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Non-kinship successors for resource sustainability

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Abstract

Rural societies with unique resources, such as indigenous culture and natural capitals, have suffered from aging residents and lack of successors due to youth outmigration by industrialization, urbanization and globalization. Little literature has studied resource transfers when successors are present or absent in such an aging society. This paper experimentally examines resource dynamics and sustainability when resource users may die with and without successors. We design a dynamic common pool resource (CPR) game and implement the field experiments in Nepalese rural areas where an aging factor of resource users with presence or absence of successors is incorporated by probabilistic exit and entry of members in a group. In the experiments, three treatments are prepared: (i) fixed group member (FGM) treatment where group members are fixed without exit, (ii) probabilistic replacement member (PRM) treatment where each group member shall stochastically exit, but a successor exists to fill the spot as a replacement and (iii) probabilistic exit member (PEM) treatment where each group member shall stochastically exit in each period. The results show that groups in FGM and PRM treatments sustain resources 3.13 and 2.52 times longer than do groups in PEM (baseline), demonstrating that resource users tend to maintain resources and cooperate for sustainability when they have successors or live long together in one place. The results also suggest that an existence of non-kinship successors can be key to trigger people's altruistic motives for outliving themselves or leaving something behind even in an aging society, affecting how resource users behave for not only intragenerational peers but also intergenerational resource sustainability.

Key Words: resource sustainability; successor; field experiment

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Contents

Nomenclature

CPR Common pool resource

FGM Fixed group member

NPR Nepalese rupee

PEM Probabilistic exit member

PRM Probabilistic replacement member

SD Standard deviation

SVO Social value orientation

1 Introduction

Rural societies with unique resources, such as indigenous culture and natural capitals, have suffered from aging residents and lack of successors (Seto et al., 2017, Morais et al., 2017). One reason for declining successors in rural societies is youth outmigration by industrialization, urbanization and globalization (Wang et al., 2016). This phenomenon raises critical questions about sustainability of various common pool resources (CPRs) in rural areas, i.e., agricultural knowledge, natural resources and culture (Joosse and Grubbstrom, 2017, Duesberg et al., 2017, Jackson et al., 2020). Cooperation among humans is an important factor of sustainability, and the evolution of collective actions beyond kinship for cooperation is considered a social anomaly and a hallmark of societies (Runge, 1986, Ostrom, 1990, Hill et al., 2014, Darden et al., 2020). Thus, scholars have examined non-kinship factors to affect actions and behaviors for resource sustainability, for example, resource growth, excludability, rivalry, social capital, norms, group size, communication and punishment (Schluter et al., 2016, Ringsmuth et al., 2019, Freeman et al., 2020). In particular, reciprocity and altruism among non-kinship relations are established to contribute to resource sustainability (Ostrom, 1990, Hayashi et al., 1999, Coleman, 2000, Pretty, 2003, Bowles and Gintis, 2013). This paper experimentally addresses CPR dynamics and sustainability when resource users can transfer resources to non-kinship successors in rural societies.

Gordon (1954) and Hardin (1968) regard CPR problems as a social dilemma, i.e., "the tragedy of the commons," where every person is assumed to behave according to their self-interest. Past studies have identified various factors to promote cooperation among resource users via lab and field experiments. Walker et al. (1990) and Walker and Gardner (1992) pioneer laboratory experiments for CPRs, showing that the resource will be extinct unless proper institutions ensure cooperation for governance. Several researchers examine cooperative behaviors of individuals in laboratory experiments mimicking natural CPRs (Keser and Gardner, 1999, Apesteguia, 2006, Oses-Eraso and Viladrich-Grau, 2007, Schnier, 2009, Janssen et al., 2011). Cardenas and Ostrom (2004) and Cardenas (2011) highlight the importance of social norms in individual behaviors for managing CPRs, conducting some field experiments with resource users who face social dilemmas in their daily life. Similarly, a group of researchers conduct field experiments to understand the roles of norms, individual attributes, social network and socio-cultural heterogeneity in utilizing CPRs (Velez et al., 2009, Fehr and Leibbrandt, 2011, Mantilla, 2015a, Gehrig et al., 2019). These studies establish that individual behaviors are shaped by institutions, norms, individual attributes and cultural factors in static or repeated CPR experiments.

Some laboratory experiments explicitly incorporate dynamic natures of CPRs, e.g., resource stock and growth rate. Mason and Phillips (1997) analyze firms' harvesting behaviors in static and dynamic environments, demonstrating that a firm size matters for harvesting behaviors. Chermak and Krause (2002) assess intergroup behaviors in dynamic CPR settings and claim that sociodemographic characteristics, such as age, gender and affiliations, are important determinants for resource sustainability. Bru et al. (2003) examine the roles of quotas and harvesting capacities for resource exploitation and confirm that exploitation is positively related to the quotas but not to the capacity of individuals or firms. Fisher et al. (2004) show that people do not exploit resources in the presence of an "intergenerational link," enhancing sustainability. Botelho et al. (2014) analyze the effect of environmental uncertainties and identify that it is negative on CPR sustainability. Kimbrough and Vostroknutov (2015) demonstrate that extracting capacity and resource growth rate are crucial factors to induce individuals to manage resources sustainably. To summarize, these laboratory experiments present that growth rate, extraction capacity, environmental uncertainties and sociodemographic characteristics can be important for sustainable management of CPRs.

Several studies have shown how socio-ecological environments influence individual social cognition and actual behaviors for managing CPRs through field experiments. Ostrom (2009) argues that communication, social cognition and culture coordinate people's behaviors in a sustainable manner for resource utilization. Leibbrandt et al. (2013) compare competitiveness between lake- and sea-based fishers, finding that the former is more competitive than the later. They suggest that daily practices with others in workplaces affect individual behaviors and social preferences for resource management. Mantilla (2015b) uses non-enforceable recommendations before individual extraction decisions in Colombian artisanal fishers and find that it decreases their extraction level.

