Collective management of an environmental threat when exposure is heterogeneous – A complementary methods approach

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Abigail Barr*, Trudy Owens* and Ashira Perera**

*University of Nottingham

**Oxford Policy Management

[1]**Abigail Barr: Affiliation** - University of Nottingham; **Address** - School of Economics, University of Nottingham, University Park, Nottingham, NG7 2RD, UNITED KINGDOM. ORCID: 0000-0002-1241-9162; Email - Abigail.Barr@Nottingham.ac.uk

[2]**Trudy Owens: Affiliation** - University of Nottingham; **Address** - School of Economics, University of Nottingham, University Park, Nottingham, NG7 2RD, UNITED KINGDOM. ORCID: 0000-0001-8676-2919; Email - Trudy.Owens@Nottingham.ac.uk

[3]**Ashira Perera: Affiliation** - Oxford Policy Management; **Address** - Oxford Policy Management, The Clarendon Centre, 52 Cornmarket St, Oxford, OX1 3HJ; Email – Ashira.Perera@opml.co.uk

Corresponding author: Trudy Owens, School of Economics, Sir Clive Granger Building, University of Nottingham, University Park, Nottingham, NG7 2RD. +44 (0) 115 9515477

Trudy.Owens@nottingham.ac.uk

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Abstract

We adopt a complementary methods approach to investigate whether and how heterogeneity in individual returns to a public good affects public good provision. We engage smallholder farmers in Sri Lanka in: a one-shot, framed, lab-in-the-field experiment, within which the farmers' rates of return to the public good are exogenously varied; and a survey including a question about the farmers' willingness to contribute time to the construction of a specific hypothetical public good, the return from which, for a given farmer, would depend on his or her circumstances in everyday life. In the former, we find weak evidence that heterogeneity in individual returns increases contributions. In the latter, we find that those facing a higher return would contribute more, but no evidence that heterogeneity has an effect, either way, at the group-level. We conclude that heterogeneity in returns does not explain why collective action remains a challenge in farming communities in developing countries. From a methodological point of view, we find that using complementary methods provides a more balanced account of communities' potential engagement in public good provision**.**

Keywords: lab-type behavioural experiment, collective action, heterogeneity, public goods game

JEL Classifications: C93, D81, O12

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1. Introduction

Multilateral organisations consider community involvement to be a key component in interventions aimed at generating and maintaining local public goods. The World Bank asserts that giving communities more agency through such projects is an important vehicle for inclusive growth, empowerment, social capital mobilisation, better governance and poverty reduction (World Bank, 2001). Reflecting this stance, Salomonsen and Diachok (2015) noted that over the preceding decade the World Bank community-based development (CBD) and community-driven development and reconstruction (CDD and CDR) interventions accounted for between 5 and 10 percent of World Bank lending.

However, fostering engagement and collective action in communities is proving difficult. It appears that even the many billions of dollars spent on CBD, CDD and CDR interventions have had very little effect on communities' capacities to act collectively once the interventions are complete. While Fearon *et al.* (2009) found a positive and significant effect in Liberia, Casey *et al.* (2012), Humphreys *et al.* (2015), Avdeenko and Gilligan (2015) and Baldwin *et al.* (2016) found no such effects in Sierra Leone, the Democratic Republic of Congo, Sudan, and Ghana respectively.

One possible reason for these disappointing results is that heterogeneity among those who need to act collectively suppresses their ability to do so. Bardhan and Mookherjee (2000, 2006), Khwaja (2004) and Mansuri and Rao (2004, 2013) present compelling evidence that within-community heterogeneities in power, influence, and social position undermine collective action within the context of CBD and CDD interventions. However, there is another type of heterogeneity that, while directly relevant, appears to have received little attention in the literature to date. It seems inevitable that, whatever public good a community commits to generating or maintaining, it will yield returns that vary across individual community members. This being the case, it may be that members who benefit relatively little will be disinclined to contribute. Knowing this, members who benefit relatively more may also be disinclined to contribute. If the positive effect of their higher return from the public good is outweighed by this negative effect of their concern about others free-riding, the heterogeneity could undermine the success and sustainability of public goods provision.

In the lab, studies involving public goods games with heterogeneous returns to the public good have yielded conflicting results about the impact of that heterogeneity on public good provision. Fischbacher *et al*. (2014) found that heterogeneity in returns lowered average contributions, while Marwell and Ames (1981) and Reuben and Riedl (2013) found the opposite. Fisher *et al*. (1995) and Molis *et al.* (2016) found no significant effect. Regarding the effect of returns on individual contributions, there was greater agreement, with Fisher *et al.* (1995), Reuben and Riedl (2013) and Molis *et al.* (2016) all reporting that subjects assigned a higher return contributed more. From this collection of papers, we could conclude that heterogeneity in public good returns across potential contributors is unlikely to be the reason for low local public good provision in rural communities in developing countries. We know, however, that student behaviour in lab experiments often differs markedly from that of developing country community members when engaged in similar experiments (see Henrich *et al.* 2005, 2016, 2010). Further, while experiments are ideally suited to facilitate the identification of causal effects, they do so at the expense of verisimilitude.

