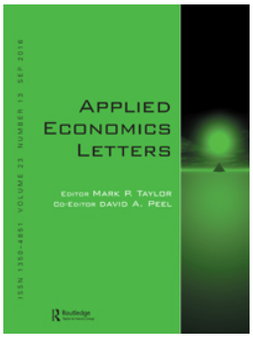

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Exploring the role of gender in common-pool resource extraction: evidence from laboratory and field experiments in fisheries

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ABSTRACT
There is active debate on gender issues in natural resource management. For example, it is proposed that women are more cooperative than men when dealing with natural resources decisions; however, few scientific studies have directly addressed this hypothesis. We provide evidence for a greater cooperative attitude in women compared to men in both college students and coastal fishing communities of Baja California, Mexico, by means of game theory experiments. In both laboratory and field experiments, women changed their behaviour towards lower extraction compared to men, when regulations, sanctions or social scolding were introduced in the games. These results suggest that raising the role of women in decision-making, along with an adequate institutional framework, may lead to a more sustainable use of natural resources.

KEYWORDS
Experimental economics; gender economics; sustainable behaviour; natural resources

JEL CLASSIFICATION
C92; C93

I. Introduction

Gender is an important but neglected issue in sustainable development (Davidson and Black 2001; Westermann, Ashby, and Pretty 2005). Natural resource extraction has been a male-dominated activity in a majority of societies and cultures worldwide, with women typically removed from decision-making processes (Bennett 2005; Gupte 2004; Upadhyay 2005). It has been proposed that this marginalization has important consequences for the sustainability of natural resource extraction. Thus, it is critically important to explore this issue further and to test the hypothesis that cooperative attitudes vary with gender.

Field observations suggest that women have, under some circumstances, more sustainable attitudes than men. An anthropological study in Baja California, Mexico, on gender and social capital (Noguera 2008) showed than young women are more interested in both the sustainable use of natural resources and in aesthetic values than men. In contrast, all interviewed men expressed their interest to join the fishery but mainly for earning 'good money' (Noguera 2008). Similarly, in our field projects in Baja California, we have observed than women are more willing to invest their time, resources and energy to develop a sustainable management plan in comparison with men. A fishing cooperative exclusively formed by women in Loreto, Baja California Sur, worked with one of us for many years in order to set up a management plan concerning marine aquarium species before starting to fish. Once they reached sustainable standards, including an evaluation of the total allowable catch and proposing marine protected areas as a reference to understand the variation on the populations exploited, they began to market the fish in the United States, which helped them raise their price by one order of magnitude. After the implementation of their management plan, they became a national example of stewardship and good management practices. In the same village, men did not get organized to collectively fish for sea cucumber, which had since the beginning a good price in the market. In this case, fishers got organized to improve their management only after they saw the benefits reaped by the organized women.

However, other examples suggest that competitive attitudes also exist among women. For example,

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Agarwal (2000) points out that when a precarious situation is present (e.g. extreme resource scarcity), women look after themselves and their children, rather than for the collectivity, becoming an important agent in enhancing natural resource overexploitation (Nebasina 1995).

The aim of this paper is to directly assess whether gender differences exist in attitudes towards natural resource extractions, and whether women are more likely to adopt cooperation when faced with social dilemmas of common-pool resource exploitation (Berigan and Irwin 2011; Simpson 2004).

II. Material and methods

Experiments were based on Cardenas (2004) and Moreno-Sanchez and Maldonado (2009). Laboratory experiments were carried out with undergraduate students (n = 85 players) from several majors at UNAM (University of Mexico), in Mexico City. Subjects were asked to decide on harvesting levels of a hypothetical fishery under common access. Field experiments involved inhabitants of Isla Natividad (i.e. islanders; n = 40 players), a fishing island off the west coast of Baja California, Mexico.

