groups). Section 3.2 summarizes the results of the polls. The analyses of rule effectiveness and rule-following behaviour takes centre stage in section 3.3.

We define *high sustainability* and *low sustainability* groups according to their ability to avoid persistent degradation of the grazing areas during the first ten rounds, i.e. when no formal rules are in place. We will see that this behaviour is highly correlated with the nationality of the players: Namibian Namas are much more cautious and unwilling to permit degradation than South African Namas, who seem to be much less willing to restrain from farming. Although this pattern is very conspicuous, there is still variation across groups within a country. Hence, we examine whether the results of our *high sustainability* versus *low sustainability* comparison are similar to a comparison of Namibians versus South Africans. Whereas nationality does not exactly capture the local norms we want to study, it has the advantage for the econometric analysis of being exogenous. This kind of robustness analysis leads to qualitatively very similar conclusions, such that we relegated it to the appendix (see Table A.4).

3.1 Behavioural regularities in absence of formal rules

Over the course of the first ten rounds, groups managed to keep on average 40% of their pastures in good condition, ranging from a minimum of 15% to a maximum of 80%. Our experimental set-up allowed us to separate individuals and groups into those attaching higher values to preventing degradation and those, where preferences for profit maximization seemed to predominate. In our set-up, strong values for sustainable pasture management are not only mirrored by intensity choices but also by area choices. Revealing sustainable behaviour in our experiment is most pronounced when resources are on the edge to collapse, i.e. in situations of asymmetric resource availability (i.e., in L_1L_2, HL_2 and HL_1). Here, it is important to choose the “right” area and a low intensity. We argue that in some groups players are guided by their environmental norms or values that seem to be common knowledge to most members and thus lead to a sustainable behavioural regularity.

A substantial variation of resource availability across groups can be attributed to both, lower extraction rates (i.e. intensities) and different behavioural patterns in situations of HL_2. Eighty-three per cent of all groups faced the situation HL_2 latest at the beginning of round 3, and half of them ended-up in a situation of low resource availability in both pastures in the following rounds. Prediger et al. (2011) use the same data and outline in more detail, that apart from choosing intensity zero, the situation of HL_2 basically offers two coherent strategies an individual could pursue: The safest strategy is to try to retain always one high quality pasture and leave the bad pasture for further exploitation. Applying an intensity of 0 or grazing on the bad area prevents the good area from degradation and unambiguously signals cooperative intentions, since both actions require personal sacrifice.[10]

45% of all subjects abstain from profit maximization when facing HL2: Roughly 22% of all subjects chose an intensity of 0 in such a situation, another 23% grazed on the bad area. The remaining 55% chose the good area. By calculating, for each situation of $HL_{2,}$ the fraction of group members who choose either intensity 0 or to graze on the bad area, accumulating these fractions over the first ten rounds, and then dividing it by the total occurrence of HL_2, we can create a variable that informs about the appreciation of sustaining high resource availability at group level. We use this variable to separate our sample according to its median (=0.425). Members of groups above the median are assumed to rather prefer resource maintenance over profit maximization and are labelled *high sustainability* groups.

In *high sustainability* groups, a fraction of only 43% chose the good pasture in a situation of HL_2. The remaining 57% (i.e. almost 3 out of 5 group members) revealed strong preferences towards preserving a good quality area, as they chose either an intensity of 0 (30%) or to graze on the bad pasture (27%). As a consequence, they managed to retain at least one good condition pasture in 74% of all situations after having faced HL_2 in the previous round. Moreover, five out of twelve groups managed to retain one good area for the entire course of the no-rule stage. By contrast, in groups below the median (*low sustainability* groups), only 5.5% abstained from grazing and more than three-quarters chose the good pasture (63% of

[10] The other strategy is to use the pastures in a rotation system: If people recognise the possibility of earlier recovery of the area which had already rested for one round (L_1), it is rational for them all to choose the area which still needs two rounds to recover (L_2). Consequently, in round 4 (and 6, 8 and 10), participants will face the same situation as in round 2, with one high quality area and one low quality area (HL_2), and will choose again that pasture which delivers the highest return. If all players adhere to this strategy, a rotation system emerges, where in every second round both grazing areas are of bad quality. In a sequence of ten rounds, the resulting total group return will be 300 tokens. However, Prediger et al. (2011) analyse group behaviour in the first stage and find that only 1 out of 24 groups followed such a pattern. Note that this is exactly the behaviour prescribed by the rotation rule. However, choosing the high area, as proposed by this second strategy, has the drawback of not clearly signalling a player's intention. Group fellows might interpret it as an attempt to establish a rotation strategy, but they could also interpret it as pure egoism.

them with intensity two) in HL_2. Hence, the vast majority of its group members seemed to aim for profit maximization or the rotation strategy (see previous footnote 9), respectively.

Yet, a rotation system evolved in only one out of the twelve low sustainability groups.. All other *low sustainability* groups were not able to solve the coordination problem which arises with the rotation strategy, but got stuck in a situation of two bad quality areas for on average 4 consecutive rounds after HL_2. The stronger preferences among *high sustainability* group members towards sustaining resource availability is also reflected in significantly lower mean intensities (.975 units vs. 1.37 units, $Z=9.54$, $p<.001$) and a much higher frequency of resource recoveries as compared to *low sustainability* groups.[11]

The subdivision of our sample according to the "sustainability norm" almost perfectly matches country origin: Eleven out of twelve groups above the median are from Namibia. In other words, preferences towards retaining high resource availability seem to be much more prevalent in Namibia than in South Africa. But why is that the case? A possible explanation is that cultural norms serve as a coordinating device, leading societies playing the exact same game to different focal points (Greif, 1994; Greif, 2005). Prediger et al. (2011) report significantly higher levels of cooperation and successful coordination in Namibia in rounds 1-10. They show that the cross-country variations are due to a combination of different historical developments and ecological preconditions. First, frequent and long-term interferences by colonial and apartheid powers led to internal conflicts caused by the pooling of different people into homelands in the South African study site, which had negative effects on norms of trust (Vollan, 2012) and partly explains the low levels of cooperation reported by (Prediger et al., 2011).[12] Second, and more important for the interpretation of our results, Prediger et al. (2011) suggest that ecological peculiarities play an important role in understanding cross-country differences in behaviour. They argue that the ecosystem in the Namibian study site is more prone to irreversible degradation. There, degradation is characterized by the occurrence of bare soil patches, which yield no future incomes, are easily observable and an unambiguous indicator of ecological change (Visser et al., 2004). By

[11] Examples for resource recoveries include, among others, switches from L_1L_2 to HL_2 or from L_2L_2 to L_2L_1, *High sustainability* groups achieved recoveries in 48% of all possible cases, compared to 21% in *low* sustainability groups.

[12] May and Lahiff (2007) report on highly contested attempts of the apartheid administration and the local management board to privatise the communal lands into individualized, exclusive economic units. These, and a high exposure to corruption, led to social disputes and culminated in a lasting "legacy of fractional division and bitterness" (Cousins, 1996, p.11) among farmers in the South African study site. Namibian resource users, on the other hand, have a longer experience in cooperative resource management and could largely sustain self-governance during apartheid rule (Kössler, 2001).

contrast, in South Africa, ecological changes are characterized by gradual shifts in species composition (Todd and Hoffman, 1999), which are more difficult to observe and interpret than bare soil patches. Prediger et al. (2011) identify the (easily observable) threat of irreversible degradation as an important cooperation enhancing ecological factor. Farmers intentionally causing degradation are ostracized. The emergent norm is more pronounced among Namibians, since the consequences of degradation – bare soils that become useless for many years- are more tangible and visible there than in the South African study site.

We believe that the preference for sustaining always at least one good condition pasture, revealed by some of our participants in the no-rule stage in situations HL_2, may reflect the precautionary ecological norm based on their daily-life experience of (irreversible) degradation in case of overuse.

3.2 Voting behaviour

After 10 rounds, all players had to vote for one of the three rules. Thereafter, they played for another 10 rounds with the rule in place that was chosen by the majority of the players in a group.[13] Results of the polls are summarized in Table 2 and regression results on determinants for voting a specific rule are presented in the online appendix. The majority of groups preferred the rotation rule, and it was consequently implemented in 14 out of 24 groups. By contrast, the quota rule was least popular. It was chosen by 20% of the participants in the first poll and eventually applied in three groups only (one in the *high sustainability* sub-sample, two in the *low sustainability* sub-sample). The remaining seven groups implemented the lottery rule. The low acceptance of the quota rule can best be understood if the local context of the study sites is considered. In both study sites, but especially in southern Namibia, people always strongly resisted external management regulations such as the levying of livestock fees (Kössler, 2001) or the limitation of stock numbers. The reluctance to limit the number of livestock (and thus to vote for a quota rule) is a phenomenon that is not solely based on economic motives but seems to be related to status seeking and other non-monetary values of livestock possession in pastoralist societies in Africa, too, and is likely to be generalized to these areas (Doran et al., 1979).

