Adaptive Investment With Land Tenure and Weather Risk: Behavioural Evidence From Tanzania*

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Abstract

Two important risks faced by many smallholder farmers in Sub-Saharan Africa are erratic weather patterns and insecure land tenure. It is likely these risks will increasingly interact as projections of more erratic weather make small-scale farming more difficult and demand for rural land grows. This paper asks how farmers in Western Tanzania view these compound risks and the influence this has on levels of investment in adaptive agricultural technologies and the demand for land certification in a lab-in-the-field setting. Presenting novel data from a series of framed decision tasks linked to a household survey, this paper explores the relationship between individual risk preferences, adaptive investment, and the demand for land certification from a group of 650 rural households in Kigoma, Tanzania. While adaptive investment increases with weather-related risk, we find it responds negatively to land tenure risk. Individual risk preferences and past experiences of real-world land disputes play significant roles in adaptive investment. We also find that demand for land certification is high; investment increases significantly after certification; and risk-averse individuals show much larger increases in investment after obtaining land certification.

Keywords: agricultural investment, climate change adaptation, tenure risk
JEL Codes: C93, C91, D80, O13, Q15

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1 Introduction

A key question in development economics is why, despite high levels of return to capital, observed levels of investment in many contexts are so low (Kremer, Rao, & Schilbach, 2019). One of the contributions of the behavioural literature has been to recognise that, in situations where returns on investment are stochastic, as they are in situations where returns depend on weather outcomes, risk aversion is likely to be an important reason for this observation (Kremer et al., 2019).

Small-scale farmers throughout Sub-Saharan Africa face various interacting risks to their livelihoods. These include uncertainty about the weather and resultant crop yields, price volatility, and, at times, insecure land tenure. These risks limit the ability of small-scale farmers to expand their agricultural operations. Coupled with a lack of market access and low investment and insurance take-up, this results in situations that have been characterized as poverty traps (Giesbert & Schindler, 2012; Barrett & Swallow, 2006). A key mechanism to mitigate against these risks is through adaptive investments in agriculture. Simple agricultural technologies, such as soil and water conservation measures, soil bunds, and irrigation systems all form part of these adaptive investments that reduce production risk. However, these measures are often labor intensive (in the case of soil and water conservation) and expensive (in the case of irrigation systems) and constitute a fixed and often non-liquid investment. This latter characteristic may be especially prohibitive for investment if there is a strong link between land tenure security and investment.

In large parts of Tanzania, and indeed in many parts of southern and eastern Africa, small-scale farmers operate with little to no cash reserves and maintain largely subsistence lifestyles outside of the formal economy, with limited access to government services. The behavioural literature has shown that behavioural responses to perceived and actual risks are often more pronounced amongst low-income earners, precisely because the consequences of negative real-life events are often more severe (Dercon & Christiaensen, 2011). As a result, small-scale farmers have been found to be highly risk-averse (Elabed & Carter, 2015; Brick & Visser, 2015; Jumare, Visser, & Brick, 2018).

However, there is little empirical evidence on how the measured risk preferences of small-scale farmers influence decisions that affect farm productivity and incomes. In particular, the question of how compound risk influences the uptake of adaptive agricultural investments has received little attention. This is an area of particular interest given the emergent threat that the effects of climate change pose to the livelihoods of small-scale farmers, and the importance of adaptive investments to mitigate against these effects. Weather-based uncertainty is one key source of risk in places where irrigation systems are underdeveloped, and weather patterns are expected to become more erratic and outcomes more severe (IPCC, 2019). While considerable uncertainty exists about the exact effects of climate change on agricultural output, Arndt, Farmer, Strzepek, and Thurlow (2012) find that food security is likely to deteriorate as a consequence of climate change. In particular, for Kigoma region in Tanzania, Arndt et al. (2012) predict a decrease of between 0.36 and 10.5% in average annual real agricultural GDP from a baseline (no climate change) scenario by 2046-50.

Moreover, despite high rates of rural-to-urban migration, rural populations throughout Sub-Saharan Africa continue to grow[1]. With this, the increase in the demand for agricultural land sometimes leads to land-related conflict (Deininger & Castagnini, 2006).[2] In the case of Tanzania, as in the

[1]For example, the number of rural inhabitants in Tanzania is expected to grow by 50% in the next 30 years (UN-DESA, 2018).

[2]In the case of Kigoma, Tanzania, where this study takes place, this problem has been accentuated by the large numbers of refugees who have been forced to migrate to the area due to violence in neighbouring Burundi and the Democratic Republic of Congo (Thomson, 2009). In addition, new urban dwellers also often seek to maintain and expand familial and cultural links to rural areas through farming, which is both economically and culturally important(Ørtenblad, Birch-Thomsen, & Msese, 2019; Njwambe, Cocks, & Vetter, 2019).

case of many other sub-Saharan African (SSA)countries, land administration systems are not well developed despite ongoing efforts by the government and various non-governmental actors[3]. While Tanzania has an ambitious village land-titling program, its coverage is still low (Schreiber, 2017). For example, in the 2017/2018 National Household Budget survey data, 94% of rural households nationally had no title deed or documentation for their main dwelling (NBS, 2018). In the 2019/2020 Extended National Panel Survey, 90% of plots surveyed in rural areas did not have any documentation issued or registered at the land registry (NBS, 2020).

This paper explores how individual risk preferences interact with the demand for adaptive investments in agriculture and the demand for formal tenure security in a context of weather and land-tenure related risk in Kigoma region, Tanzania. By means of a lab-in-the-field approach linked to a household survey, we provide evidence on how small-scale farmers in this region see these interacting risks and how this may be influencing their investment behaviour. The central behavioural evidence is based on a set of framed decision tasks in which individuals choose how much of an initial endowment to invest in an adaptive agricultural technology in a context of varying weather and land-tenure related risk. In a second stage, individuals are offered an option to purchase land certification that removes tenure-related risk; we measure the behavioural response to certification in this framed setting.

The next two sections provide a background discussion of the literature on risk in small-scale agriculture and the nature of land tenure in Tanzania. Sections 4 and 5 present the data and an overview of the behavioural choice experiments, respectively. This is followed by the study results in section 6, discussion in section 7, and conclusion in section 8.

2 Literature

This paper is principally located within the behavioural economics literature centered on understanding the role of external sources of economic risk and individual risk preferences in the uptake of new technologies in small scale agriculture (Liu, 2013; Tanaka, Camerer, & Nguyen, 2016; Holden & Quiggin, 2017). Within this literature, studies have shown that individual risk preferences play an important role in real-world uptake of agricultural technologies. While this question has received significant attention, considerable variation in the sign and nature of the relationship between risk preferences and technology adoption still exists. For example, more risk-averse individuals adopt pest-resistant BT Cotton seeds later on in China (Liu, 2013), while risk-averse individuals are more likely to adopt Drought tolerant maize in Malawi (Holden & Quiggin, 2017). Similarly, Crentsil, Gschwandtner, and Wahhaj (2020) find risk aversion speeds up aquaculture technology adoption in Ghana, while more risk-averse individuals are less likely to adopt modern farming technologies in South Africa (Brick & Visser, 2015). Closely related is work focusing on the role of risk and ambiguity aversion in the uptake of income-risk-reducing financial instruments, such as index insurance (Belissa, Lensink, & Van Asseldonk, 2020; McIntosh, Povel, & Sadoulet, 2019; Visser, Jumare, & Brick, 2020; Tadesse, Alfnes, Erenstein, & Holden, 2017). This paper contributes to this literature with new insights from novel data collected in Tanzania with a focus specifically on adaptive agricultural technologies, i.e., technologies that have higher payoffs and smooth income in the event of adverse weather outcomes - a key set of technologies given projections of more erratic weather patterns in the future.

Another strand of work has focused on the alternative direction, showing that real-world income

[3]Development assistance agencies play a key role in supporting government-led land certification programs in many African countries (for example, the USAID Feed the Future Land Tenure Assistance activity). A key step in the certification process involves surveying of plots, an activity that is expensive and requires technical capacity.

shocks, such as rainfall anomalies, also affect subjective discount rates, which can be important in the uptake of new investments (Di Falco, Berck, Bezabih, & Köhlin, 2019). Using recall information from the household survey, we explore how household characteristics and histories external to the lab setting influence behaviour in the lab-in-the-field experiment.

This paper also relates to the literature focusing on demand for and effects of land certification in contexts characterized by low formal land tenure (Manara & Regan, 2020; Bezabih, Di Falco, Mekonnen, & Kohlin, 2021; Huntington & Shenoy, 2021). There are several mechanisms through which improving individual property rights in rural settings might increase investment. On the one hand, an increased sense of long-term security in property rights might mean farmers are more willing to make long-term investments. Secondly, a formalization of property rights means that property is more liquid and farmers can "get out" what they invest in their properties (Brasselle, Gaspart, & Platteau, 2002). However, the lack of a formal, cadastral system of documented property rights does not a priori imply a lack of tenure security. Indeed, Brasselle et al. (2002) find in Burkina Faso that well-functioning traditional systems of customary land tenure can be sufficient to encourage small-scale investment. While the consensus view is that tenure security increases investment (especially long-term investments), and that view is supported by recent empirical evidence (Bezabih et al., 2021; Ruzzante, Labarta, & Bilton, 2021), other recent studies have found no link between land titling and agricultural investment (Huntington & Shenoy, 2021). Various traditional systems of land tenure continue to exist throughout rural and urban areas in many African countries, including Tanzania. In some cases, these systems rely on trust and community consensus, based on a history of occupation of a particular parcel of land and close kinship ties. In addition, as Brasselle et al. (2002) stress, the impact of tenure security on investment is difficult to determine causally, because the relationship may be prone to reverse causality.

On the other hand, Ali, Deininger, and Goldstein (2014) study the impacts of a pilot land regularization program in Rwanda and find that the program increased access to land for married women and improved investment in soil conservation measures. Deininger and Castagnini (2006) observe a negative relationship between incomplete property rights and investment in Ethiopia. Significant positive impacts of the large-scale land certification program in Ethiopia have been found on farm productivity, investment in trees, and soil conservation measures (Holden, Deininger, & Ghebru, 2009). Bezabih, Holden, et al. (2010) find that, while Ethiopia's land certification program improved farm productivity and led to moderate gains for female farmers, it did not disproportionally benefit women-headed households, which is sometimes a goal of these programs.

Lovo (2016) find that tenure insecurity, in the form of both gender-biased inheritance practices and short-term tenancy contracts, have a negative effect on soil conservation investments in Malawi. Similarly, Deininger, Xia, and Holden (2019) find that 22% of their sample of smallholder farmer respondents in Malawi are concerned about land loss, and that this lack of tenure security is associated with a loss of productivity of 9% for female farmers. In Uganda, Deininger and Castagnini (2006) find that land conflict disproportionally affects women smallholder farmers. They find that female-headed households are 11% more likely to experience land conflict and that, overall, the loss in agricultural productivity due to land conflict is between 5.5 and 11% (Deininger & Castagnini, 2006).

3 Background: Land tenure in rural Tanzania

The 1999 Tanzanian Land Act divides all land in the country into one of three types: Reserved Land (statutorily protected land such as national parks), Village Land (on which the majority of rural Tanzanians live), and General Land (all land that is not defined as Village or Reserve land)

(URT, 1999). While the president is the trustee of all land, the Ministry of Lands, through the Commissioner of Lands, can issue the rights of occupancy to citizens through various tenure arrangements.

Obtaining a Certificate of Customary Right of Occupancy (CCRO)[4] is the major mechanism for individual landowners on village land to secure their tenure formally. This certificate is issued by the village council once an application is submitted by a village land owner, conditional on the village having a village land book, which delimits the land holdings of the village. Individuals are required to pay for the cost of the surveying of their land and to purchase concrete posts that mark the borders. The costs vary according to the size of the land holdings.[5] However, despite the existing legal frameworks, unregistered, customary land tenure remains the main type of tenure in Tanzania.

The current legal framework supports women's rights to land and equal rights to property, and prohibits gender discrimination.[6] Despite this, women's de facto land rights remain relatively limited. Women are underrepresented in land-related decision-making bodies, and often lack information about laws and policies regarding land rights (Scalise, 2012; Moyo, 2017). Many traditional tenure rights in the country are based on patrilineal inheritance, to the detriment of women's land ownership rights (Tsikata, 2003). Customary traditions are sometimes used to discriminate against women, requiring them to access land through their husbands, fathers, or brothers, who often control land (Duncan, 2014; Brown, Laliberte, & Tubbs, 2003).

Customary laws play a major role in land and gender issues, especially when it comes to ownership and access to land, control over resources, inheritance, and divorce (Shivji, 1998). Patrilineal and patrilocal systems that are followed by 80% of Tanzania's diverse ethnic groups are male inheritance systems (Rwebangira, 1996). Here, men have greater access to land and female children do not inherit land because they marry away from their parental home (Rwebangira, 1996; Duncan, 2014). As a result, most women access farm land through natal families. Women often move to their husband's village and cultivate the husband's land or land owned by his family; upon divorce or the death of the husband, the woman loses the rights to the land (Duncan, 2014). Thobejane and Flora (2014) find that women who do have secure property and inheritance rights in rural Tanzania earned up to 3.8 times more income and held 35% more savings. Land tenure security remains crucial for women's economic empowerment in the long term (Namubiru-Mwaura, 2014).

4 Data collection and fieldwork activities

This paper presents insights from novel data collected in a survey of roughly 650 small-scale farming households in the Kigoma region of Western Tanzania. The household survey was followed by a set of framed behavioural decision tasks undertaken by the household heads on the following day. The fieldwork was carried out in August and September 2019[7].

[4]In KiSwahili in Tanzania the document is referred to as a "Hati ya hakimiliki ya kimila"

[5]Anecdotal evidence suggests the cost of certification of a 4-5 acre plot on village land in a rural area may be in the area of 43 USD. The cost comprises purchasing concrete posts to demarcate boundaries, as well as a per-acre surveying fee.

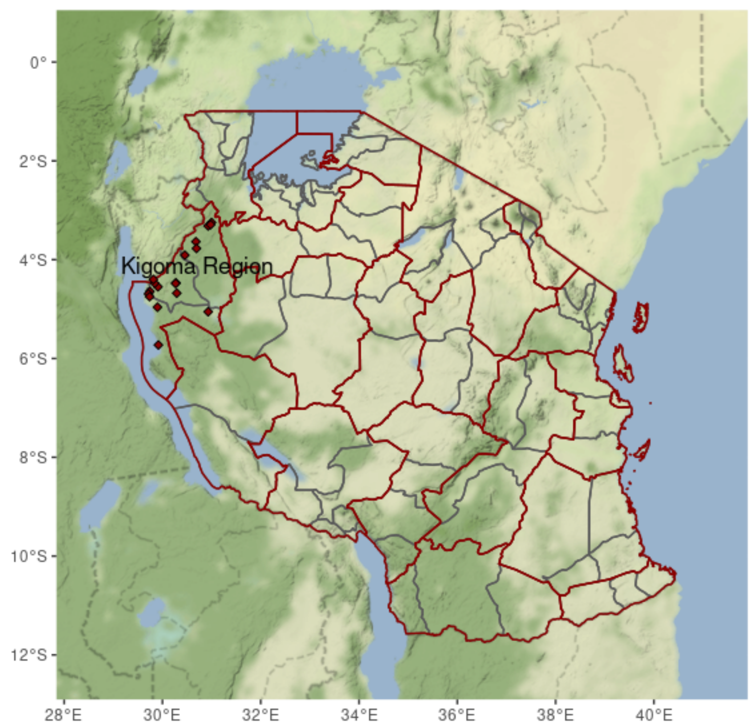
[6]For example, the Land Act prohibits customary law from discriminating against women. Tanzania's 1971 Marriage Act requires registration of monogamous and polygamous marriages, where married women are allowed to hold land individually, including polygamous wives who have individual rights to hold property. Marital property is presumed to be co-registered and spousal consent is needed when transferring or mortgaging property.

[7]All data has been anonymized. Ethics clearance for the research was obtained from the University of Cape Town (REF: REC 2019/001/001) and the University of Dar es Salaam, and permission was obtained from district and ward officers for each ward visited in the study.

A probability-proportional-to-population random sampling approach was adopted, with interviews taking place in all six of the districts within Kigoma region. In each district, three villages were randomly selected for interviews to take place in. Two of these were selected out of a pool of villages with a village land book and one was selected from a pool of villages without village land books. This division was chosen in order to ensure sufficient variation in access to formal tenure security in the form of customary right of tenure certificates. Residing in a village with an existing land book is a necessary condition for individuals to have CCROs. The size of the sample in each village was proportional to total population estimates for each district, released by local planning departments. Within villages, enumerators adopted physical random walks, starting from a central point, each going in a different direction and interviewing every fourth household they encountered. Interviews were carried out with household heads (66% of respondents) and where the household head was unavailable, the spouse (22% of respondents) or the most senior adult present. The survey lasted roughly 1-1.5 hours. The location of fieldwork activities is shown in Figure 1.

