Adaption, mitigation or inaction in the face of climate change? Experimental evidence from disaster-vulnerable areas of Papua New Guinea

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Plan of the talk

1. Adaptation vs. mitigation: policy approach
2. The Physics of climate change and the modelling of collective action
3. Fieldwork location
4. Experimental design
5. Results: Identification of cooperation types
6. Results: Ingroup

Mitigation, Adaptation, and Compensation are 3 Pillars of Climate Policy

Figure 4. Climate finance provided and mobilised in 2016-2022 per climate theme (USD billion)

Optimal Combination of Mitigation and Adaptation?

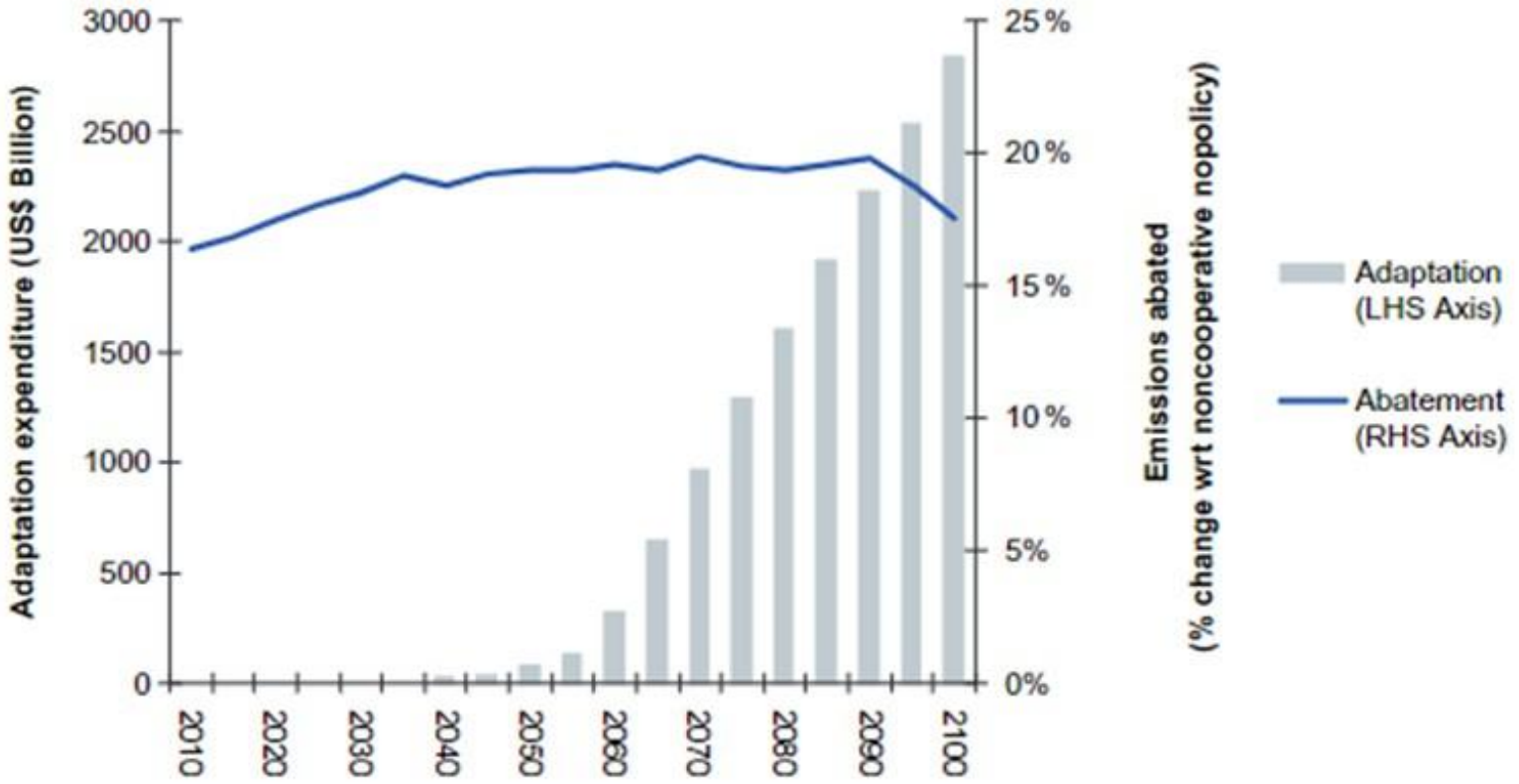


Figure 2. Mitigation and adaptation in the optimal climate change strategy

Bosello, F., Carraro, C., & De Cian, E. (2010). Climate policy and the optimal balance between mitigation, adaptation and unavoided damage. *Climate Change Economics*, 1(02), 71-92.

Optimal Combination of Mitigation and Adaptation?

Table 1. Cost and effectiveness of adaptation. Estimated (from literature) and calibrated (AD-WITCH) values for 2.5°C temperature increase above pre-industrial levels.

	Estimated adaptation costs (% of GDP)	Estimated adaptation effectiveness (% of reduced damage)	Calibrated adaptation costs in AD-WITCH (% of GDP)	Calibrated adaptation effectiveness in AD-WITCH (% of reduced damage)	Residual damages in AD-WITCH (% of GDP)	Total damages in AD-WITCH (% of GDP)	Total damages in Nordhaus and Boyer (2000) (% of GDP)	Total damages in the WITCH model (% of GDP)
USA	0.12	0.25	0.15	0.23	0.29	0.44	0.45	0.41
WEURO	0.21	0.20	0.38	0.26	1.20	1.58	2.84	2.79
EEURO	0.54	0.34	0.17	0.35	0.38	0.55	0.70	−0.34
KOSAU	0.29	0.24	0.27	0.25	0.55	0.82	−0.39	0.12
CAJANZ	0.21	0.25	0.22	0.25	0.30	0.52	0.51	0.12
TE	0.40	0.20	0.26	0.16	0.54	0.80	−0.66	−0.34
MENA	1.48	0.38	1.01	0.52	1.93	2.93	1.95	1.78
SSA	0.78	0.21	0.96	0.14	4.13	5.09	3.90	4.17
SASIA	0.54	0.19	0.66	0.08	4.85	5.51	4.93	4.17
CHINA	0.22	0.22	0.08	0.14	0.42	0.50	0.23	0.22
EASIA	0.84	0.19	0.65	0.11	3.52	4.17	1.81	2.16
LACA	0.19	0.38	0.52	0.31	1.79	2.31	2.43	2.16

Note: USA (United States), WEURO (Western Europe), EEURO (Eastern Europe), KOSAU (Korea, South Africa, Australia), CAJANZ (Canada, Japan, New Zealand), TE (Transition Economies), MENA (Middle East and North Africa), SSA (Sub-Saharan Africa), SASIA (South Asia), CHINA (China and Taiwan), EASIA (South East Asia), LACA (Latin America, Mexico and Caribbean).

Bosello, F., Carraro, C., & De Cian, E. (2010). Climate policy and the optimal balance between mitigation, adaptation and unavoided damage. *Climate Change Economics*, 1(02), 71-92.

Optimal Combination of Mitigation and Adaptation?

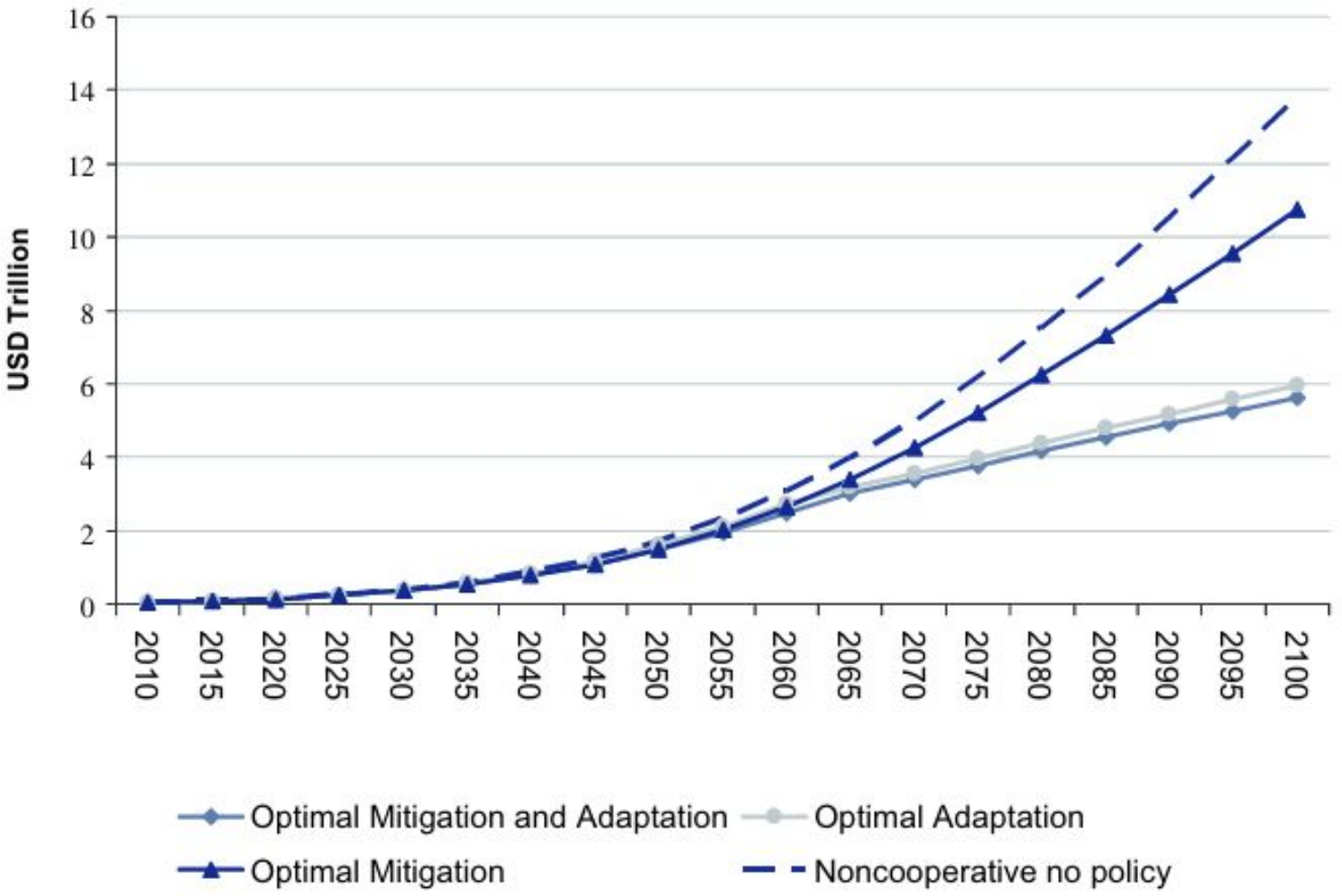


Figure 3. Contribution of adaptation and mitigation to damage reduction

Bosello, F., Carraro, C., & De Cian, E. (2010). Climate policy and the optimal balance between mitigation, adaptation and unavoided damage. *Climate Change Economics*, 1(02), 71-92.

Optimal Combination of Mitigation and Adaptation?

Table 2. Percentage change in discounted gross world product and consumption with respect to the no policy case (2010–2100, 3% discounting).

	Optimal adaptation and mitigation	Optimal mitigation	Optimal adaptation
GWP (Gross benefits)	1.27%	0.98%	1.26%
Consumption (Net benefits)	1.23%	1.18%	0.49%

Bosello, F., Carraro, C., & De Cian, E. (2010). Climate policy and the optimal balance between mitigation, adaptation and unavoided damage. *Climate Change Economics*, 1(02), 71-92.

