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The role of resource dependency for sharing increasingly scarce resources: Evidence from a behavioural experiment with small-scale fishers

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The role of resource dependency for sharing increasingly scarce resources: Evidence from a behavioural experiment with small-scale fishers

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Abstract

In this paper we investigate to what extent resource dependency, which we here define as having few (or no) options to diversify one's livelihood, affects how fishers, sharing a common fishing ground, respond to increasing resource scarcity. To this end we run a framed dynamic CPR experiment in Thailand with small-scale fishers, where we observe and compare behavioural responses of fishers that are presented with different scenarios (treatments), reflecting different degrees of resource scarcity (none, moderate and severe). The fishers differ with respect to resource dependency. We find that fishers that are more resource dependent respond differently to resource scarcity compared to less resource dependent fishers, but that this depends on the severity of resource scarcity. In the no resource scarcity treatment, more resource dependent fishers exploit more cautiously compared to less resource dependent fishers. Under moderate resource scarcity more resource dependent fishers exploit more aggressively compared to less resource dependent fishers. Under severe resource scarcity there is no difference in behaviour between the two types of fishers, both types exploit quite cautiously. Our findings contrast earlier empirical findings that resource dependent fishers continue to exploit, or exploit more under resource scarcity. We find that severe resource scarcity can trigger less exploitation of resource dependent fishers. We argue that the common-pool nature of the situation brings an additional dimension to the situation that can affect behaviour and overall outcomes significantly, and that may explain the result. We suggest that future work focus on teasing out the importance of these different drivers.

Introduction

Small-scale fisheries (SSFs) employ more than 90 percent of the world's capture fishers and fishworkers (FAO, 2016). As such they are a major income source; taking upstream and downstream activities into account and adding additional dependents (non-working household members), estimates suggest that more than 230 million people in low income countries are dependent on SSFs for their livelihoods (FAO, 2016). In addition to providing employment, they are also a critical provider of nutrition in vulnerable regions, where ninety-five percent of the landings end up as local consumption (FAO, 2018).

Climate change poses several challenges for communities relying on SSF. The biggest challenge is likely the expected negative effects on fish abundance (resource scarcity), due to changes in temperature and number of ocean heat waves, affecting production negatively (Britten et al., 2016, FAO, 2018). How will small-scale fishers respond to this challenge and what are the likely long-term consequences?

Responses to resource scarcity can be thought of as either mitigating or amplifying scarcity. Fishers can respond by reducing their fishing effort or stopping to fish more vulnerable species thereby mitigating a negative trend. Alternatively, fishers can amplify scarcity by responding to declining fish stocks by continuing to fish on the same level, or by increasing their fishing effort. This may be positive from a short-term economic viewpoint, but detrimental from a social-ecological point of view if increased effort leads to resource depletion, thereby threatening livelihoods in the long-term. There are empirical observations of both types of behavioural responses among small-scale fishers (see e.g., Cinner et al., 2009, Daw et al., 2011) but under what conditions can we expect one over the other?

In the SSF literature response to resource scarcity has gained quite some attention. There are for example several studies investigating readiness to exit fisheries due to resource scarcity. These have found considerable variation between villages and countries (Daw et al., 2012, Daw et al., 2011, Cinner et al., 2009) and it has been suggested that this difference in response to scarcity is strongly influenced by resource dependency, meaning the extent to which these fishers can rely on alternative livelihoods. Cinner et al. (2009) found that economically poorer regions with few attractive alternative livelihoods were associated with less exits and more over-fishing in response to fish stock decline. Daw et al. (2012) found that fishers in *more* economically developed sites were less inclined to exit fishery. But these were typically fishers that did not have access to other sources of livelihoods. When fishing is the only source of livelihood (even if they make a good livelihood), there is a need and/or a want to continue fishing regardless of stock decline (see also Cinner et al., 2011, Hill et al., 2011).

There are other studies in the SSF literature highlighting the different ways in which one can think of resource dependency and how that links to adaptation to negative shocks for small-scale fishers. Some fishers may for example be resource dependent because of strong cultural ties, attachment to place, and identities as fishers (Van Putten et al., 2018), which may make them less willing and likely to exit the fishery sector. Other ways to buffer against negative shocks and to mitigate resource scarcity can then instead be to use multiple gears and switch between fish species and/or seek new fishing grounds (Gonzales-Mon et al., 2021, Finkbeiner, 2015). But such adaptations often entail costs e.g. associated with the need to go out further to find fish, changing and investing in different gears (Monnier et al., 2020), and many small-scale fishers simply do not have that financial capacity. Another way (for some fishers the only way) to adapt to negative changes in stock abundance is then to diversify livelihood through additional employment as low skilled part time workers in other sectors, such as tourism, agriculture, or construction.