Linking behaviour in the lab and observed behaviour in the real world can provide a clearer understanding of the mechanisms driving the latter (Poteete and Ostrom, 2008; Falk and Heckman, 2009). Relevant to this paper, there is a small but growing literature linking lab-in-the-field experiments to real world environmental public goods and common pool resources (e.g., Cardenas and Ostrom, 2004; Aswani *et al*., 2013; Fehr and Leibbrandt, 2011; Rustagi *et* *al*., 2013). In Cardenas and Ostrom (2004) and Aswani et al. (2013) the link is realised by inviting people who rely on such common pool resources for their livelihoods to participate in the experiments and investigating how the socioeconomic characteristics of those people and their communities affect behaviour within the experiments. Fehr and Leibbrandt (2011) and Rustagi *et al*. (2013) take this a step further by investigating the relationship between individuals' behaviour in the lab and their behaviour relating to the real-world common pool resources upon which they depend. Fehr and Leibbrandt (2011) found that fishermen and shrimpers who were more cooperative and less impatient in the lab were less likely to exploit the common pool resources upon which they depend for their livelihoods. Rustagi *et al*. (2013) found that communities that had larger shares of conditional co-operators in lab experiments were more successful in forestry commons management.[i]

We apply two distinct methods in a field study aimed at establishing whether and how individual heterogeneity in public good returns impacts on public good contributions. One of our methods, similar to Bråten's (2014) one-shot public goods experiment in Peru,[ii] involves a one-shot, framed, lab-in-the-field, public goods experiment (PGG) designed to reveal subjects' willingness to contribute to public goods in the presence of exogenously-imposed heterogeneous returns from the public good. The second method involves a survey including a hypothetical contribution question (HCQ) where subjects state time contributions to the construction of a public good that would benefit them to varying degrees depending on their actual circumstances in everyday life. We examine whether local public goods provision is compromised when the returns from the public good vary across group members and whether an individual's willingness to contribute to the public good depends on his/her return from the public good.

We do this within the context of Sri Lanka's Human-Elephant Conflict (HEC) where smallholder farmers suffer from elephant-related crop and property damage, as well as deaths.[iii]

The country has one of the highest concentrations of the Asian Elephant population with over 10 percent now concentrated within two percent of the area of land in which they once roamed (Leimgruber *et al*., 2003). Curbing the land where elephants can roam for human settlements has meant that elephants frequently trample and consume crops in areas which were once their traditional migratory routes (Santiapillai *et al*., 2010). Consequently, communities settled in these areas face a growing risk of elephant-related damage.

Earlier studies by Bandara and Tisdell (2002), Jayawardene (1998) and De Silva (1998) suggest that the total economic value of crop and property damage due to the HEC amounts to US$11-12 million annually. Santiapillai *et al*.'s (2010) survey of 100 Sri Lankan villages found that 43 percent of respondents reported losing over US$200 through HEC which equates to eight months minimum monthly expenditure.

Our sample population is located in Wellawaya Divisional Secretariat, south-east Sri Lanka, and comprises 16,236 households (Department of Census and Statistics, 2013). We randomly sample 468 households from communities which are located on the periphery of three major national parks – Yala, Udawalawe (which has an elephant transit home) and Lunugamvehera – and therefore are highly exposed to the HEC. Within our sample of smallholder farmers, close to 60 percent have experienced crop damage over the three years prior to the survey.

The hypothetical local public good that the research subjects were invited to focus on was an electric fence within the community as it has the potential to mitigate exposure to the HEC risk for all community members by deterring elephants from encroaching on farmland. However, only 10 percent of the sample have access to an electric fence.[iv] Farmers themselves listed a number of reasons hampering adoption including the initial large personal outlay needed to invest in a fence and then maintain it and, for some, the concern that an individual small fence would not be effective if the whole village was not protected.[v]

The hypothetical fence presented to subjects in this study is a non-excludable and non-rival local public good designed to encompass an entire village and its surrounding cultivated lands. Provision and maintenance of the fence is subject to the free-rider problem which is well-documented in the microeconomics, behavioural, environmental and development economics literatures: selfish community members may not contribute to either its maintenance or construction but still enjoy the benefit of lower risk exposure arising from others' contributions. However, if everyone behaves selfishly, the fence will not be provided.

Our two chosen methodologies have differing strengths and weaknesses. In the lab-in-the-field PGG, we can exogenously manipulate returns to the public good, while controlling other aspects of the decision-making environment. Moreover, the PGG is incentivised so that the strategic component of decision-making about public good contributions is rendered highly salient to the subjects. The main weakness of the PGG is that the decision-making scenario may appear abstract and many steps removed from the reality of everyday life to the subjects: the experimental stakes are small relative to the cost of the real life public good; relative to the real life scenario, the strategic component may carry too high a cognitive weight in subjects' minds; and, relatedly, other aspects of the public good such as its technological novelty and the associated risks, while mentioned in the framing, may carry too low a cognitive weight in the subjects' minds.

The main strength of the hypothetical contribution question is that it is less abstract. The provision of an electric fence is a good example of a public good that is important to the communities surveyed. However, the HCQ is associated with less control and provides no opportunity to exogenously vary public good returns. It is also unincentivised, so more likely to suffer from hypothetical bias, and the subjects are likely to place less, possibly too little, cognitive weight on the strategic component of provision. Thus, the methods are complementary.

Bearing the relative strengths and weaknesses of our two methods in mind, we use each to address the same two research questions:

1.1: Are contributions to the public good in the PGG lower when the returns to the public good are heterogeneous compared to when they are homogeneous?

1.2: Are contributions to the public good in the PGG higher when the individual return from the public good is higher?

The other method, the HCQ, allows for a better match to context. We use this method to answer the following:

2.1: Are contributions to the fence in the HCQ lower in villages where the returns to the fence are more heterogeneous?

2.2: Are contributions to the fence in the HCQ higher when the individual returns from the fence are higher?

If both methods generate the same, or at least non-contradictory, findings, those findings can be viewed as providing a foundation for policy advice.

The paper is organised as follows: in Section 2, we present our experimental and survey designs; in Section 3, we describe our subject sample; in Section 4, we present our empirical results; and in Section 5, we summarise and discuss our findings before concluding in Section 6.

