Rain and Impatience: Climatic Factors and Investment in the Highlands of Ethiopia

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Abstract: This paper investigates the role of impatience on investment in soil conservation in the degraded lands of Ethiopia. We combine farm household panel data, farm specific weather data, and subjective rate of time preferences measured by an experiment conducted in two different points in time. We find that lower rainfall increases farmers' elicited impatience and via this channel reduces effort in soil conservation. We also provide evidence that impatience measures are not stable and not fixed in a developing country context. Behavioural parameters respond to climatic factors.

Keywords: soil conservation, land degradation, rainfall, impatience, field experiments, Ethiopia.

JEL classification: C93; D03; O12; Q54

Introduction

Ethiopia, like many other sub Saharan countries, has persistent food insecurity and among the highest rates of soil nutrient depletion in Africa. With a largely rural and poor population dependent upon rain fed agriculture, Ethiopia is the target of many international micro development strategies. One of these strategies has been encouraging soil conservation measures, primarily the building of bunds.[1] These measures by supporting nutrients retention and optimizing water availability (Kassie *et al.* 2012) , improve the growth of food crops. Land fertility management and the adoption of soil conservation technologies can therefore play a pivotal tool for enhancing food security for smallholder farmers in Sub-Saharan Africa.[2] Despite a number of national and international initiatives to encourage farmers to invest in them (Shiferaw and Holden, 1998, Kassie *et al.,* 2012), the adoption of these agricultural technologies is still low (Somda *et al.* 2002; Tenge *et al.* 2004; Wollni *et al.* 2010). The low adoption is a puzzling situation. Why are available (and known) technologies that deliver higher returns not more widely adopted by farmers? This paper provides an explanation that is rooted in the interaction between human behaviour and climate. We investigate how rainfall (both in the short and in the long run) and marginal rate of substitution of current for future consumption, which we term impatience, affect investment in soil conservation activities. To take into account the endogenous nature of impatience, the identification strategy relies on the joint use of panel data and a source of exogenous variation in the

[1] These bunds, made of soil or stones, create a terrace structure and are constructed across the sloping land. The task is to intercept surface runoff that is caused by rainfall, retain soil nutrients and prevent soil degradation.

[2] Given the role of soil fertility as one of the main biophysical limiting factors the adoption of soil and water conservation technologies are important determinants of agricultural productivity (Christiaensen and Demery 2007; Kassie et al., 2010; Kassie et al. 2011).

elicited rate of time preferences. We find that lower rainfall increases farmers' impatience and via this channel reduces effort in soil conservation. This paper contributes to the existing literature in two ways. First, we add to the literature on the determinants of investment on agricultural technologies by estimating the role of a crucial behavioural parameter: impatience (or the rate of time preference). To date, several factors have been identified as barriers to soil conservation investment in Africa.[3] These include household endowments of physical and human capital (Asfaw and Admassie 2004; Pender and Fafchamps 2005; Ersado 2003), exposure to agricultural extension (Abrar *et al.* 2004; Mulat *et al.* 1998), limited off-farm opportunities (Pender and Gebremedhin 2004; Pender *et al.* 2003), limited profitability (Croppenstedt *et al.* 2003; Dadi *et al.* 2004; World Bank 2006a), return uncertainty (Ardila and Innes, 1993), consumption risk (McConnell, 1983, Barbier, 1990 and Grepperud, 1997, Dercon and Christiansen, 2011), poverty (Shively, 2001), population pressure (Grepperud 1996), tenure insecurity (Deininger and Jin, 2006; Holden and Yohannes 2002; Gebremedhin and Swinton 2003; Abdulai *et al*., 2011) and inequality (Dayton-Johnson and Bardhan, 2002). This paper is the first to focus the interplay between environmental and endogenous behavioural drivers.