To complicate matters further, many of these SSFs are also threatened by over-exploitation stemming from open access regimes (Purcell and Pomeroy, 2015, Monnier et al., 2020). Long-term sustainable resource use then hinges upon whether or not fishers manage to self-organise and collectively agree on a sustainable management. Evidence from behavioural common pool resource (CPR) experiments suggests an ambiguous directional effect (of responses to resource scarcity) on cooperation and sustainable resource use. On the one hand, increasing resource scarcity can lead to less cooperation, more competition for a scarce resource, and an increase in exploitation (see e.g., Prediger et al., 2014 , Blanco et al., 2015 , Gatiso et al., 2015 , Pfaff et al., 2015). On the other hand, resource scarcity can also promote cooperative behavior because of an additional incentive to use resources sustainably in order to maximize the welfare of the entire group, leading to more cautious exploitation behaviour (Lindahl et al., 2016, Schill et al., 2015, Oses-Eraso & Viladrich-Grau, 2008, Oses-Eraso & Viladrich-Grau, 2007).

We want to contribute to these fields of research in several ways by answering the question: How does resource dependency, defined as having few (or no) options to diversify one's livelihood, affect how fishers, sharing a common fishing ground, respond to increasing resource scarcity? We answer this research question with the help of a framed dynamic CPR experiment with small-scale fishers. In this experiment we observe and compare behavioural responses over time of fishers that have been presented with different scenarios (treatments), reflecting different degrees of resource scarcity (none, moderate and severe). The participating fishers differ in resource dependency, meaning that whereas some can diversify their income, others cannot, and we can then link observed behavior to this variable. We thereby contribute to the literature on SSFs by adopting a CPR context in which it is possible for fishers to self-organise, recognizing that many of these SSFs are already under such management and additionally, that it has gained an increasing attention in fisheries as a way to address the negative consequences of open access fishing (Afflerback et al., 2014). We also contribute to this literature, where most studies on behavioural responses have been collected through survey instruments, by using a controlled behavioural experiment which means we can observe real behaviour responses rather than hypothetical (Lindahl et al. 2021). We contribute to the (experimental) CPR literature by investigating the role of resource dependency for behavioural responses when resource users face resource scarcity.

When investigating responses to resource scarcity, there are of course other contextual factors that could affect behaviour, such as access rules, infrastructure, or local ecological conditions (Gonzales et al., 2021). To tease out the role of resource dependency, in the form of being more or less able to diversify income, one needs to isolate this effect from other contextual factors. We aim to do so by systematically targeting fishing communities that differ in the degree to which they can diversify their livelihood but still share other context specific factors. While we recognize the various ways in which fishers can buffer against negative shocks (and be more or less resource dependent), we focus here on the role of livelihood diversification that involves seeking part time employment in other sectors.

Based on previous empirical findings, our overall hypothesis is that fishers that can diversify their livelihood are more likely to respond to resource scarcity by reducing their fishing effort compared to fishers that cannot diversify their livelihood. We test this hypothesis by running our experiment with small scale fishers in Thailand. We chose Thailand because SSF is a relatively large sector in Thailand and many of the fishers are also facing the main challenges we are interested in - increasing resource scarcity of unregulated fish stocks in the face of climate change. Given the number of SSF it was also relatively easy to find communities in Thailand where fishers differed in resource dependency but that were still similar with respect to other contextual variables. Exactly how we choose communities and fishers is detailed below in the methods section.

Methods

Selection of communities

To be able to isolate the effect of resource dependency on extraction behaviour it is important that the communities included in our study are similar with respect to other contextual factors, such as cultural, institutional and ecological. For this reason we decided to conduct the field work in one geographical area. We needed this area to have a relatively large population of small-scale fishers to be able to draw a big enough sample. We looked into official statistics to get information on the number of small-scale fishers in different areas in Thailand and based on these statistics, and on already established contacts, we targeted the coastal area of the province Nakhon Si Thammarat (NST), more precisely the therein located Tha Sala district, Muang district, Hua Sai district, Kanom district, Sichon district, and Pak Phanang district. See Figure 1.

