Information as a Source of Empowerment: The Role of Climate Information Services

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Berber Kramer | Carly Trachtman | Linda Zuze

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Abstract

Climate Information Services (CIS) may help smallholder-farming households adapt to increasingly erratic climactic patterns. CIS may be especially important for women farmers, given that information can empower women to have more of a say in household farming decisions. However, quantifying the welfare benefits of CIS is empirically challenging, given that farmers' agricultural investment may increase or decrease depending on the forecast content and their risk aversion levels, and we generally do not observe intrahousehold decision-making processes. To understand how CIS provision affects agricultural investment decisions, welfare, and intrahousehold bargaining outcomes, we conduct a framed lab-in-the-field experiment with 224 participants from 112 married couples in the Eastern Province of Zambia. Participants made a series of simulated, incentivized agricultural investment decisions over which we vary the CIS provided. We find that farmers use weather forecasts, and to a lesser extent investment advice, to improve their welfare. Moreover, we find that providing forecasts may help spouses to agree on agricultural investment decisions.

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About AICCRA Working Papers

Titles in this series aim to disseminate interim research on the scaling of climate services and climate-smart agriculture in Africa, in order to stimulate feedback from the scientific community.

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About AICCRA

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aiccra.cgiar.org **aiccra@cgiar.org** **CGIARAfrica**

01. INTRODUCTION

Climate change has become one of the most pressing global issues of our time (Busby et al. 2013; East-West 2021; FAO 2021). The past eight years have been the warmest period on record (WMO 2023), which has increased the risk of droughts and wildfires (Cook 2019). On the other extreme, several countries are witnessing a sharp rise in heavy rainfall and flood risks (Union of Concerned Scientists 2018). These changes form a threat to agricultural production worldwide (Carter et al. 2018; Kawasaki et al. 2016) and are especially worrying for farming households in developing countries. There, extreme weather events are already wreaking havoc on food security, livelihoods, and economic growth through lower crop yields and higher food prices, threatening child nutrition among farming households (Dimitrova 2021; Phalkey et al. 2015). These effects continue to be disproportionately felt in Africa, where resources available to cover adaptation costs are limited compared to other parts of the world (Mekonnen 2014). Rain-fed agriculture supports livelihoods for most African households; 95 percent of agricultural activity in sub-Saharan Africa is rain-fed (Abrams 2018), making them more vulnerable to negative effects of climate change.

One way to reduce the adverse impact of climate change on farming output is through climate information services (CIS). CIS provide information about climate change and early warnings about extreme weather events that help with risk management and decision-making, such as weather forecasts and advice . For example, accurate weather information can help farmers take advantage of favorable weather conditions. Careful consideration of end users' needs during programme design makes a difference for uptake. Creating advisories for specific areas and crops, for example, has proven to be a successful approach (Carr et al. 2020). Technology (such as cell phones and computer programmes) is now being used not only to deliver weather forecasts but also to influence agricultural practices (Tjernström et al. 2021). However, it helpful to communicate weather information in an understandable language and offer training and support through trusted local structures (Yegbemey et al. 2023). Climate-smart strategies like water conservation and crop rotation, which enhance output, are influenced by CIS because farmers rely on forecasts to make decisions about their agricultural practices (McKune et al. 2018). Weather information has helped farmers select what crop varieties to plant, what inputs to purchase, and even how to plant drought-tolerant crops (Maggio et al. 2018).

Using a framed field experiment, this study analyses the effects of climate information services on agricultural investments and intra-household bargaining dynamics. Women play an important role in agriculture, but their productivity levels are lower than men's, and they have access to fewer resources and support services (Croppenstedt et al. 2013; Kilic et al. 2015). However, reducing uncertainty on weather conditions that influence agricultural decision-making, and providing information on how they can best adapt to changing weather patterns or respond to weather forecasts might help to bridge this gap. Indeed, research shows that agricultural productivity in sub-Saharan Africa is higher in households where both men and women receive agricultural advisory and extension services than in households where only men receive these services (Azzarri et al. 2022), and that they have the potential to increase agricultural productivity (Azzarri and Nico 2022). Moreover, by providing women with information, CIS might empower women, and giving them a stronger voice in agricultural decision-making (Gumucio et al. 2020; Mittal 2016).

Nonetheless, gender-specific constraints that restrict women's access to information may also inhibit them from receiving climate information (Huyer et al. 2020). Previous research has shown that husbands may not share climate information with their wives (Asfaw et al. 2018; Bernier Q. et al. 2015). As a result, introducing CIS to farming communities may reinforce rather than reverse gender productivity gaps. Previous work indeed documents gender disparities usually favouring men in the frequency (Carr et al. 2018; Twyman J. et al. 2014) and type (Coulibaly J.Y. et al. 2017) of climate information accessed . Costs and benefits of CIS may also depend on an individual's ability to act on the information provided. Hence the benefits of CIS for women may be overstated if they lack bargaining power within their household, barring them from successfully negotiating with their husbands to apply the recommendations provided through CIS. To get a more realistic picture of the actual benefits they obtain, we must consider these household bargaining relationships (Kramer et al. 2023).

We use a framed field experiment with 224 respondents from 112 married couples in Zambia's Eastern province to test how CIS influences men and women smallholder farmers' investment decisions. Over a series of simulated agricultural seasons, participants are tasked with allocating a fixed seasonal endowment between risk-free savings and purchases of seeds that vary in the gains and losses associated with weather-dependent production risk. Seasons vary in the probability of favorable weather conditions, and we vary, using a within-subject design, whether participants are provided with weather forecasts, and if so, whether the forecast is accompanied by an investment advisory. To study bargaining dynamics, we also vary whether choices are made individually or together with someone's spouse, and during individual rounds, we vary who within the household receives a CIS advisory to inform later joint decisions: neither husband nor wife, husbands only, wives only, or both husbands and wives.

We find that respondents' investment decisions are influenced strongly by weather forecasts. As the forecasted probability of favorable weather increases, both men and women farmers, as well as couples, invest in riskier technologies. As a result, forecasts increase expected incomes and the variance of income. We find that forecasts also allow respondents to invest more closely to how they would have chosen to invest under certainty, thus saving instead of investing under scenarios where it will not rain and investing in a high-risk technology in scenarios where it will rain. According to a capabilities-based approach to development (Robeyns 2005; Sen 1997), this makes participants better off, as it allows them to act closer to how they would have chosen to do so in the absence of any weather uncertainty. Respondents also incorporate investment advisories on how to respond to a given forecast, but these effects are small and less robust. As a result, advisories do not increase expected income, although they do reduce the variance of income and allow respondents to invest more closely to how they would have invested under certainty. Advisories, therefore, do have positive welfare effects that could have been missed if looking only at changes in income.

We observe no strong gender differences in investments or in effects of forecasts and advisories. However, forecasts do have important implications for bargaining dynamics. On average, in the absence of a forecast, a wife's individual investment decision, compared to her husband's investments, is further away from the decisions they make as a couple. This suggests that husbands may have more bargaining power and have a stronger say in how the couple invests, resulting in investment patterns that are closer to their individual preferences. However, when provided with a forecast, couples' savings become closer to both husbands' and wives' behavior, suggesting that forecasts might help husbands and wives agree on the extent to which they should save, and reflecting preferences of both husbands and wives. Advice given to an individual before the couple makes an investment decision affects investments only if given to the husband alone, not to the wife or both husband and wife.

These findings contribute to our understanding of gender differences in the benefits of CIS. Previous research has linked gender differences in the uptake of CIS to unequal access to information. Women aren't always able to take advantage of CIS services if their mobility is limited, their time is constrained, or they can't access the technology needed. Farm cooperatives that control most agricultural information are dominated by men and tend to exclude women in their dissemination arrangements (Doss 2001). With the emergence of smartphone technology to access CIS, women are also disadvantaged as their ability to own or use smartphones is restricted (Becker, 2020). In addition to unequal access, past studies indicate that men and women may have unique reasons for not relying on CIS based on their understanding of the factors driving climate change and previous experiences with the climate information (Ngigi et al. 2022). According to a Senegalese survey, more women than men distrust CIS due to religious convictions. Men's mistrust of CIS was driven by seasonal shifts and previous unreliable forecasts (Diouf et al. 2019).

