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Yonas Alem
Jonathan Colmer

Consumption Smoothing and the Welfare Cost of Uncertainty

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Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, e-mail: W.Leininger@tu-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Roland Döhrn, Prof. Dr. Manuel Frondel, Prof. Dr. Jochen Kluve
RWI, Phone: +49 (0) 201/81 49-213, e-mail: presse@rwi-essen.de

Editorial Office

Sabine Weiler
RWI, Phone: +49 (0) 201/81 49-213, e-mail: sabine.weiler@rwi-essen.de

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Yonas Alem and Jonathan Colmer[1]

Consumption Smoothing and the Welfare Cost of Uncertainty

Abstract

Separating the effects of uncertainty from realised events, and identifying the welfare effects of uncertainty, present a number of empirical challenges. Combining individual-level panel data from rural Ethiopia with high-resolution meteorological data, we introduce a new proxy for income uncertainty – mean-preserving rainfall variability – and estimate that an increase in income uncertainty is associated with reductions in objective consumption and subjective well-being (SWB). Furthermore, 86% of the effect on SWB is attributed to the direct effects of uncertainty, consistent with a model of optimal expectations (Brunnermeier and Parker, 2005). In addition, we find that farmers in more uncertain environments are more resilient to realised rainfall shocks, consistent with a trade-off between optimism about the future and risk-management investments today. These findings suggest that the gains from further consumption smoothing are likely greater than estimates based solely on realised consumption fluctuations.

JEL Classification: I131, O13, Q12, Q56

Keywords: Income uncertainty; consumption smoothing; subjective well-being; rainfall variability

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1 Yonas Alem, University of Gothenburg, Sweden, e-mail: yonas.alem@economics.gu.se; Jonathan Colmer, University of Virginia, USA, e-mail: jonathan.colmer@virginia.edu (corresponding author). *– We thank without implicating Philippe Aghion, Allen Blackman, Jeffery Bookwalter, Gharad Bryan, Robin Burgess, Naomi Colmer, Douglas Dalenberg, Jan-Emmanuel De Neve, Paul Dolan, John Feddersen, Michael Greenstone, Greer Gosnell, Cameron Hepburn, Derek Kellenberg, Richard Layard, Peter Martinsson, Kyle Meng, Robert Metcalfe, Katrin Millock, Eric Neumayer, Jonathan Parker, Nick Powdthavee, John Van Reenen, Hendrik Wolff and seminar participants from multiple talks and conferences for helpful thoughts, comments and discussions. We are grateful to the Swedish International Development Agency (Sida) through the Environment for Development Initiative (EfD) at the University of Gothenburg, the Gothenburg Centre for Globalisation and Development, the Swedish Research Council Formas through the Human Cooperation to Manage Natural Resources (COMMONS) programme, the ESRC Centre for Climate Change Economics and Policy, and the Grantham Foundation for financial support. Part of this research was done while Alem was a Visiting Scholar at the University of California Berkeley. All errors and omissions are our own.*

1 Introduction

Economists have long recognised that an individual's sense of well-being depends not only on their average income or expenditures, but on the risk they face as well. In the presence of insurance and credit market failures, households are exposed to consumption risk and must rely on imperfect risk-sharing mechanisms. Consequently, welfare gains exist from further consumption smoothing (Paxson, 1992; Townsend, 1994; Udry, 1994; Morduch, 1995; Fafchamps and Lund, 2003; Jayachandran, 2006; Suri, 2011; Porter, 2012; Morten, 2013; Bryan et al., 2014; Dercon and Porter, 2014; Kinnan, 2017). However, these gains may be underestimated when focussing solely on the *ex post* consequences of realised income shocks.

This paper aims to understand the empirical relevance of *ex ante* income uncertainty on household welfare in rural Ethiopia – one of the least developed countries in Africa, characterised by its high vulnerability to inclement weather. Increased uncertainty about future income should affect individual well-being indirectly through the decisions that households make to smooth consumption. However, uncertainty about future income may also have a direct effect on individual well-being. While a large literature has examined the effects of realised income shocks, there has been very little examination of *ex ante* considerations.

Whether uncertainty about the future has a direct effect on well-being is ambiguous. The degree to which it does relates to the concept of anticipatory utility. Anticipatory utility has been a widely debated subject in academic and policy circles dating back to the time of Hume (1711–1776), Bentham (1789), Marshall (1891) and Jevons (1905). In "Principles of Economics", Marshall writes,

> *"...when calculating the rate at which a future benefit is discounted, we must be careful to make allowance for the pleasures of expectation."* (Marshall, 1891, p.178).

The other side of the coin is that future losses are also incorporated into utility. More recently, work in behavioural economics has explored the importance of anticipatory utility on decision-making (Lowenstein, 1987; Geanakoplos et al., 1989; Caplin and Leahy, 2001; Yariv, 2001; Brunnermeier and Parker, 2005; Brunnermeier et al., 2017).

One way in which anticipatory utility can have a direct effect on utility is if agents have distorted beliefs. A related literature has consistently documented that individuals perform poorly in assessing probabilities and overestimate the likelihood of success as a result of distorted beliefs (Weinstein, 1980; Alpert and Raiffa, 1982; Buehler et al., 1994; Rabin and Schrag, 1999; Brunnermeier and Parker, 2005; Brunnermeier et al., 2017). In the presence of partial insurance, theory suggests that uncertainty relating to future income will have an additional direct impact on welfare, beyond the *ex post* realisation of income shocks.

We present a simple model based on Brunnermeier and Parker (2005), which shows how expected future utility, or anticipated utility, can have a direct, contemporaneous effect on utility if farmers face imperfect insurance and have imperfect information about the probability that a future income shock is realised. This forecasting error, arising from imperfect information, creates a wedge between an individual's subjective probability and the objective probability of an income shock being realised, such that individuals underestimate the likelihood of a bad outcome. In this model, forward-looking farmers who care about expected future utility will make investments to maximise future utility, which may indirectly affect contemporaneous utility; however, these same farmers will also have higher contemporaneous utility if they are optimistic about the future (anticipatory utility), introducing a trade-off between risk management investments and the benefits of optimism. An increase in uncertainty about future income makes farmers less optimistic about the future. Consequently, in the presence of imperfect insurance, the model predicts that an increase in uncertainty will reduce well-being. Furthermore, farmers who are less optimistic will engage in more defensive investments to mitigate the impact of future income shocks.[1]

However, while the theoretical predictions of uncertainty are clear, measuring and identifying the effects of income uncertainty on individual well-being poses a significant empirical challenge. We seek to make progress in addressing this challenge, presenting a novel approach to measuring and identifying the effects of income uncertainty in village economies.

First, the empirical measurement of uncertainty is challenging because it is not directly observed by the econometrician. For this reason, it should be clear that there is no perfect measure. However, the literature to date, focussing largely on macroeconomic outcomes in developed countries, has produced a broad range of proxies, such as the volatility of the stock market or GDP. These measures are supported as reasonable proxies for uncertainty because when a data series becomes more volatile it is harder to forecast (Ramey and Ramey, 1995; Koren and Tenreyro, 2007; Bloom, 2009; Carriere-Swallow and Céspedes, 2013; Bloom, 2014). However, risk and uncertainty is pervasive in developing countries and affects decision-making and welfare at the individual level as well as the macroeconomic level. Accordingly, we introduce a new proxy for uncertainty – rainfall variability – that is suited to understanding the consequences of uncertainty on individual welfare in agrarian societies.

An additional challenge that arises when moving from the macroeconomic level to the microeconomic level is calculating the effects of uncertainty on individual welfare. The past

[1]An attractive feature of this framework is that it tends towards a model of rational expectations as an individual's subjective probability tends towards the objective probability. In this instance, expectations about the future no longer enter directly into current utility and income uncertainty only affects utility indirectly through the actions that farmers take to manage this uncertainty.

couple of decades has seen rapid growth in research on, and policy interest in, subjective well-being. In addition to "objective" measures of welfare, such as income and consumption, subjective measures of welfare are increasingly being used to elicit measures of experienced utility (Kahneman et al., 1997; Frey and Stutzer, 2002; Layard, 2005; Kahneman and Krueger, 2006; Dolan and Kahneman, 2008; Benjamin et al., 2012; Aghion et al., 2015; De Neve et al., 2015) to value non-market goods (Welsch, 2002, 2006; Rehdanz and Maddison, 2011; Carroll et al., 2009; Frey et al., 2010; Levinson, 2012; Feddersen et al., 2015; Baylis, 2016) and to evaluate government policy (Gruber and Mullainathan, 2005; Diener et al., 2009; Dolan et al., 2011; Levinson, 2013). Well-being is a broad measure of welfare that encompasses all aspects of the human experience. Researchers in this expanding field of economics use subjective measures of well-being to analyse and evaluate the impact of economic and non-economic factors on people's experienced utility.

Using panel data on smallholder farmers from rural Ethiopia combined with high-resolution meteorological data, we exploit plausibly exogenous variation in mean-preserving rainfall variability (the second moment of the rainfall distribution) after controlling for contemporaneous and historical rainfall shocks (the first moment) to measure and identify the effects of income uncertainty on individual well-being.

We begin by providing supporting evidence for the premise that rainfall variability is a reasonable proxy for income uncertainty. First, we show that historical rainfall variability has no effect on contemporaneous agricultural production. While this is compelling, it is not sufficient to identify the effects of uncertainty. A fundamental issue when thinking about income in rural settings is that, while yields and income are correlated, prices and wages may also be affected (Foster and Rosenzweig, 2004; Jayachandran, 2006; Colmer, 2017; Kaur, 2017). If the value of production changes, households may experience changes in cost through wages. Thus, income may be affected by rainfall variability even if yields are unaffected. We find that there is no change in the share of agricultural output that households sell, allowing for extensive margin and intensive margin adjustments. Importantly, this suggests that households aren't responding to any price changes. Second, we estimate that there is no change in the price that households receive, conditional on selling at least part of their production. Third, we find no effects of rainfall variability on the number of crops planted or the share of the main crop planted. Fourth, we find no effects of rainfall variability on the average day wage that hired workers receive, the number of workers hired, or whether any workers are hired on the farm, suggesting that there is little change in labour costs for farmers. Fifth, we explore the effects of rainfall variability on non-crop related income channels. We find no effects on the number of livestock owned, nor any effects on whether the household slaughtered or sold any livestock, an important asset. Furthermore, there are no effects of rainfall variability on the likelihood that household members are engaged in off-farm work, or have engaged in work outside of the village, either through migration or commuting. Nor are there any effects of rainfall variability on the number of off-farm work days that parents engage in – an intensive margin response. Collectively, these findings support the premise that rainfall variability has no direct effect on agricultural markets or income.

Finally, we explore the direct effects of rainfall variability on past, contemporaneous and future rainfall realisations, exploring the mean-preserving properties of rainfall variability. This is important as it allows us to directly assess the degree to which rainfall variability may be capturing any residual variation associated with contemporaneous rainfall shocks. In addition, it allows us to explore the degree to which historical rainfall shocks could have affected income in the past, resulting in persistent income effects, affecting households at the time of the survey. We show that rainfall variability is uncorrelated with historical and contemporaneous rainfall realisations. We also explore the effects of rainfall variability on future rainfall realisations, to account for concerns that rainfall variability may provide a signal about future rainfall realisations that could be incorporated into farmers' expectations at the time of the survey. If so, rainfall variability may not reflect uncertainty about future states of the world, but rather expectations about future income realisations. Again, we show that rainfall variability is not correlated with future rainfall realisations. Although one can never rule out the presence of any residual income effects, the collective evidence from these exercises suggest that rainfall variability, in this context, can act as a reasonable proxy for income uncertainty.[2]

In the main empirical exercise we explore the empirical relevance of income uncertainty on individual well-being, looking at the effects of rainfall variability on "objective" consumption and subjective well-being.

First, we document that an increase in interannual rainfall variability has a negative effect on objective realised consumption, suggesting that households are responsive to increased income uncertainty, consistent with a precautionary savings response. However, we also find significant effects of rainfall variability on life satisfaction – a more evaluative measure of subjective well-being. We estimate that rainfall variability on life satisfaction has a direct effect above and beyond the effects on realised consumption. A simple decomposition exercise suggests that the direct effect accounts for 86% of the total effect on life satisfaction. The remaining 14% is captured by the effect of uncertainty, mediated through consumption – the indirect effect. Interestingly, we find more limited effects on happiness – a more

[2]The validity of these arguments should be evaluated on a case-by-case basis if applied in alternative contexts.

contemporaneous measure of subjective well-being.

To provide further support for our interpretation of the results, we show that household membership in the dominant risk-sharing mechanism in Ethiopia, Eqqub – a voluntary association that regularly pools funds and rotates payments among its members – offsets the effects of rainfall variability on life satisfaction. In further support of an "income uncertainty" interpretation of results, we show that Eqqub membership does not offset the consumption effects. Indeed, we see that eqqub membership slightly exacerbates the consumption effects. If the estimated effects were due to realised income shocks then we would expect that the consumption reductions would also be offset by Eqqub membership. In contrast, our findings suggest that households save more through eqqub when there is greater uncertainty. These results highlight the relevance of anticipatory utility on individual welfare, suggesting that the returns to further consumption smoothing and the welfare gains associated with managing both short-run weather events and long-run environmental change are likely to be substantially greater than estimates based solely on realised changes.

In light of the relevance of anticipatory utility for individual welfare, we also examine the trade-off between risk management investments and optimism. Our main results suggest that increased uncertainty reduces well-being, consistent with the premise that in more uncertain environments, farmers are less optimistic about the future. However, the model predicts that these same farmers are more likely to engage in risk-management strategies. Consequently, we may expect that realised income shocks are likely to have a greater effect on consumption in areas that are, on average, less uncertain, capturing the trade-off between risk-management and the utility benefits of optimism. Consistent with this hypothesis we estimate that households in more uncertain environments are less sensitive to realised rainfall shocks.

Collectively, our findings suggest three things. First, the returns to further consumption smoothing are likely to be substantially greater than estimates based solely on consumption fluctuations and realised shocks. Second, when evaluating the consequences of change in the natural or economic environment, it is important to understand how expectations about future states of the world affect economic behavior, as well as the consequences of realised change. Finally, the inclusion of subjective welfare measures, alongside objective measures, may be useful in helping researchers and policymakers to understand the economic lives of the poor and evaluate broader welfare effects associated with policy interventions, important for cost-benefit analysis.

The remainder of the paper is structured as follows: section 2 presents a simple theoretical framework, based on Brunnermeier and Parker (2005); section 3 presents the data and economic context; section 4 provides supporting evidence for the premise that rainfall variability is a suitable proxy for income uncertainty; section 5 presents the identification strategy and main empirical specification; section 6 discusses our results; the final section concludes.

2 Theoretical Motivation

In this section we present a model, based on the optimal expectations framework by Brunnermeier and Parker (2005), in which beliefs about future states of the world can enter directly into the current utility function; that is, agents care about both current utility and expected future utility. While all forward-looking agents who care about expected future utility will make investments to maximise future utility, if an agent's subjective probability about a future utility shock differs from the true probability, then their beliefs about the future will affect utility today. For example, agents will have higher current utility if they are optimistic about the future; i.e., their subjective probability about a bad outcome is lower than the true probability.

2.1 Utility Maximisation Given Beliefs

Consider a world in which uncertainty about future income can be described as a binary state $s_t \in \{0, 1\}$, where $s_t = 1$ indicates that the farmer is going to experience a negative income shock and $s_t = 0$ indicates that he will not. Let $p(s_t|\underline{s}_{t-1})$ denote the true probability that state $s_t \in \{0, 1\}$ is realised following state history $\underline{s}_{t-1} = (s_1, s_2, \ldots, s_{t-1}) \in \{0, 1\}$. We depart from the standard neoclassical model in so far as agents are endowed with subjective probabilities that may not coincide with the true state. These subjective probabilities are relevant for the decision making of the agent. Conditional and unconditional subjective probabilities are denoted $\hat{p}(s_t|\underline{s}_{t-1})$ and $\hat{p}(s_t)$ respectively.

At time t, the farmer chooses consumption, c_t to maximise the present discounted value of expected utility from consumption.

$$\hat{\mathbb{E}}[U(c_1, c_2, \ldots, c_T|\underline{s}_t] \tag{1}$$

where $U(\cdot)$ is strictly increasing and strictly quasi-concave, and $\hat{\mathbb{E}}$ is the subjective expectations operator associated with $\hat{p}$, which depends on the information available to farmer i at time t.

The farmer chooses the optimal level of consumption in each period subject to his budget constraint:

$$x_{t+1} = f(x_t, c_t, s_{t+1}), \tag{2}$$

$$g(x_{T+1}) \geq 0 \text{ given } x_0 \tag{3}$$

where $f(\cdot)$ provides the evolution of the state variable, which is continuous and differentiable in x and c, and $g(\cdot)$ gives the endpoint condition. x_0 is the initial level of available resources. The optimal control variable (consumption) and induced state variable (available resource) are denoted by $c^*(\underline{\mathrm{s}}_t, \hat{p})$ and $x^*(\underline{\mathrm{s}}_t, \hat{p})$ respectively.

When the subjective probability of an income shock does not coincide with the true probability, the present discounted value of expected flow utilities of the farmer, $\hat{\mathbb{E}}[U(\cdot)|\underline{\mathrm{s}}_t]$, depends on expected future utility or anticipated utility, such that the subjective conditional belief has a direct impact. To clarify this further, consider the standard model with time-separable utility flows and exponential discounting. In this case, utility at time t,

$$\hat{\mathbb{E}}[U(\underline{\mathrm{c}}_{t-1}, c_1, c_2, \ldots, c_T|\underline{\mathrm{s}}_t] = \beta^{t-1}\left(\sum_{\tau=1}^{t-1}\beta^{-\tau}u(c_{t-\tau}) + u(c_t) + \hat{\mathbb{E}}\left[\sum_{\tau=1}^{T-t}\beta^{\tau}u(c_{t+\tau})|\underline{\mathrm{s}}_t\right]\right) \tag{4}$$

is the sum of utility from consumption in the past (memory utility), utility from contemporaneous consumption, and utility from expected future consumption (anticipatory utility).

2.2 Optimal Beliefs and Well-Being

The subjective beliefs of farmers are a complete set of conditional probabilities following any history of events, $\hat{p}(s_t|\underline{\mathrm{s}}_{t-1})$; that is, the subjective probability that a shock will occur in the future depends on the history of shocks in the past. In this way, farmers in locations that have experienced more shocks in the past may believe that they are more likely to experience a shock in the future.

Following Brunnermeier and Parker (2005) we define optimal expectations as follows, subject to several assumptions that we report in appendix B.

Definition 1 *Optimal expectations (OE) are a set of subjective probabilities* $\hat{p}^{OE}(s_t|\underline{s}_{t-1})$ *that maximise lifetime well-being*

$$\mathcal{W} := \mathbb{E}\left[\frac{1}{T}\sum_{t=1}^{T}\hat{\mathbb{E}}[U(c_1^*, \ldots, c_T^*|\underline{s}_t)]\right] \tag{5}$$

If farmers have rational expectations, (i.e, $\hat{p}(s_t|\underline{\mathrm{s}}_{t-1}) = p(s_t|\underline{\mathrm{s}}_{t-1})$) then the well-being and utility derived from the actions that farmers take will coincide. In this case, utility at time

t only depends on present consumption (i.e., current utility) and anticipatory utility does not enter into the utility function. This could be the case, for example, if an exact weather forecast or actuarially fair insurance is both available and effective. However, if subjective probabilities differ from the true probability that a shock will occur, then there will be a wedge between well-being and the farmer's utility, in this case memory utility (captured by historical income shocks), and anticipatory utility (captured by expectations about future income shocks) will enter into the utility function as in equation 4 and 6.

2.3 From Theory to Empirics

Within the context of our empirical setting we posit that if subjective probabilities deviate from objective probabilities then increases in future income uncertainty will be associated with lower contemporaneous utility. The qualitative sign of this prediction holds under the premise that higher uncertainty leads individuals to be less optimistic about the future. It may be that individuals believe that increased rainfall variability implies a higher likelihood of a negative rainfall realisation; however, it is important to note that this doesn't need to be the case in practice. Indeed, below we demonstrate that rainfall variability is mean-preserving, i.e., increases in rainfall variability are unassociated with rainfall realisations.

In addition to having lower contemporaneous utility, we also expect a reduction in consumption due to precautionary saving motives. However, this prediction would still hold under a rational expectations framework. The difference between the rational expectations and optimal expectations framework arises from the fact that anticipatory and memory utility enter affect contemporaneous well-being. If this is the case then there should be an effect of rainfall variability on well-being above and beyond the effects through precautionary saving. Within a rational expectations framework rainfall variability should only have an indirect effect on well-being – contemporaneous consumption should mediate the effects of rainfall variability on well-being.

Finally, we posit that in areas with greater uncertainty the realisation of rainfall shocks should have a smaller effect on consumption and utility due to greater investments in risk management. This is consistent with the trade-off between optimism today and income realisations in the future. If individuals are more optimistic about the future when there is less uncertainty they will underinvest in risk management strategies and/or precautionary savings.

With this in mind, the empirical objective of the paper is to explore the empirical relevance of income uncertainty and in doing so provide indirect evidence on the relevance of anticipatory utility. To do this we directly explore the testable implications of the theory in our empirical context.

3 Data

The analysis conducted in this paper uses household survey data from rural Ethiopia. We use two rounds of a panel data set – the Ethiopian Rural Household Survey (ERHS) – that covers households from 15 villages in rural Ethiopia. The ERHS was conducted by Addis Ababa University in collabouration with the Centre for the Study of African Economies (CSAE) at the University of Oxford and the International Food Policy Research Institute (IFPRI) in seven rounds between 1989 and 2009. Households from six villages affected by drought in central and southern Ethiopia were surveyed for the first time in 1989. In 1994 the sample was expanded to cover 15 villages across the major regions of Ethiopia (Tigray, Amhara, Oromia, and Southern Nations Nationalities and People's Region), representing 1,477 households. Further rounds were completed in 1995, 1997, 1999, 2004, and 2009.[3] The additional villages incorporated in the sample were chosen to account for the diversity in farming systems throughout the country.

Data Collection The sampling was constructed carefully to represent the major agro-ecological zones of Ethiopia. Consequently, the location of each village is dispersed through Ethiopia, some being more than 1,000km apart (see Figure 1 for a map of village locations). The sampling frame for the villages was strictly stratified across these zones and sub-zones, with one to three villages selected per strata.

A list of households was constructed in 1994. Within each village, stratified random sampling was used based on whether households have male or female heads. Sample sizes represent the population of each main farming system. Consequently, the data are not nationally representative, but can be considered representative of households in non-pastoralist farming systems. Attrition in the sample has also been very low. The attrition rate between 1994 and 2004 was 13.2 percent or 1.3 percent per year (Dercon and Hoddinott, 2011).

Weather Data In addition to the household survey data, rainfall and temperature data has been constructed from 6-hourly precipitation reanalysis data at the village level from the ERA-Interim data archive supplied by the European Centre for Medium-Term Weather Forecasting (ECMWF).[4] Previous studies have relied on the use of meteorological data provided by the Ethiopian meteorological service and the number of missing observations is a

[3]This paper makes use of the final two rounds (2004 and 2009) as only these years contain questions on subjective well-being.

[4]See Dee et al. (2011) for a detailed discussion of the ERA-Interim data.

concern. This has been exacerbated by the serious decline in the past few decades in the number of weather stations around the world that are reporting. Lorenz and Kuntsmann (2012) show that, since 1990, the number of reporting weather stations in Africa has fallen from around 3,500 to around 500. With 54 countries in the continent, this results in an average of fewer than 10 weather stations per country.[5]

The ERA-Interim reanalysis data archive provides 6-hourly measurements for a very rich set of atmospheric parameters, from 1$^{\text{st}}$ January, 1979 until the present day, on a global grid of quadrilateral cells defined by parallels and meridians at a resolution of 0.25 x 0.25 degrees (equivalent to 28km x 28km at the equator).[6] Reanalysis data is constructed through a process whereby climate scientists use available observations as inputs into climate models to produce a physically consistent record of atmospheric parameters over time (Auffhammer et al., 2013). This results in an estimate of the climate system that is separated uniformly across a grid, making it more uniform in quality and realism than observations alone, and one that is closer to the state of existence than any model would provide alone. This provides a consistent measure of atmospheric parameters over time and space. This type of data is increasingly being used by economists, since it fills in the data gap apparent in developing countries, where the collection of consistent weather data is lower down the priority list in governmental budgets (see Dell et al. (2014) for a review of its recent applications in the literature).

Sample Construction By combining the household data with the ERA-interim data, we create a panel that allows for microeconomic analysis of weather and climate in rural Ethiopia.

The outcome variables of interest from the economic data are objective real per capita consumption in adult equivalent units, C_{ht}, and subjective life satisfaction, $\mathcal{W}_{it} = \hat{\mathbb{E}}[U(\cdot)|\underline{\mathrm{s}}_t]$,

[5]Looking at publicly available data, the number of stations in Ethiopia included by the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Centre (NCDC) is 18; however, if we were to apply a selection rule that required observations for 365 days, this would yield a database with zero observations. For the two years for which we have economic data (2004 and 2009), weather station data is available for 50 days in Addis Ababa in 2004 and is available for all 18 stations for an average of 200 days (minimum of 67 days, maximum of 276 days) in 2009. This is likely to result in a huge increase in measurement error when this data is used to interpolate across the 63 zones and 529 woredas (districts) reported in 2008. If this measurement error is classical, i.e., uncorrelated with the actual level of rainfall measured, then our estimates of the effect of these variables will be biased towards zero. However, given the sparsity of stations across Ethiopia (an average of 0.03 stations per woreda), the placement of stations is likely to be correlated with agricultural output; that is, weather stations are placed in more agriculturally productive areas, where the need for weather information is higher. As a result, we might expect that estimates using weather stations are systematically biased upwards. For these reasons, the use of remote-sensing data on a uniform grid has great value in areas with low station density.

[6]To convert degrees to km, multiply 28 by the cosine of the latitude, e.g, at 40 degrees latitude 0.25 x 0.25 degree cells are 28 x cos(40) = 21.4 km x 21.4 km.

asked of both the household head and the spouse of the household head.

Real per capita consumption is constructed in the following way. First, all food consumption in the past 7 days is valued and scaled up to a month. In addition, expenditures on items purchased by the household in a typical month are added. On top of this, the value of own production is imputed by multiplying the quantity produced by the median price paid by other households in the same district. Finally, consumption expenditures are spatially deflated to ensure comparability over time and space. This is very important given the significant inflation observed between 2004 and 2009 due to rapid increases in world grain prices and internal monetary policy (Alem and Söderbom, 2012; Durevall et al., 2013), with average inflation peaking at 55.2% and food price inflation at 92% (Central Statistics Agency, The Federal Democratic Republic of Ethiopia, 2009).

Our measure of subjective well-being in rural Ethiopia is constructed using individual responses (from the household head and spouse) corresponding to the level of agreement with the following statement as the dependent variable: "I am satisfied with my life." A score of one is described as "Very Dissatisfied" and a score of seven is described as "Very Satisfied". These questions are similar to the standard questions used in cross-country surveys such as the World Values Survey and the Eurobaromoter Survey. We also demonstrate the robustness of our results to alternative measures of subjective well-being.

Using the weather data described above we construct our proxy for income uncertainty – rainfall variability. We start with a measure of total annual rainfall for each village, and then calculate the coefficient of variation for rainfall (CV), measured as the standard deviation divided by the mean for the previous five years, the time between survey rounds, to ensure that variation is round-specific.