Aida (2018) examines trust as social capital among farmers and confirms that intergroup trust reduces resource extraction. Chavez et al. (2018) administer both laboratory and field experiments to investigate factors that prevent people from poaching CPRs. They find no essential differences in behaviors between laboratory and field experiments, while climatic variability and other uncertainty sources cause resource users to defend resources against such poaching. Drupp et al. (2019) examine German commercial fishers' behaviors under an ill-regarded regulator and report that it is challenging to maintain CPRs when honesty is eroded by such a regulator. Wegmann and Musshoff (2019) compare between reward-and-punishment and communication rules, arguing that the former is more effective for resource sustainability than the latter.

Many CPRs, such as forests, are rich in rural areas, while a number of rural resource users has declined over time because of their aging and youth outmigration to urban areas. Therefore, CPR sustainability is claimed to be endangered (Leibbrandt et al., 2013, Watanabe et al., 2014, Shahrier et al., 2016, Timilsina et al., 2017, Takayama et al., 2018, Hernuryadin et al., 2020). However, literature has neither examined CPR dynamics and sustainability when resource users die with (or without) successors nor clarified how they use the resources in such situations. To fill the gap, we design a dynamic CPR game and implement the field experiments in Nepalese rural areas where an aging factor of resource users along with youth outmigration is incorporated by means of probabilistic exit with and without successors. In the experiments, subjects who use real CPRs in their daily life are recruited, and the following three treatments are prepared: (i) fixed group member (FGM) treatment where group members are fixed without exit, (ii) probabilistic replacement member (PRM) treatment where each group member shall stochastically exit, but a successor exists to fill the spot as a replacement and (iii) probabilistic exit member (PEM) treatment where each group member shall stochastically exit in each period. FGM is considered to correspond to a situation where rural resource users live long with the same members to maintain the resources or to approximate a situation as if kinship successors are determined to take over the resources. On the other hand, PRM (PEM) is considered to mimic a situation where rural resource users die with (without) non-kinship members to take over the resources.

2 Experimental setup

Field experiments were conducted in rural Nepalese areas consisting of a dynamic common pool resource (CPR) game, a social value orientation (SVO) game and questionnaire surveys. The dynamic CPR game is designed to examine how subjects use and/or transfer the resources with and without successors. The SVO game and questionnaire surveys are imlemented to collect subjects' social preferences and sociodemographic information, respectively.

2.1 Dynamic CPR game

Dynamic CPR game incorporates resource dynamics in a way that subjects with limited educational background can easily understand and follow. A group of 4 subjects is formed where the subjects are informed about the group size but not the identities of other members of the same group. The resource stock at the beginning of each period is denoted by x_t, where the subscript t denotes time periods $t = 1, 2, \ldots$, and an initial stock of size x_1 = 120 is given. At the beginning of each period t, subject i is asked to determine her/his individual harvest $y_{i,t}$. The escapement, s_t, is defined as $s_t = x_t - \sum_{j=1}^{4} y_{j,t}$ where $\sum_{j=1}^{4} y_{j,t}$ is the group harvest at period t. When $s_t \geq 0$, the individual payoff is $\pi_{i,t} = y_{i,t}$. When $s_t < 0$, the individual payoff, $\pi_{i,t}$, is $y_{i,t} = \frac{x_t}{4}$ for simplicity.[1] The escapement, s_t, is considered to be a remaining stock for each period t and determines the evolution of resource dynamics. The resource stock dynamics are specified as below:

$$x_{t+1} = \begin{cases} 1.5s_t = 1.5\left(x_t - \sum_{j=1}^{4} y_{j,t}\right) & \text{if } s_t > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{1}$$

In equation (1), the next-period stock x_{t+1} grows up to a $50\,\%$ increase in the escapement, and the game continues to the next period when $s_t > 0$ (the remaining stock is strictly positive). Otherwise, resource depletion results and a dynamic CPR game is terminated.

To simulate realistic conditions, we incorporate time discounting in a dynamic CPR game. We

[1] There may be other ways to divide resources when depletion occurs. However, this is chosen as the simplest way to help our subjects understand the rules of the game in the field according to our pilot tests.

prepare 20 chips in a box where 19 chips are white and 1 chip is red. At the end of each period, a representative of each group picks a chip. If the chip is white the game moves to the next period; otherwise, it is terminated. This situation resembles a discount factor of $\rho = 0.95$ in terms of time preferences. In summary, a dynamic CPR game is terminated when a group depletes the resource, i.e., $s_t \leq 0$, or when the red chip is drawn for that group. With this setup, we are interested in identifying how many periods each group can sustain resource use. The period at which each group terminates the game via resource depletion or drawing a red chip is referred to as a "terminal period." This is a measurement for the degree of sustainability.[2]

An aging factor of resource users along with the presence or absence of successors is incorporated by means of probabilistic exit and entry of members in a group as well as the treatments in experiments. The three treatments are prepared: (i) fixed group member (FGM) where group members are fixed without exit, (ii) probabilistic replacement member (PRM) where each group member may stochastically exit, but a successor fills the spot as a replacement and (iii) probabilistic exit member (PEM) where each group member may stochastically exit in each period. We hypothesize that the resource users' exit and/or replacement are crucial determinants to characterize resource dynamics and sustainability. Economic theory predicts that there should be no differences in subjects' behaviors between PRM and PEM, because an entry of successors does not affect the existing subjects' payoffs in both treatments. Therefore, people are not self-maximizers if behaviors differ between the two conditions. The treatment details are explained as follows:

- **FGM** (Treatment): Subjects are informed that their group members are going to remain the same but anonymous. First, subjects are asked to make an individual decision given an initial stock size of the group resources. The resource escapement is determined after each subject makes her/his decisions for that period. If the escapement is strictly positive and randomly drawn chips for the groups are white, the game continues for the next period. FGM treatment corresponds to a situation where rural resource users live long with the same

[2] When the game continued more than 20 periods, we stopped it due to time and money constraints as special cases. Two groups fall into the special cases.

members to maintain the resources or approximates a situation as if kinship successors are determined to take over the resources.