The findings in this paper also provide insights on what types of costs and benefits of CIS to measure. We are becoming more aware of how to quantify the fixed and variable costs (List et al. 2022), but researchers are still learning to measure CIS's gender-related effects. Conventional cost-benefit analysis methods tend to focus on monetary outcomes and do not always consider the non-monetary benefits of CIS, especially for women. The non-monetary benefits of CIS include its potential to empower women by giving them information that makes their bargaining position stronger or by offering time-saving alternatives that make their current workloads lighter (Timu et al. 2022). CIS could also convey gender-transformative messages that encourage changes in social norms. The findings presented in this study show how important it is to measure such non-monetary benefits, given that forecasts improve men's and women's capacity to align their investments under risk with their preferred allocations in the absence of risk. Moreover, the findings illustrate non-monetary benefits in terms of improved bargaining dynamics, as forecasts bring couples' allocations closer to husbands' and wives' preferences revealed during their individual allocation tasks. Given the evidence of gender differences in risk preferences, we further investigated variation in benefits when including the component of risk (Akter et al. 2016; Eckel et al. 2002; Filippin et al. 2016; Sarin et al. 2016).

The remainder of this paper is structured as follows. In the next section, we provide an overview of the context in which the experiment was conducted, including a discussion of climate change in Zambia and the linkages between gender, policy, and climate services in the country. Section 3 provides a description of the experimental methods used to evaluate how farmers respond to climate information, and how we analyze bargaining dynamics. The next section provides an overview of our results, followed by a concluding section that summarizes our main findings and provides an outlook for future research.

02. CONTEXT

The impact of climate change on Zambian agriculture

Zambians have witnessed the harsh effects of climate change on the agriculture and energy sectors, and this trend is expected to continue (Ngoma et al. 2023; World Bank 2021). Droughts and heavy rainfall have become more frequent and intense, resulting in water scarcity, crop damage, and lower crop yields (Food Agriculture Natural Resources Policy Analysis Network Earth System Governance Project 2017). A reliance on maize as a staple crop increases the population's vulnerability because maize is sensitive to variations in temperature and moisture levels (Kanyanga et al. 2013; Ngoma H. et al. 2021). Numerous groups, including government (Ministry of Agriculture 2022), are working to minimize the negative effects of climate change on smallholder farmers. Recent initiatives have involved advocating for climate-smart farming practices, expanding crop diversity (Arslan et al. 2018), and instituting unconditional cash transfer programs (Lawlor et al. 2019). Despite this commitment to improving the policy and regulatory environment, extreme weather events have been especially damaging to Zambian smallholder farmers who rely heavily on rainfed agriculture (Ministry of Finance and National Planning 2022)

Gender, policy and climate services in Zambia

Gender inequalities in household bargaining power constrain the ability of Zambian women in farming communities to make financial decisions (Barr et al. 2023). Women who deviate from the norm that spouses should not save in secret may risk of violence if discovered by their husbands. It remains to be seen if the same power dynamics affect farming investment choices. Programs and extension services can contribute to household empowerment but have traditionally been gender blind. Recent legislative changes are more gender-specific although co-ordination across government agencies might be necessary. Zambia's Climate Change Gender Action Plan (Ministry of Gender for the Republic of Zambia 2018) outlines strategies to increase capacity for a more gender-responsive approach to climate management. The just-released Zambian National Adaptation Plan (Ministry of Green Economy and Environment 2023) is preparing guidelines for including a gender perspective in climate change planning and budgeting procedures. Our findings may help to shape of these guidelines.

03. METHODOLOGY

To understand how husbands and wives respond to climate information when making agricultural investment decisions, we recruited married couples within farming communities in the Nyimba district of Zambia's Eastern province, a region frequently affected by climate-related shocks, for a framed field experiment. With a population of 136,000 (Zambia Statistics Agency 2022), Nyimba is a predominantly rural district in the southern section of the Eastern province. The study's participants were asked to make simulated, incentivized agricultural investment decisions over a series of "agricultural seasons," which they completed on a tablet application. In each round (or "season"), participants could use a fixed endowment to purchase maize seed. The probability of favorable weather conditions varied between seasons, with crop yields dependent on the amount of rainfall. We varied whether participants received forecasts, whether investment advisories accompanied the forecasts, whether their investment decisions were made individually or jointly by husbands and wives, and whether either husbands or wives received advisories during individual rounds that could potentially inform the best course of action during joint rounds.

3.1 Experimental design

Table 1 provides an overview of the experimental design. Participants completed 12 rounds of investment decisions, each corresponding to a different agricultural season, including seven rounds in which each spouse made decisions individually, and five rounds in which couples made joint decisions. We refer to the 12 different experimental conditions in Table 1 as "levels." To mitigate any order effects, husbands and wives played the first 7 levels in Table 1 individually and in a randomized order. Afterwards, they played the next 5 levels as a couple, again in a randomized order (for instance, an individual could play level 4 as their round 1, and a couple could play level 8 as their round 12). To avoid a bias from wealth effects whilst incentivizing behavior in each round, we informed participants before starting their individual rounds that one round would be randomly selected for payout.

Levels vary in terms of the availability of forecast information and advice. In control rounds (levels 4 and 9), farmers were asked to invest without any forecast information or advisories. In other rounds, we provided a weather forecast, with variation across levels in the likelihood of favorable weather conditions, which we characterize within the game as having substantial rainfall. We either provided a forecast only (levels 1, 3, 5, 6, 10, 11, and 12) or a forecast plus advice on what to do with this forecast (levels 2, 7, and 8). This included one round in which participants received a risk-free weather forecast (level 1); we varied randomly between respondents whether it would certainly rain (100%), or that it would for sure not rain (0%).

In rounds with advice, we provided two types of advice: one for profit-maximizing individuals and one for risk-averse individuals. Respondents could choose to follow either depending on how they perceived their own risk preferences. The profit-maximizing advice recommended the investment that would maximize expected payouts given the forecasted rainfall probability. The risk-averse advice was the investment that would maximize utility for a risk-averse individual.[1] Each piece of advice was a single recommendation, which could either be: do not plant, plant the low-risk variety, plant the medium-risk variety, or plant the high-risk variety. Sometimes the risk averse and profit-maximizing advice was the same.

Table 1: *Description of Experimental Levels*

Level	Forecast	Forecast rainfall probability	Advice	Player
1	X	0% OR 100%		Individual
2	X	20%	X	Individual
3	X	20%		Individual
4				Individual
5	X	40%		Individual
6	X	60%		Individual
7	X	80%	X (Some individuals, randomized)	Individual
8	X	40%	X	Couple
9				Couple
10	X	60%		Couple
11	X	80%		Couple
12	X	40%		Couple

It is important to note that the advice provided to individuals in the round with a forecast rainfall probability of 40% (level 8) may influence decisions in the corresponding round with a 40% rainfall forecast during which couples were asked to make joint decisions (level 12). In another round with individual decision-making, where the rainfall probability was 80% and participants could receive advice (level 7), we varied randomly between couples who would receive the advice: neither the husband nor the wife, only the husband, only the wife, or both. This advice could inform later decisions in rounds with joint decisions, and in particular, the joint round with an 80% forecast of rain (level 11). We will explore this variation in the analyses to shed further insights into bargaining dynamics between husbands and wives.

At the beginning of each round, the farmer received an initial endowment of 100 Zambian kwacha that they could use to invest in maize seeds to be planted on up to 10 fields of their farm. We focused on farmers purchasing only one input, maize seeds, for simplicity. We selected maize because it is a cash crop and a staple food for most Zambian households. In addition, it is sensitive to shifts in temperature and moisture levels

[1] We used a CRRA utility function. To parameterize this utility function, given the lack of studies estimating risk aversion for farmers in Zambia, we used the estimated coefficient of relative risk aversion for farmers in a study in Zimbabwe (Gandelman et al. 2015).

(Kanyanga et al. 2013; Ngoma Hambulo et al. 2021). Participants were given an identical endowment at the beginning of each season, regardless of the earnings in the previous season. Accumulated earnings from previous seasons could not be re-invested in the following seasons. For each field, the farmer had the option to invest in one of three varieties of maize seed (low, medium, or high risk) or not to plant anything. Each variety had an associated price and associated yield amounts in both the substantial rainfall condition and lack of substantial rainfall condition. Any funds not spent on seeds were kept as zero-interest savings.

Figure 1 provides an overview of cost of seeds and yields for the three varieties. The low-risk variety had the lowest price and provided both the lowest average income and the lowest variation in yield outcomes across the two rainfall scenarios. The medium-risk variety cost slightly more, but offered a slightly better yield under favorable rainfall, while the late-maturing variety was the most expensive but had the highest yield potential. In the event where there was no substantial rainfall, all three varieties would yield less revenue than the cost of the seeds, making investment in all three varieties riskier than saving the money. We conceptualized these risks to participants as differences in maturity, with the low-risk variety being early maturing, the medium-risk variety being of standard maturity, and the high-risk variety being late maturing. We helped participants recall the distinction between the varieties by using the same symbols as a local input provider to describe different maturity period lengths: zebra for early-maturing, lion for medium-maturing, and elephant for late-maturing maize varieties.