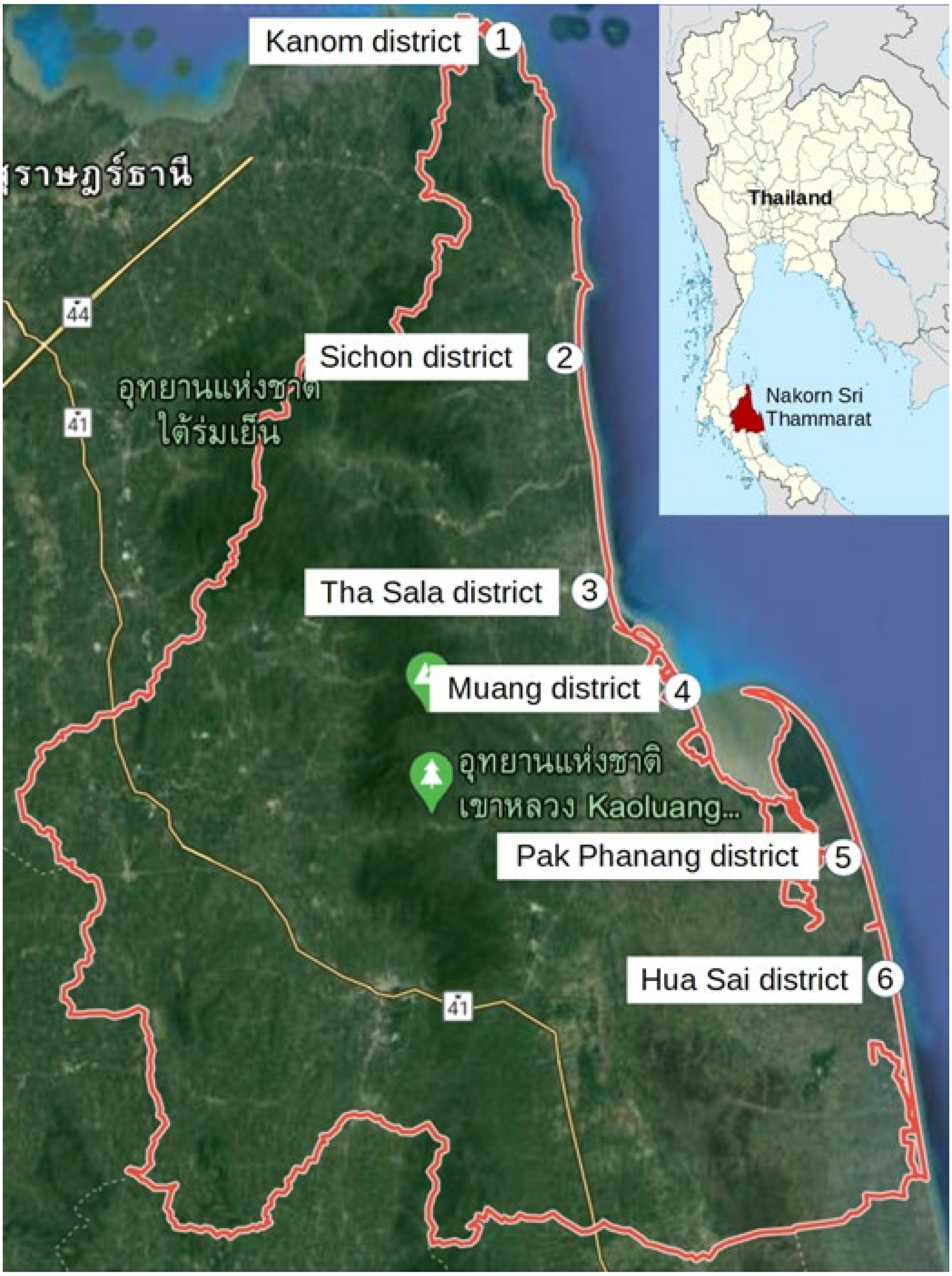

Figure 1: Map of the Study Area. Location of the different districts we visited. Fieldwork was conducted between January 2020 and July 2020 (Data source: Modified map from google maps and vmaps).

NST is one of the southern provinces of Thailand located on the western shore of the Gulf of Thailand. In 2020, the service sector, industry sector and agricultural sector (including fishery) accounted for 45.5%, 27.6% and 26.9% respectively of total GDP (Comptroller General's Department, 2020). The number of households involved in fishery in NST province are close to 5800, which makes NST the province ranked second with respect to households involved in fishery, only outranked by the Songkla Province (around 6000 households) (Community Development Department, 2015).

We interviewed our established local contact persons who work with fishing communities in the area to get more information on the different SSF communities in the districts and in particular to what extent they can be classified as resource dependent or not. Our definition for resource dependency at the community level hinges upon to what extent fishers in these communities diversify their source of livelihood. This means that we classify a community as resource dependent if the livelihood of most fishers in this community depends solely on what they catch from the sea. Fishers in a community that is less resource dependent can diversify their income, in our case e.g. by working in palm oil and rubber plantations, tourism, aquaculture, or in the fish processing industry. We wanted about half of our sample of fishers to come from resource dependent communities and about half to come from less resource dependent communities. We visited in total 10 communities along the coast, 5 of these communities we classified as resource dependent and 5 as less resource dependent.

Experimental design

A framed field experiment in the form of a dynamic common-pool resource (CPR) game was designed to capture the role of resource dependency measured in terms of alternative livelihood options for behavioral responses of small-scale fishers to potential resource scarcity. This experimental design directly builds on a series of laboratory experiments (with students as participants) introduced in Lindahl et al. (2016), which test the effect of a potential ecological regime shift on user behavior in a CPR context. Here, we are interested in the role of resource dependency for behavioral responses in the face of different degrees of resource scarcity. The particular design used here was further informed by a series of field experiments (with fishers as participants) conducted in Thailand (Lindahl and Jarungrattanapong 2018) and Colombia (Schill and Rocha 2020), which themselves also build on the previously mentioned laboratory experiments.

The experiment included a baseline group (no scarcity with certainty), and one treatment group with two different resource scarcity scenarios (moderate and severe). Figure 2 shows the underlying resource dynamics of both experimental groups. In both baseline and treatment groups, participants were confronted with a simple form of a discrete version of the logistic growth function where the minimum CPR stock size allowing for regeneration is set to five units and the maximum stock size is set to 50 units. What differs between the baseline and treatment groups is the regeneration rate between a stock size of 5-45 (compare panels A-C in Figure 2).