Experimental evidence on individual attitudes wrt climate change

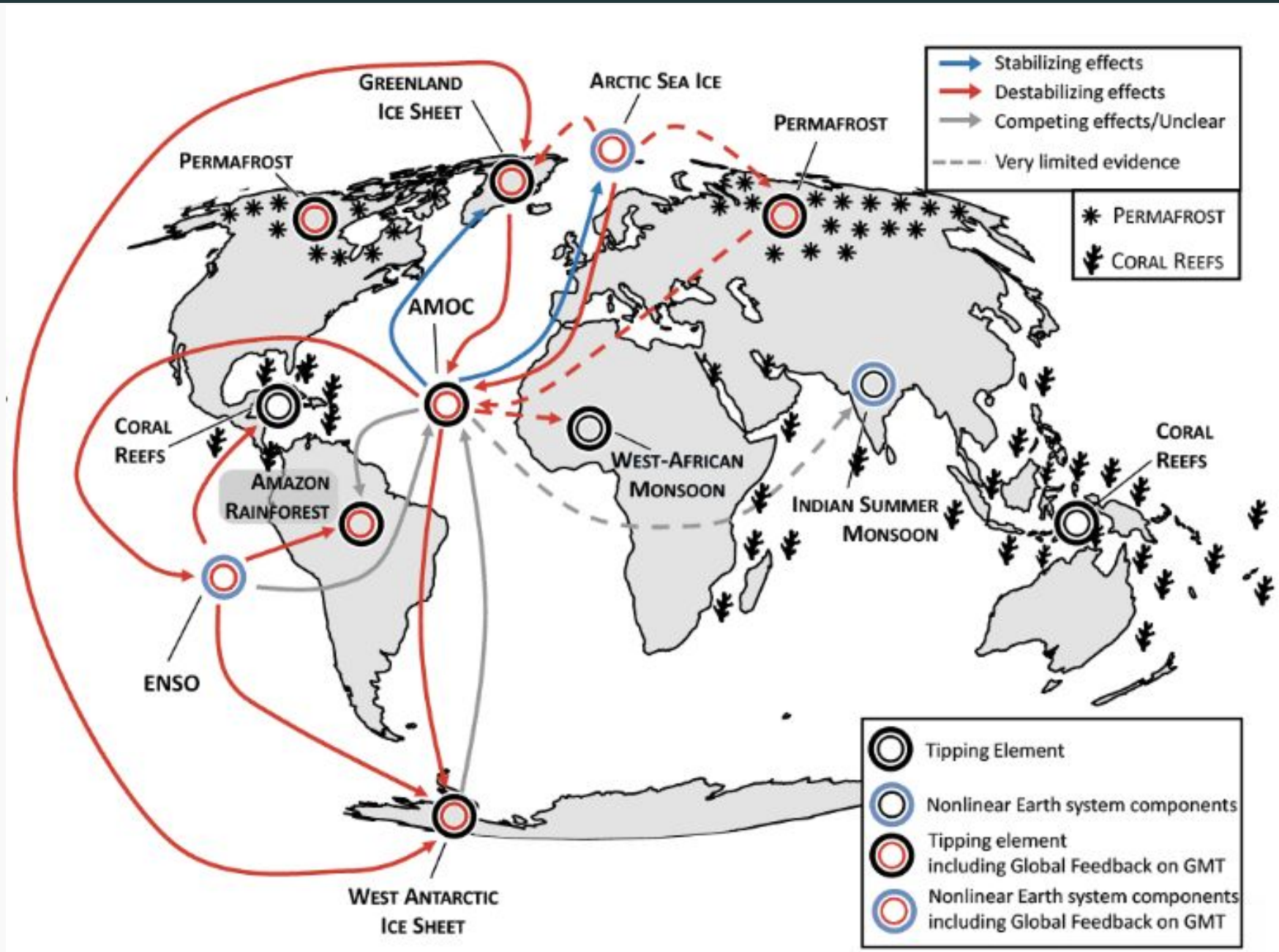
- Optimism bias wrt climate change (Beattie, 2009; Butler et al., 2024; Kube et al., 2025)
- Higher risk tolerance in low-income countries (Bouchouicha & Vieider, 2019)
- Fatalism reduces pro-environmental behavior (Sunstein, 1998; Mayer & Smith, 2019; Mahmood et al., 2020)

Research questions

- Measure preferences for adaptation, mitigation, or inaction in the face of collective risks in societies highly exposed to natural disasters
- Understand psychological underpinnings
- Evaluate ingroup bias
- Investigate whether exposure to climate risk leads to greater adaptation or mitigation

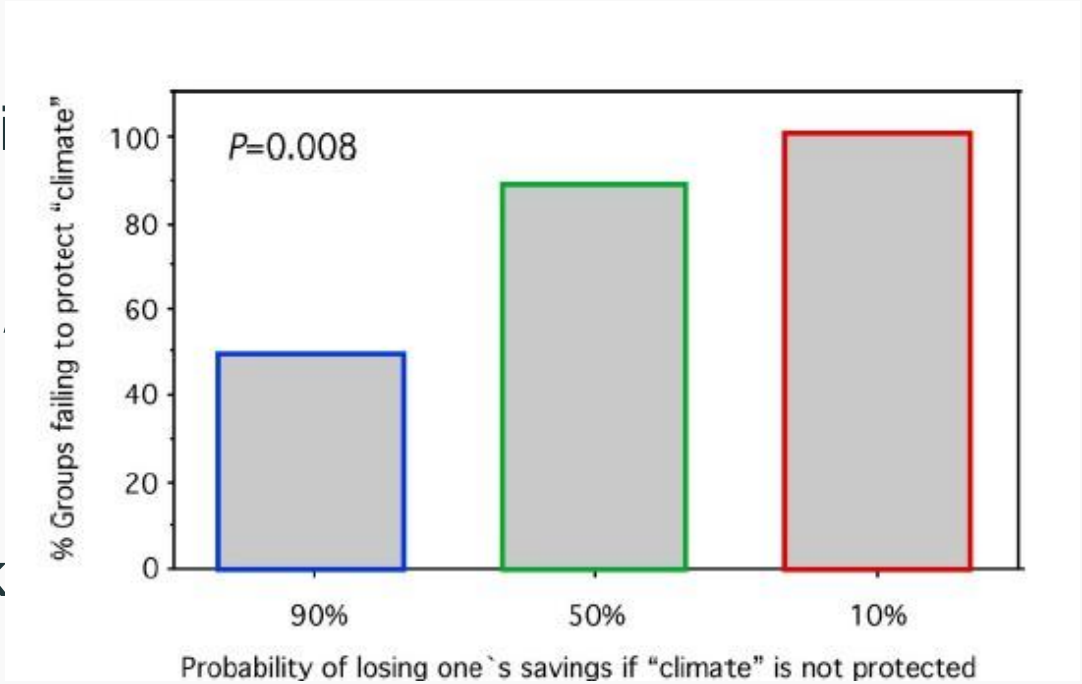
Theory

A global tipping point?

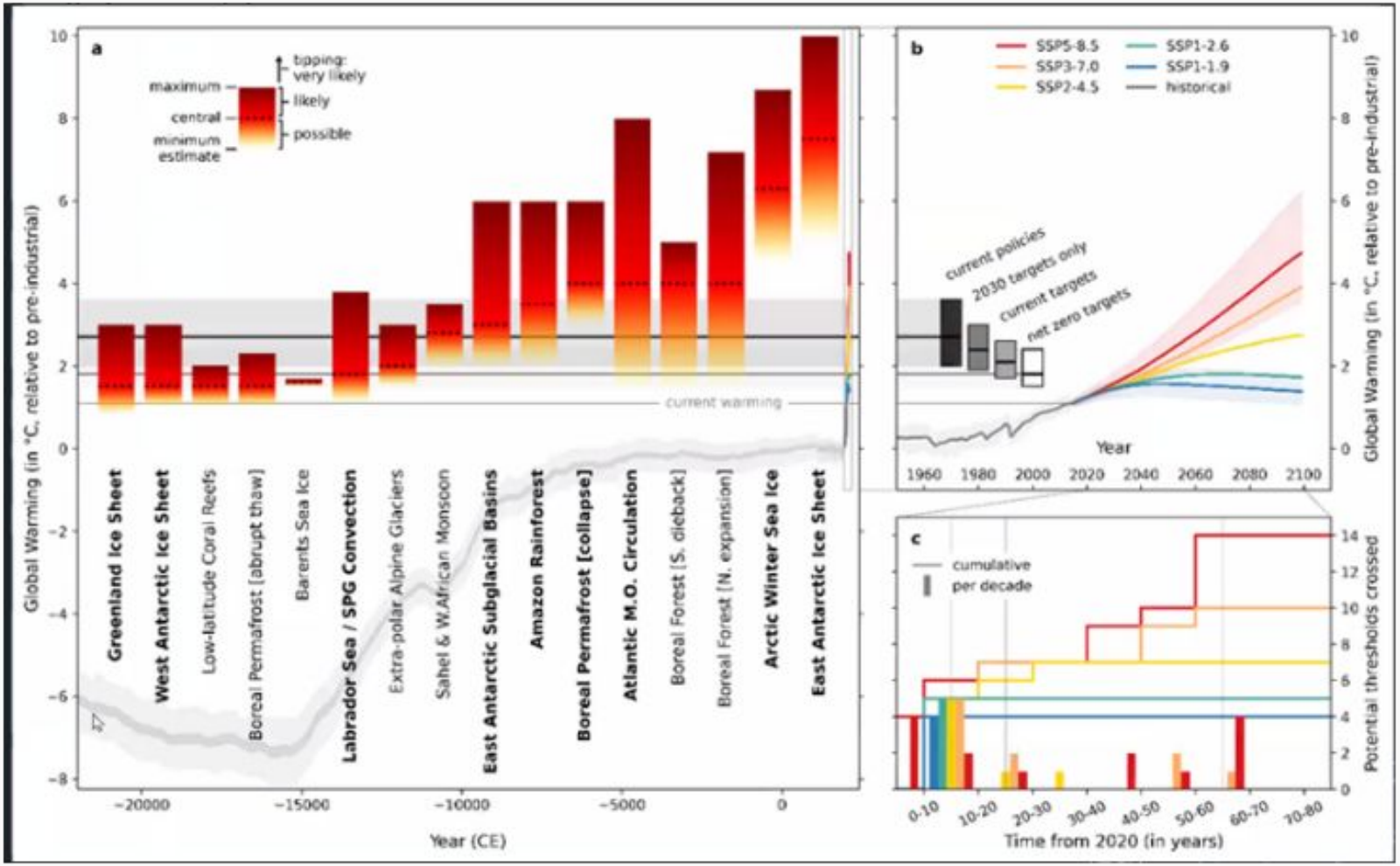


Humans are not too bad (and not too good) in coordinating

- The climate is the quintessential global publi good. Is the climate a global commons? (Hardin 1968)
- ”Collective risk social dilemma” (CRSD) (Milinsk et al. 2006, 2008; 2020; Tavoni et al., 2011; Jacquet et al., 2013) sees preserving the climate as a “Battle of the sexes” game.

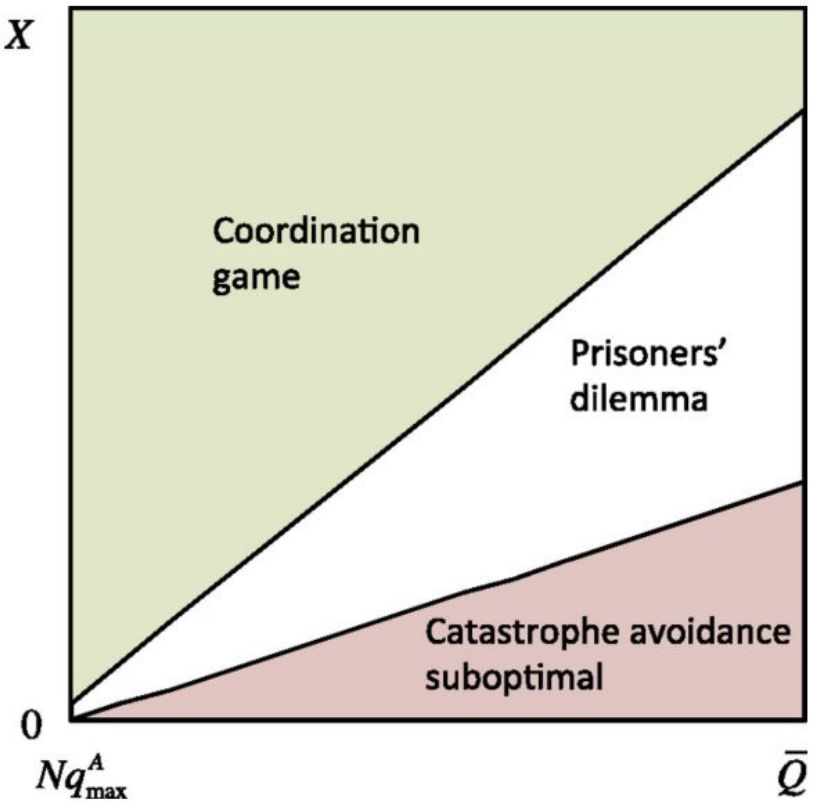


Ecosystems are characterised by tipping points with uncertain threshold



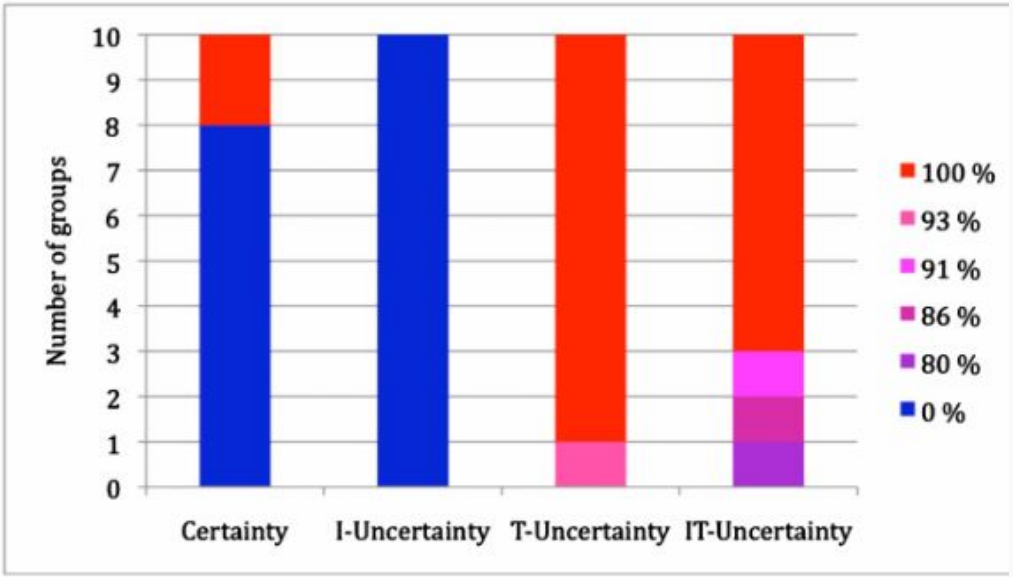
But this is really a cooperation problem!

Fig. 1.



Certainty model. Red area shows values for X and $\overline{Q}$ for which countries are collectively better off not avoiding catastrophe; here, $X < (c^B - bN)(\overline{Q}/N - q^A_{max})$. In the green area, catastrophe avoidance is a coordination game; here, $X \geq (c^B - b)\overline{Q}/N - (c^B - c^A)q^A_{max}$. In the white area, avoiding catastrophe is a prisoners' dilemma; here, if all other countries play $\overline{Q}/N$, each country prefers to abate 0. With certainty, a prisoners' dilemma arises only if b > 0.