Laboratory experiments

Experiments comprised two stages, each made up of five rounds and were played by groups of five people (Cardenas 2004). The whole experiment consisted 10 rounds of extraction. The first five rounds served as a baseline, where players could extract resources (fishes) in the absence of regulations. From the sixth round onwards, the maximum allowable catch level is announced and enforced randomly on 20% of players in each round. We applied three treatments, consisting of a baseline or control group treatment (n = 30), which remained in 'open access' (i.e. no regulations and enforcement were applied), and two enforced treatments, where a maximum extraction level was recommended by the 'authority' (which corresponds to the social optimum or Pareto-efficient equilibrium, i.e. one fish per round): public scolding (n = 20) and a penalty (n = 35) when a player was found extracting more than the recommended level. In the public scolding treatment, if a player chose a catch level higher than what allowed and was monitored, a public reprimand of his/her action was given, though benefits were kept by the player for that round. In the penalty treatment, if a player was found choosing a higher catch, a zero benefit was assigned in that round. If he/she was not monitored, the player kept his/her benefits. At the beginning of the experiment, each participant was informed about the objectives of the experiment and use of the data, and signed a written consent. At the end of the experiment, players filled in a questionnaire containing information on their gender, age, career and household income. Students knew before starting the game that there would be only one winner: the player who obtained the greatest total score received the equivalent of US$40 in cash. We decided to use this winner-takes-it-all format because we considered US$40 to be a powerful economic incentive for a public university student in Mexico (the UNAM allowance for undergraduate students is about US$130 per month). In this way, students presumably took the game seriously and focused on taking the decisions they thought would increase their chances of winning.

Field experiments

Field experiments were carried out at Isla Natividad (Figure 1), and included both men and women older than 16 years. The experiment design was the same as the one applied to UNAM students, but several on-site adjustments were implemented. We formed eight groups of five people (40 people in total, 24 men and 16 women), who represented approximately 16% of the total adult population in the island. All groups were exposed to the same experiment with the same treatments. Subjects played 20 rounds. In the first five (rounds 1 – 5), they had to decide on catches from one to eight resource units, knowing that the points or benefits would depend on both their individual and group decisions. For the following five rounds (rounds 6 – 10), participants were told that the rules remained the same, except that one person would be randomly enforced in each round. If a player chose a level higher than one fish and was monitored, a public reprimand of his/her action was given but keeping his/her benefits for that round. In rounds 11 – 15, the enforcement continued but, as with the students, the enforcement involved a penalty so that a zero benefit in that

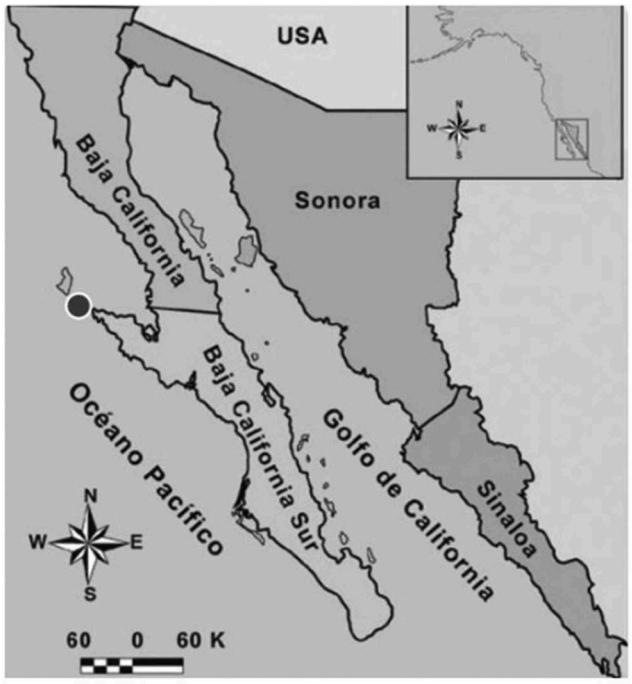

Figure 1. Location Isla Natividad (dark point), Baja California, Mexico.