In addition, we construct linear and non-linear measures of historical rainfall and temperature realisations to control for realised income shocks. As the first moment and second moment of the rainfall distribution are correlated, it is important to control for first-moment effects to isolate the effects of income uncertainty, to the degree that it is empirically relevant, from realised income effects. The following section explores the degree to which rainfall variability can be considered a reasonable proxy for income uncertainty, in light of the correlation between these measures. Across all outcomes we restrict our analysis sample to households that report data on agricultural production.

4 Rainfall Variability and Income Uncertainty

To identify the effects of income uncertainty, rather than the effects of a change in past, contemporaneous or expected future income, it is important that rainfall variability has no direct effect on income. This section provides support for the premise.

4.1 The Absence of Rainfall Variability Effects on Income-related Outcomes

Agricultural Outcomes Using data on each household's agricultural production, we calculate agricultural yields, defined as the cultivated production of each crop divided by its cultivated area.[7][8]

However, exploring the effects of rainfall variability on yields is not sufficient to rule out a change in income. While yields and income are correlated, prices, wages, and consequently labour supply decisions may also be affected (Foster and Rosenzweig, 2004; Jayachandran, 2006; Colmer, 2017; Kaur, 2017). If the price that households receive for their crops changes, or wages change, then income may still be affected. Consequently, in addition to examining the effects of rainfall variability on yields, we explore the effects of rainfall variability on the share of crop sold – an evaluation of the degree to which households respond to price effects in the event of their existence – as well as directly examining the effects of rainfall variability on price, which is available for households that sell their produce.

Using this data, we estimate crop-specific effects of rainfall variability on yield, share sold, and price,

$$\begin{aligned} \log(\mathrm{Y}_{chvt}) &= \beta \textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\ldots,t-4}}) \\ &+ \alpha_{ch} + \alpha_m + \alpha_t + \epsilon_{chvt} \end{aligned} \tag{6}$$

where $\textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}}$ is my proxy for income uncertainty – the coefficient of variation for rainfall measured over the previous 5 years – and $f(\mathrm{w}_{\underline{vt,\ldots,t-4}})$ is a function of historical weather variables measured over the previous 5 years. The weather variables included vary across specifications. In the least rigorous specification we do not include any weather controls. In the most rigorous specification we include linear and quadratic controls for rainfall and temperature over the previous 5 years and interactions between rainfall and temperature. α_{ch} captures crop–household fixed effects, α_t captures year fixed effects, and

[7] The crops used are maize, wheat, white teff, barley, sorghum, black teff, coffee, chat and enset, constituting the major staple crops and cash crops of Ethiopia.

[8] In appendix A.1 we provide an initial examination of the relationship between rainfall and yields, to underscore the importance of rainfall for the livelihoods of smallholder farmers in Ethiopia, and to shed some light on potential structure of the functional form underlying the relationship within this context. Table A1 presents the results of various specifications, all demonstrating that rainfall appears to have a positive and relatively linear relationship with yields; i.e., more rainfall is better.

α_m captures month-of-survey fixed effects.

labour Supply, Non-Crop Income, and Wealth In addition, we evaluate the potential for wage and labour supply effects, examining the average daily wage of hired farm labour, the number of worker days employed conditional on hiring labour, and whether the household hired any workers.

As well as on-farm labour decisions that affect cost, we also explore off-farm labour decisions as an alternative income-generating activity. We examine whether individuals are engaged in off-farm work, whether they are engaged in work outside of the village – a proxy for migratory behavior – and the number of days that they work off-farm. Finally, we explore whether household assets are likely to be affected through an examination of livestock – the most important marketable asset in Ethiopia, accounting for more than 90% of the total value of assets (Dercon, 2004). We examine whether households make any changes to the number of livestock they own or whether they sell or slaughter any livestock.

These outcomes are evaluated at the household level,

$$\begin{aligned} \log(\mathrm{Y}_{hvt}) &= \beta \textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\ldots,t-4}}) \\ &+ \alpha_h + \alpha_m + \alpha_t + \epsilon_{hvt} \end{aligned} \tag{7}$$

except for livestock outcomes, which are evaluated at the livestock–household level.[9].

$$\begin{aligned} \log(\mathrm{Y}_{lhvt}) &= \beta \textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\ldots,t-4}}) \\ &+ \alpha_{lh} + \alpha_m + \alpha_t + \epsilon_{lhvt} \end{aligned} \tag{8}$$

Tables 2, 3, 4, 5, and 6 present the results of these exercises. Across all specifications we find no effects of rainfall variability. These results are robust to excluding or including historical weather controls, accounting for non-linearities in the rainfall and temperature distribution, and accounting for interactions between temperature and rainfall. The estimated effects are both statistically insignificant and economically small in magnitude. Appendix A.2 provides additional results that highlight the robustness of these findings to alternative measures and time definitions of rainfall variability. Combined, these findings provide compelling support for the premise that rainfall variability has no direct effect on income.

[9]13 types of livestock are included in the analysis: Calves, Bulls, Oxen, Heifer, Cows, Sheep, Goats, Horses, Donkeys, Mules, Camels, Young Bulls, and Chicken

4.2 The Mean-Preserving Nature of Rainfall Variability

In addition to examining income-related outcomes, we directly assess whether rainfall variability is mean-preserving by evaluating the effects of rainfall variability on historical and future rainfall realisations, using the full sample of weather data described above (1979–2012). If rainfall variability is not mean-preserving and affects historical weather realisations, then our measure of income uncertainty may simply capture any residual contemporaneous or persistent impacts of realised rainfall shocks. We have seen that rainfall variability appears to have limited contemporaneous effects on agricultural and income-related outcomes, but if rainfall variability is associated with historical persistent income shocks, these could drive our main results. Furthermore, if rainfall variability is not mean-preserving and farmers update their expectations about future rainfall realisations based on changes in rainfall variability, then increases in rainfall variability may simply capture expectations about future income. Again, this was not captured in the above exercises. To explore these considerations, we regress rainfall, measured in mm, in period t on rainfall variability in the previous 5 years – the time between survey rounds – using the following specification,

$$\begin{aligned} \textsc{Rainfall}_{vt} &= \beta \textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\ldots,t-4}}) \\ &+ \alpha_v + \alpha_t + \epsilon_{vt} \end{aligned} \tag{9}$$

The results of this exercise are presented in Table 7. We find no evidence of rainfall variability having a meaningful statistical or economic effect on historical, contemporaneous, or future rainfall realisations. This supports the premise that rainfall variability is mean-preserving and so should not have a direct income or wealth effect. Indeed, the absence of direct effects on rainfall realisations significantly attenuates the mechanism through which income effects might arise.

Consequently, it is unlikely that increases in rainfall variability capture contemporaneous income effects, the persistent effects of historical income shocks, or expectations about future income realisations. While we can never rule out any residual correlation between rainfall variability and realised events, these results, combined with the exercises above, suggest that first-order concerns should be alleviated.

5 Empirical Strategy

To analyze the effects of income uncertainty on individual well-being we exploit variation in rainfall variability between survey rounds. However, to begin with we first examine the effects of rainfall variability on consumption. The effect of uncertainty on contemporaneous consumption is an empirical question: consumption expenditures may increase if farmers increase their spending on inputs that mitigate the economic consequences of future rainfall shocks (to the degree that such investments are available); consumption may decrease if farmers exhibit decreasing absolute risk aversion and engage in precautionary saving (to the degree that saving is possible); or uncertainty about future income may have no effect on present consumption if farmers are unable to smooth consumption over time. We explore the empirical relevance of these effects using the following specification,

$$\log C_{ht} = \beta \text{Rainfall Variability}_{\underline{vt,\dots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\dots,t-4}}) + \alpha_h + \alpha_m + \alpha_t + \epsilon_{hvt} \tag{10}$$

where Rainfall Variability$_{\underline{vt,\dots,t-4}}$ is the variable of interest – our proxy for income uncertainty –, and $f(\mathrm{w}_{\underline{vt,\dots,t-4}})$ is a function of historical rainfall and temperature variables defined over the previous 5 years (the time period over which our measure of rainfall variability is measured). The weather variables included vary across specifications. In the least rigorous specification we do not include any weather controls. In the most rigorous specification we include linear and quadratic controls for rainfall and temperature over the previous 5 years and interactions between rainfall and temperature. In addition, we control for household (α_h), year (α_t), and month of survey (α_m) fixed effects.

In addition to estimating the effects of income uncertainty on objective consumption, we also examine the effects of income uncertainty on subjective well-being,

$$\mathcal{W}_{it} = \beta \text{Rainfall Variability}_{\underline{vt,\dots,t-4}} + \gamma f(\mathrm{w}_{\underline{vt,\dots,t-4}}) + \alpha_i + \alpha_m + \alpha_t + \epsilon_{ivt} \tag{11}$$

where $\mathcal{W}_{ivt}$ is a measure of subjective well-being, which has been standardized to aid comparisons across alternative measures of subjective well-being recorded on different scales, Rainfall Variability$_{\underline{vt,\dots,t-4}}$ is the variable of interest, and $f(\mathrm{w}_{\underline{vt,\dots,t-4}})$ is a function of historical rainfall and temperature variables defined over the previous 5 years described above (the time period over which our measure of rainfall variability is measured).

Individual fixed effects, α_i, allow us to address any issues associated with time-invariant unobserved individual heterogeneity, which has been shown to be an important determinant of subjective well-being (Argyle, 1999; Diener and Lucas, 1999; Ferrer-i Carbonell and Frijters, 2004). In addition to individual fixed effects, we control for year fixed effects, α_t, to control for aggregate shocks, economic development, and macroeconomic policies. We also include survey month fixed effects, α_m, to control for seasonal variation in the timing of the survey.

The last term in equations 10 and 11 is the stochastic error term, ϵ_{ivt}. Standard errors are clustered at the village level, and are robust to employing the wild cluster bootstrap-t procedure to account for the small number of clusters in our sample (Cameron et al., 2008).

6 Results

6.1 Uncertainty and Objective Consumption

First we examine the effect of income uncertainty on real consumption per capita – an objective measure of household welfare. The results of this exercise are presented in Table 8.

Across all specifications and time frames, we observe that an increase in rainfall variability is associated with a contraction in real per capita consumption. In the most rigorous specification (column 5), we estimate that a one standard deviation increase in rainfall variability (3.031 points) is associated with a 10% reduction in real per capita consumption. This suggests that farmers may be engaging in some form of precautionary saving in response to increases in income uncertainty, consistent with the theoretical model under the assumption of decreasing absolute risk aversion (Brunnermeier and Parker, 2005). The results are robust to applying the wild cluster bootstrap-t procedure to account for the small number of clusters, presented in brackets, and to alternative timing definitions for rainfall variability (appendix A.3).

As a final exercise to address the small number of clusters, as well as any concerns that our results are driven by sampling variability, we engage in randomization inference. Given the short panel it is possible that changes in rainfall variability could be due to sampling variability rather than a change in the underlying "state" of income uncertainty. One push back on such an interpretation is that we find no effects of rainfall variability on a broad range of income related outcomes in section 4. Holding the sample fixed we re-assign rainfall variability across village-years 10,000 times and use these placebo realizations of rainfall variability to estimate the original model. We then plot the distribution of each estimated coefficient and compute the share of placebo β's that are higher in absolute value than the original estimate of β, providing an exact p-value. Figure 4 presents the results of this exercise. The distribution is symmetric around zero and the exact p-value is < 0.01, highlighting that it is very unlikely that our results are driven by sampling variability or due to spurious trends in rainfall variability, which would deliver an asymmetric distribution. By contrast, applying the same exercise to agricultural yields provides an exact p-value of

0.637.

6.2 Uncertainty and Subjective Well-Being

6.2.1 Uncertainty and Life Satisfaction

In addition to examining the effects of uncertainty on objective consumption we are interested in understanding the broader effects of uncertainty on individual well-being. We explore this by examining the effects of rainfall variability on life satisfaction, a measure of subjective well-being. Section 2 predicts that when there is partial insurance and the subjective probability of an income shock does not coincide with the true probability, the utility of the farmer depends on anticipatory utility, such that the subjective conditional belief has a direct effect on utility. Given the importance of rainfall as a driver of income in agrarian societies, an increase in rainfall variability increases uncertainty about future income flows.

Panel A of Table 9 presents our main results, exploring the effects of rainfall variability on life satisfaction.

In the most rigorous specification (column 5) we estimate that a one standard deviation increase in rainfall variability (2.390 points) is associated with a 0.077 standard deviation reduction in life satisfaction, around 15% of the within-individual standard deviation. Again, this inference is robust to adjusting for the small number of clusters, using the wild cluster bootstrap-t procedure.[10]

Panel B further tests the robustness and interpretation of our results by controlling directly for the logarithm of real consumption per capita. While this is a bad control (Angrist and Pischke, 2009), it allows us to test the degree to which the direct effects of uncertainty on individual well-being are mediated by the effects of rainfall variability through consumption, unbundling the channels through which rainfall variability affects individual well-being. In column 5 we estimate that controlling for consumption mediates the estimated effect of uncertainty on life satisfaction, reducing the magnitude of the coefficient from -0.0323 to -0.0278. Consequently, we argue that the effects of uncertainty on individual well-being are largely explained by direct effects, rather than effects driven through consumption. This is consistent with our theoretical framework, as well as a wide literature exploring the psychic costs of income shocks and poverty (van den Bos et al., 2009; Hare et al., 2009; Delgado and Porcellie, 2009; Doherty and Clayton, 2011), suggesting that income uncertainty can have a significant direct effect on individual welfare, above and beyond the effects of realised changes in income. Consequently, the welfare gains associated with further consumption smoothing

[10] Appendix A.3 presents robustness tests related to the timing of rainfall variability as well as an alternative measure of rainfall variability, the standard deviation of rainfall.

are likely to be substantially greater than estimates based solely on realised income shocks.

As for our estimated effect on consumption, we engage in a randomization inference exercise to provide exact p-values and test whether our results are driven by sampling variability or spurious trends. Figure 4 presents the results of this exercise. As for consumption, the distribution of estimates for life satisfaction is symmetric around zero and the exact p-value is < 0.01.

6.2.2 Uncertainty and Happiness

Within the subjective well-being literature, it is generally considered that questions based on the life satisfaction scale are more evaluative measures, whereas questions related to happiness are a better measure of present affect (Benjamin et al., 2013; Levinson, 2013).[11] While both measures of subjective well-being are highly correlated ($\rho = 0.425$), we might expect that rainfall variability should have a smaller effect on happiness (contemporaneous well-being) than life satisfaction (evaluative well-being) if it is capturing the effects of income uncertainty.

Table 10 presents the results from this analysis. In the most rigorous specification we estimate that a one standard deviation increase in rainfall variability (2.39 points) is associated with a 0.037 standard deviation reduction in happiness, equivalent to 7% of the within-individual standard deviation in happiness. This effect is substantially smaller in magnitude than the estimated effects on life satisfaction, is not robust across specifications and remains at most statistically significant at the 10% level after adjusting for the small number of clusters. Furthermore, after controlling for consumption, the effect becomes statistically insignificant across all specifications. These results are consistent with our predictions that income uncertainty should have less of an impact on contemporaneous happiness, compared to more evaluative measures of well-being. Appendix A.4 provides further support for this hypothesis by exploring the effects of rainfall variability on additional evaluative measures of subjective well-being, including an index measure, finding similar effects to the estimated effect of rainfall variability on life satisfaction.

In exploring the results of the randomization inference exercise we observe that the exact p-value is 0.0478, which while statistically significant at conventional levels, is substantially larger than the exact p-values for Life Satisfaction and Consumption (Figure (4).

[11] The happiness question is, "Taken all together, how would you say things are for you these days? Would you say you are: Not too happy; Pretty happy; Very happy?"

6.3 Heterogeneous Effects: Uncertainty and Insurance

In section 2 we discussed that in the presence of partial insurance, uncertainty relating to future income will have an additional direct impact on welfare beyond the *ex post* realisation of income shocks. Evidence of this was presented in the main results above. In this section we explore the degree to which households may be differentially able to mitigate this effect.

We explore the degree to which membership in "Eqqub", a voluntary association that regularly pools funds and rotates among members, can affect the impact of rainfall variability on life satisfaction and real per capita consumption. "Eqqub" are the dominant form of informal insurance in Ethiopia and are a balanced reciprocity risk sharing mechanism. While rotary savings are often used to allow savings to purchase an indivisable durable good, that they are also used for insurance, whereby members may pay another member to receive the pot at a time of need (Anderson and Baland, 2002; Calomiris and Rajaraman, 1998; Klonner, 2001). Given the aggregate nature of rainfall variability it may not be obvious as to how eqqub can help. However, members of Eqqub can join from distant villages, although we have no way of determining whether this is the case. A more important issue relates to the interpretation of this exercise. Eqqub's are self-organized groups and so Eqqub membership is indeed endogenous. To minimize this concern we focus on households that have always been eqqub members to avoid selection based on changes in rainfall variability. Consequently, our measure of eqqub membership is orthogonal to changes in rainfall variability. Furthermore, household that enter into are of course a selective group and so the moderating effect of eqqub on rainfall variability may also capture the unobservable characteristics of households that led them to select into membership. Consequently, any moderating effect should be interpreted carefully.

This exercise serves to provide further evidence in support of our interpretation of results: that rainfall variability captures the effects of income uncertainty, rather than a realised shock. In response to an increase in uncertainty, "insurance" should attenuate the effects of rainfall variability on life satisfaction; however, it should not have an effect on real per capita consumption as households will not have received a payout. In fact, expenditures may increase, exacerbating the effects on consumption, if households decide to invest more in "Eqqub". By contrast, if rainfall variability captures the effects of realised shocks then "insurance" should mitigate both the life satisfaction and real per capita consumption effects, as households would have received payouts over this period.

We explore the moderating effect of insurance by estimating the following regression,

$$
\begin{aligned}
Y_{it} \;\; = \;\; & \beta_1 \textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} \\
& + \beta_2 [\textsc{Rainfall Variability}_{\underline{vt,\ldots,t-4}} \times \textsc{Eqqub}_i] \\
& + \gamma f(\mathrm{w}_{\underline{vt,\ldots,t-4}}) + \alpha_i + \alpha_m + \alpha_t + \epsilon_{ivt}
\end{aligned} \tag{12}
$$

where Y_{it} is either life satisfaction or real per capita consumption, and β_2 captures the interaction between rainfall variability and membership in "Eqqub".

We define a household to be insured if an individual is part of a household that has always been part of Eqqub. Consequently, we do not explore variation in membership that could be associated with changes in rainfall variability. We compare individuals who are part of households who have always been part of Eqqub to households that have not always been part of Eqqub. Consequently, the level effect is absorbed by the individual fixed effects. The interaction term is identified as long as "always being a member of Eqqub" is not correlated with any other omitted variables that could also affect the relationship between rainfall variability and the outcomes of interest. This identifying assumption is valid even if membership is endogenous to the outcome variables themselves. Nevertheless, the focus of this exercise is to provide a consistency check for the interpretation of the previous results, and should not be thought of as identifying the causal effect of Eqqub.

In Table 11 we explore the moderating effects of Eqqub membership on life satisfaction and consumption. Panel A presents the results relating to life satisfaction and Panel B presents the results relating to consumption. In Panel A we find that, across all specifications, if a household is "insured", this completely offsets the negative effects of rainfall variability on life satisfaction, consistent with the premise that Eqqub (or other time-invariant factors associated with membership) may play a role in providing insurance for these households. These findings are robust across specifications and to adjusting standard errors to account for the small number of clusters.

By contrast, Panel B provides little evidence to suggest that Eqqub membership (or other time-invariant factors associated with membership) attenuates the effects of rainfall variability on consumption. In the event of a realised shock, we would expect that access to insurance would attenuate the negative effects on consumption. Indeed, the point estimate suggests that Eqqub membership exacerbates the effects on consumption, suggesting that Eqqub may be a mechanism through which households engage in precautionary saving. However, this effect is not robust across specifications and does not remain statistically significant after accounting for the small number of clusters.

6.4 Optimism vs. Risk Management

Consistent with a model of optimal expectations, we have shown that an increase in rainfall variability, which plausibly proxies income uncertainty for smallholder farmers in rural Ethiopia, has a significant direct effect on individual well-being above and beyond the effects through consumption. These results highlight the empirical relevance of income uncertainty on individual welfare through anticipatory utility.

In light of these results it is also interesting to explore a key prediction of the optimal expectations framework: the trade-off between optimism and risk-management investments. When there is less uncertainty, farmers will be more optimistic about the future, and have higher contemporaneous well-being in light of their optimism. However, the Brunnermeier and Parker (2005) model predicts that this will lead to underinvestment in risk management strategies. Consequently, we expect that realised income shocks are likely to have a greater effect on consumption, capturing the trade-off between risk-management and the utility benefits of optimism.

To explore this prediction we evaluate the effects of realised rainfall shocks on consumption, differentiating between villages that are, in a climatic sense exposed to more vs. less rainfall variability. We define an indicator variable, $\text{More Uncertainty}_v$, to be equal to one if, over the preceding 30 years, a village's rainfall variability exceeds the across-village average rainfall variability. 50% of the sample villages are defined to face "more uncertainty". This provides a long-run measure of between-village exposure to income uncertainty; i.e., which villages are on average exposed to greater rainfall variability and therefore greater income uncertainty. We focus on a binary measure of uncertainty to maximize power and reduce the correlation between rainfall realizations and rainfall variability.

Using this variable, we explore the differential effect of realised rainfall shocks on consumption,

$$\log C_{ht} = \beta_1 \log \text{Rainfall}_{vt-1} + \beta_2 \log \text{Rainfall}_{vt-1} \times \text{More Uncertainty}_v \quad (13)$$
$$+ \alpha_h + \alpha_m + \alpha_t + \varepsilon_{hvt} \quad (14)$$

and life satisfaction,

$$\log \mathcal{W}_{it} = \beta_1 \log \text{Rainfall}_{vt-1} + \beta_2 \log \text{Rainfall}_{vt-1} \times \text{More Uncertainty}_v \quad (15)$$
$$+ \alpha_i + \alpha_m + \alpha_t + \varepsilon_{ivt} \quad (16)$$

Table 12 presents the results of this analysis. We observe that an increase in rainfall is associated with significant increases in life satisfaction and consumption, highlighting the relevance of rainfall for individual and household welfare in these villages. However, in line with our predictions, following from the optimal expectations framework, we see that in villages that are exposed to more rainfall variability than other villages, individuals and households are significantly less responsive to changes in rainfall. This is consistent with the premise that when there is more uncertainty households make more risk management investments. Conversely, when there is less uncertainty, individuals are more optimistic about future income realisations, and consequently, invest less in risk management strategies, trading off between higher contemporaneous utility from optimism and increased sensitivity to rainfall in the event that a negative shock is realised. These findings suggest that there may be potential welfare gains from increased access to information about future weather realisations (Rosenzweig and Udry, 2013, 2014).

That being said, households in more uncertain areas are still highly sensitive to rainfall realisations, suggesting that, despite greater risk management investments, risk sharing mechanisms and consumption smoothing technologies are still imperfect. In that respect, our findings reinforce the premise that the returns to further consumption smoothing are likely much greater than estimates based solely on realised consumption fluctuations.

It is interesting to note that contemporaneous happiness is not affected by rainfall realisations in the previous year, suggesting again that it is an inappropriate measure for capturing evaluative measures of well-being. It is important to caveat that the results of this exercise are not robust to using a continuous measure of rainfall variability. Our choice of a binary measure was to maximize power.

7 Conclusion

The ability to manage consumption risk is a significant determinant of individual and household welfare in developing countries, where households live in an uncertain environment with limited access to formal financial markets. While the effects of realised income shocks are well understood, this paper has explored the empirical relevance of income uncertainty to the individual welfare of smallholder farmers in rural Ethiopia.

We first presented a simple model based on Brunnermeier and Parker (2005), which demonstrates how expected future utility, or anticipated utility, can have a direct contemporaneous effect on utility if agents face imperfect insurance and have imperfect information about the probability that a future income shock is realised. The model predicts that agents living in areas with greater income uncertainty will have lower well-being than comparable agents living in areas with less income uncertainty.

However, measuring and identifying the effects of uncertainty, through disentangling the impact of uncertainty from the impact of realised events, is a difficult task. Using panel data on smallholder farmers in rural Ethiopia combined with high-resolution atmospheric data, we exploited plausibly exogenous variation in inter-annual rainfall variability to provide prima facie evidence on the effects of income uncertainty on objective consumption and subjective well-being.

Empirically, we began by providing support for the premise that rainfall variability is a reasonable proxy for income uncertainty. We demonstrate that an increase in rainfall variability has no direct effect on agricultural production, the share of crops sold, prices, crops planted, hired labour, wages, livestock, or other off-farm income-generating channels. These results are robust across multiple specifications and time definitions. In addition, we show that rainfall variability has no effect on historical, contemporaneous, or future rainfall realisations, highlighting the mean-preserving nature of rainfall variability and substantially attenuating the mechanism through which income effects could arise. These results support the premise that rainfall variability is a reasonable proxy for income uncertainty, helping to disentangle the effects of income uncertainty from realised weather events.

Having shown that rainfall variability has no direct effect on income, we evaluate the effects of rainfall variability on objective consumption expenditures and subjective well-being. We estimate that a one standard deviation increase in rainfall variability is associated with a 10% reduction in real consumption per capita, indicating the presence of a precautionary saving channel. In addition, we estimate that a one standard deviation increase in rainfall variability would be associated with a 0.077 standard deviation decline in life satisfaction, equivalent to 15% of the within-individual standard deviation. We decompose this effect into the direct effects of income uncertainty and those mediated by the effects of income uncertainty through changes in consumption, finding that up to 86% of the estimated effect is the direct effect of rainfall variability on well-being, with only 14% of the effect arising through the effects on consumption. In addition, we find no substantive effect of rainfall variability on happiness, a more contemporaneous measure of well-being. This is consistent with the consideration that uncertainty about the future may affect more evaluative measures of well-being while having little effect on an individuals' happiness on a particular day.

In further support of an "uncertainty" interpretation of our results, we find that household membership in Eqqubs – a voluntary association that regularly pools funds and rotates payments among its members – offsets the effects of rainfall variability on life satisfaction. However, we find that Eqqub membership does not moderate the consumption effects and, if anything, exacerbates them. If the estimated effects were due to realised income shocks, rather than an increase in uncertainty, then households engaged in Eqqubs would be less likely to experience reductions in consumption over this period. By contrast, a weak exacerbation of the consumption effect suggests that Eqqubs may be an important mechanism for risk-management by providing a source of precautionary saving.

Finally, the model of optimal expectations predicts that when there is less uncertainty, farmers will be more optimistic about the future, and have higher contemporaneous utility. However, in light of their optimism they will make fewer risk management investments. Agents balance the trade-off between risk-management investments and the utility benefits of optimism. In light of our findings, we expect that realised income shocks are likely to have a greater effect on consumption and well-being in areas that are subject to less rainfall variability. In these places farmers will be more optimistic about the future and so may invest less in risk-management strategies. Consistent with this prediction we estimate that households in less uncertain environments are more sensitive to rainfall shocks, suggesting that these households are making fewer risk management investments.

Our results suggest three things: first, that the returns to further consumption smoothing are likely to be substantially greater than estimates based solely on consumption fluctuations and realised shocks; second, when evaluating the consequences of environmental or economic change, it is important to understand how expectations about future states of the world affect economic behaviour, as well as the consequences of realised change. Third, that the inclusion of subjective welfare measures alongside objective measures could be helpful for researchers and policy makers in developing a broader understanding of the economic lives of the poor.

References

Aghion, P., U. Akcigit, A. Deaton, and A. Roulet (2015): “Creative Destruction and Subjective Wellbeing,” *NBER Working Paper 21069*.

Alem, Y. and M. Söderbom (2012): “Household-level consumption in urban Ethiopia: The effects of a large food price shock,” *World Development*, 18, 291–308.