<Table 2 here>

[13] In ten groups it happened that none of the rules obtained a majority after the first poll. In that case a second voting round was carried out where participants had to choose one of the two remaining alternatives.

3.3 Do (all) democratic elected rules improve cooperation?

a) Rule efficiency after voting

In the previous section we showed that rotation was chosen by the majority in both sub-samples, while quota was the least popular rule. In this section we examine whether the introduction of the democratically elected rules per se helped to improve the sustainability of grazing management compared with the no-rule situation. For this purpose we consider data from rounds 3–10 and 13–19. We do not include the first two rounds of each stage for two reasons. First, in the rule-stage, groups started with different grazing situations, while they were the same (HH) for all groups in the beginning of the no-rule stage. Second, subjects may need 1 or 2 rounds to fully understand the implications of the new rules (note that we had no practice rounds for the rule stage). Round 20 is excluded from the analysis as subjects knew it will be the final round of the game. However, the results do not change if round 20 is considered.

We are mainly interested in the question of how democratically elected rules interact with "ecological values" revealed in the no-rule stage and which we defined as a strong preference towards keeping always at least one grazing area in good condition.

Grazing intensities were for both sub-samples slightly higher in the rule stage than in the no-rule stage: Members of *low sustainability* groups applied a mean intensity of 1.33 in rounds 3-10 and 1.375 in rounds 13-19 ($Z=0.87$, $p=0.38$, $n=900$). Their counterparts from the *high sustainability* groups chose an average intensity of 0.9 and 1 in the no-rule stage and rule stage, respectively ($Z=2.45$, $p=.014$, $n=900$). Higher intensities did not automatically translate into higher earnings: Out of the 120 individuals, 62 (51%) could increase their earnings in the rule-stage as compared to the no-rule stage. Interestingly, among those, 68% belonged to the *low sustainability* groups. Hence, members of groups that faced problems in maintaining high resource availability over the first ten rounds benefit more from rule introduction than their fellows from *high sustainability* groups. In general, all three rules we offered could work well and increased participants' earnings. However, descriptive analyses reveal substantial differences between rules: Under lottery, only one-fifth of all players could increase earnings as compared to the no-rule stage. By contrast, 80% (61%) yielded higher earnings when the quota (rotation) rule was in effect.[14]

Yet, for ecological conditions not only mean grazing intensities (or individual earnings) are

[14] In most cases individual earning did coincide with group earning (78% of cases). Similarly, if the rule led to lower group earning, also most individuals earned less (76% of cases).

important but also their timing and distribution among areas. Figure 1 therefore examines graphically the performance of *high* (left-hand side) and *low sustainability* groups (right-hand side) with respect to grazing management, separately for each treatment. The ordinate shows the percentage of pastures in good quality at the beginning of each round averaged over all groups that implemented the respective rule (i.e., 100% means two good pastures in every group). The Figure illustrates that all *low sustainability* groups faced the uncomfortable starting situation of low resource availability in both pastures when they had to implement a rule in round 11. Figure 1 further shows that the quota rule (green dashed line) was very successful in both sub-samples, but particularly in the *high sustainability* group (apart from the endgame effect). On the contrary, the lottery rule (blue dotted line) performed worst; especially in the *low sustainability* sub-sample, where none of the groups could ever reach resource recovery from bad to good condition. Most interestingly, however, the graphical examination reveals substantial differences between *high sustainability* and *low sustainability* groups under rotation (red straight line), which was the most popular rule in both sub-samples. While a typical rotation system evolved in *low sustainability* groups, with its characteristic peaks (i.e. high quality pastures) in each second round, it did not in *high sustainability* groups. This in turn indicates a higher occurrence of rule disobedience in *high sustainability* groups under rotation (otherwise a zig-zag pattern would automatically emerge).

<Figure 1 here>

We continue with the regression analysis of the effects of rule implementation on group performance. Table 3 presents results from (group-level) random-effects regressions. We estimate models with and without socio-demographic group composition.[15] Since we expect intensity and area choices to depend on some village morality we include an index measure of surveyed trust. We further control for the exogenous variable "round number", since cooperation might increase or decrease over time.

The outcome variable in all six models is defined as the number of grazing areas in good condition. It takes the values 0, 1 or 2. Taking the entire sample (model 1 and 2), it turns out that resource availability was higher in the rule stage as compared to the no-rule stage.

[15] The fraction of female subjects and farmers (ranging from 0 to 1) and the average age of the *other* group members. Trust is an index variable ranging from 0 (no trust) and 4 (high trust) constructed with answers of different statements.

However, as indicated by the interaction term, only *low sustainability* groups could significantly increase the number of pastures in good quality. We obtain qualitatively the same results if we use group earnings as the endogenous variable (see Table A.5 in the appendix). Models 3-4 and 5-6 examine the effects of each of the three rules for the *low sustainability* sub-sample and the *high sustainability* sub-sample, respectively, using random-effects regressions.

We see that the quota rule has a strong positive effect on grazing availability in both subsamples, as groups that implemented it could increase the number of good pastures significantly compared with the no-rule situation. The *high sustainability* (*low sustainability*) group(s) could increase the average number of good grazing areas from 10 (5) in the no-rule stage to 19 (7.5) after the quota had been implemented. Better resource availability also finds expression in significantly higher earnings for members of the *high sustainability* group only (see Table A.5).

On the contrary, lottery had a negative impact on grazing availability in both sub-samples (although significant for the *low sustainability* groups only). While lottery and quota had qualitatively the same effects in both sub-samples, rotation had not: *low sustainability* groups were able to increase both earnings and the average number of grazing areas in good condition under the rotation rule, while the same rule tends to have a (non-significant) negative effect for the *high sustainability* groups. The socio-economic group composition variables do not alter the above results or predict the number of grazing areas in good condition in the pooled sample. Only in the high sustainability sample, relatively young and male dominated groups with a higher share of farmer further increase the number of good grazing. It is possible that these groups represent the emerging new farmers willing to adopt good management practices independent of learned norms and heuristics. Finally, if we run random-effects regressions for rounds 13-19 only, we observe for both subsamples that lottery performed worst while quota was most successful (see Table A.6).

<Table 3 here>

b) Rule compliance after voting

The previous analysis revealed that *high sustainability* groups were not able to improve average pasture quality and earnings under the rotation rule. The graphical examination (Figure 1) further illustrated the absence of a zig-zag pattern that would have automatically emerged under rotation if people adhered to the rule. This section hence investigates differences in rule breaking behaviour between our sub-samples and the motives behind rule disobedience

Recall that, in each of the rounds 11 to 20, participants could decide to ignore the rule. However, with a chance of one-sixth, rule deviators were monitored and subsequently sanctioned. In case of detection, they had to return the money earned in the respective round. Table 4 reports the relative frequency of rule disobedience under each rule, separated by the *high sustainability* and *low sustainability* groups. Members of *high sustainability* groups did not comply in 13 % of all cases, compared with 8.3% in LS groups. The difference between the groups is significant according to a Mann-Whitney U test (Z=2.31, p=0.02, n=1200). We also find substantial heterogeneity regarding rule following behaviour among the three rules. In the *high sustainability* (*low sustainability*) sub-sample rule breaking occurred in 4% (7.3%) of all cases for lottery, while it happened in more than 17% (3.14%) of all cases for rotation and in 18% (31%) of all cases for quota. Thus, rule breaking is lowest with lottery, the rule which performed worst in both sub-samples; and highest with quota, the best rule in terms of average grazing availability. The strong group differences for rotation (Z=6.217, p<0.001) and quota (Z=1.69, p=0.09, n=150) ask for a closer look at the determinants of rule deviation under these two rules.[16]

<Table 4 here>

One reason for the much higher occurrence of rule violation under quota in the *low sustainability* groups and under rotation in *high sustainability* groups might be simply rooted in a distinct distribution of opportunities to gain from rule breaking. We will first consider the quota rule. Depending on a player's risk attitudes, a situation of low resource availability in both pastures (L_1L_1, L_1L_2 or L_2L_2) provides incentives for rule breaking as it returns an expected payoff of 2.5 tokens as compared to a safe amount of 2 tokens. Only *low sustainability* groups faced such a resource scenario under the quota rule; and indeed, rule deviation occurred frequently then, as it happened in 12 out of 40 cases. However, even if we exclude such situations from comparative analysis, the difference between the groups in

[16] Although endogeneity renders a proper analysis on the relationship between rule deviation and rule efficiency impossible, these patterns demonstrate that a high incidence of rule deviation must not necessarily hamper sustainable grazing management. Indeed, an in-depth analysis of rule violation for the lottery rule shows that resource recovery from bad to good condition was never impeded by rule deviation.

terms of rule disobedience under quota remains striking, as it still happens almost twice as much in *low sustainability* groups than in *high sustainability* groups.