- **PRM** (Treatment): Subjects are informed that their group members are going to be replaced with a probability of 10 % in each round. First, subjects need to make an individual decision given an initial stock size of the group resources. Next, for the probabilistic replacement of group members, each subject picks 1 chip from a bag that contains 10 chips where 9 are white and 1 is red. The subjects who have drawn red chips exit the game and new members enter to fill the open spots as successors. The game continues as long as the escapement is strictly positive and the chip drawn for the group is white. PRM treatment is designed to mimic a situation where rural resource users die with non-kinship people to take over the resources.

- **PEM** (Baseline): Subjects are informed that their group members are going to exit from the group with a probability of 10 % in each round. First, subjects need to make an individual decision given an initial stock size of the group resources. Next for the probabilistic exit of group members, each subject picks 1 chip from a bag that contains 10 chips among which 9 are white and 1 is red. The red chip makes subjects exit from the game and the game continues with reduced members until the only one member is left in the group because when there is only one member the tragedy of the common does not persist further. The game continues with reduced members as long as two more conditions are fulfilled, i.e., the escapement is strictly positive and randomly drawn chip for the group is white. PEM (baseline) is designed to mimic a situation where rural resource users die without non-kinship people to take over the resources.

The game reflects some fundamental features of dynamic CPR utilization in the real world: (i) dynamic nature of CPRs, (ii) time discounting and (iii) an aging factor of resource users along with presence or absence of successors. The game is considered a resource utilization problem of multiple players in an infinite horizon, possessing the following predictions of Nash equilibrium and

Pareto optimality. The symmetric Markov perfect Nash equilibrium is that each subject harvests the resource up to exhaustion at the first period, irrespective of the treatments (Puterman, 2014, Basar and Zaccour, 2019). The Pareto optimal allocation in a dynamic CPR with FGM given the infinite number of periods is that each subject waits without any harvesting until the last period at which "the game is over," and then harvests everything (Puterman, 2014). Put differently, each subject should harvest all at once after the resource grows large enough in FGM, and the allocation becomes Pareto optimal because the resource regeneration ($= 1.5$) is much higher than the discount factor ($= 0.95$) for groups in the experiments (it is better for them to wait). With the same logic, the allocation remains Pareto optimal for PEM and PRM where the resource regeneration is still higher than the product of the individual survival probability and the discount factor ($= 0.90 \times 0.95 = 0.855$).

Social value orientation (SVO) game

SVO game with the "slider method" is utilized to identify subjects as either prosocial or proself (Murphy et al., 2011). Each subject is paired with a randomly chosen subject, but is not informed who the partner is. Then she/he answers a questionnaire with six items, each of which has a slider measure that uses numbers to represent the outcomes for him/herself and the partner, for reference, see in figure 3. Subjects are asked to choose among the nine options for each item. Each subject chooses an allocation by marking a line at the point that defines her/his most preferred distribution between oneself and the other. The mean allocation for oneself $\overline{A}_s$ and that for the other $\overline{A}_o$ are computed from all six items (see in Figure 3). Then, 50 is subtracted from $\overline{A}_s$ and $\overline{A}_o$ to shift the base of the resulting angle to the center of the circle $(50, 50)$. The index of a subject's SVO is given by SVO $= \arctan \frac{(\overline{A}_o)-50}{(\overline{A}_s)-50}$. Depending on the values generated from the test, social preferences are categorized as follows: 1. altruist: SVO $> 57.15°$, 2. prosocial: $22.45° <$ SVO $< 57.15°$, 3. individualist: $-12.04° <$ SVO $< 22.45°$ and 4. competitive: SVO $< -12.04°$.

SVO framework assumes that people have different motivations and goals for evaluating resource allocations between oneself and others. Additionally, SVOs are established to be stable for a long time (see, e.g., Van Lange et al., 2007, Brosig-Koch et al., 2011, Carlsson et al., 2014). Responses that are yielded from six primary items provide complete categories of social preferences.[3] We use the six primary slider measures following Murphy et al. (2011), because it is simple and easy to implement in the fields of Nepal. It is very intuitive for subjects to understand, even with a limited level of education. As is done in psychological research, we further simplify the four categories of social preferences into two categories of prosocial and proself types: "altruist" and "prosocial" types are categorized as prosocial subjects, while "individualistic" and "competitive" types are categorized as "proself" subjects (see Murphy et al., 2011). Respondents are informed that the units in this game are points, meaning that the more points they accumulate, the more real money they will earn than others.[4]

An exchange rate of 10 experimental points equal to 1 NPR is applied to the points in SVO game to determine the monetary reward. The decisions for this SVO game are made with complete privacy as subjects are instructed not to communicate with each other. To compute the payoffs of the subjects, we collect the answer sheets from all subjects in a session. The payoff for each subject in SVO game is the summation of points from 6 selections by her/his as "You" and 6 selections by the partner as "Other." We explain the methods of random matching and the payoff calculation with the exchange rate for the real monetary incentive to subjects before starting SVO game.