round was assigned if the player cheated, otherwise, he/she kept his/her benefits but no public scolding was made. The final rounds (rounds 16 – 20) allowed communication among participants but without enforcement. Thus, in the final rounds, the players could discuss their strategies with the rest of the group. At the beginning of the experiment, each participant was informed about the objectives of the experiment and use of the data, and signed a written consent. At the end of the experiment, players filled in a questionnaire containing information on their gender, age, activity, household income, membership in the fishing cooperative and number of children. As with students, we applied a winner-takes-it-all format, where the prize consisted of a new laptop computer (value: US$840).

Econometric estimation

The econometric model was the same for both students and islanders, but the game variables (Z) and socioeconomic variables (W) presented several differences:

$$Cat_{(i,t+1)} = f\left(Cat_{(i.t)} - 1; Cat_{(j,t)} - 1; \left|Points_{(i,t)} - Points_{(j,t)}\right|; Z; W\right)$$

Where catches of fisherman i in period (i.e. round) $t + 1$ are a function of:

- Deviation from the social optimum catch in the previous round; such a variable measures a player's no-cooperation propensity (PROPNCM). This variable is important to measure the degree of cooperation by the individual before the group and for cooperating with the sustainability recommendations.
- Deviation of the average catch of other players in a previous round; such a variable measures the no-cooperation propensity of the rest of players (PROPNCO). This variable measures the willingness of players for improving society's welfare, even when other players increase their catch. This variable might reflect a level of self-regulation or co-management, as they try not to deplete the natural resource, in order to have a sustainable catch over time.
- Difference in absolute value of a player's points with respect to the rest of the group in the previous round; such a variable measures the player's aversion towards inequality (PRODES). This variable is adapted from Falk, Fehr and Fischbacker (2002).
- Game variables (Z) for students only:
  - TREATMENT is a categorical variable that takes the value of one for the baseline treatment, a value of two for the public scolding treatment and a value of three for the penalty treatment.
  - STAGE of the game, which takes the value zero for the first five rounds and one for the last five rounds.
- Game variables (Z) for islanders only:
  - TREATMENT is a categorical variable that takes the value of one for the baseline treatment, a value of two for the public scolding treatment, a value of three for the penalty treatment and a value of four for the cheap-talk treatment.
  - STAGE of the game, which takes the value zero for the first five rounds and one for last fifteen rounds.
  - EFFECT is a categorical variable that takes a value of one if the player believes that public scolding is more effective to comply with recommended catch levels, a value of two if

the player thinks that a penalty is more effective for complying and three if the player thinks no regulation is effective. The difference between treatment and effect is that the latter was a direct question, while the first is a rule of the game.
  - TRUST is a categorical variable that takes the value of one if players have trust in public institutions, a value of two if the player has trust in private institutions and three if players have no trust in neither.
- Socioeconomic variables (W) for both students and islanders:
  - AGE
  - GENDER
- Socioeconomic variables (W) for islanders only:
  - INCOME is a continuous variable.
  - JOB is a dummy variable with a value of one if the player presents activities directly related to the sea, and a value of zero if otherwise.
  - MEMBER is a dummy variable with a value of one if the player is a member of a fishermen's cooperative, and a value of zero if otherwise.
  - CHILDREN is a dummy variable with a value of one if the player has children, and a value of zero if otherwise.

The econometric models were balanced-panel models, which include both cross-sectional data (players decisions a given round) and time series data (players decisions throughout rounds). We chose to use a variable-effects panel model because such specification includes variables that do not change within observations (i.e. the same player) but do change among players (e.g. gender and age). Furthermore, the best model specification was chosen according to the following tests: Breusch and Pagan test, F-test of significance, Hausman test, as well as autocorrelation, heteroscedasticity and contemporaneous correlation tests.

III. Results and discussion

Laboratory experiments

Figure 2 shows that, among students, women extraction was more sustainable than men's as women, but not men, lowered their extractions after game rules were changed and 'the authorities' recommended a sustainable level of extraction (i.e. second stage of the game).