Alpert, M. and H. Raiffa (1982): “A Progress Report on the Training of Probability Assessors,” in *Judgement Under Uncertainty: heuristics and biases*, ed. by D. Kahneman, P. Slovic, and A. Tversky, Cambridge University Press, 294–305.

Anderson, S. and J.-M. Baland (2002): “The Economics of ROSCAS and Intrahousehold Resource Allocation,” *Quarterly Journal of Economics*.

Angrist, J. and J. Pischke (2009): *Mostly Harmless Econometrics: an empiricist's companion*, Princeton University Press, Princeton, N.J., USA.

Argyle, M. (1999): "Causes and Correlates of Happiness." in *Well-Being: The Foundations of Hedonic Psychology: scientific perspectives on employment and suffering*, ed. by D. Kahneman, E. Diener, and N. Schwarz, New York: Russel Sage Foundation.

Auffhammer, M., S. Hsiang, W. Schlenker, and A. Sobel (2013): "Using Weather Data and Climate Model Output in Economic Analyses of Climate Change," *Review of Environmental Economics and Policy*, 7, 181–198.

Baylis, P. (2016): "Temperature and Temperament: Evidence from a Billion Tweets," *Mimeo.*

Benjamin, D., O. Heffetz, M. Kimball, and A. Rees-Jones (2012): "What Do You Think Would Make You Happier? What Do You Think You Would Choose?" *American Economic Review*, 102, 2083–2110.

Benjamin, D., M. Ori Heffetz, M. Kimball, and N. Szembrot (2013): "Aggregating Local Preferences to Guide Marginal Policy Adjustments," *American Economic Review: Paper and Proceedings.*

Bentham, J. (1789): *Principles of Morals and Legislation*, Oxford: Clarendon Press.

Bloom, N. (2009): "The Impact of Uncertainty Shocks," *Econometrica*, 77, 623–685.

——— (2014): "Fluctuations in Uncertainty," *Journal of Economic Perspectives*, 28, 153–176.

Brunnermeier, M., F. Papakonstantinou, and J. Parker (2017): "Optimal Time-Inconsistent Beliefs: misplanning, procratination, and commitment," *Management Science.*

Brunnermeier, M. and J. Parker (2005): "Optimal Expectations," *American Economic Review*, 95, 1092–1118.

Bryan, G., S. Chowdhury, and A. Mobarak (2014): "Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh," *Econometrica*, 82, 1671–1758.

Buehler, R., D. Griffin, and M. Ross (1994): "Exploring the Planning Fallacy: why people underestimate their task completion times," *Journal of Personality and Social Psychology*, 67, 366–381.

Calomiris, C. and I. Rajaraman (1998): "The Role of ROSCAs: Lumpy Indivisibles or Event Insurance," *Journal of Development Economics*.

Cameron, C., J. Gelbach, and D. Miller (2008): "Bootstrap-Based Improvements for Inference with Clustered Errors," *Review of Economics and Statistics*, 90, 414–427.

Caplin, A. and J. Leahy (2001): "Psychological Expected Utility Theory and Anticipatory Feelings," *Quarterly Journal of Economics*, 116, 55–79.

Carriere-Swallow, Y. and L. Céspedes (2013): "The Impact of Uncertainty Shocks in Emerging Economies," *Journal of International Economics*, 90, 316–325.

Carroll, N., P. Frijters, and M. Shields (2009): "Quantifying the Costs of Drought: new evidence from life satisfaction data," *Journal of Population Economics*, 22, 445–461.

Central Statistics Agency, The Federal Democratic Republic of Ethiopia (2009): "Country and Regional Level Consumer Price Indices," *Data*.

Colmer, J. (2017): "Weather, Labor Reallocation, and Industrial Production: Evidence from India," *Mimeo*.

De Neve, J., G. Ward, F. De Keulenaer, B. Van Landeghem, G. Kavetsos, and N. M.I. (2015): "The Asymmetric Experience of Positive and Negative Economic Growth: global evidence using subjective well-being data," *CEP Discussion Paper No. 1304*.

Dee, D. P., S. M. Uppala, A. J. Simmons, P. Berrisford, P. Poli, S. Kobayashi, U. Andrae, M. A. Balmaseda, G. Balsamo, P. Bauer, P. Bechtold, A. C. Beljaars, L. M. van de Berg, J. Bidlot, N. Bormann, C. Delsol, R. Dragani, M. Fuentes, A. J. Geer, L. Haimberger, S. B. Healy, H. Hersbach, E. V. Holm, L. Isaksen, P. Kallberg, M. Kohler, M. Matricardi, A. P. McNally, B. Monge-Sanz, J. Morcrette, B. Park, C. Peubey, P. de Rosnay, C. Tavolato, J. Thepaut, and F. Vitart (2011): "The ERA-Interim reanalysis: configuration and performance of the data assimilation system." *Quarterly Journal of the Royal Meteorological Society*, 137, 553–597.

DELGADO, M. AND A. PORCELLIE (2009): "Acute Stress Modulates Risk Taking in Financial Decision Making," *Psychological Science*, 20, 278–283.

DELL, M., B. JONES, AND B. OLKEN (2014): "What Do We Learn from the Weather? The New Climate-Economy Literature," *Journal of Economic Literature*, 52, 740–798.

DERCON, S. (2004): "Growth and Shocks: Evidence from Rural Ethiopia," *Journal of Development Economics*, 74, 309–329.

DERCON, S. AND J. HODDINOTT (2011): "The Ethiopian Rural Household Survey 1989 - 2009: Introduction," *IFPRI*.

DERCON, S. AND C. PORTER (2014): "Live Aid Revisited: Long-Term Impacts of the 1984 Ethiopian Famine on Children," *Journal of the European Economic Association*.

DIENER, E. AND R. LUCAS (1999): "Personality and Subjective Well-being," in *Well-Being: The Foundations of Hedonic Psychology: scientific perspectives on employment and suffering.*, ed. by D. Kahneman, E. Diener, and N. Schwarz.

DIENER, E., R. LUCAS, U. SCHIMMACK, AND J. HELLIWELL (2009): *Well-Being for Public Policy*, New York: Oxford University Press.

DOHERTY, T. AND S. CLAYTON (2011): "The Psychological Impacts of Global Climate Change," *American Psychologist*, 66, 265–276.

DOLAN, P. AND D. KAHNEMAN (2008): "Interpretations of Utility and Their Implications for the Valuation of Health," *Economic Journal*, 118, 215–234.

DOLAN, P., R. LAYARD, AND R. METCALFE (2011): "Measuring Subjective Well-Being for Public Policy: recommendations on measures," *CEP Special Paper No. 23*.

DUREVALL, D., J. LOENING, AND Y. AYALEW BIRRU (2013): "Inflation Dynamics and Food Prices in Ethiopia," *Journal of Development Economics*, 104, 89–106.

FAFCHAMPS, M. AND S. LUND (2003): "Risk-sharing Networks in Rural Phillipines," *Journal of Development Economics*, 71, 261–287.

FEDDERSEN, J., R. METCALFE, AND M. WOODEN (2015): "Subjective Wellbeing: why weather matters," *Journal of Royal Statistical Society*.

FERRER-I CARBONELL, A. AND P. FRIJTERS (2004): "How Important is Methodology for the Estimates of the Determinants of Happiness?" *Economic Journal*, 114, 641–659.

FOSTER, A. AND M. ROSENZWEIG (2004): "Agricultural Productivity Growth, Rural Economic Diversity, and Economic Reforms: India 1970 - 2000," *Economic Development and Cultural Change*, 52, 509–542.

FREY, B., S. LUECHINGER, AND A. STUTZER (2010): "The Life Satisfaction Approach to Environmental Valuation," *Annual Review of Resource Economics*, 2, 139–160.

FREY, B. AND A. STUTZER (2002): *Happiness and Economics*, Princeton University Press, Princeton, N.J., USA.

GEANAKOPLOS, J., D. PEARCE, AND E. STACCHETTI (1989): "Psychological Games and Sequential Rationality," *Games and Economic Behaviour*, 1, 60–79.

GRUBER, J. AND S. MULLAINATHAN (2005): "Do Cigarette Taxes Make Smokers Happier?" *The B.E. Journal of Economic Analysis and Policy*, 5.

HARE, T., C. CAMERER, AND A. RANGEL (2009): "Self-Control in Decision-Making Involves Modulation of the vmPFC Valuation System," *Science*, 324, 646–648.

JAYACHANDRAN, S. (2006): "Selling Labor Low: Wage Responses to Productivity Shocks in Developing Countries," *Journal of Political Economy*, 114, 538–575.

JEVONS, W. (1905): *The Principles of Economics*, Macmillan and Co.

KAHNEMAN, D. AND A. KRUEGER (2006): "Developments in the Measurement of Subjective Well-Being," *Journal of Economic Perspectives*, 20, 3–24.

KAHNEMAN, D., P. WAKKER, AND R. SARIN (1997): "Back to Bentham? Exploration of experienced utility," *The Quarterly Journal of Economics*, 112, 375–406.

KAUR, S. (2017): "Nominal Wage Rigidity in Village Labor Markets," *American Economic Review*.

KINNAN, C. (2017): "Distinguishing Barriers to Insurance in Thai Villages," *Mimeo*.

KLONNER, S. (2001): "How ROSCAs Perform as Insurance," *Mimeo*.

KOREN, M. AND S. TENREYRO (2007): "Volatility and Development," *Quarterly Journal of Economics*, 122, 243–287.

LAYARD, R. (2005): *Happiness: lessons from a new science*, London: Allen Lane.

LEVINSON, A. (2012): "Valuing Public Goods Using Happiness Data: the case of air quality," *Journal of Public Economics*, 96, 869–880.

——— (2013): "Happiness as a Public Policy Tool," *Mimeo*.

LORENZ, C. AND H. KUNTSMANN (2012): "The Hydrological Cycle in Three State-Of-The-Art Reanalyses: intercomparison and performance analysis," *Journal of Hyrdrometeorology*, 13, 1397–1420.

LOWENSTEIN, G. (1987): "Anticipation and the Valuation of Delayed Consumption," *Economic Journal*, 97, 666–684.

MARSHALL, A. (1891): "Principles of Economics," *Quarterly Journal of Economics*, 5, 319–338.

MORDUCH, J. (1995): "Income Smoothing and Consumption Smoothing," *Journal of Economic Perspectives*, 9, 103–114.

MORTEN, M. (2013): "Temporary Migration and Endogenous Risk Sharing in Village India," *Mimeo*.

PAXSON, C. (1992): "Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand," *American Economic Review*, 82, 15–33.

PORTER, C. (2012): "Shocks, Consumption and Income Diversification in Rural Ethiopia," *Journal of Development Studies*.

RABIN, M. AND J. SCHRAG (1999): "First Impressions Matter: a model of confirmatory bias," *Quarterly Journal of Economics*, 114, 37–82.

RAMEY, G. AND V. RAMEY (1995): "Cross-Country Evidence on the Link between Volatility and Growth," *American Economic Review*, 85, 1138–1151.

REHDANZ, K. AND D. MADDISON (2011): "The Impact of Climate on Life Satisfaction," *Ecological Economics*, 70, 2437–2445.

ROSENZWEIG, M. AND C. UDRY (2013): "Forecasting Profitability," *NBER Working Paper 19811*.

——— (2014): "Rainfall Forecasts, Weather and Wages over the Agricultural Production Cycle," *American Economic Review Papers and Proceedings*, 104, 278–283.

Suri, T. (2011): "Estimating the Extent of Local Risk Sharing Between Households," *Mimeo.*

Townsend, R. (1994): "Risk and Insurance in Village India," *Econometrica*, 62, 539–591.

Udry, C. (1994): "Risk and Insurance in a Rural Credit Market: an empirical investigation in Northern Nigeria," *The Review of Economic Studies*, 61, 495–526.

van den Bos, R., M. Harteveld, and H. Stoop (2009): "Stress and Decision-Making in Humans: performance is related to cortisol reactivity, albeit differently in men and women." *Psychoneuroendocrinology*, 34, 1449–1458.

Weinstein, N. (1980): "Unrealistic Optimism About Future Life Events," *Journal of Personality and Social Psychology*, 39, 806–820.

Welsch, H. (2002): "Preferences over Prosperity and Pollution: environmental valuation based on happiness surveys," *Kyklos*, 55, 473–494.

——— (2006): "Environment and happiness: evaluation of air pollution using life satisfaction data," *Ecological Economics*, 58, 801–813.

Yariv, L. (2001): "Believe and Let Believe: axiomatic foundations for belief dependent utility functionals," *Yale University, Cowles Foundation Discussion Papers No. 1344.*

Table 1: Descriptive Statistics: Agriculture, Economic Activity, and Weather Data

	Mean	Std. Dev. (within)	Std. Dev. (between)	Obs.
Panel A: *Consumption*				
Real Consumption Per Capita (Birr)	75.733	69.544	28.682	2,686
textbfPanel B: *Subjective Well-Being*				
Life Satisfaction (score/max)	0.572	0.135	0.223	4,033
Happy (score/max)	0.622	0.113	0.191	4,033
Panel C: *Weather Data* (Village level):				
Rainfall Variability (σ/μ)	18.590	7.200	10.908	30
Total Rainfall (mm)	1,452.574	243.248	471.184	30
Average Temperature (°C)	19.187	0.329	1.873	30
Panel D: *Agricultural Production* (Crop level):				
Yield (kg/Ha)	1,109.769	474.883	5,751.648	3,812
Share Sold	0.230	0.111	0.331	3,812
Price (Birr/kg)	7.352	13.170	32.746	1,546
Panel E: *Crop Choice* (Household level):				
Crops Planted	2.402	0.634	1.157	2,072
Main Crop Share	0.458	0.079	0.263	2,072
Panel F: *Farm Inputs* (Household-level):				
Average Day Wage (Birr)	42.420	30.640	67.362	683
Hired Worker Days	57.394	204.922	250.671	2,053
Hired Any Workers (0/1)	0.365	0.234	0.428	2,053
Panel G: *Livestock* (Livestock-type level):				
Number Owned	0.865	0.939	2.119	33,286
Number Sold	0.145	0.424	0.644	33,286
Number Slaughtered	0.081	0.242	0.462	33,286
Panel H: *Other Income Activities* (Individual-level):				
Off-Farm Work (0/1)	0.122	0.143	0.305	1,039
Out of Village Work (0/1)	0.130	0.148	0.311	1,037
Days Worked (Previous 4 months)	27.215	10.843	32.697	536

Notes: Calculated from the 2004 and 2009 rounds of the Ethiopian Rural Household Survey (ERHS).

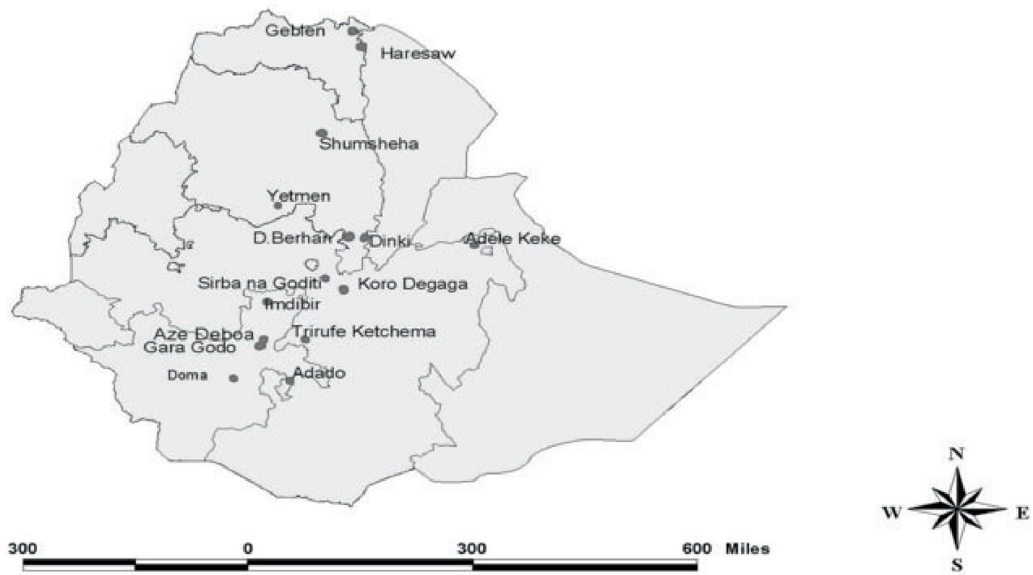

Figure 1: The ERHS Villages (Dercon & Hoddinott, 2009)

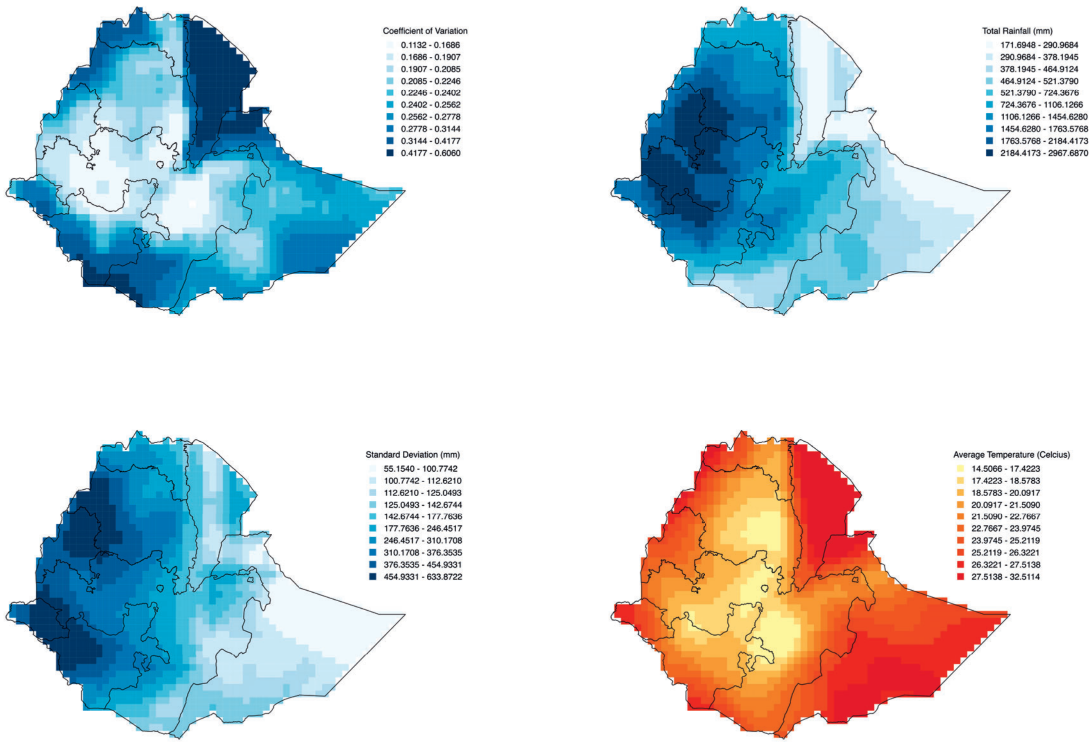

Figure 2: Spatial Variation in Rainfall and Temperature (1979–2012). Top Left = Coefficient of Variation; Top Right = Total Rainfall (mm); Bottom Left = Std Dev. Rainfall (mm); Bottom Right = Average Temperature (°C)

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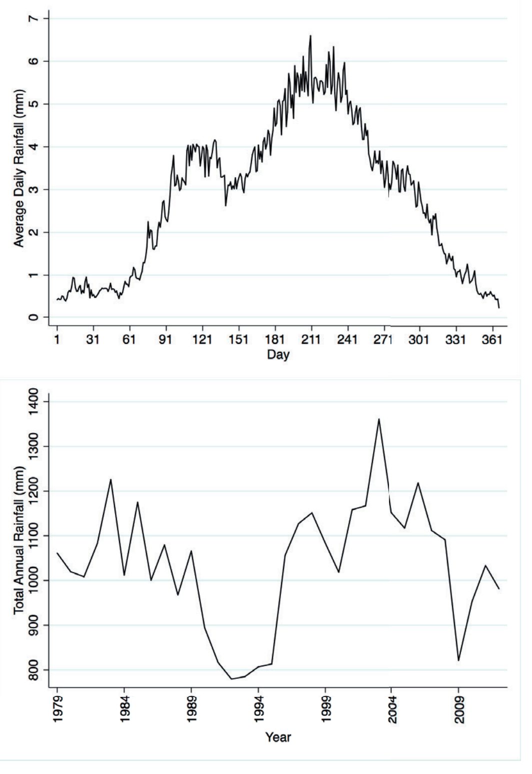

Figure 3: Temporal Variation in Rainfall (1979–2013). Top = Within-year Distribution (1979-2012 average). Bottom = Between-year Distribution

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Table 2: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Agricultural Yields, Share Sold, and Prices

	(1) log Yields	(2) log Yields	(3) log Yields	(4) log Yields	(5) log Yields
Rainfall Variability (σ/μ)	-0.0189	-0.00837	-0.00727	-0.00841	-0.00230
	(0.0123)	(0.0113)	(0.0112)	(0.0143)	(0.00773)
	[0.300]	[0.688]	[0.726]	[0.984]	[0.848]
exp(Dep. Var. Mean)	1,109.769	1,109.769	1,109.769	1,109.769	1,109.769
Treatment Std. Dev.	2.854	2.207	2.203	2.046	1.692
Observations	3,812	3,812	3,812	3,812	3,812
Fixed Effects	Crop × Household, Month, and Year				
	Share Sold	Share Sold	Share Sold	Share Sold	Share Sold
Rainfall Variability (σ/μ)	-0.00175	-0.00284*	-0.00262	-0.00289*	-0.00194
	(0.00170)	(0.00151)	(0.00149)	(0.00162)	(0.00137)
	[0.336]	[0.198]	[0.218]	[0.292]	[0.308]
Dep. Var. Mean	0.230	0.230	0.230	0.230	0.230
Treatment Std. Dev.	2.854	2.207	2.203	2.046	1.692
Observations	3,812	3,812	3,812	3,812	3,812
Fixed Effects	Crop × Household, Month, and Year				
	log Price	log Price	log Price	log Price	log Price
Rainfall Variability (σ/μ)	0.0154	-0.00207	0.00357	0.00302	-0.0119
	(0.0128)	(0.00838)	(0.0117)	(0.00624)	(0.0158)
	[0.390]	[0.834]	[0.860]	[0.634]	[0.492]
exp(Dep. Var. Mean)	7.352	7.352	7.352	7.352	7.352
Treatment Std. Dev.	1.799	1.554	1.504	1.491	0.804
Observations	1,546	1,546	1,546	1,546	1,546
Fixed Effects	Crop × Household, Month, and Crop × Year				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 3: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Crop Decisions

	(1) CROP COUNT	(2) CROP COUNT	(3) CROP COUNT	(4) CROP COUNT	(5) CROP COUNT
Rainfall Variability (σ/μ)	-0.00580	0.00216	0.00134	-0.00782**	-0.00917
	(0.00421)	(0.00566)	(0.00546)	(0.00348)	(0.00544)
	[0.206]	[0.698]	[0.782]	[0.054]	[0.130]
exp(DEP. VAR. MEAN)	2.402	2.402	2.402	2.402	2.402
TREATMENT STD. DEV.	3.88	2.846	2.840	2.653	2.154
OBSERVATIONS	2,072	2,072	2,072	2,072	2,072
	MAIN CROP SHARE	MAIN CROP SHARE	MAIN CROP SHARE	MAIN CROP SHARE	MAIN CROP SHARE
Rainfall Variability (σ/μ)	-0.000164	-0.00146	-0.00136	0.000181	0.00181
	(0.00129)	(0.00163)	(0.00158)	(0.00129)	(0.00208)
	[0.936]	[0.530]	[0.520]	[0.944]	[0.482]
exp(DEP. VAR. MEAN)	0.458	0.458	0.458	0.458	0.458
TREATMENT STD. DEV.	3.88	2.846	2.840	2.653	2.154
OBSERVATIONS	2,072	2,072	2,072	2,072	2,072
FIXED EFFECTS	HOUSEHOLD, MONTH, AND YEAR				
WEATHER CONTROLS	NO	YES	YES	YES	YES
QUADRATIC WEATHER	NO	NO	NO	YES	YES
WEATHER INTERACTIONS	NO	NO	YES	NO	YES

NOTES: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 4: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Farm Wages and Hired labour

	(1) log Avg. Wage	(2) log Avg. Wage	(3) log Avg. Wage	(4) log Avg. Wage	(5) log Avg. Wage
Rainfall Variability (σ/μ)	0.0109	0.0115	0.0234	0.0125	0.0270
	(0.0290)	(0.0247)	(0.0294)	(0.0239)	(0.0287)
	[0.721]	[0.713]	[0.553]	[0.691]	[0.499]
exp(Dep. Var. Mean)	42.420	42.420	42.420	42.420	42.420
Treatment Std. Dev.	1.816	1.741	1.455	1.739	1.398
Observations	683	683	683	683	683
	log Worker Days (Hired)	log Worker Days (Hired)	log Worker Days (Hired)	log Worker Days (Hired)	log Worker Days (Hired)
Rainfall Variability (σ/μ)	0.0121	-0.00830	-0.0175	-0.00839	-0.0314
	(0.0306)	(0.0286)	(0.0279)	(0.0276)	(0.0268)
	[0.667]	[0.737]	[0.571]	[0.791]	[0.361]
exp(Dep. Var. Mean)	57.394	57.394	57.394	57.394	57.394
Treatment Std. Dev.	1.873	1.805	1.506	1.804	1.445
Observations	727	727	727	727	727
	Hired Any Workers	Hired Any Workers	Hired Any Workers	Hired Any Workers	Hired Any Workers
Rainfall Variability (σ/μ)	0.000404	0.000744	0.000958	0.00466**	0.00416
	(0.00239)	(0.00320)	(0.00325)	(0.00160)	(0.00308)
	[0.936]	[0.850]	[0.812]	[0.022]	[0.226]
exp(Dep. Var. Mean)	0.365	0.365	0.365	0.365	0.365
Treatment Std. Dev.	3.891	2.848	2.842	2.658	2.159
Observations	2,053	2,053	2,053	2,053	2,053
Fixed Effects	Household, Month, and Year				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 5: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Livestock Assets

	(1) log Livestock	(2) log Livestock	(3) log Livestock	(4) log Livestock	(5) log Livestock
Rainfall Variability (σ/μ)	-0.000383 (0.00191)	0.00281 (0.00209)	0.00291 (0.00223)	0.00243 (0.00249)	0.000672 (0.00285)
Wild Cluster Bootstrap-t p-value	[0.906]	[0.280]	[0.320]	[0.454]	[0.846]
exp(Dep. Var. Mean)	1.273	1.273	1.273	1.273	1.273
Treatment Std. Dev.	3.975	2.435	2.433	2.240	2.116
Observations	10,397	10,397	10,397	10,397	10,397
	Own Any Livestock	Own Any Livestock	Own Any Livestock	Own Any Livestock	Own Any Livestock
Rainfall Variability (σ/μ)	0.000705 (0.000508)	0.00141 (0.000972)	0.00117 (0.00104)	0.000452 (0.00119)	0.00232** (0.000915)
Wild Cluster Bootstrap-t p-value	[0.512]	[0.270]	[0.448]	[0.830]	[0.212]
Dep. Var. Mean	0.296	0.298	0.298	0.298	0.298
Treatment Std. Dev.	5.695	3.309	3.295	2.960	2.701
Observations	34,863	34,863	34,863	34,863	34,863
Fixed Effects	Livestock × Household, Month, and Livestock × Year				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 6: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Adult Non-Farm Work