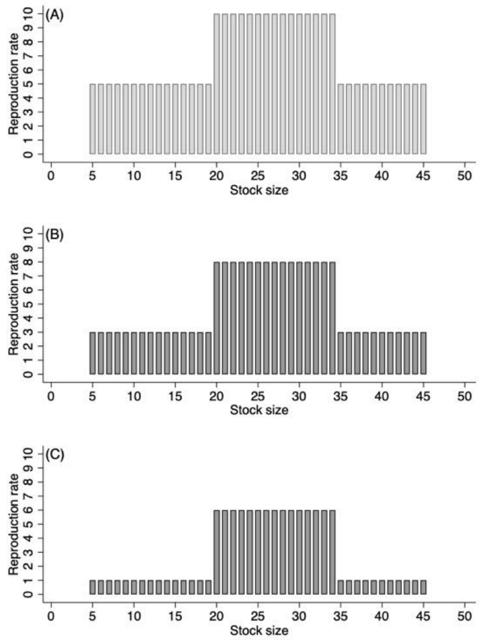

Figure 2. Graphical illustration of underlying resource dynamics. (A) represents the resource dynamics of the control/baseline group; (B) represents the resource dynamics of the moderate scenario of the scarcity treatment; and (C) represents the resource dynamics of the severe scenario of the scarcity treatment.

At the beginning of the experiment the initial fish stock was 50 units, and each caught fish was worth 10 Baht (≈ EUR 0.28/USD 0.31). The experiment consisted of two stages. In the first stage of the experiment, all participants played the baseline scenario (Figure 2A) for a maximum of 6 rounds. In the second stage, participants were randomly allocated to either continue playing baseline or to the treatment. The resource was reset to 50 units for all experimental groups and the participants played additionally a maximum 10 rounds. In the uncertainty treatment participants were informed that the reproduction rate of the fish stock had changed severely or moderately. However, participants were not informed which scenario they were actually playing. The scenario was decided by the means of a lottery (see experimental procedure). Here it is important to note that once the participants have played the first round of the second stage they could, if they properly understood the resource dynamics, deduce which scenario they were playing, because they received information about the regeneration rate (see experimental procedure). So this means that in the very first round of the second stage there was uncertainty about how scarce the resource is. From round 2 and onwards we assume that there was certainty about the scarcity scenario they were playing (we actually asked this and almost everyone figured it out).

Participants (fishers), in groups of four, were asked to catch fish from a shared fishing ground, in order to resemble field context. Individual harvesting levels were treated anonymously; however, participants had no communication restrictions, i.e., participants were able to communicate face-to-face from the start and at any point during the experiment, and were allowed to discuss common fishing strategies and could disclose their individual exploitation levels. Participants were not informed about the exact number of rounds to be played to avoid the end-of-game effect. They only knew that the experiment had two stages and that it lasted a maximum of 3 hours. The experiment was dynamic in the sense that previous decisions of the user group determined the initial conditions for decision-making in the following round. The experiment was designed as a paper-and-pencil experiment (see Janssen et al. 2014). The experimental instructions are available upon request from the authors.

Experimental procedure

The experiment was conducted in 10 rural small-scale fishing communities in the Nakhon Si Thammarat province, located on the coast of the Gulf of Thailand (see map in Figure 1), during the first half of 2020. Participants were recruited by researchers at the Sukhothai Thammathirat Open University in Nonthaburi province in close collaboration with a local coordinator, who works for a local fishery organization and is well known by the local inhabitants in the area.

All participants were first gathered and welcomed, consent forms were read out and signed. Each participant was randomly assigned to a group of four people, and precaution was taken to avoid, if possible, assigning individuals from the same household or close friends to the same group. Participants were allowed to participate only once. All participants received 200 Baht for their participation together with individual earnings ranging between 330 and 1040 Baht (including show-up fee).

Once groups were formed, participants were explained that together with their group members, they had access to a common fishing ground. During each round, participants decided how much fish they wanted to catch. Their individual catch could be between 0 (which is to not fish at all) and the total amount of fish available in the current round, which depended on how much fish was collectively extracted in the previous round. After each round, the new resource stock was calculated by the experimenters. The new stock size, aggregate level of harvest, and corresponding regeneration rate were disclosed to the group, but not individual harvesting decisions to maintain anonymity. As long as there was fish left, participants were allowed to continue playing. To make sure participants understood the game, the experimental leader went through an example, clarified remaining questions and played two practice rounds with the group before the actual experiments started.

The experimental team for each group included at least: one experimental leader (reading out the instructions and making sure that everyone understood the experiment), a resource stock calculator, a resource stock calculator assistant, and two observers. Experimental leaders rotated across treatments to minimize experimenter biases. The experiment involved 82 groups (328 participants), of which 43 groups (172 fishers) came from resource dependent communities and 39 groups (156 fishers) from less resource dependent communities. Local research assistants fluent in the local dialect played an important role in providing participants with assistance throughout the experiment.

After the maximum of 6 rounds were played, the fish stock was reset to 50 and the second stage of the game was introduced. In the resource scarcity treatment, groups were informed that a reduction in the fish reproduction rate had occurred due to environmental changes (see Figures 2B and 2C). Participants knew that changes had led either to a moderate or severe resource reduction, and groups were presented with the moderate and severe depletion resource dynamics. 26 groups (104 participants) continued to play the baseline scenario, and the remaining 56 groups (224 participants) played one of the two scarcity treatments.