Table 1 indicates the signs of the parameter estimates for the econometric model for students. The intercept is positive and significant, indicating that in the absence of other variables in the model, students chose harvesting levels of about 4.5 units. This variable comprises nonobserved effects such as the players' social status or cultural values.

The variable parameter which measures the proportion of noncooperation (PROPNCM) by the player is positive and significant. This indicates that if the player's catches deviate more from the social optimum in the previous round (i.e. she does not follow sustainability recommendations), catches in the following round will be higher. For example, if his/her level of catches in an earlier round deviates one unit away from the social optimum, in the next round he/she will harvest 0.37 units.

The variable PROPNCO indicates that if average catches of members from the rest of the group deviate in one unit from the social optimum, the player will reduce his/her catch in 0.2 units.

With respect to the variable that measures aversion to inequality (PROPDES), the sign is positive and significant. This variable indicates that if average earnings observed among the rest of the group increase in the earlier round, in the next round the player will try to increase her individual earnings. As the parameter value was rather low (0.002) among students, it indicates that they are rather indifferent to inequality. In other words, students pursue higher earnings without concern for collective benefits, an attitude that indicates a low level of social capital.

The GENDER variable presented significant but small effect. The fact of being male indicates that he will harvest 0.1 additional units in comparison with females.

The AGE variable demonstrated that older players harvested less than younger players in about 0.06 resource units.

Finally, the TREATMENT variable indicates that a policy based on penalties seems to be more efficient to reach the social optimum among university students than public scolding.