2. Experimental and Survey Designs

2.1 The lab-in-the-field Public Goods Game (PGG)

In the PGG designed for this study each subject decides whether to contribute or not to the public good, with each public good group made up of 16 individuals. The individual payoff (π_i) in Sri Lankan Rupees, from the PGG is:

$\pi_i = 400(1 - x_i) + m_i(x_i + \sum_{j \neq i} x_j)$, where $x_{i,j} \in (0,1)$ and $m_i \in (40,60,80)$. Subject i's payoff is determined by his/her contribution decision (x_i), which takes the value 1 if i contributes and zero if i does not contribute; the contribution decisions of his/her co-players ($x_{j \neq i}$); and his/her individual rate of return from the public good (m_i). The individual rate of return m_i varies according to the PGG treatment. The summation of $x_{j \neq i}$ is a count of how many of the other 15 subjects in the group contribute.[vi]

The PGG was framed as follows. A farming community which borders a nature reserve has an electric fence installed around the village to protect its crops from elephants, the farmers are responsible for its upkeep and each farmer in the community must decide whether or not to contribute to the maintenance of the fence. If the fence is poorly maintained, then it is more likely to break down and the farmers are likely to incur elephant-related crop damage. If all farmers contribute, then it will be well maintained. If one farmer decides not to contribute, (s)he will still benefit from the contributions of others, but if most of the farmers decide not to contribute, all farmers will suffer the consequences of being less well protected.[vii]

2.2 Treatments

The subjects' individual returns (m_i) from contributing to the group account varied depending on the treatment. We conducted two main treatments where all of the subjects in a group faced either *homogenous* returns or *heterogeneous* returns. Under the homogenous treatment there were three sub-treatments where individual returns varied from low to high: *hom40*, m_i =40, *hom60*, m_i =60 and *hom80*, m_i =80. Under each of these treatments the social optimum was for all subjects to contribute to the group account. Under *hom40*, *hom60* and *hom80* respectively, if all contributed, each subject earned R640, R960, R1,280, compared to R400 if none contributed.

Under the *het* treatment, half of the subjects in the group were assigned a low individual return (m_i =40) and half were assigned a high return (m_i =80). Below, we refer to these two sub-samples of subjects as being assigned to the *het40* and *het80* sub-treatments. Under *het*, if all contributed, each *het40* subject earned R640 and each *het80* earned R1,280, compared to R400 if none contributed. Under *het*, subjects knew that they were playing the PGG with other subjects, some of whom had different individual returns to their own, but did not know the proportion of subjects who had been assigned high(low) returns.

2.3 Subjects and treatment assignments

For the study we recruited members of 16 communities spread across six administrative areas of Wellawaya Divisional Secretariat, Monaragala District, Sri Lanka. In each community, a random sample of 32 household heads was drawn from the electoral register and each was invited to attend a day-long workshop or send another senior household member.[viii] Each workshop comprised of two experimental sessions and two sessions where a survey was conducted. On arrival at a workshop each subject randomly selected a badge on which was printed an ID number which indicated whether they were to attend the morning experimental session followed by the afternoon survey session, or vice-versa.

The aim was to have 16 subjects in each experimental session. However, not all the invited household heads showed-up or sent someone in their stead. Four sessions were so poorly attended that the PGG no longer represented a social dilemma and, so, had to be dropped from the analysis.[ix] The number of participants in the remaining 26 sessions varied between 16 (in 22 sessions) and 10.[x] In total, 404 smallholder farmers participated in the experiments. Table 1 presents the numbers of sessions and subjects per PGG treatment that we include in our analysis.

Table 1 here.

Table 1: Sessions and Subjects per treatment

	Sessions with 16 participants	Sessions with <16 participants	Sessions Total	Subjects

Hom40	6	0	6[#]	96
Hom60	5	1	6	92
Hom80	5	2	7	105
Het	6	1	7[##]	111

Notes: # one less than planned; ## three less than planned.

2.4 Implementation

The experiments and survey were conducted in Sinhala (the local language) with the assistance of local field researchers. The PGG began with a field researcher describing the game to the group of subjects in a session following a script written in Sinhala. Several examples were used to explain the maths of the game and, under the *het* treatment, the payoff structure was explained to high-return subjects and low-return subjects simultaneously to ensure complete comprehension. Each subject was then given a token on which they had to indicate their decision by circling one of two symbols printed on one side of the token (see Online Supplementary Material (OSM) Section B, Figures B1 and B3).[xi] After making his or her PGG decision, each participant was asked to guess how many of the other participants in his or her session had chosen to contribute. PGG earnings were calculated and paid at the end of the workshop.[xii] The average payoff in the PGG was Rs.624, which was equivalent to almost one day's farm wage at the time the experiments were conducted.[xiii]

2.5 The Hypothetical Contribution Question (HCQ)

In the individual-level survey, we asked a hypothetical contribution question (HCQ) regarding subjects' willingness to contribute time (in hours) to the construction of an electric fence. Focusing on time spent is salient in the HEC scenario given previous community-level interventions by NGOs in Wellawaya, and is relevant to the literature relating to community-driven development.[xiv] In this hypothetical scenario, a NGO provides the subjects' communities with the financial resources, construction materials and technical assistance necessary to construct an electric fence. Subjects decide how much time they are willing to provide to construct the fence.[xv] Subjects are given approximately five minutes to reflect on the scenario and to choose their time contribution from a menu of choices ranging from zero hours to more than twenty hours in two-hour intervals (see OSM Section E, Figure E1).[xvi]

2.6 Individual returns and heterogeneous returns in the HCQ

In the HCQ analysis, we proxy for individual returns from the collectively-owned electric fence using two survey variables. The first is *crop damage,* a four-year average of instances per month of HEC-related crop damage over the period 2011-14. The rationale is that those who have experienced more damage in the past will experience a greater reduction in damage once the fence is in place. The second variable is *proportion of income from farming*, which is the proportion of total annual household income in 2013/14 generated from agricultural activities. The reasoning is that those who rely more heavily on farming are, *ceteris paribus*, more exposed to the risks associated with the HEC and will therefore benefit more from the fence.