	(1) Engaged in Off-Farm Work	(2) Engaged in Off-Farm Work	(3) Engaged in Off-Farm Work	(4) Engaged in Off-Farm Work	(5) Engaged in Off-Farm Work
Rainfall Variability (σ/μ)	-0.00391*	-0.00571	-0.00629	-0.00490	-0.00881
	(0.00197)	(0.00489)	(0.00448)	(0.00534)	(0.00570)
Wild Cluster Bootstrap-t p-value	[0.830]	[0.402]	[0.336]	[0.496]	[0.366]
exp(Dep. Var. Mean)	0.122	0.122	0.122	0.122	0.122
Treatment Std. Dev.	4.641	2.130	2.101	1.946	1.829
Observations	1,039	1,039	1,039	1,039	1,039
	Engaged in Out of Village Work	Engaged in Out of Village Work	Engaged in Out of Village Work	Engaged in Out of Village Work	Engaged in Out of Village Work
Rainfall Variability (σ/μ)	0.00113	-0.00162	0.000181	-0.00442*	-0.00409
	(0.000991)	(0.00397)	(0.00423)	(0.00234)	(0.00372)
Wild Cluster Bootstrap-t p-value	[0.348]	[0.700]	[0.932]	[0.098]	[0.348]
exp(Dep. Var. Mean)	0.130	0.130	0.130	0.130	0.130
Treatment Std. Dev.	4.646	2.132	2.103	1.948	1.831
Observations	1,037	1,037	1,037	1,037	1,037
	log Days Worked (Off-Farm)	log Days Worked (Off-Farm)	log Days Worked (Off-Farm)	log Days Worked (Off-Farm)	log Days Worked (Off-Farm)
Rainfall Variability (σ/μ)	0.0325*	0.0205	0.0156	0.0676	0.0421
	(0.0181)	(0.0153)	(0.0143)	(0.0414)	(0.0445)
Wild Cluster Bootstrap-t p-value	[0.452]	[0.394]	[0.388]	[0.320]	[0.458]
exp(Dep. Var. Mean)	27.215	27.215	27.215	27.215	27.215
Treatment Std. Dev.	2.441	1.479	1.470	0.762	0.736
Observations	536	536	536	536	536
Fixed Effects	Individual, Month, and Year				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 7: Disentangling realised Income Events from Income Uncertainty: The Effects of Rainfall Variability on Rainfall realisations

Outcome Variable	Treatment Variable: Rainfall Variability (σ/μ)					Dep. Var. Mean
	(1)	(2)	(3)	(4)	(5)	(6)
Annual Rainfall (t+4)	2.142	2.550	2.462	3.039	2.805	1,376.497
	(1.693)	(2.031)	(1.986)	(1.931)	(1.996)	
	[0.234]	[0.268]	[0.266]	[0.154]	[0.232]	
Annual Rainfall (t+3)	2.286	2.406	2.361	2.594*	2.760*	1,383.802
	(1.645)	(1.836)	(1.550)	(1.383)	(1.411)	
	[0.194]	[0.242]	[0.162]	[0.060]	[0.062]	
Annual Rainfall (t+2)	2.368	2.270	3.087	3.823	4.192*	1,384.363
	(2.194)	(2.159)	(2.037)	(2.282)	(2.253)	
	[0.334]	[0.342]	[0.206]	[0.168]	[0.156]	
Annual Rainfall (t+1)	0.622	0.139	0.970	1.169	1.925	1,376.004
	(2.226)	(2.127)	(1.594)	(1.702)	(1.687)	
	[0.774]	[0.940]	[0.548]	[0.478]	[0.280]	
Annual Rainfall (t)	3.911**	2.211	1.847	1.502	1.762	1,347.258
	(1.727)	(1.335)	(1.141)	(1.071)	(1.066)	
	[0.080]	[0.176]	[0.154]	[0.186]	[0.146]	
Annual Rainfall (t-1)	1.873	0.171	0.217	0.121	0.393	1,342.532
	(1.812)	(0.874)	(1.036)	(0.959)	(1.084)	
	[0.408]	[0.964]	[0.922]	[0.982]	[0.808]	
Annual Rainfall (t-2)	1.520	-1.253	-0.846	-0.768	-0.688	1,344.297
	(1.697)	(0.717)	(0.873)	(0.766)	(0.851)	
	[0.428]	[0.166]	[0.412]	[0.406]	[0.468]	
Annual Rainfall (t-3)	2.002	-1.143	-1.048	-0.719	-0.979	1,346.462
	(1.635)	(1.163)	(0.991)	(1.004)	(1.018)	
	[0.262]	[0.454]	[0.418]	[0.586]	[0.450]	
Annual Rainfall (t-4)	2.064	-0.484	-0.483	-0.545	-1.088	1,350.294
	(1.946)	(1.478)	(1.556)	(1.549)	(1.839)	
	[0.298]	[0.888]	[0.818]	[0.816]	[0.656]	
Observations	495	495	495	495	495	
Treatment Std. Dev.	9.058	8.947	8.382	8.419	8.163	
Fixed Effects	Village, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the village level. Each coefficient relates to an individual regression. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 8: Rainfall Variability and Consumption

	Log Real Consumption Per Capita				
	(1)	(2)	(3)	(4)	(5)
Rainfall Variability (σ/μ)	-0.0189***	-0.0139***	-0.0120**	-0.0183***	-0.0326***
	(0.00307)	(0.00457)	(0.00529)	(0.00588)	(0.00485)
	[0.032]	[0.026]	[0.072]	[0.060]	[0.016]
Fixed Effects	Household, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
exp(Dep. Var. Mean)	55.257	55.257	55.257	55.257	55.257
Treatment Std. Dev.	5.930	3.463	3.434	3.087	3.031
Observations	2,686	2,686	2,686	2,686	2,686

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Our proxy for uncertainty is the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Contemporaneous and historical rainfall is measured in hundreds of mm. Contemporaneous and historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Results are robust to clustering following the bootstrap procedure to account for concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 9: Rainfall Variability and Life Satisfaction

	Life Satisfaction (Standardized)				
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Rainfall Variability (σ/μ)	-0.0192***	-0.0145**	-0.0132*	-0.0213**	-0.0323***
	(0.00455)	(0.00672)	(0.00687)	(0.00786)	(0.00569)
	[0.114]	[0.102]	[0.144]	[0.068]	[0.002]
Panel B:					
Rainfall Variability (σ/μ)	-0.0152***	-0.0116	-0.0108	-0.0180**	-0.0278***
	(0.00451)	(0.00684)	(0.00684)	(0.00773)	(0.00618)
	[0.202]	[0.170]	[0.220]	[0.110]	[0.004]
log Consumption	0.203***	0.179***	0.172***	0.175**	0.134**
	(0.0487)	(0.0509)	(0.0487)	(0.0594)	(0.0539)
	[0.006]	[0.014]	[0.008]	[0.022]	[0.032]
Direct Effect Share (%)	79	80	81	84	86
Fixed Effects	Individual, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
Treatment Std. Dev.	5.217	3.093	3.057	2.742	2.390
Observations	4,033	4,033	4,033	4,033	4,033

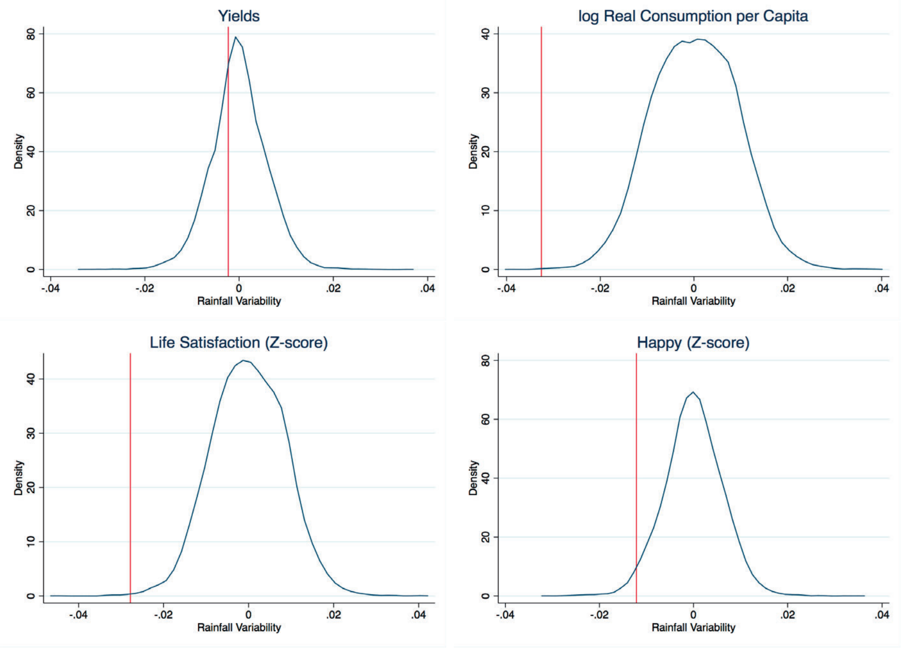
Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. All regressions include linear, quadratic, rainfall and temperature controls, as well as interactions between rainfall and temperature measures. The Direct Effect Share is calculated as the rainfall variability effect in Panel B divided by the rainfall variability effect in Panel A. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 10: Rainfall Variability and Happiness

	Happiness (Standardized)				
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Rainfall Variability (σ/μ)	-0.00695*	-0.00324	-0.00454	-0.0145*	-0.0158**
	(0.00348)	(0.00592)	(0.00597)	(0.00708)	(0.00682)
	[0.194]	[0.724]	[0.652]	[0.080]	[0.062]
Panel B:					
Rainfall Variability (σ/μ)	-0.00455	-0.00142	-0.00278	-0.0124	-0.0121
	(0.00337)	(0.00587)	(0.00609)	(0.00706)	(0.00710)
	[0.346]	[0.852]	[0.760]	[0.152]	[0.182]
log Consumption	0.122***	0.112***	0.122***	0.114**	0.108**
	(0.0339)	(0.0352)	(0.0388)	(0.0425)	(0.0428)
	[0.014]	[0.018]	[0.018]	[0.028]	[0.032]
Direct Effect Share (%)	65	43	61	86	76
Fixed Effects	Individual, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
Treatment Std. Dev.	5.217	3.093	3.057	2.742	2.390
Observations	4,033	4,033	4,033	4,033	4,033

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. All regressions include linear, quadratic, rainfall and temperature controls, as well as interactions between rainfall and temperature measures. The Direct Effect Share is calculated as the rainfall variability effect in Panel B divided by the rainfall variability effect in Panel A. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Figure 4: Randomization Inference Distributions



NOTES: Each plot represents the distribution of point estimates for rainfall variability by re-estimating equation (6), (10), and (11) on randomized placebo datasets. Each distribution is constructed by repeating the randomization and estimation procedure 10,000 times. Coefficients from the estimate using the real data are presented as vertical lines with exact p-values. Only the estimates on real consumption and life satisfaction have exact p-values < 0.01.

Table 11: Insurance Effects: Rainfall Variability and Life Satisfaction

	Life Satisfaction (Standardized)				
	(1)	(2)	(3)	(4)	(5)
Panel A:					
Rainfall Variability (σ/μ)	-0.0195***	-0.0145**	-0.0132*	-0.0213**	-0.0326***
	(0.00452)	(0.00663)	(0.00677)	(0.00784)	(0.00566)
	[0.114]	[0.102]	[0.142]	[0.066]	[0.002]
Rainfall Variability × Insured	0.0319**	0.0332**	0.0318**	0.0351*	0.0339*
	(0.0138)	(0.0148)	(0.0136)	(0.0165)	(0.0170)
	[0.040]	[0.006]	[0.008]	[0.018]	[0.062]
H_0: Rainfall Variability + (Rainfall Variability × Insured) = 0	0.0124	0.0186	0.0185	0.0138	0.0013
	(0.0139)	(0.0196)	(0.0184)	(0.0200)	(0.0198)
	Log Real Consumption Per Capita				
	(1)	(2)	(3)	(4)	(5)
Panel B:					
Rainfall Variability (σ/μ)	-0.0187***	-0.0141***	-0.0122**	-0.0184***	-0.0325***
	(0.00303)	(0.00445)	(0.00522)	(0.00587)	(0.00480)
	[0.036]	[0.022]	[0.072]	[0.058]	[0.016]
Rainfall Variability × Insured	-0.0207	-0.0190	-0.0218	-0.0152	-0.0107**
	(0.0139)	(0.0119)	(0.0136)	(0.00995)	(0.00404)
	[0.410]	[0.450]	[0.464]	[0.468]	[0.312]
H_0: Rainfall Variability + (Rainfall Variability × Insured) = 0	-0.0393**	-0.0330**	-0.0340**	-0.0335***	-0.0432***
	(0.0149)	(0.0116)	(0.0131)	(0.0104)	(0.0063)
Fixed Effects	Individual, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
Observations	4,033	4,033	4,033	4,033	4,033

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Insured is a binary variable equal to 1 if the household has been a member of eqqub for both rounds and zero otherwise. Rainfall Variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. All regressions include linear, quadratic, rainfall and temperature controls, as well as interactions between rainfall and temperature measures. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table 12: Optimism and Consumption Smoothing

	(1) Life Satisfaction	(2) Happiness	(3) logConsumption
log Rainfall	4.187***	1.526	3.091***
	(0.805)	(0.907)	(0.627)
	[0.002]	[0.244]	[0.014]
log Rainfall × More Uncertainty	-2.400***	-0.842	-1.489**
	(0.609)	(0.803)	(0.532)
	[0.014]	[0.526]	[0.056]
Individual Fixed Effects	Yes	Yes	No
Household Fixed Effects	No	No	Yes
Other Fixed Effects	Month and Year		
Observations	4,033	4,033	2,686

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. More Uncertainty is equal to 1 if the 30-year average of a village's rainfall variability exceeds the the 30-year average of rainfall variability measured across villages, 0 otherwise. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Online Appendices – Not for Publication

Contents

A Additional Results and Robustness Tests

A.1 The Agricultural Production Function

As the focus of this paper is to understand the effects of income variability, using rainfall variability as a proxy, it is important to demonstrate the relevance of rainfall realizations as a driver of agricultural production. In addition this exercise sheds light the functional form through which rainfall affects production.

Table A1 presents the results of this analysis. Across all specification we find evidence to suggest that more rainfall is better, with suggestive but limited evidence of diminishing returns. Column 1 shows that a 1 percent increase in rainfall is associated with a 2.157 percent increase in yields, highlighting the elastic responsiveness of yields to rainfall realizations. In column 2 and 3 we explore the level effect of rainfall, finding that a 100mm increase in rainfall is associated with an 18.2% increase in yields. Column 3 shows that non-linearities through a quadratic term do not appear to be too important.

Table A1: Disentangling Realized Income Events from Income Uncertainty: The Agricultural Production Function

	(1) log Yields	(2) log Yields	(3) log Yields
log Rainfall	2.157***		
	(0.638)		
	[0.012]		
Rainfall (100 mm)		0.182***	0.254**
		(0.0549)	(0.0856)
		[0.090]	[0.038]
Rainfall^2			-0.00327
			(0.00209)
			[0.440]
exp(Dep. Var. Mean)	1,109.769	1,109.769	1,109.769
Observations	3,812	3,812	3,812
Fixed Effects	Crop × Household, Month, and Year		
Temperature Controls	Yes	Yes	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. Daily average temperature controls are included in specification (1), while quadratic controls are included in specifications (2-3). Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

A.2 Rainfall Variability and Income Uncertainty

A.2.1 Timing Definitions

The main specification used throughout the paper defines rainfall variability over 5 years. The reason for this choice is that 5 years is the time between survey rounds. This ensures that there is no cross-over in the variation being exploited between rounds, e.g., for the 2009 round, rainfall variability is measured using rainfall data from 2008, 2007, 2006, 2005 and 2004. As the number of years increases there is less round-specific variation as the same years are being used to define the variability measure. For example if rainfall variability is defined over 7 years then there is a 2 year overlap in the definition of rainfall variability for the two rounds, e.g. for the 2009 round, rainfall variability would be measured using rainfall data from 2008, 2007, 2006, 2005, 2004, 2003 and 2002. The 2003 and 2002 rainfall data would also be used to define rainfall variability for the 2004 round.

Measured over shorter periods of time there will be less of a signal associated with variability after controlling for historical weather events. Indeed, we should not expect individuals to internalize changes in rainfall variability measured over very short time-frames. Furthermore, given the time between survey rounds we won't be fully controlling for weather conditions between rounds. Measured over longer time periods there is less real variation introduced into the data. However, there is no other reason to restrict rainfall variability to the 5 year period and if applied to other contexts the choice of a 5-year time period would certainly be considered ad hoc.

In this appendix we test the robustness of the results to this decision-rule table. As discussed above there are reasons that shorter or longer-time periods are less preferable; however, it is interesting to understand the robustness of our findings to alternative specifications. In the tables below we see that across all specifications results are broadly consistent with the findings presented in the main text.

Agricultural Production Using crop $\times$ household level data we explore the effects of rainfall variability on agricultural yields, the share sold of each crop and the price received for each crop, for households that sold a share of their crop.

First and foremost, there is less variation in the within-village standard deviation of rainfall variability when measured over shorter and longer periods. The maximum variation is provided when rainfall variability is over the 5-year time period, providing support for the decision rule.

In Table A2 we explore the effects of rainfall variability of agricultural yields, finding that across all time periods there is no robust relationship. The magnitude of the effect is very small and the coefficient sign is not consistent across time periods. These findings are robust to using the standard deviation of rainfall over the defined time-period as an alternative measure of rainfall variability (Table A16).

Table A3 presents our findings of the effects of rainfall variability on the share of production that is sold. Again there is no robust relationship and the magnitude of the coefficients are small. Again, these findings are robust to using the standard deviation of rainfall over the defined time-period as an alternative measure of rainfall variability (Table A17)

Table A4 explores the effects of rainfall variability on crop prices, for the subset of households that sell their crop. Here we observe that there are statistically significant declines in price measured over a 2-year time period. However, over longer time periods there are no effects of rainfall variability on price. The magnitude of the effects are small given the low baseline value and the small values of the residualized within-village standard deviation of rainfall variability for this sub-sample. As with the other outcomes of interest, these findings are robust to using the standard deviation of rainfall over the defined time-period as an alternative measure of rainfall variability (Table A18)

Tables A5 and A6 explore the effects of rainfall variability on the number of crops planted by the household and the share of the land that is allocated to the main crop (defined as the crop that has the largest share of land). Across all time definitions we find very limited evidence of changes to the number of crops or the share of the main crop. One exception is when rainfall variability is defined over a 4-year period. In this case we find that a one standard deviation increase in rainfall variability is associated with a 0.03 crop increase, a very small effect and so does not likely affect input costs in a considerable way. Given the lack of consistency across definitions and the small magnitude of this effect this effect should not be a major concern. Furthermore, this effect is not reflected in changes to yields, prices, or the share sold and so unlikely directly affects income. Results are robust to using the standard deviation of rainfall (Tables A19 and A20).

Hired Labor and Wages Tables A7 and A8, explore the effects of rainfall variability on the wages of hired labor and the number of workers hired by the household for the small subset of households that report hiring paid labor. Across all specification we find limited evidence of an effect of rainfall variability on wages or the number of worker days hired. The only exception to this is when rainfall variability is defined over a 9-year time period. In this case we find that a one-standard deviation is associated with a 7% reduction in the average day wage and a 10% increase in the number of worker days. These effects are non-trivial; however, they only relate to a small fraction of households. Furthermore there is no consistency in sign or magnitude in the other specifications. Results are robust to using the standard deviation of rainfall (Tables A21 and A22).

Table A9 explores the effects of rainfall variability on the likelihood that a household has hired any workers. Again, we find very limited evidence of any adjustments along this margin. The largest effect can once again be found when rainfall variability is defined over a 9-year period. Here we find that a one standard deviation increase in rainfall variability is associated with a 0.9% increase in the likelihood of hiring workers. However, the effect is not statistically significant after accounting for the small number of clusters. Results are robust to using the standard deviation of rainfall (Table A23).

Collectively, this evidence suggests that on the whole rainfall variability is unlikely to have a first-order effect on labor costs for households. The conjecture weakens as we increase the time-frame over which rainfall variability is measured; however, as discussed above there is less variation in rainfall variability measured over these time periods and so measuring rainfall variability over the 5-year period remains the preferred specification.

Livestock Tables A24, A25 and A26 examine the effects of rainfall variability on the number of livestock and whether the household owns any livestock over different time-definitions, using livestock $\times$ household level data. We find no robust effects of rainfall variability on the number of livestock owned, sold, or slaughtered across all specifications. Results are robust to using the standard deviation of rainfall (Tables **??**, **??** and **??**).

Given that livestock forms the most important measure of assets for these households our findings suggest that rainfall variability has a limited effect on assets/wealth.

Off-Farm Labor Supply Table A12 explores the effects of rainfall variability on whether adults engage in non-farm employment as an additional source of income. Across all timing definitions we find limited evidence that rainfall variability is associated with engagement in the non-farm labor market. The exception to this is when rainfall variability is defined over a 7-year period. However, the magnitude of this effect is small. A one standard deviation increase in rainfall variability is associated with a 0.9% decrease in the likelihood of engaging in the non-farm sector. Results are robust to using the standard deviation of rainfall (Table A27).

Similar results are found in Table A13, which examines the effects of rainfall variability on whether adults engage in employment outside of the village (a proxy for migration). We find that there is no effect in the likelihood of engaging in out of village work, except when rainfall variability is defined over a 4-year period. Here we find that a one standard deviation increase in rainfall variability is associated with a 1.1% decrease in the likelihood of working outside of the village, although it only remains significant at the 10% level after accounting for the small number of clusters. Taking the other point estimates as given the second largest effect is a 0.79% increase in the likelihood of working outside the village, demonstrating that the coefficient estimates are not robust across different time definitions. Results are robust to using the standard deviation of rainfall (Table A28).

Table A14 explores the effects of rainfall variability on the number of non-farm days worked during the last 4-months for the small subset of individuals that report to engage in such activities. We find no meaningful effects of rainfall variability on the number of days worked. Results are robust to using the standard deviation of rainfall (Table A29).

Collectively, these results suggest that rainfall variability is not having an effect on income through non-farm or off-farm activities, providing further support for the premise that rainfall variability is a reasonable proxy for income uncertainty.

Rainfall Realizations In addition, to exploring the effects of rainfall variability on contemporaneous income and wealth related outcomes, it is also important to look at how rainfall variability may affect the likelihood of historical income shocks as well as the potential future income shocks. We explore this potential by examining the direct effects of rainfall variability on rainfall realizations. This exercise is a direct test of the mean-preserving properties of rainfall, i.e., a priori there is no reason to expect that an increase in variability should affect the first-moment of the rainfall distribution. We explore the effects of rainfall variability (measured over different time-periods) on rainfall realizations contemporaneously as well as 4 years into the past and future. Furthermore, we estimate this relationship using 30 years of weather data. This means that our measure of rainfall variability in this context is a t-year moving average.

Table A15 presents the results of this analysis. Measured over the 5-year term, the preferred specification in our main analysis given the time between survey rounds. There is no relationship between rainfall variability and rainfall realizations contemporaneously, or over previous the 4-years. There appear to be weak relationships between rainfall variability and rainfall realizations 3-years into the future (significant at the 10% level). However, the magnitude of these effects are small. A one-standard deviation increase in rainfall variability is associated with a 22mm increase in rainfall. If we evaluate this using the agricultural production function results in Table A1 then such an effect could be associated with a 4% increase in yields.

Looking across different definitions of the time-period in which rainfall variability we observe a common pattern. Over smaller time-frames there appears to be little effect of rainfall variability on rainfall realizations. However, as the time-period increases from 7-years and above there appears to be more of a significant relationship between rainfall variability and rainfall realizations. This may be because over these longer periods the controls and functional forms used to control for historical rainfall shocks over longer time-frames are too restrictive meaning that we don't fully account for these effects. However, the magnitude of the effects are still not very large. The largest contemporaneous effect is measured over a 9-year period. In this specification a one-standard deviation increase is associated with a 38mm increase in rainfall, corresponding to a 7% increase in yield. However, despite this effect we observe no direct effects of rainfall variability on the agricultural outcomes discussed above. Furthermore, the range of contemporaneous estimates, across time-frames, goes from an implied 3.6% reduction in yields (20mm reduction) to a 7% increase in yields (38mm increase). The average effect of a one standard deviation increase in rainfall variability on contemporaneous rainfall across specifications is 17mm, with an implied 3.1% increase in yields.

In terms of rainfall variability's effect on historical rainfall realizations the same patterns emerge; however the magnitudes are smaller. The most robust effects are found in t-4. Here the relationship is negative. The largest effect found when rainfall variability is measured over

2-years. A one standard deviation increase in contemporaneous rainfall variability is associated with a 46mm reduction in rainfall. However, the average effect measured across all time-frames results in an 18mm reduction in rainfall (3.2% reduction in yields).

In terms of rainfall variability's effect on future rainfall realizations we again observe a similar pattern, with statistical significance increasing as rainfall variability is measured over a longer term. The largest effect is found when estimating the relationship between rainfall variability and rainfall realizations 2-years into the future, using a specification in which rainfall variability is measured over 10-years. Here we find that a one-standard deviation increase in rainfall variability is associated with a 40mm increase in rainfall 2 years later, equivalent to a 7.3% increase in yields. However, the average effect across time-periods is smaller (26mm, equivalent to a 5% increase in yields).

It is interesting to note that the sign of the effects are not consistent across estimates, i.e., rainfall variability tends to be negatively correlated with historical rainfall realizations and positively correlated with future rainfall realizations. Taking an average of across estimates within a specificiation, e.g., rainfall variability measured over 10 years the specification with the largest effects, we find that the average effect of rainfall variability on rainfall realizations between t-4 and t+4 is a 23mm increase in rainfall per year, equivalent to a 4.2% increase in yields. Using our preferred specification (5-years the time between survey rounds) the average effect is a 10mm increase in rainfall, equivalent to a 1.8% increase in yields.

We have highlighted her the largest effects of rainfall variability on historical, contemporaneous, and future rainfall realizations. Over smaller time frames (up to 7 years) rainfall variability, controlling for non-linear rainfall and temperature controls as well as interactions between these terms, does not appear to have a direct effect on rainfall realizations. However, over longer time-frames this functional form may be too restrictive, limiting our ability to control for historical rainfall shocks. Consequently, we should be cautious to interpret the effects of rainfall variability measured over longer-time periods as capturing the effects of income uncertainty.