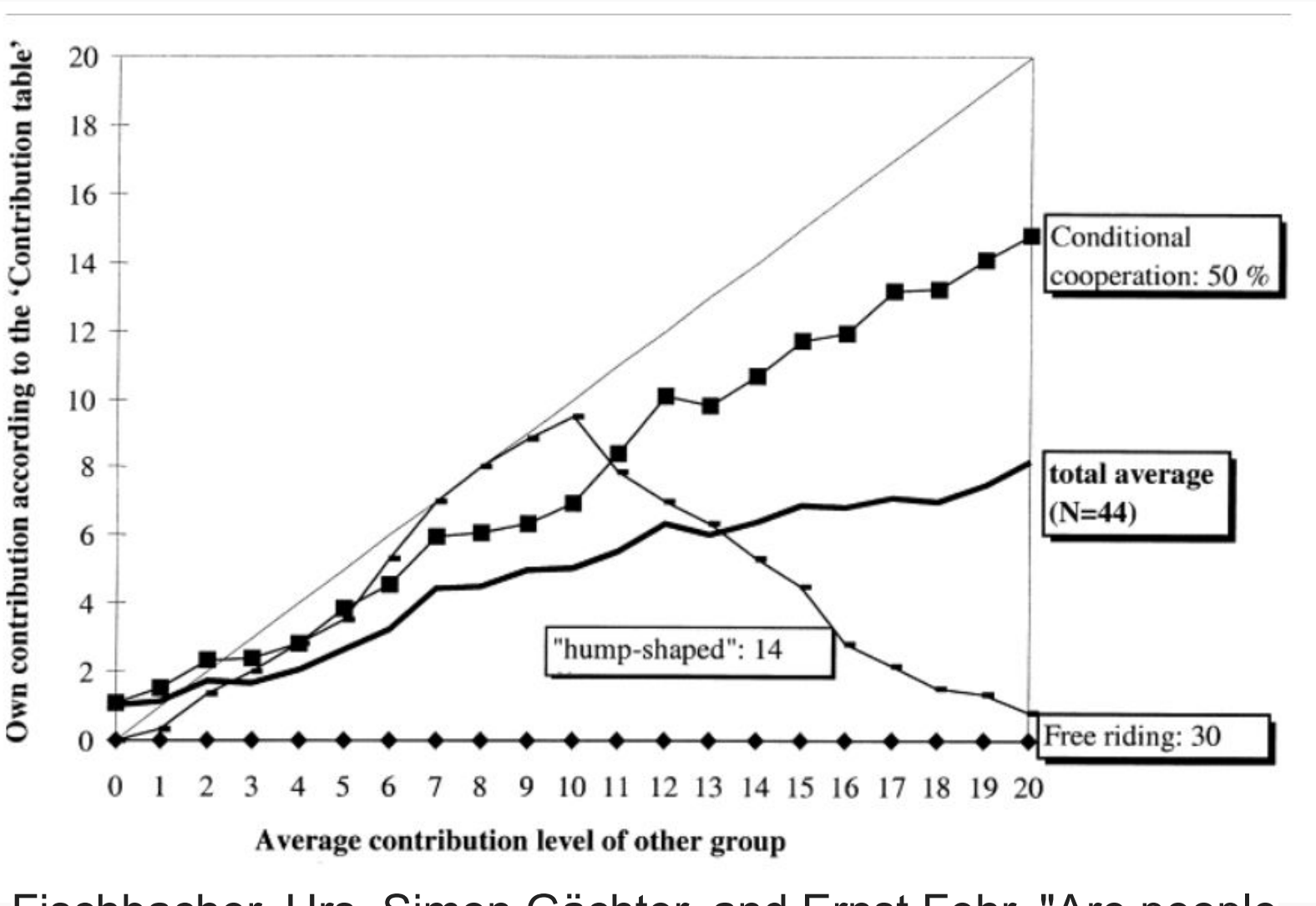
Fig. 2.



Probability of catastrophe by treatment. Catastrophe was avoided 8 of 10 times in the Certainty treatment and 1 of 10 times under Impact Uncertainty (I-Uncertainty). In contrast, the probability of catastrophe was reduced below 100% (to 93%) by only 1 of 10 groups under Threshold Uncertainty (T-Uncertainty) and by only 3 of 10 groups (to 91, 86, and 80%, respectively) under Impact-and-Threshold Uncertainty (IT-Uncertainty). In the four cases where the probability of catastrophe was reduced below 100%, the spinning wheel determined that the threshold was crossed every time.

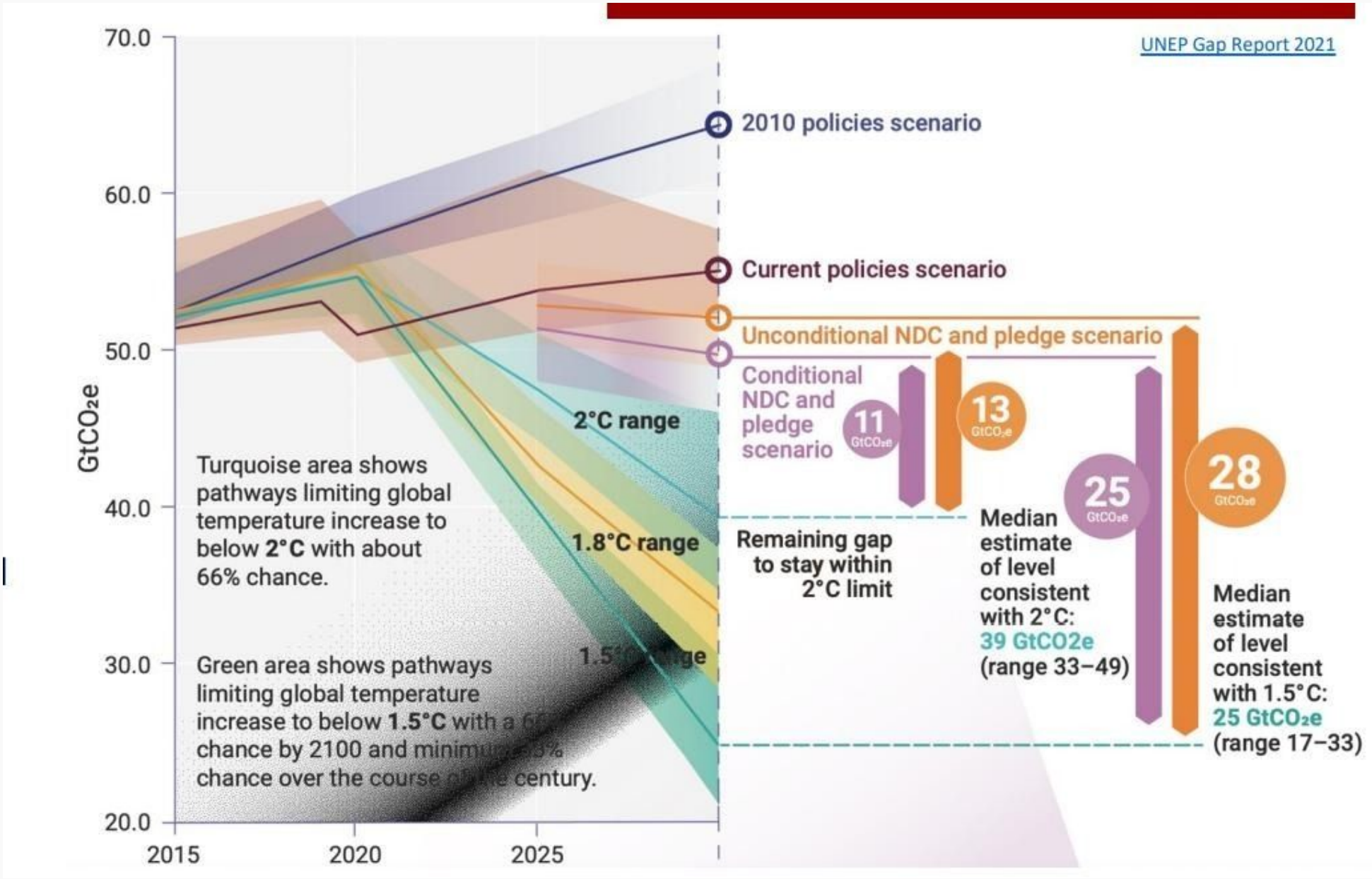
Barrett, S., & Dannenberg, A. (2012). Climate negotiations under scientific uncertainty. *Proceedings of the National Academy of*

Conditional cooperators are the majority in the population



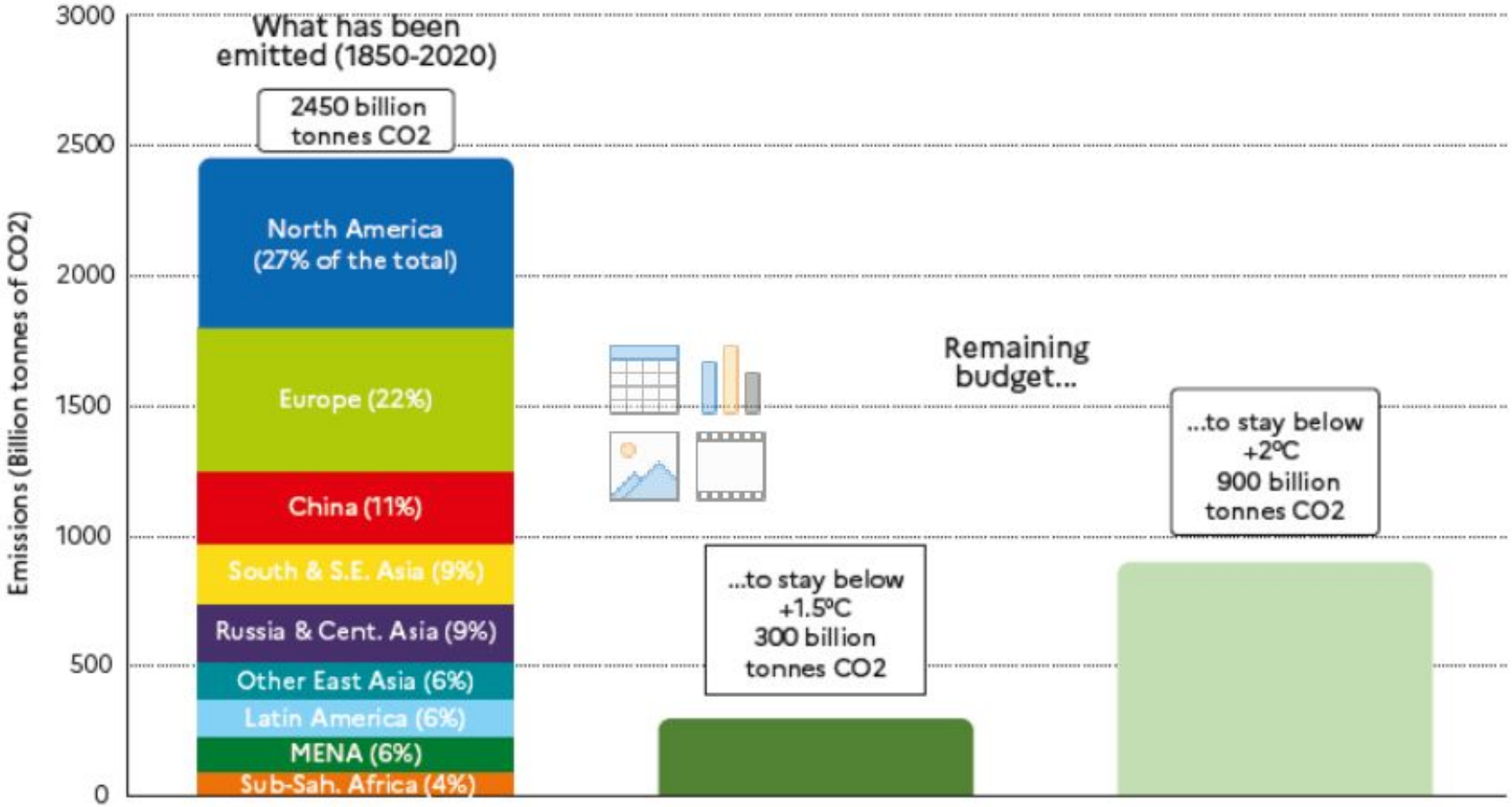
Fischbacher, Urs, Simon Gächter, and Ernst Fehr. "Are people conditionally cooperative? Evidence from a public goods experiment." *Economics letters* 71.3 (2001): 397-404.

But this is really a cooperation problem!