Figure 2 presents an overview of the fieldwork activities. Following the successful completion of

Figure 1: Location of fieldwork activities



the household survey, participants were invited to attend the experimental session on the following day, with the knowledge that they would receive monetary compensation for their time. The experimental sessions consisted of a series of games measuring risk preferences, followed by a set of framed decision tasks explained below. The experimental sessions generally lasted four hours.

Figure 2: Overview of fieldwork activities

Day 1	**Household survey** Respondents invited to experiments on day 2		
Day 2	**Risk aversion games** 7 gain frame 7 loss frame	$\longrightarrow$	**Framed decision tasks** 8 w/o option to reduce tenure risk 6 w/ option to reduce tenure risk

5 Game Design

With the primary aim of understanding the interactions between weather risk, land tenure-related risk, and levels of investment, we developed a set of decision tasks framed to resemble choices small-scale farmers might face in real life. The first of these is how much of an initial endowment to invest in one's agricultural operations in a context of uncertain weather outcomes and the potential for future land loss. This is a decision many farmers face, especially regarding investments in long-term, expensive technologies such as dams or irrigation systems that may not be very liquid and whose returns are also weather dependent. In these games (which are outlined in more detail below), farmers choose a level of investment in light of the compound risks of adverse weather outcomes and land loss. Weather and land loss outcomes occur with a set probability and determine the payoff of the investment.

The second set of framed decision tasks centers on whether to purchase formal land certification in the form of a certificate from the local government. This also is a decision many Tanzanian small-scale farmers will face in the next years as the Tanzanian government rolls out its land tenure formalization program. Obtaining a CCRO comes with a cost, and how small-scale farmers view these costs and the returns to the certification may be key factors that drive uptake of the certification program. In the games, participants are offered the option to purchase certification and then decide once more how much to invest in the adaptive agricultural technology. This allows us to understand how the purchasing of certification influences levels of investment post-certification.

In total, three sets of games were played by participants[8]. The games were generally played in an enclosed village hall or school classroom to reduce distractions, and monetarily incentivized to compensate participants for their time and to encourage participants to consider their choices carefully[9]. All sessions were facilitated in KiSwahili by the same two facilitators, who are both fluent in KiSwahili, following a pre-defined and rehearsed script.

5.1 Risk Games

Before the framed setting outlined above, the first set of 14 decision tasks in Table 1 was designed to elicit a quantitative measure of individual risk preferences. This follows a design first developed by Barr (2003) in a Zimbabwean study and used again by Dercon, Gunning, Zeitlin, et al. (2019) in Kenya. Each game comprises a decision between a risky gamble and a safe gamble, where the

[8] A detailed description of each of these tasks, as well as the protocols, is contained in the appendix. The criterion for an invitation to participate in the games was that respondents are able to read and write in KiSwahili

[9] The average payout from participating in these sessions was TSH 29000[10], which is close to the average monthly per-capita expenditure in our sample.

probability associated with the high payoff is varied across games. In order to incentivize respondents to think carefully about their choices, they stand the chance to win real money equivalent to the payoffs in the games.
The first seven of these games are played in the gains space, where participants have no initial endowment, and stand to gain some or no money. The risky gamble involves the chance to gain a large amount (Tsh 6,000) in the high-payoff outcome, or Tsh 0 in the low-payoff outcome. On the other hand, in the safe gamble, participants stand a chance to win either Tsh 2,000 in the high-payoff outcome, or Tsh 1,000 in the low-payoff outcome. These payoffs remain the same in all gain space games, but the probability of the high-payoff outcome is varied across games. Probabilities are visually represented as a set of 10 black and white balls, one of which would be drawn out of a bag at the end of the session[11].
The second set of seven risk preference elicitation games are played in the loss space. Participants start each game with an initial endowment of Tsh 6,000, and stand to lose all, some, or none of this initial endowment. The expected income in the gains space games is identical to the expected income in the corresponding loss space games. As such, the difference in behavioural response is taken as a measure of respondents' relative loss aversion. The order of the games *within* each frame was randomised. A detailed description of how this task was carried out is contained in the appendix.

Table 1: Eliciting risk preferences: Overview of Gain Frame and Loss Frame decision tasks

		Risky Gamble		Safe Gamble		
Task #	P(High payoff)	High Payoff	Low Payoff	High Payoff	Low Payoff	E(Risky-Safe)
Gain Frame: Endowment Tsh 0						
1	0.8	6000	0	2000	1000	3000
2	0.7	6000	0	2000	1000	2500
3	0.6	6000	0	2000	1000	2000
4	0.5	6000	0	2000	1000	1500
5	0.4	6000	0	2000	1000	1000
6	0.3	6000	0	2000	1000	500
7	0.2	6000	0	2000	1000	0
Loss Frame: Endowment Tsh 6000						
8	0.8	-0	-6000	-4000	-5000	3000
9	0.7	-0	-6000	-4000	-5000	2500
10	0.6	-0	-6000	-4000	-5000	2000
11	0.5	-0	-6000	-4000	-5000	1500
12	0.4	-0	-6000	-4000	-5000	1000
13	0.3	-0	-6000	-4000	-5000	500
14	0.2	-0	-6000	-4000	-5000	0

Source: Based on original design developed by (Barr, 2003); and adapted here from (Dercon et al., 2019). *Notes:* Tsh 6000 = 2.55 USD. No restrictions were placed on the consistency of participant's decisions. Games were played in the order presented here. In each task, participants are asked to chose between two gambles, a risky gamble (L) and a safe gamble (R).

In order to generate a risk preference parameter for each participant i, we take the weighted sum of the seven gain (loss) frame decisions between the risky and safe gambles, where the weighting is equal to the probability of the low payoff. Thus, $risk_{i(gain,loss)} = \sum_l l * R_{i,l}$ (for $l = 0.2, 0.3, ..., 0.8$),

[11] i.e., while the total number of balls in the bag remained 10, the ratio of white to black balls is varied to represent the probability of the high-payoff outcome. See the appendix for the detailed protocols and game overview.

where $R_{i,l}$ is a binary variable equal to one if participant i chooses the risky gamble when the probability of the low payoff is equal to l. The weighting increases as the probability of the low payoff increases. As such, individuals who score higher on these variables are seen to be more risk-loving. In the regression analysis, both gain and loss framed risk measures are included as control variables, as well as a combined measure of general risk preference, which is simply the sum of the gain and loss frame risk parameters $risk = risk_{gain} + risk_{loss}$ for each participant. In all cases, higher values of the given risk variable capture higher risk-seeking behaviour in the preference elicitation games. Assuming a constant relative risk aversion (CRRA) utility function of $u(x,r) = \begin{cases} \frac{x^{1-R}}{1-R} & if R \neq 1 \\ lnx & if R = 1 \end{cases}$, where R is the CRRA coefficient to be estimated, the expected utility of lottery i is $\theta_H * u(HP) + (1-\theta_H) * u(LP) = \theta_H * \frac{HP^{1-R}}{1-R} + (1-\theta_H) * \frac{LP^{1-R}}{1-R}$, where LP and HP indicate the low and high payoffs, respectively.

5.2 Framed investment games

The next eight framed games involve decisions on how much of an initial endowment to invest in adaptive agricultural technologies in light of the compound risks of i) poor crop yields due to bad rainfall and ii) the risk of land loss associated with tenure insecurity. In order to prevent place-specific associations with technologies from affecting the results, the specific type of technology is left open-ended, but participants are provided with examples of adaptive investments, such as irrigation, soil conservation tranches, terracing, etc.

Participants start each game with an initial endowment a of Tsh 8,000 and are presented with the choice of investing a proportion i of this (in intervals of 2000) in the adaptive technology[12]. They also have an additional amount of capital c = Tsh 10000 that they are not able to invest at this stage. There are three potential outcomes o in these games: good rainfall $o = g$, bad rainfall $o = b$, and land loss $o = l$. In addition, there is a basic farming income f_o and return on investment r_o specific to each outcome (as would be the case for adaptive investments)[13]. Each outcome occurs with a probability θ_o, where $\sum_o \theta_o = 1$. In addition, we define α to be $\frac{\theta_g}{\theta_b}$, the relative probability of good rainfall to the probability of bad rainfall, which can be low ($\alpha = 0.25$) or high ($\alpha = 1$). This allows for variation in the weather-related risk in the game.

The payoff $p(o,i)$ associated with each level of investment i and outcome o is presented in (1). The expected value $e(i)$ associated with each level of investment i is presented in (2).

$$p(o,i) = a(1-i) + c + r_o * i * a + f_o \tag{1}$$

$$e(i) = \sum_O \theta_o * p(o,i) \tag{2}$$

As shown in Table 2, the payoff with which participants exit the game is a function of the realised outcome (a random variable out of their control), as well as the amount invested (which is what they choose in the game). The payoff structure is fixed across all games and only the relative probabilities of each outcome are varied. To illustrate: in a zero investment scenario, farmers have high income (34000) when there is good rainfall and low income (19,000) when there is bad rainfall. In the case of land loss, they lose their asset, but exit the game with their initial cash endowment intact. If farmers invest all of their initial endowment (8,000), the investment acts as a hedge

[12] Participants start each game anew and endowments are not carried over from game to game. The full script is presented in appendix C

[13] In the case of land loss, $(r_l, f_l) = (0,0)$, good rains $(r_g, f_g) = (0.25, 16000)$ and bad rains $(r_b, f_b) = (2.25, 1000)$

against bad rainfall - smoothing income with regard to weather. However, in the case of land loss, the entire amount invested is lost and the endline payoffs are the lowest (10,000).

Table 2: Game payoffs associated with chosen investment level and realised outcome

	Payoffs $p(o,i)$		
Amount invested $i*a$:	Good rains	Bad rains	Land loss
0	34000	19000	18000
2000	32500	21500	16000
4000	31000	24000	14000
6000	29500	26500	12000
8000	28000	29000	10000

Notes: Participants choose how much to invest in light of the probabilities of each outcome (displayed with a pie-chart on a spinning wheel) and indicate their choice with a tick mark.

The values of θ_o and α are varied across games, all the while maintaining the same payoff structure presented in Table 2. These probabilities are represented visually by means of a pie chart on a spinning wheel[14]. In total, eight of these games are played, as shown in Table 3. Game orders are randomized. Figure 3 presents one of the games.

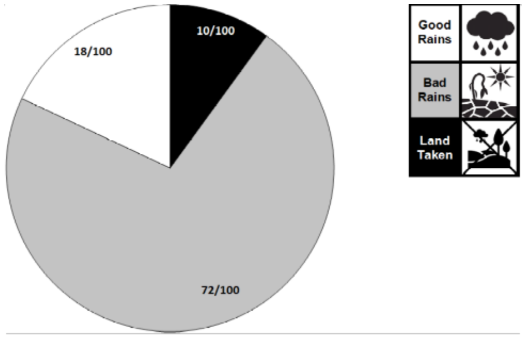
Table 3: Overview of outcome probabilities in framed investment games

Game:	P(good rain)/P(bad rain) α	P(land loss) θ_l	P(bad rain) θ_b	P(good rain) θ_g
1	0.25	0	0.8	0.2
2	1	0	0.5	0.5
3	0.25	0.1	0.72	0.18
4	0.25	0.3	0.56	0.14
5	0.25	0.5	0.4	0.1
6	1	0.1	0.45	0.45
7	1	0.3	0.35	0.35
8	1	0.5	0.25	0.25

Notes: Game orders were randomized in the following way to account for order effects: Games 1 and 2 were always played first, but their orders were alternated between groups. The orders of games 3-8 were randomized. The orders of games 9-14 were then played, and their orders were also randomized.

[14] At the end of the experimental session, one of the games is chosen at random, a participant spins the spinning wheel for that game to determine the realised outcome, and participants exit the session with the payout associated with the realised outcome and their own choice of investment in that specific game. This process was explained in full before the activities began.

Figure 3: Example of a framed game



Investment	Tick one (✓)	Good Rains	Bad Rains	Land Taken
Tsh 0		34 000	19 000	18 000
Tsh 2 000		32 500	21 500	16 000
Tsh 4 000		31 000	24 000	14 000
Tsh 6 000		29 500	26 500	12 000
Tsh 8 000		28 000	29 000	10 000

Note: The game displayed here illustrates the decision task when the likelihood of land loss is 0.1, the probability of good rains is high, and the probability of bad rains is low ($\alpha = 0.25$). Respondents are asked to choose how much of their initial investment endowment (Tsh 8,000) they would like to invest and to indicate the amount with a tick. All aids, games and protocols were translated to KiSwahili.

5.3 Land certification games

In order to understand how participants value formal tenure security in this setting, in the final set of six games, each comprises two stages. Firstly, participants are shown a game with non-zero land loss risk and weather-related risk, as before. This time, they are provided the opportunity to bid for a certificate removing any risk of land loss, using some or all of the previously un-investable capital amount c. The certificate comes at a cost, but, because it removes the risk of land loss, it also comes with an implicit benefit in terms of a higher expected payoff for the associated game.
As before, participants start with an initial endowment $a =$ Tsh 8,000 and capital amount $c =$ Tsh 10,000 in each game. Now, they can choose to bid between 0 and Tsh 10,000 of this previously reserved capital amount (in increments of 500) for a certificate [15].
If they choose not to bid for a certificate, they tick 0 on the bidding sheet shown on the right of Figure 4 and they play the game as is, in the presence of some land-tenure related risk (i.e., someone who bids Tsh 0 for a certificate will definitely play the game in the left panel of Figure 4). On the other hand, if they choose to bid between Tsh 500 and 10,000 for a certificate, and are successful in their bid, they would play the game without the risk of land loss but with the same relative probability of good rainfall and bad rainfall (i.e. θ_l differs across games with and without certification, but $\alpha = \frac{\theta_g}{\theta_b}$ remains constant). Effectively, games 3-8 in Table 3 are re-played with an option to reduce θ_t to zero, but with the cost of certification, which is subtracted from the

[15] In the first eight framed games described above, respondents also have this Tsh 10,000 as a reserve, but, in this final set of six games, it can be used to bid for the certificate. See appendix C for a full description

final payoffs. This is illustrated in Figure 4. If a participant obtains a certificate, they play the right-hand game in 4.

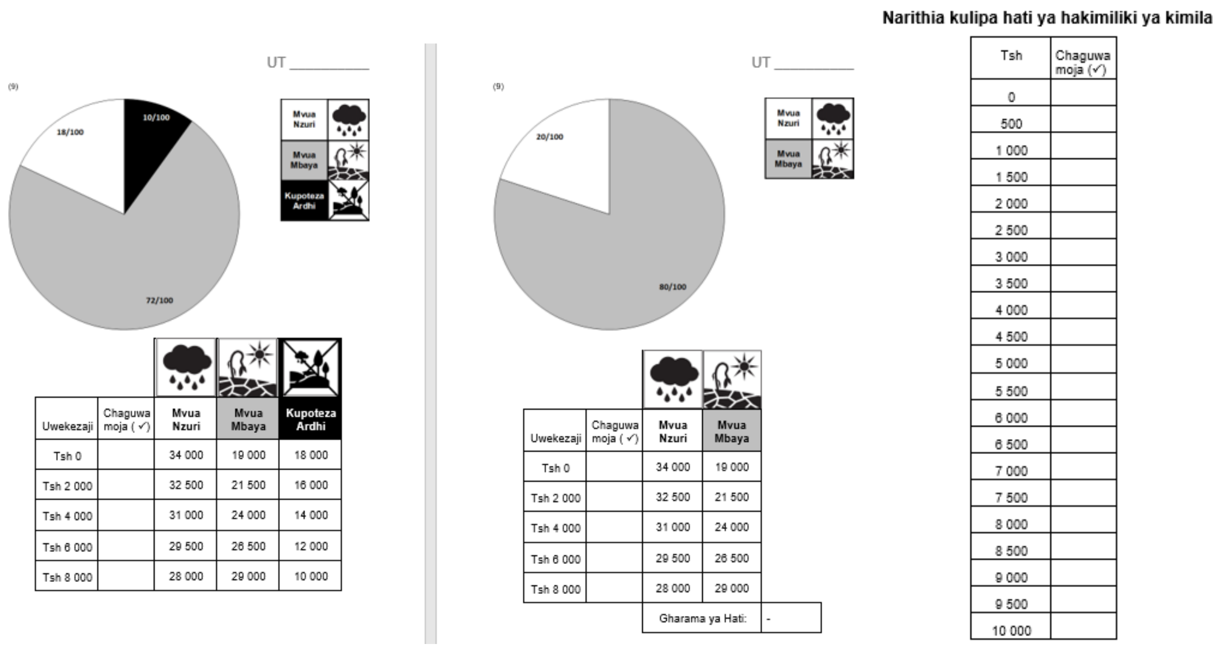
Which participants actually obtain the certification after the bidding process is decided in the following way. After participants decide whether and how much to bid for the certificate, an adapted Becker-DeGroot-Marshak method (BDM) (Becker, DeGroot, & Marschak, 1964) is used to measure their effective willingness to pay (WTP) for tenure security. In this BDM process, the final value of the certificate is not a random draw between 0 and 10,000, as it would be in a conventional BDM design. Instead, we calculate a set of feasible values of the certificate and randomly draw from this set. We calculate how much higher the expected payoff in the game is with a certificate than without one. The value of the certificate is conditional on the risks in the game as well as the level of investment. We calculate the value of the certification for each possible level of investment, and randomly draw from this set of feasible values[16].