Table A2: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Yields)

	(1) log Yields	(2) log Yields	(3) log Yields	(4) log Yields	(5) log Yields	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.0143**	-0.0240*	-0.0335***	-0.00982	-0.00608	1.227
	(0.00645)	(0.0117)	(0.0111)	(0.0159)	(0.0167)	
	[0.378]	[0.248]	[0.202]	[0.686]	[0.914]	
Rainfall Variability (σ/μ) (3 years)	-0.0206*	-0.0122	-0.0172	0.00244	0.0118*	1.678
	(0.0102)	(0.0121)	(0.0106)	(0.00670)	(0.00572)	
	[0.198]	[0.408]	[0.234]	[0.720]	[0.104]	
Rainfall Variability (σ/μ) (4 years)	-0.0319**	-0.00946	-0.00954	-0.00372	0.00604	1.471
	(0.0124)	(0.0122)	(0.0140)	(0.0140)	(0.0112)	
	[0.068]	[0.588]	[0.660]	[0.886]	[0.610]	
Rainfall Variability (σ/μ) (5 years)	-0.0189	-0.00837	-0.00727	-0.00841	-0.00230	1.692
	(0.0123)	(0.0113)	(0.0112)	(0.0143)	(0.00773)	
	[0.300]	[0.688]	[0.726]	[0.984]	[0.848]	
Rainfall Variability (σ/μ) (6 years)	-0.0275*	-0.0124	-0.00911	-0.00891	-0.00590	1.266
	(0.0147)	(0.0139)	(0.0134)	(0.0208)	(0.0113)	
	[0.342]	[0.512]	[0.618]	[0.922]	[0.768]	
Rainfall Variability (σ/μ) (7 years)	-0.0252	-0.0136	-0.0277	-0.00604	-0.0278**	1.380
	(0.0159)	(0.0131)	(0.0159)	(0.0130)	(0.0107)	
	[0.334]	[0.430]	[0.220]	[0.830]	[0.148]	
Rainfall Variability (σ/μ) (8 years)	-0.0178	-0.0280	-0.0302*	-0.0116	-0.0347	1.141
	(0.0233)	(0.0162)	(0.0163)	(0.0176)	(0.0202)	
	[0.630]	[0.216]	[0.166]	[0.682]	[0.610]	
Rainfall Variability (σ/μ) (9 years)	-0.0157	-0.0281	-0.0289	-0.0173	-0.0283	1.549
	(0.0199)	(0.0186)	(0.0188)	(0.0252)	(0.0238)	
	[0.674]	[0.330]	[0.340]	[0.930]	[0.766]	
Rainfall Variability (σ/μ) (10 years)	-0.0216	-0.0156	-0.0139	0.0160	0.0115	1.093
	(0.0171)	(0.0204)	(0.0216)	(0.0223)	(0.0172)	
	[0.310]	[0.566]	[0.654]	[0.598]	[0.678]	
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	3,812	3,812	3,812	3,812	3,812	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A3: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Share Sold)

	(1) Share Sold	(2) Share Sold	(3) Share Sold	(4) Share Sold	(5) Share Sold	(6) Share Sold Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.00103	-0.00416*	-0.00466	-0.00130	-0.00307	1.227
	(0.000966)	(0.00229)	(0.00271)	(0.00301)	(0.00309)	
	[0.492]	[0.088]	[0.102]	[0.762]	[0.702]	
Rainfall Variability (σ/μ) (3 years)	-0.00171	-0.00184	-0.00217	0.00198	0.00260	1.678
	(0.00132)	(0.00235)	(0.00251)	(0.00176)	(0.00205)	
	[0.256]	[0.524]	[0.498]	[0.422]	[0.374]	
Rainfall Variability (σ/μ) (4 years)	-0.00462**	-0.00327	-0.00325	-0.00178	-0.000936	1.471
	(0.00184)	(0.00276)	(0.00304)	(0.00278)	(0.00190)	
	[0.040]	[0.446]	[0.456]	[0.734]	[0.732]	
Rainfall Variability (σ/μ) (5 years)	-0.00175	-0.00284*	-0.00262	-0.00289*	-0.00194	1.692
	(0.00170)	(0.00151)	(0.00149)	(0.00162)	(0.00137)	
	[0.336]	[0.198]	[0.218]	[0.292]	[0.308]	
Rainfall Variability (σ/μ) (6 years)	-0.00268	-0.00239	-0.00178	-0.00451	-0.00468	1.266
	(0.00166)	(0.00229)	(0.00259)	(0.00457)	(0.00365)	
	[0.274]	[0.440]	[0.576]	[0.535]	[0.418]	
Rainfall Variability (σ/μ) (7 years)	-0.00153	-0.00159	-0.00476*	-0.000736	-0.00660**	1.380
	(0.00228)	(0.00251)	(0.00253)	(0.00289)	(0.00258)	
	[0.582]	[0.622]	[0.142]	[0.838]	[0.176]	
Rainfall Variability (σ/μ) (8 years)	0.000237	-0.00276	-0.00318	-0.00136	-0.00668*	1.141
	(0.00338)	(0.00291)	(0.00286)	(0.00369)	(0.00363)	
	[0.982]	[0.482]	[0.414]	[0.804]	[0.370]	
Rainfall Variability (σ/μ) (9 years)	0.000241	-0.00196	-0.00207	0.000614	-0.000893	1.549
	(0.00265)	(0.00304)	(0.00299)	(0.00410)	(0.00417)	
	[0.940]	[0.670]	[0.634]	[0.888]	[0.928]	
Rainfall Variability (σ/μ) (10 years)	-0.000823	0.000569	0.000256	0.00628	0.00482	1.093
	(0.00302)	(0.00358)	(0.00378)	(0.00425)	(0.00421)	
	[0.884]	[0.872]	[0.874]	[0.428]	[0.438]	
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	3,812	3,812	3,812	3,812	3,812	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A4: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Prices)

	(1) log Prices	(2) log Prices	(3) log Prices	(4) log Prices	(5) log Prices	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.0493*** (0.0135) [0.078]	-0.0475** (0.0166) [0.252]	-0.0472*** (0.00862) [0.134]	-0.0398*** (0.0110) [0.150]	-0.0335*** (0.00647) [0.020]	0.846
Rainfall Variability (σ/μ) (3 years)	-0.0496*** (0.0104) [0.086]	-0.0450*** (0.0116) [0.248]	-0.0411*** (0.00728) [0.078]	-0.0509*** (0.0122) [0.120]	-0.0153 (0.0140) [0.468]	0.715
Rainfall Variability (σ/μ) (4 years)	-0.0269 (0.0154) [0.322]	0.00181 (0.0105) [0.894]	-0.00208 (0.0126) [0.946]	0.0254 (0.0204) [0.480]	-0.00284 (0.0193) [0.904]	0.728
Rainfall Variability (σ/μ) (5 years)	0.0154 (0.0128) [0.390]	-0.00207 (0.00838) [0.834]	0.00357 (0.0117) [0.860]	0.00302 (0.00624) [0.634]	-0.0119 (0.0158) [0.492]	0.804
Rainfall Variability (σ/μ) (6 years)	-0.00423 (0.0217) [0.850]	0.0127 (0.0284) [0.810]	0.0300 (0.0227) [0.460]	0.00494 (0.0273) [0.940]	-0.0156 (0.0177) [0.486]	0.689
Rainfall Variability (σ/μ) (7 years)	-0.0646*** (0.0197) [0.022]	-0.0420** (0.0165) [0.076]	0.0222 (0.0429) [0.752]	-0.0855*** (0.0120) [0.020]	-0.0383 (0.0252) [0.352]	0.467
Rainfall Variability (σ/μ) (8 years)	0.00459 (0.0387) [0.984]	-0.0221 (0.0299) [0.530]	0.0357 (0.0324) [0.494]	0.0125 (0.0442) [0.842]	-0.0218 (0.0256) [0.478]	0.489
Rainfall Variability (σ/μ) (9 years)	0.0215 (0.0331) [0.786]	-0.00549 (0.0219) [0.810]	0.0170 (0.0169) [0.550]	0.0479** (0.0200) [0.152]	0.0207 (0.0179) [0.422]	0.638
Rainfall Variability (σ/μ) (10 years)	-0.0207 (0.0365) [0.774]	-0.00461 (0.0187) [0.812]	0.0219* (0.0120) [0.274]	0.00631 (0.0132) [0.710]	0.00268 (0.0138) [0.848]	0.693
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,546	1,546	1,546	1,546	1,546	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A5: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Crops)

	(1) Crop Count	(2) Crop Count	(3) Crop Count	(4) Crop Count	(5) Crop Count	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.0000777	0.00348	-0.000171	-0.00804	-0.00352	1.594
	(0.00320)	(0.00931)	(0.0108)	(0.0104)	(0.00894)	
	[0.936]	[0.726]	[0.992]	[0.548]	[0.804]	
Rainfall Variability (σ/μ) (3 years)	0.000781	-0.000783	-0.00544	-0.0106	-0.0103	2.043
	(0.00521)	(0.0107)	(0.00808)	(0.00638)	(0.00635)	
	[0.956]	[0.986]	[0.582]	[0.140]	[0.196]	
Rainfall Variability (σ/μ) (4 years)	-0.00519	0.000378	-0.0143	-0.0164*	-0.0139**	1.871
	(0.00625)	(0.0113)	(0.00974)	(0.00929)	(0.00626)	
	[0.458]	[0.940]	[0.250]	[0.220]	[0.042]	
Rainfall Variability (σ/μ) (5 years)	-0.00580	0.00216	0.00134	-0.00782**	-0.00917	2.154
	(0.00421)	(0.00566)	(0.00546)	(0.00348)	(0.00544)	
	[0.206]	[0.698]	[0.782]	[0.054]	[0.130]	
Rainfall Variability (σ/μ) (6 years)	-0.000294	0.0141	0.0121	-0.0102	-0.0142	1.621
	(0.00563)	(0.00905)	(0.0104)	(0.0117)	(0.0133)	
	[0.908]	[0.190]	[0.330]	[0.498]	[0.560]	
Rainfall Variability (σ/μ) (7 years)	-0.00989	-0.00509	0.00372	-0.00350	-0.00323	1.860
	(0.00663)	(0.0114)	(0.00855)	(0.0111)	(0.00942)	
	[0.166]	[0.664]	[0.706]	[0.786]	[0.802]	
Rainfall Variability (σ/μ) (8 years)	-0.0121	-0.0112	-0.00971	-0.00551	0.00445	1.484
	(0.00745)	(0.00897)	(0.00658)	(0.0112)	(0.0118)	
	[0.112]	[0.268]	[0.206]	[0.712]	[0.792]	
Rainfall Variability (σ/μ) (9 years)	-0.00930	-0.0110*	-0.00978*	0.00925	0.00856	1.820
	(0.00671)	(0.00611)	(0.00537)	(0.0145)	(0.0160)	
	[0.168]	[0.122]	[0.160]	[0.640]	[0.810]	
Rainfall Variability (σ/μ) (10 years)	-0.0142	-0.0147	-0.00914	0.0136	0.0146	1.266
	(0.00940)	(0.0101)	(0.0111)	(0.0101)	(0.00897)	
	[0.248]	[0.290]	[0.584]	[0.426]	[0.338]	
Fixed Effects			Household, Month, and Year			
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,072	2,072	2,072	2,072	2,072	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A6: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Main Crop Share)

	(1) Main Crop Share	(2) Main Crop Share	(3) Main Crop Share	(4) Main Crop Share	(5) Main Crop Share	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.000564	-0.00114	-0.000112	0.000771	-0.00391**	1.594
	(0.000724)	(0.000995)	(0.00177)	(0.00215)	(0.00156)	
	[0.626]	[0.338]	[0.930]	[0.776]	[0.098]	
Rainfall Variability (σ/μ) (3 years)	-0.00137	-0.000805	-0.000318	0.00132	-0.000334	2.043
	(0.000820)	(0.00135)	(0.00151)	(0.00203)	(0.00146)	
	[0.384]	[0.600]	[0.820]	[0.596]	[0.818]	
Rainfall Variability (σ/μ) (4 years)	-0.000681	-0.0000546	0.00188	0.00323	0.00234	1.871
	(0.00127)	(0.00187)	(0.00254)	(0.00227)	(0.00243)	
	[0.760]	[0.958]	[0.554]	[0.264]	[0.450]	
Rainfall Variability (σ/μ) (5 years)	-0.000164	-0.00146	-0.00136	0.000181	0.00181	2.154
	(0.00129)	(0.00163)	(0.00158)	(0.00129)	(0.00208)	
	[0.936]	[0.530]	[0.520]	[0.944]	[0.482]	
Rainfall Variability (σ/μ) (6 years)	-0.00183	-0.00447**	-0.00457*	-0.00286	-0.00182	1.621
	(0.00145)	(0.00206)	(0.00226)	(0.00350)	(0.00341)	
	[0.468]	[0.068]	[0.066]	[0.530]	[0.626]	
Rainfall Variability (σ/μ) (7 years)	-0.000726	-0.00291	-0.00464	-0.00311	-0.00363	1.860
	(0.00151)	(0.00237)	(0.00274)	(0.00247)	(0.00379)	
	[0.788]	[0.354]	[0.244]	[0.270]	[0.502]	
Rainfall Variability (σ/μ) (8 years)	0.000176	-0.00222	-0.00234	-0.00341	-0.00294	1.484
	(0.00204)	(0.00217)	(0.00202)	(0.00331)	(0.00449)	
	[0.942]	[0.492]	[0.474]	[0.470]	[0.806]	
Rainfall Variability (σ/μ) (9 years)	0.000580	-0.000383	-0.000276	-0.00233	-0.000806	1.820
	(0.00181)	(0.00181)	(0.00186)	(0.00325)	(0.00287)	
	[0.913]	[0.663]	[0.599]	[0.801]	[0.973]	
Rainfall Variability (σ/μ) (10 years)	0.000352	0.000631	0.00111	-0.001000	0.00299	1.266
	(0.00252)	(0.00292)	(0.00298)	(0.00218)	(0.00268)	
	[0.938]	[0.892]	[0.788]	[0.766]	[0.224]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,072	2,072	2,072	2,072	2,072	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A7: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Farm Wages)

	(1) log Avg. Wage	(2) log Avg. Wage	(3) log Avg. Wage	(4) log Avg. Wage	(5) log Avg. Wage	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.00182 (0.0343) [0.967]	0.00194 (0.0328) [0.941]	-0.0119 (0.0228) [0.669]	0.0477* (0.0246) [0.151]	0.0497 (0.0539) [0.463]	0.839
Rainfall Variability (σ/μ) (3 years)	-0.0104 (0.0298) [0.749]	-0.0128 (0.0322) [0.747]	-0.0196 (0.0235) [0.573]	-0.0139 (0.0239) [0.617]	0.00430 (0.0500) [0.823]	0.865
Rainfall Variability (σ/μ) (4 years)	0.0195 (0.0367) [0.615]	0.0282 (0.0318) [0.575]	0.0396 (0.0359) [0.445]	0.0252 (0.0285) [0.509]	0.0766* (0.0418) [0.261]	0.848
Rainfall Variability (σ/μ) (5 years)	0.0109 (0.0290) [0.721]	0.0115 (0.0247) [0.713]	0.0234 (0.0294) [0.553]	0.0125 (0.0239) [0.691]	0.0270 (0.0287) [0.499]	1.398
Rainfall Variability (σ/μ) (6 years)	0.00162 (0.0352) [0.903]	-0.0234 (0.0417) [0.631]	0.00409 (0.0452) [0.901]	-0.00994 (0.0389) [0.811]	-0.00417 (0.0394) [0.943]	0.917
Rainfall Variability (σ/μ) (7 years)	-0.0667** (0.0303) [0.908]	-0.0657** (0.0304) [0.317]	-0.0247 (0.0556) [0.697]	-0.00924 (0.0453) [0.867]	0.01000 (0.0473) [0.813]	0.751
Rainfall Variability (σ/μ) (8 years)	-0.0452 (0.0436) [0.447]	-0.0766* (0.0366) [0.397]	-0.0235 (0.0424) [0.739]	-0.0273 (0.0327) [0.529]	-0.0161 (0.0415) [0.677]	0.763
Rainfall Variability (σ/μ) (9 years)	-0.0429 (0.0349) [0.415]	-0.0591** (0.0221) [0.187]	-0.0348** (0.0127) [0.119]	-0.0572** (0.0238) [0.077]	-0.0933*** (0.0283) [0.103]	0.803
Rainfall Variability (σ/μ) (10 years)	-0.0640** (0.0220) [0.323]	-0.0604** (0.0255) [0.209]	-0.0280* (0.0149) [0.123]	-0.0170 (0.0183) [0.467]	-0.0847* (0.0433) [0.191]	0.757
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	683	683	683	683	683	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A8: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Hired Worker Days)

	(1) log Worker Days (Hired)	(2) log Worker Days (Hired)	(3) log Worker Days (Hired)	(4) log Worker Days (Hired)	(5) log Worker Days (Hired)	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.0365	-0.0220	-0.0152	-0.0699**	-0.101**	0.886
	(0.0385)	(0.0265)	(0.0290)	(0.0308)	(0.0442)	
	[0.411]	[0.481]	[0.659]	[0.137]	[0.229]	
Rainfall Variability (σ/μ) (3 years)	-0.0344	-0.00747	-0.00345	-0.0126	-0.0394	0.906
	(0.0355)	(0.0299)	(0.0293)	(0.0307)	(0.0467)	
	[0.489]	[0.815]	[0.911]	[0.703]	[0.467]	
Rainfall Variability (σ/μ) (4 years)	-0.0512	-0.0336	-0.0554	-0.0362	-0.0740*	0.885
	(0.0311)	(0.0281)	(0.0326)	(0.0272)	(0.0403)	
	[0.213]	[0.349]	[0.259]	[0.325]	[0.249]	
Rainfall Variability (σ/μ) (5 years)	0.0121	-0.00830	-0.0175	-0.00839	-0.0314	1.445
	(0.0306)	(0.0286)	(0.0279)	(0.0276)	(0.0268)	
	[0.667]	[0.737]	[0.571]	[0.791]	[0.361]	
Rainfall Variability (σ/μ) (6 years)	-0.0230	0.00461	-0.0201	0.00356	0.00833	0.930
	(0.0625)	(0.0551)	(0.0564)	(0.0437)	(0.0426)	
	[0.733]	[0.969]	[0.717]	[0.977]	[0.931]	
Rainfall Variability (σ/μ) (7 years)	0.0463	0.0521	0.0174	-0.0241	-0.0150	0.772
	(0.0567)	(0.0501)	(0.0787)	(0.0479)	(0.0443)	
	[0.587]	[0.505]	[0.869]	[0.631]	[0.655]	
Rainfall Variability (σ/μ) (8 years)	0.0784**	0.0597	0.0246	0.0267	0.0198	0.782
	(0.0357)	(0.0561)	(0.0678)	(0.0484)	(0.0459)	
	[0.207]	[0.513]	[0.907]	[0.747]	[0.735]	
Rainfall Variability (σ/μ) (9 years)	0.0656**	0.0533**	0.0423*	0.0984***	0.122***	0.822
	(0.0274)	(0.0217)	(0.0239)	(0.0308)	(0.0321)	
	[0.143]	[0.237]	[0.451]	[0.103]	[0.079]	
Rainfall Variability (σ/μ) (10 years)	0.0593*	0.0676**	0.0465	0.0341	0.111**	0.772
	(0.0308)	(0.0281)	(0.0301)	(0.0326)	(0.0480)	
	[0.527]	[0.409]	[0.419]	[0.601]	[0.171]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	727	727	727	727	727	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A9: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Hired Any Workers)

	(1) Hired Any Workers	(2) Hired Any Workers	(3) Hired Any Workers	(4) Hired Any Workers	(5) Hired Any Workers	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.00130	0.00304	0.00679**	0.00425	0.00541*	1.594
	(0.000805)	(0.00319)	(0.00294)	(0.00296)	(0.00269)	
	[0.246]	[0.458]	[0.158]	[0.282]	[0.128]	
Rainfall Variability (σ/μ) (3 years)	-0.00127	0.00455	0.00702**	0.00518*	0.00514*	2.051
	(0.00177)	(0.00421)	(0.00292)	(0.00243)	(0.00250)	
	[0.594]	[0.402]	[0.108]	[0.146]	[0.192]	
Rainfall Variability (σ/μ) (4 years)	0.000445	0.00209	0.00886**	0.00573**	0.00554*	1.876
	(0.00269)	(0.00424)	(0.00377)	(0.00218)	(0.00311)	
	[0.864]	[0.702]	[0.048]	[0.001]	[0.104]	
Rainfall Variability (σ/μ) (5 years)	0.000404	0.000744	0.000958	0.00466**	0.00416	2.159
	(0.00239)	(0.00320)	(0.00325)	(0.00160)	(0.00308)	
	[0.936]	[0.850]	[0.812]	[0.022]	[0.226]	
Rainfall Variability (σ/μ) (6 years)	-0.00212	-0.00469	-0.00413	0.00580	0.00486	1.617
	(0.00155)	(0.00304)	(0.00362)	(0.00410)	(0.00423)	
	[0.358]	[0.292]	[0.498]	[0.306]	[0.430]	
Rainfall Variability (σ/μ) (7 years)	0.000290	0.00172	0.000609	-0.000138	0.00296	1.861
	(0.00344)	(0.00532)	(0.00466)	(0.00327)	(0.00274)	
	[0.992]	[0.802]	[0.936]	[0.938]	[0.324]	
Rainfall Variability (σ/μ) (8 years)	-0.000108	0.00127	0.000822	-0.00261	0.00593	1.488
	(0.00392)	(0.00547)	(0.00469)	(0.00490)	(0.00347)	
	[0.982]	[0.862]	[0.922]	[0.718]	[0.138]	
Rainfall Variability (σ/μ) (9 years)	-0.000787	0.000235	-0.000168	-0.000567	0.00527**	1.826
	(0.00388)	(0.00449)	(0.00417)	(0.00332)	(0.00198)	
	[0.828]	[0.976]	[0.964]	[0.836]	[0.106]	
Rainfall Variability (σ/μ) (10 years)	0.00118	0.000785	-0.00113	-0.00378	0.00270	1.269
	(0.00651)	(0.00598)	(0.00598)	(0.00283)	(0.00405)	
	[0.910]	[0.936]	[0.920]	[0.206]	[0.554]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,053	2,053	2,053	2,053	2,053	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A10: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Livestock)

	(1) log Livestock	(2) log Livestock	(3) log Livestock	(4) log Livestock	(5) log Livestock	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.000669 (0.00113) [0.834]	-0.00218 (0.00239) [0.496]	-0.00248 (0.00267) [0.546]	-0.00311 (0.00362) [0.568]	-0.000544 (0.00505) [0.978]	1.486
Rainfall Variability (σ/μ) (3 years)	-0.000536 (0.00145) [0.828]	0.00136 (0.00330) [0.786]	0.00135 (0.00342) [0.776]	0.00119 (0.00324) [0.796]	0.00221 (0.00281) [0.686]	2.064
Rainfall Variability (σ/μ) (4 years)	-0.00120 (0.00175) [0.548]	0.00135 (0.00312) [0.730]	0.00216 (0.00372) [0.678]	0.000667 (0.00361) [0.842]	0.00216 (0.00368) [0.674]	1.903
Rainfall Variability (σ/μ) (5 years)	-0.000383 (0.00191) [0.906]	0.00281 (0.00209) [0.280]	0.00291 (0.00223) [0.320]	0.00243 (0.00249) [0.454]	0.000672 (0.00285) [0.846]	2.116
Rainfall Variability (σ/μ) (6 years)	-0.00131 (0.00236) [0.836]	0.00235 (0.00241) [0.450]	0.00303 (0.00277) [0.436]	0.00224 (0.00365) [0.643]	0.000848 (0.00443) [0.886]	1.536
Rainfall Variability (σ/μ) (7 years)	-0.00216 (0.00269) [0.704]	0.000135 (0.00264) [0.948]	-0.000485 (0.00319) [0.968]	-0.000438 (0.00261) [0.904]	-0.00509 (0.00697) [0.658]	1.429
Rainfall Variability (σ/μ) (8 years)	-0.00240 (0.00333) [0.732]	-0.000938 (0.00289) [0.812]	-0.000862 (0.00286) [0.816]	-0.00267 (0.00315) [0.554]	-0.00999 (0.00891) [0.444]	1.020
Rainfall Variability (σ/μ) (9 years)	-0.00261 (0.00335) [0.704]	-0.00288 (0.00313) [0.608]	-0.00303 (0.00319) [0.608]	-0.00443 (0.00426) [0.646]	-0.00591 (0.00468) [0.658]	1.689
Rainfall Variability (σ/μ) (10 years)	-0.00329 (0.00318) [0.332]	-0.00144 (0.00386) [0.752]	-0.00249 (0.00394) [0.626]	-0.00383 (0.00406) [0.444]	-0.00447 (0.00411) [0.436]	1.438
Fixed Effects	Livestock × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	10,397	10,397	10,397	10,397	10,397	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A11: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Any Livestock)

	(1) Own Any Livestock	(2) Own Any Livestock	(3) Own Any Livestock	(4) Own Any Livestock	(5) Own Any Livestock	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.000423	0.00291	0.00181	0.00306*	0.00135**	1.835
	(0.000414)	(0.00221)	(0.00119)	(0.00147)	(0.000597)	
	[0.392]	[0.360]	[0.266]	[0.074]	[0.068]	
Rainfall Variability (σ/μ) (3 years)	0.000879	0.00273	0.00238**	0.00284**	0.00271***	2.516
	(0.000626)	(0.00169)	(0.000850)	(0.000955)	(0.000753)	
	[0.336]	[0.124]	[0.058]	[0.016]	[0.056]	
Rainfall Variability (σ/μ) (4 years)	0.00109	0.00397*	0.00280**	0.00332**	0.00255**	2.411
	(0.000759)	(0.00205)	(0.00128)	(0.00137)	(0.000937)	
	[0.396]	[0.138]	[0.254]	[0.152]	[0.224]	
Rainfall Variability (σ/μ) (5 years)	0.000705	0.00141	0.00117	0.000452	0.00232**	2.701
	(0.000508)	(0.000972)	(0.00104)	(0.00119)	(0.000915)	
	[0.512]	[0.270]	[0.448]	[0.830]	[0.212]	
Rainfall Variability (σ/μ) (6 years)	0.000694	0.00152	0.000980	-0.000337	0.000355	2.175
	(0.000711)	(0.00129)	(0.000841)	(0.00199)	(0.00122)	
	[0.526]	[0.344]	[0.374]	[0.876]	[0.758]	
Rainfall Variability (σ/μ) (7 years)	0.000162	-0.000243	0.000332	-0.000782	-0.00126	2.547
	(0.000855)	(0.00145)	(0.000939)	(0.00158)	(0.00114)	
	[0.916]	[0.894]	[0.772]	[0.760]	[0.532]	
Rainfall Variability (σ/μ) (8 years)	0.000452	0.000458	-0.000470	0.000419	-0.00271	1.762
	(0.000995)	(0.00123)	(0.00116)	(0.00139)	(0.00162)	
	[0.780]	[0.818]	[0.744]	[0.822]	[0.388]	
Rainfall Variability (σ/μ) (9 years)	-0.0000931	-0.000245	-0.000324	-0.000996	-0.00181	2.351
	(0.00107)	(0.000883)	(0.000817)	(0.00125)	(0.00120)	
	[0.918]	[0.822]	[0.744]	[0.652]	[0.532]	
Rainfall Variability (σ/μ) (10 years)	0.0000190	-0.000874	0.000123	-0.00261	-0.00200	1.619
	(0.00141)	(0.00133)	(0.00146)	(0.00247)	(0.00170)	
	[0.990]	[0.508]	[0.972]	[0.420]	[0.514]	
Fixed Effects	Livestock × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	34,863	34,863	34,863	34,863	34,863	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A12: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Non-Farm Work)

	(1) Engaged in Off-Farm Work	(2) Engaged in Off-Farm Work	(3) Engaged in Off-Farm Work	(4) Engaged in Off-Farm Work	(5) Engaged in Off-Farm Work	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.00152 (0.00136) [0.848]	-0.00304 (0.00532) [0.762]	-0.00227 (0.00611) [0.912]	-0.00649 (0.00664) [0.700]	0.000679 (0.00572) [0.926]	1.152
Rainfall Variability (σ/μ) (3 years)	-0.00244 (0.00202) [0.882]	-0.000817 (0.00580) [0.910]	-0.000864 (0.00582) [0.920]	-0.00234 (0.00599) [0.754]	0.00651 (0.00468) [0.330]	1.444
Rainfall Variability (σ/μ) (4 years)	-0.00342 (0.00216) [0.858]	-0.00700 (0.00538) [0.426]	-0.00634 (0.00582) [0.468]	-0.00653 (0.00573) [0.496]	-0.00969 (0.00565) [0.396]	1.369
Rainfall Variability (σ/μ) (5 years)	-0.00391* (0.00197) [0.790]	-0.00571 (0.00489) [0.392]	-0.00629 (0.00448) [0.306]	-0.00490 (0.00534) [0.490]	-0.00957 (0.00598) [0.346]	1.417
Rainfall Variability (σ/μ) (6 years)	-0.00415 (0.00238) [0.752]	-0.00475 (0.00423) [0.456]	-0.00436 (0.00400) [0.474]	-0.00827 (0.00657) [0.390]	-0.0171* (0.00813) [0.212]	1.097
Rainfall Variability (σ/μ) (7 years)	-0.00497* (0.00242) [0.692]	-0.00700 (0.00425) [0.416]	-0.00975** (0.00336) [0.184]	-0.00668 (0.00419) [0.468]	-0.0105** (0.00409) [0.028]	0.876
Rainfall Variability (σ/μ) (8 years)	-0.00687* (0.00326) [0.630]	-0.00714 (0.00437) [0.636]	-0.00596 (0.00407) [0.500]	-0.00175 (0.00589) [0.822]	-0.00693 (0.00826) [0.462]	0.663
Rainfall Variability (σ/μ) (9 years)	-0.00762* (0.00394) [0.440]	-0.00805 (0.00522) [0.288]	-0.00755 (0.00529) [0.332]	-0.00173 (0.00619) [0.838]	-0.00458 (0.00740) [0.684]	1.281
Rainfall Variability (σ/μ) (10 years)	-0.0104** (0.00438) [0.400]	-0.0118 (0.00683) [0.498]	-0.0149** (0.00665) [0.424]	-0.00842 (0.00753) [0.634]	-0.00508 (0.00713) [0.622]	0.934
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,039	1,039	1,039	1,039	1,039	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A13: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Out-of-Village Work)