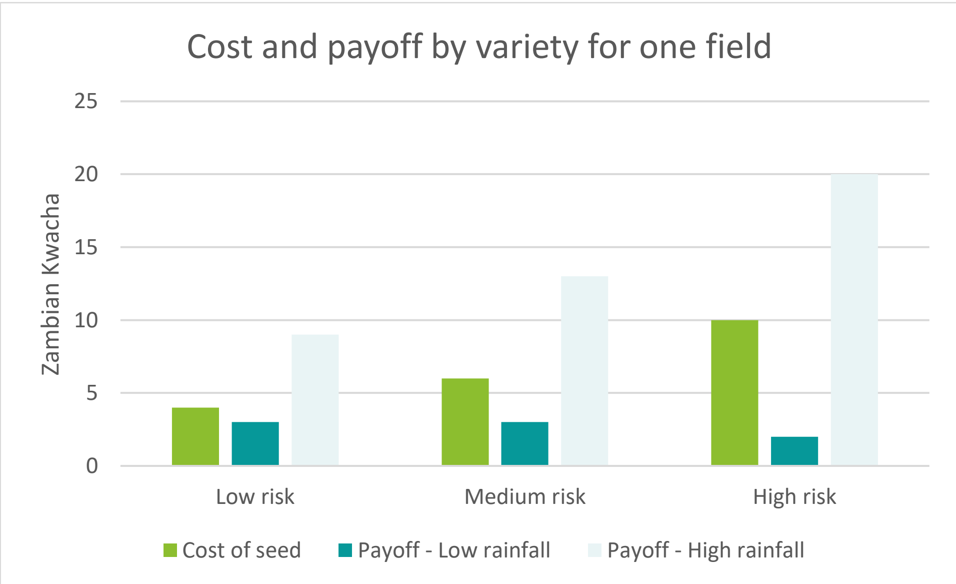

Figure 1: *Experimental prices and payoffs*

At the end of each season, income was determined by two factors: a) the funds saved after purchasing maize seeds and b) the farm's productivity, which depended on the planting decisions and rainfall outcome. Given the costs and productivity associated with investments in each variety, income for individual i from couple c in round r was calculated as:

$\text{Income}_{icr}^{R} \equiv 100 + 5 \times \text{LowRisk}_{icr} + 7 \times \text{MedRisk}_{icr} + 10 \times \text{HighRisk}_{icr}$ if it rains substantially,

$\text{Income}_{icr}^{NR} \equiv 100 - 1 \times \text{LowRisk}_{icr} - 3 \times \text{MedRisk}_{icr} - 8 \times \text{HighRisk}_{icr}$ if it does not rain substantially.

Figure 2 provides an overview of expected payouts for each rainfall probability. Without forecast, risk-averse individuals will want to set money aside in the risk-free savings option, or in the low-risk variety, given that its return varies the least across potential rainfall probabilities. When given a forecast, participants' behavior will depend on the rainfall probability. For low rainfall probabilities, profit-maximizers will want to invest in the low-risk variety. As the rainfall probability increases, investments can shift to the medium-risk variety, and once the rainfall probability is at least 80%, the high-risk variety maximizes profits. However, risk-averse individuals may want to invest relatively more of their endowment in the low-risk and medium-risk variety even when the probability of rainfall is high. In risk-free scenarios, both risk-averse and profit-maximizing individuals should either save their full endowment (0% chance of rainfall) or invest their full endowment in the high-risk variety (100% chance of rainfall).

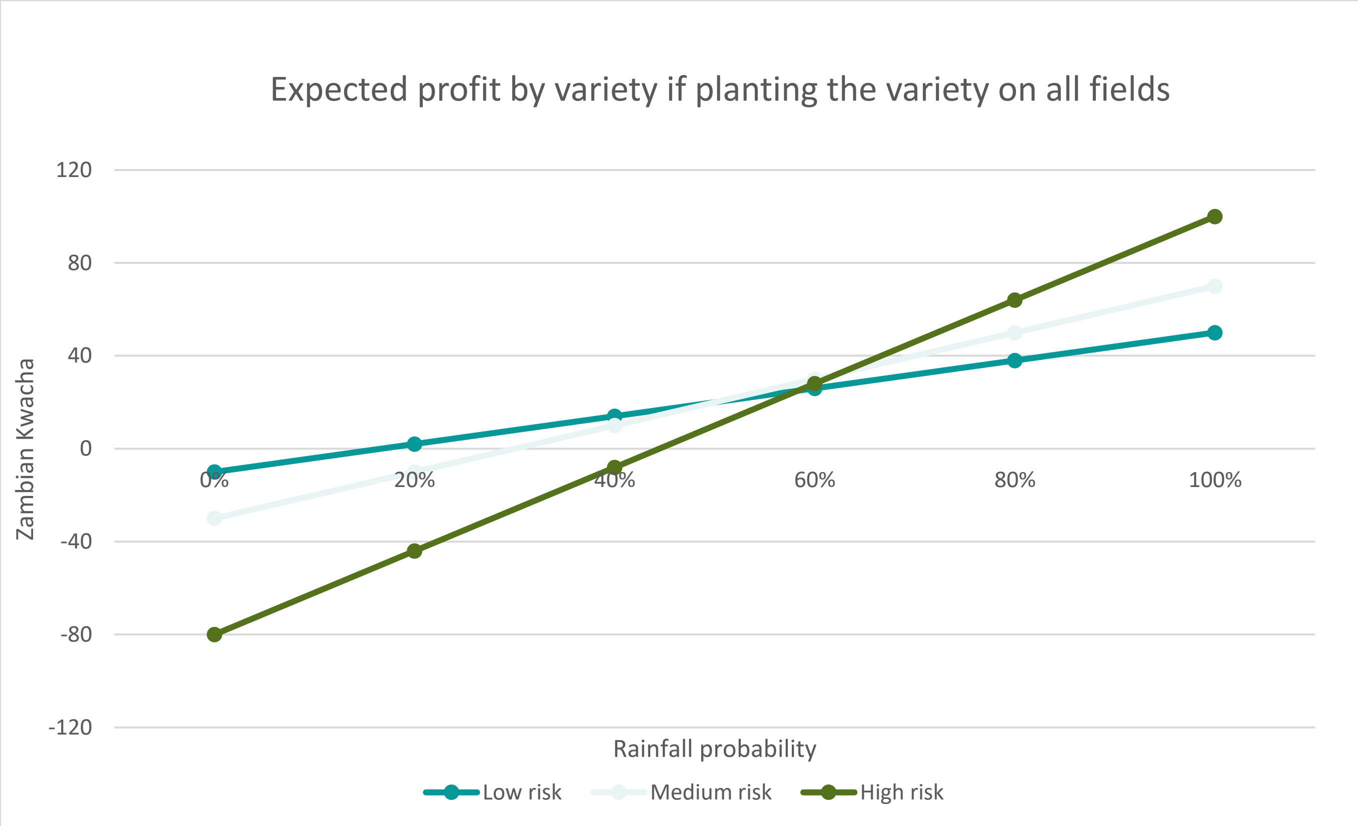

***Figure 2:** Expected profits for experimental varieties*

3.2 Empirical strategy and hypotheses

We are interested both in how climate information influences agricultural investment decisions and welfare-related outcomes, as well as how forecasts and advisories influence bargaining in the household.

Investment decisions

To estimate how climate information influences investments, we first estimate the following equation for decisions made in round $\boldsymbol{r}$ by individual $\boldsymbol{i}$ from couple $\boldsymbol{c}$,

$$Y_{icr} = \alpha_c + \text{Wife}_{icr}\beta_1 + \text{Couple}_{icr}\beta_2 + \text{Prob} \times \text{Forecast}_{icr}\gamma_1 + \text{Prob} \times \text{Advice}_{icr}\gamma_2 + r_{icr} + \varepsilon_{icr} \quad (1)$$

where our outcome variable, Y_{icr}, is the percentage of a decision-maker's endowment allocated to savings, the low-risk variety, the medium-risk variety, or the high-risk variety; α_c is a couple fixed effect to control for unobserved heterogeneity at the household level; Wife_{icr} and Couple_{icr} are dummy variables equal to one for rounds in which decisions are made by the wife alone, or the couple together, respectively (versus decisions made by the husband alone); $\text{Prob} \times \text{Forecast}_{icr}$ is a vector of dummy variables for each possible rainfall probability (0%, 20%, 40%, 60%, 80%, and 100%), equal to one if a forecast was shown with that rainfall probability (with no forecast serving as the omitted category);[2] ProbA_{icr} is a vector of three dummy variables (for rainfall probabilities of 20%, 40% and 80%) indicating whether in addition to a forecast of that rainfall probability, an investment advisory was provided; r_{icr} is a round order effect (with ordering of levels from Table 1 randomized across rounds at the player level), and ε_{icr} is a residual clustered at the couple level. We test the following hypotheses: *Hypothesis 1*: $\beta_1 \neq 0$ for savings and all three varieties. This hypothesis tests whether wives make different investments on average than their husbands. We expect that compared to their husbands, wives allocate more of their initial endowment to savings and the low-risk variety, whilst allocating less to the medium- and high-risk variety. In many settings, women have been found to make more risk-averse agricultural decisions than men (Kebede 2022).

