Individual, Collective, or Both? Testing Payment Mechanisms to Enhance Adoption of Sustainable Land-Use Systems

Amandine Belard, Stefano Farolfi, Gabriel Bayle, Hambulo Ngoma, Tarisai Pedzisa, Françoise Gérard, and Damien Jourdain

Introduction

SLUS and Environmental Services

- Transition towards **sustainable land-use systems** (SLUS) needed in Sub-Saharan Africa (SSA) to mitigate and adapt to changing climatic conditions and environmental degradation
- Low adoption of SLUS:
  - Immediate costs
  - Risks
  - Potential reduced private gains (at least in the short run)
- But, SLUS generate **environmental services** (ES) at both farm and landscape level
  - Farm level: Improved soil fertility → private good
  - Landscape level: improved water quality, reduced soil erosion, improved biodiversity… → public good

⇒ **Social dilemma**: individual farmers bear the costs of SLUS adoption, while many benefits are shared collectively

Payment for Environmental Services

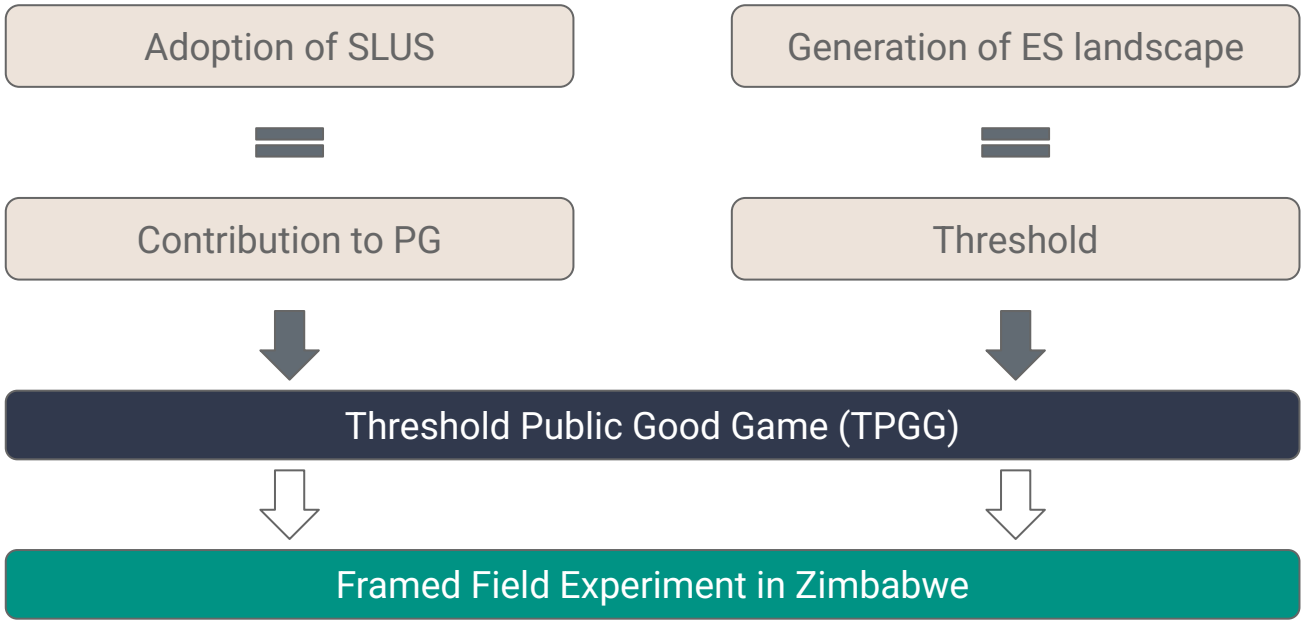
- Need a **flexible policy** tools that can help overcome this social dilemma by **compensating farmers** for the public goods they generate
    - Can address imbalance between private costs and public benefits
- We consider a PES that makes **direct payments** to ES providers (*e.g.,* farmers) **conditional** on implementing SLUS and are entirely voluntary
    - Generally at **individual level**
- Often **fall short** of generating landscape level ES (Rudolf et al., 2022)
- Many ES emerge when critical **threshold** of adoption across the landscape (Limbach et al., 2023)
- PES can be adapted: payment is made only when a **collective level** of SLUS adoption or ES generation is reached (Pinero et al., 2020) ⇒ **collective PES**