2.2 Experimental procedures

Experiments are conducted in the fields of Nepalese rural areas, such as Gorkha, Lamjung, Palpa, Rupandehi, Chitwan, Dhading and Makwanpur districts (figure 1). These districts consist of many small villages with a low population density and most people engage in agriculture and forestry where farms and forest areas are managed as CPRs. Each group consists of members drawn at random from different villages with cooperation of local NGOs and governmental offices for a session per day. This approach is adequate to avoid situations where subjects in a session

[3] Following Van Lange et al. (2007), social value orientations (SVOs) are taken as a proxy for individual social preferences in this research.

[4] For details, see the instructions in figure 3.

know each other. Several undergraduate students are hired as research assistants (RAs) from Tribhuvan University to support the execution of the experiments.

[Figure 1 about here.]

The first author administered the experiments with RAs. One session comprises a dynamic CPR game, a SVO game, questionnaire surveys and final payments. In each session, $20 \sim 28$ subjects ($5 \sim 7$ groups) are gathered (formed) at district community halls or schools, and one treatment among (i) fixed group member (FGM), (ii) probabilistic replacement member (PRM) and (iii) probabilistic exit member (PEM baseline) is randomly assigned to a session. In PRM, we prepare extra $4 \sim 8$ subjects and ask them to wait in a different room and fill up sociodemographic questionnaires.[5] A total of 628 subjects have participated in the experiments and 157 groups are organized where 65, 50 and 42 groups are in (i) FGM, (ii) PRM and (iii) PEM (baseline), respectively. On an average, one session takes around $2 \sim 3$ hours. We send an invitation letter to the randomly selected households and one member per household is invited to participate in our experiments. The participation rate is approximately 85 % $\sim$ 95 %, which is high due to the pecuniary incentive mentioned in the invitation letters.

Upon arriving at the location, subjects per session gather into one hall and receive experimental instructions in their native language (Nepali). The experimenter (the first author) once more gives a verbal explanation of the experimental rules to subjects. Next, subjects give their consent by signing a form for participating and following the rules of the experiments. Anonymity is maintained throughout the session. First, Q&A and quizzes are conducted for double-checking subjects' understanding and we confirm that subjects fully understand the rules. We do not start dynamic CPR and SVO games unless subjects correctly answer quizzes. Second, each subject is asked to draw a chip for her/his individual ID from a bag. Third, each subject is guided by RAs and the experimenter according to the ID for taking a specific seat in a different room. In this process, the groups are formed in the way that subjects never know who belong to their group.

[5] We conducted a total of 27 sessions under time and budget constraints that partly come from geographic nature in Nepal. When some subjects could not play a dynamic CPR game, they only receive the benefit of an average payment per session.

RAs distribute questionnaires to subjects in a room and explain all the experiment procedures again to subjects. Subjects are asked to fill up pre-questionnaires for collecting some basic socio-demographic information. In explaining a dynamic CPR game, we have used neutral terminologies such that the resource stock and escapement in each period are expressed as “tokens” and “remaining tokens.” In addition, the next-period resource stock and the growth rate are also expressed as “next-period tokens,” and “50 % increment” in the remaining tokens. There are neither computers nor internet connections in the field. Therefore, everything has been managed manually by the experimenter and RAs for running each session.

For a dynamic CPR game, experimenters announce that each group is given an initial endowment of 120 tokens at the beginning of the first period, and each subject needs to make her/his individual decision of how many tokens to harvest in a period. After individual harvest decisions, research assistants calculate each group’s harvest which is the sum of the total tokens demanded (or harvested) by four subjects in a group, letting subjects know the group harvest. However, subjects do not have information about other members’ individual harvests in their group. The remaining tokens in each period are the difference between the “tokens” and “total tokens demanded” by the four subjects in their group. Unless the remaining tokens are zero or the chip for the group is red, the group moves to the next period with information about the next-period tokens, i.e., 1.5 times the remaining tokens that reflects 50 % resource growth on escapement. Subjects are paid real money based on the cumulative payoffs of all their decisions where the experimental tokens are converted to real Nepalese rupee (hereafter, NPR) with a conversion rate of one experimental token equal to 2 NPR. Subjects earn 500 NPR ($\approx$ 5 USD) on an average with a minimum of 300 NPR and a maximum of 3000 NPR. After finishing a dynamic CPR game, subjects go through a SVO game and post-questionnaire surveys. Then, each subject receives her/his payment which is calculated to be a summation of her earnings from (i) show-up fee, i.e., 100 NPR ($\approx$ 1 USD), (ii) dynamic CPR game 500 NPR and (iii) SVO game 100 NPR on an average.

3 Results

Table 2 presents summary statistics of subjects' sociodemographic information at group level, i.e., education, age, yearly household income, number of household members, percentages of male members and percentages of prosocial members. The average age of subjects in a group range between 30 and 40 years across all treatments representing a proper distribution of an economically active population. Subjects have 9 years of average schooling, suggesting that people in rural areas have in general a limited level of education and most of them are engaged in farming activities. The percentages of male members in a group are approximately between 30 % and 40 %. Sex ratio is female-biased presumably because of the outmigration of young men to urban areas or foreign countries to look for an employment (UNDP, 2017, Bhawana et al., 2017). The average household income in all treatments is between 90 and 100 thousand NPR that reflects the current GDP per capita of the country. Overall, the summary statistics of sociodemographic information presented in table 2 are representative of the population of the contemporary rural society where subjects have secondary education and they mostly engage in agriculture and forestry resources managements.

[Table 1 about here.]

Social value orientation (SVO) game is utilized to identify subjects as either prosocial or proself and the percentages across the treatments are reported in table 2. In FGM, 75 % of subjects are the prosocial and 61 % in PRM and PEM (baseline). This result indicates that the majority of subjects are prosocial in our study, implying that two or more members are expected to be prosocial in one group. The literature demonstrates that prosociality measured by the SVO is a plausible predictor of cooperative actions spanning sustainable resource use and voluntary contributions to public goods (Van Lange et al., 1997, 2011, Kimbrough and Vostroknutov, 2015, Shahrier et al., 2016, Timilsina et al., 2017, Hauge et al., 2019). Later part, we will discuss how prosociality matters for resource sustainability across the three treatments in a dynamic CPR game.