Hypothesis 2: $\beta_2 = 0$ for all outcome variables. This hypothesis implies that couples' savings, as well as investments in the three varieties, do not significantly differ from those made by husbands. If we find that husbands' and wives' decisions are different from one another, then this would imply that husbands have a larger say in household-decision-making, and that a couple's decisions are primarily influenced by—and thus reflect—a husband's preferences.

Hypothesis 3: $\gamma_1 \neq 0$ for savings and investments in the three varieties. We hypothesize that forecasts increase the amount allocated to savings and the low-risk variety (to the medium- and high-risk variety) when the probability of rainfall is low (high). For more risk averse decision-makers, providing a forecast could lead to less risk-averse investments than in the scenario without forecast, and reduce the amount saved compared to that scenario even when the probability of rainfall is 40%.

Hypothesis 4: $\gamma_2 \neq 0$ for all outcome variables. That is, we assume that advisories influence investments, but do not hypothesize in which direction they affect investments, given that decision-makers' response to advisories will depend on their risk aversion and the way in which an advisory for a respondent's self-perceived level of risk aversion differs from investments based on forecasts only.

We also estimate Equation (1) with interactions for whether a decision was made by the wife alone or the couple together, vis-à-vis the type of climate information provided. Specifically, if we define a vector $\text{CIS}_{icr} = \text{Prob} \times \text{Forecast}_{icr} \oplus \text{Prob} \times \text{Advice}_{icr}$, combining the dummy variables for the two types of information (forecast and advisories) included in Equation (1), then we estimate:

$$Y_{icr} = \alpha_c + \text{Wife}_{icr}\beta_1 + \text{Couple}_{icr}\beta_2 + \text{CIS}_{icr}\gamma + \text{Wife}_{icr} \times \text{CIS}_{icr}\theta_1 + \text{Couple}_{icr} \times \text{CIS}_{icr}\theta_2 + r_{icr} + \varepsilon_{icr} \qquad (2)$$

Hypothesis 5: $\theta_1 \neq 0$ ($\theta_2 \neq 0$). Wives (couples) respond to climate information services – forecast and/or advisories – in a different way than husbands playing individually.This final hypothesis considers the effect of CIS on preferences and intrahousehold bargaining outcomes based on the capabilities approach. We assume that decisions made in individual rounds reflect an individual's preferences, but that decisions made in joint rounds will reflect the outcomes of a bargaining process, and that household members with more bargaining power will exert a greater influence on joint decisions. If this is the case, providing forecast information could shift investment decisions to align more closely with the preferences of the person who receives the information, and introducing couples to climate information may positively impact women's bargaining power.

[2] We do not control for the probability of rainfall separately, since without forecast, decision-makers did not know what the probability of rainfall would be. Robustness checks show that in the absence of forecasts, decisions indeed do not respond to variation in the probability of rainfall are available on request.

Welfare effects

We are also interested in welfare effects. We estimate effects on welfare using two approaches. First, defining p_{icr} as the probability of rain, we estimate the following equation for three outcome variables (expected income, the variance of income, and expected utility):[3]

$$Y_{icr} = \alpha_c + \text{Wife}_{icr}\beta_1 + \text{Couple}_{icr}\beta_2 + \text{Forecast}_{icr}\gamma_1 + \text{Advice}_{icr}\gamma_2 + p_{icr} + r_{icr} + \varepsilon_{icr} \quad (3)$$

Hypothesis 1 above would imply that women make more risk-averse investments. This would result in lower incomes and a lower variance of income ($\beta_1 \neq 0$). Hypothesis 2 indicates that couples are not expected to make different decisions from husbands, meaning that we would not expect differences in expected income or the variance of income either (thus we will test $\beta_2 \neq 0$). Hypothesis 3 implies that respondents act on forecasts by reducing investments in riskier high-return assets when the probability of rainfall is low, whilst increasing investments in these assets when it will rain with a higher probability. This will increase not only income, but also the variance of income ($\gamma_1 \neq 0$). To estimate the net welfare effect, we also estimate effects on expected utility. Finally, the effect of advisories on expected income, its variance, and expected utility will depend on how the advice differs from decisions when provided with a forecast. Seeing advice on how to maximize profits may encourage risk-averse respondents to take riskier actions, which will increase their expected income, and its variance. Likewise, exposure to risk-averse advice might lead a respondent who tends to take risks to make decisions that decrease both expected income and its variance. Thus, advisories may have a positive or negative effect ($\gamma_2 \neq 0$).

We also estimate Equation (3) with interactions for the type of CIS provided, and the type of player (wife or couple), so that the coefficients on the main effects of CIS, $\gamma = \gamma_1 \oplus \gamma_2$, provide an estimate of effects for husbands, and coefficients on the interaction terms, θ_1 and θ_2, can be used to determine the additional effects for wives and couples, respectively:

$$Y_{icr} = \alpha_c + \text{Wife}_{icr}\beta_1 + \text{Couple}_{icr}\beta_2 + \text{CIS}_{icr}\gamma + \text{Wife}_{icr} \times \text{CIS}_{icr}\theta_1 + \text{Couple}_{icr} \times \text{CIS}_{icr}\theta_2 + p_{icr} + r_{icr} + \varepsilon_{icr} \quad (4)$$

A second approach to analyze welfare effects is by looking for evidence of utilitarian welfare improvements without making assumptions on the functional form of participants' utility functions. For this, we compare decisions taken (1) when an individual was facing drought with certainty (a 0% rain forecast) versus rounds with risk (a 20%, 40%, 60% or 80% rain forecast) during which it did not rain; and (2) when it would rain with certainty (a 100% rain forecast) versus rounds with risk during which it did rain (but under the scenarios with risk, a respondent would not know yet whether or not it was going to rain). For each round with risk, we calculate the absolute difference between investments made in that round and those made in the one round with certainty. This variable indicates the extent to which respondents, conditional on a given outcome (rain or no rain), do what they would have preferred to do under certainty, if they had known beforehand whether or not it would rain, which (assuming the participant is not risk loving) would have to give them a weakly positive utility increase. For this outcome variable, we expect similar effects, and estimate similar models as Equations (3) and (4), but not including controls for the probability of rainfall or round effects, since these are controlled for in the construction of the dependent variable.

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[3] We use expected income, $\text{E(Income)} = p_{icr}\text{Income}^{R}_{icr} + (1 - p_{icr})\text{Income}^{NR}_{icr}$, with Income^{R}_{icr} representing income when it rains and Income^{NR}_{icr} when it does not rain, to construct the variance of income, $\text{Var}(\text{Income}_{icr}) = p_{icr}\left(\text{Income}^{R}_{icr} - \text{E}(\text{Income}_{icr})\right)^2 + (1 - p_{icr})\left(\text{Income}^{NR}_{icr} - \text{E}(\text{Income}_{icr})\right)^2$. To calculate expected utility, we parameterize the utility function using the natural logarithm of income, which implies a preference structure with constant relative risk aversion, and a degree of risk aversion equal to one, $\rho = 1$, yielding $\text{EU}(\text{Income}_{icr}) = p_{icr}\log(\text{Income}^{R}_{icr}) + (1 - p_{icr})\log(\text{Income}^{NR}_{icr})$.