A lottery determined which scenario (moderate or severe, Figure 2B vs. 2C) the participants played in the resource scarcity scenario. For this, an urn was filled with ten balls of green and red color.

Green balls represented the moderate-scarcity scenario, while red balls represented the severe-scarcity scenario. The ten balls in the urn were selected from a bowl containing 20 balls of which ten were red and ten were green. To ensure that the probability range for either scenario being played was between 0.2 and 0.8, the urn was firstly filled with two green and two red balls and, then, the remaining eight balls were randomly selected from the bowl containing the 18 mixed red and green balls. Neither the experimental leaders nor the participants knew the exact number of green and red balls that were in the end in the urn. Afterwards, the urn was covered, and one ball was randomly drawn to determine the scarcity scenario. Experimental leaders registered the groups' scarcity scenario without letting the participants know (although as we already mentioned they could figure the scenario out from round 2 of the new stage if they properly understood the resource dynamics). The lottery resulted in 24 groups (96 participants) playing the resource moderate-scarcity scenario, and 32 groups (128 participants) the severe-scarcity scenario. Table 1 illustrates the distribution of the number of groups (and fishers) in each treatment and across the two types of communities.

Table 1. Distribution of groups and participants across treatments. Number of participants in parentheses.

	Resource dependent communities	Less resource dependent communities
Baseline	14 (56)	12 (48)
Moderate	12 (48)	12 (48)
Severe	17 (68)	15 (60)

To better understand the responses of small-scale fishers to potential resource scarcity, the above described experiments were complemented with interviews with participants. All participants were interviewed collecting information on demographic and household questions.

Analysis

Formulating hypotheses

In this section we formulate hypotheses that can guide our empirical analysis. We formulate these hypotheses based on our research question and based on findings in previous literature (see Introduction).

Just to remind the reader, our research question is about how resource dependency at the community level (defined as being able to diversify one's income through another source of livelihood) affects how fishers respond to increasing resource scarcity. More specifically, we want to test if fishers from communities with less opportunities for livelihood options (more resource dependent) respond differently to resource scarcity compared to communities that are less resource dependent.

So what do we mean with response and how do we measure this in the analysis? In our experiment, fishers respond to the different situations by extracting more (or less) from the common pool individually and as a group. The group resource extraction is directly linked to the state of the resource, in our case the resource stock size, where more exploitative behaviour translates to a smaller stock size and potentially resource depletion. From a sustainability perspective it is interesting to make this connection and we will therefore focus on this as our measurement and compare stock sizes between treatments.

Based on previous research our overall hypothesis is that fishers in communities that can diversify their livelihood (from now on we refer to them as less resource dependent) are more likely to respond to resource scarcity by reducing their fishing effort compared to communities that are more resource dependent, hence they will sustain a higher stock size. We now need to operationalise this hypothesis. First we want to see how fishers respond under normal conditions. Thus our first testable hypothesis is:

H0a: In the first stage of the game, the average resource stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers. In the second stage of the game, only considering groups who faced normal conditions the average resource stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers.

We then move on to analyse responses to unknown and known resource scarcity. We begin with unknown resource scarcity.

H0b: In the first round of the second stage of the game, the average stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers.

We can then proceed to analyze behavior under known resource scarcity (moderate and severe).

H0c: From the second round and onwards during the second stage of the game (when there is resource scarcity), the average stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers. This is true for both the moderate and severe scenario.

Statistical approach

We use STATA 16 for our statistical analysis. To test our hypotheses we compare group average values of stock size after extraction ('intermediate stock size'). We use nonparametric hypothesis tests when we can reject the normality assumption at the 5% significance level (Shapiro-Wilk test; Shapiro and Wilk 1965). In particular, we then use a Wilcoxon rank-sum test (MWW; also known as Mann–Whitney two-sample statistic; Wilcoxon 1945; Mann and Withney 1947) after we made sure that the assumption of equality of variances is not violated (using Levene's test; Levene 1960). If we cannot reject the normality assumption, we use standard two-sample t-tests (ref). We use multiple linear regression models to estimate average treatment effects, including interaction effects. We test the regression models regarding the assumptions of normally distributed residuals and heteroscedasticity. To account for heteroscedasticity, we use robust standard errors (robust sandwich type estimators; Elfron 1982, Long and Ervin 2000). We report exact p-values.

Results

The role of resource dependency under 'normal' conditions

In order to test the effect of resource dependency under 'normal' conditions (i.e. no increased resource scarcity), we first focus on Stage 1 only. We find that the average stock size after exploitation for groups from resource dependent (24.25; SD=1.31) is slightly higher than the average stock size after exploitation for groups from less resource dependent communities (22.64; SD=1.34). Statistical analysis indicates that the distributions of average stock size after extraction between resource dependent and less resource dependent communities are not statistically different (MWW, P=0.241). We furthermore find that the probability that the average stock size after extraction of a random group of less resource dependent communities is larger than that of a random group of more resource dependent communities is 0.424. These results are in line with the left panel of Figure 3, which compares average stock size over time of groups from resource dependent with groups from less resource dependent communities. Groups from resource dependent communities sustain in each round of Stage 1 on average higher stock sizes (see Figure 3, left), however, this difference is not large.