The summary statistics of terminal periods for each treatment are presented in table 2. The table shows the median (mean) terminal periods are 7.63 (6.00) in FGM and 4.67 (4.00) in PRM and 1.80 (1.00) in PEM (baseline). These results imply that most groups in FGM and PRM successfully continue a dynamic CPR game for more than 6 and 4 periods,respectively. On the other hand, more than 50 % of groups in PEM (baseline) exhaust the resource at the first period and never proceed to the second period. For the groups in which the game lasted for 20 periods, we asked the group members to stop the game due to time and budget constraints. The standard deviation of terminal periods is 5.56 in FGM, 2.19 in PRM and it is only 1.68 in PEM (baseline). These statistical findings indicate that groups in FGM and PRM sustain the resource longer than those in PEM (baseline).

[Figure 2 about here.]

Figure 2 shows the corresponding histograms where the vertical axis denotes the frequency and the horizontal axis terminal periods. The figure suggests that terminal periods are more broadly distributed in FGM and PRM than in PEM (baseline). In particular, the highest spike in the frequency distributions of terminal periods in PEM (baseline) occurs at period 1, confirming that more than 50 % of groups in PEM (baseline) terminate the game at the first period. We include the following question in the post-questionnaires: "how do you play the game?" A considerable number of subjects in PEM (baseline) have answered the question as follows, "I wish to play the game for longer, but it was uncertain if I will continue to the next period," wherein PRM subjects answered "I play the game for several rounds and I was replaced by another new member who continues the game." Most of the subjects in these two treatments give these types of answers. It appears that subjects recognize some utility of playing the game longer in the presence of successors, even though by no means do they get feedback from their successors. On the other hand, subjects in PEM (baseline) do not restrain their harvests and deplete the resource in the first period due to their concerns of exit from the group with 10 % probability.

To confirm the significant difference in the frequency distribution of terminal periods among treatments, we conduct a Mann-Whitney test (Conover, 1999). The null hypothesis is that the terminal periods' distributions are the same between the groups in the following pairs: (1) FGM vs. PRM (2) PRM vs. PEM (baseline) and (3) PEM (baseline) vs. FGM. The test statistic and the p-value are (1) FGM vs. PRM ($Z = 2.41, p = 0.02$), (2) PRM vs. PEM (baseline) ($Z = 5.80, p < 0.01$) and (3) FGM vs. PEM (baseline) ($Z = 7.23, p < 0.01$). Thus, pairs (1) and (2, 3) reject the null hypothesis at 5 % and 1 % statistical significance, respectively. The Mann-Whitney test results statistically confirm that the distribution of terminal periods is significantly different among FGM, PRM and PEM (baseline). The overall percentages of red-chip termination among all termination instances are 33 %, 16 % and 15 % in FGM, PRM and PEM (baseline), respectively. Red-chip terminations are more common for FGM than PRM and PEM (baseline). These results are consistent with the theoretical prediction that the fraction of red-chip termination should increase with the duration of the game.

Given these statistical significances of the Mann-Whitney tests, we run median regression models to characterize the treatment effects and perform the robustness check by taking terminal periods as a dependent variable. Table 1 reports the coefficients of the independent variables on terminal periods in median regression models 1 to 4. Independent variables are treatment dummy variables for FGM and PRM as opposed to the PEM (baseline), the percentage of prosocial members in each group and other sociodemographic variables averaged over group members. Table 1 reports the estimated coefficients and their respective standard errors with statistical significance. In model 1, both FGM and PRM treatments exhibit positive effects on the median terminal periods with 1 % significance level. Specifically, the median terminal period is estimated to increase by 3.13 times in FGM and by 2.52 times in PRM in comparison to PEM (baseline), given that all other factors are fixed. These effects are considered economically significant, illustrating the strong effects of treatment dummies. Note that FGM treatment corresponds to a situation where rural resource users live long with the same members to maintain the resources or approximates a situation as if kinship successors are determined to take over the resources. On the other hand, PRM (PEM baseline) is designed to mimic a situation where rural resource users die with (without) non-kinship people to take over the resources. Thus, we conclude that the existence of non-kinship successors is a key to triggering people's altruistic motives for outliving themselves or leaving something behind in an aging society, affecting how resource users behave for intragenerational peers and intergenerational resource sustainability.

Table 1 represents the results of the median regression with other model specifications by incorporating sociodemographic parameters as independent variables. The main results of models 2, 3 and 4 do not differ from those of model 1 and the percentages of prosocial members in a group have a statistically significant effect at 1 % level in all models 2, 3 and 4. The estimated coefficient for the percentages of prosocial members in a group is statistically and economically significant; an increase in the percentage of prosocial members by 100 % is estimated to result in an increase in the median terminal periods by 6.72 times. These results show that prosociality is a robust predictor for resource sustainability in rural areas in agreement with some literature (Shahrier et al., 2016, Timilsina et al., 2017). Model 3 in table 1 excludes treatment variables and include sociodemographic as well as social capital variables. We have found that only prosociality affects the terminal periods in positive directions. As shown by prior studies, treatment dummies may result in biased estimates when their effects on other predictor variables are not negligible (Jacob et al., 2018), and thus we have tried different regression specifications as above. In summary, the number of prosocial members and the treatment variables have significant effects, irrespective of the specifications used in the models.