Bargaining power

A final analysis explores whether forecasts influence the way in which couples make their decisions. For this, we interpret an individual's decision as their preferred allocation, and our dependent variable is the absolute difference between a couple's allocation versus one's individual allocation under similar scenarios, which were repeated for individuals and couples: no forecast, a forecast with a 40% probability of rain, and a forecast with a 60% rainfall probability. We are unable to look at the effects of advisories in this way since there were no individual and couple rounds with advisories for forecasts with similar rainfall probabilities.[4] Our estimating equation for this variable is:

$$\left|Y_{cr}^{H/W} - Y_{cr}^{Couple}\right| = \alpha_c + \text{Wife}_{icr}\beta + \text{Forecast}_{icr}\gamma + \text{Wife}_{icr} \times \text{Forecast}_{icr} + \varepsilon_{icr} \quad (4)$$

Finally, to analyze the effects of advisories on spouses' bargaining power, we use the randomization of couples into one of 4 experimental conditions in the individual round with an 80% rainfall forecast (level 7): neither spouse receives advice; the wife only receives advice; the husband only receives advice; or both spouses receive advice. We analyze effects of these treatments on behavior in a later round with the same 80% forecast probability but no advice, when the couple plays jointly (level 11). To test whether having received additional information provides a spouse with bargaining power in a later decision, we estimate:

$$Y_{cr} = \text{Wife Advice}_{cr}\beta_1 + \text{Husband Advice}_{cr}\beta_2 + \text{Couple Advice}_{cr}\beta_3 + r_{cr} + \varepsilon_{cr}, \quad (5)$$

where dependent variables are savings, spending on the low-, medium-, and high-risk varieties, and income.

3.3 Sampling and Procedures

The experiment was implemented in one camp (a camp is the smallest administrative division that precedes a village and consists of 29 villages, on average) of the Nyimba district. We purposefully identified a camp that was not participating the Strengthening Climate Resilience and Alternative Livelihoods in Agro-Ecological Regions I and II in Zambia (SCRALA) initiative. The camp was also chosen because it straddled two of the country's three agro-ecological regions. It reflected the Eastern province in terms of crop production, availability of climate information, and climatic risk. We collaborated with a local camp officer and a camp agricultural committee to raise awareness about the project, which was presented as a workshop on 20th September 2023. For each of the eight zones within the camp, we randomly selected two villages to conduct the experiment (the two villages in the first zone were used to pilot the experiment. The data from the pilot was used to finalize the research tool and not for the main data analysis. Participants from these two villages registered voluntarily with the camp agricultural committee to participate in the study. Eight couples were then chosen randomly from a list of volunteers, plus an additional couple from each village as a contingency should one of the couples fail to show up. In most sessions, all nine couples attended the workshop on the scheduled date. The extra pair was paid a show-up fee but did not attend the workshops.

Each workshop began with introductions, followed by a group explanation of the investment task, including the design of the planting activity and the concept of rainfall probability. To explain probability, a bag was filled with white and blue balls, and volunteers from the group were asked to select a ball from the bag while

[4] In individual rounds, advisories were provided for forecasts with a 20% and 80% probability of rain, whereas couples were presented with an advisory for a forecast in which the probability of rain was 40% (see Table 1).

blindfolded. Blue balls symbolized high rainfall, while white balls represented low rainfall, and if the bag was filled with a larger number of blue balls, then this meant a greater probability of high rainfall. During the experimental task itself, participants used a tablet application designed specifically to simulate planting crops during an agricultural season. Before starting the first round, the tablet took participants through several practice rounds where they could ask the fieldworkers questions. Echoing the group demonstration, in rounds with forecasts, the app presented rainfall probabilities as five rain clouds that could be shaded blue, or unshaded. More blue clouds suggested a greater chance of high rainfall, while more white clouds represented a higher chance of low rainfall. If advice was also provided in a round, it was on the same screen as the forecast clouds. Participants were made aware that they were not required to follow any recommendations. We also reminded participants that there was no guarantee of rainfall. The seasonal rainfall was only revealed after all investment decisions had been made.

Each couple was assigned to one fieldworker. Couples decided amongst themselves who would start. This person would complete their 7 rounds individually, in the absence of their spouse, who was seated in a separate area. Next, the spouse would complete their 7 individual rounds, again in private, with the other spouse seated elsewhere. After both husband and wife had played individually, the couple was given the tablet to play together to complete their 5 joint rounds. In this joint part of the experiment, a couple could only provide one decision per task. No discussions were allowed among couples waiting for their turn. Fieldworkers facilitated this by determining seating arrangements for participants, including where individuals waiting for their turn would sit, before beginning the workshop in a community. We used identity badges with anonymous session IDs to help fieldworkers correctly pair participants with their spouses, and to enter the correct ID in the tablet application where decisions were recorded.

We chose to implement a framed field experiment to observe behavior under various rainfall probabilities, as well as compare similar decisions made individuals and couples, which may be infeasible in real life. However, there is always the concern that participants may act differently in an artificially constructed setting than they would in real life. To offset this limitation and encourage participants to think seriously about their decisions, we introduced monetary incentives that resembled payments that farmers would receive from maize sales. After completing individual and joint rounds of the experiment, couples rolled a 12-sided die, with the 12 sides corresponding to the 12 rounds of the experiment. The number on which the dice would roll determined for which round participants would be paid their earned income (revenues from maize seeds planted plus savings). If the dice landed on the numbers 1 through 7 (individual rounds), the participants were each notified separately of the amount they would be paid from their respective rounds. If the dice landed on 8 to 12 (the joint rounds), they would both receive the same sum and be notified at the same time (and hence the couple would receive two times that income in total). Critically, levels with various treatment conditions were presented in a randomized order even between husbands and wives, so individual rounds for which participants received payouts may have been different. This gives some "plausible deniability" about earnings, such that a wife may be able to lie to her husband about her individual earnings. In this way, we aimed to give players similar incentives, and reveal individual preferences during the individual rounds, despite any norms which might dictate that wives should surrender any earnings to their husbands.

After the couples' rounds were completed, we also administered individual surveys to each participant, which was completed by 224 of the 228 individuals who participated in the experiment. The survey covered demographics, access to and use of CIS, income sources and household assets, household decision-making, and anticipated seed choice decisions. At the end of the workshop, before earnings were paid out, two feedback sessions (one for men and one for women) were held. We asked participants what they liked and disliked about the experiments, whether they would have benefited from more information before completing the experimental tasks, how the forecasts in the experiment compared to those encountered in real life, and what they would change to make the experiment more realistic.

04. RESULTS

4.1 Sample Composition

To provide information on the population targeted by the experiment, Table 2 describes the composition of married couples within our sample. Households in our sample are highly engaged in agriculture, with production or sale of produced goods being the main source of livelihood for 75 percent of participants. Despite 25 percent of the sample having another main source of livelihood, all households grew white maize in the last season, and the vast majority also grew additional crops, such as groundnut or soya bean. A little over half of agricultural households receive input subsidies through Zambia's Farmer Input Support Program (FISP), and the average household owns about 10 acres of land. Literacy in this population is quite low, given that only 41 percent of respondents have at least a primary school education (grades 1-7). Moreover, around 18 percent of respondents have no schooling at all. Despite this, a relatively high 75 percent of respondents own a smartphone. Additionally, respondents in this context are familiar with CIS. In fact, 89 percent report accessing at least some type of climate information. Among those who do access CIS, 69 percent say their most important source of information is the radio, followed by extension agents for 14 percent.

