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How Does Scarcity Affect Extraction of Resources?

A study about land use as a common-pool resource dilemma using survey and field-experimental data collected in northern Namibia

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Abstract

The aim of this study is to analyze how scarcity of resources affects at what rate users decide to extract or appropriate resources. We investigate this by conducting a survey and an economic field experiment in northern Namibia. The participants in our study are small-scale farmers who regularly make decisions about either staying on their old fields or clearing forest areas for new ones. We compare environments where resources are abundant against environments where resources are scarce.

Results from both the survey and the experiment show that a scarce environment does not cause faster extraction, but under scarcity the rate of extraction is lower than in an abundant environment. Survey results also reveal that abundant stocks tend to attract additional users.

Topics: Commons and natural resource management

Keywords: resource, experimental economics, scarcity, land use, forest, Namibia

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Introduction

Scarcity of resources is a central problem in many economic concerns; natural resources in particular are expected to become increasingly scarce in the near future considering worldwide economic development, a growing world population as well as growing per capita consumption and changing consumption styles (e.g. Haddeland et al. 2014; Mancosu et al. 2015; Schneider et al. 2011). In case of a resource stock becoming scarce, but not yet depleted, competition for what is left could increase and thereby extraction rates being sped up as users rush to secure the remaining resource stocks (Grossman & Mendoza 2003; Roux et al. 2015). If there is reason to conserve that resource, for example when a minimum stock is required for regrowth (like fishing grounds) or social benefits from the resource accrue (like collectively used forests or pastures), scarcity could however also stimulate a more considerate use of the remaining stock: the smaller it is, the less can be extracted without endangering the survival of the resource (Kramer 1989). In case of abundance on the other hand, there is no competitive pressure, but also little reason to use the resource in a conserving manner. Hence, scarcity could in theory evoke different and opposing behavioral effects.

The aim of this study is to empirically examine the effects of scarcity in settings where a natural resource can be accessed by a group of users. We investigate this by conducting a household survey in northern Namibia to get information on real world behavior using forest and land use as an example for relevant natural resource management in the region. Local users repeatedly have to make decisions about how often and how much forest area they clear in order to convert it into arable farmland. Further, an economic field experiment is employed to gain additional insights regarding the individual decision making about extraction from a common resource.

Particular features of choosing forests as the resource for this study are that their state can be assessed at any time and clearing activities be observed by all users. Clearing decisions made by individual farmers have consequences for everyone in the community. If individuals take this into account in their actions, they show, as termed in the literature, social, or other-regarding preferences. In a common-pool resource situation, non-selfish behavior, which leads to better outcomes for the group as a whole, is called cooperation. Cooperation as a deviation from selfish, or, as some might call it, rational behavior has been extensively studied in economics. E. Ostrom put a particular focus on studying natural resources as a common good (Schlager & Ostrom 1992; Ostrom et al. 1994; Ostrom et al. 1999; Ostrom 1999).

While the focus of this study is set on investigating behavioral responses to scarcity, it should be considered that, depending on the type of resource, scarcity can also have a direct non-behavioral effect on extraction rates: If increasing scarcity means that further appropriation requires higher effort, users might decrease their extraction due to simple economic considerations and stop entirely when extraction costs exceed yields. Grossman & Mendoza (2003) formalize this discussion in a theoretical model. We argue that clearing of forest is a suitable type of resource use to study the behavioral response, as a decline of forest area does not or only to a small degree make finding another parcel to clear more difficult. Hence, as long as there is some forest left, the individual costs as well as the benefits of clearing a hectare of forest do not depend on how much forest is left.

Background

The research was conducted in the Kavango region in northern Namibia (Figure 1). Unlike most of the southern, drier parts of Namibia, the Kavango area is a tropical zone with wet and dry seasons; large forests cover most of the region. Due to seasonal rainfall farmers are able to grow annual crops during the rainy season and harvest in austral autumn, after the rain has ceased. The vast majority of the rural population is engaged in agriculture with crop farming being the primary component of their livelihood and cattle farming taking the second relevant role[1] (Namibian Ministry of Lands and Resettlements 2015). As the soil is mostly sandy, fertility decreases rapidly and farmers leave their fields after few years to clear new ones in the adjacent forests (Mendelsohn 2009; Brown 2010). The freshly cleared forest area is then converted into more fertile, nutritious fields which can be used for cultivation for some years. This practice is known as shifting cultivation[2] and together with area expansion of cropping it leads to degradation of forest in the region and a reduction of remaining, available land (Brown 2010).

This has already become evident in densely populated areas along the Okavango River where remaining land has recently become scarce and acquisition sometimes competitive (Pröpper et al. 2015). There have even been disputes over the acquisition of land for crop growing (Brown 2010). Further inland, however, forest stocks are still more abundant. But forests are not just available land

[1] Farming in Kavango is however predominantly on subsistence level as there is little surplus produced due to low yields and limited market access (Brown 2010).
[2] In this particular case semi-permanent as villagers do not usually entirely abandon the area and move their whole household and equipment to another area, but only move their fields further into forest land (Ruthenberg 1980)

for future agricultural use, they also constitute an important component of livelihoods for small-scale farming households and their communities. Such benefits that the environment, and in particular forest areas, provide are ecosystem services. For Kavango residents that can include possibility of collecting resources like firewood, timber and foods (Flower & Rooyen 2001). Surrounding forests become particularly important in the season before the harvest. Firstly, because they provide an additional source of food when grain stocks from the previous year's harvest are depleted (Flower & Rooyen 2001). Secondly, because cattle herds are sent into the forest for grazing in order not to harm the growing crops during that time (Flower & Rooyen 2001). Indeed, it is estimated that a household's direct yield value from the surrounding forests is much larger than the crop value from their individual fields (Pröpper et al. 2015; see also Angelsen et al. 2014 and Wunder et al. 2014 on the role and importance of livelihoods that depend on forests). One hectare of field however produces higher yields than a hectare of forest. Therefore, clearing forest and cultivating new fields is individually more profitable in the short term (Pröpper et al. 2015). Due to climate and soil quality in Kavango, regrowth of forest on fields that were left fallow again is marginal and negligible as it takes centuries to regrow to its previous state.

Our qualitative interviews and quantitative surveys show that authorities and villagers are aware of this practice being a problem in the long run and for future generations. Forests provide to the communities a multitude of benefits as explained above.[3] We therefore interpret the forest situation as a social dilemma, which develops over time. Clearing some hectares of forest does not cause a big loss in that moment or even year, but after some years of clearing, the damage done by deforestation accumulates[4]. This circumstance will also be reflected in the design of the conducted common-pool resource game, where social payoffs do not happen continuously but at the end of the game. Similarly, the lag between direct private yields and social benefits that occur later incorporates an uncertainty as

[3] On a larger scale, forests reduce the danger of desertification in dry areas, decrease erosion of soils and offer habitats for many species, hence preserving biodiversity. Globally, they contribute to carbon sequestration and thereby help combating climate change. Slower rates of shifting and clearing would therefore not only bring about benefits to the local communities and allow more sustainable long-term land use but also contribute to a globally better environment.

[4] Note that clearing must not be considered as bad behavior as agriculture constitutes a major part of livelihood for most people in the area and poverty might not leave scope for deliberate reductions of consumption to conserve environmental resources.

villagers do not know how much of the resource will be left by the other users (Kramer 1989). This uncertainty is particularly important when resources are scarce.

Land in the Kavangos, forests as well as fields for cultivation, is mostly not privately owned by the people who use it. Formally, it is communal land owned by the state but traditional authorities, such as village headmen, exercise some degree of control over the land (Mendelsohn, 2009). They do for example make decisions about granting land to migrants who wish to settle in their area. In many villages there are some rules established about clearing parcels in the forest in order to create fresh fields. If so, the headman usually has to be asked for permission to clear, but clearing is not usually denied to local villagers (Mendelsohn 2009). Mendelsohn (2009) already points out that communal tenure provokes individual interests to exploit the commonage resource to the maximum. Locally, within the village, land that is cleared and cultivated is normally considered property of the respective farmer[5]. However, without formal, private land rights and titles there are little long-term investments into land and no possibility to use it as collateral (Mendelsohn 2009; Namibian Ministry of Lands and Resettlements 2015).

Deforestation in Kavango is aggravated by an increasing demand for land, brought about not only by a growing population but also by migrants, who come to Kavango looking for unused land for conversion into farmland (Mendelsohn 2009; Brown 2010). While in the past many have come from Angola, it is now predominantly migrants from northwestern parts of Namibia, where forest and available land has already been depleted, as well as households who move within the Kavango territories in order to find and secure available land for farming. This information was given to us during explorative interviews in the region in 2016 and confirmed by many participating interviewees. Also within the Kavango territory farmers have started settling in the hinterland only in the last decades, a development that has been made possible only by drilling holes for water supply (Pröpper et al. 2010, Mendelsohn 2009). Migrating to resource abundant areas when the local resource becomes depleted can be interpreted as an adaptation strategy to scarcity. This is an important aspect to consider as having the option of migration to abundant areas might change behavior towards faster extraction. If on the other hand individuals were bound to stay in the same place, they would possibly try to act in more sustainable ways as to preserve long term benefits.

[5] Sometimes farmers can make claims on forest parcels they intend to clear in the future. These are often adjacent to their old field. Forest areas that have not yet been cleared do however in general not belong to individual villagers.

State of the art on scarcity response

Surprisingly few studies have paid interest to how the size of a resource stock affects its development and survival. Essential work on natural resources in particular and the role and use of ecosystem was conceptualized by E. Ostrom in the 1990s (e.g. Schlager & Ostrom 1992; Ostrom et al. 1999). In 2007, E. Ostrom formalized a framework of important variables for analyzing socioecological systems, which also includes the size of the resource system (Ostrom 2007).[6] Some marketing (e.g. Gierl & Huettl 2010) and psychology studies (e.g. Roux et al. 2015) have analyzed which responses scarcity of goods and products could provoke but according to their findings, no clear picture could be drawn but the results depend on the particular situations and circumstances. Other studies look at cases where scarcity of goods or resources is problematic; they suggest counter-measures (e.g. Krause et al. 2003) but do not take into account the level of scarcity as an explanatory variable on human behavior. Two studies looked at cooperation in irrigation system management. Firstly, Uphoff et al. (1990) in Sri Lanka and they suggest that the relationship between scarcity and the degree of cooperation is non-linear: cooperation is highest when the resource is somewhat scarce, i.e. neither very scarce nor abundant. Bardhan (2000) investigates a similar environment in India and also finds that extreme scarcity has a negative effect on cooperation. Cinner et al. (2011) follow a different approach by asking Tanzanian fishers how they would react to reductions in stock. They do however

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[6] Out of her framework, the variables identifiable as particularly relevant for our study are:

(1) Size or number of the resource unist: This represents the primary variable of interest in this study (not to be confused with size of the resource system). Regrowth or replacement rates would in theory also play a role, but are not overly relevant for the context of forestry in Kavango.