Collective Threshold PES

- Contractual inter-dependencies among participants that necessitate coordination (Barnaud et al., 2018)
- Traditionally implemented because reduce **transaction costs** and **facilitate monitoring**
- Such PES may facilitate **additional forms of cooperation** (Nourani et al., 2020):
  - Bulk purchasing
  - Group investment
  - resource -sharing arrangements
- Platforms for **knowledge sharing** and **innovation** in agricultural practices (Bodin, 2017; Wynne-Jones et al., 2020)
- Empirical evidence on which design feature of PES **prompt coordination** remains limited (Gatiso et al., 2018)

⇒ Identify payment systems that **incentivize farmers to coordinate** in their adoption of SLUS

Representing the Social Dilemma



Objectives

First Objective

Determine which payment system can best incentivize smallholder farmers to reach the threshold

1. ***Collective payment:*** triggered by the attainment of the collective threshold and proportional to the aggregated contributions

   → makes threshold more attractive

   → does not reduce strategic uncertainty (make decisions without knowing what others will do)

2. ***Individual payment***: unconditional on threshold attainment and proportional to the farmer's own contribution level

   → weakens social dilemma as reduce farmers' potential losses if threshold not reached

3. ***Combined payment***: collective + individual payment

   → increases likelihood of achieving the threshold

   → manage individual risks

Second Objective

Identify the role of social and risk preferences on contribution levels

- ***Trust***: reduce perceived strategic uncertainty, encourage participation, willingness to contribute to the public good (Ansink et al., 2017, Kim et al. 2022)
- ***Reciprocal behavior***: individuals respond to the contributions of others with their own → positive feedback loop (Ostrom, 1998)
- ***Other-regarding preferences***: individuals may contribute because care about others' welfare and derive utility from improving collective outcomes (Blanco et al., 2021; Fehr and Schmidt, 1999; Fishbacher and Gächter, 2010)
- ***Risk attitude***: risk averse individuals may be less willing to take the risk of contributing compared to risk tolerant individuals (Kocher et al., 2015; Teyssier, 2012)

Third Objective

How framing may affect contribution levels

- Additional experimental treatment where **payment structure is not explicitly presented**
  - In the three other treatments farmers knew they would receive a **'bonus'** for contributing to the PG
  - ***No-policy-framing treatment***
- Contributes to the debate regarding the **role of framing**:
  - Empirical evidence on whether **the way incentives are communicated** influences farmers' willingness to contribute to the public good

Case Study

Case Study: Smallholder Farmers in Zimbabwe

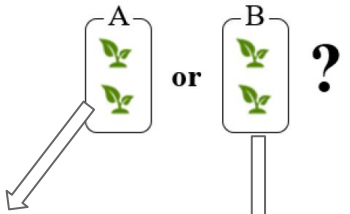
- Farms less than 2ha → need coordination for landscape levels benefits
- Communal area (42% of land in Zimbabwe): interplay of **individual** and **collective** dimensions
  - Example: roaming livestock & mulching
- Study in the district of **Murehwa**
  - Need to adopt sustainable practices that increase yields to combat food insecurity and poverty
- Why would farmers in Murehwa benefit from coordinating in their adoption?
  - Inorganic fertilizer necessary but overuse ⇒ harm soil and water quality
  - Pest management; example: sorghum & birds
  - Controlled roaming livestock
  - Coordination to address economic challenges (bulk purchasing, market access)