A tempting situation for rule deviation under rotation exists, if the prescribed area is in bad condition, while at the same time the banned area is of high quality. In such a scenario, rule violators can realize an expected *net* gain of 3.67 tokens (6.67 tokens minus 3 tokens), and hence have strong incentives for rule violation. Only 2.5% of all resource scenarios under rotation offered such a constellation, all were in the *high sustainability* sub-sample, and the rate of rule deviation in these situations was about 23%, i.e. slightly higher than overall rule disobedience in the *high sustainability* groups. But as for quota, an exclusion of these cases does not alter the fact that *high sustainability* group members broke the rotation rule significantly more frequently than their counterparts from the *low sustainability* groups. It is worth mentioning that in all other resource scenarios rule deviation is at odds with the assumption of self-regarded payoff-maximizing behaviour, since 1) the expected payoff from rule deviation is always lower than the safe amount accruing to someone who obeys the rule, and 2) the net gain is never positive, even if we assumed an unusual high degree of risk-loving behaviour. Henceforth, for the rotation rule we can summarize that the much higher incidence or rule deviation in *high sustainability* groups as compared to *low sustainability* groups cannot be explained by self-regarding payoff considerations.

The observation that profit considerations are not the main drivers behind differences in the incidence of rule breaking is also confirmed by random-effects probit estimations for rotation rule are presented in Table 5. The binary variable "profit consideration" has a positive sign but its impact on rule breaking is insignificant. Similarly, one's own agreement to the implemented rule does not have explanatory power for the choice of breaking the rotation rule either.[17] We also consider a proxy for an individuals' preference towards sustaining high resource availability. The variable *sustainability norm* ranges between 0 and 1, and relates to the cases in which an individual facing a situation of HL_2 either chose zero intensity or to graze on the bad condition area in all cases of HL_2. A value of 0 (1) means that an individual always (never) applied an intensity greater than 0 on the area in good condition in a situation of HL_2.In line with the descriptive analysis, the more frequently a player chose intensity 0 or to graze on the bad area in situations of HL_2 in the no-rule stage, the more likely did she violate the rotation rule.

[17] We only present results for estimation of the rotation rule since the sample size for the other two rules might be too small. However, qualitatively similar results are obtained also for quota and lottery.

The results for the rotation rule further suggest that having been detected rule violating and consequently sanctioned in the previous round did not reduce the probability of rule breaking in the following round. However, repeated sanctions seem to have a weak deterrent effect. Altogether, 8 out of 120 players were sanctioned repeatedly, and none of them more than twice.[18] In line with our results from Table 3 we find that older people are more likely to break the rule – and thus prefer to follow their personal norm. Thus, it seems that the conflict between norm and external rules is also one of age: Younger people are more likely to adhere to rules while older people have difficulties.

<Table 5 here>

4 Discussion

The previous analyses have shown that both the majority of *high* and *low sustainability* groups opted for the rotation rule. In the *high sustainability* subsample, however, this rule turned out to be ineffective in terms of improving grazing availability and earnings due to a high incidence of rule disobedience. This stands in strong contrast to the *low sustainability* groups, which could benefit from the introduction of the rotation rule. It has also been demonstrated that rule breaking in *high sustainability* groups was in most cases *not* motivated by profit considerations (26%). This section aims to shed more light on the motives behind rule violation under rotation among members of *high sustainability* groups.

For this purpose, it is helpful to first recall the rotation rule's mechanisms: Regardless of the starting point in round 11, if people follow the rotation rule they will face the situation HL_2 latest at the beginning of round 13 (as they would have had in the end of round 11, if they had started in HH). The rotation rule now prescribes players to use the area which is in good quality for two consecutive rounds so that the banned grazing area will automatically be good in round 15, provided all adhere to the rule. Indeed, as illustrated in Figure 1 and Table 6, this is exactly what we observe for the *low sustainability* groups when the rotation rule is in effect. When confronted with HL_2, 95% of all *low sustainability* group members choose the good condition area (H) with an intensity of 1 or 2 units, and the remainder choose an intensity of 0. We observed similar behavioural patterns under HL_2 in the rounds prior to the introduction of the rotation rule (see section 3.1 and Table 6). There, 79% of all *low*

[18] Six persons under rotation (all Namibian in high sustainability groups) and two under quota (both South African in low sustainability groups)

sustainability group members chose the high quality pasture and a similar fraction (6%) abstained from grazing.[19] However, there is one striking difference in behaviour between the no-rule stage and the rule stage: Once the rotation rule was introduced, nobody of *low sustainability* group members grazed on the bad quality pasture in HL_2 anymore, while this happened in 15% of all cases before the rule was enacted (see Table 6). As a consequence, in the no rule stage, 50% of all *low sustainability* groups faced a situation of L_2L_2 in the round following HL_2. In such a situation, no coordination contrivance exists, and groups got stuck in situations of bad quality in both pastures for several rounds. However, even those *low sustainability* groups who were confronted with a situation of L_1L_2 instead of L_2L_2 in the following round were in most cases not able to tacitly coordinate their actions towards choosing the L_2 area, thereby allowing automatic recovery of the L_1 area. By contrast, after rule introduction, all *low sustainability* groups ended-up in a situation of L_2L_1 in the round after HL_2 (i.e. the good pasture H degraded to a bad pasture L_2) and could successfully establish a rotation system as they obeyed the rule by choosing the L_2 pasture for another round. Thus, the implementation of the rotation rule helped them to overcome the coordination problem they suffered from in rounds 1-10.

Let us now consider the *high sustainability* groups. Recall that, by definition, they put more emphasis on avoiding degradation in the no-rule stage than *low sustainability* groups. This is reflected by lower grazing intensities, higher recovery rates, and a larger fraction of group members playing intensity 0 (41%, see Table 6) or grazing on the bad area (21%) when confronted with HL_2 in the rounds prior to rule implementation. As outlined above, the rotation rule would have required them to change behaviour under HL_2 as it prescribes to always use the good quality area when the bad area is banned from grazing. But we do *not* see any substantial behavioural change after rule introduction compared with rounds 1–10 in the case of asymmetric grazing availability HL_2. As indicated in Table 6, similar fractions of *high sustainability* group members continue choosing either zero intensity or the bad area after the rotation rule had been introduced, and hence did not choose H, as prescribed by the rule.[20] Indeed, by choosing the bad area instead of the good pasture, *high sustainability* group members violated the rule in 20% of all cases of HL_2. Altogether, trespassing under HL_2

[19] Note the numbers slightly differ from those reported in section 3.1. In section 3.1, we refer to the full sample of *low* and *high sustainability* group members, while here we only refer to those groups that implemented the rotation rule.

[20] Interestingly, this observation holds true not only for the groups that implemented the rotation rule, but for all *high sustainability* groups.

accounted for one-thirds of all cases of rule violation observed for *high sustainability* groups under rotation.[21]

<Table 6 here>

All *high sustainability* groups that voted for rotation were from Namibia. As explained in more detail in section 3.1 and by Prediger et al. (2011), there is evidence that the strong preferences towards retaining always one pasture in good condition shared especially among Namibian farmers may be influenced by ecological peculiarities Namibians face in real life. Ecological research carried out in the Namibian study site revealed that the ecosystem is very sensitive to overuse, and that a degraded pasture can be irreversibly destroyed, yielding no future returns (Visser et al., 2004). Hence, the prevention of degradation is extremely important to sustain Namibian farmer's basis of existence. This seems to be common knowledge among them and explains why they operate very prudently (at least in the experiment). Based on experience from real life, they attach importance to retaining one good area as a buffer for "very bad times", and this shared experience helped them to tacitly and successfully coordinate their actions in the experiment before the rule was enacted. We argue that the actions prescribed by the rotation rule were counterintuitive to subjects for whom retaining high resource availability has priority. This would also explain why especially those subjects, who deliberately chose to graze on the bad area or to abstain from grazing instead of maximizing profits and accepting the (temporary) degradation of the grazing area (i.e. those with strong *sustainability* norms), were most likely to violate the rotation rule (see Table 5).