4.2 Investment Decisions

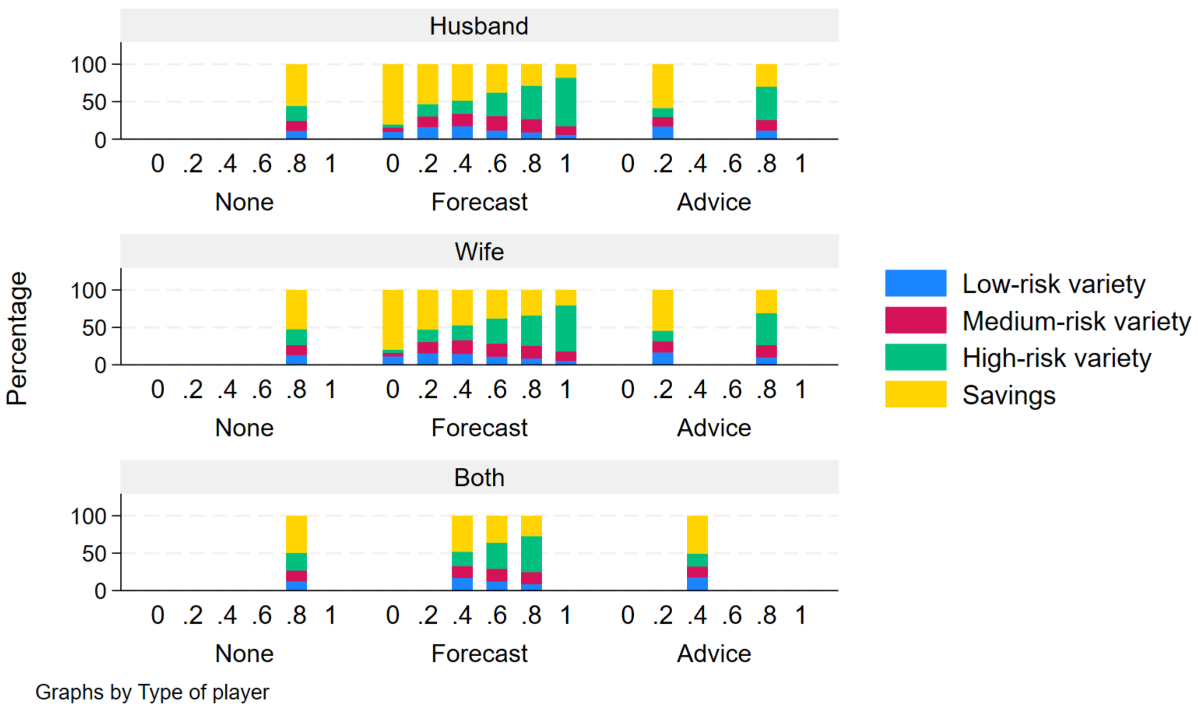

Figure 3: *Investment decisions by husbands, wives, and couples*

We first discuss findings on how individuals' and couples' investment decisions change when they are provided with forecasts and advice, and thereby test our five hypotheses provided in Section 3.2. As a first indication, a summary of husbands' wives, and couples' investment decisions are displayed in Figure 3. Each stacked bar shows the average percentage of the seasonal endowment that is saved and invested in each seed variety, without controlling for any additional variables. A critical thing to note when looking at the results is that given experimental session length limitations, we opted not to include levels with forecasts only, and forecasts plus advice, for all possible probabilities for both individuals and couples. This is why investment decisions are not observed for every rainfall probability in the presence of advice, and in decisions taken jointly by both husband and wife. This figure further shows that both individuals and couples respond to the rainfall probability that is communicated through the forecast, with relatively lower amounts allocated to savings and higher amounts allocated to the high-risk variety as the probability of rainfall increases.

In Table 3, we estimate Equations 1 (odd number columns) and 2 (even number columns, for our four different investment choice indicators: savings and investment in low-, medium-, and high-risk seeds. The table also indicates when a specific effect is only being identified from variation in individual decisions or couple decisions. First, based on Hypotheses 1 and 2, we would expect to observe differences in investments made by wives and husbands, but not in investments made by couples and husbands. Instead, we see visually in Figure 3 as well as in our coefficient estimates that on average, neither wives nor couples save or invest differently than husbands do, which is consistent only with Hypothesis 2. The only notable exception is that when wives are making investment decisions without any forecast information, they spend about 1.8 more kwacha (1.8% of their original endowment) on seeds of the low-risk variety. This effect is reversed by receiving a forecast with a positive chance of rain, as demonstrated by the negative coefficients on the interaction between wife and forecasts. Hence, forecasts may help wives overcome risk-averse behavior associated with not knowing the probability of rain.

Second, consistent with Hypothesis 3, we see that forecasts have a consistently significant impact on investment decisions. Specifically, as is visually evident in Figure 3, the higher the probability of rain forecasted, the more participants invest in the medium- and high- risk varieties, and the less they invest in the low-risk variety and savings. For example, when participants receive a forecast with a 20% chance of substantial rainfall, they spend about 4% more of their original endowment on the low-risk variety, and 5% less on the high-risk variety, compared to when they do not have a forecast. Likewise, when participants receive a forecast with an 80% chance of rain, they save 23% less of their initial endowment, and spend 22% more on the high-risk variety. In contrast to Hypothesis 5, we do not see evidence of couples or wives differentially responding to forecast receipt (except for forecasts mitigating wives' overinvestment in the low-risk variety discussed above).

Third, consistent with Hypothesis 4, we see additional changes in investments when the forecasts are accompanied with advice on how to invest given that forecast. When respondents receive advice along with a forecast of either 20% or 40%, they spend an additional 3-5% of their budget on savings, and 2-5% less on the high-risk variety. They hence respond to the advice for 20% forecasts, which instructed farmers not to plant or to plant the low-risk variety depending on their risk tolerance, and to some extent to the advice for 40% forecasts, which instructed farmers to plant the low-risk variety. The effects of advice for the 20% forecast may be slightly muted given that rounds were presented in a random order, allowing for the possibility that during the round with a 20% forecast and no advice, the participant may have already seen the advice for the 20% forecast. However, when individuals get a forecast of 80% rain (in which the recommendation is to plant the high-risk variety), they do not seem to respond to this. If anything, they plant a bit more of the low-risk variety, and a bit less of the medium-risk variety, than if they did not have this advisory. We do not detect any difference in how wives respond to advice compared to husbands, again in contrast to Hypothesis 5.

There are two additional caveats worth noting in interpreting these results. First, while most of the coefficients are identified from within-respondent variation in behavior between rounds, there is one key exception. The effect of receiving advice for the 80% forecast is identified using between-respondent variation, because we randomized across couples whether the husband, wife, both, or neither received advice (see level 7 in Table 1 and the description in Section 3.1). Second, each respondent played a risk-free round with either a 0% chance or a 100% chance of rain (see level 1 in Table 1), so the variation for each of those coefficients is only being identified using a (randomly selected) subset of the sample.

4.3 Welfare Effects

Given that individuals changed their investments in response to forecast information, the key question is whether this change indeed made participants better off. We explore this question in Table 4, where we estimate Equations 3 (odd number columns) and 4 (even number columns) for various welfare outcomes. For all welfare measures, we generally do not detect a differential effect of forecasts or advice on wives or couples as opposed to husbands. However, it is possible that we are underpowered to detect such effects. Thus, we mostly focus on the odd numbered columns for the sake of interpretation.

Receiving a forecast increases participants' income by 12.5 kwacha on average (column 1), which is about 10% of the average income earned by participants across all rounds, but also increases the variance of this income, by about 66% of the mean income variance in the sample (column 3). Without forecast, participants may not have a good sense of the distribution of rainfall outcomes, and hence may feel uncomfortable taking risks. When provided with forecasts, participants at least know the level of risk, which may encourage them to take at least some risk. Receiving advice in addition to this forecast does not further increase average income, whilst mitigating the effects of receiving a forecast on the variance of income by approximately 13 percent. This is likely because the advice given to respondents causes them to invest more in the low-risk variety regardless of the forecast probability (see Table 3 and Section 4.2).

Assuming a log utility function, we find that forecasts increase participants' expected utility, and this effect is stronger for participants who also receive advice (column 5). This suggests that both forecasts and advice make participants better off, though the marginal utility increase from also receiving advice is only around 33% of the effect of receiving a forecast. Moreover, these effects are both relatively small; the effect of receiving a forecast is about 1.3% of the mean value of expected utility, and adding advice as well only gets this up to about 1.7% of mean utility. Additionally, column 6 suggests that receiving forecasts might be slightly less utility-enhancing for couples than for husbands.[5]

While choosing a utility function makes the issue of looking at changes in utility more tractable, our results may be sensitive to choices of functional form. Hence, we perform an additional test, which requires fewer assumptions about the utility function, whereby we ask whether individuals can act more closely to how they optimally would have acted if they were certain that it would (not) rain given that it did (not) rain. Assuming that individuals are risk neutral or risk averse, and that their preferences are locally smooth, getting closer to this "ideal" behavior under certainty must constitute a welfare improvement. To test whether individuals can act more closely to their preferences without risk, we again estimate Equations (3) and (4), but now restricting observations to include rounds with rainfall risk only and using as outcome variable the absolute difference between investments made in that round, and those made in the one round with certainty. We only use individually made decisions, given that we do not observe couples' decisions in the risk-free scenarios.

Table 5 presents the results for this outcome variable. Controlling for the forecasted probability of rain, both forecasts and additional advice provided along these forecasts allow participants to invest more similarly to how they would have invested without risk, suggesting that they likely experience welfare improvements from both forecasts and the additional advice. Notably, it was important to elicit individuals' behavior in risk-free rounds, since even in these rounds, respondents do not always make profit-maximizing decisions. Indeed, only 52% of players plant nothing when they know it will not rain, and only 29% of players invest their entire budget in the high-risk variety when they know it will rain for sure. Focus group discussions suggest that this may reflect other preferences, such as a preference to always grow something (even if they know they will get a

[5] In terms of robustness, all results in Table 4 remain roughly the same if we 1) control for rainfall probability as a continuous variable instead of indicators, 2) control for whether it rained instead of rainfall probability indicators (except for the utility results), and 3) eliminate risk-free rounds with a 0% or 100% chance of rainfall.

poor harvest) or the preference to have food ready at different times in the season (even though the incentives of the experiment were not designed to promote such behavior). Focus groups also suggest that players may not fully believe the forecasts of 0% and 100% because they do not believe that weather can be known with certainty (even in the context of our experiment). Although this could challenge our interpretation, we see a strong response to the different types of forecasts, lending credence to the idea that households use them to update their beliefs closer to what is suggested by the forecast.