At the village level, we proxy for heterogeneous returns from the electric fence using the variance of *crop damage* and the variance of *proportion of income from farming* within a village, across households. These are denoted *var*(*crop damage)* and *var*(*proportion of income from farming),* respectively.

2.7 Control variables

As mentioned, only 10 percent of the sample owns a small-scale electric fence around the perimeter of their farms. To control for possible liquidity constraints, we include total household income. In addition, while an electric fence may be seen as an effective mitigating tool there is also concern that some farmers may be wary of adopting this relatively new technology. The negative effect of risk aversion on technology adoption in developing countries is well documented (Rosenzweig and Binswanger, 1993; Fafchamps, 2003; Foster and Rosenzweig, 2010; Dercon and Christiaensen, 2011) and can extend to public goods. To control for the potential impact of households' perceptions regarding the riskiness of adopting new technologies, and hence their contribution to the public good, we include a measure of risk aversion.

We elicited the subjects' levels of risk aversion by engaging them in a Binswanger-type (1980) gamble choice (GC) task (visual aid in OSM Section D, Figure D1). In this task, each subject had to choose one out of six gambles. Every gamble yielded either a high or low payoff, each with probability 0.5. The payoff from the chosen gamble was determined by playing a 'which-hand-is-it-in' game that involved the subject guessing which of the researcher's hands contained a blue (high payoff) rather than a yellow (low payoff) counter. Table 2 presents the six gambles, their expected values, and payoff standard deviations.

Table 2 here.

Table 2: Gamble Choice Task Choices

Gamble	Low payoff (Rs.)	High payoff (Rs.)	Expected value (Rs.)	Standard deviation (Rs.)
A	200	200	200	0
B	180	380	280	100
C	160	480	320	160
D	120	600	360	240
E	40	760	400	360
F	0	800	400	400

In addition, we control for HEC prevention effort using the variable *watch-huts,* which is the total number of watch-huts owned by a household. Inclusion of *watch-huts* allows us to investigate whether households who are heavily invested in the time-consuming, perilous, established approach of surveying their farmlands from watch-huts respond differently to the provision of the electric fence, which represents a relatively newer and potentially more efficient approach to HEC management. Finally, we also control for each subject's gender, age, years of schooling, marital status, household size, number of farm plots, whether the subject is a household head, and whether the household head is a farmer.

3. Descriptive Statistics

Table 3 presents descriptive statistics for the sample. The variable *contribute in PGG* equals one if a subject decided to contribute their token to the public good. In the PGG, 41 percent of subjects chose to contribute. The variable *HCQ contribution* is the number of hours a subject states that (s)he is willing to contribute to construction of the electric fence. 48.3 percent of subjects were willing to provide at least 20 hours to constructing the electric fence (see OSM, Section E, Figure E1). On average, subjects were willing to contribute 14.24 hours.

On average, there were 15.7 participants per session and sessions were evenly split between mornings and afternoons.[xvii]

The subjects are on average 44 years old, have 9 years of schooling, and live in households with 4 members. Two-thirds of the subjects are female, 88 percent are married, and 39 percent are household heads. Farming is reported as the main activity for 76 percent of the sample. On average, subjects' households earn 56 percent of their household income from agricultural activities (village-level variance ranges from 12 to 23 percent), and occupy 1.64 farm plots (*number of plots*). During the period 2011-2014, the average household experienced 0.77 instances of crop damage per month (*crop damage*) with the village-level variance of crop damage instances across households varying from 0.09 to 9.17.

Table 3 here.

Table 3: Variable Description and Descriptive Statistics for PGG and HCQ

Variable Name	Description	Obs.	Mean	Std.Dev	Min	Max
Games						
PGG contribution	1 if *i* contributed to the public good, 0 otherwise	404	0.413	0.493	0	1
HCQ contribution	Time *i* is willing to contribute to the construction of an electric fence (in hours, 0-20+, 20+ coded as 21)	404	14.238	6.423	0	21
Session characteristics						
Session size	Number of participants in session attended by *i*	404	15.658	1.152	10	16
Morning session	1 if *i* participated in the PGG in the morning, 0 otherwise	404	0.552	0.498	0	1
Individual characteristics						
Risk aversion	1 if *i* chose A or B in GC task, 0 otherwise	404	0.188	0.391	0	1
Age	*i*'s age in years	403	43.801	13.717	19	77
Female	1 if *i* is female, 0 otherwise	404	0.6756	0.469	0	1
Married	1 if *i* is married, 0 otherwise	404	0.876	0.330	0	1
Years of schooling	*i*'s total number of years of schooling	403	8.861	3.724	0	17
Household head	1 if *i* is the household head, 0 otherwise	404	0.394	0.489	0	1
Farming household head	1 if household head's main activity is farming, 0 otherwise	404	0.760	0.428	0	1
Household characteristics						
Household size	Total number of members in the household	404	3.864	1.342	1	8
Number of plots	Total number of farm plots occupied by each household	404	1.636	0.735	1	5
Watch-huts	Number of watch-huts on plots occupied by *i*'s household	404	0.688	0.706	0	4
Total household income	Log of sum of agricultural income from maha season 2013/14, yala season 2013, non-agricultural income in 2013 and remittances in 2013; annual figure	404	11.525	1.845	0	14.691
Proportion of income from farming	Household *i*'s agricultural income as a proportion of total household income in 2013/2014 (multiplied by 10)[xviii]	404	5.614	4.146	0	10
Crop damage	Average crop damage instances per month in 2011-2014	404	0.768	1.754	0	16.099
Var(crop damage)	Within-village variance of average monthly crop damage instances between 2011 and 2014 across households	404	3.048	3.291	0.086	9.167
Var(proportion of income from farming)	Within-village variance of agricultural income as a proportion of total household income in 2013/2014 (multiplied by 10) across households	404	15.938	2.202	12.681	22.699

Table 3: continued

4. Results

We begin by presenting mean treatment effects on PGG contribution decisions. Then, by estimating Logit and Tobit models, we analyse whether individual and heterogeneous returns affect contribution decisions in both the PGG and HCQ contexts.