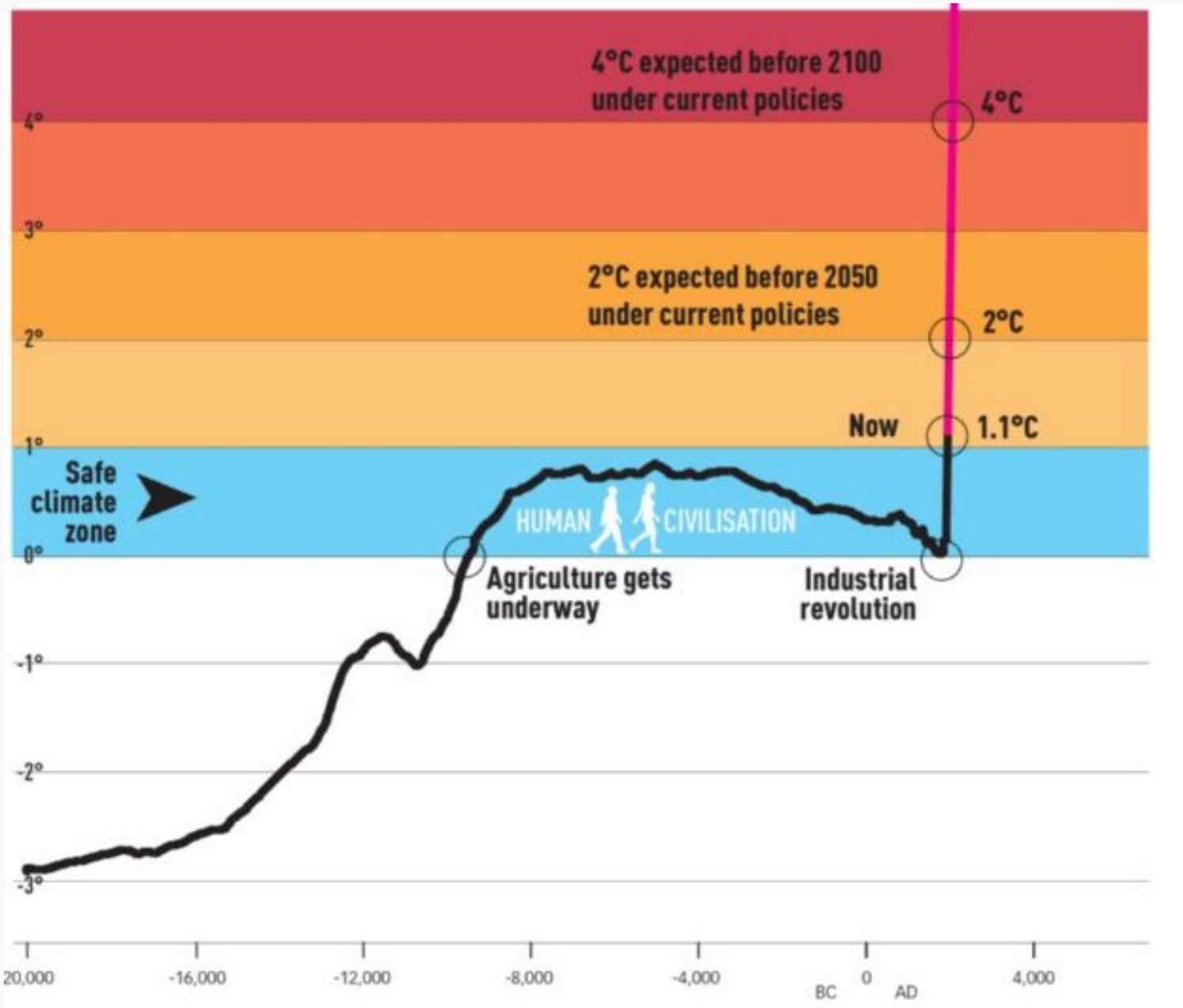
Differentiated responsibilities

Figure 6.2 *Historical emissions vs. remaining carbon budget*

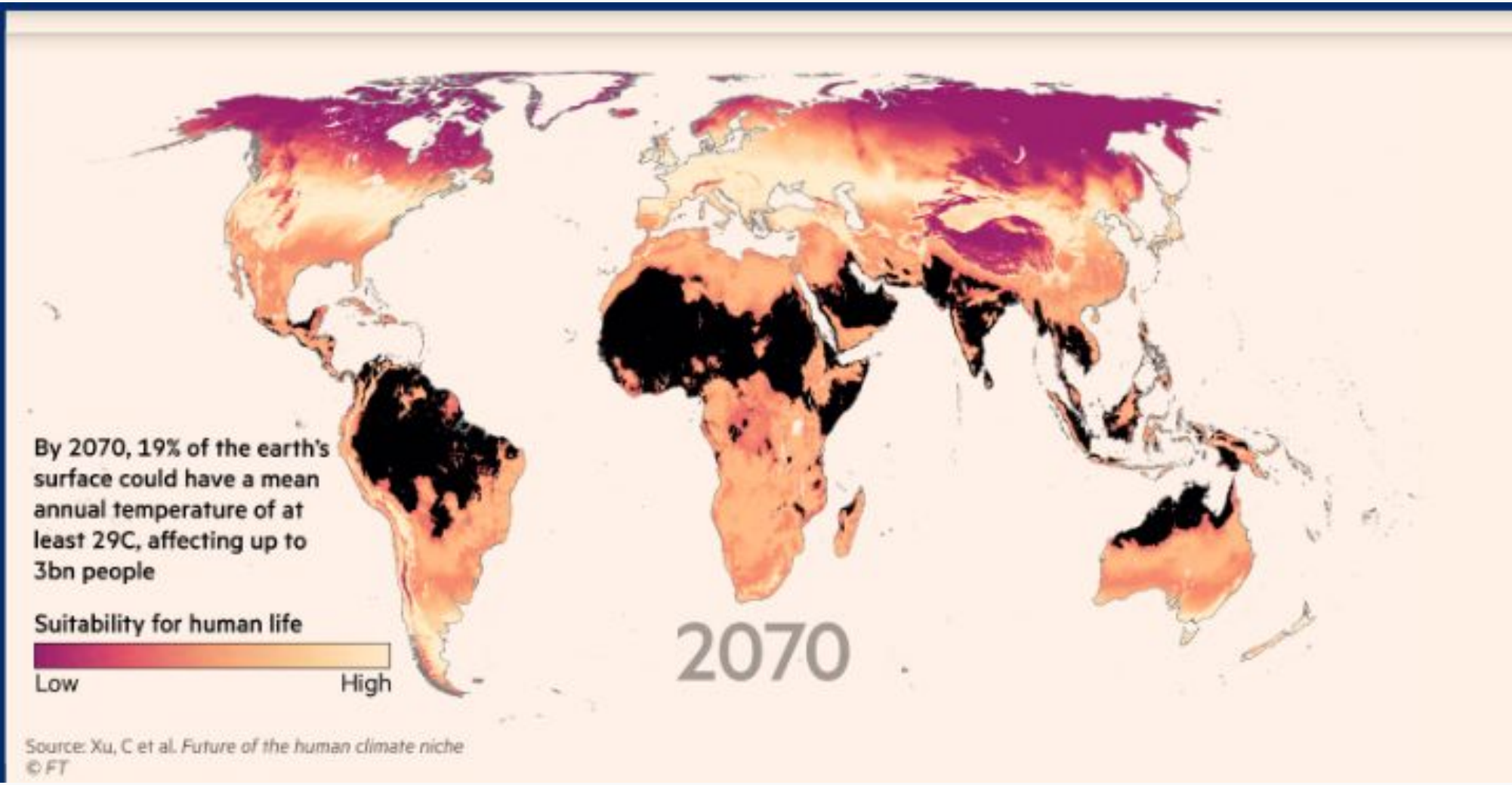


Interpretation: *The graph shows historical emissions by region (left bar) and the remaining global carbon budget (center and right bars) to have 83% chances to stay under 1.5°C and 2°C, according to IPCC AR6 (2021). Regional emissions are net of carbon embedded in imports of goods and services from other regions.* ***Sources and series:*** *wir2022.wid.world/methodology and Chancel (2021). Historical data from the PRIMAP-hist dataset.*

Temperature evolution



Impacts

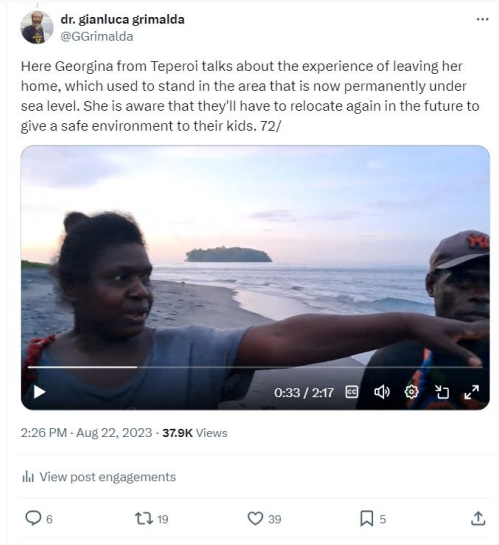

By 2070, 19% of the earth's surface could have a mean annual temperature of at least 29C, affecting up to 3bn people
Suitability for human life
Low
High
2070
Source: Xu, C et al. Future of the human climate niche
© FT

Fieldwork location

Ethnographic account

- 300,000 people inhabitants Societies are horticulturalists and also rely on fishing/hunting.
- Matrilineal matrilocal society
- 10-year civil war, which ended in 1997
- First “climate refugees” relocated from Carteret islands to Bougainville in 2009; relocation still ongoing

Exposure to natural hazards



Why PNG? The first “climate refugees” come from nearby

This article is more than **15 years old**

Climate change displacement has begun – but hardly anyone has noticed

The first evacuation of an entire community due to manmade global warming is happening on the Carteret Islands

Rising sea levels have eroded much of the coastlines of the low-lying Carteret Islands situated 50 miles from Bougainville Island, in the South Pacific. Photograph: Jeremy Sutton-Hibbert /Greenpeace


Digicel
BUKA MARKET

Main market

The “lab in the field”


FUNDRAISING

Experimental design

Essential features of the game

Choice among **three lotteries** characterised by:

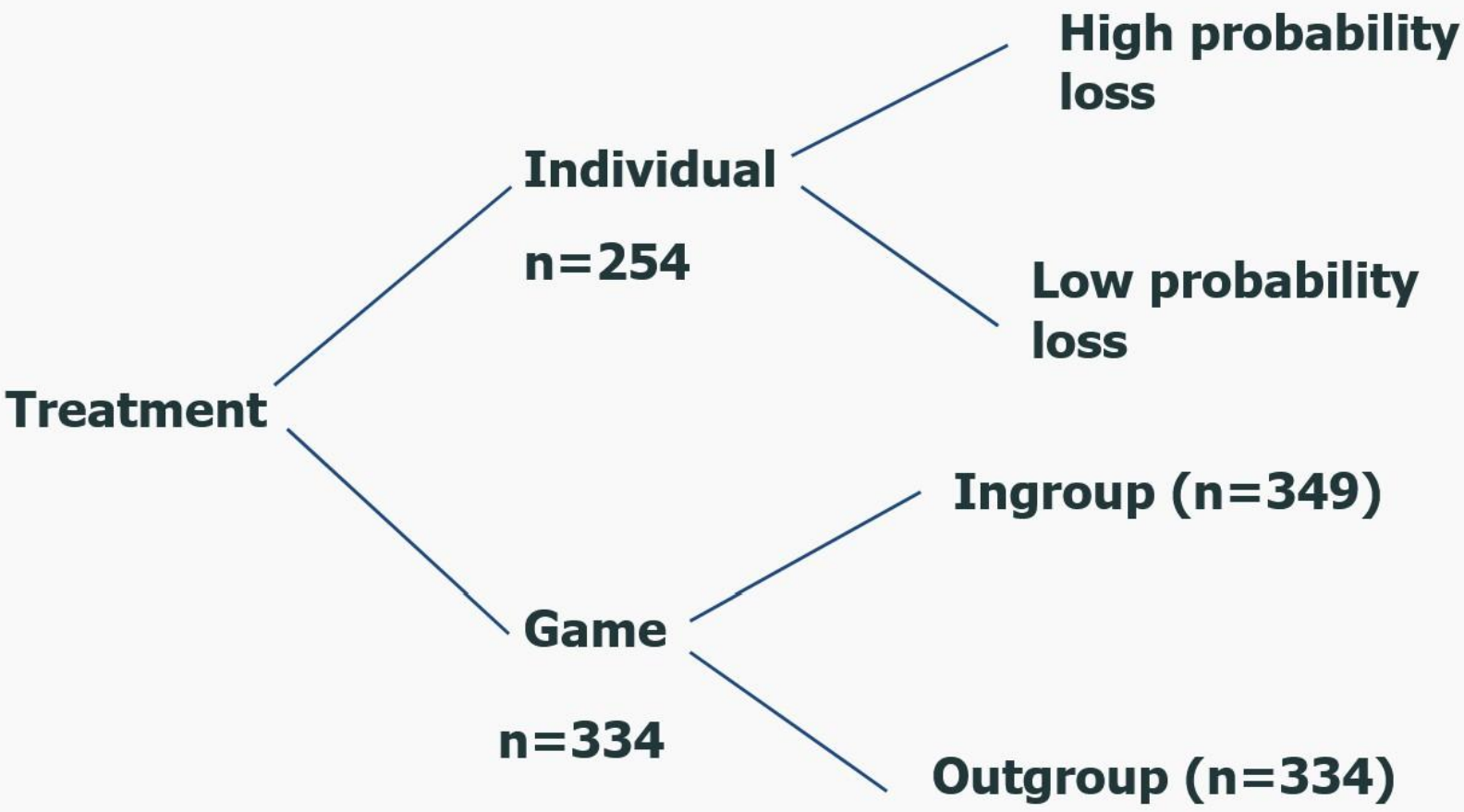
(a) **Status quo** (high loss with high probability)

(b) **Adaptation** (individual protection upon an investment: Reduced loss but probability of loss unchanged)

(c) **Mitigation** (collective action upon an investment: Reduced collective probability of loss but loss unchanged)