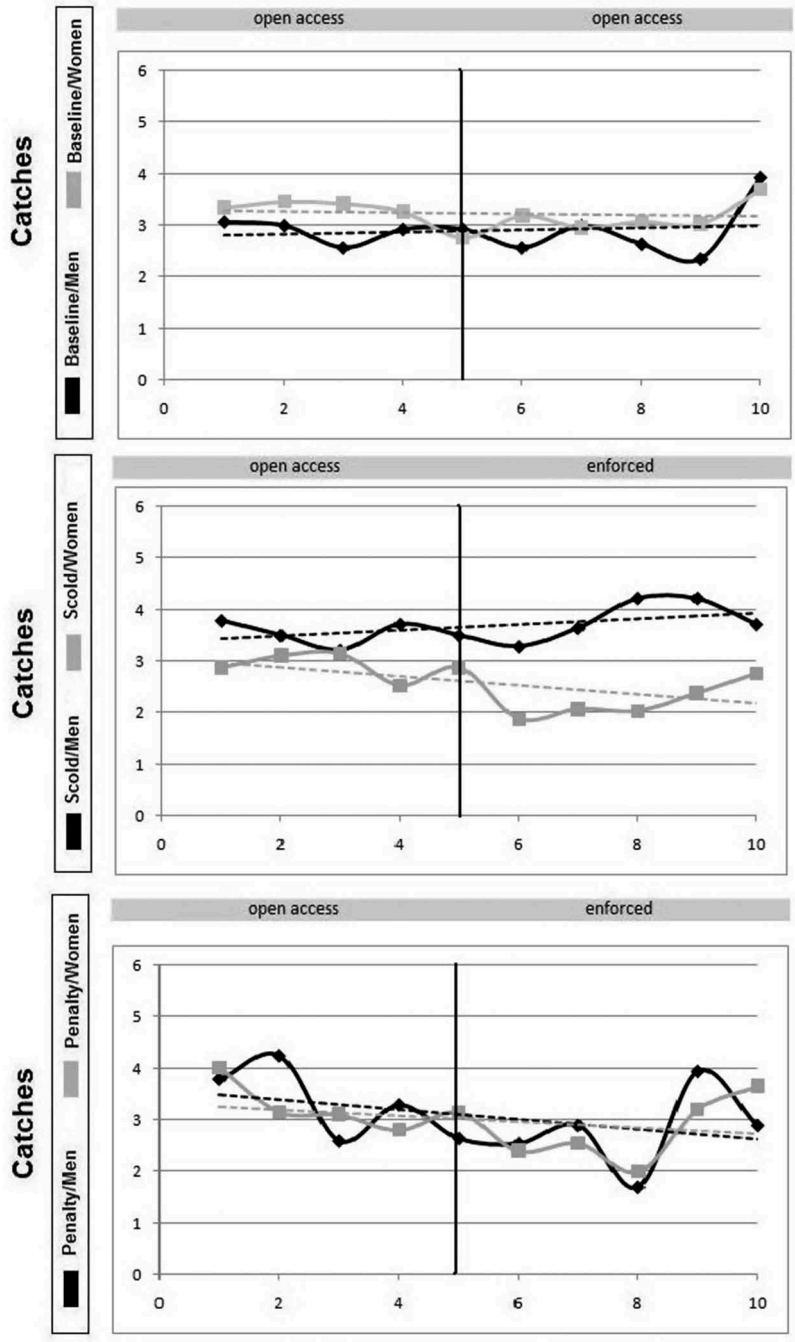

Figure 2. Paths showing the chosen level of extractions by gender among university students in two-stage experiments, where stage 1 is the baseline (open access) and stage 2 is after rules have changed (enforcement). Top: control group. Middle: treatment with public scolding. Bottom: treatment with penalty.

ANOVA test: reject the null hypothesis, at least one group is different ($p < 0.001$).

Field experiments

The variation in average catches according to GENDER among islanders under different treatment demonstrates that women are more responsive than men, reducing their average harvesting levels (Figure 3). Public scolding had a greater effect in women (reducing catches in 53%) than in men (reducing catches in 23%). Penalties had similar effects for men (reduction of catches of about 37%) and women (44%).

Table 2 shows the results of the econometric model for islanders. The constant term in the

Table 1. Results from laboratory experiments with undergraduate students at UNAM, Mexico.

Cat (t + 1)	Coef.	Het-corrected SE	[95% Conf.	Interval]
PROPNCM	0.371***	0.041	0.291	0.452
PROPNCO	−0.198***	0.064	−0.324	−0.071
PRODES	0.002**	0.001	−0.001	0.003
STAGE	−0.192	0.152	−0.491	0.106
GENDER	**0.094***	**0.148**	**−0.197**	**0.385**
AGE	−0.063	0.025	−0.197	0.385
TREATMENT	−0.136*	0.085	−0.302	0.030
Cons	4.498	0.693	3.139	5.857
Number of obs.	765			
Number of groups	85			
Prob > chi^2	0.000			

S.S.: * = 10%, ** = 5%, *** = 1%.

econometric model indicates that players harvested, in average, about 3.0 units. Compared to students, islanders had a lower catch levels. This might indicate that their decisions were influenced by nonobserved factors such as stewardship towards natural resources, or cultural values that are transmitted through generations.

The variable that measures noncooperation by players (PROPNCM) indicates that their harvesting levels deviates less from the social optimum in comparison with students.

The variable PROPNCO indicates that for each unit harvested by one player in the previous round, another player will catch 0.15 resource units. This coefficient shows the degree of punishment or retribution that players apply for the behaviour of other players. For students, such coefficient was −0.19, which means that, for each additional resource unit taken by the rest of players, in the next round, the player will decrease her catch in 0.19. Therefore, islanders have a greater concern for punishing the behaviour of fellow players than students have. We might conclude that a sense of community is stronger among islanders than among students.