4.1 Contributions in the PGG

On average, 41 percent of the subjects chose to contribute their token to the PGG public good. The proportions across treatments lie in the range 0.33 to 0.51 (see Figure 1).

Figure 1 provides a preliminary answer to our first question: **1.1:** Are contributions to the public good in the PGG lower when the returns to the public good are heterogeneous compared to when they are homogeneous?

Result 1.1 (preliminary): We find mean PGG contribution rates are higher when returns are heterogeneous. The left-hand graph in Figure 1 reveals that the mean contribution in *het* is significantly higher than the mean contributions in *hom.* The mean pooled contribution rate under *hom40*, *hom60*, and *hom80* was 38.2 percent, the corresponding rate under *het* was 49.5, and the difference between the two was significant at the 5 percent level (t=2.069 (p=0.039); z=2.061 (p=0.039)).[xix]

Figure 1 here

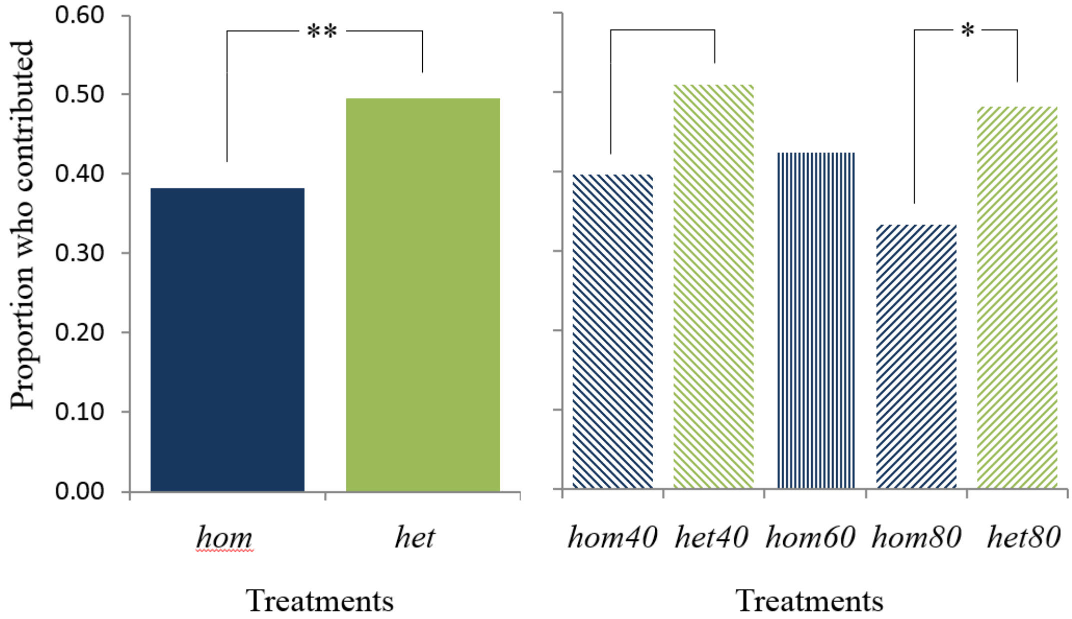

Figure 1: Contribution rates across PGG treatments

Notes: Blue and blue-striped bars denote treatments where individual returns are homogeneous within-session; green and green-striped bars denote treatments where individual returns are heterogeneous within-session; ** difference significant at 5 percent level (according to both two-sided t-tests and Mann-Whitney rank-sum tests); * difference significant at 10 percent level (according to both two-sided t-tests and Mann-Whitney rank-sum tests).

The bar heights in the right-hand graph in Figure 1 suggest that both those facing the lower return, 40, and those facing the higher return, 80, respond positively to heterogeneity in returns. However, only the difference for high return subjects, i.e., between *hom80* and *het80*, is significant at the 10 percent level.

Figure 1 also provides a preliminary answer to our second question: **1.2:** Are contributions to the public good in the PGG higher when the individual return from the public good is higher?

Result 1.2 (preliminary): The right-hand graph in Figure 1 presents no evidence of the likelihood of contributing increasing with individual return from the public good.

4.2 Multivariate analysis of contributions in the PGG

To explore the robustness of preliminary results 1.1 and 1.2, we now move onto the multivariate analyses. Table 4 presents the marginal effects derived from two logit models each taking the PGG decision as the dependent variable. The dependent variable *PGG contribution* is equal to one if the subject contributed their token to the public good, and zero otherwise. In both estimations, non-independence within sessions is accounted for by adjusting the standard errors for clustering at the session level. In both models the explanatory variables of interest are *Het*, which equals 1 if the decision was made under the *het* treatment and zero otherwise, and *Individual returns*, which equals 40, 60, or 80, depending on sub-treatment assignment.[xx]

In Model 1, we control for an extensive set of session characteristics, individual characteristics, household and farm characteristics, including those we use as proxies for individual returns in the analysis of the HCQ, and community fixed effects. In this model neither *Het* nor *Individual returns* bears a significant coefficient, the individual characteristics are jointly highly significant, as are the community fixed effects, and the household and farm characteristics are individually and jointly insignificant.