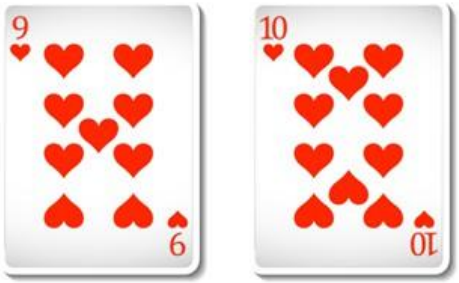
Experimental design

back

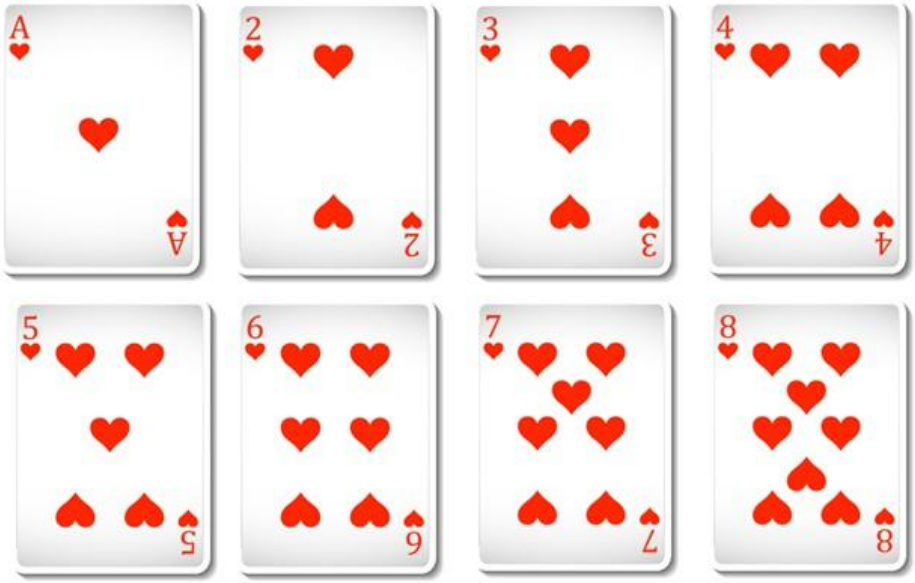


Individual treatment

Lottery 1 - status quo scenario



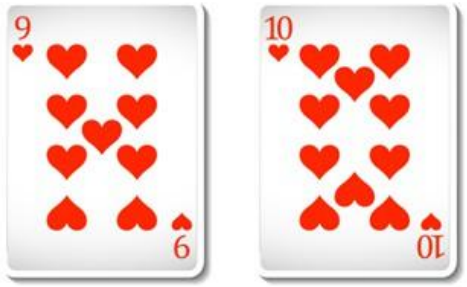
12 $



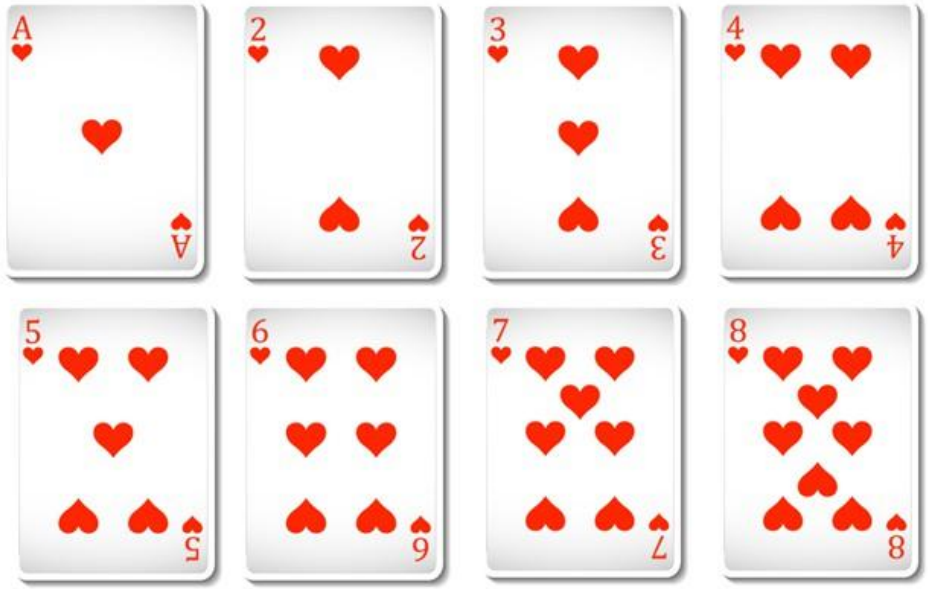
2 $

EV= 4 ; s2= 17.8

Lottery 2 - adaptation scenario



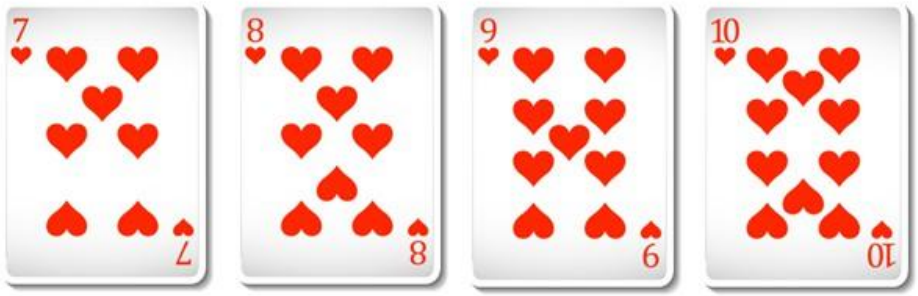
10 $

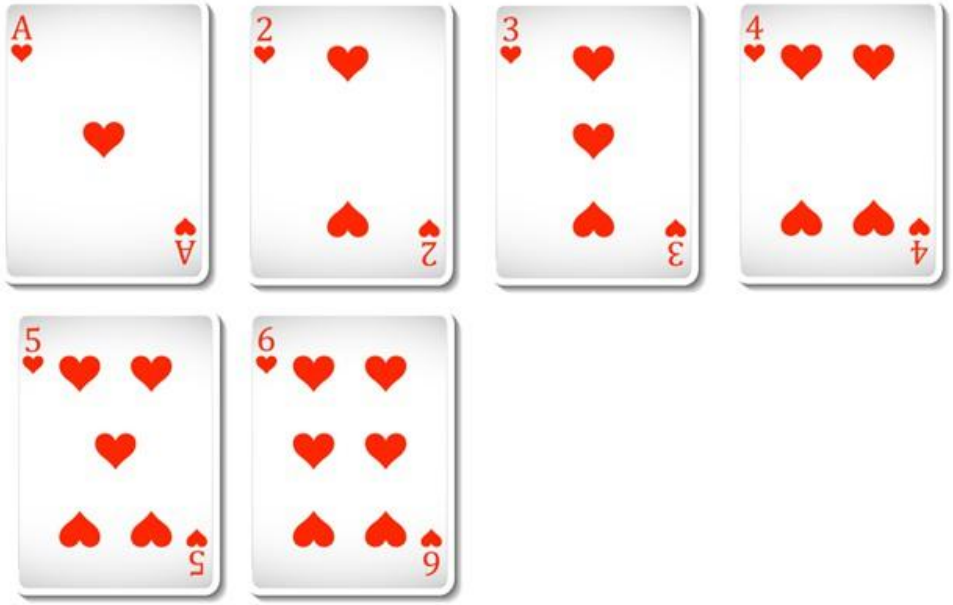


5 $

EV= 6 ; s2= 4.4

Lottery 3 - mitigation scenario





EV= 4 ; s2= 26.7

Design Individual condition

	High loss probability	Low loss probability
Lottery 1	K12 with $1 - P = 20\%$ K2 with $P = 80\%$	K12 with $1 - P = 40\%$ K2 with $P = 60\%$
Lottery 2	K10 with $1 - P = 20\%$ K5 with $P = 80\%$	K10 with $1 - P = 40\%$ K5 with $P = 60\%$
Lottery 3	K10 with $1 - P = 40\%$ K0 with $P = 60\%$	K10 with $1 - P = 70\%$ K0 with $P = 30\%$

Design Individual condition

	High Loss Probability treatment	Low Loss Probability treatment
Lottery 1	EV = 4; $s^2 = 17.8$	EV = 6; $s^2 = 26.7$
Lottery 2	EV = 6; $s^2 = 4.4$	EV = 7; $s^2 = 6.7$
Lottery 3	EV = 4; $s^2 = 26.7$	EV = 7; $s^2 = 23.3$

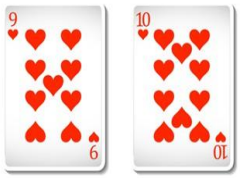
Game Treatment

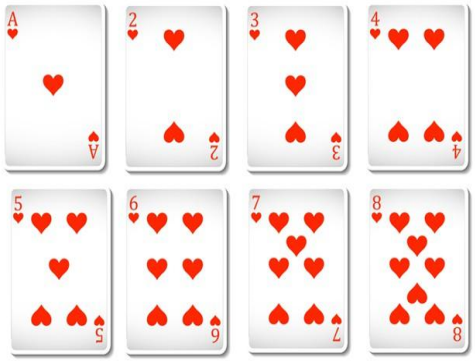
Key features

- Same payoffs/probabilities as Individual condition.
- Two players are matched
- Choice of L3 reduces of probability of losses for Alter for all lotteries.
- Extra “premium” when both players choose L3.
- Loss event the same for both players
- Within-subject: ingroup + outgroup choice

Lottery 1 - status quo scenario

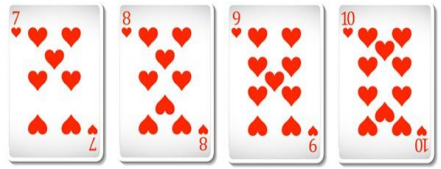
(a) If Alter chooses Lottery 1 or 2

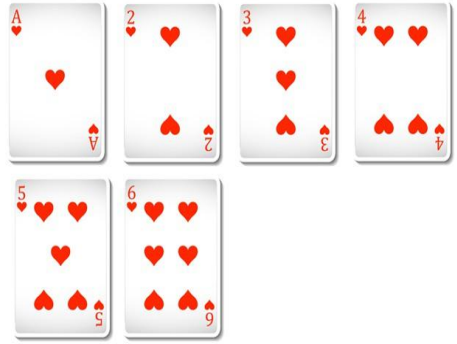




EV= 4 ; s2= 17.8

(b) If Alter chooses Lottery 3

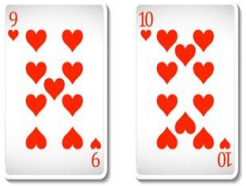


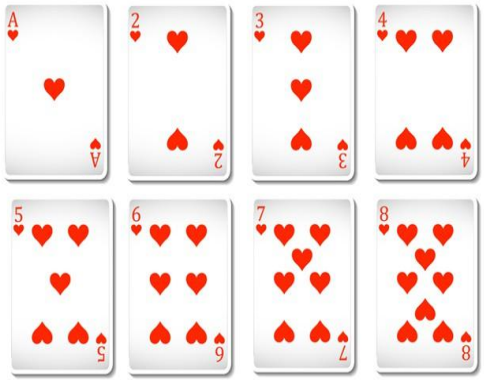


EV=6 ; s2=26.7

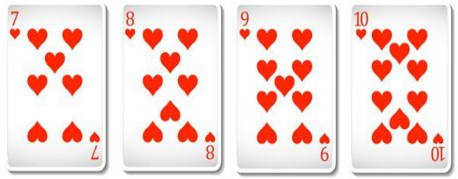
Lottery 2 - adaptation scenario

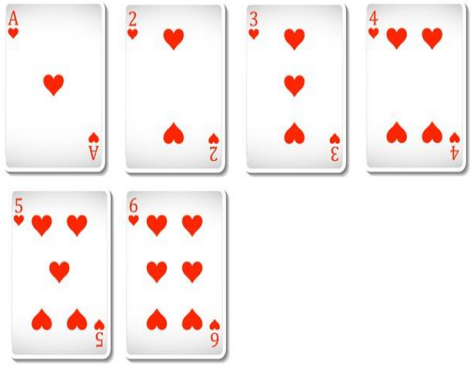
(a) If Alter chooses Lottery 1 or 2





(b) If Alter chooses Lottery 3



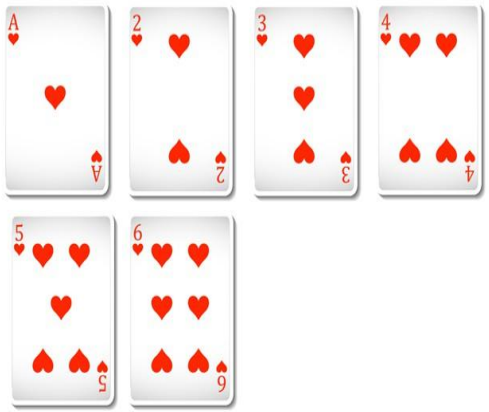


EV= 6 ; s2= 4.4

EV= 7 ; s2= 6.7

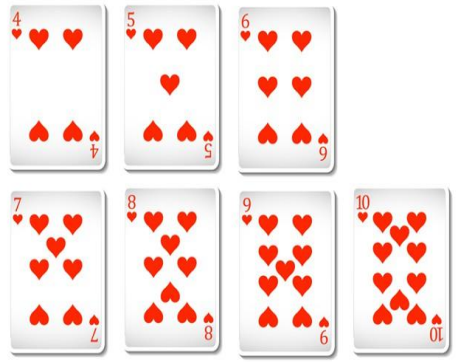
Lottery 3 - mitigation scenario

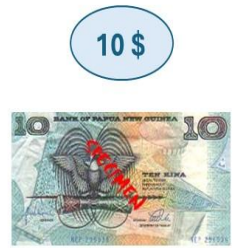
(a) If Alter chooses Lottery 1 or 2

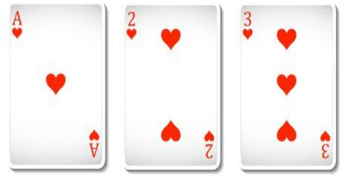


EV= 4 ; s2= 26.7

(b) If Alter chooses Lottery 3







EV= 7 ; s2= 23.3

Study Design: Matrix of Available Lottery Choices in the Game Treatment

Ego	If Alter Chooses Lotteries 1 or 2		If Alter Chooses Lottery 3
	Lottery 1	Lottery 2	Lottery 3
Lottery 1	K12 with $1 - P = 20\%$ K2 with $P = 80\%$	K12 with $1 - P = 40\%$ K2 with $P = 60\%$	K12 with $1 - P = 40\%$ K2 with $P = 60\%$
Lottery 2	K10 with $1 - P = 20\%$ K5 with $P = 80\%$	K10 with $1 - P = 40\%$ K5 with $P = 60\%$	K10 with $1 - P = 40\%$ K5 with $P = 60\%$
Lottery 3	K10 with $1 - P = 40\%$ K0 with $P = 60\%$	K10 with $1 - P = 70\%$ K0 with $P = 30\%$	K10 with $1 - P = 70\%$ K0 with $P = 30\%$

Expected values of lotteries in game

Ego	Alter		
	Lottery 1	Lottery 2	Lottery 3
Lottery 1	(4,4)	(4,6)	(6,4)
Lottery 2	(6,4)	(6,6)	(7,4)
Lottery 3	(4,6)	(4,7)	(7,7)

Expected values of lotteries in game

Ego	Alter		
	Lottery 1	**Lottery 2**	**Lottery 3**
Lottery 1	(4,4)	(4,6)	(6,4)
Lottery 2	(6,4)	(6,6)	(7,4)
Lottery 3	(4,6)	(4,7)	(7,7)

Expected values of lotteries in social welfare form

Ego	Alter		
	Lottery 1	Lottery 2	Lottery 3
Lottery 1	(8)	(10)	(10)
Lottery 2	(10)	(12)	(11)
Lottery 3	(10)	(11)	(14)

Analyses and hypotheses

Essential features

- Three main “types” of cooperative agents -selfish, conditional, and unconditional cooperators (Fischbacher et al., 2001).
- Higher propensity to take risks in individual than in collective situations for individuals averse to betrayal (Bohnet et al., 2008).
- Cooperation is higher in ingroup than outgroup interactions (Romano et al., 2020).
- Individuals tend to act more pro-socially in situations of existential threat (Jonas et al., 2002).