One may wonder why so many *high sustainability* group members voted for the rotation rule then. We believe that it was the name "rotation" that led people to vote for it, leaving aside the details of the rule, as rotation is likely to be positively connoted. Three aspects support this claim. Firstly, in both study sites private commercial farmers pursue rotation systems where the infrastructure (water points and fences) allows the rotation of livestock between different camps. Rotation systems facilitate the regeneration of grazing lands, and henceforth are frequently applied in semi-arid environments in order to prevent overuse. Since commercial farmers are more successful than communal farmers in terms of income

[21] Remarkably is further the observation that rule violators in *high sustainability* groups applied in 57% of all cases of rule deviation an intensity of one unit instead of maximizing expected returns by applying an intensity of two units.

generation, some participants might feel the need to imitate these strategies. Secondly, extension officers from the Ministry of Agriculture promote rotation on communal land in their brochures and visits to the field. Research carried out in the Namibian study site (8 out of 12 Namibian groups implemented the rotation rule) suggests that many communal farmers want to adopt such a coordinated rotation system. Fifty per cent of all interviewed farmers who participated in a household survey believe that it is possible to practice rotational grazing in the communal areas (pers. communication A. Lourens, Dept. of Agriculture, Namibia, 2004). Similarly, Falk et al. (2012) report that 78% of respondents in southern Namibia claimed to practice rotational grazing but only 12% acknowledged controlling their stocking rates. Thirdly, rotation patterns have similarities with informal rotation systems that were traditionally applied by the people in the study sites before the colonial administration forced them into sedentariness.[22]

During the game, *high sustainability* group members, who may have had a different understanding of how rotation should operate, recognized that the rotation rule contrasted with what they had been doing successfully in the rounds prior to its implementation, and which is furthermore in strong contrast with their local knowledge of trying to prevent a grazing area from degradation. This conflict between the rule and internalised preferences based on real-life experiences may explain the high occurrence of rule breaking under rotation rule in the *high sustainability* groups (which were all from Namibia). The functioning of externally drafted rules can be further undermined, if people do not consider the formal law as being the 'source of rightfulness'. Data from the 2008 Afrobarometer survey reveal that 47% of the people in the Namibian study region disagree with the statement that 'people have to obey the law', compared with 15% of respondents from the South African study region and 39% of people in the Namibian study site (15% in South Africa) do not agree that courts make binding decision and 52% do not agree that people must pay taxes (15% in South Africa).

5 Conclusion

We investigated rule following behaviour and efficiency of rules in a framed common-pool resource experiment carried out with experienced CPR users in southern Africa. In contrast to

[22] It might be that people in our study sites pursue a different rotation pattern without any serious degradation of grazing quality. They allow their animals to graze on one area, but move out of the area at the earliest signs of damage. In our experiments, the degradation was much more serious since possible (maximum) earnings declined substantially from 8 to 3.

related studies on the effects of endogenous rules, the rules we tested are based on real life institutions which have been developed and applied in everyday life to govern resource extraction.

Our study has three important and closely interlinked results: First, and at odds with previous studies in this vein, we find that democratic decision-making processes alone may not be sufficient to improve the social welfare of the group. In our setting, only the quota rule could enhance cooperation and grazing availability in both subsamples of high and low sustainability groups. However, similar to Vollan (2008) for the same study area, very few people were in favour of this rule. Its' low acceptance may be due to negative experiences participants made in real-life with similar policies that restrict livestock numbers. This observation confirms results from laboratory studies, which report that, if given the choice, subjects do not necessarily vote for a rule that enhances *cooperation* most. For example, there is evidence that subjects avoid the implementation of punishment institutions if they have alternatives (e.g. reward rules), even though punishment rules often turn out to be the most effective ones in terms of cooperation enhancement if elected (e.g. Bothelo et al., 2009; Ertan et al., 2009; Guillen et al., 2006; Sutter et al., 2010).[23]

Second, our results show that the reason for the absence of welfare improvements is that people broke the proposed rules frequently, even if they themselves had voted for its implementation. Interestingly, payoff considerations were in most cases not the driving forces behind rule breaking. An in-depth analysis of rule disobedience under the rotation rule rather lends support for the claim that a conflict between this rule and preferences for retaining high resource availability is the reason for the high occurrence of rule deviation under rotation among members of the *high sustainability* groups, which were all from Namibia. This effect is also stronger for older individuals.

This leads over to our third and major result: The impact of democratically elected rules seems to strongly depend on its reconcilability with internalized (ecological) norms, and hence can vary substantially between populations, even if they share a common ethnic and cultural origin and pursue the same livelihood strategies. This claim has been frequently made in the literature on the determinants of successful collective action (see e.g. Ostrom, 2007), but our study is (to our best knowledge) the first experimental one, that provides

[23] An elected quota rule did not improve cooperation in Vollan (2008) for Namibia but did so in South Africa.

empirical evidence for that.[24] In those groups that had performed well through tacit coordination in the first 10 rounds, only the implemented rule that was in conflict to the local norm was broken relatively frequently. Our interpretation is that these groups may have felt disturbed by the need to introduce formal rules, and ignored them even though they were the result of a democratic process. In addition it might be that voting as a collective choice rule is not accepted as a way to legitimise the operational rule of pasture management. This reasoning can be substantiated with data from the Afrobarometer survey 2008.[25] Among the people in the Namibian study region only 26% (compared with 100% for the study region in South Africa) think that leaders should be chosen through regular, open and honest elections and the remaining 74% preferred “some other method”. This seemingly surprising experimental outcome might also arise with anti-corruption policies, anti-doping legislations in sports or other institutional reforms whenever the implementing party is pressured to act according to what is called ‘best practice’. The resulting agreed-upon rules look as if they should work, but they often don’t as they do not connect to, or change with, the strong habits or norms that people have internalised. Also in co-management regimes for natural resources, communities are required to adopt formal rules instead of keeping the status quo. This ‘forced’ implementation, even if backed by democratic decision making processes, may thus do more harm than good.[26] In such cases it is essential to have effective communication about rules to achieve a shared meaning of rules among the actors and how they relate to the rules-in-use. Without communication, “confusion will exist about what actions are required, permitted, or forbidden” (Ostrom, 2005). Our study provides evidence that the introduction of formal rules can cause efficiency losses and high enforcement cost for government authorities if they are in conflict with norms based on traditional ecological knowledge. Therefore many scholars have expressed the need to make co-management *adaptive*; acknowledging that rule-making is a trial and error process that needs ample opportunities for renegotiation, learning and adaptation and that affected people should have a chance to participate in the drafting of rules if policy makers want to increase the probability of rule compliance (Dietz et al., 2003; Olsson et al., 2004; Plummer and Armitage, 2006).

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[24] Because of the interaction between implemented rules and norms, and the fact that the latter evolve within a certain social, ecological and cultural context (see also Ostrom (2000); Poteete et al. (2010)), laboratory experiments administered to students from Western societies can only partly help in designing optimal rules for real resource users.

[25] Which of the following statements is closest to your view? Statement 1: We should choose our leaders in this country through regular, open and honest elections. Statement 2: Since elections sometimes produce bad results, we should adopt other methods for choosing this country’s leaders.

[26] As in the described situations, our experimental design did not provide the participants with the possibility of not implementing any of the proposed rules.

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TABLE 1: Individual payoff table for each round

Grazing quality \ *Intensity*	0	1	2
Good	*0*	*7*	*8*
Bad	*0*	*2*	*3*

Note: The payoff table is the same for both locations (area A and area B).

TABLE 2: Voting outcomes

	Lottery		**Rotation**		**Quota**	
Individual votes	1st Poll	2nd Poll	1st Poll	2nd Poll	1st Poll	2nd Poll
High sustainability	32%	33%	55%	57%	13%	10%
Low sustainability	28%	25%	45%	50%	27%	25%
Total	30%	29%	50%	53%	20%	18%
Implemented rules by groups	n	%	n	%	n	%
High sustainability	4	33.3	7	58.3	1	8.3
Low sustainability	3	25	7	58	2	17
Total	7	29	14	58	3	13

Note: In the upper panel, the number of people who voted for lottery, rotation and quota after the first and second poll, respectively, is given in relative figures. In the lower panel, the number of groups that adopted a particular rule is given in absolute and relative figures.