Methodology

Game Settings & Payoff functions

- Threshold public good game
- **Framed experiment** to mimic experimental settings
  - No mention of SLUS or environmental aspects in the instructions
- Farmers (subjects) endowed with 4 plots
- **Groups of 4 subjects** ⇒ 16 plots per group
- Subjects need to choose between allocating each of their 4 plots to cropping system A or B where:
  - Private returns for A > Private returns for B
  - But for cropping system B there is collective returns if threshold reached
- Threshold ⇒ 8 plots in cropping system B

Choice between cropping system:



Analogous to private good/current system

Analogous to public good/generate ES

Payoff functions

Payment type	Payoff function	Equation
Baseline	$\begin{cases} 100(4-x_i)+40x_i+20(x_i+X_{-i}) & \text{if } X \geq 8, \\ 100(4-x_i)+40x_i & \text{if } X < 8 \end{cases}$	1
Individual payment	$\begin{cases} 100(4-x_i)+61x_i+20(x_i+X_{-i}) & \text{if } X \geq 8, \\ 100(4-x_i)+61x_i & \text{if } X < 8 \end{cases}$	2
Collective payment	$\begin{cases} 100(4-x_i)+40x_i+31(x_i+X_{-i}) & \text{if } X \geq 8, \\ 100(4-x_i)+40x_i & \text{if } X < 8 \end{cases}$	3
(No-policy-framing) Combined payment	$\begin{cases} 100(4-x_i)+61x_i+31(x_i+X_{-i}) & \text{if } X \geq 8, \\ 100(4-x_i)+61x_i & \text{if } X < 8 \end{cases}$	4

Note: The parameters are $\alpha = 1$, $\beta = 0.4$, $w_i = 4$, $\lambda = 0.2$, $\rho = 0.21$ and $\kappa = 0.11$. x_i corresponds to the number of plots the subject puts under cropping system B. $(4 - x_i)$ corresponds to the number of plots under cropping system A. X is the total number of plots the group puts under cropping system B.

No-policy-framing treatment

Plots in cropping system A	Plots in Cropping system B	Gains for plots in cropping system **A**	Gains for plots in cropping system **B**	Total **individual gains**
4	0	400	0	400
3	1	300	40	340
2	2	200	80	280
1	3	100	120	220
0	4	0	160	160

(a) Baseline

Plots in cropping system A	Plots in Cropping system B	Gains for plots in cropping system **A**	Gains for plots in cropping system **B**	**Individual bonus** for plots under cropping system **B**	Total **individual gains**
4	0	400	0	0	400
3	1	300	40	1 x 21 = **21**	361
2	2	200	80	2 x 21 = **42**	322
1	3	100	120	3 x 21 = **63**	283
0	4	0	160	4 x 21 = **84**	244

(b) Policy framing combined payment

Plots in cropping system A	Plots in Cropping system B	Gains for plots in cropping system **A**	Gains for plots in cropping system **B**	Total **individual gains**
4	0	400	0	400
3	1	300	61	361
2	2	200	122	322
1	3	100	183	283
0	4	0	244	244

(c) No-policy-framing combined payment

Note: This figure presents an excerpt of the instructions provided to subjects. In the table given to participants in the no-policy-framing treatment, while the individual payoffs remain identical to those in the combined payment group, the explanations provided are the same as those given to subjects in the baseline. The additional payment is thus explicit in only in the combined payment group. The table for collective returns were similarly presented, see Appendix G.

Prosocial Preferences and Risk Attitude

- **Altruism**: dictator game (Forsythe et al., 1994)
- **Trust** and **reciprocity**: trust game (Berg et al., 1995)

} Strategy method

- **Risk** attitude: 'Bomb' Risk Elicitation Task (BRET; Crosetto and Filippin, 2013)

1	2	3	4	5
6	7	8	9	10
11	12	13	 14	15
16	17	18	19	20
21	22	23	24	25

1	2	3	4	5
6	 7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Experimental Sessions