Second, we contribute to the expanding literature on behavioural development economics by providing evidence on an important *behavioral* implication of climatic factors: the effect of rainfall on farmers' time preferences (or impatience). We run experiments with the same household in two different points in time. We find that rainfall

[3] A review of the literature on the determinants of conservation is out of the scope of this paper.

is associated to increased impatience. This result is novel and relevant.[4] We also find (using panel data) evidence that rate of time preferences may not be not fixed and stable in a developing country context (Harrison *et al.*, 2002). This seems to point out that in a developing country context these behavioral parameters are in fact “malleable” and responding to weather conditions (see, Voors *et al.*, 2011 for analogous evidence using cross sectional evidence from conflicts in Burundi). We probed our experimental measure of impatience and test if it is an appropriate characterization of real farmer behaviour. We use panel data to estimate the correlation individual contribution to *iddir* (a rotating saving scheme typical of Ethiopia) and the experimentally elicited measure of impatience. In the absence of perfectly functioning markets, these associations play a very extremely important role in the communities (Anderson and Balland, 2002).[5] Moreover, participation in these schemes serve the purpose of a commitment device (Ambec and Treich, 2007; Dagnelie and Lemay-Boucher, 2012). Many individuals join them in order to commit themselves to savings (Gugerty, 2001; Ashraf, 2006). More impatient farmers can use them to save resources that would be otherwise consumed. We find that the experimental measure is strongly correlated with participation in these schemes. The elicitation procedure maps remarkably well into with this real life measure of impatience.[6]

[4] It should be stressed that a number of observational studies have documented the relation between rate of time preferences or impatience and soil conservation. All of them, however, assume that rate of time preferences are fixed and exogenous (see (Jagger and Pender, 2003; Shiferaw and Holden; 1999; Shiferaw and Holden, 2000; Yesuf and Kohlin, 2008).

[5] Through this association a group of people hold regular meetings. At each meeting, all participants contribute a fixed amount of money into a “pot”. The pot is then allocated to a particular participant of the association by means of a. Each member can receive the pot once and the scheme is over when all members have received the pot once.

[6] Farmers were paid only a show up fee. Our experimental measure should therefore be considered hypothetical. This result provides further evidence on the possible use of hypothetical measures in

Background, Data and Design

Ethiopia's frequent and well-documented exposure to weather shocks makes it a prime area to investigate the implications of weather factors on conservation. During the last forty years, Ethiopia has experienced many severe droughts, leading to production levels that fell short of basic subsistence levels for many farm households (Tilahun, 2010). Weather events are in fact considered to be the most important problem for these farmers as their welfare remains lowered many years after the drought or the flood happened (Dercon, 2004).

The focus of our study are randomly selected agricultural households in 14 villages from East Gojjam and South Wollo zones in the Amhara region in the highlands of Ethiopia. The vast majority of the population in these areas is dependent on rain fed agriculture. The altitude is above 1500 meters and particularly South Wollo has a very precipitous landscape with the Rift Valley to the East and the Blue Nile gorge to the West. Rainfall is erratic and the area is notorious for its recurrent droughts over the last decades, necessitating both domestic and international relief interventions. The steep hills are to a large extent denuded of vegetation. Marginal lands are cultivated due to high population pressure, and soil erosion is a serious problem for the already low productivity in agriculture. In short, this might very well be one of the poorest and most vulnerable populations in the world. These are subsistence farm households whose agricultural production is largely consumed within the family network.

describing real behaviour (e.g., Chesson and Viscusi, 2000; Viscusi et al. 2008; Dohmen et al., 2011). More details are provided on the next section.

A panel data collection effort was initiated in this area in the late 1990's by Addis Ababa University in collaboration with the University of Gothenburg. The purpose of the data collection was to understand the links between poverty and natural resource utilization in the Highlands of Ethiopia. We use the two rounds of the survey that included the elicitation of farmers' impatience, June 2005 and June 2007. We observe 763 households in 14 villages in the two regions in the two rounds. The survey includes a module recorded farmers effort spent on soil conservation. This is a continuous variable that record how much time was allocated for the construction of new soil conservation structures (such as soil bunds or stone bunds) during the past 12 months.

[TABLE 1 ABOUT HERE]

Basic descriptive statistics are presented in Table 1. We focus on the construction of plot bunds (either in soil or stones).

Rainfall variables were constructed from the respective monthly data from the stations in the neighbourhood of the farm. Then, the *Inverse Distance Weighing* method of spatial interpolation was used to impute the household specific rainfall (and their variability) using latitude and longitude information of each household. Two metrics of rainfall are considered: the average monthly rainfall and the coefficient of variation of monthly rainfall in the year 2005 and the year 2007. The next section we will present more background information on the extent of variation at both the temporal and spatial level.