TABLE 3: The effect of rules on grazing availability

Y = Number of grazing areas in good condition	Pooled		Low sustainability groups		High sustainability groups	
	(1)	(2)	(3)	(4)	(5)	(6)
Rule stage (i.e. round > 10)	0.232***	0.232***				
	(0.087)	(0.087)				
High sustainability groups	0.750***	0.699***				
	(0.102)	(0.116)				
Rule stage**High sustainability* groups	-0.274	-0.274				
	(0.176)	(0.177)				
Lottery			-0.204***	-0.207***	-0.290	-0.300
			(0.044)	(0.058)	(0.209)	(0.197)
Rotation			0.279***	0.297***	-0.077	-0.062
			(0.062)	(0.063)	(0.134)	(0.139)
Quota			0.721***	0.662***	1.197***	1.133***
			(0.061)	(0.062)	(0.024)	(0.063)
Socio-economic group composition						
Fraction female		-0.327		-0.128		-1.128**
		(0.253)		(0.220)		(0.512)
Average age		-0.018		0.003		-0.044***
		(0.011)		(0.006)		(0.016)
Fraction with little education		0.547		-0.282		1.185
		(0.505)		(0.282)		(1.029)
Fraction of permanent workers		-0.055		0.236		0.081
		(0.400)		(0.242)		(0.481)
Fraction of farmers		0.079		0.045		0.650*
		(0.349)		(0.247)		(0.377)
Average trust		0.093		0.130		-0.074
		(0.166)		(0.147)		(0.223)
Constant	0.208***	0.699	0.208***	-0.156	0.958***	2.711***
	(0.044)	(0.596)	(0.045)	(0.532)	(0.095)	(0.825)
Observations	360	360	180	180	180	180
Number of session	24	24	12	12	12	12
r2_w	0.0263	0.0263	0.139	0.135	0.123	0.122
r2_b	0.518	0.613	0.697	0.799	0.177	0.548
r2_o	0.230	0.270	0.221	0.236	0.139	0.253
chi2	60.51	89.06	389.1	585.9	3854	10846

Note: Random-effects regressions of "number of good grazing areas" on treatment rules. Only rounds 3-10 and 13-19 are considered. In rounds 3 to 10, all rule indicators (*rule stage* in model 1; *lottery, rotation* and *quota* in models 2-3) are zero. Robust standard errors, clustered at group level, are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

TABLE 4: Summary of descriptive statistics for rule breaking behaviour

	Low sustainability groups	High sustainability groups
Lottery	7.3% (n=150)	4% (n=200)
Rotation	3.1% (n=350)	17.4% (n=350)
Quota	31% (n=100)	18% (n=50)
Total	8.8% (n=600)	13% (n=600)

TABLE 5: Marginal effects after random-effects probit regressions for rule breaking under the rotation rule.

	Rotation	
	(1)	(2)
Own agreement	0.378	-0.077
	(0.242)	(0.251)
Profit consideration	0.236	0.082
	(0.205)	(0.234)
Round	-0.013	0.019
	(0.033)	(0.034)
Final Round	0.326	0.310
	(0.278)	(0.295)
Sanction in previous round	1.000***	1.128***
	(0.351)	(0.391)
Cumulated Sanctions in previous rounds	-0.606**	-0.629***
	(0.282)	(0.241)
Sustainability norm	1.227***	1.276***
	(0.369)	(0.379)
Socio-economic Controls		
Female (=1)		-0.387
		(0.278)
Age		0.117**
		(0.053)
Age²		-0.002**
		(0.001)
Little education		0.296
		(0.367)
Permanent work (=1)		0.038
		(0.286)
Farmer (=1)		0.054
		(0.241)
Trust		0.049
		(0.173)
Observations	700	590
Loglikelihood	-208.431	-161.626
chi2	25.021	26.781
p	0.001	0.021

Note: Random-effects probit estimations. The dependent variable takes 1 if the subject broke the rule and 0 otherwise. *** p<0.01, ** p<0.05, * p<0.1

TABLE 6: Area choices when grazing situation is HL_2, for those groups with rotation treatment

	Rounds 1-10 (before Rotation is enacted)			Rounds 11-20 (when Rotation is enacted)		
	No Intensity	**Bad Grazing**	**Good Grazing**	**No Intensity**	**Bad Grazing**	**Good Grazing**
Low sustainability groups	5 (6%)	12 (15%)	63 (79%)	6 (5%)	0	114 (95%)
High sustainability groups	49 (41	25 (21%)	46 (38%)	45 (35%)	30 (23%)	55 (42%)

Note: Area choices, if grazing situation is HL_2, for those groups who had chosen the rotation treatment. The rotation rule requires individuals to use the good grazing after recovery in round 13, 15, 17 and 19.

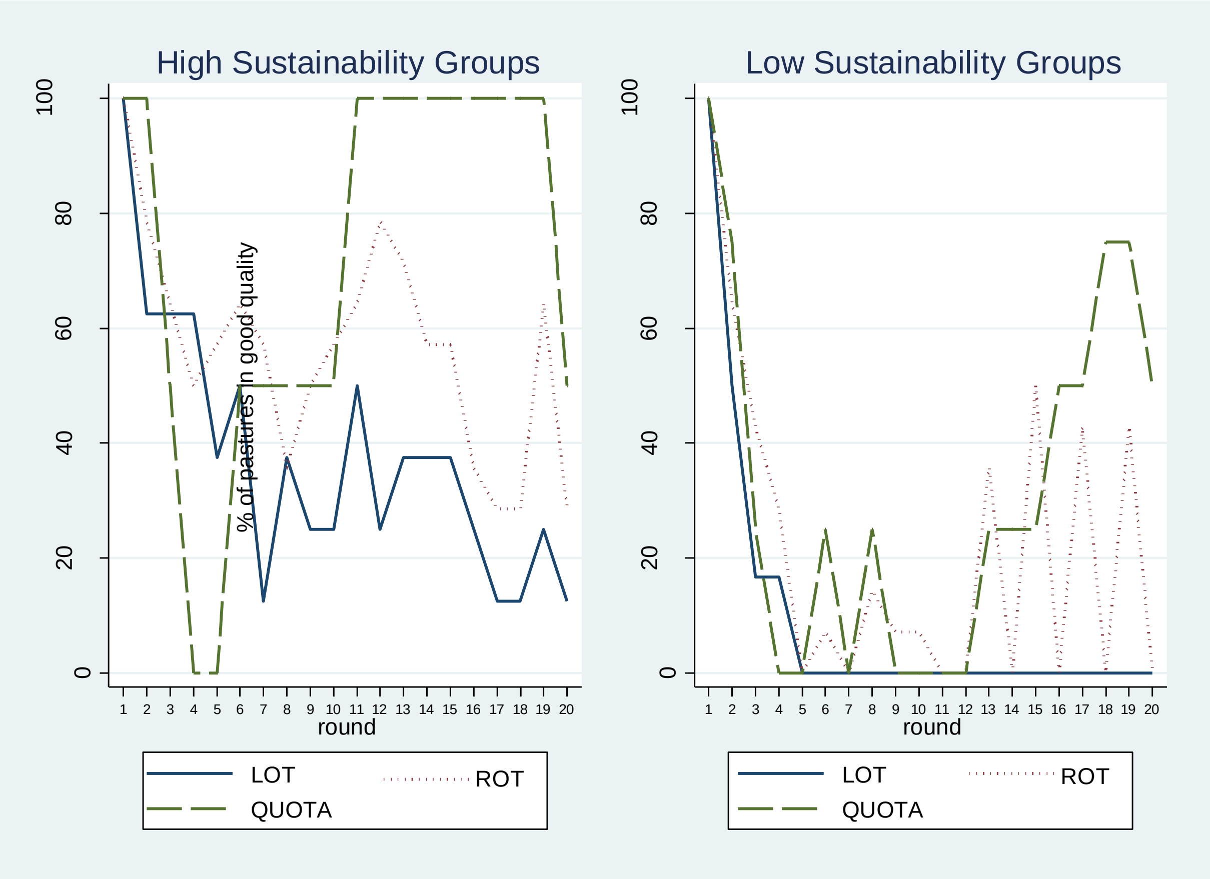

FIGURE 1: Performance of High Sustainability and Low Sustainability groups over the course of the game, separately by rule.