In games with low land loss risk, the implicit value of a certificate is relatively low, while in games with high levels of land loss risk, the implicit value of a certificate is high. This amendment allows us to ensure that participants who bid to pay an amount higher than the set of feasible values of the certificate will definitely obtain the certificate. This in turn allows us to observe whether their behaviour changes (i.e., whether they invest more) after obtaining the certificate, compared to the exact same games played in the initial set of eight games.

To illustrate: if a participant facing the risks associated with game 3 in Table 3 bids high enough to obtain the certification, they go on to play game 1. If they do not bid high enough to obtain the certification, they play game 3 as initially presented.

[16] Participants were informed that the facilitators knew the true value of the certificate in each game and were encouraged to think carefully about how much the certificate is worth for them.

Figure 4: Example of framed land certification game with bidding sheet on the right



Note: The game displayed here illustrates the decision task when land tenure risk is 0.1, the probability of bad rains is high, and the probability of good rains is low. All participants are shown the two separate games presented here. Respondents are then asked to choose whether they would like to use part of their initial endowment (up to Tsh 10,000) to bid for a certificate that would remove the risk of land loss and allow them to play the right-hand game. Participants who are successful in their bid play the game on the right and participants who are not successful in their bid (or choose not to bid) play the game on the left.

6 Results

6.1 Household and plot-level descriptive statistics

Table 4 provides an overview of household-level summary statistics. Households in the sample are overwhelmingly engaged in subsistence agriculture. Average per-capita expenditure in our sample is Tsh 30,607 (equivalent to roughly 13 USD per month). Nearly all (96%) of the households in the sample engage in crop farming (mostly maize, cassava and beans), while about two in five participate in livestock farming. Only 4% of households have a member who had been engaged in salaried employment in the 12 months preceding the survey. Fifteen percent of the households in the sample are headed by women.

Levels of formal (certified) tenure security are low. While 93% of households say they own their dwelling, only 8% of households possess a customary right of occupancy certificate and 58% of households have no written documentation for their main dwelling. Households who do possess a CCRO had paid Tsh 22,000 on average for it - although it is unlikely this is an accurate reflection of the cost faced by most rural residents, given the financial support of NGOs for certification in Kigoma. The average maximum stated willingness to pay (WTP) for a CCRO, elicited through a contingent valuation method (shown in appendix G)[17] using a double-bounded format with an open-

[17] The full text of the WTP elicitation is in the appendix. In this section of the household survey, the nature and potential benefits of customary right of occupancy certificates were explained to participants (proof of ownership,

ended follow-up, is more than double this, at Tsh 50,000[18]. A significant proportion of households

Table 4: Household level summary statistics

Variable	Mean	s.d.	p50	min	max
Head age	49.69	15.78	49.00	20.00	102.00
Head yrs educ	5.62	3.35	7.00	0.00	17.00
HH size	7.66	3.65	7.00	1.00	27.00
Dependency ratio	1.15	0.92	1.00	0.00	6.00
Female:male HH members	1.20	0.85	1.00	0.00	9.00
Female Head	0.15	0.36	0.00	0.00	1.00
Per capita exp	30607.19	35412.11	20552.27	0.00	325000.00
Asset index	0		1.05	-1.42	5.49
Dwelling rooms	3.82	1.66	3.00	1.00	10.00
Piped water access	0.05	0.21	0.00	0.00	1.00
Electricity connection	0.04	0.19	0.00	0.00	1.00
Salaried employment	0.04	0.19	0.00	0.00	1.00
Crop farming	0.96	0.19	1.00	0.00	1.00
Animal farming	0.37	0.48	0.00	0.00	1.00
Crop income	758551.33	3470710.42	180000.00	0.00	71900000.00
Livestock income	71040.68	292245.12	0.00	0.00	3500000.00
Land related variables:					
Ownership of dwelling	0.93	0.26	1.00	0.00	1.00
No documentation for main dwelling	0.58	0.49	1.00	0.00	1.00
Total land holdings (acres)	4.64	8.36	3.00	0.00	126.00
Past land disputes	0.17	0.37	0.00	0.00	1.00
Past land loss due to disputes	0.07	0.25	0.00	0.00	1.00
Max WTP for CCRO	50321.37	59901.97	35000.00	0.00	900000.00
Number of plots	2.30	2.08	2.00	0.00	25.00
Possess a CCRO	0.08	0.27	0.00	0.00	1.00
In process of obtaining CCRO	0.14	0.35	0.00	0.00	1.00
How long in CCRO ap process (months)	104.23	799.87	6.00	0.00	7300.00
Cost of CCRO	21784.41	29765.89	20000.00	0.00	150000.00
How long did it take to get a CCRO?	45.90	306.25	3.00	0.00	2190.00
N	645				

report experiencing land disputes. Seventeen percent of households attest to having experienced land disputes in the past and 7% have lost land due to such disputes. The main reasons households cite for wanting a CCRO are the prevention of land disputes (35%) and prevention of land loss (48%), while the cost of the certificates is the main reason for not wanting a certificate.

On average, households own 4.64 acres (1.88 ha) of land. Most plots are small in size, as shown in Table 5, where plot-level summary statistics are presented. When asked about the market value of

prevention of land loss, easier resale). Thereafter, the effort involved in the certification process was described (including the need for a surveyor to survey the land). Participants were advised there is no correct answer and that the question was a hypothetical one, but were encouraged to think carefully about their answers.

[18] Anecdotal evidence suggests that the 'market' rate to obtain a CCRO is roughly Tsh 100,000 for a 5 acre plot and about 60% of respondents in our sample who do have a CCRO say they obtained it with government or NGO support. Those who obtained and paid for CCROs on their own paid on average Tsh 37,000.

their plots, respondents report a mean of Tsh 3,9 million (1695 USD[19]) per acre, with a median of Tsh 800,000 per acre (347 USD). Only 4% of plots are held by means of a customary right of occupancy certificate. Thirty-five percent of households report feeling very secure that their land is not at risk of being taken, 50% feel somewhat secure, and 15% of respondents report feeling somewhat insecure or very insecure.

The plot-level data suggests that levels of adaptive investments are relatively low. On about two-fifths of plots, farmers report not using any soil and water conservation measures. Forty-two percent of households reported planting multi-year trees and only 1% of plots are irrigated.

[19] 1 USD = Tsh 2,300 in August 2019

Table 5: Plot-level summary statistics

Variable	Mean	Std. Dev.	Min	Max
Plot size (acres)	2.32	5.09	0.13	100
Ownership status of plot				
Owned	0.95	0.22	0	1
Rented	0.02	0.14	0	1
Used for free	0.02	0.15	0	1
Other	0.01	0.08	0	1
Way in which plot was acquired				
Purchased	0.38	0.49	0	1
Inheritance	0.32	0.47	0	1
Gift from non family	0.01	0.10	0	1
Gift from family	0.05	0.21	0	1
Land allocation from village council	0.13	0.34	0	1
Loan	0.00	0.04	0	1
Other	0.11	0.31	0	1
Plot documentation				
No written documentation	0.62	0.49	0	1
Certificate of Customary Right of Occupancy	0.04	0.20	0	1
Inheritance letter	0.06	0.24	0	1
Letter of allocation from village government	0.07	0.25	0	1
Land sale agreement	0.20	0.40	0	1
Other	0.02	0.13	0	1
Plot value (Tsh)	2 232 266	9 202 348	0	2.00E+08
Ever involved in land disputes regarding plot?	0.11	0.31	0	1
How secure do you feel no one will take plot?				
Very secure	0.35	0.48	0	1
Somewhat secure	0.50	0.50	0	1
Somewhat insecure	0.13	0.34	0	1
Very insecure	0.02	0.13	0	1
Investment related questions				
Main SWC method on plot				
None	0.39	0.49	0	1
Terraces	0.19	0.39	0	1
Soil/stone bund	0.03	0.17	0	1
Planting trees	0.03	0.16	0	1
Mulching	0.22	0.41	0	1
Ridging	0.13	0.33	0	1
Other	0.01	0.10	0	1
Spending on Main SWC in last year (Tsh)	27 876	79 705	0	1 400 000
Secondary SWC method on plot				
None	0.74	0.44	0	1
Terraces	0.07	0.25	0	1
Soil/stone bund	0.03	0.16	0	1
Planting trees	0.03	0.17	0	1
Mulching	0.06	0.23	0	1
Ridging	0.07	0.25	0	1
Other (s..)	0.01	0.11	0	1
Spending on secondary SWC in last year (Tsh)	2 303	14 626	0	300 000
HH planted multi-year trees on plot? (1=yes)	0.42	0.49	0	1
Number of permanent trees planted on plot?	56.57	610.73	0	19600
Plot rain-fed or irrigated? (1=rain-fed)	0.99	0.11	0	1

N=1186 plots. Households were asked to describe the characteristics of up to three most important agricultural land parcels.

6.2 Household survey results - Willingness to pay for land certification

While the main empirical results presented in section 6.4 relate to the framed behavioural choice experiments, here we also present results on the willingness to pay for CCROs elicited in the household survey. These certificates are the main mechanism through which rural Tanzanian residents are able to formalize their land tenure and, for example, enable holders to use land as collateral in credit applications. A Tanzanian government program is underway to extend CCROs nationally, but access is still very low.

The household survey includes a module that elicits respondents' actual WTP for CCROs outside of the experimental setting, using a double-bounded format with an open-ended follow up (Johnston et al., 2017)[20]. In this process, respondents are first introduced to the subject of land certification by a narrative introduction read out loud by the interviewer, which describes the potential benefits and costs of land certification. They are then asked to think carefully about the monetary value they would place on certification and provided an opportunity to ask questions. After this, participants are asked whether they would purchase certification if it was offered to them at a hypothetical price of Tsh 50,000 (20 USD). This baseline figure was derived by the authors based on discussions with local officials on the actual cost of certification for a 2-4 acre plot. The initial yes/no response to this question determines whether respondents face a higher or lower price in a second question (Tsh 80,000 in the case of a "yes" response or Tsh 20,000 in the case of a "no" response). These two questions are followed by an open-ended question about the maximum value participants place on certification, which is bounded by their responses in the first two questions.

Table 6 presents OLS regression results where the maximum WTP for a CCRO is regressed on various household characteristics. The dependent variable is the log of willingness to pay for a CCRO reported by the household. On average, WTP for CCROs is positively correlated with household socioeconomic status (captured here by means of a wealth index[21]), and household size.

In addition, households that had made more long-term investments in their plots, such as planting trees and spending money on soil and water conservation methods, also report higher WTP on average for CCROs, controlling for socioeconomic status. Respondents may see the land certification process as a way of protecting investments they have already made on their plots, and participants with more fixed investments appear to place higher value on land certification.

[20] The narrative and exact questions are presented in Appendix F

[21] The wealth index is created via principal component analysis on the following asset counts: televisions, motorbikes, cellphones, bicycles, radios, goats, cattle. A correlation matrix is presented in appendix H

Table 6: OLS regressions: Log of maximum stated willingness to pay for land certification in the household survey regressed on household characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
HHsize	0.026**	0.022**	0.022**	0.023**	0.023**	0.024**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Wealthindex	0.271***	0.258***	0.258***	0.242***	0.242***	0.217***
	(0.033)	(0.033)	(0.033)	(0.035)	(0.035)	(0.035)
Log SWC spending	0.011*	0.010*	0.010*	0.010	0.010	0.010
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Log nr. trees planted		0.053***	0.053***	0.051***	0.051***	0.045**
		(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
Size of land (acres)				0.006	0.006	0.006
				(0.004)	(0.004)	(0.004)
Past land disputes					0.026	0.077
					(0.114)	(0.118)
Female headed HH						-0.194
						(0.128)
Female respondent						-0.111
						(0.083)
Constant	10.202***	10.137***	10.137***	10.111***	10.108***	10.171***
	(0.095)	(0.100)	(0.100)	(0.101)	(0.102)	(0.106)
N	604	604	604	604	603	602
R^2	0.133	0.146	0.146	0.149	0.150	0.160

Standard errors in parentheses

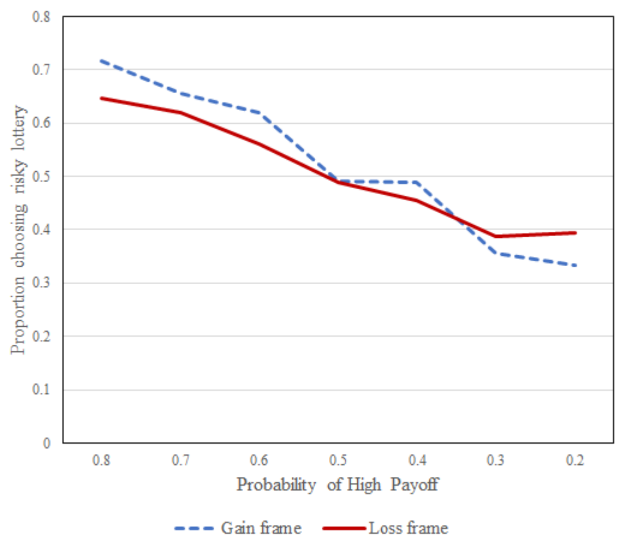
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: In each case, the dependent variable is the log of maximum stated willingness to pay for a Customary right of occupancy certificate, elicited through a double-bounded format with an open-ended follow up Contingent Valuation exercise.

6.3 Risk preferences

Figure 5 presents the proportion of respondents choosing the risky gamble in the initial seven gain-framed and seven loss-framed risk preference elicitation games (presented in Table 1). On average, the proportion of respondents choosing the risky gamble declines as the probability of the high payoff in the gamble decreases.

Figure 5: Risk preference elicitation games: Proportion of respondents choosing risky gamble.



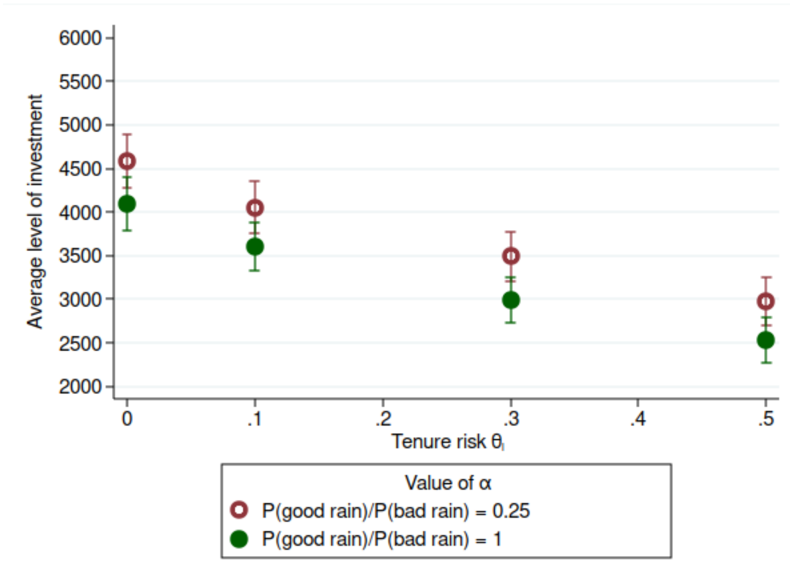
Note: N=460. A total of seven gain-framed and seven loss-framed games were played, in each instance varying the probability of the high payoff outcome (from 0.8 to 0.2, as shown in the figure above), while keeping the actual payoffs constant within gain-framed games and within loss-framed games. At each probability level, the expected income from the gain- and loss-framed games is equal. In the loss-framed games, participants start each game with an endowment of Tsh 6000. In the gain-framed games, participants start with Tsh 0.