	(1) Engaged in Out of Village Work	(2) Engaged in Out of Village Work	(3) Engaged in Out of Village Work	(4) Engaged in Out of Village Work	(5) Engaged in Out of Village Work	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.00137	0.00687*	0.00521	-0.00465	-0.000686	1.153
	(0.001000)	(0.00340)	(0.00418)	(0.00357)	(0.00499)	
	[0.168]	[0.214]	[0.490]	[0.306]	[0.898]	
Rainfall Variability (σ/μ) (3 years)	0.00191	0.00151	0.000954	-0.00692***	-0.00502	1.444
	(0.00140)	(0.00422)	(0.00481)	(0.00226)	(0.00294)	
	[0.154]	[0.752]	[0.890]	[0.048]	[0.104]	
Rainfall Variability (σ/μ) (4 years)	0.00241	-0.00647	-0.0103***	-0.00990***	-0.00881***	1.369
	(0.00163)	(0.00406)	(0.00329)	(0.00159)	(0.00246)	
	[0.122]	[0.290]	[0.066]	[0.020]	[0.082]	
Rainfall Variability (σ/μ) (5 years)	0.00113	-0.00162	0.000181	-0.00442*	-0.00312	1.418
	(0.000991)	(0.00397)	(0.00423)	(0.00234)	(0.00358)	
	[0.184]	[0.762]	[0.968]	[0.130]	[0.518]	
Rainfall Variability (σ/μ) (6 years)	0.00305	0.00478*	0.00405	-0.00466	-0.000402	1.097
	(0.00223)	(0.00262)	(0.00252)	(0.00364)	(0.00432)	
	[0.160]	[0.168]	[0.250]	[0.354]	[0.966]	
Rainfall Variability (σ/μ) (7 years)	0.00120	-0.00306	-0.00183	-0.00368*	0.00914	0.867
	(0.00140)	(0.00370)	(0.00432)	(0.00201)	(0.00525)	
	[0.368]	[0.520]	[0.794]	[0.262]	[0.498]	
Rainfall Variability (σ/μ) (8 years)	0.0000209	-0.00431	-0.00455	-0.00225	0.00739	0.664
	(0.00192)	(0.00278)	(0.00285)	(0.00373)	(0.0111)	
	[0.936]	[0.392]	[0.356]	[0.620]	[0.790]	
Rainfall Variability (σ/μ) (9 years)	-0.000120	0.00199	0.00223	0.00327	-0.000631	1.281
	(0.00248)	(0.00304)	(0.00299)	(0.00430)	(0.00406)	
	[0.988]	[0.542]	[0.484]	[0.524]	[0.888]	
Rainfall Variability (σ/μ) (10 years)	-0.000264	0.00380	0.00458	-0.00233	-0.00622	0.935
	(0.00321)	(0.00274)	(0.00300)	(0.00397)	(0.00570)	
	[0.944]	[0.186]	[0.124]	[0.668]	[0.510]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,037	1,037	1,037	1,037	1,037	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A14: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Off-Farm Days Worked)

	(1) log Days Worked (Off-Farm)	(2) log Days Worked (Off-Farm)	(3) log Days Worked (Off-Farm)	(4) log Days Worked (Off-Farm)	(5) log Days Worked (Off-Farm)	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.00700	0.0349	0.0503*	0.145***	0.191***	0.341
	(0.0113)	(0.0396)	(0.0274)	(0.0360)	(0.0372)	
	[0.752]	[0.474]	[0.266]	[0.032]	[0.362]	
Rainfall Variability (σ/μ) (3 years)	0.0162	0.0400	0.0563**	-0.00704	0.0774	0.253
	(0.0171)	(0.0437)	(0.0250)	(0.0783)	(0.0741)	
	[0.606]	[0.404]	[0.134]	[0.908]	[0.722]	
Rainfall Variability (σ/μ) (4 years)	0.0323	-0.0225	0.0671	0.00964	0.0629	0.203
	(0.0215)	(0.0892)	(0.0922)	(0.0746)	(0.116)	
	[0.378]	[0.878]	[0.530]	[0.892]	[0.526]	
Rainfall Variability (σ/μ) (5 years)	0.0325*	0.0205	0.0156	0.0676	0.0172	0.245
	(0.0181)	(0.0153)	(0.0143)	(0.0414)	(0.0979)	
	[0.446]	[0.416]	[0.370]	[0.314]	[0.798]	
Rainfall Variability (σ/μ) (6 years)	0.0441*	0.0576***	0.0476**	0.0595***	0.0265	0.445
	(0.0225)	(0.0147)	(0.0195)	(0.0111)	(0.0431)	
	[0.776]	[0.622]	[0.452]	[0.542]	[0.972]	
Rainfall Variability (σ/μ) (7 years)	0.0226	0.0188	0.0172	0.0428	-0.00112	0.418
	(0.0228)	(0.0203)	(0.0122)	(0.0480)	(0.0356)	
	[0.414]	[0.204]	[0.744]	[0.190]	[0.642]	
Rainfall Variability (σ/μ) (8 years)	0.0411	0.0537***	0.0568**	0.00132	-0.0258	0.212
	(0.0283)	(0.0145)	(0.0197)	(0.0533)	(0.0960)	
	[0.754]	[0.290]	[0.788]	[0.980]	[0.872]	
Rainfall Variability (σ/μ) (9 years)	0.0435	0.0638*	0.0720*	0.0416	-0.0699	0.309
	(0.0284)	(0.0325)	(0.0359)	(0.0720)	(0.0763)	
	[0.726]	[0.286]	[0.338]	[0.796]	[0.586]	
Rainfall Variability (σ/μ) (10 years)	0.0765***	0.0662	0.0529	0.107	-0.0432	0.316
	(0.0237)	(0.0569)	(0.0866)	(0.111)	(0.0662)	
	[0.180]	[0.502]	[0.796]	[0.728]	[0.730]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	536	536	536	536	536	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A15: Disentangling Realized Income Events from Income Uncertainty: The Effects of Rainfall Variability on Rainfall Realizations

Outcome Variable	Treatment Variable: Rainfall Variability (σ/μ)								
	(1) (2 years)	(2) (3 years)	(3) (4 years)	(4) (5 years)	(5) (6 years)	(6) (7 years)	(7) (8 years)	(8) (9 years)	(9) (10 years)
Annual Rainfall (t+4)	-0.494	1.157	0.778	2.805	-0.785	-0.987	0.994	2.064	3.317**
	(0.858)	(2.101)	(1.712)	(1.996)	(2.302)	(1.813)	(1.600)	(1.502)	(1.294)
	[0.526]	[0.652]	[0.698]	[0.232]	[0.768]	[0.602]	[0.536]	[0.166]	[0.028]
Annual Rainfall (t+3)	0.844	1.824*	2.726	2.760*	4.505**	1.149	1.388	3.456	4.790**
	(0.960)	(1.022)	(1.879)	(1.411)	(1.915)	(2.252)	(2.024)	(2.051)	(1.949)
	[0.418]	[0.094]	[0.208]	[0.062]	[0.048]	[0.646]	[0.484]	[0.156]	[0.056]
Annual Rainfall (t+2)	0.353	1.215	2.668	4.192*	4.138**	6.188***	3.766*	4.599**	6.821***
	(1.155)	(1.633)	(1.611)	(2.253)	(1.879)	(1.886)	(2.058)	(2.082)	(2.243)
	[0.824]	[0.576]	[0.184]	[0.156]	[0.098]	[0.016]	[0.158]	[0.090]	[0.038]
Annual Rainfall (t+1)	-2.017*	-0.434	0.388	1.925	3.377*	4.124***	5.790***	3.751*	4.552**
	(0.992)	(1.431)	(1.445)	(1.687)	(1.705)	(1.380)	(1.440)	(1.749)	(1.866)
	[0.120]	[0.814]	[0.822]	[0.280]	[0.090]	[0.024]	[0.008]	[0.080]	[0.050]
Annual Rainfall (t)	-1.746**	-1.054	0.570	1.762	3.533**	4.673***	5.644***	6.249***	4.766***
	(0.683)	(0.851)	(1.171)	(1.066)	(1.289)	(1.489)	(0.979)	(1.188)	(1.512)
	[0.074]	[0.248]	[0.658]	[0.146]	[0.032]	[0.014]	[0.002]	[0.000]	[0.018]
Annual Rainfall (t-1)	1.746**	-0.972	-0.814	0.393	1.583	2.784**	3.607**	3.985***	4.526***
	(0.683)	(0.710)	(0.788)	(1.084)	(1.197)	(1.272)	(1.553)	(1.088)	(1.127)
	[0.072]	[0.188]	[0.270]	[0.808]	[0.276]	[0.056]	[0.018]	[0.008]	[0.002]
Annual Rainfall (t-2)	0.138	2.109*	-0.283	-0.688	0.574	1.482	2.363	3.170*	3.972**
	(1.415)	(1.020)	(0.561)	(0.851)	(1.257)	(1.330)	(1.538)	(1.479)	(1.810)
	[0.926]	[0.100]	[0.632]	[0.468]	[0.936]	[0.414]	[0.212]	[0.072]	[0.050]
Annual Rainfall (t-3)	-0.388	-0.479	0.418	-0.979	-1.192	0.0914	0.951	1.812	2.648*
	(0.934)	(1.368)	(1.511)	(1.018)	(1.051)	(1.086)	(1.265)	(1.752)	(1.362)
	[0.690]	[0.720]	[0.706]	[0.450]	[0.346]	[0.892]	[0.432]	[0.308]	[0.066]
Annual Rainfall (t-4)	-4.061***	-2.846**	-2.141*	-1.088	-2.595*	-3.347***	-1.887***	-0.898	0.0577
	(1.287)	(1.318)	(1.119)	(1.839)	(1.304)	(1.023)	(0.630)	(0.725)	(1.272)
	[0.044]	[0.192]	[0.128]	[0.656]	[0.092]	[0.028]	[0.004]	[0.220]	[0.962]
Observations	495	495	495	495	495	495	495	495	495
Treatment Std. Dev.	11.345	9.861	8.970	8.163	7.515	7.019	6.566	6.179	5.938
Fixed Effects	Village, Month, and Year								
Weather Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quadratic Weather Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather Interactions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the village level. Each coefficient relates to an individual regression. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

A.2.2 An Alternative Measure of Rainfall Variability – Standard Deviation of Rainfall

The following tables replicate the results discussed above, using the standard deviation of rainfall as our proxy for income uncertainty instead of the coefficient of variation.

Table A16: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Yields)

	(1) log Yields	(2) log Yields	(3) log Yields	(4) log Yields	(5) log Yields	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.0867	-0.111	-0.160*	0.0846	0.0709	0.185
	(0.0538)	(0.0748)	(0.0808)	(0.131)	(0.127)	
	[0.412]	[0.294]	[0.214]	[0.662]	[0.672]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.127	-0.0385	-0.0678	0.0837	0.105*	0.241
	(0.0791)	(0.0731)	(0.0619)	(0.0586)	(0.0523)	
	[0.260]	[0.692]	[0.364]	[0.238]	[0.136]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.248**	-0.0926	-0.0934	-0.0229	0.0418	0.202
	(0.0853)	(0.0845)	(0.0892)	(0.128)	(0.0856)	
	[0.060]	[0.414]	[0.458]	[0.990]	[0.616]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	-0.150	-0.0780	-0.0686	-0.0666	-0.0311	0.220
	(0.0917)	(0.0799)	(0.0769)	(0.107)	(0.0644)	
	[0.274]	[0.562]	[0.624]	[0.994]	[0.738]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.257**	-0.0985	-0.0848	-0.0761	-0.0751	0.164
	(0.0981)	(0.118)	(0.106)	(0.155)	(0.0840)	
	[0.160]	[0.568]	[0.564]	[0.886]	[0.608]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.225*	-0.0624	-0.190	-0.0401	-0.237**	0.166
	(0.109)	(0.118)	(0.140)	(0.101)	(0.0926)	
	[0.188]	[0.738]	[0.346]	[0.828]	[0.166]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.228	-0.200	-0.217	-0.0921	-0.279*	0.149
	(0.148)	(0.136)	(0.129)	(0.131)	(0.157)	
	[0.386]	[0.350]	[0.268]	[0.658]	[0.552]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.160	-0.184	-0.190	-0.104	-0.240	0.197
	(0.134)	(0.147)	(0.149)	(0.191)	(0.185)	
	[0.472]	[0.474]	[0.508]	[0.994]	[0.770]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.157	-0.0759	-0.0626	0.139	0.0584	0.164
	(0.104)	(0.121)	(0.124)	(0.129)	(0.136)	
	[0.182]	[0.642]	[0.734]	[0.410]	[0.812]	
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	3,812	3,812	3,812	3,812	3,812	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A17: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Share Sold)

	(1) Share Sold	(2) Share Sold	(3) Share Sold	(4) Share Sold	(5) Share Sold	(6) Share Sold Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.00433	-0.0164	-0.0169	0.0226	0.0131	0.185
	(0.00905)	(0.0107)	(0.0135)	(0.0268)	(0.0290)	
	[0.596]	[0.130]	[0.244]	[0.594]	[0.792]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.00802	-0.00264	-0.00425	0.0284	0.0302	0.241
	(0.0127)	(0.0131)	(0.0144)	(0.0161)	(0.0182)	
	[0.542]	[0.852]	[0.786]	[0.294]	[0.300]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.0372**	-0.0277	-0.0268	-0.0130	-0.00179	0.202
	(0.0130)	(0.0190)	(0.0200)	(0.0216)	(0.0154)	
	[0.028]	[0.438]	[0.370]	[0.738]	[0.936]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	-0.0142	-0.0199	-0.0180	-0.0177	-0.0108	0.220
	(0.0131)	(0.0122)	(0.0117)	(0.0124)	(0.0121)	
	[0.324]	[0.314]	[0.288]	[0.478]	[0.480]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.0281**	-0.0145	-0.0120	-0.0240	-0.0314	0.164
	(0.0107)	(0.0215)	(0.0214)	(0.0354)	(0.0290)	
	[0.088]	[0.594]	[0.636]	[0.644]	[0.476]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.0186	-0.00298	-0.0312	-0.000311	-0.0494*	0.166
	(0.0131)	(0.0244)	(0.0241)	(0.0249)	(0.0237)	
	[0.298]	[0.948]	[0.332]	[0.998]	[0.240]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.0119	-0.0172	-0.0204	-0.00761	-0.0481	0.149
	(0.0199)	(0.0243)	(0.0227)	(0.0286)	(0.0312)	
	[0.746]	[0.610]	[0.528]	[0.876]	[0.400]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.00706	-0.00867	-0.00932	0.0111	-0.00334	0.197
	(0.0164)	(0.0229)	(0.0226)	(0.0302)	(0.0339)	
	[0.832]	[0.816]	[0.846]	[0.784]	[0.970]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.0146	0.00814	0.00692	0.0469**	0.0358	0.164
	(0.0242)	(0.0195)	(0.0206)	(0.0204)	(0.0288)	
	[0.798]	[0.710]	[0.732]	[0.202]	[0.384]	
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	3,812	3,812	3,812	3,812	3,812	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A18: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Prices)

	(1) log Prices	(2) log Prices	(3) log Prices	(4) log Prices	(5) log Prices	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.278***	-0.294**	-0.289***	-0.222**	-0.225***	0.123
	(0.0733)	(0.109)	(0.0601)	(0.0927)	(0.0433)	
	[0.046]	[0.286]	[0.156]	[0.320]	[0.024]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.310***	-0.305***	-0.276***	-0.330***	-0.0879	0.110
	(0.0663)	(0.0704)	(0.0459)	(0.0747)	(0.0939)	
	[0.064]	[0.258]	[0.100]	[0.164]	[0.472]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.180*	0.0197	-0.00417	0.147	-0.0881	0.114
	(0.0936)	(0.0751)	(0.0961)	(0.131)	(0.159)	
	[0.258]	[0.794]	[0.986]	[0.536]	[0.766]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.0632	-0.0605	-0.0285	-0.00185	-0.169	0.117
	(0.0794)	(0.0525)	(0.0783)	(0.0292)	(0.132)	
	[0.548]	[0.354]	[0.818]	[0.904]	[0.448]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.279**	-0.0292	0.159	-0.0954	-0.109	0.105
	(0.119)	(0.190)	(0.183)	(0.174)	(0.114)	
	[0.188]	[0.860]	[0.576]	[0.656]	[0.476]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.473***	-0.287**	0.169	-0.635***	-0.270	0.069
	(0.0911)	(0.115)	(0.290)	(0.0796)	(0.167)	
	[0.030]	[0.054]	[0.706]	[0.022]	[0.312]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.367	-0.226	0.233	-0.107	-0.183	0.067
	(0.261)	(0.181)	(0.240)	(0.297)	(0.176)	
	[0.382]	[0.290]	[0.534]	[0.784]	[0.406]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.0236	-0.131	0.0794	0.262*	0.0334	0.079
	(0.220)	(0.133)	(0.117)	(0.126)	(0.140)	
	[0.962]	[0.490]	[0.650]	[0.210]	[0.810]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.203	-0.102	0.0506	-0.122	-0.0839	0.115
	(0.125)	(0.105)	(0.0964)	(0.132)	(0.0997)	
	[0.376]	[0.510]	[0.774]	[0.812]	[0.580]	
Fixed Effects	Crop × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,546	1,546	1,546	1,546	1,546	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A19: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Crops)

	(1) Crop Count	(2) Crop Count	(3) Crop Count	(4) Crop Count	(5) Crop Count	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	0.00925	0.0600	0.0422	0.0272	0.0807	0.240
	(0.0287)	(0.0538)	(0.0628)	(0.0848)	(0.103)	
	[0.830]	[0.356]	[0.606]	[0.812]	[0.596]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	0.0196	0.0292	0.000680	-0.0249	-0.0198	0.291
	(0.0452)	(0.0750)	(0.0539)	(0.0694)	(0.0689)	
	[0.732]	[0.730]	[0.992]	[0.762]	[0.794]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.0409	-0.00653	-0.0816	-0.118*	-0.0984**	0.254
	(0.0483)	(0.0833)	(0.0697)	(0.0561)	(0.0446)	
	[0.456]	[0.996]	[0.406]	[0.104]	[0.016]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	-0.0343	0.0257	0.0202	-0.0539*	-0.0718*	0.275
	(0.0375)	(0.0461)	(0.0466)	(0.0287)	(0.0401)	
	[0.422]	[0.614]	[0.654]	[0.116]	[0.090]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.0123	0.108	0.0992	-0.0718	-0.112	0.201
	(0.0426)	(0.0789)	(0.0832)	(0.0865)	(0.104)	
	[0.734]	[0.234]	[0.330]	[0.526]	[0.560]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.0769	-0.0343	0.0601	-0.0284	-0.0308	0.217
	(0.0509)	(0.104)	(0.0880)	(0.0928)	(0.0772)	
	[0.188]	[0.756]	[0.534]	[0.780]	[0.774]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.104**	-0.0840	-0.0714	-0.0569	0.000600	0.192
	(0.0448)	(0.0734)	(0.0605)	(0.0859)	(0.0872)	
	[0.048]	[0.308]	[0.306]	[0.620]	[0.999]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.0833*	-0.109**	-0.0998**	0.0347	0.0371	0.230
	(0.0471)	(0.0458)	(0.0399)	(0.0994)	(0.128)	
	[0.182]	[0.074]	[0.094]	[0.800]	[0.958]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.104	-0.150**	-0.121	0.0156	0.0169	0.192
	(0.0755)	(0.0641)	(0.0755)	(0.0771)	(0.0798)	
	[0.336]	[0.214]	[0.442]	[0.962]	[0.890]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,072	2,072	2,072	2,072	2,072	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A20: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Main Crop Share)

	(1) Main Crop Share	(2) Main Crop Share	(3) Main Crop Share	(4) Main Crop Share	(5) Main Crop Share	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.00423	-0.00767	-0.000474	0.00533	-0.00223	0.240
	(0.00542)	(0.00955)	(0.0162)	(0.0223)	(0.0242)	
	[0.582]	[0.456]	[0.978]	[0.864]	[0.506]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.00984	-0.00448	-0.00122	0.0109	0.00910	0.291
	(0.00690)	(0.0126)	(0.0138)	(0.0192)	(0.0189)	
	[0.340]	[0.770]	[0.942]	[0.708]	[0.736]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.00301	0.00568	0.0167	0.0309	0.0267	0.254
	(0.0106)	(0.0163)	(0.0197)	(0.0199)	(0.0199)	
	[0.816]	[0.800]	[0.512]	[0.176]	[0.268]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	-0.000174	-0.00744	-0.00673	0.00704	0.0116*	0.275
	(0.00925)	(0.00916)	(0.00906)	(0.00827)	(0.00614)	
	[0.968]	[0.508]	[0.516]	[0.522]	[0.226]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.0139	-0.0336*	-0.0336*	-0.0182	-0.0123	0.201
	(0.0119)	(0.0179)	(0.0183)	(0.0254)	(0.0275)	
	[0.400]	[0.074]	[0.074]	[0.616]	[0.804]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.00672	-0.0221	-0.0409	-0.0225	-0.0265	0.217
	(0.0113)	(0.0202)	(0.0270)	(0.0195)	(0.0315)	
	[0.672]	[0.336]	[0.250]	[0.288]	[0.598]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.0000932	-0.0179	-0.0189	-0.0233	-0.0202	0.192
	(0.0155)	(0.0189)	(0.0180)	(0.0255)	(0.0283)	
	[0.999]	[0.478]	[0.466]	[0.480]	[0.908]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	0.00556	0.000808	0.00172	-0.0117	-0.00607	0.230
	(0.0127)	(0.0144)	(0.0148)	(0.0224)	(0.0215)	
	[0.722]	[0.934]	[0.866]	[0.650]	[0.922]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	0.00564	0.0171	0.0205	0.0133	0.0270*	0.192
	(0.0128)	(0.0170)	(0.0167)	(0.0129)	(0.0127)	
	[0.668]	[0.430]	[0.348]	[0.372]	[0.154]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,072	2,072	2,072	2,072	2,072	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A21: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Farm Wages)

	(1) log Avg. Wage	(2) log Avg. Wage	(3) log Avg. Wage	(4) log Avg. Wage	(5) log Avg. Wage	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.0170	-0.0254	-0.0756	0.358*	0.342	0.120
	(0.181)	(0.202)	(0.143)	(0.179)	(0.368)	
	[0.923]	[0.927]	[0.669]	[0.155]	[0.465]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.0995	-0.139	-0.147	-0.113	-0.0780	0.139
	(0.170)	(0.186)	(0.145)	(0.147)	(0.262)	
	[0.621]	[0.633]	[0.523]	[0.577]	[0.823]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.00352	0.150	0.217	0.109	0.398	0.120
	(0.212)	(0.225)	(0.275)	(0.205)	(0.281)	
	[0.999]	[0.695]	[0.541]	[0.683]	[0.293]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.0326	0.0306	0.0890	0.0369	0.116	0.199
	(0.210)	(0.173)	(0.209)	(0.162)	(0.202)	
	[0.843]	[0.853]	[0.733]	[0.815]	[0.645]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.186	-0.258	-0.0425	-0.121	-0.0747	0.133
	(0.232)	(0.273)	(0.308)	(0.261)	(0.264)	
	[0.437]	[0.427]	[0.935]	[0.653]	[0.793]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.444*	-0.448*	-0.112	-0.128	0.0419	0.104
	(0.224)	(0.243)	(0.379)	(0.304)	(0.347)	
	[0.247]	[0.315]	[0.755]	[0.773]	[0.875]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.437	-0.503*	-0.130	-0.211	-0.117	0.103
	(0.302)	(0.273)	(0.307)	(0.224)	(0.325)	
	[0.443]	[0.385]	[0.773]	[0.503]	[0.687]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.317	-0.387***	-0.236**	-0.264	-0.720***	0.105
	(0.215)	(0.123)	(0.0827)	(0.184)	(0.208)	
	[0.409]	[0.157]	[0.143]	[0.359]	[0.061]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.360***	-0.350*	-0.158	-0.0988	-0.454*	0.125
	(0.118)	(0.168)	(0.103)	(0.118)	(0.257)	
	[0.427]	[0.205]	[0.197]	[0.491]	[0.193]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	683	683	683	683	683	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A22: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Hired Worker Days)

	(1) log Worker Days (Hired)	(2) log Worker Days (Hired)	(3) log Worker Days (Hired)	(4) log Worker Days (Hired)	(5) log Worker Days (Hired)	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.196	-0.0882	-0.0616	-0.479*	-0.696**	0.127
	(0.223)	(0.175)	(0.182)	(0.226)	(0.304)	
	[0.523]	[0.669]	[0.767]	[0.155]	[0.231]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.186	0.0132	0.0113	-0.0403	-0.110	0.144
	(0.224)	(0.191)	(0.185)	(0.193)	(0.273)	
	[0.569]	[0.971]	[0.987]	[0.841]	[0.681]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.249	-0.149	-0.294	-0.157	-0.347	0.125
	(0.227)	(0.206)	(0.272)	(0.205)	(0.273)	
	[0.581]	[0.549]	[0.403]	[0.509]	[0.323]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.0881	0.0164	-0.0134	0.00442	-0.137	0.205
	(0.248)	(0.200)	(0.203)	(0.190)	(0.198)	
	[0.643]	[0.993]	[0.903]	[0.999]	[0.521]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.240	0.157	-0.0366	0.0808	0.129	0.135
	(0.384)	(0.376)	(0.406)	(0.298)	(0.289)	
	[0.677]	[0.773]	[0.919]	[0.841]	[0.751]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	0.0287	0.307	-0.0346	-0.0989	-0.0624	0.107
	(0.445)	(0.390)	(0.550)	(0.347)	(0.329)	
	[0.995]	[0.511]	[0.955]	[0.731]	[0.777]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	0.386	0.348	0.0745	0.188	0.138	0.105
	(0.410)	(0.434)	(0.497)	(0.340)	(0.355)	
	[0.533]	[0.703]	[0.981]	[0.783]	[0.773]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	0.217	0.290	0.211	0.422	0.911***	0.107
	(0.341)	(0.165)	(0.190)	(0.301)	(0.257)	
	[0.561]	[0.661]	[0.749]	[0.473]	[0.055]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	0.128	0.281	0.141	0.0524	0.356	0.127
	(0.314)	(0.279)	(0.270)	(0.263)	(0.338)	
	[0.799]	[0.599]	[0.743]	[0.869]	[0.455]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	727	727	727	727	727	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A23: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Hired Any Workers)