In Model 2, from which we exclude the set of household and farm characteristics, the coefficient on *Het* is positive and significant at the 10 percent level, while that on *Individual returns* remains insignificant and close to zero.[xxi] According to this model, at the mean, participants are 6.7 percentage points more likely to contribute when returns are heterogeneous compared to when they are homogenous.[xxii] [xxiii]

Result 1.1 (continued): Heterogeneity in returns has a positive and significant effect on PGG contributions when we control for individual characteristics and community fixed effects (Model 2). However, the effect loses significance when we also control for household and farm characteristics (Model 1).

Result 1.2 (continued): Individual returns have no effect on PGG contributions.

Table 4 here.

Table 4: Logit Analysis of Public Goods Game Contribution Decisions

Dependent variable = 1 if *i* contributed in PGG, 0 otherwise

	Model 1		Model 2	
Het (heterogeneous returns)	0.054		0.067	*
	(0.048)		(0.037)	
Individual returns	$4.71e^{-5}$		$-4.87e^{-4}$	
	(0.001)		(0.001)	
Female	-0.149	*	-0.122	
	(0.080)		(0.081)	
Age	0.020		0.026	
	(0.019)		(0.018)	
Age squared	$-2.22e^{-4}$		$-2.84e^{-4}$	
	(0.000)		(0.000)	
Years of schooling	0.009		0.011	
	(0.008)		(0.008)	
Married	-0.049		0.011	
	(0.077)		(0.070)	
Household head	0.074		0.081	
	(0.102)		(0.105)	
Risk averse	0.123	*	0.114	*
	(0.069)		(0.066)	
Total household income (log)	-0.014			
	(0.018)			
Household size	0.036			
	(0.024)			
Farming household head	0.063			
	(0.071)			
Number of plots	0.023			
	(0.045)			
Proportion of income from farming	-0.006			
	(0.007)			
Crop damage	-0.016			
	(0.012)			
Watch-huts	0.035			
	(0.036)			
Morning session	-0.019		-0.014	
	(0.040)		(0.038)	
Session size	0.014		0.006	
	(0.015)		(0.015)	
Community fixed effects (CFEs) included	Yes		Yes	
Joint sig. of individual chars (p-value)	<0.001		<0.001	
Joint sig. of household chars (p-value)	No		-	
Joint sig. of CFEs (p-value)	<0.001		<0.001	
Pseudo R-squared	0.128		0.115	

Observations	402	402

Notes: Marginal effects, evaluated at the mean, and standard errors, clustered at the session level, presented; *** p<0.01, ** p<0.05, * p<0.1.

That the household and farm characteristics are individually and jointly insignificant in Model 1 is worthy of note. It suggests that subjects do not bring their real-life farming and HEC context into the lab and their PGG decision-making. Among the individual characteristics, *Female* and *Risk averse* bear significant coefficients. Women are less likely to contribute and risk averse subjects are more likely to contribute. The second result is surprising. It could be owing to the frame; risk averse subjects may have a stronger preference for the security that the electric fence affords.

4.3 Results from the HCQ

Here, we use the responses made to the HCQ by the sample of subjects who also took part in the PGG to estimate a series of Tobit models of HCQ contribution behaviour. Recall that *HCQ contribution* is the number of hours which subjects are willing to contribute to construction of the hypothetical electric fence. It takes values from 0 to 20 in two-hour intervals with an additional option to indicate willingness to contribute more than 20 hours. 48.3 percent of the farmers in our sample indicated that they would contribute more than 20 hours. We coded these "greater than 20" responses as 21 and then treat the dependent variable as truncated.

The two Tobit models in Table 5 provide answers to questions **2.1:** Are contributions to the fence in the HCQ lower in villages where the returns to the fence are more heterogeneous, i.e., where cross-household variance in crop damage and reliance on farming for income is higher? and **2.2:** Are contributions to the fence in the HCQ higher when the individual returns from the fence are higher, i.e., when experienced crop damage and reliance on farming for income are higher?

Table 5 here.

Table 5: Tobit Analysis of Responses to Hypothetical Contribution Question
Dependent variable=hours contributed to construction of hypothetical fence

	HCQ Model 1	**HCQ Model 2**	**HCQ Model 3**
Var(crop damage)	0.200*	0.143	
	(0.120)	(0.137)	
Var(proportion of income from farming)	0.270**	0.234	
	(0.139)	(0.152)	
Crop damage	1.010***	1.230***	1.271***
	(0.360)	(0.406)	(0.421)
Proportion of income from farming	0.380***	0.396***	0.387***
	(0.117)	(0.123)	(0.123)
Female		-3.203**	-3.655**
		(1.582)	(1.691)
Age		0.160	0.214
		(0.174)	(0.180)
Age squared		-0.003	-0.003*
		(0.002)	(0.002)
Years of schooling		-0.109	-0.142
		(0.156)	(0.162)
Married		-1.114	-1.466
		(1.326)	(1.350)
Household head		-0.882	-1.506
		(1.493)	(1.586)
Risk averse		-2.250*	-2.380*
		(1.371)	(1.439)
Household size		-0.368	-0.409
		(0.297)	(0.305)
Total household income (log)		-0.204	-0.103
		(0.321)	(0.289)
Farming household head		-1.094	-1.019
		(1.439)	(1.568)
Number of plots		-4.406***	-4.559***
		(0.812)	(0.803)
Watch-huts		2.790***	2.786***
		(1.101)	(1.070)
Community dummies?	No	No	Yes
Community dummies jointly significant?	-	-	Yes***
R-squared	0.014	0.038	0.044
Observations	404	402	402

Notes: Standard errors, in parentheses, clustered at the session level; *** p<0.01, ** p<0.05, * p<0.1; Tobit upper limit truncated at 21 hours. Applying OLS yields similar results. Inferences about returns and risk aversion are robust to the exclusion of the *watch-huts* variable.