6.4 Framed investment games

Result 1(a): Adaptive investment decreases with increasing land tenure risk.
Figure 6 presents average levels of investment in the first eight framed games, under varying levels of tenure risk (θ_l) and varying levels of the probability of good rainfall relative to the probability of bad rainfall (α). In each game, participants are presented with a spinning wheel illustrating the land tenure risk θ_l (which takes a value of 0, 0.1, 0.3 or 0.5), as well as the risks of good rainfall and bad rainfall. In light of these risks, participants choose how much of an endowment of Tsh 8,000 to invest in an adaptive technology. On average, participants invest less as the risk of losing the investment increases (i.e. when θ_l increases, i.e. the risk of land loss increases).
Result 1(b): Adaptive investment increases as weather-related risk increases.
In all games, average levels of investment in adaptive agricultural technologies are higher when the risk of adverse weather outcomes is higher (i.e., when the probability of bad rainfall is higher than the probability of good rainfall: $\alpha = 0.25$). In other words, investment levels increase as the risk-adjusted returns to investment increase with respect to weather outcomes. Results 1(a) and (b) are confirmed in OLS regressions, including individual and household controls in Table 7.
Result 1(c): Observed investment is significantly lower than under expected income maximisation.
Overall, observed levels of investment are much lower than they would be if undertaken by an agent purely seeking to maximise expected payoffs in light of the risks. For example, in all games where land tenure risk $\theta_l = 0$, the expected payoff-maximising level of investment is Tsh 8,000. Instead, we observe that levels of actual investment are between 4,200 and 4,600, nearly half of that. For all levels of tenure risk below 0.5, the expected payoff-maximising level of investment is Tsh 8,000 for games where $\alpha = 0.25$. Instead, we observe much lower levels of investment, suggesting that

loss aversion is an important driver of investment decisions in this setting. For games with $\alpha = 1$ (i.e., where the chance of good rainfall compared to the chance of bad rainfall is equal), expected payoffs are maximised by investing the full endowment (8,000) for all games with tenure risk below 0.3.

Figure 6: Sample average investment levels in behavioural experiments games 1-8



Note: As shown in Table ??, in games 1,3,4 and 5, the ratio of the odds of good rainfall relative to the odds of bad rainfall was kept constant at 0.25 (low odds), and for games 2,6,7 and 8 the ratio of the odds of good rainfall to the odds of bad rainfall was equal to 1 (Equal odds). N=405. 95% confidence intervals shown.

Result 1(d): Risk aversion, socio-economic status, gender, and experience of past land disputes are significantly correlated with levels of adaptive investment.
Table 7 presents pooled OLS regression results of the level of investment in a game regressed on the game characteristics and the participants' elicited *risk* score[22], as well as household and individual controls from the survey. Levels of investment are positively correlated with participants' individual risk scores when controlling for individual and household factors. More risk-averse participants, who we define here as those below the median *risk* score, invest on average Tsh 270 less than those above the median. The OLS results also show a positive correlation between participant socioeconomic status (measured by a wealth index) and levels of investment in the framed games. Wealthier participants invest more. Female respondents generally invest slightly more than males. Participants who report having experienced past land disputes on their own land also invest significantly less in the experimental sessions. Female respondents invest about Tsh 230 more than male respondents, controlling for household factors and measured individual levels of risk aversion.
Controlling for individual and household factors, the risk of land loss is negatively correlated with adaptive investment. An increase in land loss risk from 0 to 1 is associated with a decrease in investment of Tsh 3,200 on average. In addition, when the probability of good rainfall to bad

[22] This is the variable *risk* defined in Section 5.1.

rainfall increases, participants invest less in adaptive technologies.

Table 7: OLS: Level of investment in the first set of 8 framed games regressed on game characteristics and various measures of individual risk preferences

	(1)	(2)	(3)
Land loss risk: θ_l	-3186.9***	-3206.3***	-3206.3***
	(275.4)	(275.5)	(273.7)
Pr(gr)/Pr(br): α	-588.4***	-586.5***	-586.5***
	(141.3)	(141.4)	(140.3)
Risk averse	-211.2**	-223.1**	-269.8**
	(106.3)	(106.4)	(105.9)
Wealth index	179.1***	181.7***	147.2**
	(57.22)	(59.48)	(61.25)
Female HH head	-79.00	-27.87	30.78
	(176.9)	(178.7)	(179.8)
Female	238.1**	218.8*	228.0*
	(119.8)	(120.1)	(121.1)
Head age	2.945	3.401	0.762
	(3.611)	(3.621)	(3.732)
Head educ	0.391	0.476	0.308
	(0.389)	(0.387)	(0.397)
HH size	30.52*	24.66	24.70
	(15.57)	(15.81)	(15.65)
Past land disputes		-289.7**	-452.4***
		(136.9)	(138.8)
Size of land holdings		1.810	9.624*
		(5.464)	(5.482)
District controls	N	N	Y
Constant	4229.5***	4299.1***	5088.3***
	(236.9)	(239.1)	(275.5)
N	3000	2992	2992

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Risk averse indicates a *risk* score above the median. The sample size reflects a set of 3000 decision tasks carried out by is 395 individuals who completed 8 framed games each.

6.5 Land certification

In the second set of six framed games, participants can bid for certification. Each game progresses in the following manner. First, all participants are presented the same game with some level of positive tenure-related risk (θ_l = 0.1, 0.3, or 0.5) and probability of good rainfall relative to bad rainfall (α = 0.25 or 1). Participants are given time to consider how much they would like to pay for land certification that removes tenure risk, and they record their bid on a bidding sheet. Secondly, the BDM draw described in section 5.3 takes place. Participants who bid lower than the figure yielded in the BDM draw do not obtain the certification and play the game they were initially presented with (i.e., with positive tenure-related risk). Participants whose bids are higher than the figure yielded by the BDM draw obtain the certification and play a game with the same relative probability of good to bad rainfall (α) as the initial game, but without any tenure-related risk.

Result 2(a): Willingness to pay for land certification increases as land tenure risk increases, participants overweigh small risks of land loss.

Figure 7 plots the average WTP for certification (represented by hollow and solid circles), over varying levels of land loss risk θ_t and different relative probabilities of good rainfall to bad rainfall α. It also displays the realised cost of certification drawn in the Quasi-Random BDM process (represented by hollow and solid triangles), and the proportion of participants who obtain certification in each game (represented by hollow and solid squares). The cost of certification can be seen as being representative of the implicit value of certification (i.e. the cost drawn in the quasi-random BDM process is drawn from a set of values bounding the increase in expected income associated with playing the game without that given value of land loss risk.[23]

We observe firstly that participants are always willing to pay more than the implicit value of certification in the game (the WTP is always higher than the cost). Secondly, participants appear to place a disproportionate weight on low levels of land tenure risk, by bidding much higher than the implicit value of certification when land tenure risk is low ($\theta_t = 0.1$) than when land tenure risk is high ($\theta_t = 0.5$), where average WTP is more in line with the implicit value of certification. On average, participants bid slightly higher for certification as land tenure risk increases, but given the large change in the value of certification as land tenure risk increases, the WTP bids are remarkably stable. Although average WTP for certification is slightly higher in games where the probability of good rainfall relative to bad rainfall is higher (i.e., where $\alpha = 1$), this difference is not statistically significant.

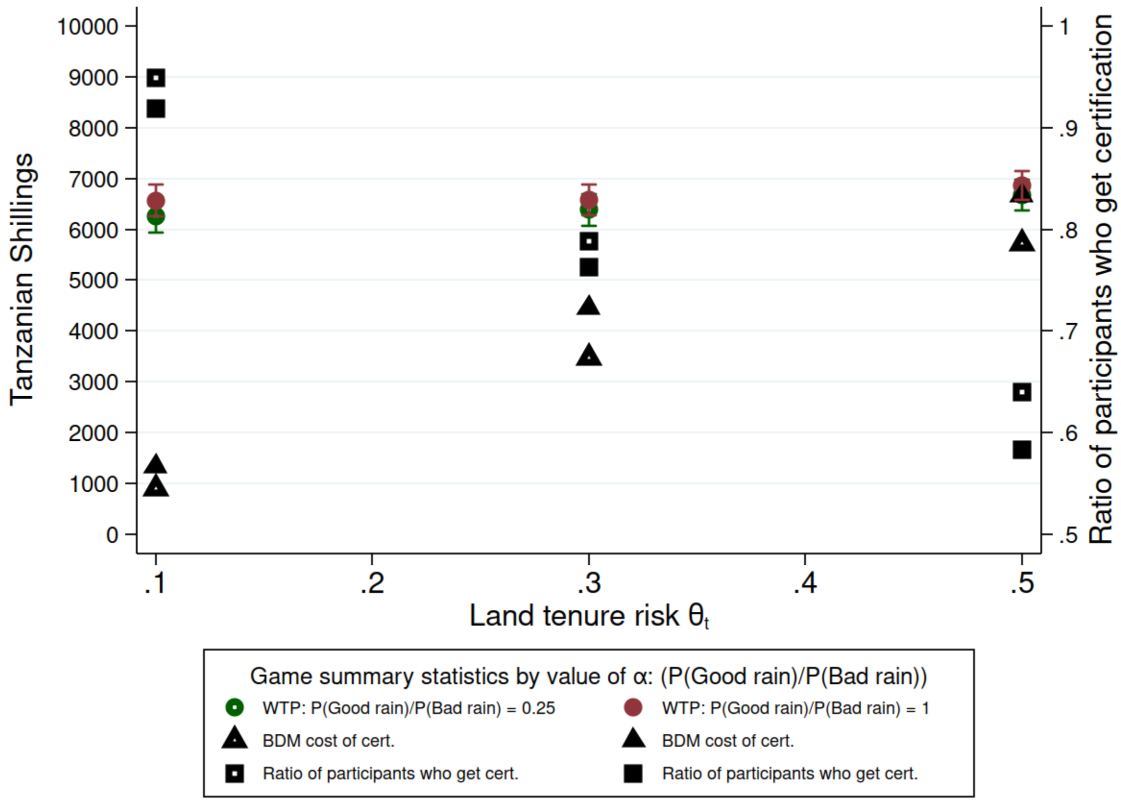
Result 2(b): No significant differences in WTP for certification by risk type.

Table 8 once more disaggregates average bids for certification in each of the WTP games by risk type. In this case, while one might expect risk-averse participants to show higher demand for certification, we do not observe this in the data. Within each risk type, the WTP for certification increases with tenure risk θ_t.

Table 9 presents OLS regression results where the WTP for certification in the framed setting is regressed on various game, household and individual factors. Wealthier households, households with younger household heads, and smaller households report higher willingness to pay for certification.

[23]How much expected income increases when land loss risk is removed depends on how much investment the participant chooses in the game. Removing land loss risk can be very valuable for a participant who intends to invest all their endowment, but less valuable for a participant who has no intentions to invest because they maintain their endowment without risk. In the BDM process we select five values (because there are five possible levels of investment) for the cost of certification that represent the increase in expected income in the game played without land loss risk and the random draw determining the actual cost of certification takes place from this set of five values.

Figure 7: Sample average WTP for certification under various levels of tenure risk



Note: The figure presents the average sample level of investment for these two scenarios with varying levels of tenure risk. N=405

Table 8: Mean willingness to pay, by risk type

WTP			Risk loving		Risk averse		Difference	
Game	α	θ_l	mean	sd	mean	sd	b	t
1	0.25	0.1	6277.23	3380.86	6237.62	3166.28	-39.60	(-0.12)
2	0.25	0.3	6512.38	3222.06	6262.38	3241.59	-250.00	(-0.78)
3	0.25	0.5	6653.47	3203.11	6663.37	3134.31	9.90	(0.03)
4	1	0.1	6564.36	3283.20	6532.18	3188.16	-32.18	(-0.10)
5	1	0.3	6831.68	3008.92	6306.93	3172.46	-524.75	(-1.71)
6	1	0.5	7027.23	2957.07	6688.12	2936.60	-339.11	(-1.16)
Total			39866.34	14928.67	38690.59	14949.74	-1175.74	(-0.79)
N			202		202		404	

Table 9: OLS: Experimental WTP for land certification in framed games regressed on game characteristics, individual and household controls

	(1)	(2)	(3)	(4)	(5)
Land loss risk θ_l	890.012**	887.995**	876.582**	973.361**	973.361**
	(390.443)	(392.483)	(386.975)	(393.263)	(391.034)
Pr(good rains)/Pr(bad rains) α	309.368*	298.680*	297.609*	221.008	221.008
	(170.145)	(171.000)	(168.848)	(171.480)	(170.798)
Risk averse		-195.957	-162.163	-71.606	-8.008
		(128.250)	(126.550)	(129.497)	(130.990)
Log(inv in previous games)			262.903**	107.142	212.561*
			(125.418)	(125.506)	(128.558)
Wealthindex				495.789***	502.820***
				(71.393)	(74.610)
Female headed HH				293.616	342.276
				(211.760)	(210.153)
Female				-18.033	-63.738
				(151.611)	(154.828)
Head age				-20.912***	-17.997***
				(4.832)	(4.853)
Head educ				-0.871	-0.726
				(0.551)	(0.539)
HH size				-52.298***	-49.398**
				(20.274)	(20.020)
Past land disputes				55.899	156.857
				(162.208)	(167.985)
Size of land holdings				-5.885	-9.633
				(6.094)	(6.227)
District controls	N	N	N	N	Y
Constant	6093.154***	6191.316***	3592.759***	6572.954***	5038.478***
	(172.649)	(186.583)	(1288.329)	(1278.602)	(1345.780)
N	2448	2424	2370	2196	2196
R^2	0.003	0.004	0.006	0.037	0.047

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Result 2(c): Investment is significantly higher for participants with land certification in the framed setting.
Table 10 shows average levels of investment in the final six WTP games, for participants with and without certification. Participants with certification invest between Tsh 1500 and Tsh 2600 more than those without certification (as high as 120% more).

Table 10: Investment in final six framed WTP games for participants with and without certification

WTP Game	α	Initial θ_l	W/Certifcation mean	W/Certifcation sd	No certification mean	No certification sd	Difference b	Difference t-stat
1	0.25	0.1	5116.28	2779.35	2476.19	2891.70	-2640.09***	(-4.08)
N=			387		21		408	
2	0.25	0.3	5410.26	2775.34	3380.95	2597.05	-2029.30***	(-6.26)
			312		84		396	
3	0.25	0.5	5639.85	2679.08	3646.26	2613.98	-1993.59***	(-7.33)
			261		147		408	
4	1	0.1	5029.33	2727.69	2303.03	2555.45	-2726.30***	(-5.84)
			375		33		408	
5	1	0.3	5337.62	2798.36	3113.40	2414.70	-2224.22***	(-7.62)
			311		97		408	
6	1	0.5	5084.03	2837.60	3529.41	2888.82	-1554.62***	(-5.40)
			238		170		408	

Notes: Here participants who obtain certification play a game without tenure risk, but with the same relative probability of good rains to bad rains α. The number of participants falling into each group (with and without certification) is shown in the row below each game.

In table 11, investment in the final set of six framed games is regressed on each participant's willingness to pay, the realized cost of certification in that game obtained through the BDM process, game characteristics, and a marker for whether the participant actually obtains certification, along with various individual and household controls. Here we observe that respondents who placed more value on certification invested more. On average, a 10% increase in WTP for certification is associated with a Tsh 750 increase in investment in the subsequent game. In line with the results presented in table 10, participants who obtain certification invest significantly more than those who do not, controlling for individual risk preferences and household controls.
Finally, respondents who report having experienced past land disputes display significantly lower levels of investment, as seen in the first set of eight framed games in table 7.
Result 3: Increases in investment following obtaining land certification are much larger for risk-averse than risk-loving participants.
In this section, we ask how certification impacts levels of investment in the framed games by comparing levels of investment before and after obtaining certification, by risk type. In the initial set of eight framed games, all participants play two games where α - the ratio of the probability of good rainfall to the probability of bad rainfall - varies, but where there is no land tenure-related risk $\theta_l = 0$. These are games 1 and 2 in table 3. In the final six land certification games, those participants who do manage to obtain certification that removes land tenure risk once more play one of the two initial games.
Here, we compare the levels of investment for the same game (i.e., with the same values of $\theta_l = 0$

Table 11: OLS: Level of investment in WTP framed games regressed on game characteristics and various measures of individual risk preferences