Note: The Figure shows the average "Number of good grazing areas" at the beginning of each round for each rule. Round 1 represents the beginning of the game. In each session and round, the number of good grazing areas can be 0, 1 or 2. At the beginning of round 11, the rules were voted and active from that round onwards. Performance is measured by the percentage of pastures in good quality at the beginning of each round. Lottery: solid blue line. Rotation: dotted brown line. Quota: dashed green line. The left-hand (right-hand) side shows the performance of the rules for the *high sustainability* groups (*low sustainability* groups).

Appendix

This appendix is not intended to be published in Ecological Economics. It is a supplementary appendix and is meant to be made available to interested readers on the journal's websites. It contains descriptive statistics, additional tables with robustness checks and sensitivity analyses and the experimental protocol.

Appendix A: Procedures and sample characteristics

At the beginning of a session, the instructions were read aloud and two to three practice rounds were played. Before the experiments started, participants were asked to disperse within the room to ensure that nobody could see the decisions of others. The experiment lasted twenty rounds. In each round, the participants received a decision card where they had to write down their player number, the grazing intensity (0, 1 or 2) and the area (A or B) in which they want to graze. When all had made their decisions, the experimenter collected the decision cards. He then announced and presented visually the aggregate group intensity for each grazing area as well as the resulting resource quality in the following round. After the final round was completed, the participants were asked to fill out a survey on their demographics and resource use in their village. Table A.1 presents a summary of socio-demographic characteristics of our subjects, separated by countries. Most subjects attended secondary school and 38% are female. The average age ranges between 17 and 78 and differs significantly between the Namibian and South African sample (t=2.75***). The latter was on average seven years older. Less than a quarter of our subjects were married. This is in accordance with official census data.[27]

In both study areas, formal wage-employment opportunities are rare and for most households farming is an important part of their livelihood (Kuiper and Meadows, 2002). In the communal lands of Berseba (Namibia) and the Leliefontain reserve in Namaqualand (South Africa), most inhabitants live directly or indirectly from livestock keeping based on subsistence. Nevertheless, only 29% of the subjects indicated livestock keeping as the activity in which they received the most *cash income* during the year. This should not hide the fact that the majority possesses livestock. For many residents of the communal areas in both countries, however, livestock is mainly used for own consumption and to hedge against risks and hence constitutes only one source of income amongst others. In the Namibian sample, we

[27] Central Bureau of Statistics (2006): Namibia Household Income and Expenditure Survey 2003/2004.

(randomly) recruited more farmers than in South Africa. About 36% stated casual work (on average less than 10 hours a week) being their main economic activity and 16% were permanently employed.

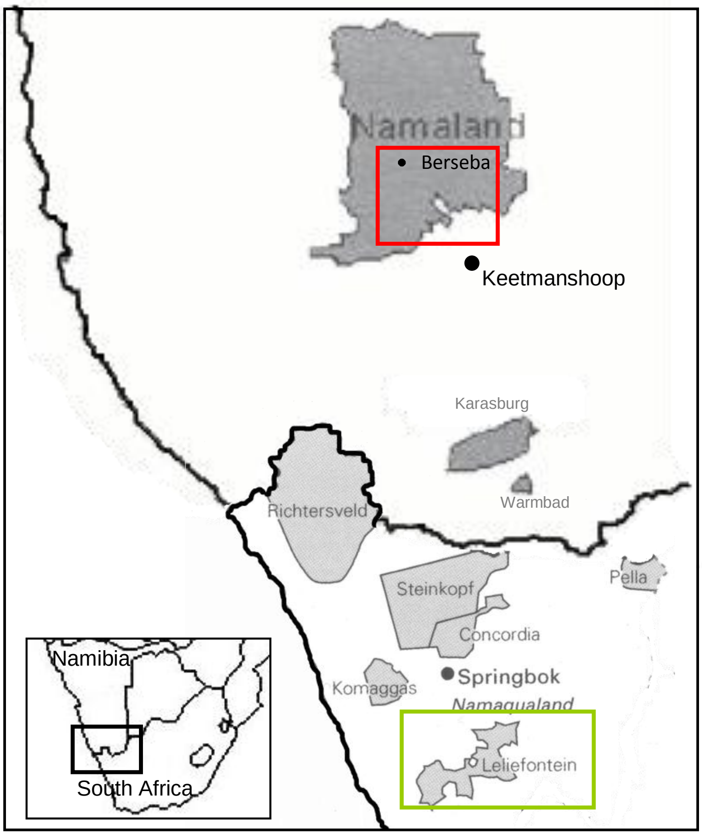

FIGURE A.1: Map of the study site.
The experiments were conducted in the communal lands of Berseba in Namibia (rectangle with red frame) and in the Leliefontein reserve in the Namaqualand in South Africa (rectangle with green frame).

TABLE A.1: Descriptive summary of socio-demographic variables

	Obs.		Mean		Std. Dev.		Min		Max	
Variable	**NAM**	**RSA**	**NAM**	**RSA**	**NAM**	**RSA**	**NAM**	**RSA**	**NAM**	**RSA**
Education	58	59	3.91	3.95	0.283	0.955	3	1	4	7
Age	56	57	33.11	40.63	12.948	16.245	17	18	69	78
Married	58	59	0.22	0.24	0.421	0.429	0	0	1	1
Female	60	60	0.38	0.38	0.490	0.490	0	0	1	1
Economic activity										
Permanent work	58	58	0.17	0.16	0.381	0.365	0	0	1	1
Farmer	58	58	0.33	0.24	0.473	0.432	0	0	1	1
Casual work	58	58	0.40	0.33	0.493	0.473	0	0	1	1

Notes: The variables married, female, permanent work, farmer and casual work are categorical variables. Age is measured in years. Education is an ordinal scaled variable with the characteristics "some primary school"

(1.7%), “primary school” (12%), “secondary school” (80%), “technical” (3.4%) and “university/post-university” (2.6%).

Appendix B: Further analyses

3.1 Descriptive results of differences in behaviour in rounds 1-10 (no-rule stage)

Table A.2 summarizes mean intensities and frequency of intensity choices under different resource scenarios for *high* and *low sustainability* groups. Apparently, members of *high sustainability* groups behaved more cooperatively and coordinated their actions more successfully under all six resource scenarios (i.e. HH, HL_1, HL_2, L_1L_1, L_1L_2 and L_2L_2).[28] Using intensity choices as proxies for cooperativeness, we find that *high sustainability* members applied significantly lower mean intensities than their fellows from *low sustainability* groups (*high sustainability*=.975 vs. *low sustainability*=1.37, Z=9.54, p<.0001). Lower grazing intensities resulted in more successful resource management. Over the course of the first ten rounds, 56% of the pastures remained in good quality in the *high sustainability* groups. In sharp contrast to them, *low sustainability* groups had difficulties in both, maintaining high resource availability and recovering from bad area conditions. *Low sustainability* groups were quickly trapped in a situation in which both grazing areas were in bad condition. They achieved grazing recoveries in only 21% of all possible cases, compared to 48% in the *high sustainability* groups.[29] At the beginning of round 11, i.e. when the polls took place, none of the grazing areas were in good quality in the *low sustainability* groups compared to 62.5% in the *high sustainability* groups.

[28]The scenarios HL_2 and HL_1 are subsumed under HL; the scenarios L_1L_1, L_1L_2 and L_2L_2 are summarized under LL in Table A.2.
[29] Examples for improvements include a switch from L_1L_2 to HL_2, or from L_2L_2 to L_2L_1.

TABLE A.2: Cooperation pattern in the first ten rounds

	***High sustainability* group**			***Low sustainability* group**		
Intensity/ Resource availability	**HH (n=175)**	**HL (n=320)**	**LL (n=105)**	**HH (n=80)**	**HL (n=135)**	**LL (n=385)**
0	11.43	34.06	53.33	2.50	5.93	16.62
1	46.29	44.38	29.52	32.50	37.04	38.70
2	42.29	21.56	17.14	65.00	57.04	44.68
Mean	**1.31**	**0.87**	**0.64**	**1.63**	**1.51**	**1.28**

Note: The table shows the relative frequency of individual intensity choices as well as the mean intensities in rounds 1-10 for the situations of (1) high resource availability in both grazing areas (HH), (2) high resource availability in one grazing area (HL), and (3) low resource availability in both grazing areas (LL), separately for the *high sustainability* group (right-hand side) and the *low sustainability* group.