Table 1 also presents descriptive statistics on characteristics of the household (such as age of household head and household size), which we later use to control for household composition. To control for other types of adverse events that affect both impatience and time allocated to conservation activities we used dummies that may capture idiosyncratic shocks (if a member of the household died during last year or if the household experienced a theft or if the household experienced more general financial shocks.) We also include control for asset endowments such as land. Admittedly this control is likely to be endogenous and therefore we make no attempt to interpret those coefficient estimates. We include it only with the intent of showing the consistency and stability of the relationship between our (exogenous) variable of interest and the left hand side variables across different specifications. All of the regressions include household fixed effect allows to control for time invariant characteristics such as ability and soil quality and time fixed effects to control for wide market or political effects.

Eliciting farmers' time preference

The design follows the existing experimental literature by asking farmers to choose between a smaller pay-off immediately and receiving a larger pay-off later (Tversky and Kahnemann, 1986; Benzion et al., 1989; Shelley, 1993). Sample questions are as follows: would you prefer a payment of 50 Ethiopian Birr today or 65 Ethiopian Birr in the next year? Would you prefer 50 Ethiopian Birr today or 80 Ethiopian Birr in the next year?[7] We interpret the choice of the immediate payment as "impatient." Because no actual payments were associated to the choice, our behavioural measure is thus indicating the individual hypothetical willingness to wait for a payment. The choice of next year is appropriate in an agricultural set up as 12 month implies a different growing season. An important issue surrounding the use of hypothetical metrics is their capacity to capture

[7] The other values 105, 130, 160, 195 were presented as repeated, randomized choice sets.

real behaviour. In the context of the elicitation of risk preferences, for instance, it has been argued that experiments where real money is involved provide an incentive-compatible measure for behaviour (e.g., Binswanger, 1980; Holt and Laury, 2002; Eckel and Grossman, 2008, Choi et al. 2007).[8] Incentive compatible measures of behaviour, besides being more expensive than hypothetical ones, are not easy to implement in developing country context.[9] Farmers in remote rural areas of Ethiopia may not trust the research team and choose current payments irrespective of their actual preferences. There is, therefore, a practical and "tactical" problem associated to real payments in eliciting rate of time preferences. Thaler (1981) makes this point lucidly: "*Would subjects believe they would get paid in five years?"* Hypothetical questions have thus the advantage of tackling these problems and allow us to ask questions about the future (Frederick, Lowenstein and O'Donoghue, 2002; Viscusi *et al.* 2008). While hypothetical measures of behavior are not a *perfect substitute* of real stakes ones,[10] they are definitively source of important behavioural information (Dohmen et al., 2011). Moreover, a growing body of economics literature indicates that hypothetical measures map remarkably well into actual behavior into incentive-compatible time preference experiments (Jaeger et al., 2007; Dohmen and Falk, 2010; Dohmen et al. 2011; Visher et al., 2013).

In our context, the use of a hypothetical measure is validated in two ways. First, we compare the value of the elicited rate of time preference with the one elicited by an

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[8] Hypothetical biases may distort the elicitation of individual's behavioral parameters (Camerer and Hogarth, 1999; Holt and Laury, 2002).

[9] See Ashraf, Karlan and Yin (2006) for the use of hypothetical rate of time preferences in the Philippines.

[10] Papers identifying time preferences from aggregate consumption data: Hausman (1979); Warner and Pleeter (2001); DellaVigna and Malmendier (2006); Lawrance (1991); Gourinchas and Parker (2002); Cagetti (2003); Laibson et al. (2003, 2005)

incentivised experiments run with a sub sample of 262 of the same farm households (Yesuf; 2004). The results are remarkably similar. Our elicited median subjective impatience is 36%, while the value elicited via the incentivised experiment is 43%. Second, we test if it does correlate (in a meaningful way) with a real life *proxy* of impatience: farmer's contribution to *iddir*. In a sub Saharan context, this type of expenditure is a meaningful metrics for time preferences as participation in rotating saving and credit schemes as they are used by more impatient individual as commitment devices (participation in these schemes is a commitment device (Ambec and Treich, 2007; Dagnelie and Lemay-Boucher, 2012; Ashraf et al., 2006).

[Table 2 – About Here]

More impatient farmers can use them to save resources that would be otherwise consumed and not accumulated. The use of panel data allows for controlling for time invariant unobservables that can be correlated with the measure of impatience. We find that the elicited experimental measure does correlate in a statistically significant way with the observed real life behaviour.