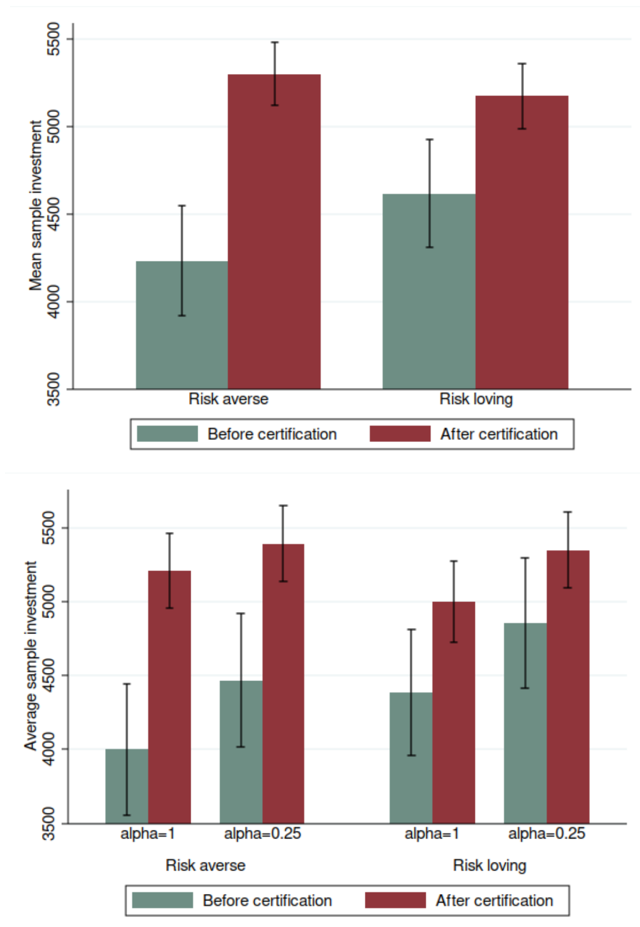
	(1)	(2)	(3)
Log WTP	749.160***	754.983***	775.053***
	(105.456)	(111.742)	(111.614)
Log Cost of certification	89.813	57.428	49.800
	(79.664)	(81.148)	(81.512)
Pr(good rains)/Pr(bad rains) α	-429.849***	-473.892***	-488.049***
	(151.157)	(156.974)	(156.490)
Obtained certification	969.824***	870.553***	877.531***
	(200.576)	(208.467)	(208.219)
Risk averse	35.965	90.058	31.739
	(112.663)	(117.947)	(118.331)
Wealthindex		250.286***	242.450***
		(64.814)	(68.187)
Female headed HH		-49.255	-28.085
		(199.528)	(201.333)
Female		161.388	217.460
		(135.801)	(140.177)
Head age		12.504***	11.080***
		(4.036)	(4.111)
Head educ		1.714***	1.665***
		(0.373)	(0.386)
HHsize		-26.899	-31.443*
		(17.247)	(17.402)
Past land disputes		-296.551**	-424.230***
		(150.433)	(154.295)
Size of land holdings		0.569	5.577
		(6.073)	(6.450)
District Controls	N	N	Y
Constant	-2803.371***	-3003.640***	-2439.458***
	(852.666)	(936.744)	(945.162)
N	2272	2108	2108
R^2	0.085	0.096	0.106

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

and α), before and after the participant obtains certification. These results are thus restricted to those participants who do obtain the certification in the games. We disaggregate the results by risk type. Figure 8 shows that participants playing the same game after obtaining certification invest significantly more than they had invested before obtaining certification (i.e., in the first round of framed games). This increase in investment is especially pronounced for more risk-averse individuals below the median *risk* score. The difference in investment we observe between two games with the same values of α and θ_l, but which are played before and after the participant obtains a certificate, is much larger for more risk-averse participants than for risk-loving participants. For participants below the median *risk* score (i.e., risk-averse participants), investment after obtaining certification is 25% higher than before. For individuals above the median *risk* score (risk-loving), the increase in investment after certification is about 12% higher than pre-certification levels. The second plot in figure 8 additionally disaggregates the investment levels by the nature of the relative probability of good to bad rainfall in the game α and shows that the pattern described above is consistent in games with both high and low levels of α.

Figure 8: Investment levels before and after obtaining certification



Note: risk-loving and risk-averse here refers to individuals below and above the median *risk* score defined in Section 5.1. α = P(good rainfall)/P(bad rainfall). The investment is structured in such a way that when α is low, an expected income maximising individual would invest more given that the adaptive investment smooths income in the case of bad weather outcomes. The figure presents levels of investment in the exact same game, played before the participant had the option to purchase certification and after the participant had gone through the process of receiving certification.

7 Discussion

Why observed levels of investment are so low in many low-income countries despite high returns to capital is a key question in the economics literature (Kremer et al., 2019). Finding answers to this question and understanding the drivers of investment in contexts of weak institutions, low incomes, and credit constraints is a pressing issue. The emergent threat of climate change to the livelihoods of small-scale farmers adds urgency to the question of how to encourage investment in adaptive agricultural technologies in rural settings (Ruzzante et al., 2021; Eichsteller, Njagi, & Nyukuri, 2022). Small-scale farmers face weather-related risks and competition for land, both of which are projected to increase in the next decades. Investment in adaptive agricultural technologies will be important in limiting associated welfare losses.

Mounting empirical evidence also suggests that secure land tenure is an important factor in encouraging longer-term investments in agriculture, such as water and soil retention technologies and irrigation systems, all of which can help small-scale farmers adapt to weather and climate changes (Ruzzante et al., 2021).

The household survey results (N=650) show that there is high demand for land certification amongst rural farmers in Kigoma region. Close to one in five (17%) of respondents report having experienced land disputes. Participants cite reduction in land-related conflict and land loss as the main benefits of land certification. The cost of certification is cited as the main reason respondents do not want it.

Despite this, respondents are willing to pay for certification. We estimate average willingness to pay for CCROs at Tsh 50,000 (20 USD). This figure is significantly lower than the USD 350 Daniel et al. (2011) (cited in Bezu and Holden (2014)) estimate of the cost of hiring private land surveyors in urban Dar es Salaam. Learning from Ethiopia's low-cost certification program, where certification costs per plot as low as USD 1 were achieved (Bezu & Holden, 2014), may thus be an important factor in increasing the roll-out of CCROs in Tanzania.

In our framed setting we find that while participants behave rationally in the way they respond to weather- and land tenure-related risks, they display levels of investment in adaptive agricultural technologies that are significantly lower than what would maximise expected income and lower income variability. Levels of investment decline as the risk posed to those investments increases (as land loss risk increases). Investment also increases as the expected returns to investment increases (as weather-related risk increases). Overall however, participants invest much less than would be expected in an expected income maximising setting, suggesting loss aversion plays an important role in these decisions. This echoes results from other work - despite high returns, investment remains low.

We also observe evidence that more risk-averse individuals display lower levels of investment in adaptive technologies in this setting. This evidence is notional, but nonetheless striking given that the type of technology studied here is intended to reduce overall income risk. In this sense one might think of the risk of land loss crowding out investments in adaptive technologies - especially for risk-averse individuals.

Secondly, we find that lower socioeconomic status and household experiences of past real-world land disputes all contribute to lower levels of investment in adaptive technologies in this framed setting, despite the fact that increased investment reduces personal income risk. Participants respond strongly to the risk of land loss by reducing investment in adaptive technologies that could help smooth income in the case of adverse weather outcomes.

In the final set of six framed games, we observe that participants place a disproportionately high weight on low levels of land loss risk by being willing to pay much higher for certification than the implicit value of the certification - at low levels of tenure risk. Willingness to pay for certification increases slightly as land tenure risk increases but not as dramatically as the implicit value of certification in the games increases. We find no significant differences in willingness to pay for certification between risk-loving and risk-averse participants. This puzzling result may be a reflection of different motivations driving demand for certification between risk-loving and risk-averse individuals. It is possible that risk-averse individuals are willing to pay a high premium for certification because it removes land loss risk, while risk-loving individuals are willing to pay a high premium because of the benefits of obtaining certification has for subsequent expected income from investment.

After obtaining certification, individuals playing the same games they had played before invest substantially more in adaptive technologies. These increases in investment are substantially larger for risk-averse individuals. Thus certification can be seen to function as a mechanism to encourage risk-averse participants to invest in adaptive technologies. Risk-averse participants show much larger increases in investment in adaptive technologies after obtaining land certification, compared to risk-loving participants.

These findings should be seen in light of some acknowledged limitations to this study. Firstly, participants in this study are provided with full information on the magnitude and consequences of risks in our setting. In reality, individuals are likely to operate with very different levels of uncertainty on the actual magnitude of risks. Secondly, while we argue that the payoffs from investment presented here are likely to be qualitatively similar to those associated with real life adaptive investments, important differences may exist.

8 Conclusion

This paper investigates the demand for investment in adaptive agricultural technologies and land certification. Presenting results from primary data collected in Kigoma Region in northwestern Tanzania, we use a set of behavioural experiments to explore how small-scale farmers in this area view the interactions of weather and land tenure risks and how these risks impact their investment in adaptive technologies and demand for land certification. In doing so, we contribute to the literature exploring behavioural drivers of the uptake of technologies that have the potential to make small-scale agriculture less risky (Landmann, Lagerkvist, & Otter, 2021; Visser et al., 2020; Liu, 2013). Similarly, we contribute to the literature that asks how to encourage the uptake of adaptive investments that can help improve yields and income stability in light of forecasts of increasingly erratic weather patterns (Kremer et al., 2019). Existing work in behavioral economics has shown that individual risk preferences can be important in the uptake of new technologies in small scale agriculture (for example Liu (2013) in the case of Bt cotton seeds in China). Other work has shown that real-world income shocks also affect subjective discount rates which can be important in the uptake of new investments Di Falco et al. (2019). Secondly, we contribute to the literature on the demand for and effects of formal land certification in low-income countries (Bezu & Holden, 2014; Bezabih et al., 2021).

Taken together, our results suggest that individual risk preferences are likely to play a significant role in the uptake of investments in adaptive technologies. Given the fixed nature of many adaptive investments, such as soil bunds and irrigation systems, removing risks of land loss, whether through certification or other mechanisms, may generate a behavioural response to encourage more of these long-term investments. We find evidence that participants overweight small absolute risks of land loss. Land certification may be an important tool in increasing the resilience of small-scale farmers to climate change.

References

Ali, D. A., Deininger, K., & Goldstein, M. (2014). Environmental and gender impacts of land tenure regularization in Africa: Pilot evidence from Rwanda. Journal of Development Economics,

110, 262–275.
Arndt, C., Farmer, W., Strzepek, K., & Thurlow, J. (2012). Climate change, agriculture and food security in Tanzania. The World Bank.
Barr, A. (2003). Trust and expected trustworthiness: experimental evidence from Zimbabwean villages. The Economic Journal, 113(489), 614–630.
Barrett, C. B., & Swallow, B. M. (2006). Fractal poverty traps. World development, 34(1), 1–15.
Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. Behavioral science, 9(3), 226–232.
Belissa, T. K., Lensink, R., & Van Asseldonk, M. (2020). Risk and ambiguity aversion behavior in index-based insurance uptake decisions: Experimental evidence from Ethiopia. Journal of Economic Behavior & Organization, 180, 718–730.
Bezabih, M., Di Falco, S., Mekonnen, A., & Kohlin, G. (2021). Land rights and the economic impacts of climatic anomalies on agriculture: evidence from Ethiopia. Environment and Development Economics, 26(5-6), 632–656.
Bezabih, M., Holden, S., et al. (2010). The role of land certification in reducing gender gaps in productivity in rural Ethiopia. Environment for Development Discussion Paper-Resources for the Future (RFF)(10-23).
Bezu, S., & Holden, S. (2014). Demand for second-stage land certification in Ethiopia: Evidence from household panel data. Land Use Policy, 41, 193–205.
Brasselle, A.-S., Gaspart, F., & Platteau, J.-P. (2002). Land tenure security and investment incentives: puzzling evidence from Burkina Faso. Journal of Development Economics, 67(2), 373–418.
Brick, K., & Visser, M. (2015). Risk preferences, technology adoption and insurance uptake: A framed experiment. Journal of Economic Behavior & Organization, 118, 383–396.
Brown, A., Laliberte, K., & Tubbs, E. (2003). Advocating for social change and development: An analysis of the capacity of local women's organizations in Tanzania. George Washington University, Washington, DC: Elliott School of International Affairs.
Crentsil, C., Gschwandtner, A., & Wahhaj, Z. (2020). The effects of risk and ambiguity aversion on technology adoption: evidence from aquaculture in ghana. Journal of Economic Behavior & Organization, 179, 46–68.
Daniel, A., Collin, M., Deininger, K., Dercon, S., Sandefur, J., & Zeitlin, A. (2011). Land titling in urban slums: The demand curve for property rights & the price of female empowerment (Tech. Rep.). unpublished working paper.
Deininger, K., & Castagnini, R. (2006). Incidence and impact of land conflict in Uganda. Journal of Economic Behavior & Organization, 60(3), 321–345.
Deininger, K., Xia, F., & Holden, S. (2019). Gendered incidence and impacts of tenure insecurity on agricultural performance in Malawi's customary tenure system. The Journal of Development Studies, 55(4), 597–619.
Dercon, S., & Christiaensen, L. (2011). Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia. Journal of Development Economics, 96(2), 159–173.
Dercon, S., Gunning, J. W., Zeitlin, A., et al. (2019). The demand for insurance under limited trust: Evidence from a field experiment in Kenya. Centre for the Study of African Economies Working Paper(WPS2019-06).
Di Falco, S., Berck, P., Bezabih, M., & Köhlin, G. (2019). Rain and impatience: Evidence from rural Ethiopia. Journal of Economic Behavior & Organization, 160, 40–51.
Duncan, J. (2014). Women's land rights guide for Tanzania. Landesa Center for Women's Land Rights.

Eichsteller, M., Njagi, T., & Nyukuri, E. (2022). The role of agriculture in poverty escapes in Kenya–Developing a capabilities approach in the context of climate change. World Development, 149, 105705.

Elabed, G., & Carter, M. R. (2015). Compound-risk aversion, ambiguity and the willingness to pay for microinsurance. Journal of Economic Behavior & Organization, 118, 150–166.

Giesbert, L., & Schindler, K. (2012). Assets, shocks, and poverty traps in rural Mozambique. World Development, 40(8), 1594–1609.

Holden, S. T., Deininger, K., & Ghebru, H. (2009). Impacts of low-cost land certification on investment and productivity. American Journal of Agricultural Economics, 91(2), 359–373.

Holden, S. T., & Quiggin, J. (2017). Climate risk and state-contingent technology adoption: shocks, drought tolerance and preferences. European Review of Agricultural Economics, 44(2), 285–308.

Huntington, H., & Shenoy, A. (2021). Does insecure land tenure deter investment? Evidence from a randomized controlled trial. Journal of Development Economics, 150, 102632.

IPCC. (2019). Special report: Climate change and land. International Panel on Climate Change Special Report. Retrieved from https://www.ipcc.ch/srccl/

Johnston, R. J., Boyle, K. J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T. A., ... others (2017). Contemporary guidance for stated preference studies. Journal of the Association of Environmental and Resource Economists, 4(2), 319–405.

Jumare, H., Visser, M., & Brick, K. (2018). Risk preferences and the poverty trap: A look at farm technology uptake among smallholder farmers in the Matzikama Municipality. In Agricultural adaptation to climate change in africa (pp. 169–198). Routledge.

Kremer, M., Rao, G., & Schilbach, F. (2019). Behavioral development economics. In Handbook of behavioral economics: Applications and foundations 1 (Vol. 2, pp. 345–458). Elsevier.

Landmann, D., Lagerkvist, C.-J., & Otter, V. (2021). Determinants of small-scale farmers' intention to use smartphones for generating agricultural knowledge in developing countries: Evidence from rural India. The European Journal of Development Research, 33(6), 1435–1454.

Liu, E. M. (2013). Time to change what to sow: Risk preferences and technology adoption decisions of cotton farmers in china. Review of Economics and Statistics, 95(4), 1386–1403.

Lovo, S. (2016). Tenure insecurity and investment in soil conservation. Evidence from Malawi. World Development, 78, 219–229.

Manara, M., & Regan, T. (2020). Eliciting demand for title deeds: lab-in-the-field evidence from urban Tanzania.

McIntosh, C., Povel, F., & Sadoulet, E. (2019). Utility, risk and demand for incomplete insurance: Lab experiments with Guatemalan co-operatives. The Economic Journal, 129(622), 2581–2607.

Moyo, K. (2017). Women's access to land in Tanzania: The case of the Makete district (Unpublished doctoral dissertation). Kungliga Tekniska högskolan.

Namubiru-Mwaura, E. (2014). Land tenure and gender: approaches and challenges for strengthening rural women's land rights. Women's Voice, Agency, Participation Research Series 2014 No.6. World Bank.

NBS. (2018). Tanzania national bureau of statistics, 2017-2018 household budget survey dataset. https://www.nbs.go.tz.

NBS. (2020). Tanzania national bureau of statistics, national panel survey 2019-2020 - extended panel with sex disaggregated data. https://microdata.worldbank.org/index.php/catalog/3885.

Njwambe, A., Cocks, M., & Vetter, S. (2019). Ekhayeni: Rural–urban migration, belonging and landscapes of home in South Africa. Journal of Southern African Studies, 45(2), 413–431.

Ørtenblad, S. B., Birch-Thomsen, T., & Msese, L. R. (2019). Rural transformation and changing rural–urban connections in a dynamic region in Tanzania: Perspectives on processes of inclusive development. The European Journal of Development Research, 31(1), 118–138.

Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. World Development, 146, 105599.

Rwebangira, M. K. (1996). The legal status of women and poverty in Tanzania (Vol. 100). Nordic Africa Institute.

Scalise, E. (2012). Indigenous women's land rights: Case studies from Africa. State of the World's Minorities and Indigenous Peoples, 57, 58.

Schreiber, L. (2017). Registering rural rights: village land titling in Tanzania, 2008–2017. Innovations for Successful Societies, Princeton University. Available online: http://succefulsocieties. princeton. edu/(accessed on 25 August 2019).

Shivji, I. G. (1998). Not yet democracy: Reforming land tenure in Tanzania.

Tadesse, M. A., Alfnes, F., Erenstein, O., & Holden, S. T. (2017). Demand for a labor-based drought insurance scheme in Ethiopia: a stated choice experiment approach. Agricultural Economics, 48(4), 501–511.