3.2 Rule Voting

We use binary probit regressions to investigate the determinants of rule choice.[30] We include individual earnings and the distribution of earnings within the group as explanatory variables. (*Cumulated) earnings* measures total individual earnings realized in the round prior to voting (over the first ten rounds) and (*Cumulated) standard deviation of earnings* measures the distribution of earnings in the round prior to voting (within the group over rounds 1-10). If everyone played selfishly, inequality as well as absolute earnings would be low. If everyone played cooperatively, inequality should be low and earnings high. If some people played selfishly and others tried to cooperate, inequality should be large. Lastly, we consider a proxy for an individuals' preference towards sustaining high resource availability. The variable *sustainability norm* ranges between 0 and 1, and relates the cases in which an individual facing a situation of HL_2 either chose zero intensity or to graze on the bad condition area to all cases of HL_2. A value of 0 (1) means that an individual always (never) applied an intensity greater than 0 on the area in good condition in a situation of HL_2.

The results of the binary probit regressions are presented in Table A.3. Subject with a stronger preference towards sustaining high resource availability (measured by the relative frequency of choosing intensity 0 or the bad area in HL_2) do not seem to be in favour of any particular rule. *Sustainability norm* is insignificant in all three models. It is further worth mentioning that the quota rule is chosen in situations of a high within group inequality in terms of earnings in the round prior to the voting. Exactly the opposite holds true for the

[30] In the regression we report results concerning the decisive second vote. Results do not change when analysing the first poll.

lottery rule, which is more likely to be voted for if within group inequality was low in round 10. We also find heterogeneous effects of cumulated individual earnings: Subjects who realized high earning over the first ten rounds were more likely to vote for rotation and less likely to vote for quota.

Table A.3: Marginal effects of binary probit regressions of rule choice, including socio-economic controls

	Lottery		Rotation		Quota	
	(1)	(2)	(3)	(4)	(5)	(6)
Cumulated ind. earnings	-0.003	-0.003	0.013**	0.014**	-0.010*	-0.012**
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Cumulated stddev. of earnings	0.002	-0.003	0.008	0.009	-0.013	-0.012
	(0.010)	(0.010)	(0.012)	(0.013)	(0.009)	(0.010)
Earnings in round 10	0.008	0.018	-0.021	-0.028	0.013	0.012
	(0.022)	(0.016)	(0.021)	(0.019)	(0.012)	(0.011)
Stddev. of earnings in round 10	-0.084*	-0.116**	0.013	0.040	0.069**	0.078***
	(0.049)	(0.051)	(0.046)	(0.050)	(0.030)	(0.030)
Sustainability norm	-0.194	-0.109	0.189	0.094	0.008	0.010
	(0.119)	(0.161)	(0.149)	(0.197)	(0.176)	(0.198)
Socio-economic Controls						
Female (=1)		-0.064		0.232**		-0.157**
		(0.081)		(0.113)		(0.067)
Age		-0.024		0.040**		-0.013
		(0.017)		(0.017)		(0.009)
Age²		0.000		-0.000**		0.000
		(0.000)		(0.000)		(0.000)
Little education		-0.255		0.026		0.170*
		(0.161)		(0.180)		(0.103)
Permanent work (=1)		-0.190*		0.278**		-0.031
		(0.112)		(0.112)		(0.095)
Farmer (=1)		0.028		0.033		-0.047
		(0.121)		(0.132)		(0.084)
Trust		-0.073		0.049		0.041
		(0.086)		(0.096)		(0.051)
Observations	120	104	120	104	120	104
r2_p	0.04	0.12	0.17	0.14	0.12	0.25
chi2	4.99	15.79	7.79	33.4	22.69	67.13
p	0.4	0.12	0.05	0.00	0.00	0.00

Note: Marginal effects of binary probit regression of voting for rule choice. *Little education* is a binary variable taking the value of 1 if the subject completed at maximum primary school (13.7%). *Permanent work* takes 1 if the subject has a permanent job (16%) and *Farmer* takes 1 if livestock keeping constitutes the subjects main source of cash income. The reference category for *Farmer* and *Permanent work* are casual workers, pensioners

and unemployed who depend on remittances. Due to missing values for some of the core socio-economic variables, the sample size reduces to 104 (from 120). *Trust* is an index variable ranging from 0 (no trust) to 4 (high trust). It is based on the answers to three statements for which subjects had to indicate their level of agreement (ranging from 1=strongly disagree to 4=strongly agree): (1) Most people in this village are basically honest and can be trusted, (2) Members of this village are always more trustworthy than those in other villages, (3) In this village one has to be alert, or someone will take advantage of you. The last question (3) was rescaled to bring it into accordance with statements (1) and (2).
Reported standard errors are clustered at session level; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

3.3 Rule efficiency

Table A.4 is analogous to Table 3 in the manuscript, but examines differences between Namibian and South African groups (instead of differences between *high* and *low sustainability* groups). Whereas nationality does not exactly capture the norms we want to study, it has the advantage for the econometric analysis of being exogenous. However, as reported in Table A.4, a cross-country comparison leads to qualitatively the same conclusions as the comparison between *high* and *low sustainability* groups. Hence, the results presented in the manuscript are robust.

TABLE A.4: Cross-country comparison of the effects of rules on grazing availability

Y= Number of grazing areas in good condition	(1) Pooled	(2) South Africa	(3) Namibia
Rule stage (i.e. round number >0)	0.199**		
	(0.099)		
Rule stage*Namibia	-0.208		
	(0.180)		
Namibia	0.708***		
	(0.114)		
Lottery		-0.229***	-0.206
		(0.046)	(0.262)
Rotation		0.318***	-0.088
		(0.050)	(0.118)
Quota		0.699***	1.214***
		(0.064)	(0.021)
Constant	0.229***	0.229***	0.937***
	(0.045)	(0.046)	(0.108)
Observations	360	180	180
Number of session	24	12	12
r2_w	0.0188	0.150	0.117
r2_b	0.499	0.801	0.105
r2_o	0.218	0.243	0.110
p	4.96e-09	0	0
chi2	41.56	876.8	4406

Notes: Random-effects regressions of "number of good grazing areas" on treatment rules. Only rounds 3-10 and 13-19 are considered. "Namibia" is a categorical variable taking 1 for Namibian groups and 0 for South African groups. In rounds 3 to 10, all rule indicators (*rule stage* in model 1; *lottery, rotation* and *quota* in models 2-3) are zero. Robust standard errors, clustered at group level, are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.5 is analogous to Table 3 in the manuscript but reports the results of random-effects regression of *group earnings* (instead of number of pastures in good condition) on the treatment rules. In column (1), the full sample is considered. It becomes apparent that groups could realize significantly higher earnings in rounds 13-19 as compared to rounds 3-10. However, the interaction term between rule stage and *high sustainability* groups also suggests that this claim holds only for *low sustainability* groups. Models 2 and 3 examine the effects of each of the three rules for the *low sustainability* sub-sample and the *high sustainability* sub-sample, respectively. Though the implementation of the quota rule led to a significant increase in resource availability in both groups (Table 3 in manuscript), only *high sustainability* groups could significantly improve their group earnings as compared to the no-rule stage. On the contrary, lottery had a negative impact on earnings in both sub-samples and only *low sustainability* group members benefited from the implementation of the rotation rule.

TABLE A.5: The effects of rules on group earnings

Y=Group earnings	(1) Pooled	(2) Low sustainability groups	(3) High sustainability group
Rule stage (i.e. round number > 10)	4.295***		
	(1.594)		
Rule stage**High sustainability* groups	-5.781**		
	(2.542)		
High sustainability groups	3.115*		
	(1.712)		
Lottery		-2.228***	-5.535***
		(0.783)	(1.868)
Rotation		7.679***	0.210
		(1.246)	(2.271)
Quota		2.234	2.830***
		(4.726)	(1.056)
Constant	14.979***	14.979***	18.094***
	(0.939)	(0.964)	(1.470)
Observations	360	180	180
Number of session	24	12	12
r2_w	0.0230	0.0736	0.0368
r2_b	0.00322	0.431	0.0181
r2_o	0.0209	0.114	0.0278
p	0.0190	0	0
chi2	9.951	45.41	35.23

Note: Random-effects regressions of "group earnings" on treatment rules. Only rounds 3-10 and 13-19 are considered. In rounds 3 to 10, all rule indicators (*rule stage* in model 1; *lottery*, *rotation* and *quota* in models 2-3) are zero. Robust standard errors, clustered at group level, are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.6 reports the results of Random-Effects estimations where we regress the number of good grazing areas in rounds 13-19 on the rule variables. Model 1 considers the *low sustainability* groups and Model 2 refers to the *high sustainability* groups. For both groups we observe that lottery was the least effective rule, while quota was the most effective one in terms of grazing availability.