(2) Property rights systems: Land rights are held informally by community and regulations about forest clearing are partly existent, but often rather lax.

(3) Number of users: Obviously, the larger the number of users who access the resource stock, the less each user can take until the resource is depleted (Kramer 1989). Similarly, if the resource is to be conserved, users can take less compared to a situation where the stock is plentiful. In this context, mobility of users could be added as an additional relevant variable if moving to another resource stock is possible as an adaptation strategy to scarcity or depletion.

and (4) The resource users' dependence on the resource: Dependence is given in the context as farming is not an activity for additional profit only or even leisure, but determines people's indispensable livelihood. There are however some sustainable alternatives, such as conservation farming, which could potentially allow a more sustainable use of forests and land. Also, intensification of cultivation, for example by the use of fertilizers, could possibly reduce demand for land and thereby reduce the need to clear regularly. But such methods have not yet been extensively introduced or applied in Kavango.

not describe or interpret it as a situation where competition increases due to scarcity. Much of the more recent literature that centers on the behavioral response to scarcity is experimental. Scientific insights about decision making in social dilemma situations have been established and extended with the help of economic experiments in the last decades, such as common-pool resource games, that isolate (behavioral) effects and allow identifying factors that cannot be explained by standard economic theory. An early experimental study on the effects of scarcity was conducted by Rutte et al. (1987). They found in a common-pool resource experiment with university students as participants and sequential decisions on extraction that more resources were extracted in an abundant environment. They also already distinguish between exogenous (environmental) and endogenous (player-induced) scarcity with the result that the difference in extraction rates between the scarcity and the abundance condition are greater in the exogenous condition. Similarly, Osés-Eraso et al. (2007) and Osés-Eraso & Viladrich-Grau (2008) examined appropriation rates in common-pool resource situations in another classroom experiment. Their findings also suggest that initial, exogenous scarcity reduced appropriation rates. Endogenously increasing scarcity that is caused by the subjects' previous decisions also reduces appropriation rates, albeit to a lesser degree so that depletion cannot be prevented in the long run. Gatiso et al. (2015) on the other hand found contrasting results in a forestry-framed field experiment: A scarcity environment led to higher extraction rates than under abundance in a common-pool resource game where the social benefit of slower extraction accrued from a constant regrowth rate of stocks. Their findings are also confirmed by Blanco et al. (2015) who conducted a common-pool resource experiment in Columbia that was framed as water extraction. They compare different levels of reductions in resource availability and find that in the scarcest environment, appropriation rates are highest.[7]

An important distinction that several of the aforementioned authors make is between external, as environmentally-given and exogenous scarcity, that is induced by resource users' behavior. It becomes intuitively clear why the difference is crucial: By unsustainably extracting resources, users reveal and signal their behavior which likely leads other users, even those who would have been willing to restrain from excessive extraction, to also act selfishly and try to secure some resources

[7] Maldonado et al. (2009) experimentally tested scarcity and abundance situations, where scarcity is modelled by smaller private benefits from extracting (as cost of extraction is higher at scarcity). The scarcity condition was not externally induced, but endogenous on previous decisions of the group. If the group extracted too much then in the next round of the game scarcity applied. They found significantly higher extraction rates in low stock (scarcity). Their study is however not really comparable to ours as scarcity is not understood as competition for remaining resources

before they are taken by others. In common-pool situations, scarcity can make the social multiplier of cooperating become zero: If an actor or a group of actors decide to conserve resources, others might come and take them before any social benefit from conservation accrues. Given that the other players have already revealed themselves as selfish, conservation then becomes an unattractive if not entirely unreasonable strategy. Or as Kramer (1989) puts it: If scarcity is a consequence of failed cooperation, then users likely respond by not cooperating either (cf. Osés-Eraso & Viladrich-Grau 2008).

In the present context, it might at first seem unclear if scarcity of forests in Kavango should be considered exogenous or endogenous. If there had been no anthropogenic influence, there would probably be no meaningful differences in forest availability apart from some natural variations in forest cover density. There are however differences, especially between the Kavango hinterland, which has only been populated in the last decades (Mendelsohn 2009) and the more populous riverside. The differences in forest availability are therefore not attributable to different individual behavior of farmers but must be seen as a consequence of decades of clearing by more people living at the Okavango River.[8] [9] For this study we hence understand existing scarcity as an external circumstance. At the same time further deforestation should not be considered as inevitable but as a consequence of unsustainable individual decision making. This is also reflected in the design of the experiment where external scarcity is introduced as a treatment. Due to the dynamics of the game, which goes over several rounds, there is not only external scarcity present, but it can additionally worsen by decisions made by players.

The novel contribution of this study consists of four factors and their combination:

(1) The setting into the field context in northern Namibia with small-scale farmers as participants who make similar decision in their real lives. One particular advantage is that there are communities participating who live in resource-abundant and communities who live in increasingly scarce areas. They are otherwise, culturally and socioeconomically, similar which allows a fair comparison.

[8] The possibility that current deforestation is also endogenous on different individual behavior between river and inland farmers cannot be entirely rejected, but it is most certainly not the only or main reason for the current difference in levels of deforestation

[9] This should not obscure the fact that due to currently high population growth and potential changes in ways of life as well as agricultural habits and methods deforestation is now more than ever becoming an urgent challenge in the Kavangos.

Further, it is to our knowledge the first study that looks at resource scarcity in a situation where extraction decision and consequences are long term and not short term, like in water extraction or fishing scenarios.

(2) Combining survey data about real world behavior with insights from a behavioral field experiment that represents a comparable situation.

(3) Introducing an experimental scarcity environment and comparing it with an abundance one. Other experimental studies compared either levels of abundance or levels of scarcity but not one competitive environment where resources could be depleted against an uncompetitive one where resources could not be depleted.[10] Consequently, it is not possible to relate effects to different levels of scarcity but in return the effect of competition for resources can be precisely isolated.

(4) Employing a newly designed, dynamic common-pool resource game where social benefits of the forest accrue at the end, which well represents the situation in the given environment, as it incorporates the temporal distance between short term private and long-term social payoffs.[11]

Noteworthy, the observed behavior in the experiment is found to correlate significantly with stated real-life behavior in terms of clearing forest, i.e. farmers who state in the survey to clear more fields in real life also tend to clear more in the common-pool resource game. This allows the assumption that the results from the experiment are externally valid.

The general hypothesis to be tested in the empirical part of this paper is formulated as:

> ***H0:*** *There is no difference in extraction rates from a Common-Pool Resource in a scarce and in an abundant environment*
>
> ***H1:*** *In a scarce environment, extraction rates from a Common-Pool Resource are different from those in an abundant environment*

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[10] Actually Osés-Eraso & Viladrich-Grau (2008) used a scarcity environment that could be depleted, but there was nonetheless no restriction in extractions, but instead the social benefits became negative, if the resource was being overharvested.

[11] Of course, since all payoffs of the game were done on the same day, there is no real delay between private and social benefits, but since the social benefits only happen at the end of each game, there is insecurity about how much forest will be left by the end. This characteristic would not be as relevant if social benefits occurred in every round.

The hypothesis is kept neutral, as no direction of a potential effect could be identified ex-ante.

Following Ostrom's (2007) thoughts on sustainability science, this study may not be understood as providing solutions or definite answers to the questions posed but must be seen as a contribution to literature on the relevant topics. Behavioral findings in particular are sensitive to the environment and situations they were observed in. As possible policy application, results from this study might allow anticipating effects of increasing resource scarcity and help designing adequate policies in response.

Method

The empirical approach of this research is twofold: In the first part findings from the survey are analyzed to disclose farmers' real behavior in the wake of different levels of resource scarcity. The degree of scarcity in a village is assessed in various ways: Firstly, it is assumed that villages along the river show higher degrees of deforestation than villages that are located further inland. This assumption is in line with existing literature and can be confirmed by examining satellite images of the Kavango region (Figure 2). Secondly, survey answers about the state of the forest and the availability of land are analyzed for correlations with individual land use patterns, in particular clearing behavior. While the river vs. inland distinction is a clear and objective one, answers from the survey are as perceived by the respective respondent. We believe that it is interesting to analyze both types of measurements and additionally check for consistency between them.

In the second part results from the common-pool resource experiment are analyzed. They are meant to identify behavioral patterns and isolate the potential behavioral effects induced by scarcity from other non-observable influences that are present in the real world environment.

Sample

In winter 2016 (June – August) explorative interviews and surveys were conducted with Namibian officials, workers from development institutions, traditional authorities and with local farmers in the Kavango region in preparation of the main research. In winter 2017 (May – August) the individual surveys and experiments were conducted in 39 randomly selected rural villages in two Kavango East districts (Kahenge and Kapako) and two Kavango West districts (Mashare and Ndiyona). Two central and partly urban districts in between were left out due to their proximity to the town of Rundu. Preconditions were also that the village had more than 80 inhabitants and was not more than a day's drive away from the nearest tar road. Additionally, the sample was split in two halves in order to get a roughly equal number of villages on both the more densely populated riverside and further inland where forests are still more abundant. The total sample of this study consists of 979 villagers, out of which 252 also participated in the scarcity experiment (126 in each of the two treatments).[12] Socioeconomic characteristics of the whole sample are shown in Table 1. Split samples for river vs. inland as well as the two experimental treatments are reported in Tables 2 and 3.

Procedure

We visited each village's headman several days ahead of the experiments in order to arrange an appointment for a village meeting so that all villagers could be informed and invited. We made it clear beforehand that some monetary compensation would be offered for participating but also that only a certain number of people would be able to take part in what we called "workshops". At the beginning of the village meeting, participants who were willing to participate would be randomly drawn by lot, a process which was mostly perceived as fair by everyone. The same lots also determined the allocation of experimental groups. Our local, trained research assistants then explained the procedure and the instructions of the common-pool resource game, making the rules very clear, also by showing posters and giving examples for different decisions but without valuing or recommending any particular behavior.[13] Special attention was being paid to make it clear that the game is not a "zero sum" situation about dividing the yields, but that cooperating actually increases the total benefits for the group as a whole. Before the game was played and the particular treatment instructions were read, treatment groups were spatially divided to ensure that other group's decisions or their treatment instructions could not influence the outcome. Tests for understanding were carried out with the group and individually. Our assistants also gave additional help and instruction to those who did not understand everything right away and those who needed help with using the tablet computers that were used for decision making. We did however make sure that everybody was fit for the decision making in the real game and did not require assistance once the game started. Hence, all game

[12] All participants took part in economic experiments, but the remaining 727 participants played different games or treatments that were related to another research. These results are not reported here. Answers from the surveys on real world behavior from all participants are however relevant for this study and therefore included in the analysis.