- Pen and paper
- Instruction explained in Shona by one leader, two additional assistants to help subjects fill in the questionnaires
- **In-between design**: subjects played the same treatment over 8 rounds
- Group **randomly** and **anonymously** assigned (same group over all periods)
- Answer **sheet collected (and returned) in between each round** to:
    - Compute the total number of plots under cropping system B for each group
    - Determine if threshold was reached
    - Calculate individual payoffs
- **Communication prohibited** during sessions
- Each game had a color and at the end of session one game randomly selected to be paid
- Self-reported trust questions + socio-demographic questionnaire

Sampling

- 3 wards in Murehwa, 5 villages per wards, 2 sessions per village, 1 village a day
- Treatment randomly assigned for each session
- Each session = 20 participants
- Recruitment through extension officers

	Ward 4	Ward 26	Ward 28	Total number of subjects
Baseline	40	36	40	116
Collective payment	36	40	40	116
Combined payment	40	40	40	120
Individual payment	40	40	40	120
No-policy-framing combined payment	40	36	40	116
Total number of subjects	196	192	200	588

Note: This table summarizes the distribution of participants across wards and treatments. In three of the sessions, we had only 16 participants instead of the intended 20.

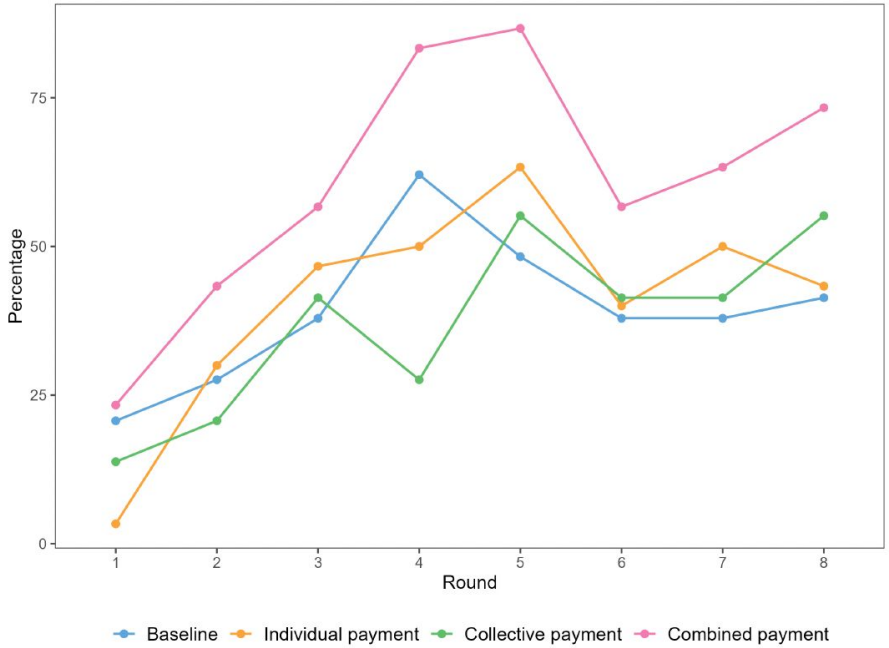
Econometric Model

- Outcome variable: **individual contributions**
- Cluster nature of data
  - Correlation between contributions of *i* in t and t-1
  - Correlation between contributions of *i* and *j* (except for period 1)
- **Mixed effect** model allow to account for these unobservable characteristics (Andersson et al., 2018; Singmann & Kellen, 2019)
- Mixed effects also allow to include fixed effects (round dummy, enumerator effects, prosocial preferences, risk attitudes, socio-demographics)
- Robustness checks: **multiverse analysis**

Results

Treatment Effects with Policy Framing (1)

- Comparison of baseline vs. the other treatments where the payment is explicit
- Figure: percentage of groups reaching the threshold
  - Combined payment treatment reached the threshold 61% of the time
  - 37-41% for the other treatments



Note: This graph illustrates the percentage of groups that reached the threshold for each treatment in each round. The threshold is met when a group collectively contributes at least 8 plots to cropping system B.