Table 5 presents the marginal effects evaluated at the sample mean for each of the explanatory variables in the Tobit estimations. In Model 1, we include the two proxies for individual returns to the fence*,* *crop damage* and *proportion of income from farming,* and the community-level variances in these two variables to proxy for heterogeneity in individual returns. The coefficients on *Var(crop damage)* and *Var(proportion of income from farming),* our proxies for heterogeneity in returns, are both positive and significant. We also find positive and highly significant effects of *crop damage* and *proportion of income from farming*, our two proxies for real-life expected individual returns to the electric fence, on HCQ contributions.

In Model 2, we also include *watch-huts* (HEC prevention) and individual and other household characteristics. The *watch-huts* variable has a positive and highly significant effect. *Risk aversion* has a negative effect on HCQ contributions confirming our conjecture that new technologies do carry a perception of risk. We also find women contribute less time, perhaps due to gender specific norms about who should do what jobs; older household members contribute less time; and finally, the more plots a household has the less time they contribute.[xxiv]

The two proxies for heterogeneity in returns, *var(crop damage)* and *var(proportion of income from farming*), become both individually and jointly insignificant in Model 2. However, the effects of the two proxies for individual returns, *Crop damage* and *Proportion of income from farming* remain positive and highly significant.

In HCQ Model 3, we replace the proxies for heterogeneity with a full set of community fixed effects. These are jointly highly significant and, so, this is our preferred model for the purposes of interpretation. An additional instance of crop damage experienced per month increases the HCQ time contribution by 1.27 hours. A 10 percent increase in the proportion of income generated through farming increases the time contribution by 0.39 hours. Watch-hut ownership has a large, positive and significant effect on HCQ contributions to the electric fence: each additional watch-hut owned increases the HCQ time contributions by 2.79 hours.

Each additional plot occupied by a household leads to a 4.56 hours reduction (at the mean) in the HCQ time contribution.

In summary and in response to research questions 2.1.and 2.2, the HCQ analysis indicates that:

Result 2.1: Within village, cross-household variance in experienced crop damage and in reliance on farming, both of which proxy for heterogeneity in real-life returns from the electric fence, have positive but insignificant effects on HCQ contribution decisions; and

Result 2.2: Individual experiences of crop damage and reliance on farming, both of which proxy for individual returns from the electric fence, have a positive and significant effect on HCQ contribution decisions.

5. Summary and discussion

Results 1.1 and 1.2: A simple comparison of mean PGG contributions suggests that heterogeneity in returns has a positive effect on PGG contributions. This effect is robust to the inclusion of individual characteristics and community fixed effects in the analysis, but is not robust to the inclusion of a set of household and farm characteristics, even though the latter are jointly insignificant.

Results 2.1 and 2.2: The Tobit analysis of the HCQ indicates that real-life proxies for heterogeneous returns from the public good, *var(crop damage)* and *var(proportion of income from farming)*, have no effect on HCQ contributions. However, the two proxies for expected individual returns from the electric fence have a positive and highly significant effect. The positive and significant coefficient on *watch-huts*, after controlling for exposure, is also interesting. It indicates that households who are more invested in an established approach to HEC management are more willing to invest in the new higher tech approach. This is consistent with these households perceiving the fence as a potentially less time-consuming and perilous approach to HEC management.

While the findings derived from our two methods are not the same, neither are they contradictory. Taken together, they suggest that heterogeneity in individual returns to public goods does not explain why public good creation and maintenance remains a challenge in communities across the developing world. Our data suggests that, in such circumstances, those expecting a high return from the public good step up and those expecting a low return do not step down.

Being risk averse had differing effects on PGG and HCQ contributions. In the PGG, being risk averse increases the likelihood of contributions. In the HCQ, being risk averse has a negative and marginally significant effect on time contributions. In relation to the PGG, we speculated that the strategic risk associated with contributing to public good provision would receive a relatively high cognitive weight. Given this, we expected that the more risk averse would be less likely to contribute. That we find the opposite is consistent with risk-averse individuals being used to coping with risk collectively and, so, choosing to contribute in the PGG, framed as contributing to a risk-mitigating public good, out of habit. In contrast, we speculated that in the HCQ decision-making process, a lower cognitive weight would be placed on the interactive aspect of the public good provision and a higher weight on the risk associated with the novel technology.

6. Conclusions

In conclusion, we find that heterogeneity in individual returns to public goods does not explain why public good creation and maintenance remains a challenge to communities across the developing world. When returns to local public goods are heterogeneous, those expecting a high return from the public good step up and those expecting a low return do not step down.

These results add to the growing literature examining collective action and public good provision in both the lab and in everyday life. In contrast to the literature arguing that heterogeneity in power, influence, and social position suppresses collective action (Bardhan and Mookherjee, 2000, 2006; Khwaja, 2004; and Mansuri and Rao, 2004, 2013), in this paper, we look at another, arguably more fundamental, type of heterogeneity, namely, heterogeneity in individual returns to the public good, and find that this does not suppress collective action. In line with lab experiments designed to investigate the same issue (Fisher *et al*., 1995; Reuben and Riedl, 2013; and Molis *et al.*, 2016) we find that those receiving a higher return contribute more.