[13] Protocols and instructions were translated by our assistants from English into the respective local languages and then translated back into English by another assistant in order to ensure that all translated instruction were on point. Also, all wordings and phrases used in the instructions were discussed intensively with our local assistants in preparation of the experiment as to make all instructions clear and easily understandable.

decisions could be made by the players individually and anonymously. Before the game started, one trial round was played yet the result from this trial round was not made public.

After finishing the common-pool resource game, individual surveys were conducted with each player. Payments according the participant's and her group members' decisions were done in the very end individually and in private. The whole workshop took about 4-5 hours in each village. Payoffs averaged at 78N$ (~6US$) per participant, which is more than an average local daily wage.

The common-pool resource game

For the experiment a forestry-framed common-pool resource game was designed that resembled decision making about clearing new fields in real life. Participants could earn real money according to their own and their group members' decisions. The experiments are based on the dynamic common-pool resource game described by Hoenow & Kirk (2018) which goes over four rounds: There were always 7 players in a group playing the game together. In each round, players had to decide privately and anonymously whether to clear a new field or to stay on their old one. Decisions were made using tablet computers (Figure 3) and no communication between players was allowed. The socially optimal outcome is reached when everyone decides to stay on their old field. Staying means getting a smaller private yield of one bag, represented by 1N$, from the old field. Individually, one can earn more from clearing new fields as a fresh field yields three and a half bags, represented by 3,50N$ in the game. It is therefore individually optimal to always clear (Nash equilibrium). Each clearing of a new field does however decrease the size of the forest by one parcel. After every round, it was announced how many hectares had been cleared in that round by the group as a whole. It was not revealed who had cleared and who had not. Forest parcels, represented by trees in the poster (Figure 4) were then crossed out so that all players could asses the current stock of the forest at any time. At the end of the game, all players received their benefit from the forest which equals the number of parcels left, i.e. 1N$ per parcel of forest.[14] [15]The game is kept simple by asking players to decide only between the two options "staying" and "clearing" in each round. The accumulated private yields as well as the social benefits that occur at the end add up linearly. Earning are represented with the real dollars as paid after the

[14] Even though some households also sell goods that they collect from the forest, most of the forest goods are for self-consumption and cannot easily be monetarized or the total benefit's value be estimated.

[15] The game design does not incorporate the possibility of decreasing marginal benefits of forest size or a threshold level, at which the forest provides a maximum of social benefits. Any forest stock above such a threshold could be cleared with no or little negative externalities.

game[16] and decisions made with tablet computers where the two options are additionally represented by simple pictures (Figure 3).

Figure 4 illustrates the “abundance” stock of 28 parcels of forest, as played in the first period by all players and in the second period by the participants playing the “abundance” treatment. Due to the total forest stock in the abundance treatment consisting of 28 parcels of trees, there is no competition in resource extraction: Since there are 7 players per group and the game is played over four rounds, the maximum that can be extracted if all players always clear is 4 x 7 = 28 parcels. The forest can therefore only be depleted at the end of the very last round. If at least one player decides to stay in at least one round, there will be forest left at the end. Consequently, no player hast to worry about not being able to clear anymore towards the end of the game. Figure 4 was also used as a poster to reveal the remaining parcels of forest to the group after each round of playing.

The sequence of rounds and treatments is illustrated in Figure 5. After playing the abundance treatment for the first period the game restarted. In the second period the control (abundance) group played the same game again but the scarcity treatment group then faced a reduced resource stock of 14 parcels of forest. Another poster, which looks similar to the one in Figure 4 but shows only 14 trees, was used for the scarcity treatment. By using this treatment design, scarcity effects can be analyzed from two perspectives: Firstly, as a within-subject design where the same player’s change in behavior from “abundance” in period 1 to “scarcity” in period 2 is analyzed. Secondly, as a between-subject design, where players’ behavior in the “scarcity” environment of the second period is compared to the control group, who played another “abundance” environment in the second period. Additionally, a difference-in-differences approach can be applied, in which the changes from Period 1 to Period 2 are compared over the two experimental treatments. Another reason for choosing this design instead of directly starting with the scarcity environment was to indirectly point out the difference between an abundant and a scarce environment: If player of the scarcity treatment had started with the 14 parcels of forest as in period 2 right away, it would not have in the same way been

[16] Payoffs for staying and clearing were set after intensive pre-testing for calibration and allowing a reasonable final compensation for participating. For simplicity, we renounced the possibility of introducing a game currency that must then be converted into real money.

perceived as a scarce environment as they could not have known about the existence of the abundance environment.[17]

I. The Abundance Environment (control treatment)

The Game is framed as a dynamic Common Pool Resource Game where the social benefit occurs at the end. Since there are no discount rates used over the rounds, each decision affects the final private and social outcome equally and the personal payoff can effectively be written for each round individually. The order of decisions does therefore not make any difference in economic terms. They might however play a behavioral role, as in the dynamic game players will learn about the other group members' decision after each round and possibly respond to that by behaving in a certain way in the following rounds.

For the whole game over 4 rounds (r) the total payoff of a player (U) can be written as a function of all decisions made by her and the other players. Her total payoff (U) then equals the sum of the payoffs over all four rounds. Therefore:

$$\bigcup_i \left(c_{i,r}, c_{j,r}\right) = 3,50 * \sum_{r=1}^{4} c_{i,r} + 1 * \sum_{r=1}^{4} \left(1 - c_{i,r}\right) + 1 * \sum_{r=1}^{4} \left(1 - c_{i,r}\right) + 1 * \sum_{r=1}^{4} \left((6 - \sum_{j=1}^{6} c_{j,r}) \right)$$

(Equation 1)
which can be reduced to

$$\bigcup_i \left(c_{i,r}, c_{j,r}\right) = 32 + 1,50 * \sum_{r=1}^{4} c_{i,r} - \sum_{r=1}^{4} \sum_{j=1}^{6} c_{j,r}$$

U_i = total payoff of player *i* in the game

$c_{i,r}$ = decision by player *i* (0 = stay, 1 = clear) in round *r*

$c_{j,r}$ = decisions by other players *j={1,2,3,4,5,6}*, (0 = stay, 1 = clear) in round *r*

r = round = *{1, 2, 3, 4}*

[17] The alternative, to give an explanation to the players in the scarcity treatment that other groups were playing an abundance treatment could possibly have deteriorated results by inducing unwanted behavioral influences, such as the feeling of unfairness or bad luck.

It becomes clear that in each round clearing increases one's individual payoff and also for the whole game it is individually optimal to clear a new field in every round.[18] For the group as a whole however, the total payoffs are maximized when no player clears any new field.

II. The Scarcity Environment

After the end of round four the game restarted. For the second period of the game, the control (abundance) group repeated the same game as in the first period, i.e. starting with a new forest stock of 28 parcels. The scarcity treatment group however started with a reduced stock of only 14 parcels of forest (50% of the control and period 1 stock). The payoffs remained the same: 3.50$ for a freshly cleared field and 1$ for staying on an old field. At the end of round 4 each player receives 1$ for every parcel of forest that is left.

With the reduced "scarcity" stock of 14 parcels, it is possible in the extreme case of all 7 players always clearing that the forest gets depleted by the end of round 2. Consequently, in case there is no forest left, no more clearing is possible but all players receive a yield for staying of 1$ for the remaining rounds of the game. Before playing round 3 and round 4 it can also happen that there are

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[18] Even though the social benefit of the forest is framed in a way that it occurs at the end of the game, the payoff of a player ($\prod$) can also be written for each round individually: Player *i* makes a binary decision in each round to either clear or not clear a new field. Let c_i be 1 when player *i* decides to clear and 0 when she decides to stay. $\sum c_j$ is the sum of clearing by the other players in that round. Then:

$$\prod_i (c_i, c_j) = 3{,}50 * c_i + 1 * (1 - c_i) + 1 * (1 - c_i) + 1 * (6 - \sum_{j=1}^{6} c_j)$$

$$\textit{which can be reduced to}$$

$$\prod_i (c_i, c_j) = 8 + 1{,}50 * c_i - \sum_{j=1}^{6} c_j$$

$\prod_i$ = payoff player i

c_i = decision by player *i* (0 = stay, 1 = clear)

c_j = decisions by other players *j={1,2,3,4,5,6}* (0 = stay, 1 = clear)

It then follows for the payoff over all 4 rounds:

$$\bigcup_i = \sum_{r=1}^{4} \prod_{i,r} (c_{i,r}, c_{j,r}) = 3{,}50 * \sum_{r=1}^{4} c_{i,r} + 1 * \sum_{r=1}^{4} (1 - c_{i,r}) + 1 * \sum_{r=1}^{4} (1 - c_{i,r}) + 1 * \sum_{r=1}^{4} \left((6 - \sum_{j=1}^{6} c_{j,r}) \right)$$

These considerations do however not apply for the scarcity treatment as here the possible decisions in the later rounds depend on all players' previous decisions. The game can therefore not be split up into four equal rounds as it can be in the abundance case.

less than 7 parcels of forest left. If in those rounds more players decide to clear than there are parcels left, the yield for clearing is reduced from 3.50$ to 2$. We set this as a simple rule in order to keep things easy and to avoid calculating with fractional numbers. It should be considered that with a reduced clearing yield of 2$ players should be theoretically indifferent between clearing and staying as 1$ from staying plus 1$ from social benefits that accrues from the spared parcel of forest in the end sums up to the 2$ that can alternatively be earned right away by clearing. This consideration does however not hold due to two reasons: Firstly, no player knows what the other players in her group are going to decide in the current round. Therefore, there is still the possibility of getting 3,50$ and thereby increasing one's payoff by clearing in case the numbers of players clearing does not exceed the numbers of forest parcels left. And secondly, as explained earlier, even if the expected gain from clearing is the reduced 2$, it is conceivable that the forest is entirely taken by the other players instead, leaving no social benefits for anyone in the end.

To sum up, even if a farmer or a group of farmers restrain themselves from excessive clearing, the forest stock could easily be depleted by the other users in the scarce environment. In economic terms, this means the social multiplier of cooperating (i.e. not extracting) is unknown as it depends in the other players' decisions. It could become zero if the spared resources are instead entirely taken by the other players.[19]

Nevertheless, the scarcity treatment does not change the individually or socially optimal decisions in the first two rounds of the game compared to the abundance environment. It remains individually optimal to clear and socially optimal not to clear. This also holds if the forest stock drops below 7 parcels in the later rounds, but then the additional considerations about scarcity come into play. In a first step we therefore compare only the first two rounds of each treatment and analyze endogenous effects of the later rounds in a second step.