Treatment Effects with Policy Framing (3)

Testing difference in contributions

Comparison	Mean contribution baseline	Mean contribution treatment	p-value	Sig.
Baseline vs. Individual payment	6.53	6.78	0.503	
Baseline vs. Collective payment	6.53	6.81	0.425	
Baseline vs. Combined payment	6.53	8.07	<0.001	***

Note: * p < 0.1, ** p < 0.05, *** p < 0.01. Wilcoxon tests were performed to test the difference in contributions between treatment groups where the payment system is explicit. The threshold is met when a group collectively contributes at least 8 plots to cropping system B.

Treatment Effects with Policy Framing (4)

	Dependent variable:		
	Contribution to PG		
	(1)	(2)	(3)
Individual payment	0.051	0.152	0.158
	(0.128)	(0.108)	(0.110)
Collective payment	0.012	0.038	0.088
	(0.130)	(0.110)	(0.114)
Combined payment	0.382***	0.379***	0.374***
	(0.120)	(0.101)	(0.104)
TPPG: Contribution first round		0.263***	0.257***
		(0.034)	(0.034)
DG: Sent by P1		0.099**	0.092**
		(0.039)	(0.039)
DG: First order belief		−0.036	−0.033
		(0.034)	(0.034)
TG: Trust		0.004	−0.0001
		(0.042)	(0.042)
TG: Reciprocity		0.085**	0.079*
		(0.041)	(0.041)
Risk BRET		−0.046	−0.035
		(0.034)	(0.035)
Age			0.015
			(0.041)
Size of household			0.068**
			(0.034)
Number of cattle			0.007
			(0.034)
Size of farm (acres)			−0.010
			(0.033)
Female			−0.064
			(0.075)
Head of household			−0.011
			(0.087)
Married			0.019
			(0.079)
Have at least secondary education			0.187**
			(0.081)
Remittances less than 100 USD			0.110
			(0.158)
Off-farm			−0.010
			(0.069)
Intercept	1.001***	0.958***	0.731***
	(0.121)	(0.107)	(0.212)
Rounds dummies	*Yes*	*Yes*	*Yes*
Enumerators dummies	*Yes*	*Yes*	*Yes*
Observations	3,776	3,768	3,760
Log Likelihood	-6,481.083	-6,440.685	-6,441.018

Notes: *p<0.1; **p<0.05; ***p<0.01. Two missing values in the dataset: one for age and one for BRET. All continuous variables were mean-centered. Sample means of continuous variables: TPPG Contribution (first round) = 1.1, Dictator Game sent by P1 = 1.4, Dictator Game first order belief = 2.1, Trust Game trust = 1.6, Reciprocity = 1.3, Risk (BRET) = 13, Age = 48, Farm size = 2.1 acres, Household size = 5.7 members. Observations from the no-policy-framing combined payment treatment are excluded. Estimates from linear mixed effects model with random effects for subject and experimental group.

The Role of Policy Framing

- Comparison between baseline, combined payment with policy framing and no-policy-framing treatment

Comparison	Mean contributions baseline or policy framing treatment	Mean contributions no-policy-framing treatment	p-value	Sig.
Baseline vs. No-policy-framing treatment	6.53	6.4	0.492	
Policy framing vs. No-policy-framing treatment	8.07	6.4	0.000	***

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Wilcoxon tests were performed to compare contributions between the baseline group and no-policy-framing combined payment treatment, and between policy framing combined payment treatment and no-policy-framing combined payment treatment.

Discussion and Conclusion

Main Results (1)

- We looked at 3 payment types:
  - Individual payment
  - Collective payment
  - Combined payment
- Only subjects in the combined payment contributed sufficiently to reach the threshold
  - The individual payment component provides a **safety net** by reduces the losses in case the threshold is not reach, while the collective component creates **incentives for landscape-level coordination**
  - This dual payment structure can be interesting to implement in the initial years of PES for developing trust among participants

Main Results (2)

- **Policy framing matters**: if remove the mention of a ‘bonus’ while keeping the same payment levels ⇒ contributions returned to baseline
  - Anchoring effect and a positive-frame effect
  - Presentation of the payments to farmers matters (both in experimental settings and real-life)
- Altruism and unconditional cooperation influenced contributions
  - **Role of intrinsic motivations**

Limits

1. **No communication** among subjects ⇒ that would not be the case in real-life if such scheme was implemented (at least in case of smaller groups)
2. **No environmental dimension** although it may play a role (positive or negative) in motivations to contribute
3. In our design, **no spatial connectivity** between plots albeit it may be necessary for generation of certain ES (agglomeration payment/bonus)

Thank you!