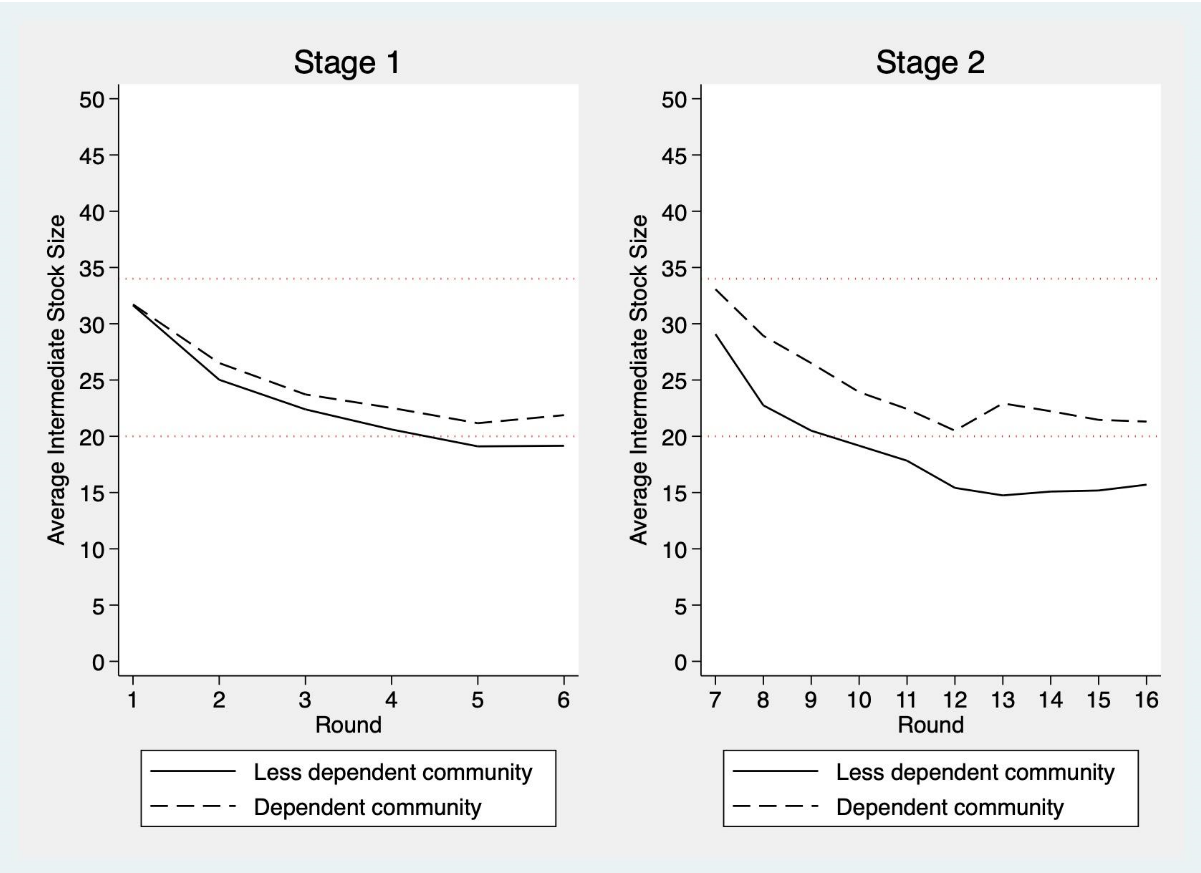

Figure 3. Time series of average stock size after exploitation (intermediate stock size) for groups of resource dependent and less resource dependent communities. The left panel shows the time series for Stage 1 (round 1-6) and the right panel shows time series for Stage 2 (round 7-16). The red dotted lines indicate the stock size area with the highest regeneration rate.

We then focus on Stage 2 (see right panel of Figure 3). Since we are only interested in "normal conditions", we use only data from the control treatment (Baseline) (N=26). Using a two-sample t-test, we find that stock size averages are statistically different from each (P=0.0533); groups from resource dependent communities (26.7; SD=1.98) sustain on average higher stock size than groups from less dependent communities (20.13; SD=2.61). Hence, we can partly reject our first hypothesis (H0a).

Result 1: In the first stage of the game, the average resource stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers. In the second stage of the game, however, (when only considering groups who faced normal conditions, i.e. played baseline) the average resource stock size of resource dependent fishers differs significantly from the average resource stock size of non-resource dependent fishers.

The role of resource dependency when facing increased but uncertain scarcity

To determine effects of increased but uncertain scarcity, given differences in resource dependency, we fitted a multiple linear regression with resource stock size after exploitation as dependent variable, while controlling for uncertain scarcity, resource dependency as well as interaction effects between the independent variables. We focus on the first round of Stage 2 only. We find that uncertain scarcity (i.e. uncertainty about whether scarcity is moderate or severe) has a significantly positive effect on average resource stock size after exploitation in the first round of Stage 2. This result is independent of resource dependency. Hence, although fishers respond to the uncertain scarcity we cannot reject our second hypothesis because there is no difference in average stock size after exploitation between resource dependent and less dependent communities.