TABLE A.6: The effects of rules on grazing availability in rounds 13-19

	(1)	(2)
	Rounds 13-19	
Y= Number of grazing areas in good condition	*Low sustainability* groups	*High sustainability* groups
Lottery	0	0.536**
	(0.0987)	(0.216)
Rotation	0.490***	0.980***
	(0.0646)	(0.163)
Quota	0.929***	2***
	(0.121)	(0.432)
Constant		
Observations	84	84
Number of session	12	12
sigma_e	0.452	0.476
sigma_u	0	0.393
chi2	116.5	63.65
Loglikelihood	-52.52	-67.28

Notes: Random-effects regressions of "number of good grazing areas" on treatment rules. Only rounds 13-19 are considered. Robust standard errors, clustered at group level, are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix C: Experimental instructions

Instructions of the first stage (=rounds 1 to 10, without rules)

This exercise is intended to recreate a situation in which a group of communal farmers must make decisions about the use of a commonly owned grazing resource. Each group consists of 5 persons. We will play several rounds equivalent to, for example, years or grazing seasons.

You can graze with your animals in two grazing areas, **area A** and **area B**. We will play this game for several rounds. In each round you have to make a choice in which area to graze, and the intensity you want to farm with. You can choose between an intensity of **0, 1 and 2**.
An intensity of **0** means that you are not farming in this round. **1** means you farm with low stocking rate and **2** means that you farm with high stocking rate.

The higher the intensity you choose the more points you will get. However, the number of points you get in each round does not only depend on your intensity but also on the condition of the grazing area. The grazing areas can be in a **good** or **bad** condition.

Let us take a look at the PAYOFF TABLE here to ease the understanding of the exercise [show the poster]. To be able to play you will receive the PAYOFF TABLE equal to the one shown here in the poster [distribute the PAYOFF TABLE, wait until everybody got its sheet].
This table contains all the information that you need to calculate your points depending on the current GRAZING CONDITION and the INTENSITY you want to farm with. In the far right column named

"GRAZING CONDITION" you can see that each grazing area can be in a good or bad condition. The next column labeled INTENSITY indicates the intensities you can graze with: As mentioned above, these are 0, 1 or 2. The higher the intensity the more points and therefore money you can earn.

One picture of the coins refers to one point.

When you choose to keep your animals in an area with a good condition, you can earn 0, 7 or 8 points dependent whether you have chosen an intensity of 0, 1 or 2. If you, on the other hand, chose to graze your animals on a grazing area with bad condition, you can earn 0, 2 or 3 points dependent whether you have chosen an INTENSITY of 0, 1 and 2.

In the last column you can see the earnings you can receive per round. Every point refers to 0.25 RAND. Therefore, 4 points are 1 RAND.
For example, if you graze with an intensity of 1 in a pasture in **good** condition, you get 7 points and therefore 1.75 RAND. If you graze with an intensity of 1 in a pasture in **bad** condition, you get 2 points and therefore 0.5 RAND.

As you can see at the given examples, your earnings do not only depend on your chosen intensity but also on the condition of the grazing area.

The resource condition can change in each grazing area. The grazing condition depends on its condition in the previous round and the total intensity the group played in this round on the respective area. The GOOD condition can move to a BAD condition when FIVE or more units of group intensity are invested in an area. A BAD condition can move to a GOOD condition when not more than ONE unit of intensity is allocated in the same grazing area for two successive rounds. For example a GOOD condition will be a BAD condition in the next round when 5 units of group intensity are applied in one area. A BAD condition will move into a GOOD condition when no intensity or not more than an intensity of 1 is invested in the area for two successive (consecutive) rounds.

At the beginning of each round, I will announce the condition of the resource at each of the two grazing areas. To play in each round you must fill in a yellow DECISION CARD [distribute decision cards] that you get handed before each round.

Please take a look at the DECISION CARD now. There are 3 lines. In the upper line you must write your player number [you can find your player numbers on the red card you have on your clipboard].
In the next line you must decide whether you want to graze on area A or area B by writing an A or B respectively.
In the last line you must choose the intensity you want to graze with, by writing 0, 1 or 2. You will get this decision card in each round.

It is very important that we keep in mind that the decisions are absolutely individual, that is, that the numbers you write on the decisions card are private and that we do not show them to the rest of participants. We will collect the DECISION CARDS from all participants, and will define the points for each individual and the condition of the resource in the next round for each grazing area.

When I announce the intensity level in each area and the conditions of the grazing in each area, we will write these conditions on the boards so that you know which payoff table to use in the next round.

Remember that the units you earn depend on your own decisions and your fellow villagers and will become money at the end of the exercise.

Let us explain this with an example.
[here we run a round with an example]
Are there any questions about this? [MONITOR: pause to resolve questions.]

We will have first a few rounds of practice that will NOT count for the real earnings, just for practicing of the game.

In the first round the condition of both grazing areas is good. This means, you use the GOOD PAYOFF TABLE in each location.

Instructions of the second stage (=rounds 11 to 20, with rules)

[After 10 real rounds we let the participants vote for one of three rules.]
We give you the opportunity to start over the game with a different rule. I will describe three rules and you write down on your VOTING CARD your favourite rule. The monitor will collect the votes and count them. [If two rules get 2 votes, we do a new voting round with only these to rules]

The rule which receives the most votes will be implemented.

Lottery rule. With this rule we draw randomly and visible for everybody for each player in every round an area the player is allowed to graze. When we throw a 1, 2 or a 3 you can graze in A. Otherwise you can graze in B. Then you can fill in your area and your effort on the yellow DECISION SHEET. We throw a dice each round. When you graze in an area which you are not allowed to, the result of the dice throwing affect your payoff. When we throw a six an inspector comes to the region and check on your areas. If you are located in a place you are not allowed to, you have to pay back this rounds earning. For example if the player grazes in the place A with 2 effort units when the allowed place to graze is B and the dice yield 6, the player pays back the earning of this round.

Rotation rule. Only one area is allowed to be grazed in each round. There is a rotation AABBAABBAABBAA of a ban where you are not allowed to harvest. It means that:
Round 11 ban in A
Round 12 ban in A
Round 13 ban in B
Round 14 ban in B
Round 15 ban in A
Round 16 ban in A
Round 17 ban in B
Round 18 ban in B
Round 19 ban in A
Round 20 ban in A
Thus in the fourth round you are not allowed to graze in area B. When you graze, but are not allowed to, the throwing of a dice determines whether you need to pay a penalty. If we throw a six, the penalty is to return back the earning of this round.

Quota rule: Each of you is allowed to put an intensity of 0 or 1 per round. We throw a dice every round. If we throw a six, an inspector comes to the region to check on your intensity choices. If a participant writes 2 units of intensity on its YELLOW DECISION SHEET, and the inspector is present, the participant has to return back the earning of this round.

Summary:
Rule 1: randomly determined area where to graze
Rule 2: rotating turns where to graze
Rule 3: maximum of 1 unit of intensity per round.

Do you have any questions about the rules?
Write down your favourite rule on the VOTING CARD, by writing a 1, a 2 or a 3. And turn it in to the monitor.

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Björn Vollan, Sebastian Prediger, Markus Frölich

Co-managing common pool resources: Do formal rules have to be adapted to traditional ecological norms?

Abstract
We examine the effectiveness of three democratically chosen rules that alleviate the coordination and cooperation problems inherent in collectively managed common-pool resources. In particular we investigate how rule effectiveness and rule compliance depends on the prevailing local norms and ecological values held by resource users. For this purpose, we employ a framed field experiment that is based on a rangeland model for semi-arid regions and carried out with communal farmers in Namibia and South Africa. Participants could vote for three 'best practice' management rules found in many places around the world that are discussed for implementation in the study area: (temporary) private property rights, rotational grazing or limitation of livestock numbers. All rules were designed in a way that facilitated cooperation or coordination of actions. The focus of this study lies on the interactions between these rules and prevalent ecological norms exhibited in the rounds prior to rule implementation. In contrast to previous lab experimental studies, we find that democratic voting of rules is not sufficient for high rule compliance and an overall enhancement in cooperation. Rules turned out to be inefficient if they were in conflict with the prevalent ecological norm.

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