4 Discussion and conclusion

Our major interest is to reveal how the presence/absence of kinship or non-kinship successors may affect CPR sustainability with resource users in rural areas where population flows out through death or migration. To achieve this goal, we have conducted a dynamic common pool resource (CPR) experiment in Nepalese rural areas. In the areas, population outflow (death and outmigration) and inflow of successors (birth and immigration) were controlled by means of probabilistic exit and entry, respectively, of members in groups of subjects. The results suggest that the CPR sustainability is highly dependent on how population flows in and out. Specifically, stationary

Table 1: Median regression for terminal periods of a dynamic CPR game

	Model 1	Model 2	Model 3	Model 4
Group with FGM treatment	5.00***	3.33***		3.13***
	(0.833)	(0.737)		(0.840)
Group with PRM treatment	3.00***	2.67***		2.52***
	(0.927)	(0.788)		(0.907)
Percentage of prosocial members in a group		6.67***	7.30***	6.72***
		(1.33)	(1.651)	(1.489)
Percentage of male members in a group			1.21	0.54
			(1.370)	(1.188)
Av. education in a group			0.17	0.01
			(0.189)	(0.166)
Av. age in a group			0.01	−0.01
			(0.061)	(0.054)
Av.household income in a group			-5.05×10^{-7}	-2.74×10^{-7}
			(7.59×10^{-6})	(6.69×10^{-6})
Constant	1.00***	−2.33**	−2.88	−2.22
	(0.626)	(0.966)	(3.498)	(3.033)
Number of observations	157	157	157	157
Pseudo R^2	0.18	0.25	0.15	0.25

Numbers in parentheses are robust standard errors
***significant at the 1 percent level, **significant at the 5 percent level and *significant at the 10 percent level.

societies with fixed and long-lived members (or with kinship successors) are the most sustainable (FGM), and societies with non-kinship successors are the second-best sustainable (PRM). Sustainability is minimized when population flows out without any successor (PEM baseline). The results identify that the presence of successors irrespective of kinship or non-kinship relation makes a large difference for CPR sustainability (FGM versus PEM baseline or PRM versus PEM baseline), being particularly insightful in terms of resource management and transfers in rural societies of many countries. Overall, the results can be interpreted to be a warning that resource sustainability will be significantly damaged by the recent trend of population declines that is universally occurring in rural areas.

The reason why FGM (PRM) and PEM (baseline) result in significantly different degrees of sustainability is far from being obvious from theoretical points of view and worth discussing in the details. On the one hand, the PEM (baseline) result in which the resources were quickly depleted seems to be in line with some classical theory of rational agents in economics as well as theory of biological evolution based on natural selection acting upon genes' selfish reproductive success. Basic theory of behavioral evolution predicts that animals or humans should generally care only about their benefits and their kinship relation, unless some reciprocity mechanisms are involved (Hamilton, 1970, Nowak and Sigmund, 2005, Dawkins, 2006, Clark et al., 2020). They should not care about prefect strangers' benefits with whom they and their kinship persons will never interact directly or indirectly in the future. In addition, human psychology is under the influence of natural selection and understandable at least in part by the theory of evolution. Thus, it is obvious that resource users in a society would care about sustainable management of local resources if their own descendants (kinship successors) will succeed to the resources. Clearly, such a biological argument does not apply to the PRM result where no kinship is involved. It is well acknowledged that human behaviors often apparently deviate in this way from the theoretical predictions based on selfish players or genes, Nowak and Sigmund (1998), Bowles and Gintis (2002), Saulin et al. (2018) and Beeler-Duden and Vaish (2020), and it seems that our result in PRM treatment provides an example of such deviations.

From another viewpoint, it is worth discussing why subjects in PEM (baseline) do not cooperate to make the resources sustainable, while those in PRM do. Note that the two settings are different only in terms of the presence/absence of successors. In both settings, the probability that two of the three subjects draw red chips and hence exit simultaneously is only 0.01, being very tiny. Thus, even when a subject exits the game in PEM (baseline), the other two members of the same group are highly likely to stay in the game. Therefore, if subjects are willing to save resources for their successors as found in PRM, they should do so for the current group members for the same reason in PEM (bseline) as well. However, this is not what we find in the experiment, i.e., the resource is depleted much earlier in PEM (baseline) than in PRM.

There may be multiple mechanisms underlying the nontrivial difference. Specifically, guilt aversion or its flip side, such as warm glow, might play some roles in explaining the results. Guilt aversion and warm glow can impose some pressures on subjects to restrain themselves from being selfish or unsustainable for several reasons. First, the expected number of other subjects affected by her/his decisions are larger in PRM than in PEM (baseline); it is exactly two in PEM but more in PRM. Therefore, subjects may understand the impact of their decisions on others, feeling guilty, or similarly, warm glow. With the same logic, subjects in PEM (baseline) can put less weight on future resource use, because their restraining effort is likely to be wasted due to the extinction of the group due to the exit of members. Second, in PRM, the sense of guilt might have been further enhanced by the asymmetric structure of intergenerational competition reminiscent of the dictator game. That is, a subject in the current group can steal everything from her/his potential successors who join the game afterward, but the opposite is not true. Thus, future members are socially weak, and one would feel uncomfortable in stealing from such weak people. A very similar explanation is that the sense of responsibility is evoked by the asymmetric structure. That is, subjects might have paid attention to the successors' benefits, because the successors do not have neither controls nor voices over the current members' decisions, and hence the current members are entirely responsible for the consequences of the decisions (Syropoulos and Markowitz, 2021). Perhaps such explanations similarly apply to past field experiments in rural areas of Bangladesh and Nepal where it is shown that people care about fairness and welfare of future generations (Shahrier et al., 2017, Timilsina et al., 2021).