Tanaka, T., Camerer, C. F., & Nguyen, Q. (2016). Risk and time preferences: Linking experimental and household survey data from Vietnam. In Behavioral economics of preferences, choices, and happiness (pp. 3–25). Springer.

Thobejane, T. D., & Flora, T. (2014). An exploration of polygamous marriages: A worldview. Mediterranean Journal of Social Sciences, 5(27 P2), 1058.

Thomson, J. (2009). Durable solutions for Burundian refugees in Tanzania. Forced Migration Review, 33, 35–37.

Tsikata, D. (2003). Securing women's interests within land tenure reforms: recent debates in Tanzania. Journal of Agrarian change, 3(1-2), 149–183.

UN-DESA. (2018). United Nations Department of Economic and Social Affairs, population division. World Urbanization Prospects: The 2018 revision, online edition.

URT. (1999). United Republic of Tanzania Land Act 1999. Retrieved from https://procedures.tic.go.tz/media/The%20Land%20Act%201999.%20Cap%20113.pdf

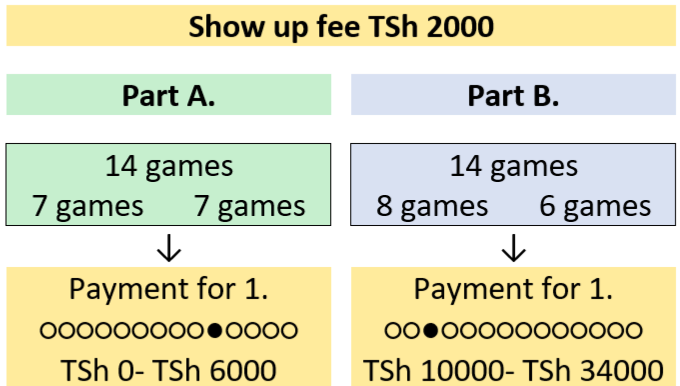
Visser, M., Jumare, H., & Brick, K. (2020). Risk preferences and poverty traps in the uptake of credit and insurance amongst small-scale farmers in South Africa. Journal of Economic Behavior & Organization, 180, 826–836.

A Script: Overview of activities

Introduction:
(FACILITATOR, READ OUT:)
Good day. Thank you everyone for joining use here today. Before we start, let us introduce ourselves. Our names are [........] and we work for the University of Dar es Salaam and the University of Cape Town.
The purpose of these activities we are going to do today is linked to the survey that we carried out with you. We will ask you to make a series of decisions. There are no right answers, and we only ask that you think very carefully about the decisions you make. You need to make decisions that you feel are right for you. The decisions you make will help us to understand how you feel about risk and this in turn will help us to understand how to develop ways for you to deal with the risks that you face as farmers.
You will also be able to earn real money from the decisions you make today, that you can take home.
You play these games as individuals, not in groups. So please donâ€™t talk to anyone while we are playing the games. If you have ANY questions at any stage you can just raise your hand and someone will come and answer your question privately. The exercise today will take three-four hours. Participation in the sessions is voluntary. If you decide not to take part, you may leave at any time, even after you have started playing â€“ but then you will not earn any money. If you prefer to stay, we ask that you sign the form that our assistants are bringing around right now indicating your consent to participate in the games.
(HAND OUT THE CONSENT FORMS)
This form says that you understand participation in these games is voluntary and that you can leave whenever you want to. But if you do leave before we have finished playing all the games, you wonâ€™t receive any money. Is everyone finished signing the forms? Ok, someone is going to come around and collect the forms from you.
(COLLECT CONSENT FORMS)
Overview of activities and description of payments
(FACILITATOR, READ OUT:)
I am now going to give you and overview of the activities we will carry out today and the money you will be able to earn through your participation. For showing up and participating at this event today, we are going to pay you TSh 2000 (INDICATE ON POSTER - figure 9). However, you will only receive this payment if you complete all the activities. In addition to this, you will also be able to make more money based on the decisions you make. Today we will be playing two sets of games- part A and part B (GESTURE ON POSTER - figure 9).

The first set of games is comprised of 14 decisions [GESTURE ON POSTER]. At the end of the day we will select one of these games out of a box and you will receive the payment associated with the choice you made in that game. You stand to earn between TSh 0 to TSh 6000 in Part A. The second set of games is also comprised of 14 decisions [GESTURE ON POSTER]. At the end of the day, we will select one of these games out of a box and you will receive the payment associated with the choice you made in that game. You stand to earn between TSh 10 000 and TSh 34000 in Part B.
Are there any questions?

Figure 9: Overview of activities and potential payments.



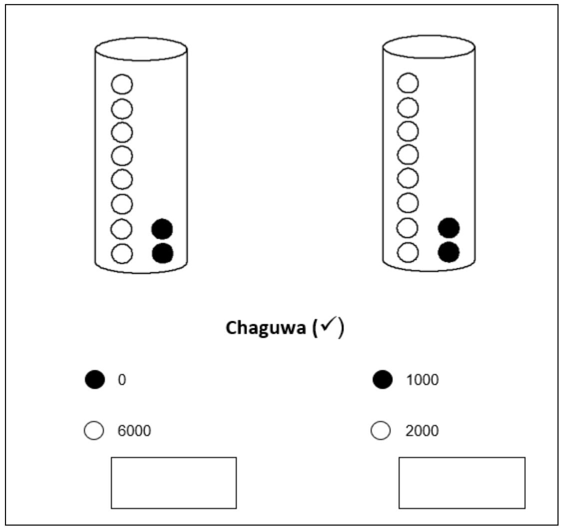
B Script: Elicitation of risk preferences

(FACILITATOR READ OUT:)
This part of the session involves a series of 14 games where we will ask you to make a decision each time. For each game, we will ask you to choose between two lotteries involving real money. At the end of the game, we will select one of the decisions you made out of a bag, and you will get to take home the amount of money that you earn from that particular decision.
We will first start with 7 games where you start with no money and you can make money.

Gain frame: I am now going to explain to you how these 7 games work: Here are two bags, bag 1 and bag 2 [GESTURE TO BAG PROPS]. In each bag, there are always only ten balls. [SHOW ON POSTER - figure 10]. Some of the balls are white and some of the balls are black [HOLD UP ONE WHITE AND ONE BLACK BALL].
In both bag 1 and bag 2, the number of white and black balls are the same. [GESTURE TO BAGS]. But the amount of money you can get if we choose a white ball or a black ball is different between bag 1 and bag 2.
In this game we will ask you to choose whether you prefer bag 1 or bag 2 and we will record your choice.
This is very important: if there are more white balls in the bag, it is more likely that if we take one ball out of the bag â€“ that it will be white. If there are more black balls in the bag, it is more likely that if we take one ball out of the bag -that it will be black.
I will now explain the first choice for you, and then we will go on to the next choices.

In Choice 1 there are 8 white balls and 2 black balls in both bag 1 and bag 2 [GESTURE TO THE POSTER - figure 10]. If you choose bag 1 and we take out a black ball, you will get TSh 0 and if we take out a white ball, you will get Tsh6000 [INDICATE THIS ON THE POSTER - figure 10]. If you choose bag 2 and we take out a black ball, you will get TSh 1000, if we take out a white ball, you will get TSh 2000. You should decide whether you prefer the bag 1 or bag 2 and you should indicate your choice with a tick in the box below that bag. This is very important: There is no right answer to these decisions, we only want to ask you to think very carefully about them and then to make the decision you prefer the most.
Are there any questions?

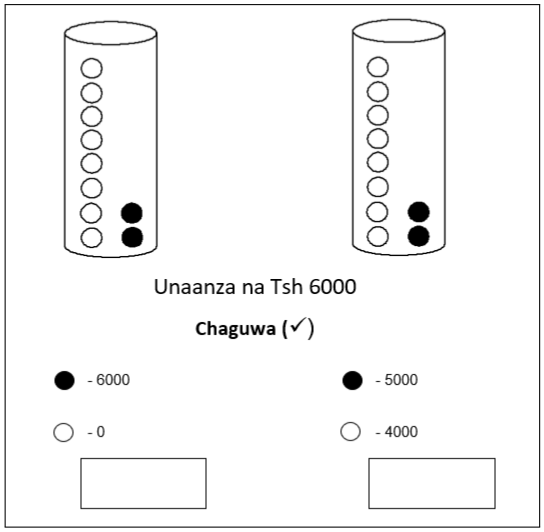
Figure 10: **Gain Frame:** 0.8 probability of High Payoff



Source: These games are based on the design initially advanced by Barr (2003) in rural Zimbabwe and replicated by Dercon et al. (2019) in rural Kenya. *Notes:* A total of seven gain frame and seven loss frame games were played, in each instance varying the probability of the High pay-off, while keeping the pay-off constant. In the loss frame games, participants start each game with an endowment of Tsh 6000.

Loss frame: We are now going to play the second set of 7 games. In these 7 games you will start each game with TSh 6000 [INDICATE ON THE POSTER - figure 11]. We will again ask you to choose whether you prefer bag 1 or bag 2 and we will record your choice.
I will now explain the first choice for you, and then we will go on to the next choices. In this game there are 8 white balls and 2 black balls in both bag 1 and bag 2 [GESTURE TO THE POSTER]. If you choose bag 1 and we take out a black ball, you will lose TSh 6000 and if we take out a white ball, you will lose Tsh 0 [INDICATE THIS ON THE POSTER]. If you choose bag 2 and we take out a black ball, you will lose TSh 5000, if we take out a white ball, you will lose TSh 4000.
You need to decide whether you prefer the bag 1 or bag 2 and you should indicate your choice with a tick in the box below that bag.
Once more, this is very important: There is no right answer to these decisions, we only want to ask you to think very carefully about them and then to make the decision you prefer.

Figure 11: **Loss Frame:** 0.8 probability of High Payoff.



Source: These games are based on the design initially advanced by Barr (2003) in rural Zimbabwe and replicated by Dercon et al. (2019) in rural Kenya. *Notes:* A total of seven gain frame and seven loss frame games were played, in each instance varying the probability of the High pay-off, while keeping the pay-off constant. In the loss frame games, participants start each game with an endowment of Tsh 6000.

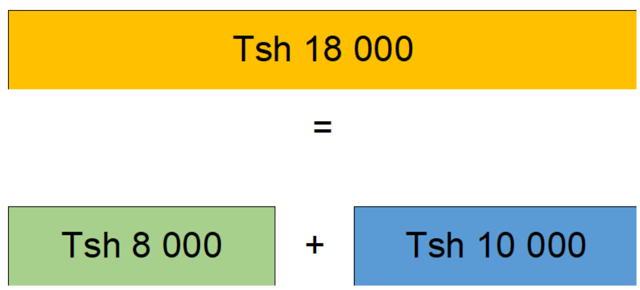
C Script: Framed hypothetical choice experiments

[TAKE ALL POSTERS OFF THE BOARD]
Preamble
In this next session we are going to play 8 games that involves decisions similar to what you normally make in your farming activities. Being a farmer, there are decisions you make on how to improve your harvest, such as investing money in improving your land. In these games today we are going to consider investments in your land (such as using soil conservation tranches, terracing, irrigation etc) that may help to increase your harvest in case of bad rains.
These investments may include planting your crops like cassava on ridges that conserve moisture and prevent surface runoff or making contours of crop residue in pineapple fields to conserve moisture, provide compost manure and prevent surface run off or to have irrigation to water your crops when the rains are bad [SHOW POSTER 3].
These investments have a cost and you cannot always be sure if your investment will increase your income or whether the money you spend is a waste. These investments help you to increase your harvest if there is bad rain, but if there is good rain then it can be a waste of money because it is not necessary.
Because these investments are costly and take a lot of effort you will probably only go ahead with them if you believe there is a large chance that there will be bad rains in the coming seasons. But, if you believe there is a large chance of good rains, then you may prefer not to spend your money on these investments.
(Are there any questions at this stage?)
The second thing that may determine how much we invest in our land is how much we feel secure in the land that we hold. It might be that we are not sure if someone else will take the land from us in future. If someone else can take the land, then it may be a bad decision to invest our money

in the land, because you can lose that money. On the other hand, if you feel secure in your land, and you feel these is very little chance that someone will take your land, then you may be more willing to invest your money in the land.
(Are there any questions at this stage?)
Introduction:
Now I am going to explain to you how this game works. In this game we are going to ask you how much money you want to invest in your farm. At the start of this game you will have TSh 18000 [INDICATE POSTER - figure 12]. Of this Tsh 18000, you can use Tsh 8000 to invest in your farm. [SHOW ON POSTER] and you will have Tsh 10000 as savings. We are going to ask you how much of your Tsh8000 you want to invest.

Now, we know that sometimes there are good rains and sometimes there are bad rains. On your

Figure 12: Overview of endowments



Notes: Respondents start each framed game with an endowment of Tsh 18,000. Of this initial amount, they can use Tsh 8000 for adaptive investments in their land. In the second part of the exercise they can choose to use some of the remaining Tsh 10,000 to purchase land certification, if they so choose.

farm, when there are good rains the harvest is very good. And when there are bad rains, the harvest is very bad. So lets say in any year, if there is good rain, then even if you donâ€™t invest your money in your farm, you will have a very good harvest [SHOW 340000 on POSTER 6 - figure 13] If on the other hand there is bad rains, then your harvest will be very low [SHOW 19000 on poster 6].

On the other hand, If you invest your money in terracing or irrigation and there turns out to be bad rains, then your investment will help you to increase your harvest. If there are bad rains, then the more you invest, the more your income will be in the end [INDICATE ON POSTER 6 - figure 13]. If you invest your money in terracing or irrigation and it turns out that there is good rain, then your investment will not be necessary. Because investment is a cost, if you invest and the rains turn out to be good, that cost gets subtracted from your income, but it does not improve your yields so much if there are good rains. If there is good rains, then the more you invest, the less your income will be in the end. [INDICATE THIS ON POSTER 6 - figure 13]
So as you can see, each level of investment will result in a different income from your harvests and the income that you get depends on whether there is good rain or bad rain.
(Are there any questions at this stage?)

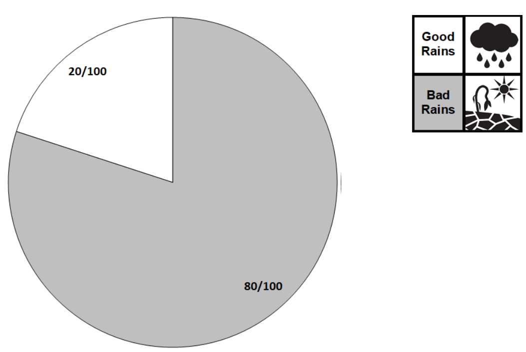
As you can see, [POINT TO POSTER 6. AND EXPLAIN - figure 13] here we show the amounts of money that you can invest in your land. You can choose how much you want to invest and we will ask you to record your choice with a tick. You can keep all your money and invest 0, or you

Figure 13: Payoff table without land loss risk

Investment	Tick one (✓)	Good rains	Bad rains
Tsh 0		34 000	19 000
Tsh 2 000		32 500	21 500
Tsh 4 000		31 000	24 000
Tsh 6 000		29 500	26 500
Tsh 8 000		28 000	29 000

can invest 2000, 4000, 6000 or 8000. You can only choose ONE level of investment in each game. Now as I said before â€“ sometimes there are good rains and sometimes there are bad rains. I am going to explain to you how we will find out if there is good rain, or if there is bad rain.
In each game there is a chance of having good rains or having bad rains. We show how likely each of these events are with this wheel [SHOW SPINNING WHEEL - figure 14]. The bigger the slice, the bigger the chance. As you can see that in this wheel [SHOW WHEEL - figure 14] there is a very big chance of a bad rain and only a small chance that there is good rain.
In this spinning wheel [SHOW ANOTHER SPINNING WHEEL] there is an equal chance that there is good rain or bad rain. So this is how this game will work. How much money you make in

Figure 14: Spinning wheel example - first example



this game depends on whether there is good rain or bad rain and how much money you chose to invest.
To find out which situation happens [good rainfall, bad rainfall or land taken], we are going to spin the wheel [SHOW SPINNING WHEEL] and where the wheel lands in relation to this ARROW is the situation that ends up happening. For example, if the arrow lands at good rain, then that is the outcome that takes place. If the arrow lands on bad rain, then that is the outcome that takes place. [ILLUSTRATE EACH BY SPINNING AND STOPPING THE WHEEL IN TURN].