These findings should be encouraging for development practitioners, particularly those aiming to engage Sri Lankan communities in the construction of electric fences to mitigate the risk of the Human-Elephant Conflict. First, our sample comprises households from across sixteen rural communities in an area of Sri Lanka where there is high, but heterogeneous, exposure to the Human-Elephant Conflict. The results from both the behavioural and survey data provide corroboratory evidence that the success of community-level interventions would not be compromised by those who are weakly exposed to HEC. Second, evidence from the survey data shows that real-life individual returns play an important role in the sustainability of community-based interventions. Households who are more invested in an established approach to HEC management (in this case, surveying from watch-huts) are more willing to invest in the new higher-tech approach. This may also bode well for any future alternative measures to HEC management and mitigation beyond the construction of electric fences. With regard to research methodology, we find that complementary methods provides a more balanced account of communities' potential engagement in HEC-mitigating public good provision**.**

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[i] It should be noted that not all of the researchers who have sought such correlations have found them. Stoop *et al.* (2012) found that recreational fishermen were very cooperative in the lab, while being utterly uncooperative when fishing, and Torres-Guevara and Schlüter (2016) failed to replicate Fehr and Leibbrandt's (2011) findings among fishermen in a neighbouring country.

[ii] Bråten (2014) found contributions to the public good were significantly higher in communities with joint-ownership property rights than communities with individual-ownership rights.

[iii] Over 70 human and 200 elephant mortalities annually have been documented in Sri Lanka (Santiapillai *et al*., 2010; Fernando *et al*., 2011).

[iv] Within our sample, households use a combination of methods for deterring elephants. Focusing on January 2014, we observe that popular methods include flashing torches (71 percent), lighting firecrackers (66 percent), lighting fires at night (58 percent), and surveying from watch-huts (44 percent).

[v] In our specific site 10 percent of the sample have an electric fence which is owned and maintained privately. However, at the time of the research design there was an NGO trialling community-maintained fences. The PGG and HCQ scenarios were developed with this trial in mind and as such are framed as being reliant on collective efforts to maintain the fence. The assumption in these scenarios is that farmers will collectively maintain the whole fence, rather than just their specific section. If a specific farmer does not contribute to maintaining the fence while others do, then (s)he enjoys the

benefit of lower risk exposure arising from others' contributions. If everyone behaves selfishly, then the fence will fall into disrepair and not be effective.

[vi] While the PGG was designed to be undertaken in groups of 16, in the field, some of the groups were smaller (more on this below). Given the specific structure of the PGG that we implemented, this did not affect subjects' individual rates of return from own and others' contributions. However, it may have affected the number of contributions to which the latter rate was applied, i.e., $\sum_{j \neq i} x_j$, and anticipating this may have caused subjects to adjust their decisions. Accounting for this possibility in the analysis leaves the main findings unchanged.

[vii] Detailed instructions and the full protocol are available in the Online Supplementary Materials (OSM).

[viii] Participants were told that the project was to investigate the impact of risk on their lives, that they would be playing games involving money and that the money would be supplied by the researchers.

[ix] We dropped a further two sessions where the PGG was conducted with a different frame.

[x] One *het* and one *hom80* session involved 15 participants; one *hom60* session involved 12; and one *hom80* session involved 10. In the one *het* treatment session that involved 15 participants, 8 were assigned the high return (m_i =80), 7 the low return (m_i =40). Accounting for session size in the analysis leaves the main findings unchanged

[xi] To ensure that decisions could be kept private during the PGG, participants were seated at least 1.5m apart facing the instructor and given clipboards to which their tokens were attached. They were told: "Your decisions in this game will be strictly confidential. In order to guarantee confidentiality we ask you not to communicate with each other at any time during the game. If you talk to each other we will have to stop the game and nobody will earn any money." The gamble choice decisions were made during one-on-one interviews.

[xii]At the end of the session, participants were invited individually to receive their payments in private.

[xiii] All subjects were paid a show-up fee of Rs.250 and their payoffs from participation in the experiments. No breakdown was given.

[xiv] For example, NGOs, have been involved in the restoration of natural reservoirs ('tanks') and building of wells to facilitate agricultural activities. Donors have provided funding for materials and community members have contributed labour for construction.

[xv] This volunteering of time was considered as a one-off investment.

[xvi] To put in context, the use of watch-huts is the most time-consuming and labour-intensive prevention method. Households in the sample spend on average 28 person-days per month and 12 person-hours per day surveying from watch-huts in the maha season. Comparatively less time is spent manning watch-huts during the drier yala season (on average 10 person-days per month and 7-8 person-hours per day).

[xvii] In OSM, Table F1, we report balance tests for all variables across treatments. In general, randomisation did lead to a balance across treatments.

[xviii] The actual figures for proportion of income from farming lie between 0 and 1 but we multiply each figure by 10 to ensure the magnitudes for the *proportion of income from farming* and *crop damage* and *HCQ contribution* are comparable.

[xix] If we exclude *hom60* from the sample and compare mean contribution rates between *hom* (*hom80* and *hom40* pooled) and *het*, we are still able to reject the null of no difference, but at the 10 percent level.

[xx] We also estimate a model containing only *Het* and *Individual returns* as explanatory variables. In this model, the effects of both *Het* and *Individual returns* are insignificant. If village fixed effects are included, the coefficient on *Het* is positive and significant (p=0.064). Results available from the authors on request.

[xxi] When the participants' guesses of the number of others contributing is included as a regressor in any of the model specifications mentioned above, the coefficient on the guess is positive and highly significant and the coefficients on *Het* and *Individual returns* are insignificant. In regressions taking the guesses as the dependent variable the coefficients on *Het* and *Individual returns* are, once again, insignificant. Results available from the authors on request.

[xxii] When we estimate the same two models, while restricting the sample to decision made only in sessions involving 16 participants, *het* becomes significant at 5 percent level. These estimations are reported in OSM, Table F2.

[xxiii] When an interaction between *Het* and *Individual return* is included in the analysis, it is always insignificant and, in Model 2, renders *Het* insignificant. Results are available from the authors on request.

[xxiv] We report descriptives by gender in OSM, Table F3.