Hypothesis 1

- **H1a:** Choice of Lottery 3 is more frequent in the Game treatment than in the Individual treatment if:
  - Unconditional cooperators + trusting conditional cooperators
    > distrusting conditional cooperators + betrayal-averse cooperators
- **H1b:** Choice of Lottery 3 is less frequent in the Game treatment than in the Individual treatment if:
  - Unconditional cooperators + trusting conditional cooperators
    < distrusting conditional cooperators + betrayal-averse cooperators

Hypothesis

- Individuals will choose Lottery 3 **more frequently in the ingroup** than in the outgroup condition**.**
- **Greater exposure to climate disasters** affects the choice of Lottery 3 and increases the frequency with which individuals choose Lottery 2 or 3.

Decision Types in Individual vs. Game Treatments

Decision Type	Individual Treatment Choice	Game Treatment Choice
Selfish (Preference for Status Quo)	Lottery 1	Lottery 1
Selfish (Preference for Adaptation)	Lottery 2	Lottery 2
Unconditional cooperator	No predictable choice	Lottery 3 (regardless of counterpart's choice)
Conditional Cooperator (Trust)	No predictable choice	Lottery 3 (expects counterpart to choose Lottery 3)
Conditional Cooperator (Distrust)	No predictable choice	Avoids Lottery 3 (expects counterpart not to choose Lottery 3)

Sampling

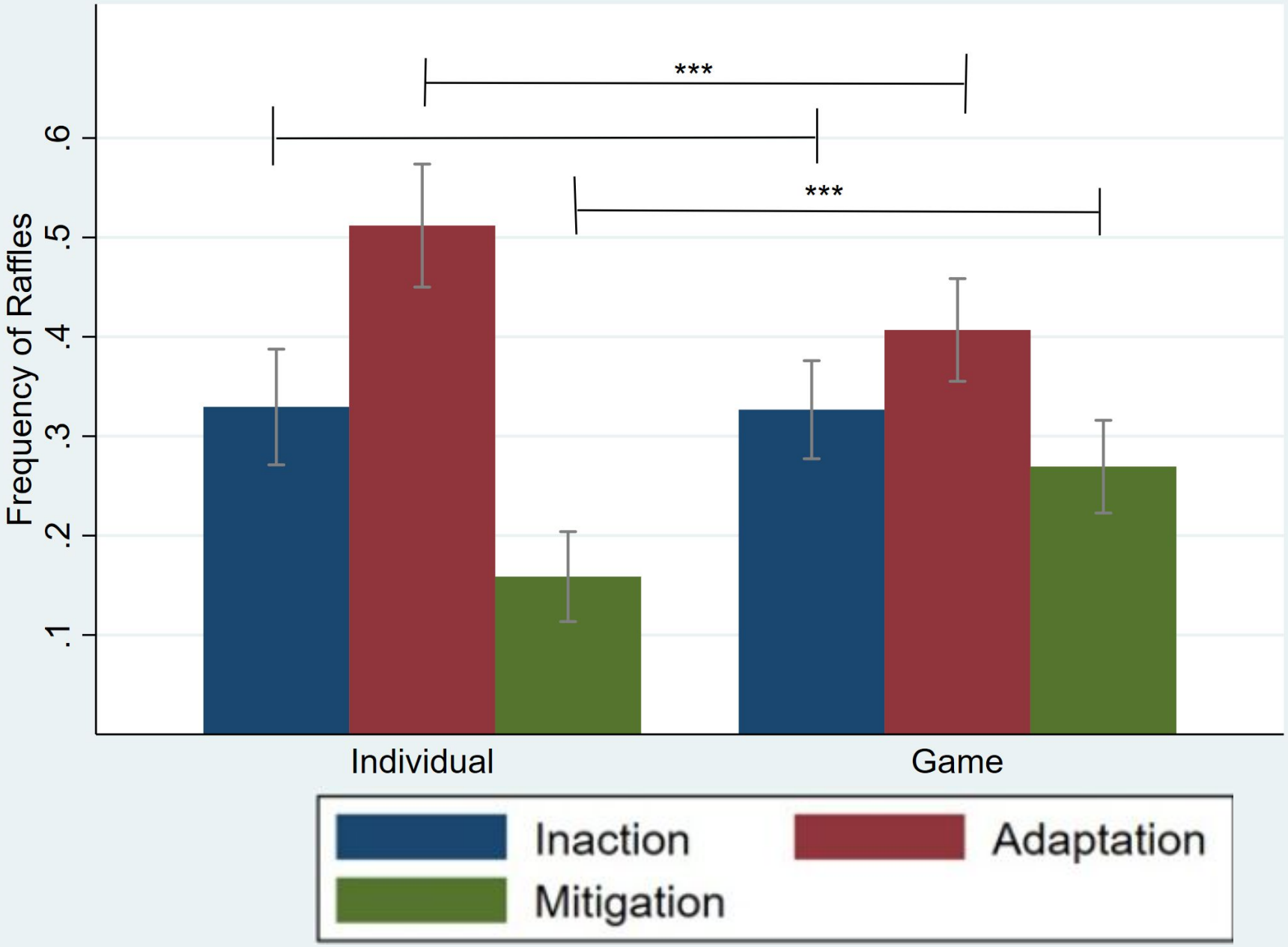
Data Collection Procedures

- A **census list** was obtained from each village, broken down by household.
- **One participant was randomly selected from each household.** In households with many members (exceeding 5 or 6 adults), two or three participants may have been selected.
- **Sample size**: Our sample size is $N = 603$