4.4 Bargaining Power

Next, we analyze how intrahousehold dynamics may come into play when interpreting forecasts and advice. Using similar logic to the previous argument about utility improvements, forecasts and advice may help individuals become better off by helping reduce any differences between joint decisions made as a couple and decisions that each spouse would have preferred and made on their own (when they did not have to bargain with someone else). We therefore construct an outcome variable that takes the absolute difference between decisions made as an individual and decisions made as a couple using the rounds without forecast, with a 40% forecast, and a 60% forecast. These are matching forecast probabilities that were used in both individual and couple rounds without advice. Results could be sensitive to the rainfall probabilities used, but having no forecast, a 40% forecast and a 60% forecast does cover a wide range of possible outcomes.

In Table 6, odd-numbered columns estimate a basic model for this outcome variable with couple fixed effects and a dummy variable indicating observations for which the individual decision was made by the wife (with observations for which the individual decision was made by the husband as the omitted category). In even-numbers, we extend this model by estimating Equation 4. Odd-numbered columns document the important finding that relative to husbands' decisions, wives' individual decisions are, on average, further away from how spouses invest as a couple. Compared to the mean deviation in the sample, wives have 24% larger gaps in savings behavior, and 21%, 6%, and 34% larger gaps in spending on the low-, medium-, and high-risk varieties, respectively. This suggests that wives have less bargaining power on average, and that decisions taken jointly as a couple reflect husbands' preferred allocations.

Even-numbered columns show that receiving a forecast can help reduce this gap for both husbands and wives, at least with respect to savings. Over 50% of the 14 Kwacha gap between an individual's savings and couples' savings is mitigated by the couple receiving a forecast. We observe no significant coefficient on the interaction term in column (2), meaning that receiving a forecast reduces gaps between a couple's decisions and decisions made individually for both husbands and wives. This suggests that receiving forecasts helps both spouses agree more on preferred investments. Notably, additional findings (available upon request) show that the average couple takes about 1 minute and 23 seconds to play a round, which is longer than the average individual, who takes about 1 minute and 15 seconds to play a round. Perhaps couples deliberate to some extent before taking a decision, though notably not for that much longer than individuals decide themselves. This difference is also mainly driven by husbands, who take only 1 minute and ten seconds on average to play an individual round, as opposed to wives, who take one minute and 19 seconds on average.

Given the potential of information to increase bargaining power, we also ask whether the effects of giving advice (instead of only a forecast) on joint decisions depend on the recipient of that advice. Specifically, we ask whether advice given to wives only, husbands only, or both spouses earlier in the game might influence couples' decisions in later rounds. We explore this question by estimating Equation 5 in Table 7, focusing on the joint round with an 80% probability forecast. During the individual round with an 80% probability of rain, we randomized who within the couple (if any) would see the advice to invest in the high-risk variety. Given small sample sizes, we may be underpowered to detect effects here. However, we find couples spend about 10% less of their budget on savings and 11% more on the high-risk investment, when only the husband gets advice, compared to when neither spouse gets advice. While the same qualitative pattern follows when wives only get advice or couples both get advice, the magnitudes of the effects are much smaller, and hence the coefficients are insignificant. This suggests that husbands are most effective at wielding additional external information to influence decisions made as a couple.

05. CONCLUSION

Our experiment adds to the growing evidence about the potential for climate information to improve farmers' capacity to respond to climate change. We find evidence that farmers change their investment strategies in response to forecasts. Providing investment advisories alongside a forecast further influences investments, albeit to a lesser extent. This showcases the sheer power of providing farmers with additional information; even without providing farmers with advice, simply informing farmers of the likelihood of different weather outcomes allows them to adjust their investments in order to increase their incomes and overall utility. In this sense, forecast information can empower farmers to make the most informed decisions possible, and use their agency to improve their own livelihoods. Critically, providing climate information at scale is likely less "heavy touch" and much cheaper than other common interventions aimed at changing smallholder farmers' behavior, such as input subsidies, insurance provision, and extensive trainings. Additionally, our study presents some suggestive evidence that providing couples with forecast information might help them agree upon investment decisions. Critically, without forecast information, spouses may each have different underlying beliefs about the probability of favorable weather conditions. Forecasts can help individuals each update their beliefs toward a common value, and which may help them start bargaining from a place of shared understanding.

Critically, traditional cost-benefit analyses of climate information services may miss some of the benefits that we are able to quantify using our experimental approach. Notably, our experimental design allows us to control for variation in the underlying probability of different weather conditions, which can very clearly highlight differences in income from accessing different types of climate information. But beyond, our approach shows how climate information services can help behave in ways that are more similar to how they would have liked to invest, would they have known the ex-post weather realization ex ante. This constitutes key welfare improvements that may not always correspond to an increase in income. Moreover, our approach highlights the possibility of climate information services to help couples align on preferred investment decisions, especially in an environment where women seem to have little intrahousehold bargaining power.

However, at the same time, our results must be interpreted carefully. In addition to the design-related caveat mentioned above that couples and individuals did not receive all combinations of forecasts and advice at every rainfall probability, it is also important to reflect on the external validity. There are many ways in which decisions in our lab-style setting differ from the types of investment decisions farming households must make in real life. For one, real-world production decisions are more complex than the experimental choice of which seed to plant, as farmers optimize their usage of a portfolio of different incomes that may have complementary relationships. Additionally, while forecasts provided in our game were always "correct" in the sense that the probabilities implied by forecasts were the actual probabilities that specific weather conditions would occur, this is often not the case in real life. The underlying "data generating process" of how weather conditions are determined cannot be known, making all forecasts potentially inaccurate. Moreover, farmers may receive climate reports from many sources, of varying degrees of trustworthiness and complexity. Such information may be challenging to evaluate, especially in populations with low literacy levels.

Considering this, a potentially promising avenue for climate information service provision may be through "edutainment" programs, which provide forecast information and advice to farmers in an entertaining and less complex way. For example, the television program "Shamba Shape Up" in Kenya regularly broadcasts simple weather forecasts to farmers, with clear implementable suggestions for how to respond to this weather forecast in terms of farm investment decisions and practices. A similar program called "Munda Make Over" has recently launched in Zambia, and may have a similar potential to provide simple, consistent, and reliable forecasts and advice to farmers. One impediment to this avenue may be low television ownership; only 12.5% of respondents report owning a TV, and of those who access climate information services, only 6.5% report getting any CIS through television. However, as mobile phone proliferation expands throughout Zambia and sub-Saharan Africa, policymakers will have the opportunity to harness the increased capacity for information sharing to empower farmers in improving their own livelihoods.

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TABLES

Table 2: *Description of Sample Composition*

Statistic	Mean	St. Dev.	Median	Min	Max	N
Age	43.0	13.1	42	19	79	220
Respondent is Female	0.50	0.50	1	0	1	224
Years Married	24.1	12.2	24	3	55	219
Number of Children	5.92	2.67	6	0	14	224
Respondent has at least Primary Education	0.41	0.49	0	0	1	224
Agriculture is Main Livelihood Source	0.75	0.43	1	0	1	224
Respondent Grew White Maize Last Season	1.00	0.00	1	1	1	224
Respondent Grew Groundnut Last Season	0.83	0.38	1	0	1	224
Respondent Grew Soya Bean Last Season	0.72	0.45	1	0	1	224
Household Receives FISP Benefits	0.54	0.50	1	0	1	224
Household Land Area (Acres)	10.2	10.2	8	1	79	192
Household Owns a TV	0.13	0.34	0	0	1	224
Individual Owns a Cell Phone	0.75	0.44	1	0	1	224
Individual Accesses CIS	0.89	0.31	1	0	1	224

Table 3: *Impact of Forecasts and Advice on Investment Decisions*

	Savings		Low-risk variety		Medium-risk variety		High-risk variety	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Player: Wife	-0.71	-2.82	-0.45	1.81*	0.53	-0.27	0.63	1.28
	(1.24)	(2.92)	(0.48)	(1.08)	(0.63)	(1.22)	(1.38)	(2.61)
Player: Couple	-1.48	-4.54	0.02	0.91	-1.67	0.11	3.12	3.52
	(2.19)	(3.11)	(0.99)	(1.28)	(1.37)	(1.74)	(2.46)	(2.84)
Forecast: 0% rain	27.53***	25.98***	-1.20	-1.21	-9.05***	-7.89***	-17.28***	-16.88***
(Individuals only)	(2.22)	(3.44)	(1.20)	(1.43)	(1.05)	(1.44)	(2.05)	(2.58)
Forecast: 20% rain	-0.06	-1.94	3.91***	5.09***	0.64	0.49	-4.48***	-3.63*
(Individuals only)	(1.74)	(2.64)	(0.79)	(1.04)	(0.87)	(1.20)	(1.43)	(2.02)
Forecast: 40% rain	-4.31**	-6.67***	4.11***	6.04***	3.25***	3.53***	-3.05**	-2.90
	(1.69)	(2.53)	(0.74)	(0.99)	(0.81)	(1.24)	(1.28)	(1.97)
Forecast: 60% rain	-15.10***	-17.23***	-0.59	0.35	4.30***	5.93***	11.39***	10.95***
	(1.79)	(2.76)	(0.61)	(0.87)	(0.70)	(1.26)	(1.65)	(2.52)