Result 2: In the first round of the second stage of the game, the average stock size of resource dependent fishers does not differ significantly from the average resource stock size of non-resource dependent fishers. However, whether or not there is scarcity has a significantly positive effect on average stock size after exploitation.

Table 2. Regression analysis. Estimated treatment effect given differences in resource dependency, including interaction effects. Stock size after exploitation of round 1 in Stage 2 as response variable.

	Stock size after exploitation (round 1 of Stage 2)	
	Estimated treatment effect (robust std. err.)	**p-value**
Scarcity	5.806 (2.507)	0.023
Resource dependency	3.988 (2.767)	0.154
Interaction term		

Scarcity # dependent community	-4.394 (3.125)	0.164
Constant	29.083 (2.230)	0.000
R^2	0.1038	
Observations	82	

The role of resource dependency when facing increased and known scarcity

Figure 4 shows average stock size after exploitation over time for Stage 2 according to resource dependency (dependent vs. less dependent communities). We see that both resource dependency and the level of scarcity play a role. There is a difference in the patterns of average stock size after exploitation between the panels (A, B, C), indicating treatment effects. Moreover, there is also a difference within the panels comparing average stock size after exploitation of resource dependent with less resource dependent communities, indicating potential interaction effects. In the next step, we use regression analysis to analyse these effects.

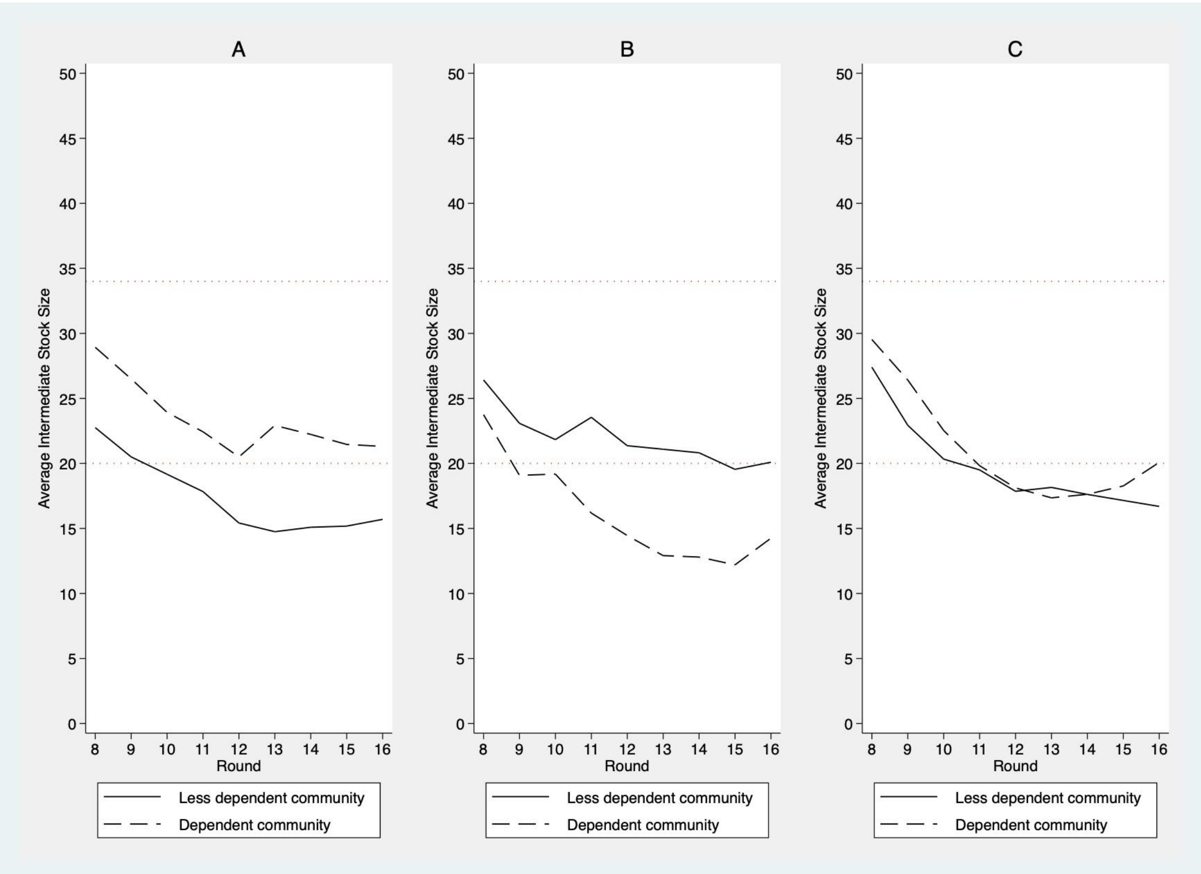

Figure 4. Time series of average stock size after exploitation (intermediate stock size) across treatments in Stage 2. Panel A shows the time series for Baseline groups; Panel B shows the time series for moderate severity; and Panel C shows the time series for severe scarcity. Time series start at round 8, the round from which the severity of the resource scarcity was known to the participants. Panel A is the same as the Stage 2 panel in Fig. 3 but starting at round 8 (rather than round 7). The red dotted lines indicate the stock size area with the highest regeneration rate.