Theory of Rate of Time Preference and Investment

In this section we provide some theoretical background to explain the instability of impatience in a developing country context. The rate of time preference and the level of investment, L, are both consequences of external factors, like weather. Rate of time preference elicitation reveals the terms an agent requires to make a sure investment, given his extant portfolio of assets. Level of investment is the agent's revealed choice of what to add to his portfolio.

More formally, consider an agent's choices in two periods. Let U^i be utility in period i, (it depends on consumption in period i) and let ρ be the rate of utility discounting. Agents maximize discounted utility, $U^1 + (1+\rho)^{-1}U^2$. In keeping with the finance literature we let $m = U'^2/((1+\rho)\, U'^1)$ be the pricing kernel. A RTP elicitation is an offer, in addition to the agent's menu of investments, of a set of choices of sure investments. A sure investment decreases first period utility by U'^1; it pays off r units of consumption good in period two (for the assumed cost of one unit in period one.) Therefore the utility payoff is $-U'^1 + r\, U'^2/(1+\rho)$. Rearranging this expression, the sure investment that just leaves the agent indifferent between taking and not taking the offer has the property the $Emr = 1$, where r is the rate of return on that investment. Thus the elicitation reveals impatience, r, and Em, which is 1/r.

The elicited r is not likely to be a constant. In developed countries it should depend upon the offered interest rates in organized markets. Agents take the interest rate as given and adjust their consumption so that $Emr = 1$. In less developed countries, like Ethiopia, poor rainfall results in hunger and an unfulfilled desire to borrow, so that r becomes very large. Consumption today is worth much more than consumption at a later date. The theoretical takeaway is that the elicitation does not measure just the rate of personal time preference ρ, which one might think of as a constant. Rather it measures Em which instead is influenced by market and natural forces.[11]

[11] This insight belongs to Irving Fisher.

The conservation project is an investment. In exchange for work done in the near-term, the agent receives additional payment, in the form of more crop yield, in subsequent periods. The agent chooses how much work to do on an investment project, with each unit of work reducing current consumption by one unit and increasing second period consumption by f(L) units. Let R(L) = f', the return on the marginal unit of investment. R is decreasing with L. Investing also has the effect of changing consumption in the two periods, hence m is a function of L. It is a function of L because increasing L decreases first period consumption and increases first period marginal utility. It does exactly the opposite in the second period, so m is decreasing in L. The pricing kernel is also a function of all random events that affect utility, for instance the adequacy of rainfall for a farmer, or other shocks to income. The first order conditions for investment are that E[m(L) R(L)] = Em ER+ cov(m,R) = 1[12]. Equivalently, ER(L) = r - r cov(m, R)

Let us now consider conditions sufficient to find a relationship between elicited r and L. Assume that one sees a low r in some particular state of nature. If we assume that whatever has led to a low r has not changed the cov(m,R) nor R itself, then a low r must go along with a high Em, a low second period consumption, a low R, and a high L. This fits intuition as people who are willing to invest for lower returns should already have used more of an existing investment that has decreasing marginal rates of return.

The maximization of utility is with respect to a constraint on income, so it is natural to ask what the effect of more income or wealth should be on both r and L. An increase in income in period t will optimally lead to increases in consumption in all succeeding periods. To accomplish this spreading of income over time, the agent will

[12] ERm < 1 and L =0 is the Kuhn-Tucker condition for no investment.

need to increase investment. So the general tendency will be for L to increase with income or wealth. This is only a general tendency, because farmers can well have exhausted all their opportunities to invest in soil conservation and for those farmers L will be non-decreasing.

The wealth of the farm population arises from savings from agricultural operations. The profitability of these operations depends upon human capital and weather. So it is natural to proxy wealth as a function of past weather and human capital measures like schooling.

Looking at farmers who face different levels of risk, one would expect that those with the riskier prospects would invest less. Risk, in this case, is given by ER –r =- r cov(m,R). This covariance arises largely from the weather. Places with higher weather variability have higher variability in the return to conservation measures, L. They also have higher variability in m, as their income and wealth are more volatile than those with more certain climate. When an agent experiences a bad weather shock, his consumption will be lower than expected, so his marginal utility and his m will be higher than its expectation. If the returns to his conservation investment are lower also, then we have the classic case where the covariance is negative and the risk premium of R over r is positive. In this case, higher variability leads to higher risk premium and lower investment. This is the finding that is well established in risk literature (e.g., Just and Pope, 1978, Chavas, 2004; Rosenzweig and Binswanger, 1983, Dercon and Christiansen, 2011)

An alternative explanation for weather variability reducing the investment in the conservation activity is that the activity is only useful in some states of nature, for instance with moderate rainfall. When it rains too much, the water simply swamps over the bund and when it does not rain it does not matter if there is a bund. Hence increasing the variability in the weather can reduce the mean value of the conservation activity.