The variable PROPDES presented a coefficient of 0.0012 among islanders, while in the case of students, it was 0.0017. We observe then that students are: either

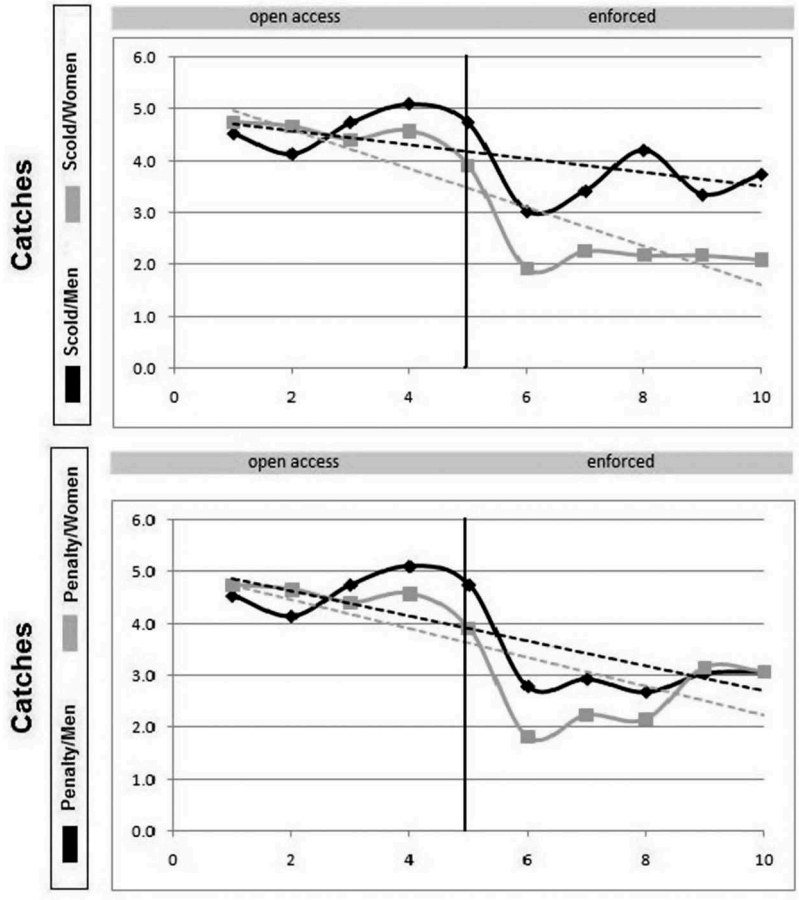

Figure 3. Paths showing the chosen level of extractions by gender among islanders in two-stage experiments, where stage 1 is the baseline (open access) and stage 2 is after rules have changed (enforcement). Top: treatment with public scolding. Bottom: treatment with penalty.

ANOVA test: reject the null hypothesis, at least one group is different ($p < 0.001$).

Table 2. Results from laboratory experiments with islanders at Isla Natividad, Mexico.

Cat (t + 1)	Coef.	Het-corrected SE	[95% Conf.	Interval]
PROPNCM	0.309***	0.042	0.225	0.392
PROPNCO	0.147***	0.060	0.028	0.266
PRODES	−0.001***	0.001	−0.002	−0.003
STAGE	−1.551***	0.251	−2.043	−1.059
GENDER	**1.048*** **	**0.295**	**0.469**	**1.626**
AGE	−0.008	0.010	−0.028	0.012
INCOME	0.001***	0.000	0.000	0.000
EFFECT	−0.613***	0.115	−0.838	−0.388
TRUST	0.198**	0.106	−0.009	0.405
JOB	−0.999***	0.272	−1.533	−0.466
MEMBER	0.325	0.232	−0.129	0.779
CHILDREN	−0.212	0.209	−0.621	0.198
TREATMENT	0.496***	0.088	0.323	0.669
Cons				
Number of obs.	760			
Number of groups	40			
Prob > chi^2	0.000			

S.S.: * = 10%, ** = 5%, *** = 1%.

less averse to inequality than islanders, or that islanders ponder more on physical units rather than in monetary units. Anyhow, for both groups this coefficient was rather small.