In order to avoid last-round effect, players were not told in advance how many periods, i.e. repetitions of the game they were going to play in total. There was indeed a third period of the game played after the end of period 2, but observations from this third period are part of another study, and therefore not discussed here.

Experimental treatment groups

[19] Note that no mathematical equation as in Equation 1 is provided for the scarcity treatment as it would results in too many possible cases once less than seven forest parcels are left.

Note that the two treatments were allocated randomly across all villages. Whether the village was located in a scarce (river) or abundant (inland) area did not play any role for treatment allocation. Hence, there were groups from both, scarce real environments and abundant real environments playing in-game scarcity and in-game abundance treatments.

When separating the sample into the two treatment groups, the majority of average socioeconomic values does not differ significantly from each other (Table 3). A joint Hotelling-test for equality of treatment groups (Test 1) indicates that the allocation of players to abundance and scarcity groups was random. However, a few variables show significant differences between the two treatments according to single Mann-Whitney U-Tests: the number of adult household members ($p < 0.05$), the bags of yield produced ($p < 0.05$), the number of children in the household ($p < 0.1$), the income earned from farming ($p < 0.1$) as well as the cultured area measured in hectares ($p < 0.1$). These differences in treatment allocation must be considered in the analysis.

Results

In the following chapter the survey results are firstly analyzed in order to gain insights about how resource scarcity affects real world behavior. In the second part, experimental results are analyzed and presented.

I. Survey Results

For the analysis of the survey, the frequency of clearing and the size of the area cleared by farming households[20] are used as separate indicators for appropriation of new land. Further key variables to be examined on the dependent side are the total number of hectares cultivated by a farming household, the harvest yield per hectare and a dummy for recently leaving fields fallow. The key variables that are used to measure scarcity, and thereby aim to explain differences in behavior, are: (1) whether the village is located at the river or inland, (2) whether land is perceived as sufficient for all villagers by the interviewee, (3) whether the acquisition of land is perceived as rivalrous, and (4) whether the

[20] We had to refrain from the prospect of creating a full panel dataset about both clearing and size of cleared area based entirely on the memory of our respondents. Each survey contained a lot of questions about the respective experiment, socioeconomics, context, environment perception as well as agricultural practices and took about 20-30 minutes per respondent. While the frequency of clearing counts how many times a household has cleared a new field since the year 2000, the area cleared refers to the size of the last clearing action in hectares. During extensive pre-tests in the field it became clear that asking about the field sizes cleared in each single year since 2000 would not have generated reliable, precise data.

interviewee believes that the forest will still be there and roughly the same size in 10 years from the point of the surveys conducted. The following statements and their significance are based on the results of Mann-Whitney U-Tests for ratio-scaled variables and Chi2-Tests for binary categorical variables.

Preliminary findings show that:

(1) Location

Individuals who live along the river clear less often und cultivate fewer hectares than those who live inland (Table 5). The average size of parcels cleared does not seem to depend on the location.

(2) Individual perception of available land being sufficient

Individuals, who perceive land as sufficient for everyone, clear more often and larger parcels of forest than those who perceive land as scarce (Table 6). There is no correlation with the total hectares cultivated per household.

(3) Individual perception of land acquisition being rivalrous

Individuals, who perceive land acquisition as rivalrous, clear less often and clear smaller parcels of forest than those who perceive acquisition as non-rivalrous (Table 7). There is again no correlation with the total hectares cultivated per household.

(4) Individual perception of the future of the forest being safe

Individuals, who perceive the future of the forest as safe and expect it not be overly degraded in the following 10 years, show no difference in clearing frequency or size, but cultivate more hectares than those who perceive the forest's future as unsafe. Also, they more often leave fields fallow (Table 8).

(5) Use of forest

No differences in use of forest benefits are found between river and inland locations. Villagers state that forest provide them with a range of benefits, primarily fruits (91,4%), timber (91,3%), firewood (83,6%), but also grazing area for their animals (65,2%) as well as further benefits like collecting herbs and hunting animals. More than a quarter (26,3%) of respondents also sell forest products for profit.

(6) Land use intensity and fertilizer use

Land use intensity measured as yields per hectare does not seem to be related to any of the variables that were examined to measure scarcity. It could have been expected that a possible response to scarcity of land is an intensification of agriculture, yet the data at hand does not say so (Tables 5, 6, 7 & 8). Yields per hectare are positively correlated with the use of (mineral) fertilizer (Test 2). However only n=67, which is roughly 7% of farmers in the sample use them. From qualitative survey answers, it became clear that the acquisition and use of mineral fertilizers in Kavango is impeded, mostly by high prices, limited knowledge on appliance and extension services as well as insufficient means of transportation. This is also reflected by the fact that fertilizers are much more likely to be used by richer farmers who run larger farms and produce more yields. Further research whether stimuli and support in increasing fertilizer use could decrease clearing of forests is advised.

(7) Leaving fields fallow

Almost half of the farming households left at least one of their fields fallow in the last 5 years. Those who perceive the future of the forest as safe, do more often leave fields fallow on average. The decision to do so does however not show a correlation with any of the other scarcity variables (Tables 5, 6, 7 & 8).

(8) Domestic migration

Farmers who have moved to the village less than 20 years before tend to clear more often than those who were born in the same village or have lived there for more than 20 years. They also tend to be younger, but apart from that do not differ in socioeconomic characteristics (Table 9). Farmers who have migrated more recently (less than 5 years before) cultivate more land on average, but no significant differences in clearing behavior could be found. The share of villagers who have migrated[21] to the place is much higher in inland villages (38%) than at the river (10%). This confirms that the hinterland Kavango has only recently been populated., as stated in the literature. The slight differences in clearing frequency and size of land cultivated do however disappear when testing the River and Inland sample separately. Thus, the correlations found in the first place are due to migrants being more likely to populate the more resource abundant inland. Controlling for the location in a multivariate regression (Reg.Table 1) confirms that migrants do not per se take more land than village natives. It can however be interpreted that areas with abundant forest stocks are preferred destinations for migration. This is supported by 47,3% of those who are not villages natives stating that better farming conditions were the reason for moving to the current place.

[21] Migrants, if not otherwise indicated refers to individuals who have come to a place less than 20 years before.

(9) Location of perception of scarcity

According to the villagers' perceptions as stated in the survey, forests are scarcer at the riverside than inland. This firstly demonstrates in land being significantly more often perceived as sufficient if the village is located inland ($p < 0.01$). Secondly, in rivalry in acquisition of new land being more likely to be found at the river ($p < 0.1$). And thirdly, in the perception that the forest will be safe for the future being more often found at inland locations ($p < 0.01$). These findings and p-values were derived using Chi2-tests for categorical variables (Tests 3,4 & 5) and are important for the analysis as they confirm the essential assumption about elevated levels of forest scarcity in villages near the Okavango River. In all villages that were visited there was still forest area left, which means that even if clearing rates are lower in scarce areas it was not due to sheer unavailability. In the worst case, in villages in densely-populated areas near the town of Rundu, the forest frontier has been driven few kilometers away from the center of the village by the time our research took place. This still leaves the possibility of reduced clearing rates being a consequence of institutional regulations within the village. It seems plausible that such regulations are more likely to be introduced in areas where scarcity and depletion are a real threat.

(10) Rules about clearing forest

Indeed, 59,7% of respondents stated that rules about clearing forest were established in their villages. This answer correlates positively with the statement that rivalry emerged during acquisition of new land ($p < 0.1$) and negatively with the perception of land being sufficient ($p < 0.05$). Rules about clearing are also more likely to be found in villages at the river, namely 56,9% in inland villages vs. 62,4% at the river ($p < 0.1$) (Tests 6, 7, 8 & 9). On the outcome side, results show that the presence of rules about clearing forest for conversion into agricultural land significantly reduces the frequency of clearing and the total of hectares cultivated per farming household (Tests 10, 11 & 12). Also, there are way more farmers who stated they had been denied clearing by the given institutions, mostly the headman in their village, at least once in places where clearing rules are established (Test 13). The average parcel size when clearing does however not appear to be affected by such rules (Test 11). To conclude, institutional regulations about clearing are more likely to be found in scarce areas and, if introduced, they are significantly negatively correlated with the frequency of clearing and the size of the total cultivated area.

The presence of rules about clearing in places of resource scarcity and their apparently negative impact on clearing behavior is of great relevance for interpreting the survey results. Descriptive and inductive results from single tests presented above might not be able to distinguish between behavioral effects that originate from scarcity and non-behavioral effects originating from such institutional regulations.

We therefore employ three different methods in order to shed light on whether the results found are due to behavioral response or institutional regulations or both: Firstly, we re-test clearing behavior but only with a reduced subsample that excludes all individuals affected by clearing rules. Secondly, we estimate multivariate regression models that include both, the scarcity environment and the institutional regulations as explanatory variables. And thirdly, the Common-Pool resource experiment is supposed to expose the behavioral response and separate it from all other potential influences (see subchapter II. Experimental Results).

The sample is now reduced to only those who are not affected by institutional rules set about clearing forest. There remain n= 395 observations (40,3% of original sample). The tests (Tables 10, 11, 12 & 13) do indeed show that in the absence of rules the difference in clearing frequency and cultivated hectares if even larger between river and inland than it is for the whole sample. This confirms that scarcity has an effect on resource extraction that is not induced by institutional regulations.

Next, multivariate regression models are estimated with three main variables that represent clearing behavior: clearing frequency, clearing size and hectares cultivated, on the endogenous side. Results from the regression tables (Reg.Table 1, first column) for clearing frequency confirm that both, the River variable and the clearing rules are highly significant with a negative coefficient. Further, the variable for land being perceived as sufficient has a strong positive correlation with clearing frequency. The same applies for tenure security and farming as main profession. Socioeconomic characteristics like age, gender, education and wealth do not seem to play a very important role. The regression results also confirm that being a migrant does not have an impact on clearing frequency

Regression Table 1

	freq1 b/p	size1 b/p	hectares1 b/p
River	-0.232***	0.041	-0.500***
	(0.00)	(0.73)	(0.00)
Land_sufficient	0.206***	0.392***	0.011
	(0.00)	(0.00)	(0.95)
Land_rivalry	-0.068	-0.318**	0.310*
	(0.28)	(0.04)	(0.10)
Forest_safefuture	-0.051	0.334**	0.384**
	(0.39)	(0.02)	(0.02)
Clearing_rules	-0.166***	0.220*	-0.140
	(0.01)	(0.06)	(0.34)
Tenure_safety	0.134***	0.637***	0.093
	(0.00)	(0.00)	(0.46)
Adults_in_hh	0.040***	0.103***	0.128***
	(0.00)	(0.00)	(0.00)
Assets_Index	0.015	0.017	0.044
	(0.54)	(0.69)	(0.35)
Farmer	0.604***	0.642***	0.905***
	(0.00)	(0.00)	(0.00)
Cattle_owned	-0.000	-0.001***	0.004***
	(0.83)	(0.00)	(0.00)
Bags_farming_yield	0.002	0.019***	0.045***
	(0.31)	(0.00)	(0.00)
Migrant	0.052	0.154	-0.184
	(0.49)	(0.32)	(0.29)
_cons	-0.291*	-2.639***	0.576
	(0.09)	(0.00)	(0.37)
F	11.683	13.479	49.586
r2	0.115	0.165	0.233
N	922.000	857.000	911.000

* p<0.10, ** p<0.05, *** p<0.01

The regression table for parcel size cleared (Reg.Table 1, second column) confirms the previously conducted single tests by finding no effect of location, whereas perceived sufficiency of land does significantly increase the parcel size cleared. Surprisingly, a positive correlation with clearing rules is found, albeit only at $p < 0.1$. The coefficient for being a migrant is again insignificant.