Appendixes

Robustness Checks: Multiverse Analysis

- “Researchers degree of freedom”
  - Variable coding and transformation
  - Missing values and outliers handling
  - Econometric model selection

  ⇒ these ultimately influence statistical results (Götz et al., 2024; Simonsoh et al., 2020; Steegen et al., 2016)

- Each path of analytical choices is called a “universe”
- A collection of all possible model specifications that can address a research question is called a ‘multiverse’
- A way to ‘counteract’ p-hacking

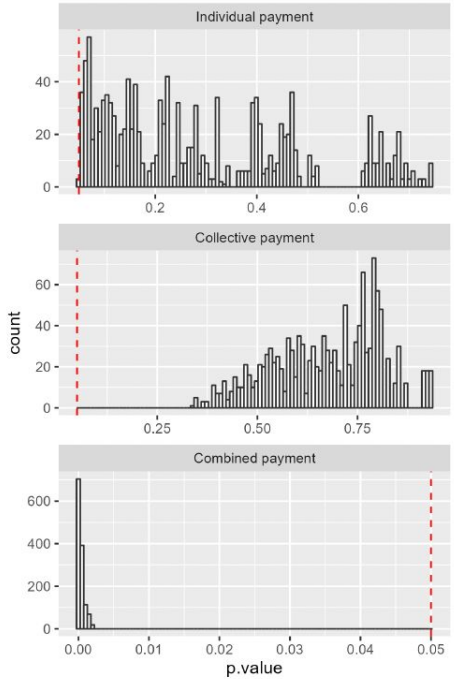
Multiverse Analysis: Analytical Paths

Measure	Analytical options
	Variable Coding
Reciprocity	1. Number of tokens sent back for each amount received 2. Mean return across all received amounts by Player 2 3. **Mean proportion returned relative to Player 1's sent amount**
Education	1. Original categorical levels 2. Binary: No formal education 3. **Binary: Secondary education or higher**
Remittances	1. Four-level factor (none to >USD 500) 2. **Binary: Less than USD 100**
	Covariate Selection
Pro-social Preferences	1. None 2. Self-reported trust measures only 3. **Game-derived measures only** (trust, risk, other-regarding preferences) 4. All measures combined
Demographics	1. None 2. Basic demographics (education, gender, age) 3. **Full set** (education, age, female, household size, cattle owned, farm size, household head status, marital status, remittances, off-farm income)
TPPG: Contribution first round	1. Excluded 2. **Included**
Round Fixed Effects	1. **Included**
Enumerator Fixed Effects	1. **Included**
	Model Structure
Random Effects	1. Subject-level only 2. Experimental group-level only 3. **Both subject and group levels**

Notes: Specifications in **bold** correspond to model 3 in Table 6. For computational efficiency, related indicators for pro-social preferences, risk attitudes, and demographics are grouped together.

Specification curve

P-values histograms



Note: Distribution of p-values for each treatment across universes. The dashed line indicates p = 0.05.

Treatment Effects with Policy Framing (2)

Mean contribution by Round and Treatment

Round	Baseline	Individual payment	Collective payment	Combined payment
1	4.55	3.13	4.38	4.77
2	5.55	6.40	5.83	6.70
3	6.90	7.13	7.07	8.10
4	7.48	8.03	7.00	9.37
5	7.83	8.37	7.66	10.23
6	6.97	6.43	7.72	8.40
7	6.45	7.73	7.14	8.07
8	6.55	6.97	7.66	8.93

Note: This table present the mean contribution per treatment and per round.