The variable STAGE shows that the imposition of a rule for enforcing catches led to reducing harvesting levels among islanders (an average of 1.5 units). Such reduction was higher in comparison with students (0.19 units). Thus, fisheries management was more efficient in the case of islanders.

When analysing catches with respect to GENDER, men harvested more than women in about one unit of resource. In contrast with students, this coefficient was significant and had a higher value for islanders than among male students. Thus, men presented higher harvesting levels than women in both lab and field experiments, but island women showed a more sustainable attitude than female students. As with students, AGE was inversely proportional to harvesting levels.

The variable TREATMENT shows that the best policy for islanders was public scolding, while among students it was a penalty. This means that a community sense of reputation had a greater weight in decision-making in islanders than among students.

INCOME was significant and shows that the higher the income, the higher the level of harvesting. However, the coefficient value was rather small (0.00003). The variable EFFECT, the public scolding treatment was confirmed as being the most effective deterrent.

An important variable is TRUST, because islanders expressed their confidence on institutions. Its coefficient had a value of 0.19 (statistically significant at 10%), indicating that the transition from a public to a private institution increased their catch by 0.19 resource units. Thus, we could argue that they have more confidence or respect for activities, rules and partnerships with private rather than public institutions (NGO). In this particular case, this may reflect the work of the NGO COBI (Comunidad y Biodiversidad A.C.) that for several years has been working together with the fishermen's cooperative of Isla Natividad.

The variable JOB (significant at 1%) shows that those islanders exclusively devoted to fishing, either diving or with administrative tasks in the cooperative, harvested on average less than those who are not engaged in such activities. This might measure the stewardship that fishermen have of natural resources. Nevertheless, we observed that if the player is a member of the cooperative (variable MEMBER), he would harvest on average 0.32 additional resource units compared to nonmembers. We may explain this either by a sense of exclusivity of fishing rights. Alternatively, people who are not members may have alternative activities for a living.

CHILDREN was not statistically significant but had a coefficient of −0.21, suggesting a possible sense of legacy to future generations since a player's harvesting levels diminished in 0.21 resource units if he/she had children.

IV. Discussion and conclusions

Our results demonstrated that women extractions were more sustainable than men's as they lowered their extractions after game rules were changed and 'the authorities' recommended a sustainable level of extraction (i.e. second stage of the game). In fact, for both men and women, a penalty resulting in lower benefits was an effective deterrent with respect to public scolding. However, in both treatments, women changed their behaviour towards lower extractions, whereas men did not care about being scolded as long as they won the game. In fact, many gender differences found in experiments are explained by the behaviour of women towards the context of the game, being more sensitive to experiment's rules (Croson and Gneezy 2009). Other studies have found that women can be more risk-averse than men (Eckel and Grossman 2008; Revollo and

Aguilar 2014), and that when dealing with resources directly related to nourishing, this trend is exacerbated (Bird 2007).

Although a number of international treaties have explicitly recognized the role of women in the use and conservation of natural resources, a gap still remains from agreements towards actual application (Deda and Rubian 2004). In fact, recognizing a formal role of women in natural resource use is rather recent and limited to some industrialized countries (Frangoudes and Keromnes 2008). It would be tempting to argue that women should replace men from natural resource management; however, a gender mix seems to be more effective as far as evidence is concerned. For instance, when women form part of forest management agencies in Nepal and India, forest condition either was better or improved than in regions without gendered institutions (Agarwal 2009). Thus, diminishing gender inequalities allows both women and men to enhance their economic welfare (Tindall and Holvoet 2008).

The key is thus to give women a formal and decisive role in top decision-making, along with men. Indeed, the presence of women leads to improved group functioning, greater cooperation, solidarity and conflict resolution, facilitating compliance by other women and thus reducing surveillance costs (Agarwal 2009; Meinzen-Dick et al. 1997; Westermann, Ashby, and Pretty 2005). Such attitudes, along with an adequate institutional framework, can lead to a more sustainable use of natural resources.

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