The regression table for total hectares (Reg.Table 1, third column) cultivated as dependent variable also confirms the negative effect of the location at the river. There is no significant effect of clearing rules present here. Again, there is no significance found for the migration dummy.

In all three regression models, multicollinearity of explanatory variables, for example between location and rules established, does not appear to be a problem according to variance inflation factors tests for the independent variables. Homoskedasticity in error terms is however not always found, which should to some degree be countered by including robust standard errors in all models.

Overall the results from the survey clearly point towards reduced clearing and smaller areas of cultivated land per household in the presence of scarcity. While one has to be careful about the interpretation of results from single tests, further splitting of the sample and estimating multivariate regression models showed that reduced clearing in the presence of scarcity is not just a consequence of established institutional regulations. It is nonetheless an important finding that such institutions tend to be introduced in areas of increasing scarcity and that they effectively reduce average frequencies of clearing forest. Another relevant, albeit not overly surprising, finding is that migrants are more attracted to resource abundant areas, in this case inland Kavango. There, extraction rates are higher, but results reveal this as a consequence of abundant stocks and not caused by individually different clearing behavior of migrants.

II. Experimental Results

Since background conditions in all villages are somewhat different and the decision about clearing forest may depend on many factors, survey results are complemented by the experiment in order to isolate the behavioral response to scarcity. As discussed in the previous chapter about the survey findings, institutional regulations on village level that depend in the degree of scarcity are a major concern for identifying and clearly separating scarcity effects.

Amongst the main concerns are institutional regulations on village level that depend on the degree of scarcity and affect clearing behavior, as discussed in the previous chapter using findings from the survey. Also, we have argued that forest is a resource where a reduction in stock does not make finding more of the resource much more difficult. This at least appears plausible on the local village level and as long as there is some forest left. Even so, the possibility that an increasing distance of the farms to the next suitable parcel of forest affects clearing decisions cannot be entirely dismissed. Furthermore, other non-observed factors, such as variations in soil or forest quality, might play a role and have not been accounted for. Next to institutional regulations about clearing there could also be informal rules. Such informal rules could on the other hand also be interpreted as social norms and therefore as behavioral. The experimental approach therefore complements the survey findings with the purpose of addressing the aforementioned reservations.

Figure 6 illustrates results from the experiment in both periods over the two treatments. The values shown are average clearings per player in the first two rounds of each period. Noteworthy, there is no initial difference in average clearing between the two treatment groups in the first period, when all players are confronted with the abundance environment[22]. This is important as it shows that the two subsamples do not start differently, which facilitates interpretations in the following analysis.

Firstly, results from the within-subject perspective are presented by testing individual clearing in the first two round of period 1 against clearing in the first two round of period 2. As illustrated in Figure 6, there is a reduction in clearing from period 1 to period 2 from 1.036 to 0.929 parcels in the control group, who played the abundance environment in both periods. The difference is slightly significant according to a nonparametric Wilcoxon signed-rank test at $p < 0.1$ (Test 14). In the treatment group, who played the scarcity environment for period 2, average clearing decreased from 1.009 to 0.687. The difference is highly significant according to the Wilcoxon signed-rank test at $p < 0.01$ (Test 15).

Secondly, differences in clearing in period 2 are to be tested between subjects. It turns out that players who played the abundance environment clear on average 0.929 parcels whereas players in the scarcity environment clear 0.687 parcels. The difference is significant according to a Mann-Whitney U-test at $p < 0.05$ (Test 16).

As a third measure, the differences in changes from period 1 to period 2 can be compared across the two treatments. This makes a reasonable addition because clearing rates also decreased in the control treatment from period 1 to period 2. There is no self-evident explanation for this, but it can be hypothesized that the reduction in clearing might be attributable to a learning- or restart-effect that occurs when the game is repeated. Considering that such an effect has also taken place in the scarcity treatment subgroup, it should not be falsely attributed to the treatment effect. By comparing only the differences in changes instead of the absolute clearing averages, the decrease observed in the control group is compensated. Further, this approach should also be less sensitive to differences in initial behavior in the first period. In fact, results here likewise state that the reduction of clearing rates from the abundance to the scarcity treatment is significantly greater than in the control group at $p < 0.01$, (Test 17).

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[22] No difference between clearing in Period 1 was found across the two treatments according to a Mann-Whitney U-test. In order to keep results comparable, values refer to the first two rounds only in all periods and treatments (Test 18).

Regression Table 2

	rP2_R12a	rP2_R12b	rP2_R12c	rP2_R12d	rP2_R12e
	b/p	b/p	b/p	b/p	b/p
Scarcity	-0.242**	-0.234**	-0.226**	-0.176*	-0.199**
	(0.03)	(0.03)	(0.04)	(0.10)	(0.01)
Adults_in_hh		0.032	0.034	0.041*	0.014
		(0.22)	(0.20)	(0.07)	(0.31)
Kids_in_hh		-0.037**	-0.040**	-0.041**	-0.026*
		(0.04)	(0.03)	(0.02)	(0.06)
Bags_farming_yield		-0.002	-0.002	-0.004	-0.002
		(0.37)	(0.38)	(0.15)	(0.16)
Income_farming			0.000	0.000	-0.000
			(0.93)	(0.71)	(0.27)
Hectares_cultivated			-0.005	-0.020	0.004
			(0.78)	(0.31)	(0.79)
Age				0.005	0.007*
				(0.33)	(0.06)
Female				-0.022	0.039
				(0.85)	(0.66)
Schooling_years				-0.015	0.008
				(0.34)	(0.45)
Head_of_hh				0.315**	0.151
				(0.02)	(0.14)
Farmer				0.168	0.248*
				(0.36)	(0.10)
Cattle_owned				0.004*	0.003
				(0.06)	(0.10)
Migrant				-0.015	-0.037
				(0.91)	(0.74)
Clearing_rules				-0.037	-0.073
				(0.73)	(0.36)
Land_sufficient				-0.085	-0.060
				(0.54)	(0.50)
Land_rivalry				-0.262**	-0.146
				(0.04)	(0.11)
Cleared_frequency				0.028	-0.026
				(0.64)	(0.70)
Cut_S1_R4_mi					0.019**
					(0.04)
Cleared Period 1					0.357***
					(0.00)
River					0.052
					(0.55)
_cons	0.929***	0.977***	0.978***	0.707**	-0.441
	(0.00)	(0.00)	(0.00)	(0.03)	(0.12)
F	5.086	2.700	1.841	3.602	27.681
r2	0.022	0.042	0.044	0.173	0.559
N	227.000	227.000	225.000	225.000	225.000

* p<0.10, ** p<0.05, *** p<0.01

In theory, the random treatment allocation would make further analysis and controlling for additional influences redundant, as a truly random distribution of participants and their characteristics would in a sufficiently large sample allow any effect found to be clearly attributable to the treatment. Since our sample is not very large (n = 252) and there were already some differences in socioeconomic characteristics found across the two treatments, additional multivariate regression analyses are conducted to control for such heterogeneities. Also, analyzing whether socioeconomic and other variables show any correlations with experimental clearing decisions might lead to useful behavioral insights. It will be particularly interesting to investigate if experienced real scarcity has an effect on behavior in the game.

Regression results are presented in Regression Table 2. Most importantly, the coefficient for the dummy for the scarcity treatment remains negative and significant for most models. According to the coefficient, the scarcity treatment leads to a reduction in clearing between 0.176 (model 4) and 0.243 (model 1) parcels on average in the first two rounds, which can be interpreted roughly as a 10% reduction per round compared to the abundance treatment. In the second model all variables that were found to differ between the two treatment groups were added to control for heterogeneities and exclude the possibility of confounding treatment with sampling effects. It turns out that no variable except for the number of children in a household correlates significantly with game decisions on clearing. There is no apparent explanation for why the number of children could have a negative impact on game decisions, especially since no other socioeconomic variable, such as age, gender or education, seems to be consistently correlated. The inclusion of number of children into the model does however not affect the coefficient and significance of the treatment variable and can therefore be considered unproblematic. In model 5 the player's decisions from the previous period as well the clearing of the other group members are added as explanatory variables. By doing so the coefficient of determination becomes much larger, while the coefficient of the treatment dummy does not change much. The location of the village, i.e. the level of real-world scarcity, as experienced by players, does not affect decisions in the experiment. Similarly, all measures of perceived scarcity as well as real-world established rules about clearing do not show any influence.

To sum up, it turns out that experimental results are indeed in line with findings from the survey and show that extraction is significantly lower in the scarcity environment compared to the abundance environment. This applies for both the within- and the between subject perspective. The results surprisingly contrast recent field-experimental findings from Gatiso et al. (2015) and Blanco et al. (2015) and are more in line with older classroom experiments by Rutte et al. (1987) as well as Osés-Eraso et al. (2007) and Osés-Eraso & Viladrich-Grau (2008). The experimental nature of the results therefore supports the idea that reduced extraction rates under scarcity are not only a result of non-availability or institutional regulations, but an actual behavioral pattern. An interpretation attempt could attribute this difference in behavior to the users' concern for the survival of the resource. A more economic approach might be able to explain this by non-linearity of forest benefits: A large forest might still yield sufficient benefits even if parts of it are cleared. If there is less forest left however, further clearing has a more substantial negative impact on the benefits that the remaining forest can generate. In such a situation there would be diminishing marginal social benefits from forest. Forest and land users might intuitively or deliberately take this into account when making their clearing decisions. Such individual decisions are further supported by institutional regulations being more likely to be found in scarce areas. Notably, diminishing social benefits of the forest resource were not incorporated in our experimental design. Finding reduced extraction rates under scarcity in the experimental setting would therefore conflict with this reasoning on a strongly rational level. A possible reconciling explanation could be found in presuming that participants bring considerations from the real world into the game, even though they do not apply there. However, in the survey no differences in forest use or benefits could be found between scarcer river and more abundant inland locations. An alternative qualified explanation for the present findings is given by Kramer (1989) who suggests that a group facing a common, externally induced threat or challenge, such as scarcity, might be more inclined to cooperate due to increased group identification and social cohesion.