While there are alternative possibilities, the most likely results in this model are that we should observe (1) high L in the same time and place as low r and (2) more risk leads to a higher ratio of ER/r, probably a rise in ER, lower L, and a fall in r.

Identification strategy

The use of panel data allows us to use the both spatial and temporal exogenous variation in rainfall to estimate the parameters of interest. The two years of surveys are quite different from a rainfall point of view. On average in the areas of the survey, the year 2005 was characterized by an annual rainfall (in mm) of 1126 and a coefficient of variation of 0.083. The year 2007, was characterized by more rainfall (1285 mm) and higher extent of variability (coefficient of variation of 1.1). The two levels of rainfall are statistically different from each other (t = -22.4 with degrees of freedom =1524, we reject the null hypothesis at 1 per cent). There is also a large extent of spatial variation.

Table 2 reports both the annual rainfall and its coefficient of variation at the village level. Rainfall ranged from 990 mm to 1180 mm in 2005 and from 1237.86 mm to 1506.2 in 2007. While 2007 was a wetter year for every village in the dataset some village experienced an increase of about 9% while others of 25%. Interesting variation becomes apparent when one considers rainfall variability. Again, while 2007 has been on average more rainfall variability, some villages actually experienced a noticeable reduction (-21%) in the coefficient of variation while other a very large increase (+66%).

It also should be stressed that within-village variation is as important as the between-village variation.[13] Table 3a reports the standard deviation decomposition into between and within components of the key climatic variables.

[TABLE 3 – ABOUT HERE]

[TABLE 3a – ABOUT HERE]

To investigate the role of impatience (or rate of time preference) on the investment in soil conservation we need to estimate (1).

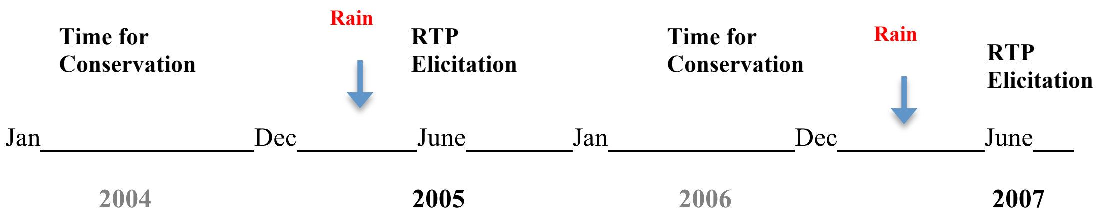
$$Soil\ Conservation_{ht} = \alpha_0 + \alpha_1\ rtp_{ht} + \beta_1 X_{ht} + u_{ht} \quad (1)$$

where the indices h and t indicate household h at time (year) t. A household's socioeconomic characteristics and farm characteristics are represented by X_{ht}. Finally, u_{ht} and v_{ht} denote the disturbance that can vary over time as well as across households. We use households fixed effect panel data estimator and add village and time fixed effects. This allows controlling for time invariant characteristics of the household, the village as well as for households and village invariant time effects such as policies, or price shocks that may have affected this area in the period covered by the dataset. The use of panel data allows us to obtain consistent parameter estimate even if time invariant unobservable heterogeneity is correlated with the variable of interest.

Impatience, may still be endogenous though. We therefore use a fixed effect IV estimator. We need to find a source of exogenous variation in the rate of time preference that allows us to estimate the parameter of interest. To this end, we exploit the different timing of the experiment to elicit the rate of time preference and the conservation decision. The identification strategy can be represented in the graph below.

[13] In case our variables of interest would vary only at the village-year level, then we would have had only 28 observations to work with. This is not the case.