To determine average effects of moderate versus severe scarcity, given differences in resource dependency, we fitted a multiple linear regression with average resource stock size after exploitation in Stage 2 as dependent variable, while controlling for moderate and severe scarcity, resource dependency as well as interaction effects between the independent variables. We find that scarcity does not have a significant effect on average resource stock size after exploitation. However, resource dependency significantly influences average stock sizes (*p*=0.070). Resource dependent communities sustain on average higher stock sizes compared to less resource dependent communities. However, in comparison to groups from less resource dependent communities facing no scarcity, groups from resource dependent communities faced with moderate scarcity sustain on average lower stock sizes (*p*=0.16). This effect is stronger than the positive effect of resource dependency. Hence, we can only partly reject our third hypothesis (H0c): there is a significant difference in average stock size after exploitation comparing dependent with less dependent communities for the moderate scenario of resource scarcity.

Result 3: From the second round and onwards during the second stage of the game (when there is resource scarcity), the average stock size of resource dependent fishers differs significantly from the average resource stock size of non-resource dependent fishers. However, we only find a significant negative effect of moderate scarcity in combination with resource dependency.

Table 3 Regression analysis. Estimated average treatment effects given differences in resource dependency, including interaction effects. Average stock size after exploitation as response variable.

	Average stock size after exploitation (Stage 2)	
	Estimated average treatment effect (robust std. err.)	**p-value**
Moderate scarcity	4.133 (3.712)	0.269
Severe scarcity	2.08 (3.105)	0.505
Dependent community	5.667 (3.087)	0.070
Interaction terms		
Moderate scarcity # dependent community	-11.608 (4.713)	0.016
Severe scarcity # dependent community	-3.946 (4.246)	0.356
Constant	18.033 (2.419)	0.000
R^2	0.088	
Observations	82	

Discussion and Conclusion

In this paper we wanted to investigate how resource dependency, defined as having the option or not to diversify one's livelihood, affect how fishers, sharing a common fishing ground, respond to increasing resource scarcity. Based on previous empirical findings, our overall hypothesis was that fishers that can diversify their livelihood are more likely to respond to resource scarcity by reducing their fishing effort compared to fishers that cannot diversify their livelihood. To test our hypothesis we ran a framed dynamic CPR experiment with small-scale fishers, where we could observe and compare behavioural responses over time of small-scale fishers that were presented with different scenarios (treatments), reflecting different degrees of resource scarcity (none, moderate and severe). The participating fishers differ in resource dependency, meaning that whereas some could diversify their income, others could not, and we could then link observed behavior to this variable.

We can first conclude that before we introduce the treatments, in the first stage of the game there is no significant difference in behaviour between resource dependent and less resource dependent fishers. Also before the exact scarcity scenario has been revealed (there is uncertainty about the severity of scarcity) there is also no significant difference in behavior. But when we introduce the treatments in the second stage of the game we find that resource dependent fishers respond differently to resource scarcity compared to less resource dependent fishers, but that this depends on the severity of resource scarcity. In the no resource scarcity treatment, resource dependent fishers exploit more cautiously compared to less resource dependent fishers. Under moderate resource scarcity there is also a significant effect but here resource dependent fishers exploit more aggressively compared to less resource dependent. Under severe resource scarcity there is no difference in behaviour between the two types of fishers, both types of fishers exploit quite cautiously.

These results could reflect that there are two contrasting forces at work. On the one hand responding with more aggressive exploitation behavior (which is in line with our overall hypothesis) can reflect that resource dependent fishers need to continue fishing to secure their livelihood. This is what we would expect based on empirical findings from the SSF literature. On the other hand responding with less aggressive exploitation behavior can reflect that more is at stake for resource dependent communities, triggering more cooperative behaviour (and less over-exploitation) to secure future livelihoods, which is in line with previous experimental results on commons management.

For future work we need to tease out these potential explanations and drivers more in detail so we account for them in policy design. Solutions that center on making small scale fishing more profitable, for example by incentivizing some fishers to leave the sector may not only fail to recognize that some fishers cannot leave the sector, but also that the common-pool nature of many of these fisheries bring an additional strategic/social dimension to the situation that can affect behaviour and overall outcomes significantly. Based on our results we suggest turning to one of Ostrom's design principles for successful commons management, the importance of facilitating arenas for conflict resolution. Such an arena could be especially important for strengthening community ties, for building social relationships, and for knowledge sharing (about ecological conditions), which we think can be essential in these vulnerable communities.

To strengthen our conclusions, however, additional studies, e.g., in different field settings, would need to confirm our findings. For one, it would be interesting to take the design to other locations, both within Thailand (keeping ethnicity and culture constant), but also to locations that differ with respect to socio-economic conditions. It would also be interesting to investigate whether (other) individual characteristics can be linked to behavioural responses.

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