Conclusion

The findings show that scarcity of resources does not speed up individual extraction rates in the given setting. On the contrary, individuals clear more fields where forest stocks are abundant. These results can be policy relevant when considering conservation measures. They show that such policies should not neglect resources or areas that appear abundant and imply the total conservation effect might be greater when targeting abundant stocks or zones first. Furthermore, abundant resource stocks are more likely to attract additional users than scarce areas, as also shown by the survey findings. The more cautious extraction in scarce environment as found in the survey could also be explained by nonlinear social benefits of the resource.

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Figures

Fig. 1: The Kavango area in Namibia

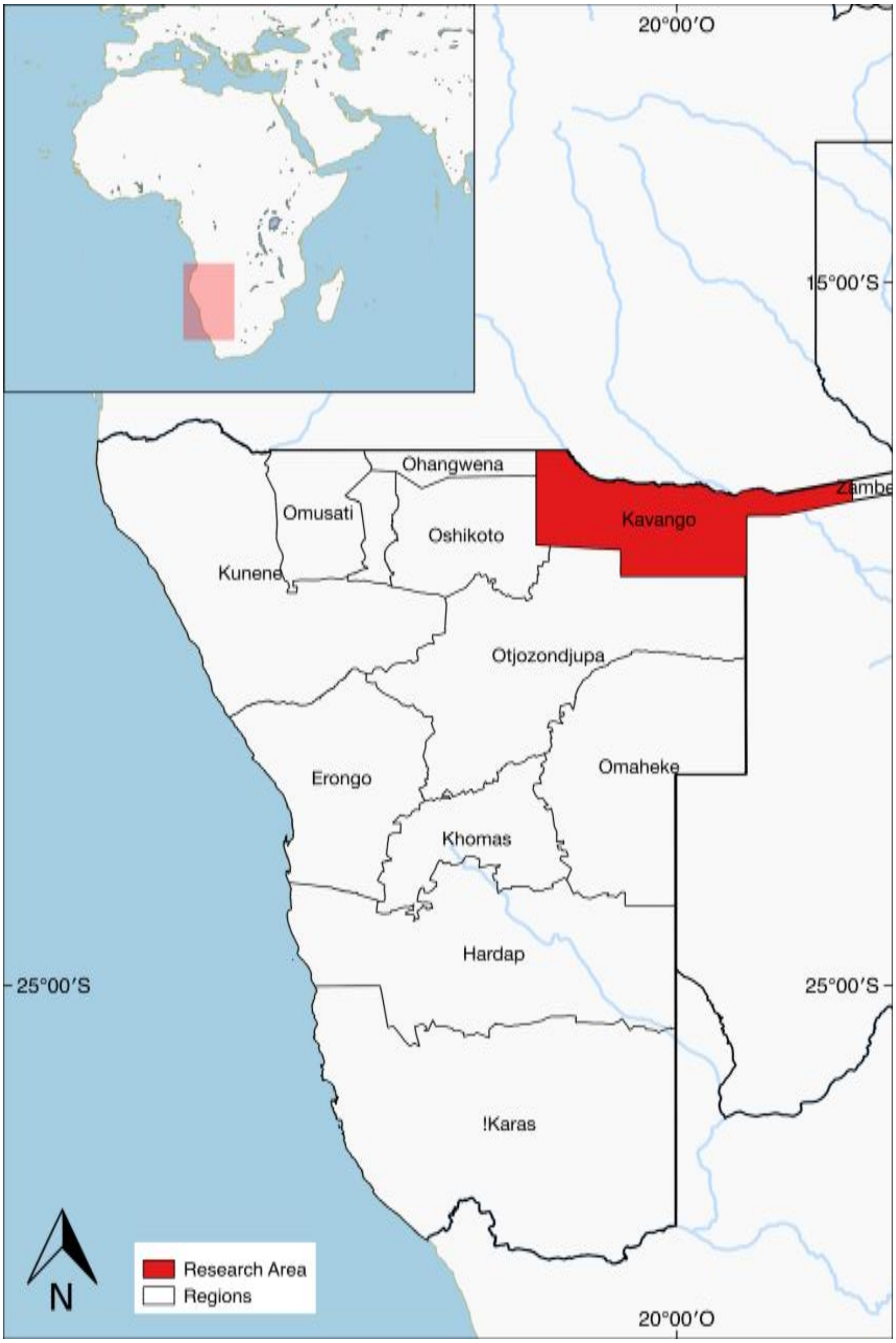


Fig. 2: Satellite Image of Kavango Region, source: google maps 2018

Fig. 3: Tablet computer screen for making decision about staying or clearing

Fig. 4: Poster showing 28 parcels of forest

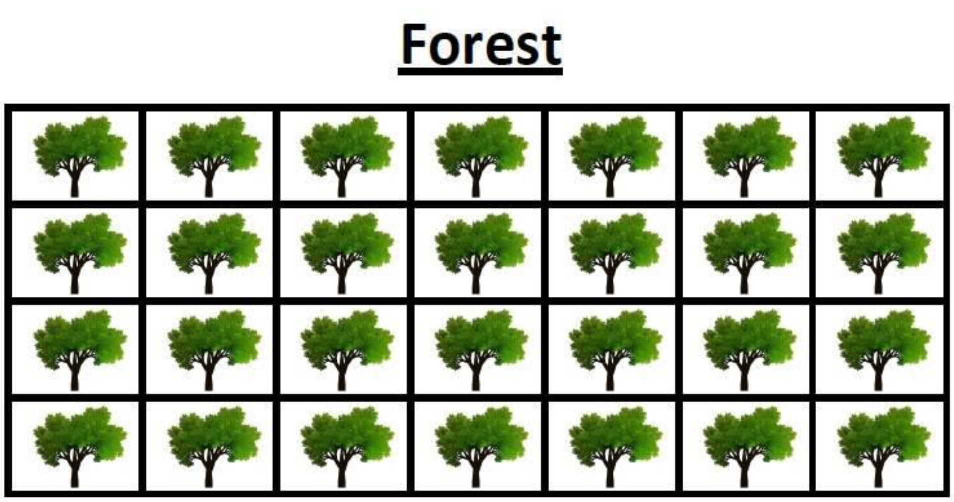
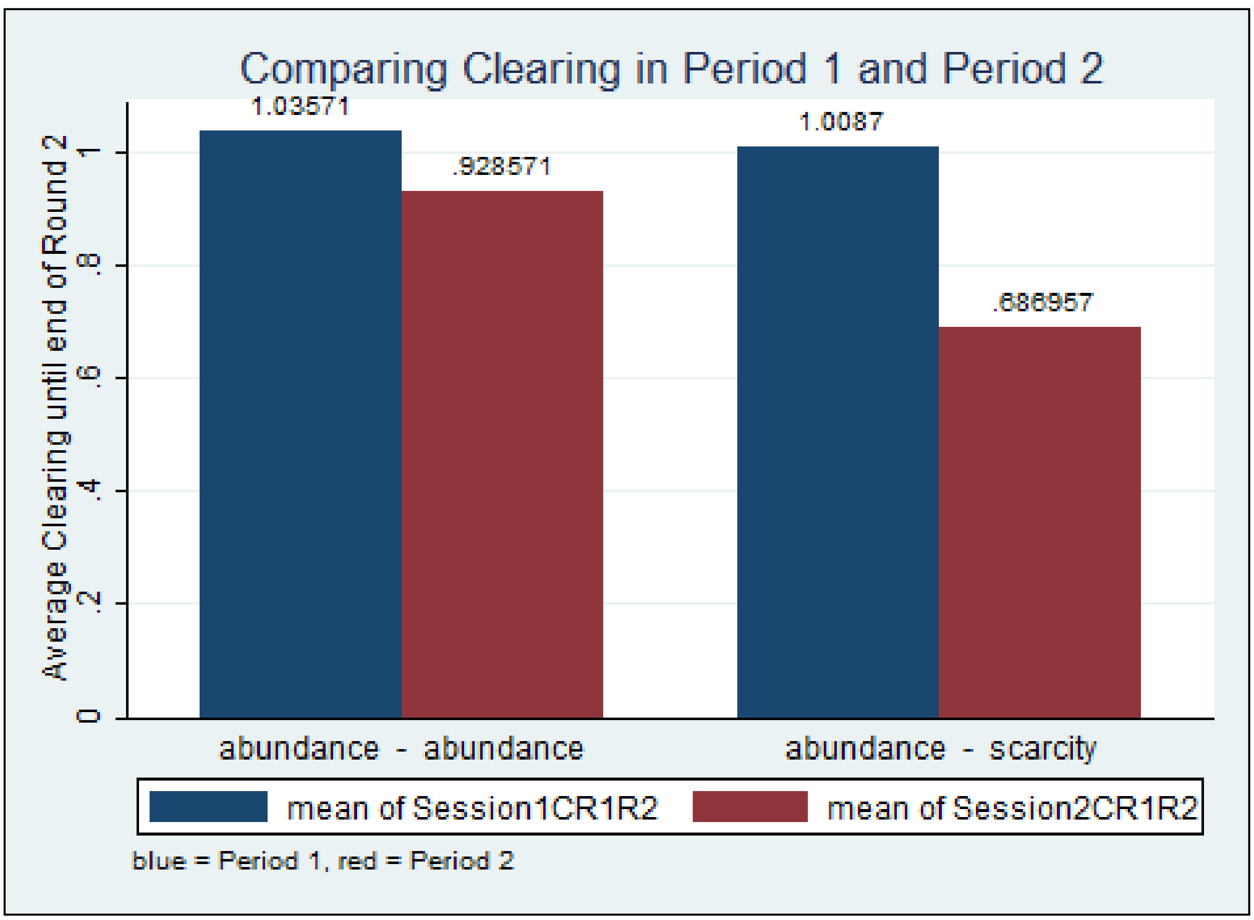


Fig. 5: Game and Treatment Design

Period	Rounds	Control group "abundance"	Treatment group "scarcity"
Period 1	Round 1 Round 2 Round 3 Round 4	Abundance (28)	Abundance (28)
Period 2	Round 1 Round 2 Round 3 Round 4	Abundance (28)	Scarcity (14)