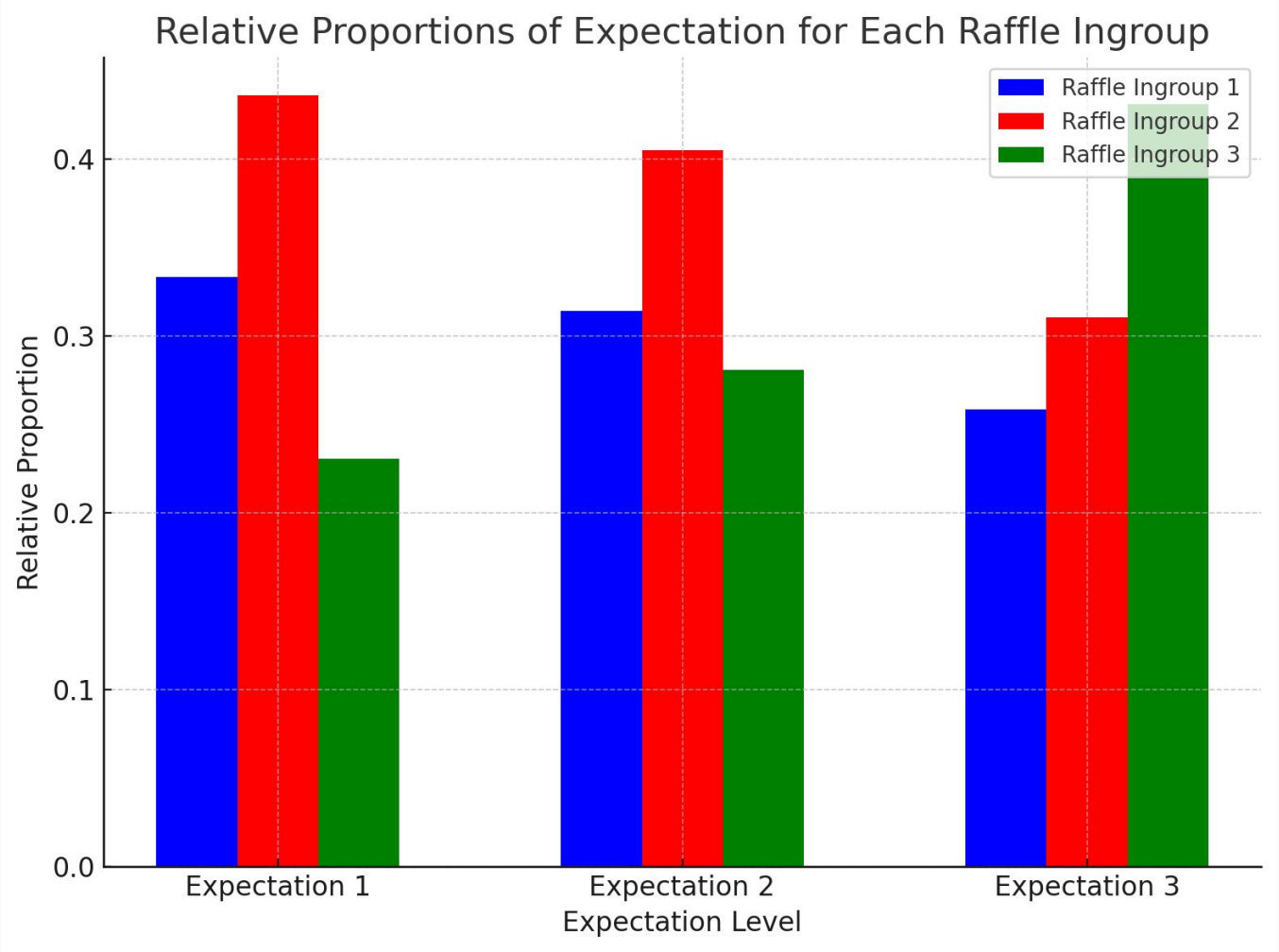
Results

Type Identification

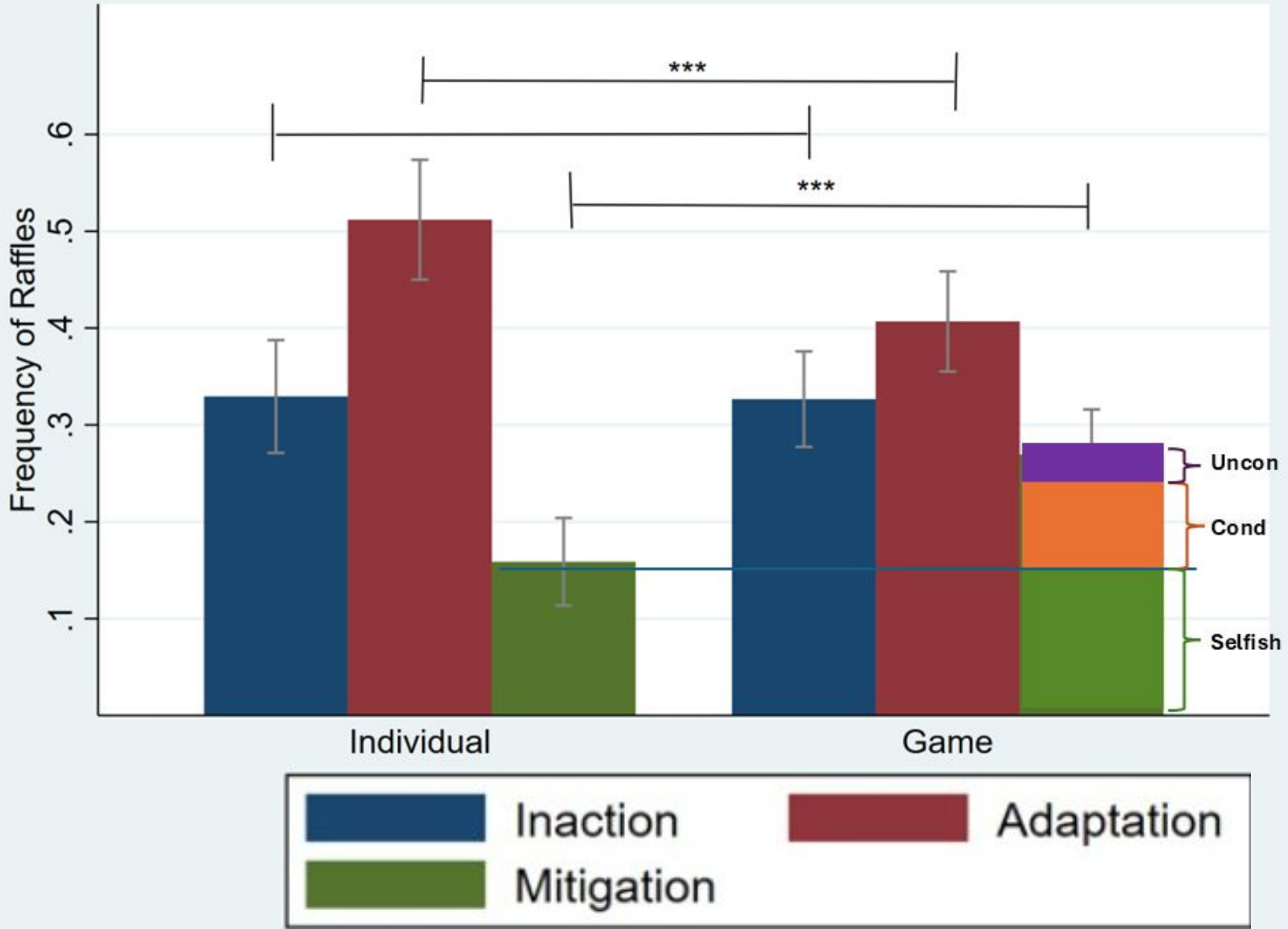
Individual vs Game Treatment



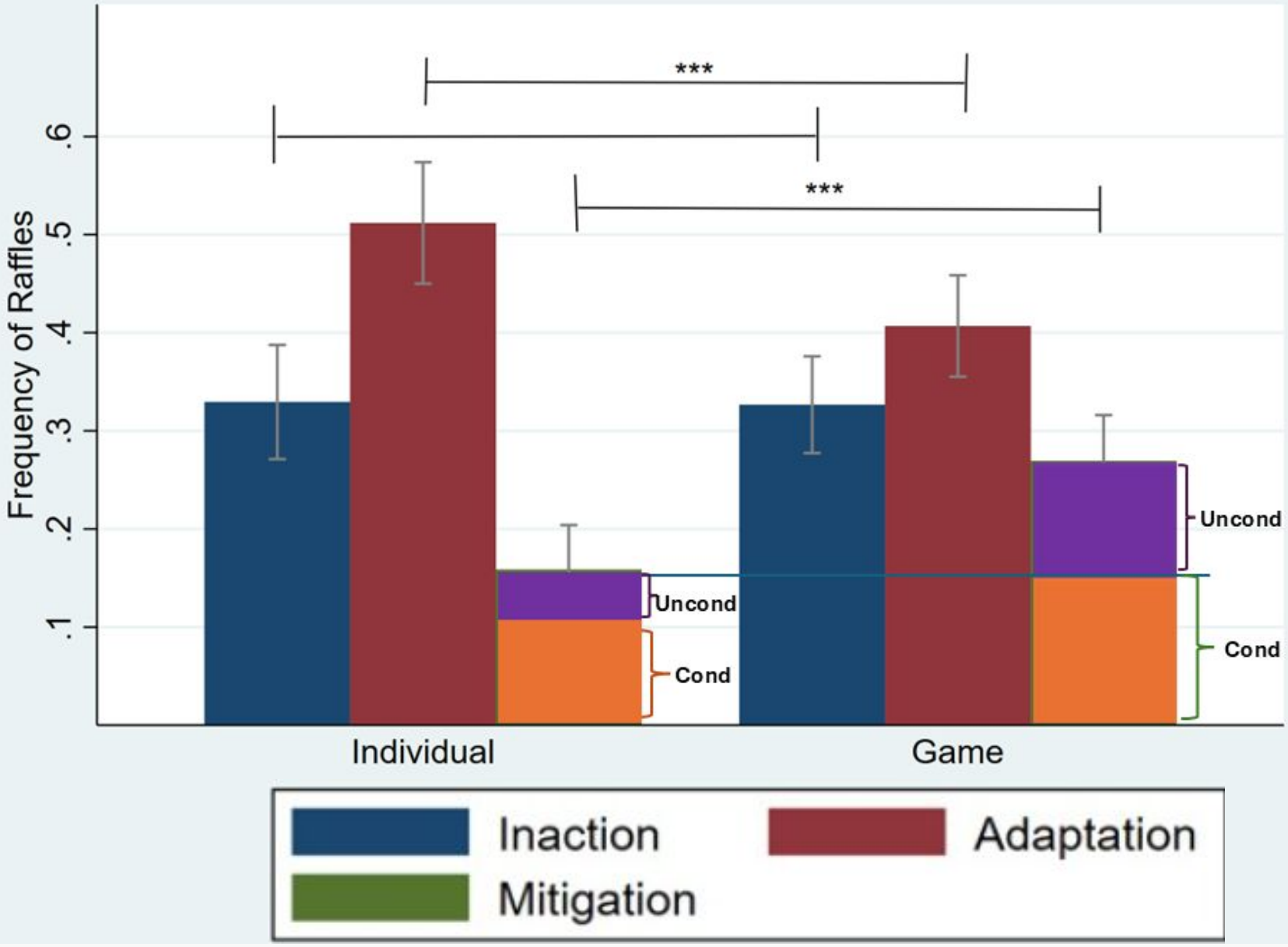
Expectations by choice



Estimation of unconditional and conditional cooperators: Lower bound



Estimation of unconditional and conditional cooperators: Upper bound

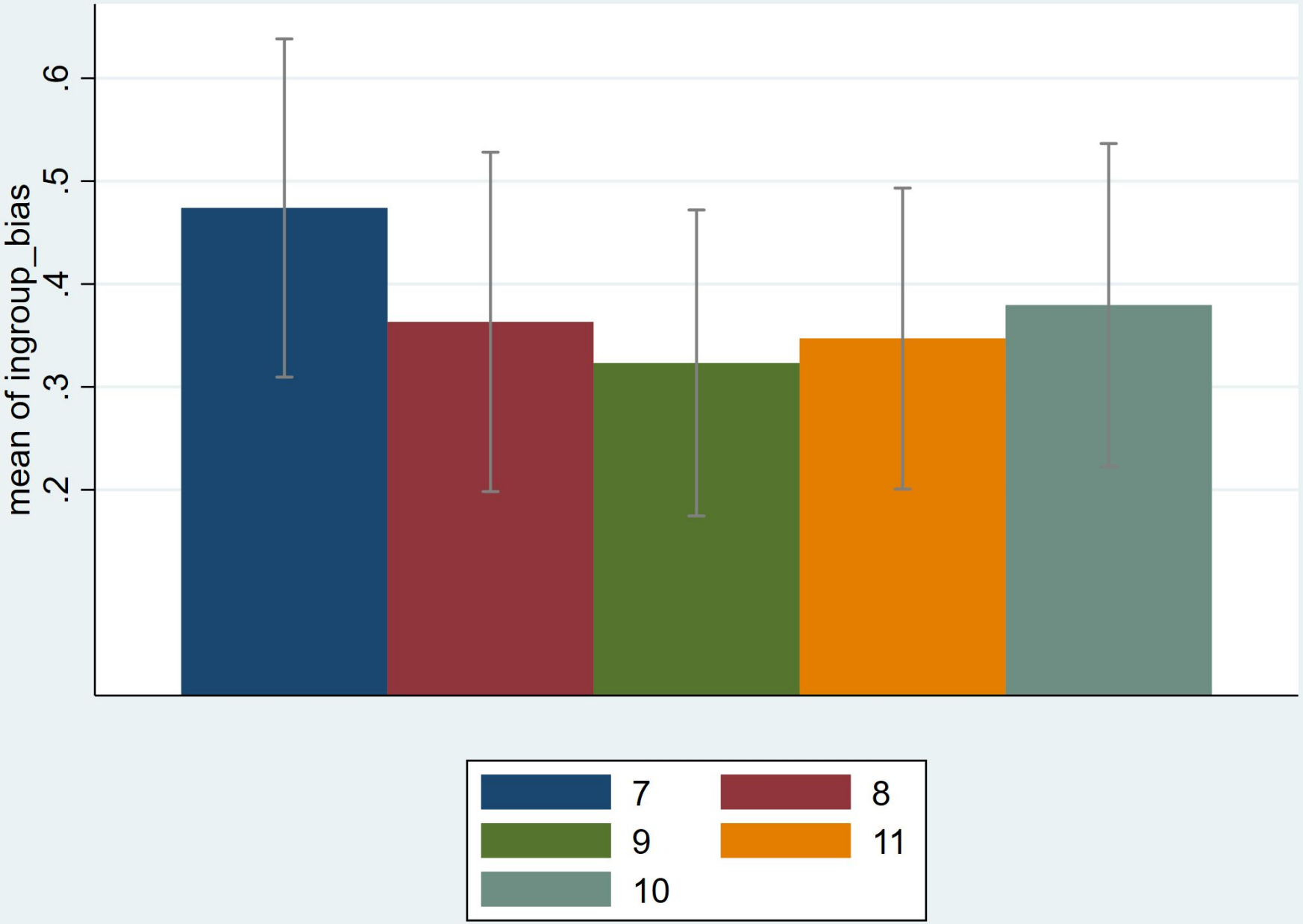


Ingroup bias

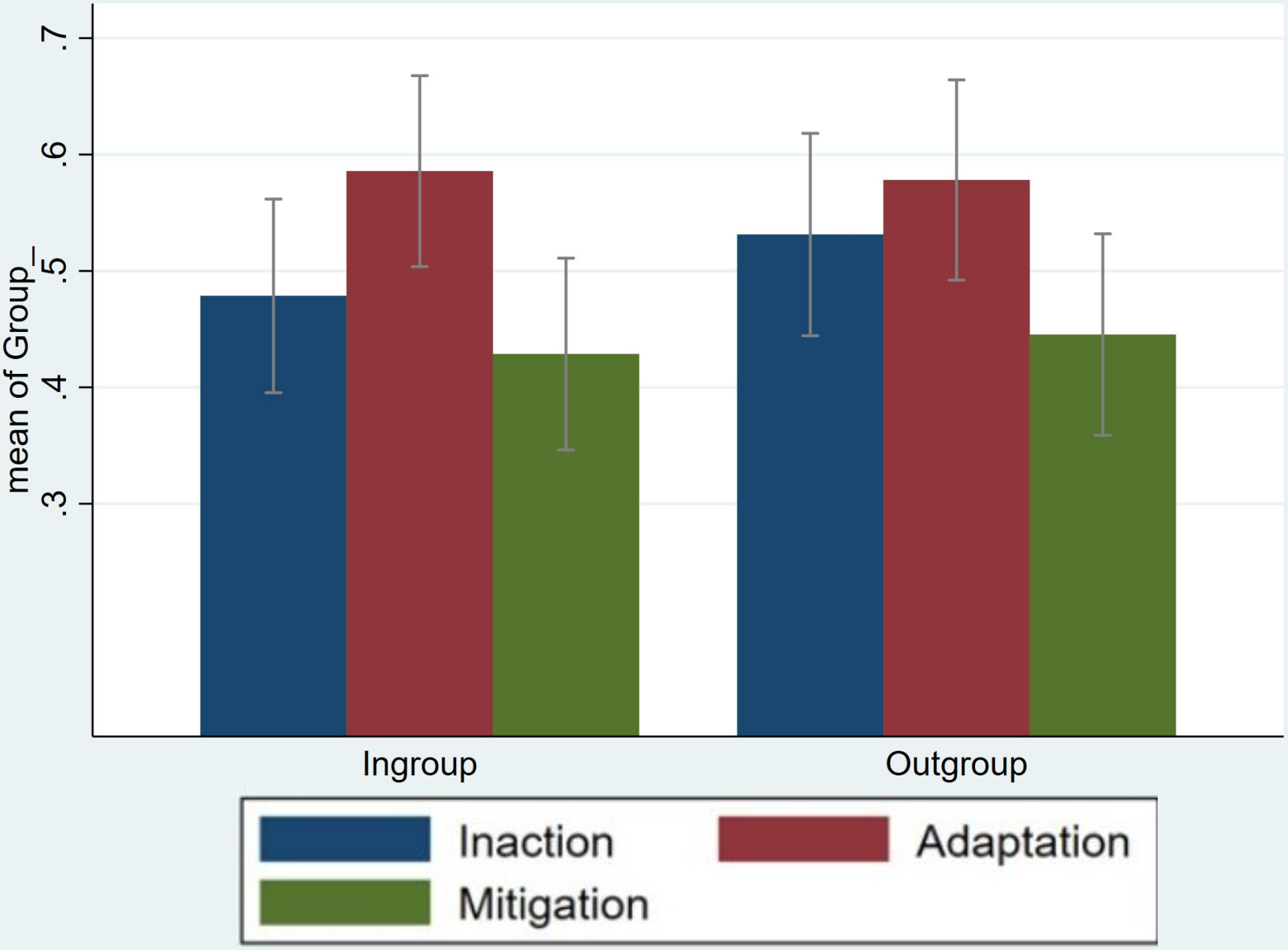
Survey based index of ingroup bias

Question	Options
How much do you like:	• People from your village • People from a village from the South
How much do you feel close to:	• People from your village • People from a village from the South
How good are:	• People from your village • People from a village from the South
How much do you trust:	• People from your village • People from a village from the South
Cronbach alpha	• 0.67 • 0.62