	(1) Hired Any Workers	(2) Hired Any Workers	(3) Hired Any Workers	(4) Hired Any Workers	(5) Hired Any Workers	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.0108*	0.0240	0.0492**	0.0304	0.0388**	0.240
	(0.00587)	(0.0230)	(0.0208)	(0.0205)	(0.0175)	
	[0.196]	[0.370]	[0.138]	[0.220]	[0.084]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.00973	0.0356	0.0513**	0.0399**	0.0391*	0.292
	(0.0130)	(0.0289)	(0.0205)	(0.0184)	(0.0184)	
	[0.548]	[0.350]	[0.114]	[0.140]	[0.180]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	0.0127	0.0374	0.0747***	0.0592***	0.0520**	0.255
	(0.0210)	(0.0280)	(0.0229)	(0.0190)	(0.0242)	
	[0.608]	[0.290]	[0.018]	[0.001]	[0.066]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.00694	0.0114	0.0129	0.0400***	0.0445	0.275
	(0.0183)	(0.0224)	(0.0232)	(0.0108)	(0.0253)	
	[0.794]	[0.682]	[0.664]	[0.004]	[0.144]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.00685	-0.0279	-0.0250	0.0604*	0.0596*	0.201
	(0.0146)	(0.0260)	(0.0296)	(0.0289)	(0.0323)	
	[0.654]	[0.424]	[0.568]	[0.150]	[0.266]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	0.00399	0.0105	-0.00226	0.00451	0.0386	0.217
	(0.0256)	(0.0444)	(0.0392)	(0.0265)	(0.0264)	
	[0.904]	[0.842]	[0.952]	[0.910]	[0.214]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.000923	0.00586	0.00220	-0.0149	0.0562*	0.192
	(0.0280)	(0.0426)	(0.0377)	(0.0383)	(0.0279)	
	[0.954]	[0.914]	[0.999]	[0.770]	[0.082]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.00763	0.000697	-0.00249	-0.0110	0.0454***	0.231
	(0.0276)	(0.0349)	(0.0328)	(0.0278)	(0.0146)	
	[0.774]	[0.999]	[0.920]	[0.678]	[0.088]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	0.0157	0.00679	-0.00363	-0.0302	0.00496	0.191
	(0.0418)	(0.0379)	(0.0373)	(0.0197)	(0.0281)	
	[0.810]	[0.894]	[0.930]	[0.204]	[0.880]	
Fixed Effects		Household, Month, and Year				
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,053	2,053	2,053	2,053	2,053	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A24: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Livestock Owned)

	(1) Number of Livestock	(2) Number of Livestock	(3) Number of Livestock	(4) Number of Livestock	(5) Number of Livestock	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.000300	0.00264	0.000468	0.00173	-0.00115	1.875
	(0.00144)	(0.00575)	(0.00370)	(0.00529)	(0.00578)	
	[0.904]	[0.790]	[0.964]	[0.838]	[0.898]	
Rainfall Variability (σ/μ) (3 years)	0.000975	0.00571	0.00499**	0.00623**	0.00653**	2.569
	(0.00201)	(0.00464)	(0.00222)	(0.00265)	(0.00269)	
	[0.724]	[0.390]	[0.102]	[0.070]	[0.164]	
Rainfall Variability (σ/μ) (4 years)	0.000900	0.00903*	0.00685*	0.00777**	0.00667*	2.459
	(0.00233)	(0.00433)	(0.00342)	(0.00343)	(0.00347)	
	[0.808]	[0.184]	[0.184]	[0.146]	[0.260]	
Rainfall Variability (σ/μ) (5 years)	0.000932	0.00387*	0.00348*	0.00192	0.00467*	2.755
	(0.00212)	(0.00199)	(0.00195)	(0.00253)	(0.00258)	
	[0.760]	[0.200]	[0.202]	[0.478]	[0.208]	
Rainfall Variability (σ/μ) (6 years)	0.000462	0.00397	0.00304	0.000814	0.00181	2.220
	(0.00263)	(0.00290)	(0.00231)	(0.00453)	(0.00341)	
	[0.918]	[0.310]	[0.334]	[0.884]	[0.706]	
Rainfall Variability (σ/μ) (7 years)	-0.00171	-0.00224	-0.00139	-0.00351	-0.00351	2.597
	(0.00296)	(0.00365)	(0.00327)	(0.00374)	(0.00357)	
	[0.718]	[0.660]	[0.764]	[0.514]	[0.516]	
Rainfall Variability (σ/μ) (8 years)	-0.000918	-0.000806	-0.00255	-0.00100	-0.00560	1.796
	(0.00354)	(0.00368)	(0.00336)	(0.00374)	(0.00580)	
	[0.868]	[0.882]	[0.588]	[0.850]	[0.542]	
Rainfall Variability (σ/μ) (9 years)	-0.00171	-0.00209	-0.00224	-0.00407	-0.00588	2.400
	(0.00375)	(0.00359)	(0.00352)	(0.00541)	(0.00614)	
	[0.796]	[0.746]	[0.802]	[0.826]	[0.778]	
Rainfall Variability (σ/μ) (10 years)	-0.00294	-0.00225	-0.000525	-0.00897	-0.00696	1.653
	(0.00472)	(0.00492)	(0.00536)	(0.00871)	(0.00610)	
	[0.576]	[0.706]	[0.946]	[0.436]	[0.400]	
Fixed Effects	Livestock × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	34,863	34,863	34,863	34,863	34,863	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A25: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Livestock Sold)

	(1) Number of Livestock Sold	(2) Number of Livestock Sold	(3) Number of Livestock Sold	(4) Number of Livestock Sold	(5) Number of Livestock Sold	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	0.00107**	0.000727	0.000915	0.00229	0.00188	1.875
	(0.000488)	(0.00133)	(0.00146)	(0.00182)	(0.00243)	
	[0.128]	[0.624]	[0.570]	[0.454]	[0.672]	
Rainfall Variability (σ/μ) (3 years)	0.00161*	0.000746	0.000865	0.00149	0.00198	2.567
	(0.000874)	(0.00188)	(0.00168)	(0.00179)	(0.00170)	
	[0.142]	[0.796]	[0.648]	[0.500]	[0.448]	
Rainfall Variability (σ/μ) (4 years)	0.00209*	0.00121	0.00181	0.00173	0.00156	2.459
	(0.00107)	(0.00175)	(0.00203)	(0.00179)	(0.00185)	
	[0.168]	[0.626]	[0.568]	[0.532]	[0.670]	
Rainfall Variability (σ/μ) (5 years)	0.00209**	0.000421	0.000425	0.00148	0.00171	2.755
	(0.000934)	(0.00127)	(0.00132)	(0.00122)	(0.00147)	
	[0.138]	[0.798]	[0.816]	[0.43]	[0.516]	
Rainfall Variability (σ/μ) (6 years)	0.00212*	0.000352	0.000430	0.00250	0.00257	2.220
	(0.00108)	(0.00110)	(0.00111)	(0.00206)	(0.00216)	
	[0.138]	[0.816]	[0.74]	[0.388]	[0.444]	
Rainfall Variability (σ/μ) (7 years)	0.00279**	0.00199	0.00195	0.00220	0.00295*	2.597
	(0.00130)	(0.00120)	(0.00123)	(0.00137)	(0.00148)	
	[0.130]	[0.184]	[0.202]	[0.236]	[0.238]	
Rainfall Variability (σ/μ) (8 years)	0.00357**	0.00323**	0.00339**	0.00271*	0.00524**	1.796
	(0.00157)	(0.00144)	(0.00142)	(0.00145)	(0.00229)	
	[0.06]	[0.04]	[0.068]	[0.204]	[0.170]	
Rainfall Variability (σ/μ) (9 years)	0.00294*	0.00275	0.00275	0.00401*	0.00501**	2.400
	(0.00145)	(0.00162)	(0.00162)	(0.00205)	(0.00206)	
	[0.096]	[0.206]	[0.202]	[0.446]	[0.436]	
Rainfall Variability (σ/μ) (10 years)	0.00294	0.00162	0.000377	0.00158	0.000748	1.653
	(0.00202)	(0.00201)	(0.00205)	(0.00272)	(0.00248)	
	[0.212]	[0.570]	[0.910]	[0.714]	[0.844]	
Fixed Effects	Livestock × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	34,863	34,863	34,863	34,863	34,863	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A26: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Number of Livestock Slaughtered)

	(1) Number of Livestock Slaughtered	(2) Number of Livestock Slaughtered	(3) Number of Livestock Slaughtered	(4) Number of Livestock Slaughtered	(5) Number of Livestock Slaughtered	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.000118	-0.000596	-0.00102	-0.000462	-0.000578	1.875
	(0.000419)	(0.00123)	(0.000853)	(0.00139)	(0.00119)	
	[0.800]	[0.636]	[0.336]	[0.748]	[0.830]	
Rainfall Variability (σ/μ) (3 years)	-0.000287	0.000191	0.0000366	0.000262	0.00116*	2.569
	(0.000634)	(0.000890)	(0.000681)	(0.000801)	(0.000594)	
	[0.684]	[0.892]	[0.968]	[0.804]	[0.354]	
Rainfall Variability (σ/μ) (4 years)	-0.000454	0.000785	0.000536	0.000505	0.000417	2.459
	(0.000682)	(0.00104)	(0.00106)	(0.00113)	(0.00115)	
	[0.602]	[0.530]	[0.702]	[0.772]	[0.822]	
Rainfall Variability (σ/μ) (5 years)	-0.0000951	0.000331	0.000277	0.0000235	-0.0000576	2.755
	(0.000793)	(0.000523)	(0.000544)	(0.000694)	(0.000751)	
	[0.906]	[0.612]	[0.658]	[0.978]	[0.96]	
Rainfall Variability (σ/μ) (6 years)	-0.000281	0.000386	0.000281	-0.000481	-0.000499	2.220
	(0.000826)	(0.000663)	(0.000645)	(0.00117)	(0.00115)	
	[0.708]	[0.634]	[0.732]	[0.768]	[0.788]	
Rainfall Variability (σ/μ) (7 years)	-0.000861	-0.00132	-0.00136	-0.00163*	-0.000702	2.597
	(0.000566)	(0.000803)	(0.000856)	(0.000776)	(0.000664)	
	[0.412]	[0.270]	[0.314]	[0.234]	[0.454]	
Rainfall Variability (σ/μ) (8 years)	-0.000684	-0.000965	-0.00103	-0.000697	0.00103	1.796
	(0.000951)	(0.000613)	(0.000714)	(0.000785)	(0.00132)	
	[0.572]	[0.300]	[0.314]	[0.486]	[0.658]	
Rainfall Variability (σ/μ) (9 years)	-0.00112	-0.00115*	-0.00116*	-0.000234	-0.000361	2.400
	(0.000943)	(0.000635)	(0.000635)	(0.00135)	(0.00161)	
	[0.412]	[0.242]	[0.260]	[0.862]	[0.832]	
Rainfall Variability (σ/μ) (10 years)	-0.00248*	-0.00162	-0.00168	-0.00193	-0.00151	1.653
	(0.00118)	(0.00105)	(0.00106)	(0.00212)	(0.00215)	
	[0.188]	[0.192]	[0.162]	[0.500]	[0.670]	
Fixed Effects	Livestock × Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	34,863	34,863	34,863	34,863	34,863	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A27: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Non-Farm Work)

	(1) Engaged in Off-Farm Work	(2) Engaged in Off-Farm Work	(3) Engaged in Off-Farm Work	(4) Engaged in Off-Farm Work	(5) Engaged in Off-Farm Work	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	-0.00922	0.00157	0.00950	-0.0237	0.000673	0.184
	(0.0109)	(0.0394)	(0.0455)	(0.0369)	(0.0208)	
	[0.856]	[0.902]	[0.814]	[0.664]	[0.966]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	-0.0158	0.0155	0.0154	0.00707	0.0587*	0.202
	(0.0177)	(0.0480)	(0.0481)	(0.0499)	(0.0297)	
	[0.884]	[0.784]	[0.786]	[0.940]	[0.230]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	-0.0217	-0.0180	-0.0141	-0.0188	-0.0580	0.152
	(0.0213)	(0.0568)	(0.0572)	(0.0563)	(0.0628)	
	[0.870]	[0.812]	[0.820]	[0.786]	[0.596]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	-0.0282	-0.0268	-0.0346	-0.0151	-0.0515	0.153
	(0.0193)	(0.0501)	(0.0462)	(0.0533)	(0.0621)	
	[0.800]	[0.660]	[0.574]	[0.802]	[0.554]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	-0.0290	-0.0248	-0.0230	-0.0242	-0.110	0.112
	(0.0221)	(0.0368)	(0.0337)	(0.0618)	(0.0862)	
	[0.804]	[0.598]	[0.624]	[0.744]	[0.390]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	-0.0369	-0.0506	-0.0754**	-0.0501	-0.0642	0.114
	(0.0224)	(0.0362)	(0.0297)	(0.0351)	(0.0398)	
	[0.710]	[0.426]	[0.208]	[0.464]	[0.126]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	-0.0499*	-0.0536	-0.0436	-0.0104	-0.0229	0.102
	(0.0255)	(0.0357)	(0.0328)	(0.0424)	(0.0547)	
	[0.600]	[0.600]	[0.484]	[0.820]	[0.684]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	-0.0594*	-0.0607	-0.0554	-0.0125	-0.0283	0.177
	(0.0334)	(0.0442)	(0.0447)	(0.0422)	(0.0512)	
	[0.414]	[0.280]	[0.348]	[0.826]	[0.696]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	-0.0731	-0.0922	-0.106	-0.0549	-0.0214	0.136
	(0.0494)	(0.0667)	(0.0661)	(0.0572)	(0.0460)	
	[0.484]	[0.516]	[0.522]	[0.638]	[0.742]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,039	1,039	1,039	1,039	1,039	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A28: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Out-of-Village Work)

	(1) Engaged in Out of Village Work	(2) Engaged in Out of Village Work	(3) Engaged in Out of Village Work	(4) Engaged in Out of Village Work	(5) Engaged in Out of Village Work	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	0.0100 (0.00761) [0.194]	0.0414 (0.0258) [0.282]	0.0299 (0.0322) [0.496]	-0.0406 (0.0232) [0.290]	-0.0146 (0.0257) [0.590]	0.184
Rainfall Variability ($\sigma, 100mm$) (3 years)	0.0146 (0.0109) [0.148]	0.0111 (0.0323) [0.778]	0.00879 (0.0347) [0.854]	-0.0504** (0.0193) [0.070]	-0.0364* (0.0195) [0.044]	0.202
Rainfall Variability ($\sigma, 100mm$) (4 years)	0.0219 (0.0141) [0.084]	-0.0571 (0.0330) [0.212]	-0.0678** (0.0265) [0.122]	-0.0748*** (0.0154) [0.022]	-0.0629* (0.0317) [0.242]	0.153
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.00999 (0.00893) [0.192]	-0.0205 (0.0361) [0.654]	0.00409 (0.0397) [0.958]	-0.0370 (0.0253) [0.244]	-0.0252 (0.0410) [0.688]	0.153
Rainfall Variability ($\sigma, 100mm$) (6 years)	0.0293 (0.0186) [0.104]	0.0460** (0.0205) [0.126]	0.0429** (0.0194) [0.162]	-0.0298 (0.0333) [0.456]	0.00847 (0.0446) [0.888]	0.112
Rainfall Variability ($\sigma, 100mm$) (7 years)	0.0154 (0.0128) [0.214]	-0.0281 (0.0329) [0.514]	-0.0172 (0.0391) [0.794]	-0.0314* (0.0173) [0.244]	0.0505 (0.0454) [0.592]	0.114
Rainfall Variability ($\sigma, 100mm$) (8 years)	0.00785 (0.0144) [0.570]	-0.0371 (0.0237) [0.356]	-0.0393 (0.0245) [0.322]	-0.0233 (0.0264) [0.486]	0.0194 (0.0663) [0.854]	0.102
Rainfall Variability ($\sigma, 100mm$) (9 years)	0.00374 (0.0212) [0.844]	0.00677 (0.0243) [0.768]	0.00931 (0.0241) [0.702]	0.0109 (0.0275) [0.702]	-0.0105 (0.0264) [0.732]	0.177
Rainfall Variability ($\sigma, 100mm$) (10 years)	0.00606 (0.0303) [0.854]	0.0189 (0.0308) [0.524]	0.0208 (0.0300) [0.468]	-0.0225 (0.0323) [0.626]	-0.0378 (0.0405) [0.564]	0.136
Fixed Effects			Household, Month, and Year			
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	1,037	1,037	1,037	1,037	1,037	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A29: Disentangling Realized Income Events from Income Uncertainty: Defining Rainfall Variability Over Different Time Frames (Off-Farm Days Worked)

	(1) log Days Worked (Off-Farm)	(2) log Days Worked (Off-Farm)	(3) log Days Worked (Off-Farm)	(4) log Days Worked (Off-Farm)	(5) log Days Worked (Off-Farm)	(6) Within Group Std. Dev
Rainfall Variability ($\sigma, 100mm$) (2 years)	0.0334	0.133	0.173	1.103**	1.726***	0.042
	(0.0750)	(0.211)	(0.147)	(0.423)	(0.306)	
	[0.770]	[0.602]	[0.476]	[0.136]	[0.150]	
Rainfall Variability ($\sigma, 100mm$) (3 years)	0.108	0.202	0.270	-0.283	0.790	0.026
	(0.126)	(0.262)	(0.184)	(0.430)	(0.576)	
	[0.592]	[0.488]	[0.274]	[0.564]	[0.724]	
Rainfall Variability ($\sigma, 100mm$) (4 years)	0.266	-0.428	-0.0986	-0.418	-0.0556	0.025
	(0.171)	(0.911)	(0.868)	(0.812)	(0.962)	
	[0.294]	[0.830]	[0.836]	[0.606]	[0.958]	
Rainfall Variability ($\sigma, 100mm$) (5 years)	0.310*	0.174	0.0899	0.462	0.00657	0.036
	(0.151)	(0.134)	(0.138)	(0.331)	(0.645)	
	[0.358]	[0.446]	[0.590]	[0.402]	[0.999]	
Rainfall Variability ($\sigma, 100mm$) (6 years)	0.245	0.149	0.107	0.305	-0.195	0.049
	(0.190)	(0.169)	(0.113)	(0.389)	(0.301)	
	[0.534]	[0.618]	[0.566]	[0.562]	[0.752]	
Rainfall Variability ($\sigma, 100mm$) (7 years)	0.475**	0.469***	0.375*	0.504***	0.172	0.046
	(0.189)	(0.133)	(0.197)	(0.108)	(0.430)	
	[0.226]	[0.214]	[0.814]	[0.212]	[0.770]	
Rainfall Variability ($\sigma, 100mm$) (8 years)	0.444**	0.426***	0.458**	-0.0285	-0.237	0.025
	(0.191)	(0.121)	(0.178)	(0.437)	(0.840)	
	[0.498]	[0.378]	[0.764]	[0.950]	[0.836]	
Rainfall Variability ($\sigma, 100mm$) (9 years)	0.517**	0.600*	0.699**	0.256	-0.486	0.037
	(0.188)	(0.304)	(0.323)	(0.699)	(0.740)	
	[0.368]	[0.230]	[0.292]	[0.842]	[0.664]	
Rainfall Variability ($\sigma, 100mm$) (10 years)	0.686**	0.644	0.519	0.789	-0.334	0.046
	(0.282)	(0.608)	(0.841)	(0.967)	(0.454)	
	[0.120]	[0.564]	[0.764]	[0.688]	[0.716]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	536	536	536	536	536	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the household level. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A30: Disentangling Realized Income Events from Income Uncertainty: The Effects of Rainfall Variability on Rainfall Realizations

Outcome Variable	Treatment Variable: Rainfall Variability (σ, 100mm)				
	(1)	(2)	(3)	(4)	(5)
Annual Rainfall (t+4)	19.89*	23.44	24.40*	33.00**	31.09**
	(10.87)	(13.38)	(13.63)	(11.93)	(12.32)
	[0.130]	[0.188]	[0.194]	[0.018]	[0.050]
Annual Rainfall (t+3)	18.90	20.59	21.31	28.03**	28.49**
	(12.72)	(14.61)	(13.97)	(10.54)	(11.25)
	[0.222]	[0.292]	[0.248]	[0.038]	[0.058]
Annual Rainfall (t+2)	10.98	7.269	12.61	27.08	28.43
	(16.14)	(16.58)	(14.85)	(16.34)	(16.17)
	[0.518]	[0.686]	[0.494]	[0.154]	[0.154]
Annual Rainfall (t+1)	5.074	-3.592	2.911	9.370	13.79
	(17.50)	(17.45)	(13.36)	(13.38)	(13.57)
	[0.764]	[0.838]	[0.868]	[0.508]	[0.378]
Annual Rainfall (t)	56.06***	22.81*	20.94*	17.00	18.66*
	(12.41)	(11.44)	(10.74)	(10.40)	(10.33)
	[0.001]	[0.152]	[0.166]	[0.184]	[0.148]
Annual Rainfall (t-1)	41.41**	4.538	5.590	5.161	6.994
	(14.78)	(6.483)	(7.589)	(8.230)	(8.738)
	[0.042]	[0.554]	[0.560]	[0.628]	[0.506]
Annual Rainfall (t-2)	34.09**	-10.68***	-7.374	-5.637	-5.061
	(13.52)	(3.175)	(4.593)	(4.470)	(4.906)
	[0.088]	[0.022]	[0.134]	[0.268]	[0.330]
Annual Rainfall (t-3)	39.04**	-11.34	-10.89	-7.390	-8.784
	(14.84)	(9.673)	(8.139)	(8.732)	(8.426)
	[0.050]	[0.376]	[0.258]	[0.494]	[0.372]
Annual Rainfall (t-4)	34.08	-12.87	-13.65	-14.33	-17.54
	(20.08)	(14.86)	(14.77)	(15.48)	(16.40)
	[0.156]	[0.562]	[0.476]	[0.490]	[0.412]
Observations	495	495	495	495	495
Treatment Std. Dev.	1.217	1.160	1.065	0.998	0.981
Fixed Effects	Village, Month, and Year				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the village level. Each coefficient relates to an individual regression. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A31: Disentangling Realized Income Events from Income Uncertainty: The Effects of Rainfall Variability on Rainfall Realizations

Outcome Variable	Treatment Variable: Rainfall Variability (σ, 100mm)								
	(1) (2 years)	(2) (3 years)	(3) (4 years)	(4) (5 years)	(5) (6 years)	(6) (7 years)	(7) (8 years)	(8) (9 years)	(9) (10 years)
Annual Rainfall (t+4)	-1.278	15.63	16.42	31.09**	4.195	3.120	22.22	33.54	46.05**
	(6.028)	(14.12)	(12.32)	(14.61)	(13.27)	(15.92)	(19.28)	(17.30)	
	[0.768]	[0.372]	[0.248]	[0.050]	[0.774]	[0.836]	[0.190]	[0.114]	[0.020]
Annual Rainfall (t+3)	3.840	18.24*	27.47*	28.49**	39.72**	13.54	14.36	34.08	47.08*
	(7.506)	(8.715)	(13.45)	(11.25)	(13.38)	(16.46)	(17.15)	(21.21)	(24.77)
	[0.592]	[0.084]	[0.096]	[0.058]	[0.020]	[0.422]	[0.380]	[0.146]	[0.108]
Annual Rainfall (t+2)	-4.940	-3.513	14.15	28.43	28.74*	42.40**	22.57	28.31	50.26**
	(7.539)	(11.44)	(12.17)	(16.17)	(14.20)	(14.93)	(16.78)	(18.67)	(23.27)
	[0.472]	[0.738]	[0.312]	[0.154]	[0.120]	[0.034]	[0.244]	[0.188]	[0.084]
Annual Rainfall (t+1)	-14.99*	-10.01	-3.470	13.79	26.71*	32.00**	43.35***	26.56*	33.51*
	(8.330)	(11.39)	(11.58)	(13.57)	(14.23)	(12.48)	(12.82)	(14.87)	(17.04)
	[0.100]	[0.450]	[0.768]	[0.378]	[0.114]	[0.048]	[0.016]	[0.124]	[0.090]
Annual Rainfall (t)	-9.295	-4.727	7.529	18.66*	36.03***	47.73***	53.86***	59.52***	48.65***
	(7.265)	(10.10)	(11.27)	(10.33)	(11.30)	(11.45)	(9.271)	(11.35)	(11.63)
	[0.258]	[0.662]	[0.540]	[0.148]	[0.022]	[0.006]	[0.000]	[0.002]	[0.004]
Annual Rainfall (t-1)	9.295	-4.192	-3.096	6.994	19.60*	33.50**	45.16***	48.68***	54.52***
	(7.265)	(4.891)	(6.669)	(8.738)	(9.842)	(11.57)	(13.01)	(11.44)	(13.22)
	[0.256]	[0.386]	[0.598]	[0.506]	[0.080]	[0.010]	[0.004]	[0.004]	[0.002]
Annual Rainfall (t-2)	-5.638	8.758	-2.613	-5.061	3.413	13.18	24.50**	35.60***	41.44**
	(11.89)	(11.04)	(4.604)	(4.906)	(6.779)	(7.717)	(11.21)	(11.03)	(15.33)
	[0.698]	[0.438]	[0.580]	[0.330]	[0.726]	[0.134]	[0.070]	[0.014]	[0.014]
Annual Rainfall (t-3)	-6.825	-12.75	-3.819	-8.784	-9.351	-1.834	8.968	20.30	32.56**
	(5.801)	(11.93)	(13.91)	(8.426)	(7.131)	(6.788)	(8.301)	(13.37)	(13.04)
	[0.322]	[0.344]	[0.884]	[0.372]	[0.296]	[0.926]	[0.296]	[0.154]	[0.038]
Annual Rainfall (t-4)	-32.32***	-26.25**	-27.66**	-17.54	-24.16**	-26.74***	-17.79***	-6.578	6.958
	(9.659)	(10.43)	(10.55)	(16.40)	(10.69)	(6.921)	(5.021)	(4.949)	(9.470)
	[0.028]	[0.084]	[0.034]	[0.412]	[0.076]	[0.006]	[0.002]	[0.276]	[0.392]
Observations	495	495	495	495	495	495	495	495	495
Treatment Std. Dev.	1.508	1.222	1.088	0.981	0.902	0.840	0.780	0.726	0.684
Fixed Effects	Village, Month, and Year								
Weather Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quadratic Weather Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather Interactions	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the village level. Each coefficient relates to an individual regression. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

A.3 Main Results

A.3.1 Timing Definitions

As explored for the supporting results, I also examine the sensitivity of the main results to defining rainfall variability over different time frames, ranging from two to 10 years. These results are presented in Tables A32.

Consumption First, we re-explore the effects of rainfall variability on consumption (Table A32). We find similar results when rainfall variability is defined over 2-6 years. However, when rainfall variability is defined over longer periods the effects quickly lose statistical significance. This may be due to the reduction in independent variation across rounds associated with expanding the time horizon. These findings are broadly robust to using an alternative measure of rainfall variability, the standard deviation of rainfall, discussed below (Table A35).

Life Satisfaction Second, we re-explore the effects of rainfall variability of life satisfaction (Table A33. We find similar results when rainfall variability is defined over all years (2-10) years; however, results become statistically insignificant when rainfall variability is defined over very short periods (2-3 years) or long periods (9-10 years) after accounting for the small number of clusters. Again, these findings are broadly robust to using an alternative measure of rainfall variability, the standard deviation of rainfall (Table A36).

Happiness Third, we re-explore the effects of rainfall variability on happiness (Table A34. Unlike the results for consumption and life satisfaction the effects of rainfall variability on happiness are not robust across timing definitions, supporting the premise that income uncertainty has less of an effect on contemporaneous subjective well-being, compared to more evaluative measures of subjective well-being. These inferences hold when using an alternative measure of rainfall variability, the standard deviation of rainfall (Table A37).