Whatever psychological mechanisms are involved, it seems that restraint is meaningful for subjects so long as the game is continued by someone, if not by themselves. In fact, in the post-experiment interviews, subjects in PRM comment that they ought to maintain the resource pool for future players. If the same logic and account apply to real societies, teaching a intergenerational nature of common pool resources among resource users or making them conscious about the presence of successors seems to be key for resource sustainability, as argued in (Bardsley and Sugden, 2006). That is, societies may lose sustainability if members are not conscious enough about the possible consequences of their myopic decisions on future generations who have neither controls nor voices. This argument may apply not only to the problem of declining local populations but even to a stable or growing population in which the intergenerational nature of common pool resources is increasingly obscured by the global transfers of resources. Some studies with dynamic CPR games also show that making subjects well-aware of the intergenerational influences of their decisions can change their behaviors to increase sustainability (Shahrier et al., 2017, Timilsina et al., 2021). In these studies, generations are set to be non-overlapping which is considered an ideal experiment setup to make generational interaction completely asymmetric. Such non-overlapping generation games, however, do not allow simulating many factors supposedly important in considering declining rural populations. Those factors include aging, uncertainty about life length, gradual reduction of the population size and replacement of outgoing individuals by successors (or overlapping nature of generations). Thus, our setup adopting probabilistic exit and entry of members is better suited for the problem of declining rural populations, and perhaps it is generally considered realistic as a model of human societies in many situations. Overlapping-generation games are, however, more complex than non-overlapping generation games, and therefore understanding psychological mechanisms causing the differences between treatments shall be challenging.

We mention some limitations and directions for future research. The current experiments do not underpin some real motivations of resource users regarding why people care about non-kinship successors. Therefore, future research shall collect the details about subjects' motivations through post-experiment interviews and exploring such mechanisms may be promising. The underlying motivations can be linked with community norms, social interactions and individual networks to identify the non-kinship succession orientations in societies. Finally, we note that the probabilistic exit and replacement of group members introduced by the present study can be applied to other experimental settings to study the effects of uncertain life combined with different life experiences of an individual. These caveats notwithstanding, we believe that this study is an essential first step to characterize resource sustainability concerning the existence/absence of kinship and non-kinship successors. The absence of proper succession policy even with non-kinship warn that some unique common pool resources may face sustainability problems.

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Detailed instruction of the social value orientation (SVO) games

[Figure 3 about here.]

List of Figures

Figure 1: Rural areas of Nepal: Locations of the field experiments, Gorkha, Lamjung, Palpa, Rupandehi, Chitwan, Dhading and Makwanpur

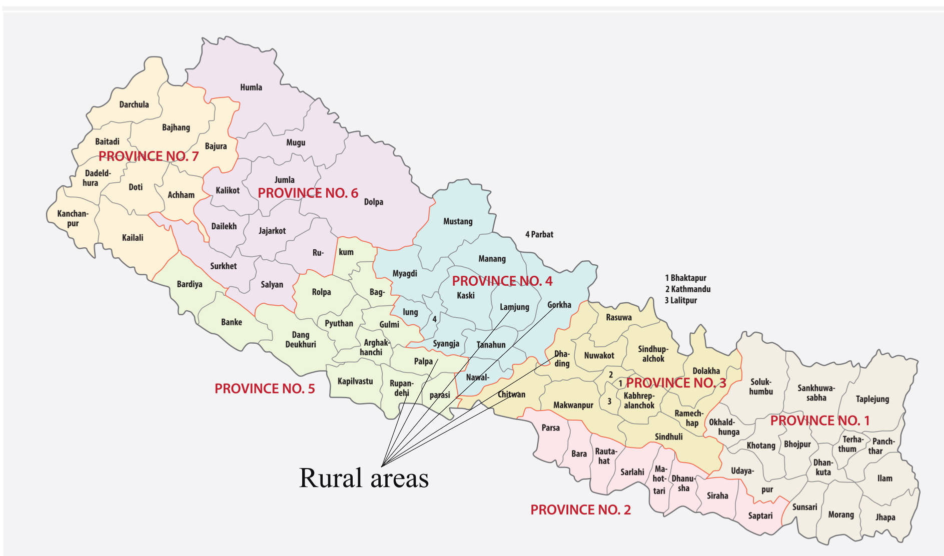


Figure 2: Distributions of terminal periods across the treatment with PRM, FGM and PEM (baseline): The numbers in the support (domain) of a histogram corresponds to terminal periods while the range represents frequency