So in each game we will ask you to look at the wheel, and to think very carefully about how

much money you want to invest and then to tick the box indicating your choice.
So now we are going to play a practice round and then we will play the first games.
Lets go through an example. Lets say we are faced with this wheel [SHOW WHEEL]. The first step is that you need to think about the chance of each event occurring. Here we see there is a very large chance that there will be bad rains. There is a small chance that there will be good rains.
The second step is that you need to decide, based on the chance in the wheel how much you want to invest [SHOW POSTER 8 - figure 13].
If you decide not to invest any of your money, then you will tick Tsh 0. Then we will spin the wheel. If it stops with the arrow pointing to good rain then you keep your Tsh 18000 and because there is good rain, you get a good harvest as well, so you will end up with a total of Tsh 34000. If the spinning wheel lands on Bad rain, you will keep your Tsh18000, but because there is bad rain, you will only get a bad harvest so you will only end up with a total of Tsh 19000 [IN EACH CASE SPIN AND STOP THE WHEEL TO ILLUSTRATE].
If you decide to invest Tsh 2000, then you will tick Tsh 2000. Then we will spin the wheel. If it stops with the arrow pointing to good rain then you keep your Tsh 16000 that you did not invest and because there is good rain, you still get a good harvest, but because there is good rain it is not so necessary to make the investment the Tsh2000 you spent on your investment is a bit of a waste. You will end up with a total of Tsh 32500. If the spinning wheel lands on Bad rain, you will keep your Tsh16000 that you did not invest, but because there is bad rain, you will get a bad harvest. However, the investment you made helps you to improve your harvest a bit and you will end up with a total of Tsh 21500[IN EACH CASE SPIN AND STOP THE WHEEL TO ILLUSTRATE].

[Illustrate for 6000 and 8000]

Once you have made your decision about how much to invest, we will record your choice and, we will put all of the games in a box and take one of the games out of the box and you will receive the earnings associated with your decision and the outcome in that game [Illustrate this].
This means you donâ€™t know which of the games will be chosen and so in order to maximise your chances of earning money, you should try to play your best in each game.
(PLAY GAMES 1 and 2 without land tenure risk)

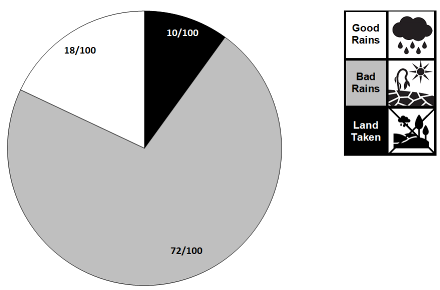
So now we have played the first games. As we mentioned before, in this game, there is also a chance that someone will take your land in the future. For example, it may be that the government takes your land or you have a dispute with a neighbour who takes the land, or maybe if you are a woman a man can take your land. If you invest your money and someone takes your land, then you will lose all of the money that you invested, and you will also not get any income from the harvest.
So now we are going to play more games, but this time we will assume that there is also a chance that someone takes your land. So here is what happens to your investment when someone takes your land. If you invest Tsh2000 in your farm and someone takes your land, then you will lose that Tsh 2000, and you will only have Tsh16000 left [INDICATE ON POSTER 7 - figure 15]. If you invest all Tsh8000 and someone takes your land, then you will lose all that Tsh8000 that you invested, and you will only have Tsh10000 left.
So in these games there are now three things that can happen. There can be good rains, there can be bad rains and your land can be taken [SHOW POSTER 7]. How much money you make in the each of these situations depends on how much you invest in your farm. If you invest nothing, then you can make Tsh 34000 if there is good rain, you can make Tsh19000 if there is bad rains and Tsh 18000 if your land is taken.
If you invest your money then you will make less money if there is good rain, but you will make

Figure 15: Payoff table example with land loss risk

Investment	Tick one (✓)	Good rains	Bad rains	Land taken
Tsh 0		34 000	19 000	18 000
Tsh 2 000		32 500	21 500	16 000
Tsh 4 000		31 000	24 000	14 000
Tsh 6 000		29 500	26 500	12 000
Tsh 8 000		28 000	29 000	10 000

more money if there is bad rain and you will lose all the money you invested if your land is taken [SHOW POSTER 7]. We will again ask you to make a decision on the amount of money you want to invest and indicate it with a tick.
How do we know what situation ends up happening? Once again, we will show the chance of each event taking place with a wheel like this [show wheel - figure 16].

Figure 16: Spinning wheel illustration with land loss risk



In this wheel [SHOW WHEEL - figure 16], there is a small chance of a good rain years and there is a big chance that the rains will be bad, and there is also a small chance that your land will be taken.

In this spinning wheel [SHOW ANOTHER WHEEL] there is a large chance (1 in 2) that someone takes your land.

In this wheel [SHOW ANOTHER WHEEL], the chance that there is good rain or bad rain is equal, but here there is also a slightly smaller chance that your land is taken.

To find out which situation happens [good rainfall, bad rainfall or land taken], we are going to spin the wheel [SHOW SPINNING WHEEL] and where the wheel lands in relation to this ARROW is the situation that ends up happening. For example, if the arrow lands at good rain, then that is the outcome that takes place. If the arrow lands on bad rain, then that is the outcome that takes place. If the arrow lands on land taken, then that outcome takes place. [ILLUSTRATE EACH BY SPINNING AND STOPPING THE WHEEL IN TURN].

So when making your decisions about how much to invest, first you need to consider the chance of each outcome: Bad rain, Good rain or Land Taken by looking at the spinning wheel. The bigger the area, the bigger the chance.
Next you have to choose how much you are going to invest by making a tick in the table. Then we will spin the wheel to see which outcome happens and we will see how much you invested to determine how much your earnings are for that game.
Lets go through an example. Lets say we are faced with this wheel. The first step is that you need to think about the chance of each event occurring. Here we see there is a very large chance that there will be bad rains. There is a small chance that there will be good rains and an even smaller chance that your land will be taken.

The second step is that you need to decide, based on the chance in the wheel how much you want to invest [SHOW POSTER 8].

If you decide not to invest any of your money, then you will tick Tsh 0. Then we will spin the wheel. If it stops with the arrow pointing to good rain then you keep your Tsh 18000 and because there is good rain, you get a good harvest as well, so you will end up with a total of Tsh 34000. If the spinning wheel lands on Bad rain, you will keep your Tsh18000, but because there is bad rain, you will only get a bad harvest so you will only end up with a total of Tsh 19000. If it lands on land taken, you will keep your Tsh 18000, but because someone takes your land, you donâ€™t receive any income from the harvest, so you will have a total of Tsh 18000 [IN EACH CASE SPIN AND STOP THE WHEEL TO ILLUSTRATE].

If you decide to invest Tsh 2000, then you will tick Tsh 2000. Then we will spin the wheel. If it stops with the arrow pointing to good rain then you keep your Tsh 16000 that you did not invest and because there is good rain, you still get a good harvest, but because there is good rain it is not so necessary to make the investment the Tsh2000 you spent on your investment is a bit of a waste. You will end up with a total of Tsh 32500. If the spinning wheel lands on Bad rain, you will keep your Tsh16000 that you did not invest, but because there is bad rain, you will get a bad harvest. However, the investment you made helps you to improve your harvest a bit and you will end up with a total of Tsh 21500. If it lands on land taken, you will lose the Tsh 2000 that you invested and you wonâ€™t get any income from your harvest and you will end up with only Tsh16000.[IN EACH CASE SPIN AND STOP THE WHEEL TO ILLUSTRATE].

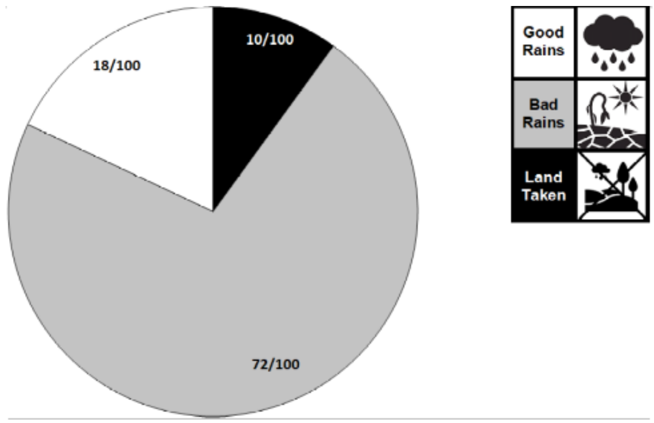
[Illustrate for 6000 and 8000]

Once you have made your decision about how much to invest, we will record your choice and then we will spin the wheel to see which outcome occurs and we will record that as well. At the end of the day, we will put all of the games in a box and take one of the games out of the box and you will receive the earnings associated with your decision and the outcome in that game [Illustrate this]. This means you donâ€™t know which of the games will be chosen and so in order to maximise your chances of earning money, you should try to play your best in each game.

[Are there any questions at this stage?]

SERIES 2. Option to buy certification.
We are now going to play the final set of 6 games for today [Indicate on POSTER 1 - figure 2]. These games will be similar to the last ones. Remember that in the last games there was a chance

Figure 17: Example of framed game



				
Investment	Tick one (✓)	**Good Rains**	**Bad Rains**	**Land Taken**
Tsh 0		34 000	19 000	18 000
Tsh 2 000		32 500	21 500	16 000
Tsh 4 000		31 000	24 000	14 000
Tsh 6 000		29 500	26 500	12 000
Tsh 8 000		28 000	29 000	10 000

Notes: The game displayed here illustrates the decision task when land tenure risk is 0.1, the probability of good rains is high and the probability of bad rains is low. Respondents are asked to choose how much of their initial investment endowment (Tsh 8000) they would like to invest. The returns to the investment are variable, depending on the weather and land loss outcome which is determined by means of a spinning wheel. The pay-offs displayed in the table illustrate the net amount they would end with associated with any given level of investment and weather or land outcome.

that your land would be taken away. If this happened you lost all the money you invested. Now in this game, we are going to give you an option to buy a certificate and if you buy a certificate, you will remove the chance that someone takes away your land. So say we play this game. You can choose. If you donâ€™t want to buy the certificate, you will play this game [indicate on wheels below]. If you do get the certificate, you will play this game and you donâ€™t need to worry about your land being taken away [show game on right with certificate].

So how can you buy this certificate? You will again start this game with Tsh 18000, but here you can use your Tsh 10000 of savings to buy a land certificate. [SHOW ON POSTER 4] If you get the certificate, you will again choose how much of your Tsh 8000 you want to invest.

You have the choice to decide whether you want to buy this certificate and how much you would like to pay for this certificate. The maximum cost of the certificate is TSh 10000.You can decide how much you want to pay between TSh 0 and TSh 10000 and we will ask you to indicate your choice with a tick [INDICATE ON POSTER 9]. If you buy the certificate, the money you pay for the certificate will be deducted from the final amount of money you end the game with. Weâ€™ve said this before.

However, because the certificate takes away the chance that your land will be taken, the certificate has a real value. In order to encourage you to think very carefully about how much you are willing to pay for the certificate, we are going to use the following procedure to determine whether you get the certificate for the price you offer to pay for it. We know what the value of the certificate is and are going to put some numbers that are close to the value in a bag and will pick one of the numbers out of the bag. If the number you offer to pay for the certificate is above or equal to the number we pick out of the bag, then you will get the certificate. If the number you offer to pay is below the number we pick out of the bag, you wonâ€™t get the certificate. This means that the more money you offer to pay for the certificate, the more certain you will be of getting it. However, the cost of the certificate will be subtracted from your final earnings, so you also donâ€™t want to pay too much for it. This means you need to think very hard about what it is worth to you.

Figure 18: Bidding sheet

Narithia kulipa hati ya hakimiliki ya kimila

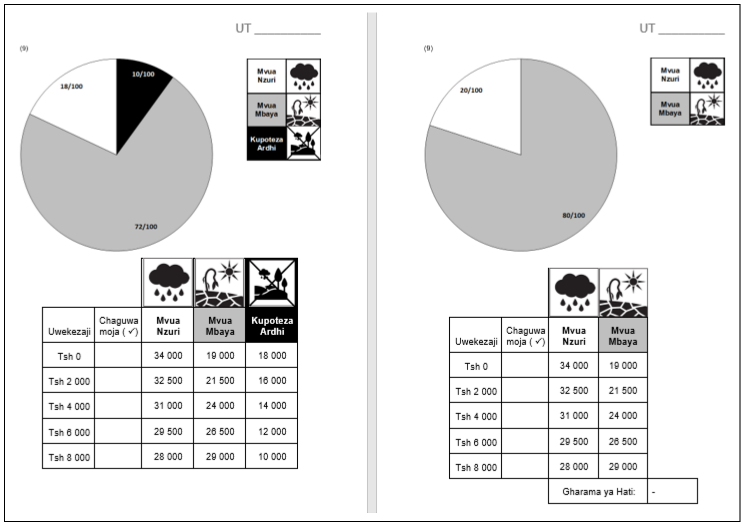
Tsh	Chaguwa moja (✓)
0	
500	
1 000	
1 500	
2 000	
2 500	
3 000	
3 500	
4 000	
4 500	
5 000	
5 500	
6 000	
6 500	
7 000	
7 500	
8 000	
8 500	
9 000	
9 500	
10 000	

Notes: Here respondents are asked to bid for the land certification that removes any risk of land loss. They are endowed with Tsh 10,000 and are asked how much they would bid in order to obtain the certificate. The actual value of the certificate is then determined by a BDM method.

If you buy the certificate, you will play the investment game again, but this time with no risk that your land is taken. And you will be asked how much you want to invest. If you do not want the certificate or if you do not get the certificate, then you will also play the investment game again, but you will still face the risk that your land is taken.
Let us illustrate this with an example [SHOW POSTER 10]. In this case, there is a 1 in 2 chance that your land will be taken away [show wheel 1]. If your land is taken away, you lose all the money

you invest in the land. If, on the other hand, you get the certificate, then there is no chance that your land is taken away [show wheel]

Figure 19: Willingness to pay games



Uwekezaji	Chaguwa moja (✓)	Mvua Nzuri	Mvua Mbaya	Kupoteza Ardhi
Tsh 0		34 000	19 000	18 000
Tsh 2 000		32 500	21 500	16 000
Tsh 4 000		31 000	24 000	14 000
Tsh 6 000		29 500	26 500	12 000
Tsh 8 000		28 000	29 000	10 000

Uwekezaji	Chaguwa moja (✓)	Mvua Nzuri	Mvua Mbaya	
Tsh 0		34 000	19 000	
Tsh 2 000		32 500	21 500	
Tsh 4 000		31 000	24 000	
Tsh 6 000		29 500	26 500	
Tsh 8 000		28 000	29 000	
		Gharama ya Hati:		-

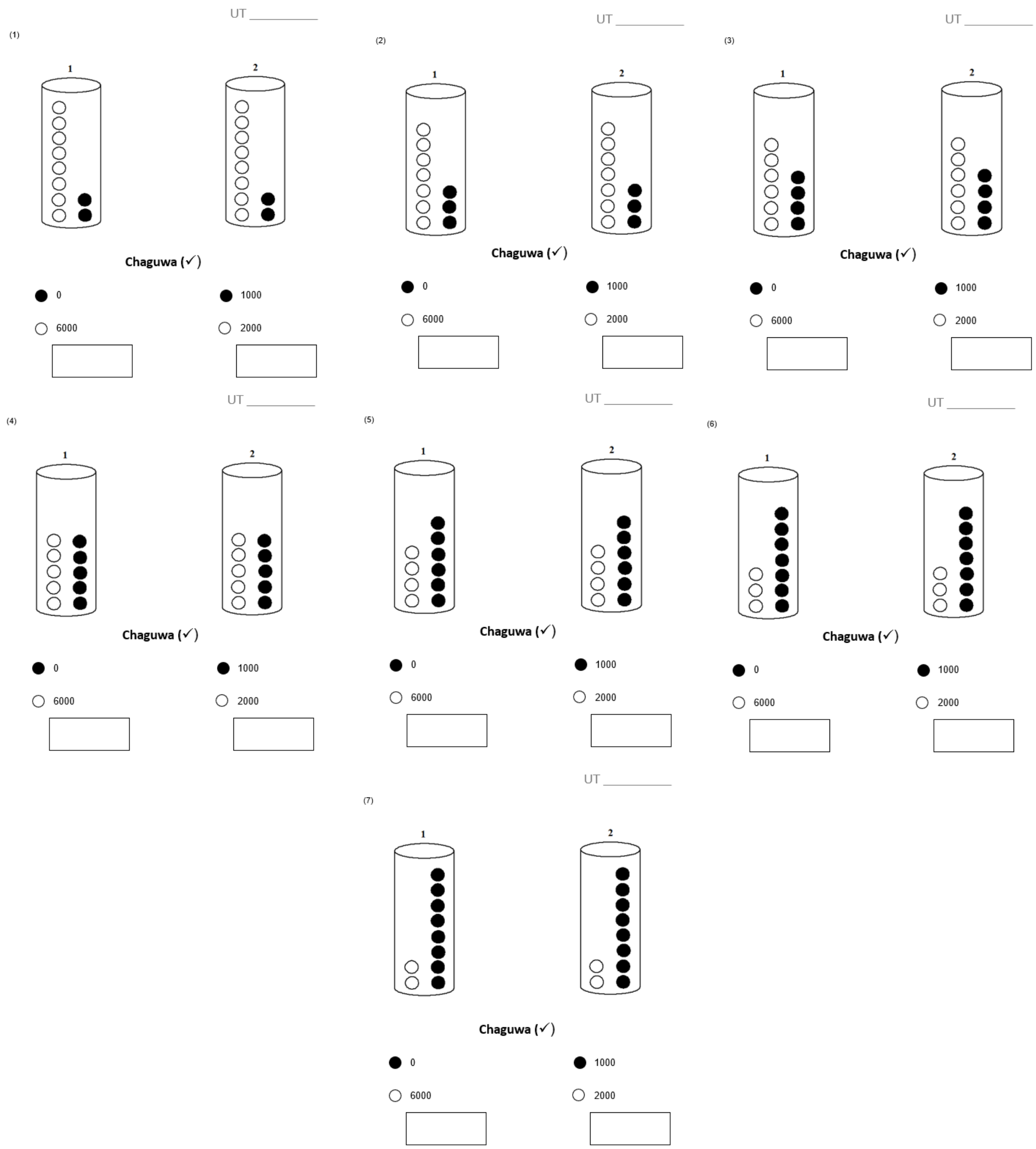
Notes: Respondents started the bidding process facing the risks displayed in the left-hand figure. If they were successful in obtaining a certificate, they play the game on the right. If not, they play the game on the left.