Forecast: 80% rain	-22.69***	-27.02***	-3.37***	-2.26**	3.28***	3.97**	22.77***	25.31***
	(2.11)	(3.54)	(0.74)	(1.13)	(0.98)	(1.84)	(1.97)	(3.65)
Forecast: 100% rain	-34.71***	-38.00***	-6.80***	-5.55***	-1.94	-2.00	43.46***	45.55***
(Individuals only)	(2.99)	(3.92)	(0.83)	(1.02)	(1.20)	(1.71)	(3.34)	(4.52)
Advice: 20% rain	3.21**	5.00***	0.90	0.78	-1.23	-1.42	-2.87**	-4.36**
(Individuals only)	(1.31)	(1.80)	(0.72)	(1.08)	(0.81)	(1.13)	(1.41)	(1.67)
Advice: 40% rain	4.31***	2.57*	1.14	0.79	-1.96**	-1.40	-3.49*	-1.97
(Couples only)	(1.44)	(1.48)	(0.77)	(0.81)	(0.84)	(0.88)	(1.78)	(1.82)
Advice: 80% rain	0.02	2.36	1.88**	2.99*	-2.57*	-3.35	0.67	-2.00
(Individuals only)	(2.04)	(3.34)	(0.88)	(1.60)	(1.33)	(2.28)	(2.59)	(4.69)
Wife x 0% Forecast		1.92		-0.05		-0.91		-0.96
		(4.76)		(2.15)		(2.02)		(3.15)
Wife x 20% Forecast		2.44		-2.50*		1.75		-1.68
		(3.06)		(1.46)		(1.51)		(2.78)
Wife x 40% Forecast		1.64		-4.37***		1.47		1.26
		(3.31)		(1.50)		(1.65)		(3.15)
Wife x 60% Forecast		2.52		-2.23*		-1.29		1.00
		(3.28)		(1.28)		(1.80)		(3.62)
Wife x 80% Forecast		9.02**		-1.57		0.85		-8.30
		(4.18)		(1.71)		(2.39)		(5.01)
Wife x 100% Forecast		5.16		-2.72*		1.59		-4.03
		(3.82)		(1.38)		(2.15)		(4.95)
Wife x 20% Advice		-3.57		0.24		0.37		2.96
		(2.56)		(1.45)		(1.71)		(2.39)
Wife x 80% Advice		-6.38		-3.05		0.75		8.67
		(4.46)		(2.23)		(2.74)		(6.26)
Couple x 40% Forecast		5.41*		-1.44		-2.29		-1.68
		(2.83)		(1.12)		(1.64)		(2.79)
Couple x 60% Forecast		3.84		-0.61		-3.58**		0.35
		(2.63)		(1.21)		(1.63)		(2.84)
Couple x 80% Forecast		4.82		-1.33		-2.52		-0.97
		(3.03)		(1.10)		(1.76)		(3.38)
Round and couple effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2128	2128	2128	2128	2128	2128	2128	2128
Mean Dep Var	45.82	45.82	12.93	12.93	15.05	15.05	26.20	26.20

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: *Impact of Forecasts and Advice on Welfare Indicators*

	Income		Variance of income		Expected utility	
	(1)	(2)	(3)	(4)	(5)	(6)
Player: Wife	0.32	6.18	45.94	80.77	-0.01	0.02
	(2.07)	(5.96)	(65.83)	(123.23)	(0.01)	(0.01)
Player: Couple	10.66	14.79*	198.40	245.41*	-0.00	0.03
	(6.55)	(8.00)	(136.31)	(146.97)	(0.02)	(0.02)
Forecast: Yes	12.52***	15.92***	1171.05***	1199.94***	0.06***	0.07***
	(3.85)	(5.62)	(91.79)	(122.34)	(0.01)	(0.01)
Advice: Yes	-0.58	-0.84	-154.51***	-175.00**	0.02***	0.03***
	(2.69)	(4.11)	(53.50)	(85.17)	(0.01)	(0.01)
Wife x Forecast		-8.05		-67.69		-0.03
		(6.25)		(125.56)		(0.02)
Wife x Advice		4.92		109.16		-0.02
		(5.60)		(102.94)		(0.01)
Couple x Forecast		-4.34		-52.92		-0.03**
		(6.52)		(111.09)		(0.01)
Couple x Advice		-4.82		-57.44		-0.02
		(6.40)		(133.45)		(0.01)
Round effects	Yes	Yes	Yes	Yes	Yes	Yes
P(Rainfall) Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Round effects	Yes	Yes	Yes	Yes	Yes	Yes
Couple effects	Yes	Yes	Yes	Yes	Yes	Yes
P(Rainfall) Indicators	Yes	Yes	Yes	Yes	Yes	Yes
N	2128	2128	2128	2128	2128	2128
Mean Dep Var.	121.2	121.2	1753.9	1753.9	4.70	4.70

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: *Impact of Forecasts and Advice on Distance to Optimal Behavior Under Certainty*

	Absolute difference in decisions made during rounds with and without risk							
	Savings		Low-risk variety		Medium-risk variety		High-risk variety	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Player: Wife	3.42	1.09	0.88	2.70*	2.00*	-0.06	2.62	3.26
	(1.29)	(0.26)	(1.17)	(1.85)	(1.92)	(-0.04)	(1.04)	(0.78)
Forecast: Yes	-4.31*	-6.19*	1.43*	2.44**	3.01***	1.70	-4.96**	-5.45*
	(-1.67)	(-1.78)	(1.78)	(2.23)	(3.56)	(1.53)	(-2.37)	(-1.92)
Advice: Yes	-3.72**	-1.27	-0.82	-0.52	-3.06***	-2.59*	-4.18**	-0.05
	(-2.22)	(-0.49)	(-1.07)	(-0.42)	(-3.06)	(-1.73)	(-2.22)	(-0.02)
Wife x Forecast		4.08		-2.08		2.76*		1.26
		(0.96)		(-1.22)		(1.75)		(0.35)
Wife x Advice		-4.52		-0.46		-0.94		-7.45*
		(-1.22)		(-0.30)		(-0.57)		(-1.87)
Couple Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	700	700	700	700	700	700	700	700
Mean Dep Var	27.42	27.42	8.95	8.95	9.72	9.72	27.21	27.21

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: *Impact of Forecasts and Advice on Gap Between Individuals' and Couples' Behavior*

	Absolute difference in decisions made individually versus jointly							
	Savings		Low-risk variety		Medium-risk variety		High-risk variety	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Player: Wife	3.57***	2.80	1.32***	1.14	1.16*	0.54	5.65***	3.12
	(3.09)	(1.13)	(2.81)	(1.31)	(1.91)	(0.50)	(4.53)	(1.51)
Forecast: Yes		-7.50***		-0.02		-0.91		-3.04
		(-3.93)		(-0.03)		(-0.90)		(-1.56)
Wife x Forecast		1.14		0.27		0.94		3.79
		(0.45)		(0.28)		(0.72)		(1.53)
Couple Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	672	672	672	672	672	672	672	672
Mean Dep Var	14.32	14.32	6.22	6.22	8.28	8.28	16.79	16.79

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 7: *Impact of Advice Recipient Identity on Later Joint Investment Decisions*

	Savings	Low-risk variety	Medium-risk variety	High-risk variety	Income
	(1)	(2)	(3)	(4)	(5)
Advice: Wife Only	-4.73	0.23	0.99	3.50	1.27
	(3.89)	(1.44)	(2.52)	(6.01)	(14.03)
Advice: Husband Only	-10.15**	-1.83	0.76	11.22*	13.48
	(3.92)	(1.45)	(2.54)	(6.05)	(14.13)
Advice: Both	-2.21	-1.17	-1.02	4.39	10.43
	(3.86)	(1.43)	(2.50)	(5.96)	(13.92)
Round effects	Yes	Yes	Yes	Yes	Yes
N	112	112	112	112	112
Mean Dep. Var	27.27	8.64	16.23	47.86	154.17

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

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