Timing



Conservation was taken respectively in the years 2004 and 2006. The elicitation of the rate of time preference was implemented in June 2005 and in June 2007. Basically, after that the short rain season is over. The impatience is therefore elicited after the conservation decision. We use rainfall in the months of February and May 2005 and 2007 as instruments. Given that is rainfall that happened after that the conservation decision was undertaken it is not related to the latter. Assuming that the farmer's impatience elicited in 2007 is correlated with farmer's impatience elicited in 2005, rainfall in the February-May period can serve as source of exogenous variation in the rate of time preference. We probed the relevance of this instrument via the conventional statistics. These are reported at the bottom of table 4 and table 5. The second stage and the first stage regressions are represented by equations (1) and (2).

$$rtp_{ht+1} = \alpha_2 + \alpha_{34} rain_{ht+1} + \beta_2 X_{ht} + \nu_{ht}, \qquad (2)$$

To exploit the information on rtp elicited at a different (future) point in time, we need to assume that there is a pattern of correlation between rtps at different dates. We need to assume a weighted symmetric estimator patter (Maddala and Kim, 1998), hence

$rtp_{ht+1} = \rho \, rtp_{ht} + e_{it}$ (2.1)

$rtp_{ht} = \rho \, rtp_{ht+1} + u_{it}$ (2.2)

If ρ is statistically different from 0 then future values for rtp can be used to 'backforecasting' its previous values. The equation (2.2) can be used to replace the rtp in (1). We have estimated the value of this parameter and found a value of 0.1 statistically significant at the 5% significance level. If one is interested only in the sign and the statistical significance of α_1 then no other procedure is necessary. If, however, one is interested in the quantitative dimension of α_1 then given that (1) is:

$Soil\ Conservation_{ht} = \alpha_0 + \rho \, \alpha_1 rtp_{ht+1} + \beta_1 X_{ht} + v_{it}$ (3)

where $v_{it} = u_{it} + e_{it}$, , the estimated parameter.

Discussion of the results

Table 4 reports the estimation results. Column 1 reports the regression of time spent on conservation measures on annual rainfall (divided into long and short rainy seasons). We included year and household fixed effects. Column 2 adds non-climatic shocks. Column 3 adds household size and age. Column 4 uses the same controls as column 3, but with the sample available to estimate column 5, which adds land, tenure security and lagged rainfall. The coefficients on rainfall are unchanging across all these specifications. Beyond the climate variables, only household size affects the allocation of time to conservation activities. All shocks and other controls contribute little.   We find that weather factors are the most important.

[TABLE 4 – ABOUT HERE]

We now turn to the results of the estimation of equation (2). These are reported in the table 4. For consistency, we have used the same set of controls as in the estimation of equation (1).

[TABLE 5 – ABOUT HERE]

While the rainfall level is statistically significant, the estimated for coefficient of variation is positive and statistically significant. Importantly, the coefficient is very consistent and stable across different specifications. RTP increases in response to more rainfall variability. The implication of this result is that farm households that are exposed to unexpected low or large level of rainfall are less forward looking. This result is of interest for two reasons. It highlights that behavioural parameters are endogenous, while most of the existing conservation and adoption literature that use these as explanatory variables assume that they are (e.g., Shiferaw and Holden, 2000; Liu and Wang, 2013). Second, the panel data analysis provides more evidence that behavioural parameters may not stable over time (Harrison et al. 2005; Andersen et al. 2006). Voors et al. (2011), have challenged this view by showing cross sectional evidence on exposure to shocks (violent conflicts in Burundi) induces a shift in preferences. They find that individuals that have experienced violence alter their rate of time preferences.[14]

[14] Malmendier and Nagel (2011), find that individuals who have experienced low stock-market returns throughout their lives report lower willingness to take financial risk, are less likely to participate in the stock market, and, conditional on participating, invest a lower fraction of their liquid assets in stocks.

Using alternative climate variables

It may be argued that investment is soil conservation would respond more to long term climatic characteristics rather than the weather of a given year. To investigate this possibility we estimate the model using two important climatic variables, the standardized precipitation index (SPI) and the evapotranspiration index (SPEI). The former relies on a definition of drought general enough to be comparable across areas and time. The standardized precipitation index (SPI), first introduced by McKee et al.(McKee et al. 1993, 1995), is a locally and frequency based characterization of precipitation levels. Guttman (Guttman 1998, 1999) widely contributed to its popularisation by showing some of its key advantages over the Palmer Drought Severity Index (Palmer, 1965), the index of choice at the time[15]. The SPI allows the comparison of hydrological conditions across space and time(Hayes et al. 1999), is flexible enough to consider different kind of droughts (e.g. hydrological conditions at months' scale affecting agriculture or at years' scale affecting large-scale water management), simple and tractable, and parsimonious in terms of data requirement.