If you choose that you don't want the certificate, then you can tick Tsh 0 and you will play the first game [Indicate on poster]. If you want to buy the certification that allows you to play the second game, then you need to choose a number between Tsh0 and Tsh10000 and indicate your bid with a tick. We will then record your choice, draw a number out of the bag and if your number is above or equal to the number we draw from the bag, you will play game 2. If it is below the number we draw from the bag, you will play game 1.

Then once we have seen which game you play, you will choose how much to invest, and we will spin the wheel to see which situation ends up taking place. If you play game 1, we will spin wheel 1 and if you play game 2, we will spin wheel 2.
(Are there any questions?)

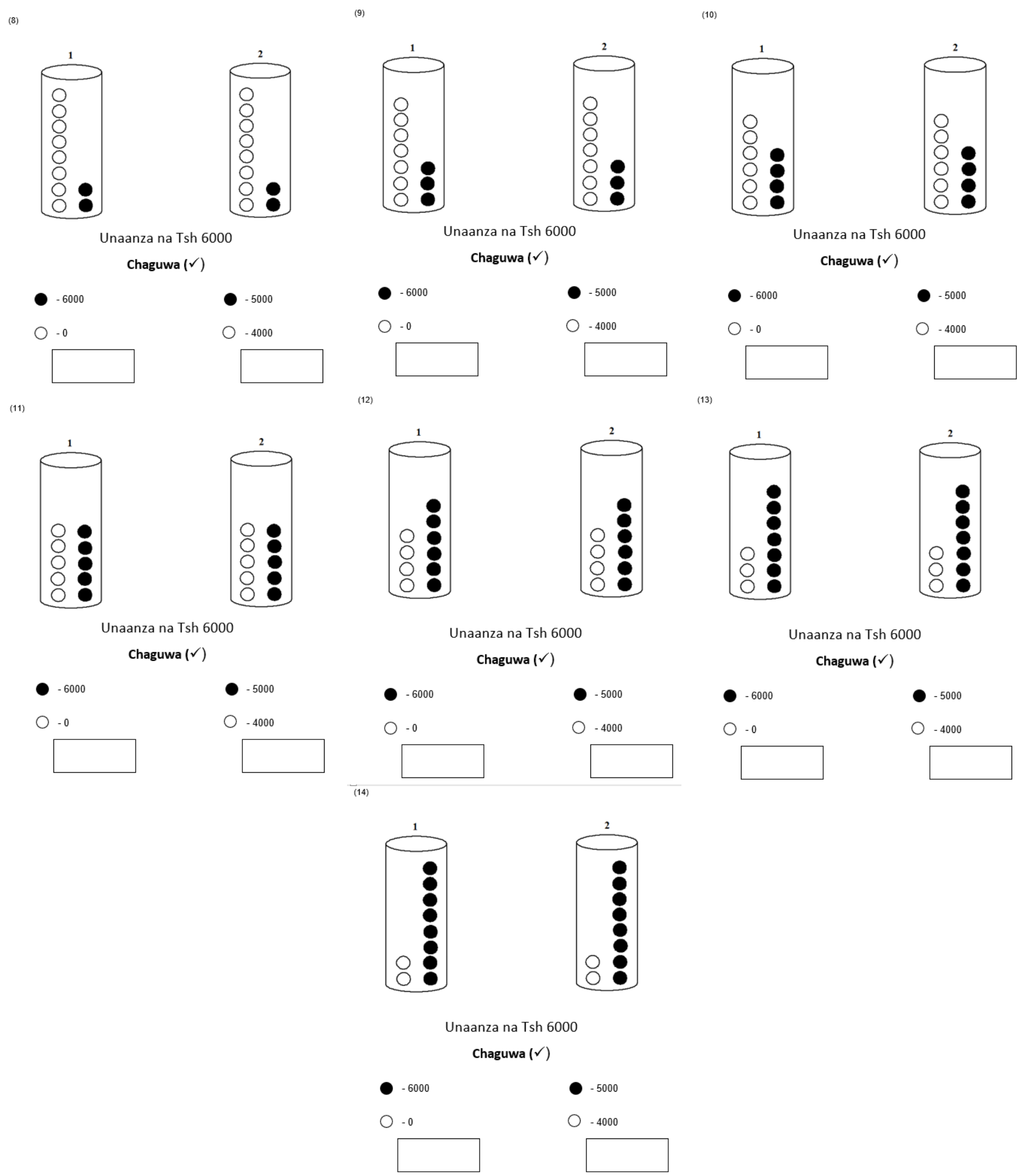
D Overview of all gain frame and loss frame risk games

Figure 20: Overview of gain frame risk games.



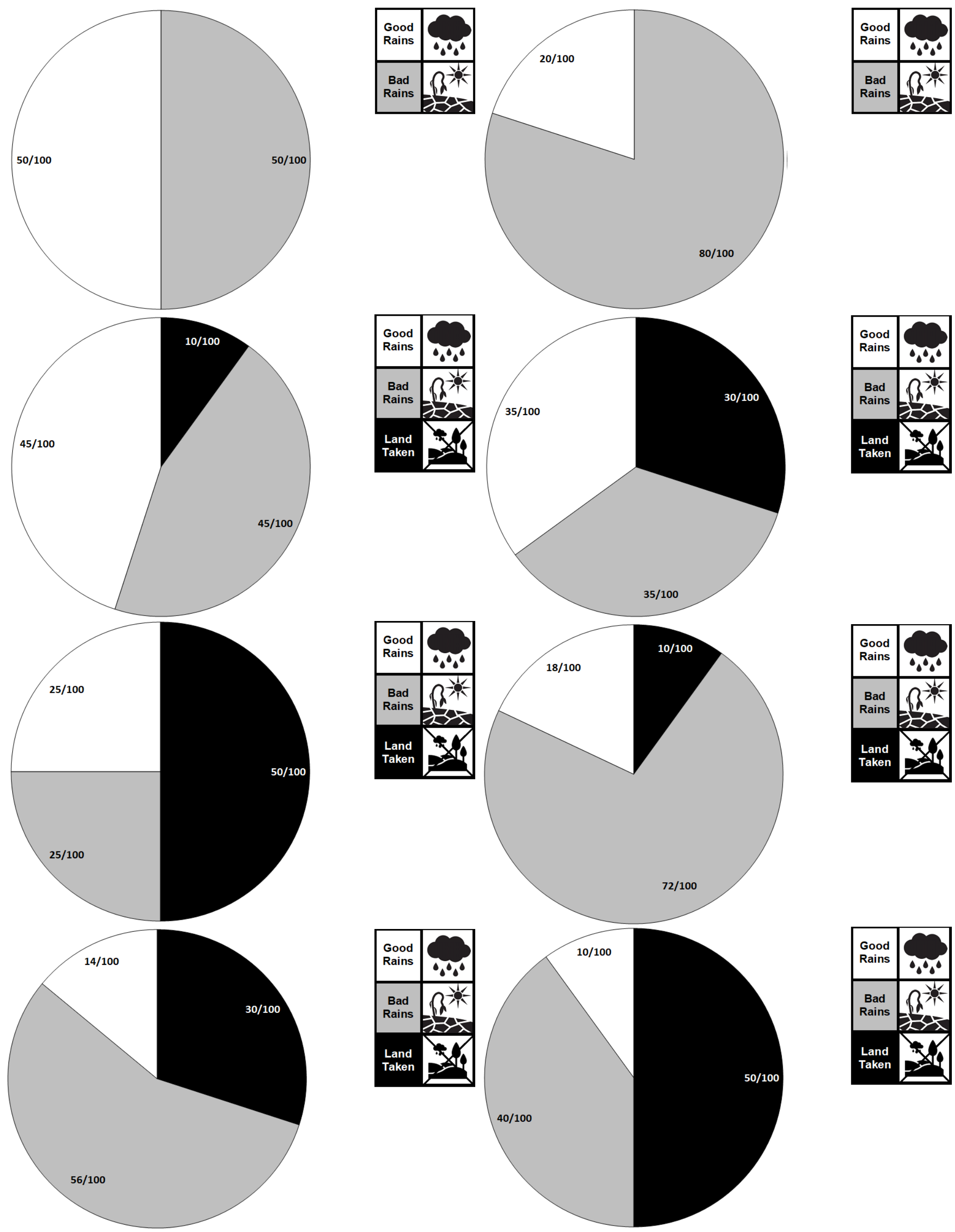
Notes: Games were played in the order presented here.

Figure 21: Overview of loss frame risk games.



Notes: Games were played in the order presented here.

E Overview of all framed decision tasks



Notes: Game orders were randomized in the following way to account for order-effects: The games in the first row were always played first (in alternating order). Thereafter the following 6 games were played in random order.

F Willingness to pay for land certification - elicitation in household survey

Land certification Label	**Interviewer read out**: I would now like to ask you about about how much you would be willing to pay for a customary right of occupancy certificate for your land (Hati ya hakimiliki ya kimila). As you know, having a customary right of occupancy certificate is a way of showing that you own your land and therefore it means your land will be more secure. It can also help you to be able to sell your land or to access finance. It is also a way of preventing land related conflicts in future by clearly specifying where your land starts and ends. [Interviewer show a copy of a Hati ya Hakimiliki ya Kimila certificate].
Land certification Label	However, in order to get a customary right of occupancy certificate there is a long process that needs to take place. For example, a surveyor needs to travel here to your land to accurately mark where your land starts and ends and the local government needs to issue you with a certificate. These processes cost some money.
Land certification Label	This is a hypothetical question and there are no right or wrong answers. I want you to consider whether you would be willing to pay for a customary right of occupancy certificate.. However, it is very important that you think very carefully about this question and answer truthfully.
Land certification Label	As you consider your decision, keep in mind the various things that you spend money on and how those decisions will be affected by your choice. For example, if you decide to buy the customary right of occupancy certificate you may have less money available to purchase food or seeds or other items. Or you may have to work more to earn the additional income to pay for the certificate.
Land certification Q.18 **want_cert_a** **Household** [Go To [want_cert_c] if:current.want_cert_a = 2]	*Consider that the cost of a CCRO (Hati ya Hakimiliki ya Kimila) was Tsh 50 000 that your household has to pay. Would you purchase this certificate for your land at this price?* (1)Yes,(2)No,(-99)Refuse,(-88)Dont know
Land certification Q.19 **want_cert_b** **Household** [Go To [max_wtp] if:current.want_cert_b = 1] [Go To [max_wtp] if:current.want_cert_b = 2]	*Consider that the cost of a CCRO (Hati ya Hakimiliki ya Kimila) was Tsh 80 000 that your household has to pay. Would you purchase this certificate for your land at this price?* (1)Yes,(2)No,(-99)Refuse,(-88)Dont know
Land certification Q.20 **want_cert_c** **Household**	*Consider that the cost of a CCRO (Hati ya Hakimiliki ya Kimila) was Tsh 20 000 that your household has to pay. Would you purchase this certificate for your land at this price?* (1)Yes,(2)No,(-99)Refuse,(-88)Dont know
Land certification Q.21 **max_wtp** **Household**	*What is the most you would pay for a CCRO (Hati Ya Hakimiliki Ya Kimila)?*

G Attrition

Table 12: Probit regression. Dependent variable: HH survey respondent not individually identified in experimental data

	(1)
	noexp
noexp	
HH head age	0.00369
	(1.06)
HH head education	-0.111***
	(-6.05)
Female HH head	0.000468
	(0.00)
Respondent = HH head	0.0358
	(0.60)
Wealthindex	-0.165**
	(-3.10)
Own land certification	0.287
	(1.50)
Constant	0.0444
	(0.19)
N	635

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

H Additional results and summary statistics

Table 13: Correlation matrix for variables used in Wealth index

	tvs	motorbikes	celtels	bicycles	radios	goats	cattle
tvs	1						
motorbikes	0.2575	1					
celtels	0.1162	0.1142	1				
bicycles	0.061	0.1413	0.2551	1			
radios	0.2019	0.1394	0.2744	0.1747	1		
goats	0.051	0.0261	0.0306	0.1603	0.116	1	
cattle	0.0491	0.0167	0.0787	0.282	-0.0037	0.1555	1

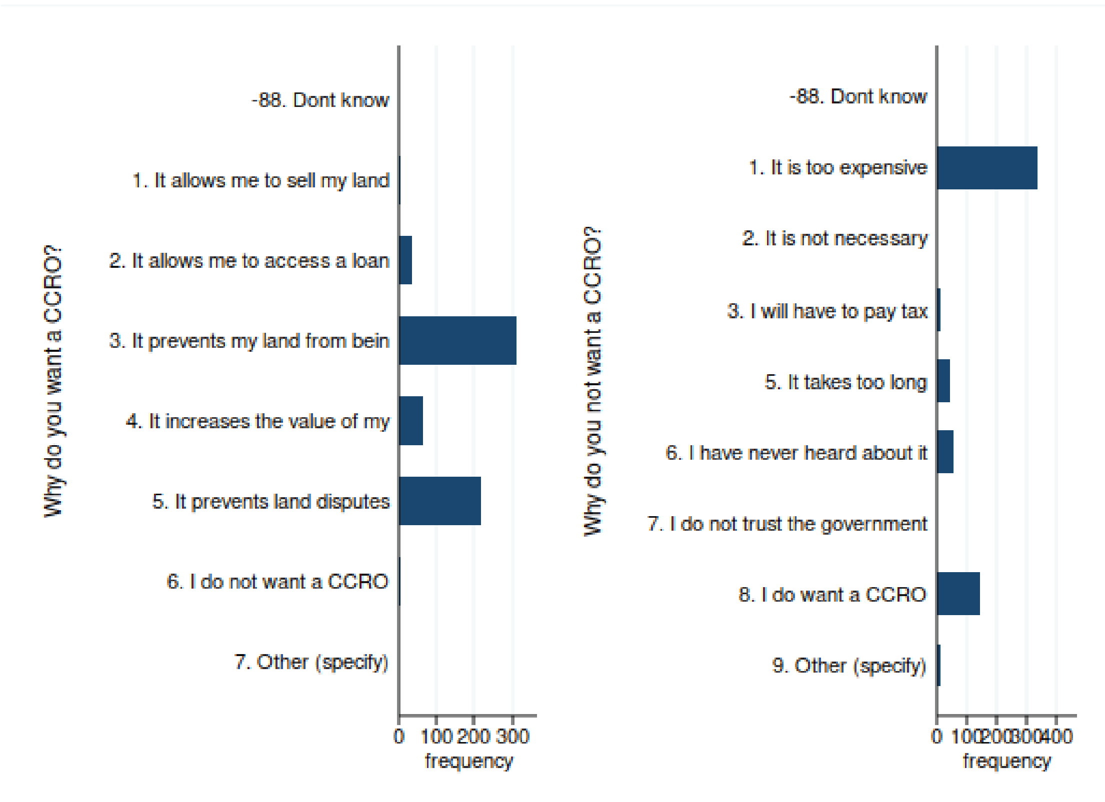
Table 14: Probit regression: Ownership of a CCRO.

	(1)	(2)	(3)
	own_ccro	own_ccro	own_ccro
HH size	0.041**	0.051**	0.052**
	(0.020)	(0.021)	(0.021)
Head educ	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Head age	0.004	0.006	0.002
	(0.005)	(0.005)	(0.006)
Female headed HH	-0.191	-0.136	-0.135
	(0.237)	(0.242)	(0.252)
Wealth index	0.066	0.082	0.106
	(0.072)	(0.075)	(0.083)
log estimated land value		-0.013	-0.015
		(0.030)	(0.030)
Size of land holdings			0.017**
			(0.007)
Past land disputes			0.324
			(0.202)
District controls	N	N	Y
Constant	-1.972***	-1.995***	-2.480***
	(0.270)	(0.492)	(0.623)
N	637	617	616

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 22: Reasons for wanting/not wanting a CCRO



N=642, both questions asked to all participants