Fig. 6: Experiment Results



Tables

Table 1: Variables overview and averages

	variable mean	sd	min	max
Age	38.37	14.55	17	92
Female	0.59	binary	0	1
Schooling_years	6.27	3.86	0	19
Head_of_hh	0.44	binary	0	1
Adults_in_hh	4.03	2.75	0	23
Kids_in_hh	4.04	2.83	0	20
Assets_Index	1.84	1.36	0	8
Bags_farming_yield	10.18	15.46	0	203
Income_farming	467.21	1825.39	0	25000
Cattle_owned	14.11	98.99	0	3000
Hectares_cultivated	2.70	2.43	0	20
Hectares_cleared	1.42	2.33	0	40
Farmer	0.91	binary	0	1
Cleared_frequency	0.87	0.91	0	11
Migrant	0.24	binary	0	1
Tenure_safety	3.62	0.67	0	4
Land_rivalry	0.30	binary	0	1
Land_sufficient	0.73	binary	0	1
Yield_per_ha	4.47	5.55	0	60
Forest_profit	0.26	binary	0	1
Forest_safefuture	0.30	binary	0	1
Observations	979			

Table 2: Sample split River/Inland and differences

	river mean	sd	inland mean	sd	difference	p
Age	37.81	14.10	38.91	14.96	1.10	0.3484
Female	0.61	binary	0.57	binary	-0.04	0.175
Schooling_years	6.96	3.75	5.60	3.84	-1.36***	0.0000
Head_of_hh	0.42	binary	0.45	binary	0.03	0.351
Adults_in_hh	4.09	2.80	3.98	2.70	-0.11	0.4974
Kids_in_hh	4.03	2.82	4.05	2.85	0.03	0.7070
Assets_Index	1.94	1.46	1.75	1.24	-0.19	0.1637
Bags_farming_yield	8.84	14.55	11.37	16.14	2.53***	0.0010
Income_farming	393.56	1733.12	532.70	1903.08	139.14**	0.0163
Cattle_owned	10.63	29.86	17.50	135.78	6.87**	0.0152
Hectares_cultivated	2.41	2.24	2.98	2.58	0.57***	0.0000
Hectares_cleared	1.41	2.66	1.43	1.97	0.03	0.2891
Farmer	0.90	binary	0.92	binary	0.02	0.293
Cleared_frequency	0.73	0.64	1.00	1.10	0.27***	0.0001
Migrant	0.10	binary	0.38	binary	0.28***	0.000
Tenure_safety	3.60	0.71	3.65	0.64	0.05	0.740
Land_rivalry	0.33	binary	0.28	binary	-0.05*	0.065
Land_sufficient	0.69	binary	0.77	binary	0.08**	0.003
Yield_per_ha	4.43	5.71	4.51	5.40	0.08	0.3921
Forest_profit	0.25	binary	0.27	binary	0.02	0.510
Forest_safefuture	0.25	binary	0.36	binary	0.11***	0.000
Observations	482		497		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 3: Sample split experimental treatments and differences

	abundance mean	sd	scarcity mean	sd	difference	p
Age	40.54	14.94	37.52	13.61	3.02	0.1451
Female	0.64	binary	0.57	binary	0.07	0.246
Schooling_years	5.79	4.08	6.44	3.83	-0.65	0.1769
Head_of_hh	0.46	binary	0.37	binary	0.10	0.125
Adults_in_hh	4.00	3.01	3.29	2.22	0.71**	0.0252
Kids_in_hh	4.35	3.15	3.83	3.01	0.52*	0.0899
Assets_Index	1.97	1.47	1.62	1.33	0.35	0.1105
Bags_farming_yield	10.79	12.38	9.58	18.50	1.21**	0.0130
Income_farming	367.78	1017.15	256.00	1045.53	111.78*	0.0533
Cattle_owned	12.67	21.58	11.74	28.19	0.93	0.3973
Hectares_cultivated	2.64	1.62	2.87	3.15	-0.22*	0.0703
Hectares_cleared	1.48	1.55	1.89	2.80	-0.41	0.4772
Farmer	0.93	binary	0.91	binary	0.02	0.641
Cleared_frequency	0.93	0.82	1.01	1.09	-0.08	0.6487
Migrant	0.21	binary	0.25	binary	-0.03	0.549
Tenure_safety	3.60	0.65	3.68	0.55	-0.09	0.728
Land_rivalry	0.31	binary	0.24	binary	0.07	0.204
Land_sufficient	0.77	binary	0.82	binary	-0.05	0.350
Yield_per_ha	4.61	4.71	3.87	3.45	0.74	0.1076
Forest_profit	0.41	binary	0.38	binary	0.03	0.607
Forest_safefuture	0.34	binary	0.38	binary	-0.04	0.512
Observations	126		126		252	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 5: Sample split River/Inland and differences

	Village at river mean	sd	village inland mean	sd	Diff	p
Cleared_frequency	0.73	0.64	1.00	1.10	0.27***	0.0001
Hectares_cleared	1.41	2.66	1.43	1.97	0.03	0.2891
Hectares_cultivated	2.41	2.24	2.98	2.58	0.57***	0.0000
Yield_per_ha	4.43	5.71	4.51	5.40	0.08	0.3921
Field_fallow	0.47	binary	0.44	binary	-0.03	0.309
Observations	482		497		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
 * significant at p<0.1
 ** significant at p<0.05
 *** significant at p<0.01

Table 6: Sample split Land sufficient and differences

	Land sufficient perceived mean	sd	Land sufficient not perceived mean	sd	Diff	p
Cleared_frequency	0.95	0.98	0.65	0.66	-0.30***	0.0000
Hectares_cleared	1.57	2.08	1.03	2.86	-0.54***	0.0000
Hectares_cultivated	2.74	2.46	2.58	2.36	-0.16	0.1547
Yield_per_ha	4.56	5.76	4.21	4.88	-0.35	0.3444
Field_fallow	0.47	binary	0.43	binary	-0.04	0.305
Observations	716		263		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
 * significant at p<0.1
 ** significant at p<0.05
 *** significant at p<0.01

Table 7: Sample split Rivalry and differences

	Rivalry in acquisition perceived mean	sd	Rivalry in acquisition not perceived mean	sd	Diff	p
Cleared_frequency	0.76	0.81	0.91	0.95	0.15***	0.0069
Hectares_cleared	1.05	2.32	1.59	2.32	0.54***	0.0000
Hectares_cultivated	2.84	2.75	2.64	2.28	-0.20	0.5260
Yield_per_ha	4.45	5.59	4.48	5.53	0.03	0.9029
Field_fallow	0.48	binary	0.44	binary	-0.04	0.268
Observations	298		681		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
 * significant at p<0.1
 ** significant at p<0.05
 *** significant at p<0.01

Table 8: Sample split Forest Future and differences

	Future of forest Perceived as safe mean	sd	Future of forest perceived as unsafe mean	sd	Diff	p
Cleared_frequency	0.86	0.78	0.87	0.97	0.01	0.6072
Hectares_cleared	1.78	3.39	1.25	1.59	-0.53	0.2188
Hectares_cultivated	3.05	2.77	2.55	2.26	-0.51***	0.0004
Yield_per_ha	4.13	4.95	4.63	5.80	0.50	0.1450
Field_fallow	0.51	binary	0.43	binary	-0.07**	0.037
Observations	298		681		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 9: Sample split Migration and differences

	Migrant mean	sd	Village Native mean	sd	Diff	p
River	0.21	binary	0.58	binary	0.38***	0.000
Age	36.29	14.60	39.04	14.48	2.75***	0.0043
Female	0.57	binary	0.60	binary	0.03	0.455
Schooling_years	5.88	4.14	6.39	3.76	0.51*	0.0554
Head_of_hh	0.41	binary	0.44	binary	0.03	0.419
Adults_in_hh	4.00	2.66	4.05	2.78	0.05	0.8765
Kids_in_hh	3.74	2.60	4.14	2.90	0.39	0.1001
Assets_Index	1.77	1.17	1.87	1.41	0.10	0.6301
Bags_farming_yield	10.32	19.09	10.14	14.12	-0.18	0.4471
Income_farming	298.66	1142.22	520.98	1992.41	222.32	0.2041
Cattle_owned	24.07	195.51	10.93	26.80	-13.14	0.6744
Farmer	0.89	binary	0.92	binary	0.02	0.270
Tenure_safety	3.68	0.66	3.60	0.68	-0.08	0.0228
Land_rivalry	0.26	binary	0.32	binary	0.06*	0.071
Land_sufficient	0.74	binary	0.73	binary	-0.01	0.653
Yield_per_ha	4.17	4.38	4.56	5.87	0.39	0.7692
Forest_profit	0.21	binary	0.28	binary	0.07**	0.025
Forest_safefuture	0.30	binary	0.30	binary	0.00	0.982
Cleared_frequency	0.97	0.92	0.83	0.91	-0.14**	0.0144
Hectares_cleared	1.65	3.26	1.35	1.94	-0.30	0.1040
Hectares_cultivated	2.70	2.67	2.70	2.35	-0.00	0.5916
Field_fallow	0.41	binary	0.47	binary	0.07*	0.067
Observations	237		742		979	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 10: Sample split River/Inland and differences, without clearing rules

	River		Inland		(3)	
	mean	sd	mean	sd	b	t
Cleared_frequency	0.78	0.64	1.19	1.16	0.41***	(4.21)
Hectares_cleared	1.40	3.26	1.47	1.63	0.07	(0.29)
Hectares_cultivated	2.54	2.52	3.18	2.44	0.64*	(2.55)
Yield_per_ha	4.21	5.10	4.50	4.71	0.28	(0.54)
Field_fallow	0.50	0.50	0.45	0.50	-0.05	(-0.96)
Observations	181		214		395	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 11: Sample split Land sufficient and differences, without clearing rules

	Land perceived As sufficient		Land not perceived as sufficient		)	
	mean	sd	mean	sd	b	t
Cleared_frequency	1.10	1.03	0.69	0.71	-0.41***	(-3.53)
Hectares_cleared	1.51	1.61	1.21	4.31	-0.31	(-1.01)
Hectares_cultivated	2.94	2.61	2.72	2.09	-0.21	(-0.71)
Yield_per_ha	4.33	4.50	4.54	6.04	0.21	(0.34)
Field_fallow	0.51	0.50	0.33	0.47	-0.18**	(-3.11)
Observations	304		91		395	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 12: Sample split Rivalry and differences, without clearing rules