(a) FGM (b) PRM (c) PEM

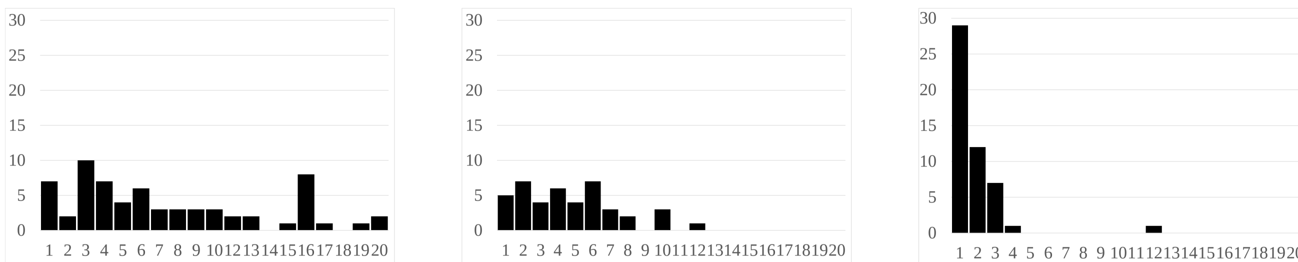
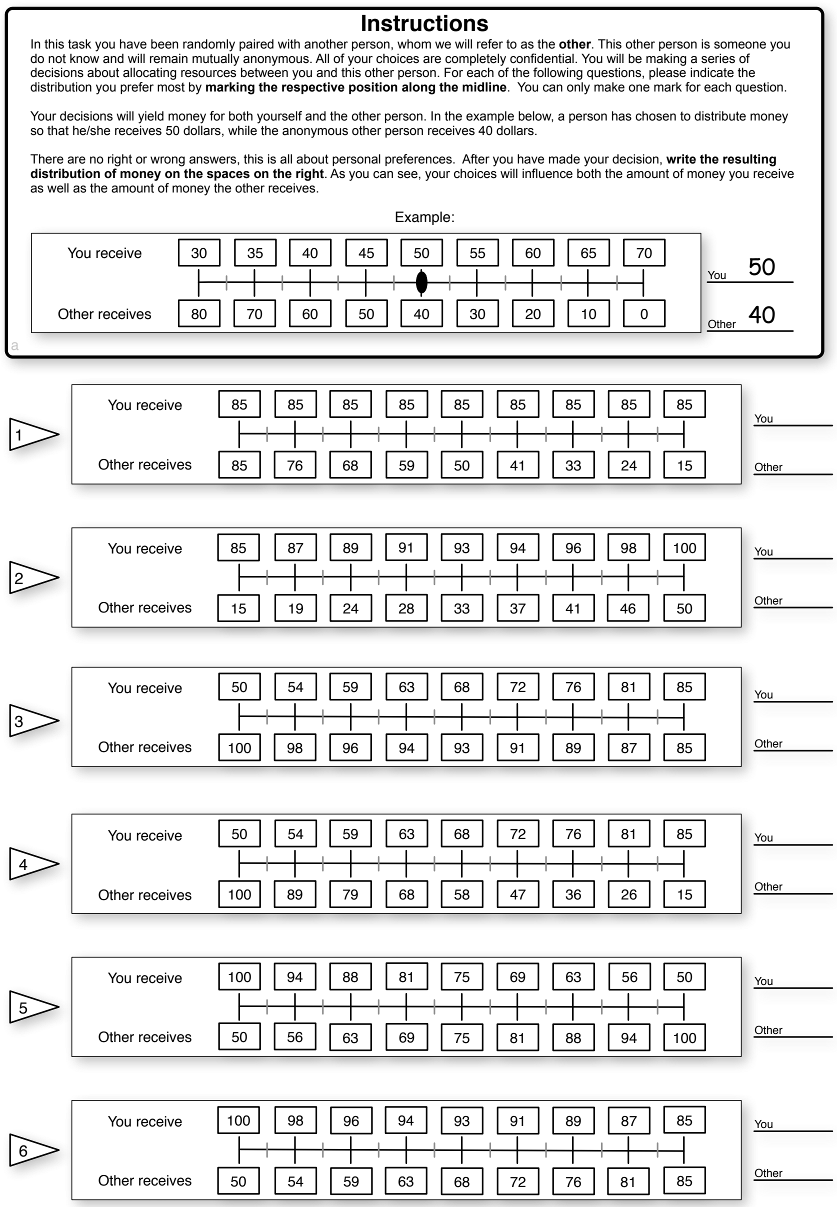


Figure 3: Instructions for the “slider method” to measure social value orientations (Murphy et al., 2011)



List of Tables

Table 2: Summary statistics of the subjects' sociodemographic information and the experimental results of groups

	FGM	PRM	PEM (Baseline)	Overall
The terminal periods[1]				
Average (Median)[8]	7.63 (6.00)	4.67 (4.00)	1.80 (1.00)	4.98 (3.00)
SD[7]	5.56	2.80	1.68	4.67
Min	1.00	1.00	1.00	1.00
Max	20.00	12.00	12.00	20.00
Percentage of prosocial members in a group[2]				
Average (Median)	0.75 (0.75)	0.61 (0.60)	0.61 (0.50)	0.67 (0.75)
SD	0.23	0.23	0.21	0.23
Min	0.25	0.00	0.25	0.00
Max	1.00	1.00	1.00	1.00
Percentage of male members in a group [3]				
Average (Median)	0.38 (0.25)	0.43 (0.45)	0.34 (0.25)	0.38 (0.25)
SD	0.30	0.30	0.31	0.30
Min	0.00	0.00	0.00	0.00
Max	1.00	1.00	1.00	1.00
Education (Years)[4]				
Average (Median)	9.60 (9.50)	8.81 (9.21)	8.65 (8.63)	9.09 (9.25)
SD	2.21	2.35	2.41	2.30
Min	4.75	3.50	4.25	3.50
Max	16.00	12.40	13.00	16.00
Age[5]				
Average (Median)	33.99 (32.50)	38.04 (38.51)	33.74 (33.50)	34.99(34.00)
SD	7.39	8.85	5.80	7.55
Min	20.00	20.75	21.75	20.00
Max	56.00	52.50	45.75	56.00
Average income [6]				
Average (Median)	92.32 (95.00)	95.95 (100.00)	117.42 (114.37)	101.29(100.00)
SD	61.75	27.99	49.54	51.63
Min	22.50	43.75	25.00	22.50
Max	265.00	150.00	285.00	285.00
Number of groups (N)	65.00	42.00	50.00	157.00

[1] Average terminal periods of groups.
[2] Average percentage of prosocial members in a group categorized by "SVO".
[3] Average percentage of male members in a group.
[4] Average education level of the group members represents by the years of schooling.
[5] Average age of group members.
[6] Average yearly households income level of a group given in thousand (000).
[7] SD, stands for standard deviation.
[8] Median in parentheses.
Fixed group member (FGM), probabilistic replacement member (PRM) and probabilistic exit of member (PEM)