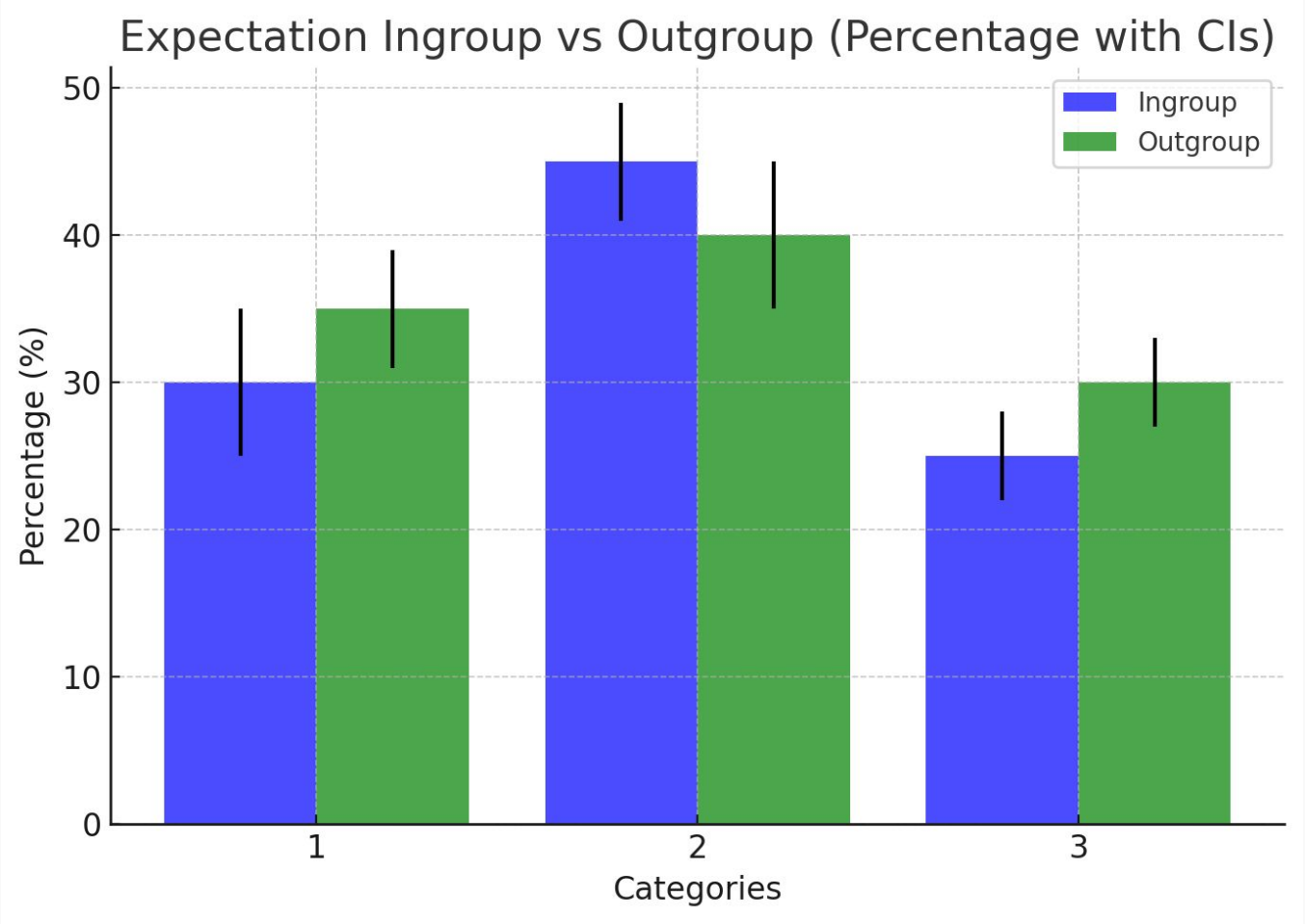
Ingroup bias by village



Ingroup and Outgroup effect



Expectations in Ingroup / Outgroup conditions



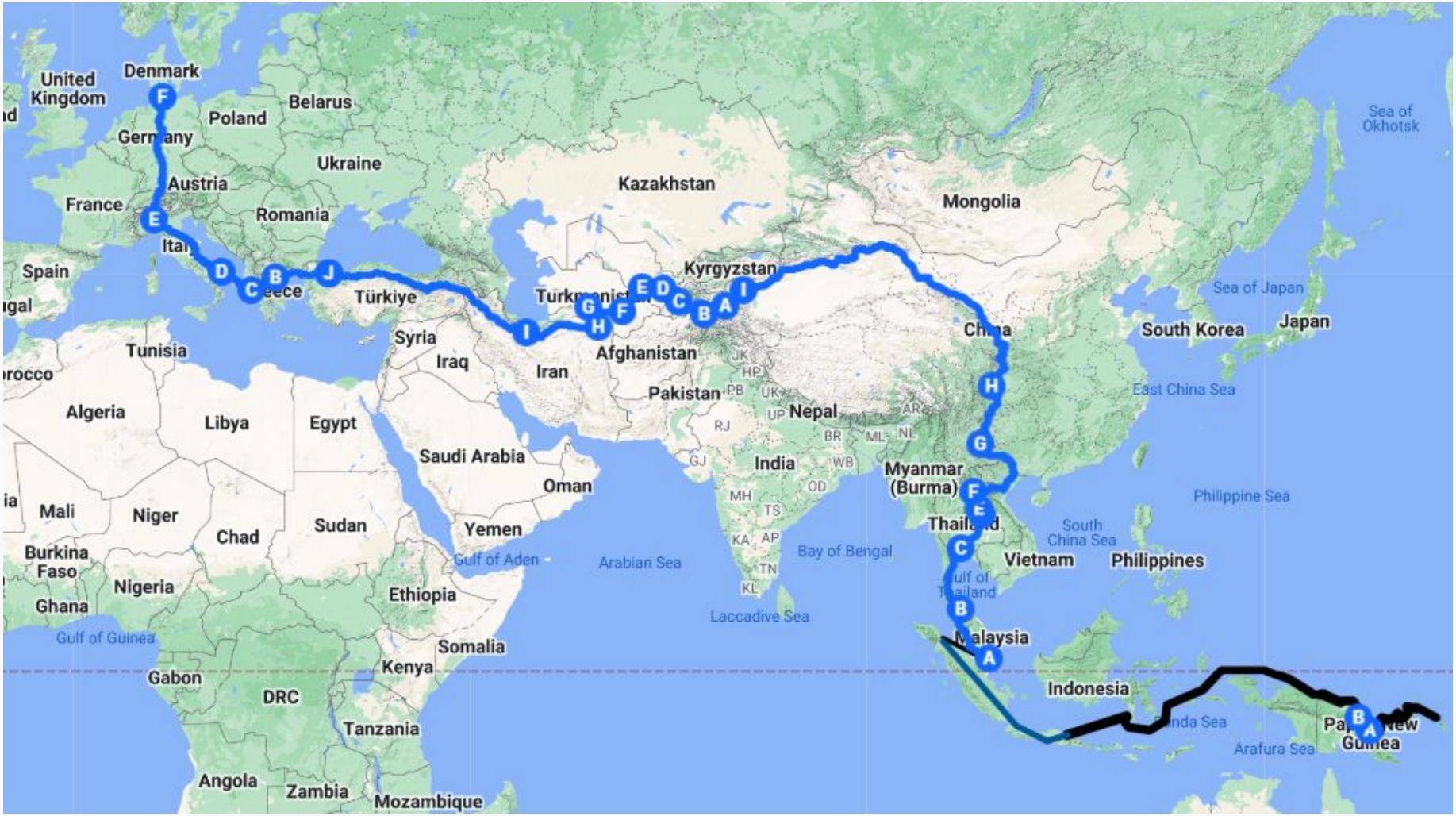
External Validity

- **Understanding of Climate Change:** Impact of Deforestation (81.93
- **Protection Measures:** No significant relationship between taking protection measures in real life and raffle participation
- **Adaptation Actions and Raffle 2:** No significant relationship between understanding climate change and adaptation actions with Raffle 2 participation.
- **Mitigation Actions and Raffle 3:** No significant relationship between mitigation actions and Raffle 3 participation

Conclusions

- The most preferred lottery is the **adaptation** one (41% in the Game condition and 51% in the Individual condition)
- 16% of participants choose Lottery 3 in the Individual condition while 27% in the Game condition.
- **Lottery 2 is the modal choice**, but about 32% of the sample choose 'status quo' lottery (lottery 1) in both conditions.
- **Expectations**: a third of the participant can be classified as a conditional cooperator, while two thirds are unconditional cooperators.
- **No ingroup effect** is observed in decisions between village members.

My no-fly travel



My book


tagli
Feltrinelli
Gianluca
Grimalda
A fuoco
Il mondo brucia
è ora di disobbedire

Vearovira Rutu!

Climate Change Exposure

Climate Data Challenges

Hypothesis (H3): Greater individual and collective exposure to climate disasters will increase the frequency with which individuals choose either Lottery 2 or Lottery 3.

- Individuals tend to act more pro-socially when faced with existential threats (Jonas et al., 2002).

Exposure to Climate Hazards:

- Due to the lack of comprehensive climate disaster data in Bougainville, we construct an index using geospatial data to systematically identify drought and extreme event risks.
- We measure the monetary costs of climate disasters based on self-reported experiences and losses.

index

Index: Data Sources

- **CHIRPS:** High-resolution rainfall estimates combining satellite data.
- **MODIS NDVI:** Measures vegetation health and stress.
- **ERA5 Soil Moisture:** Provides insights into water availability.
- **MODIS Evapotranspiration:** Measures water loss via evaporation and plant transpiration.

Methodology

- GPS data extraction for each village.
- Anomaly calculation for each variable yearly (Precipitation, NDVI, Soil Moisture, ET).
- Calculation of Drought Risk Index (DRI) and Extreme Event Index (EEI) for each village.
- Temporal range 2003 to 2023 (20 years) to capture both short and long-term trends.

Indices DRI and EEI

Drought Risk Index (DRI)

- Precipitation weighted (40%), NDVI (20%), Soil Moisture (20%), and Evapotranspiration (-20%).

Extreme Event Index (EEI):

- Binary index identifying extreme environmental conditions using anomalies in the same variables.

Composite Index

$$\text{Composite Index} = 0.6\times \text{ DRI} + 0.4\times \text{ EEI}$$

Risk Levels by Village:

- Highly Favorable: Keuru, Pokpok, Hanahan, Ramunrata.
- Moderate Drought Risk: Loloho, Tavidua, Tanamalo, Poposoko, Nokia.
- Unfavorable (High Drought Risk): Hangan, Tsundawan.

Climate Change Index Exposure

Village	Summarized Index	Scaled Index	Interpretation
1	1.6352E+16	16.35200	Highly Favorable
2	3.49167E+15	3.49167	Moderate Drought Risk
3	3.49064E+15	3.49064	Moderate Drought Risk
4	2.30507E+16	23.05070	Highly Favorable
5	-7.87653E+15	-7.87653	Unfavorable: High Drought Risk
6	7.77163E+15	7.77163	Moderately Favorable
7	2.38873E+15	2.38873	Moderate Drought Risk
8	2.33257E+15	2.33257	Moderate Drought Risk
9	2.34098E+16	23.40980	Highly Favorable
10	-1.35161E+16	-13.51610	Unfavorable: High Drought Risk

GSEM - Results

Monetary Loss: significant influence of climate change exposure on monetary loss.

Adaptation/Mitigation preferences: higher adaptation preference is associated with lower monetary loss.

CC Exposure: No significant effect in both outcomes, though the direction of the coefficient changes across outcomes.

Education: More education is associated with higher monetary loss

The higher the index, the lower the individual monetary loss

Climate Change Index Exposure

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
raffle_ingroup_binary						
adapt_mitig_pref						
2	.1423559	2.382944	0.06	0.952	-4.528129	4.81284
3	.2293893	2.428437	0.09	0.925	-4.53026	4.989038
4	.1968598	3.111948	0.06	0.950	-5.902446	6.296165
education_years	.1627535	.2551309	0.64	0.524	-.3372938	.6628007
adapt_mitig_pref#c.education_years						
2	-.0715986	.2667538	-0.27	0.788	-.5944265	.4512293
3	-.1278751	.270985	-0.47	0.637	-.658996	.4032459
4	-.1095961	.3607299	-0.30	0.761	-.8166138	.5974215
monetary_loss_individual	-.0000861	.0000783	-1.10	0.272	-.0002395	.0000674
cc_exposure	-.0049641	.0116327	-0.43	0.670	-.0277639	.0178356
_cons	-.0239649	2.284869	-0.01	0.992	-4.502226	4.454296
monetary_loss_individual						
adapt_mitig_pref	-.8586896	.1894484	-4.53	0.000	-1.230002	-.4873775
cc_exposure	-.0380001	.0136837	-2.78	0.005	-.0648196	-.0111806
education_years	.1555533	.0662792	2.35	0.019	.0256485	.2854581
income	-.000017	.0005501	-0.03	0.975	-.0010951	.0010611
_cons	3.261412	.7437422	4.39	0.000	1.803704	4.71912

Fatalis
m

Variable	Response Options	Frequency (%)
Personal control over the future	1. Change future	44 (21.75%)
	2. God/spirits govern future	126 (61.76%)
	3. Don’t know	34 (16.67%)
Humanity’s ability to change the future	1. Change future	43 (21.08%)
	2. Cannot change	125 (61.27%)
	3. Don’t know	36 (17.65%)
Role of luck in rewards	1. Just luck	116 (57.14%)
	2. Rewards for deeds	51 (25.12%)
	3. Don’t know	36 (17.73%)
Consequences of theft	1. Nothing bad	84 (41.38%)
	2. Something bad	99 (48.77%)
	3. Don’t know	20 (9.85%)
Averting climate change	1. Can be averted	21 (10.29%)
	2. Cannot be averted	137 (67.16%)
	3. Don’t know	46 (22.55%)

Table 5: Fatalism Beliefs