	(1)		(2)		(3)	
	mean	sd	mean	sd	b	t
Cleared_frequency	0.80	0.68	1.08	1.06	0.28*	(2.51)
Hectares_cleared	0.86	1.49	1.66	2.77	0.81**	(2.83)
Hectares_cultivated	3.18	2.91	2.78	2.32	-0.40	(-1.42)
Yield_per_ha	3.86	3.47	4.56	5.30	0.70	(1.21)
Field_fallow	0.49	0.50	0.47	0.50	-0.02	(-0.37)
Observations	107		288		395	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Table 13: Sample split Forest Future and differences, without clearing rules

	(1)		(2)		(3)	
	mean	sd	mean	sd	b	t
Cleared_frequency	1.08	0.84	0.97	1.04	-0.11	(-1.03)
Hectares_cleared	1.63	3.80	1.35	1.53	-0.28	(-1.03)
Hectares_cultivated	3.03	2.18	2.82	2.64	-0.20	(-0.76)
Yield_per_ha	4.33	4.82	4.40	4.92	0.07	(0.13)
Field_fallow	0.47	0.50	0.47	0.50	0.00	(0.06)
Observations	128		267		395	

P value for Mann-Whitney U-test or Chi2 test in case variable is binary
* significant at p<0.1
** significant at p<0.05
*** significant at p<0.01

Tests

Test 1: Hotelling test for equality of experimental treatment

```
Hotelling test for joint equality of treatment groups

        2-group Hotelling's T-squared = 30.940635
        F test statistic: ((228-21-1)/(228-2)(21)) x 30.940635 = 1.3429774

        H0: Vectors of means are equal for the two groups
                      F(21,206) =    1.3430
       Prob > F(21,206) =    0.1511
```

Test 2: MWU-test for yield per hectare and fertilizer use

```
. ranksum Yield_per_ha , by(Fertilizer)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

  Fertilizer |      obs    rank sum    expected
-------------+---------------------------------
           0 |      804    345756.5      349740
           1 |       65     32258.5       28275
-------------+---------------------------------
    combined |      869      378015      378015

unadjusted variance  3788850.00
adjustment for ties   -11102.79
                     ----------
adjusted variance    3777747.21

Ho: Yield_~a(Fertil~r==0) = Yield_~a(Fertil~r==1)
             z =  -2.050
    Prob > |z| =   0.0404
```

Test 3: Chi2-test: Location and Land sufficient

```
.
 tabulate Land_sufficient River, chi2

       Land_suffi |         River
            cient |         0          1 |     Total
       -----------+----------------------+----------
                0 |       113        150 |       263
                1 |       384        332 |       716
       -----------+----------------------+----------
            Total |       497        482 |       979

         Pearson chi2(1) =   8.7541   Pr = 0.003
```

Test 4: Chi2-test: Location and Rivalry

```
.
 tabulate Land_rivalry River, chi2

  Land_rival |         River
          ry |         0          1 |     Total
-----------+----------------------+----------
           0 |       359        322 |       681 
           1 |       138        160 |       298 
-----------+----------------------+----------
       Total |       497        482 |       979 

          Pearson chi2(1) =   3.4054   Pr = 0.065
```

Test 5: Chi2-test: Location and Forest Future

```
.
 tabulate Forest_safefuture River, chi2

  Forest_saf |         River
     efuture |         0          1 |     Total
-----------+----------------------+----------
           0 |       319        362 |       681 
           1 |       178        120 |       298 
-----------+----------------------+----------
       Total |       497        482 |       979 

          Pearson chi2(1) =  13.7771   Pr = 0.000
```

Test 6: Chi2-test: Clearing rules and Land sufficient

```
. tabulate Land_sufficient Clearing_rules , chi2

  Land_suffi |    Clearing_rules
       cient |         0          1 |     Total
-----------+----------------------+----------
           0 |        91        172 |       263 
           1 |       304        412 |       716 
-----------+----------------------+----------
       Total |       395        584 |       979 

          Pearson chi2(1) =   4.9339   Pr = 0.026
```

Test 7: Chi2-test: Clearing rules and Rivalry

```
. tabulate Land_rivalry Clearing_rules , chi2

  Land_rival |    Clearing_rules
          ry |         0          1 |     Total
-----------+----------------------+----------
           0 |       288        393 |       681 
           1 |       107        191 |       298 
-----------+----------------------+----------
       Total |       395        584 |       979 

          Pearson chi2(1) =   3.5109   Pr = 0.061
```

Test 8: Chi2-test: Clearing rules and Forest Future

```
. tabulate Forest_safefuture Clearing_rules , chi2

        Forest_saf |    Clearing_rules
           efuture |         0          1 |     Total
        -----------+----------------------+----------
                 0 |       267        414 |       681
                 1 |       128        170 |       298
        -----------+----------------------+----------
             Total |       395        584 |       979

          Pearson chi2(1) =   1.2086   Pr = 0.272
```

Test 9: Chi2-test: Clearing rules and Location

```
. tabulate River Clearing_rules , chi2

                   |    Clearing_rules
             River |         0          1 |     Total
        -----------+----------------------+----------
                 0 |       214        283 |       497
                 1 |       181        301 |       482
        -----------+----------------------+----------
             Total |       395        584 |       979

          Pearson chi2(1) =   3.0827   Pr = 0.079
```

Test 10: MWU-test: Clearing rules and Clearing frequency

```
. ranksum Cleared_frequency , by( Clearing_rules )

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

        Clearing_r~s |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      395    211050.5      193550
                   1 |      584    268659.5      286160
        -------------+---------------------------------
            combined |      979      479710      479710

        unadjusted variance    18838867
        adjustment for ties  -3689047.1
                             ----------
        adjusted variance      15149820

Ho: Cleare~y(Clear~es==0) = Cleare~y(Clear~es==1)
                     z =   4.496
            Prob > |z| =   0.0000
```

Test 11: MWU-test: Clearing rules and Clearing Size

```
. ranksum Hectares_cleared , by( Clearing_rules )

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

        Clearing_r~s |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      385      179956    176137.5
                   1 |      529      238199    242017.5
        -------------+---------------------------------
            combined |      914      418155      418155

        unadjusted variance    15529456
        adjustment for ties  -1093548.4
                             ----------
        adjusted variance      14435908

Ho: Hect~red(Clear~es==0) = Hect~red(Clear~es==1)
                     z =   1.005
    Prob > |z| =   0.3149
```

Test 12: MWU-test: Clearing rules and total hectares cultivated

```
. ranksum Hectares_cultivated , by( Clearing_rules )

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

        Clearing_r~s |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      393    199933.5    190408.5
                   1 |      575    269062.5    278587.5
        -------------+---------------------------------
            combined |      968      468996      468996

        unadjusted variance    18247481
        adjustment for ties  -729109.98
                             ----------
        adjusted variance      17518371

Ho: Hect~ted(Clear~es==0) = Hect~ted(Clear~es==1)
                     z =   2.276
    Prob > |z| =   0.0229
```

Test 13: Chi2-test: Clearing rules and Clearing denied

```
. tabulate Clearing_denied Clearing_rules , chi2

        Clearing_d |    Clearing_rules
             enied |         0          1 |     Total
        -----------+----------------------+----------
                 0 |       368        473 |       841
                 1 |        27        111 |       138
        -----------+----------------------+----------
             Total |       395        584 |       979

          Pearson chi2(1) =  28.8270   Pr = 0.000
```

Test 14: Experiment: Wilcoxon-signed-ranks-test: Changes in clearing from period 1 to period 2 for abundance group

```
. signrank Session1CR1R2 = Session2CR1R2 if treatmentNo == 1 //

                Wilcoxon signed-rank test

                sign |      obs   sum ranks    expected
        -------------+---------------------------------
            positive |       20      1956.5      1503.5
            negative |       11      1050.5      1503.5
                zero |       81        3321        3321
        -------------+---------------------------------
                 all |      112        6328        6328

         unadjusted variance   118650.00
         adjustment for ties     -457.25
         adjustment for zeros  -45110.25
                      ----------
         adjusted variance      73082.50

         Ho: Session1CR1R2 = Session2CR1R2
              z =   1.676
    Prob > |z| =   0.0938
```

Test 15: Experiment: Wilcoxon-signed-ranks-test: Changes in clearing from period 1 to period 2 for scarcity group

```
 signrank Session1CR1R2 = Session2CR1R2 if treatmentNo == 9 //

         Wilcoxon signed-rank test

                 sign |      obs   sum ranks    expected
         -------------+---------------------------------
             positive |       41      3704.5        2295
             negative |       10       885.5        2295
                 zero |       64        2080        2080
         -------------+---------------------------------
                  all |      115        6670        6670

         unadjusted variance   128397.50
         adjustment for ties    -1666.00
         adjustment for zeros  -22360.00
                               ----------
         adjusted variance     104371.50

         Ho: Session1CR1R2 = Session2CR1R2
                      z =   4.363
    Prob > |z| =   0.0000
```

Test 16: Experiment: MWU-test: Differences between clearing in period 2 between abundance and scarcity treatment

```
. ranksum Session2CR1R2, by (Scarcity)

        Two-sample Wilcoxon rank-sum (Mann-Whitney) test

            Scarcity |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      112       13760       12768
                   1 |      115       12118       13110
        -------------+---------------------------------
            combined |      227       25878       25878

        unadjusted variance   244720.00
        adjustment for ties   -32298.67
                             ----------
        adjusted variance     212421.33

        Ho: S~2CR1R2(Scarcity==0) = S~2CR1R2(Scarcity==1)
                     z =   2.152
    Prob > |z| =   0.0314
```

Test 17: Experiment: MWU-test: Differences in differences in clearing between abundance and scarcity group

```
. ranksum  SChange1to2 , by (Scarcity)

        Two-sample Wilcoxon rank-sum (Mann-Whitney) test

            Scarcity |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      112       13864       12768
                   1 |      115       12014       13110
        -------------+---------------------------------
            combined |      227       25878       25878

        unadjusted variance   244720.00
        adjustment for ties   -66741.78
                             ----------
        adjusted variance     177978.22

        Ho: SChang~2(Scarcity==0) = SChang~2(Scarcity==1)
                     z =   2.598
    Prob > |z| =   0.0094
```

Test 18: Experiment: MWU-test: Equality of clearing in Round1&2 between abundance and scarcity treatment

```
. ranksum Session1CR1R2, by (Scarcity)

        Two-sample Wilcoxon rank-sum (Mann-Whitney) test

            Scarcity |      obs    rank sum    expected
        -------------+---------------------------------
                   0 |      112       12891       12768
                   1 |      115       12987       13110
        -------------+---------------------------------
            combined |      227       25878       25878

        unadjusted variance   244720.00
        adjustment for ties   -28020.19
                             ----------
        adjusted variance     216699.81

        Ho: S~1CR1R2(Scarcity==0) = S~1CR1R2(Scarcity==1)
                     z =   0.264
    Prob > |z| =   0.7916
```