Table A32: Rainfall Variability and Consumption

	Log Real Consumption Per Capita					Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall Variability (σ/μ) (2 years)	-0.01000***	-0.0360***	-0.0369***	-0.0478***	-0.0270***	1.887
	(0.00205)	(0.00488)	(0.00743)	(0.00753)	(0.00489)	
	[0.020]	[0.004]	[0.008]	[0.010]	[0.080]	
Rainfall Variability (σ/μ) (3 years)	-0.0173***	-0.0303***	-0.0306***	-0.0318***	-0.0206***	2.598
	(0.00269)	(0.00816)	(0.00861)	(0.00921)	(0.00588)	
	[0.034]	[0.040]	[0.030]	[0.030]	[0.038]	
Rainfall Variability (σ/μ) (4 years)	-0.0259***	-0.0364***	-0.0373***	-0.0411***	-0.0340***	2.494
	(0.00361)	(0.00657)	(0.00827)	(0.00761)	(0.00463)	
	[0.050]	[0.014]	[0.006]	[0.008]	[0.014]	
Rainfall Variability (σ/μ) (5 years)	-0.0189***	-0.0139***	-0.0120**	-0.0183***	-0.0326***	2.808
	(0.00307)	(0.00457)	(0.00529)	(0.00588)	(0.00485)	
	[0.032]	[0.026]	[0.072]	[0.060]	[0.016]	
Rainfall Variability (σ/μ) (6 years)	-0.0181***	-0.00564	0.0000331	-0.00906	-0.0158*	2.257
	(0.00406)	(0.00906)	(0.00659)	(0.0114)	(0.00776)	
	[0.100]	[0.612]	[0.998]	[0.592]	[0.312]	
Rainfall Variability (σ/μ) (7 years)	-0.0166**	0.000946	-0.00448	0.00210	-0.00573	2.694
	(0.00606)	(0.00843)	(0.00604)	(0.00829)	(0.00721)	
	[0.328]	[0.946]	[0.606]	[0.878]	[0.656]	
Rainfall Variability (σ/μ) (8 years)	-0.0198**	-0.0103	-0.00579	-0.000781	0.00193	1.866
	(0.00795)	(0.00806)	(0.00595)	(0.00787)	(0.00971)	
	[0.326]	[0.618]	[0.526]	[0.948]	[0.904]	
Rainfall Variability (σ/μ) (9 years)	-0.0168*	-0.0178**	-0.0179***	0.00445	-0.00359	2.449
	(0.00895)	(0.00744)	(0.00525)	(0.0101)	(0.00905)	
	[0.402]	[0.362]	[0.226]	[0.758]	[0.772]	
Rainfall Variability (σ/μ) (10 years)	-0.0245*	-0.0166	-0.0253	0.0194	0.0138	1.651
	(0.0119)	(0.0133)	(0.0165)	(0.0116)	(0.0156)	
	[0.434]	[0.526]	[0.442]	[0.188]	[0.622]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,686	2,686	2,686	2,686	2,686	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the household. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A33: Rainfall Variability and Life Satisfaction

	(1) Life Satisfaction	(2) Life Satisfaction	(3) Life Satisfaction	(4) Life Satisfaction	(5) Life Satisfaction	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.0104***	-0.0278**	-0.0313**	-0.0413***	-0.0370***	1.683
	(0.00284)	(0.00975)	(0.0107)	(0.0100)	(0.0113)	
	[0.164]	[0.066]	[0.108]	[0.052]	[0.258]	
Rainfall Variability (σ/μ) (3 years)	-0.0182***	-0.0240**	-0.0262**	-0.0290**	-0.0252**	2.270
	(0.00399)	(0.0105)	(0.00995)	(0.0102)	(0.00961)	
	[0.074]	[0.102]	[0.130]	[0.086]	[0.198]	
Rainfall Variability (σ/μ) (4 years)	-0.0259***	-0.0262***	-0.0289**	-0.0360***	-0.0310***	2.096
	(0.00353)	(0.00848)	(0.0107)	(0.0107)	(0.00909)	
	[0.052]	[0.034]	[0.038]	[0.042]	[0.022]	
Rainfall Variability (σ/μ) (5 years)	-0.0192***	-0.0145**	-0.0132*	-0.0213**	-0.0323***	2.393
	(0.00455)	(0.00672)	(0.00687)	(0.00786)	(0.00569)	
	[0.114]	[0.102]	[0.144]	[0.068]	[0.002]	
Rainfall Variability (σ/μ) (6 years)	-0.0227***	-0.0126*	-0.0108	-0.0351***	-0.0408***	1.920
	(0.00467)	(0.00638)	(0.00654)	(0.00937)	(0.00858)	
	[0.108]	[0.178]	[0.224]	[0.028]	[0.024]	
Rainfall Variability (σ/μ) (7 years)	-0.0270***	-0.0210***	-0.0242***	-0.0218***	-0.0308***	2.384
	(0.00466)	(0.00574)	(0.00530)	(0.00660)	(0.00643)	
	[0.056]	[0.060]	[0.040]	[0.096]	[0.040]	
Rainfall Variability (σ/μ) (8 years)	-0.0313***	-0.0278***	-0.0266***	-0.0263***	-0.0317***	1.669
	(0.00661)	(0.00330)	(0.00402)	(0.00324)	(0.00912)	
	[0.102]	[0.008]	[0.010]	[0.004]	[0.056]	
Rainfall Variability (σ/μ) (9 years)	-0.0302***	-0.0319***	-0.0319***	-0.0249**	-0.0296**	2.122
	(0.00679)	(0.00398)	(0.00388)	(0.00987)	(0.0103)	
	[0.128]	[0.042]	[0.038]	[0.244]	[0.252]	
Rainfall Variability (σ/μ) (10 years)	-0.0463***	-0.0379***	-0.0371**	-0.0104	-0.0132	1.429
	(0.00699)	(0.00979)	(0.0128)	(0.0127)	(0.0124)	
	[0.018]	[0.096]	[0.130]	[0.694]	[0.508]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	4,033	4,033	4,033	4,033	4,033	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A34: Rainfall Variability and Happiness

	(1) Happiness	(2) Happiness	(3) Happiness	(4) Happiness	(5) Happiness	(6) Within Group Std. Dev
Rainfall Variability (σ/μ) (2 years)	-0.00208 (0.00263) [0.524]	0.00554 (0.00924) [0.588]	-0.00129 (0.00906) [0.974]	-0.0105 (0.00694) [0.104]	-0.000610 (0.00554) [0.952]	1.683
Rainfall Variability (σ/μ) (3 years)	-0.00248 (0.00373) [0.574]	0.00481 (0.00839) [0.608]	0.00109 (0.00746) [0.836]	-0.00609 (0.00572) [0.330]	-0.00118 (0.00419) [0.810]	2.270
Rainfall Variability (σ/μ) (4 years)	-0.00639 (0.00377) [0.258]	-0.00205 (0.0111) [0.918]	-0.0102 (0.0123) [0.576]	-0.0187 (0.0116) [0.216]	-0.0164 (0.00953) [0.182]	2.096
Rainfall Variability (σ/μ) (5 years)	-0.00695* (0.00348) [0.194]	-0.00324 (0.00592) [0.724]	-0.00454 (0.00597) [0.652]	-0.0145* (0.00708) [0.080]	-0.0158** (0.00682) [0.062]	2.393
Rainfall Variability (σ/μ) (6 years)	-0.00534 (0.00457) [0.370]	0.00776 (0.00618) [0.282]	0.00650 (0.00646) [0.396]	-0.0153 (0.0118) [0.404]	-0.0165 (0.0114) [0.432]	1.920
Rainfall Variability (σ/μ) (7 years)	-0.0102** (0.00421) [0.130]	-0.00719 (0.00734) [0.432]	-0.00631 (0.00774) [0.516]	-0.0100 (0.00586) [0.252]	-0.0157* (0.00834) [0.318]	2.384
Rainfall Variability (σ/μ) (8 years)	-0.0140** (0.00519) [0.108]	-0.0110* (0.00623) [0.172]	-0.0124* (0.00600) [0.134]	-0.0118 (0.00797) [0.330]	-0.0187 (0.0116) [0.380]	1.669
Rainfall Variability (σ/μ) (9 years)	-0.0166*** (0.00439) [0.030]	-0.0169*** (0.00405) [0.034]	-0.0169*** (0.00402) [0.040]	-0.00800 (0.0113) [0.670]	-0.0144 (0.00948) [0.560]	2.122
Rainfall Variability (σ/μ) (10 years)	-0.0218** (0.00782) [0.046]	-0.0200** (0.00889) [0.134]	-0.0203* (0.0109) [0.192]	-0.00502 (0.0110) [0.668]	-0.0153 (0.0101) [0.206]	1.429
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	4,033	4,033	4,033	4,033	4,033	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the coefficient of variation for rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

A.3.2 An Alternative Measure of Rainfall Variability – Standard Deviation of Rainfall

In addition, to exploring the effects of the coefficient of variation for rainfall, we also explore an alternative measure, the standard deviation of rainfall to ensure that the effects. Tables A35, A36, A37, A38, and A39 report the results of this exercise.

As discussed above, the inferences made about the main results are robust across different timing definitions (Tables A35, A36, and A37).

In addition, we test the robustness of the Eqqub findings in Table A38. We find similar results to those found using the coefficient of variation. That is, eqqub membership appears to offset the effects of rainfall variability on life satisfaction but no consumption, supporting the interpretation that eqqub membership is being used as a precautionary savings device, rather than paying out in response to a realized income shock.

We also test the robustness of the optimism findings in Table A39. As with the results using the coefficient of variation, we find that rainfall shocks in villages that are, on average, more uncertain tend to be less sensitive to the realized rainfall shocks on life satisfaction and consumption. This is consistent with a model of Optimal Expectations (Brunnermeier and Parker (2005), in which farmers trade-off the benefits of optimism about the future with risk management investments. In villages where farmers face more uncertainty, they may be less optimistic and so invest more in risk-management strategies, mitigating the economic consequences of environmental shocks.

Table A35: Rainfall Variability and Consumption

	Log Real Consumption Per Capita					Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall Variability (σ, 100mm) (2 years)	-0.0695***	-0.185***	-0.177**	-0.220**	-0.123**	0.330
	(0.0162)	(0.0502)	(0.0649)	(0.0775)	(0.0417)	
	[0.032]	[0.058]	[0.074]	[0.118]	[0.176]	
Rainfall Variability (σ, 100mm) (3 years)	-0.122***	-0.186**	-0.184**	-0.182**	-0.119**	0.372
	(0.0262)	(0.0651)	(0.0676)	(0.0787)	(0.0443)	
	[0.034]	[0.068]	[0.070]	[0.124]	[0.090]	
Rainfall Variability (σ, 100mm) (4 years)	-0.199***	-0.280***	-0.271***	-0.300***	-0.259***	0.328
	(0.0219)	(0.0537)	(0.0612)	(0.0523)	(0.0306)	
	[0.016]	[0.006]	[0.004]	[0.014]	[0.014]	
Rainfall Variability (σ, 100mm) (5 years)	-0.141***	-0.0907***	-0.0765*	-0.113*	-0.242***	0.352
	(0.0305)	(0.0298)	(0.0375)	(0.0571)	(0.0404)	
	[0.040]	[0.012]	[0.064]	[0.158]	[0.012]	
Rainfall Variability (σ, 100mm) (6 years)	-0.139***	-0.0233	0.0117	-0.0194	-0.124	0.258
	(0.0348)	(0.0750)	(0.0546)	(0.106)	(0.0818)	
	[0.096]	[0.788]	[0.894]	[0.886]	[0.378]	
Rainfall Variability (σ, 100mm) (7 years)	-0.129**	0.0321	-0.0222	0.0318	-0.0356	0.322
	(0.0481)	(0.0694)	(0.0545)	(0.0693)	(0.0612)	
	[0.320]	[0.726]	[0.764]	[0.762]	[0.704]	
Rainfall Variability (σ, 100mm) (8 years)	-0.160***	-0.0686	-0.0350	-0.00475	0.0236	0.251
	(0.0493)	(0.0658)	(0.0489)	(0.0604)	(0.0708)	
	[0.278]	[0.642]	[0.616]	[0.950]	[0.818]	
Rainfall Variability (σ, 100mm) (9 years)	-0.131*	-0.122*	-0.124**	0.0231	-0.0266	0.323
	(0.0679)	(0.0665)	(0.0511)	(0.0693)	(0.0641)	
	[0.390]	[0.410]	[0.324]	[0.766]	[0.776]	
Rainfall Variability (σ, 100mm) (10 years)	-0.162	-0.0841	-0.121	0.115	0.0921	0.275
	(0.101)	(0.105)	(0.123)	(0.0724)	(0.0903)	
	[0.310]	[0.598]	[0.534]	[0.300]	[0.576]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	2,686	2,686	2,686	2,686	2,686	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the household. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A36: Rainfall Variability and Life Satisfaction

	(1) Life Satisfaction	(2) Life Satisfaction	(3) Life Satisfaction	(4) Life Satisfaction	(5) Life Satisfaction	(6) Within Group Std. Dev
Rainfall Variability (σ, 100mm) (2 years)	-0.0661**	-0.0851	-0.0862	-0.0855	-0.0534	0.285
	(0.0266)	(0.0591)	(0.0723)	(0.0933)	(0.0975)	
	[0.232]	[0.248]	[0.352]	[0.536]	[0.788]	
Rainfall Variability (σ, 100mm) (3 years)	-0.123***	-0.116	-0.126	-0.127	-0.103	0.322
	(0.0389)	(0.0743)	(0.0746)	(0.0870)	(0.0866)	
	[0.114]	[0.240]	[0.298]	[0.272]	[0.424]	
Rainfall Variability (σ, 100mm) (4 years)	-0.191***	-0.162**	-0.161**	-0.216**	-0.191**	0.277
	(0.0317)	(0.0648)	(0.0734)	(0.0833)	(0.0721)	
	[0.030]	[0.052]	[0.076]	[0.086]	[0.068]	
Rainfall Variability (σ, 100mm) (5 years)	-0.142***	-0.0892	-0.0784	-0.135*	-0.233***	0.300
	(0.0410)	(0.0508)	(0.0526)	(0.0677)	(0.0605)	
	[0.132]	[0.160]	[0.226]	[0.154]	[0.014]	
Rainfall Variability (σ, 100mm) (6 years)	-0.196***	-0.102*	-0.0895	-0.285***	-0.386***	0.221
	(0.0307)	(0.0530)	(0.0537)	(0.0930)	(0.0660)	
	[0.042]	[0.152]	[0.200]	[0.048]	[0.014]	
Rainfall Variability (σ, 100mm) (7 years)	-0.235***	-0.176***	-0.216***	-0.180***	-0.269***	0.284
	(0.0301)	(0.0507)	(0.0363)	(0.0596)	(0.0495)	
	[0.024]	[0.060]	[0.016]	[0.104]	[0.020]	
Rainfall Variability (σ, 100mm) (8 years)	-0.271***	-0.223***	-0.214***	-0.205***	-0.250***	0.223
	(0.0311)	(0.0248)	(0.0298)	(0.0251)	(0.0596)	
	[0.024]	[0.008]	[0.008]	[0.012]	[0.020]	
Rainfall Variability (σ, 100mm) (9 years)	-0.261***	-0.253***	-0.254***	-0.192**	-0.225***	0.277
	(0.0427)	(0.0273)	(0.0263)	(0.0661)	(0.0718)	
	[0.058]	[0.024]	[0.026]	[0.250]	[0.320]	
Rainfall Variability (σ, 100mm) (10 years)	-0.343***	-0.269***	-0.255***	-0.0963	-0.0970	0.245
	(0.0750)	(0.0722)	(0.0841)	(0.0708)	(0.0704)	
	[0.030]	[0.076]	[0.098]	[0.308]	[0.312]	
Fixed Effects	Household, Month, and Year					
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	4,033	4,033	4,033	4,033	4,033	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A37: Rainfall Variability and Happiness

	(1) Happiness	(2) Happiness	(3) Happiness	(4) Happiness	(5) Happiness	(6) Within Group Std. Dev
Rainfall Variability (σ, 100mm) (2 years)	-0.0105	0.0691	0.0389	0.0170	0.0394	0.285
	(0.0211)	(0.0431)	(0.0422)	(0.0534)	(0.0281)	
	[0.676]	[0.278]	[0.456]	[0.750]	[0.262]	
Rainfall Variability (σ, 100mm) (3 years)	-0.0134	0.0547	0.0327	-0.0124	0.0108	0.322
	(0.0315)	(0.0540)	(0.0439)	(0.0453)	(0.0360)	
	[0.712]	[0.402]	[0.518]	[0.826]	[0.792]	
Rainfall Variability (σ, 100mm) (4 years)	-0.0502	-0.0190	-0.0604	-0.146	-0.133*	0.277
	(0.0311)	(0.0888)	(0.0917)	(0.0838)	(0.0691)	
	[0.244]	[0.934]	[0.702]	[0.190]	[0.138]	
Rainfall Variability (σ, 100mm) (5 years)	-0.0554*	-0.0280	-0.0384	-0.127**	-0.151**	0.300
	(0.0281)	(0.0392)	(0.0400)	(0.0457)	(0.0528)	
	[0.196]	[0.662]	[0.558]	[0.026]	[0.014]	
Rainfall Variability (σ, 100mm) (6 years)	-0.0501	0.0610	0.0522	-0.133	-0.163	0.221
	(0.0330)	(0.0529)	(0.0538)	(0.0964)	(0.102)	
	[0.320]	[0.342]	[0.412]	[0.336]	[0.364]	
Rainfall Variability (σ, 100mm) (7 years)	-0.0886***	-0.0720	-0.0649	-0.0843	-0.139*	0.284
	(0.0297)	(0.0638)	(0.0689)	(0.0493)	(0.0678)	
	[0.070]	[0.374]	[0.502]	[0.244]	[0.276]	
Rainfall Variability (σ, 100mm) (8 years)	-0.117***	-0.0957*	-0.106*	-0.0969	-0.155*	0.223
	(0.0342)	(0.0509)	(0.0508)	(0.0589)	(0.0788)	
	[0.044]	[0.176]	[0.136]	[0.278]	[0.292]	
Rainfall Variability (σ, 100mm) (9 years)	-0.145***	-0.146***	-0.146***	-0.0690	-0.121*	0.277
	(0.0289)	(0.0272)	(0.0270)	(0.0812)	(0.0641)	
	[0.008]	[0.006]	[0.004]	[0.686]	[0.632]	
Rainfall Variability (σ/μ) (10 years)	-0.166***	-0.180***	-0.181***	-0.0995*	-0.130**	0.245
	(0.0518)	(0.0485)	(0.0600)	(0.0534)	(0.0523)	
	[0.022]	[0.022]	[0.060]	[0.166]	[0.108]	
Fixed Effects			Household, Month, and Year			
Weather Controls	No	Yes	Yes	Yes	Yes	
Quadratic Weather Controls	No	No	No	Yes	Yes	
Weather Interactions	No	No	Yes	No	Yes	
Observations	4,033	4,033	4,033	4,033	4,033	

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the standard deviation of rainfall. Historical measures of atmospheric parameters correspond to the time period, over which rainfall variability is measured. Historical rainfall is measured in hundreds of mm. historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A38: INSURANCE EFFECTS: RAINFALL VARIABILITY, LIFE SATISFACTION, AND CONSUMPTION

	(1)	(2)	(3)	(4)	(5)
	LIFE SATISFACTION (Standardized)				
Panel A:					
RAINFALL VARIABILITY (σ, 100mm)	-0.145***	-0.0910*	-0.0804	-0.138*	-0.239***
	(0.0408)	(0.0498)	(0.0514)	(0.0673)	(0.0568)
	[0.130]	[0.160]	[0.198]	[0.150]	[0.008]
RAINFALL VARIABILITY × INSURED	0.177**	0.205**	0.195**	0.218**	0.216*
	(0.0780)	(0.0836)	(0.0757)	(0.0970)	(0.102)
	[0.066]	[0.006]	[0.000]	[0.016]	[0.064]
H_0: RAINFALL VARIABILITY + (RAINFALL VARIABILITY × INSURED) = 0	0.0325	0.113	0.114	0.080	-0.022
	(0.0768)	(0.119)	(0.110)	(0.131)	(0.138)
	LOG REAL CONSUMPTION PER CAPITA				
	(1)	(2)	(3)	(4)	(5)
Panel B:					
RAINFALL VARIABILITY (σ, 100mm)	-0.140***	-0.0909***	-0.0765*	-0.113*	-0.241***
	(0.0303)	(0.0299)	(0.0381)	(0.0572)	(0.0404)
	[0.042]	[0.012]	[0.066]	[0.166]	[0.012]
RAINFALL VARIABILITY × INSURED	-0.0975	-0.0794	-0.0997	-0.0541	-0.0209
	(0.0796)	(0.0740)	(0.0852)	(0.0648)	(0.0363)
	[0.460]	[0.472]	[0.472]	[0.506]	[0.672]
H_0: RAINFALL VARIABILITY + (RAINFALL VARIABILITY × INSURED) = 0	-0.237**	-0.170**	-0.176*	-0.167*	-0.262***
	(0.0892)	(0.0791)	(0.0889)	(0.0824)	(0.0526)
FIXED EFFECTS	INDIVIDUAL, YEAR, MONTH				
WEATHER CONTROLS	NO	YES	YES	YES	YES
QUADRATIC WEATHER CONTROLS	NO	NO	NO	YES	YES
WEATHER INTERACTIONS	NO	NO	YES	NO	YES
Observations	4,033	4,033	4,033	4,033	4,033

NOTES: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is the individual. Rainfall variability is defined as the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Historical rainfall is measured in hundreds of mm. Historical temperature is measured in °C. All regressions include linear, quadratic, rainfall and temperature controls, as well as interactions between rainfall and temperature measures. Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

Table A39: Optimism and Consumption Smoothing

	(1) Life Satisfaction	(2) Happiness	(3) logConsumption
log Rainfall	4.213***	1.529	3.091***
	(0.784)	(0.882)	(0.627)
	[0.004]	[0.194]	[0.014]
log Rainfall × More Uncertainty	-2.245***	-0.783	-1.489**
	(0.605)	(0.734)	(0.532)
	[0.008]	[0.446]	[0.056]
Individual Fixed Effects	Yes	Yes	No
Household Fixed Effects	No	No	Yes
Other Fixed Effects		Month and Year	
Observations	4,033	4,033	2,686

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. More Uncertainty is defined as .... More Uncertainty is equal to 1 if .... Cluster robust standard errors are reported in parentheses. Wild Cluster Bootstrap-t p-values (null-imposed, 1,000 replications) are reported underneath in brackets, addressing concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008).

A.4 Alternative Measures of Subjective Well-Being

To provide further support for our argument we show that rainfall variability has a similar effect on alternative, evaluative measure of life satisfaction. Different measures of subjective well-being provide different perspectives on the process by which respondents reflect on, or experience, their lives. These measures lie closer to the end of the continuum representing more evaluative judgements of life, similar to the measure of life satisfaction.

The measures examined are responses to the statement *"In most ways my life is close to ideal"* and *"So far I have gotten the important things I want in life"*, *"If I could live my life over, I would change almost nothing"*, in which responses are based on a 7-point scale ranging from *strongly disagree"* to *"strongly agree"*. In addition, we explore response to the Cantril Ladder, "Where on the ladder is your standing?", in which responses are on a 10-point scale with 10 being the best possible and 0 being the worst possible. In addition, we consider a standardized index of all evaluative measures of subjective well-being, including life satisfaction.

The estimated effects are comparable to the life satisfaction results presented in the main text. We estimate that a one standard deviation increase in rainfall variability (2.39 units) is associated with a 0.089 standard deviation reduction in the index, with similar magnitudes across each of the individual responses.

Similar results are found when using the standard deviation of rainfall in place of the coefficient of variation (Table A41).

Table A40: Rainfall Variability and Alternative Measures of Subjective Well-Being - Coefficient of Variation

	(1) Cantril Ladder (Standardized)	(2) "Life is Close to Ideal" (Standardized)	(3) "Got the Important things in Life" (Standardized)	(4) "I'd Change" Nothing" (Standardized)	(5) Index (Standardized)
Panel A: Ideal Life:					
Rainfall Variability (σ/μ)	-0.0132*	-0.0136**	-0.0364***	-0.0309***	-0.0375***
	(0.00685)	(0.00489)	(0.00440)	(0.00745)	(0.00428)
Fixed Effects	Individual, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
Observations	4029	4027	4031	4029	4033

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the individual level. Our proxy for uncertainty is the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Contemporaneous and historical rainfall is measured in hundreds of mm. Contemporaneous and historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Results are robust to clustering following the bootstrap procedure to account for concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008)

Table A41: Rainfall Variability and Alternative Measures of Subjective Well-Being – Standard Deviation

	(1) Cantril Ladder (Standardized)	(2) "Life is Close to Ideal" (Standardized)	(3) "Got the Important things in Life" (Standardized)	(4) "I'd Change" Nothing" (Standardized)	(5) Index (Standardized)
Panel A: Ideal Life:					
Rainfall Variability (σ/μ)	-0.119*	-0.0631	-0.233***	-0.220**	-0.257***
	(0.0566)	(0.0481)	(0.0703)	(0.0810)	(0.0660)
Fixed Effects	Individual, Year, Month				
Weather Controls	No	Yes	Yes	Yes	Yes
Quadratic Weather Controls	No	No	No	Yes	Yes
Weather Interactions	No	No	Yes	No	Yes
Observations	4029	4027	4031	4029	4033

Notes: Significance levels are indicated as * 0.10 ** 0.05 *** 0.01. The unit of analysis is at the individual level. Our proxy for uncertainty is the coefficient of variation for rainfall, measured over the previous 5 years, the time period between each survey round. Historical measures of atmospheric parameters correspond to this period. Contemporaneous and historical rainfall is measured in hundreds of mm. Contemporaneous and historical temperature is measured in °C. Cluster robust standard errors are reported in parentheses. Results are robust to clustering following the bootstrap procedure to account for concerns relating to the small number of clusters (Cameron, Gelbach, Miller, 2008)

B Theory Appendix

In Brunnermeier and Parker (2005) several assumptions are required in order to define optimal expectations. We state these assumptions here. The first assumption requires that subjective probabilities satisfy four properties.

Assumption 1 *Subjective probabilities are restricted in the following ways:*

i $\sum_{s_t \in S} \hat{p}(s_t|\underline{s}_{t-1}) = 1$

ii $\hat{p}(s_t|\underline{s}_{t-1}) \geq 0$

iii $\hat{p}(s'_t) = \hat{p}(s'_t|s'_{t-1})\hat{p}(s'_{t-1}|s'_{t-2}) \dots \hat{p}(s'_1)$

iv $\hat{p}(s_t|s_{t-1}) = 0$ *if* $p(s_t|s_{t-1}) = 0$

Assumption 1(i) states simply that subjective probability must add up to one; assumptions 1(i) - (iii) state that the law of iterated expectations holds for subjective probabilities; and assumption 1(iv) states that in order to believe something is possible, it must be possible.

The optimal beliefs for the farmer are the subjective probabilities that maximise the farmer's lifetime well-being and are defined as the expected time-average of the farmer's utility. Assumption (2) states that finite present discounted value of expected flow utilities exist for all possible subjective beliefs.

Assumption 2 *(Conditions on the farmer's problem):*
For all subjective probabilities, $\{\hat{p}\}$ *satisfying Assumption 1,*

$$\hat{\mathbb{E}}[U(c_1^*, c_2^*, \dots, c_T^*|\underline{s}_t] < \infty, \forall \underline{s}_t \tag{1}$$