Light rains in the middle of the rainy season might be the first sign of an incoming drought in a given area, while the same level of precipitation can be considered as totally normal at other times of the year or in another area and the addresses precisely these kind of issues. The SPI is a localized and statistical measure of precipitation. It offers a comparable index across times and regions. Indeed, it is based indeed on local frequency:

[15] The Palmer Drought Severity Index (PDSI) is based on a water balance equation taking into account precipitation, moisture supply, runoff and evaporation demand at the surface level. According to Vicente-Serrano et al. (2010), although some of the weaknesses of the PSDI have been solved by Wells et al. (2004), the main weakness of the PDSI identified by Guttman (1998) has not been addressed: the fixed temporal scale between 9 to 12 months and the fact that PDSI values are affected by conditions up to four years in the past.

given a series of cumulative local monthly precipitation over an extended period (30 years is deemed acceptable), probability functions are fitted on each monthly distribution and then standardized. Most commonly, a gamma distribution is fitted with a maximum likelihood estimator.

The SPI is symmetrically distributed around zero, a value of zero representing normal conditions, whilst below and above zero values represent dry and wet conditions respectively, with values between -0.5 and 0.5 considered as nearly normal. Although the SPI is theoretically unbounded, values below -3 and above 3 are extremely rare as they occur with a probability of 0.1%. Assuming that weather events are identically and independently distributed, catastrophic droughts and floods can be defined as SPI values above and below $\pm$ 2.3, i.e. a drought or flood with a return period of 100 years (Guttmann 1999). Values above and below $\pm$ 1.9 can also be considered as extreme events as they have a return period of 35 years, that is more than one generation.

Recently, Vincente-Serrano et al. (2010) have proposed focusing on the evapotranspiration index (SPEI) in order to take Climate change into account. The intuition is the same, the only change being that it is not precipitation, but the evapotranspiration index that is standardized. There are several evapotranspiration indices, but they are all based on the same logic, namely the difference between precipitation and potential evapotranspiration. The simplest potential evapotranspiration index in terms of data requirement is the Thornton index. The only data needed are the latitude and the temperature. The detailed derivation of the SPEI can be found in Vincente-Serrano et al. (2010).

Note that climate change affects both changes in precipitation and temperature. Vincente-Serrano et al. (2010) have proposed the standardized precipitation evapotranspiration index (SPEI) in order to take into account the influence of temperature on hydrological conditions. Its statistical concept and properties are essentially the same as the SPI, although here it is the difference between precipitation and potential evapotranspiration, i.e. the net balance of water, which is standardized. As both temperature and precipitation have an impact on agricultural production and the livelihood of rural populations and as the SPEI is more sensible in the context of change, we settle for the SPEI index as our standardized measure of weather.

Table 5 reports the results when these alternative climatic measures are used. The results for the estimated coefficient for impatience are very similar. The climatic variables are statistically significant.

Conclusion

The investment in conservation structures increases in rainfall, decreases in its coefficient of variation, and increases in household size. No other variables significantly influence this investment. The elicited impatience, on the other hand, does not change with average rainfall, increases in the coefficient of variation, possibly decreases with financial shocks, and decreases with larger land holdings.

The effect of additional mean rainfall is to increase investment and leave r unchanged. From Kassie et al. (2008) we expect that increased rainfall decreases R, that is bunds are most profitable with lower rainfall. We have ruled out L increasing because r decreased. Among the remaining possibilities is that increasing rainfall changes wealth in a way that decreases m (or just its cov(m,R)) so that the risk premium falls and more is invested.

The effect of additional variance across the year is that L falls and r rises. If the coefficient of variation is really a risk measure for rainfall, then theory only predicts that the ratio of ER to r rises. This is consistent with L falling. But what of r rising? One possibility is that increased coefficient of variation leads to lower income and a desire to borrow, hence a lower r, the rate at which the agent will lend. In conclusion, putting the two empirical results presented in this paper *i)* rainfall variability affects the uptake of productive conservation investment and *ii)* put together may indicate that future patterns of increased rainfall variability will have a detrimental impact on private initiative to undertake soil conservation measure. One direct, by inducing farmers to choose less profitable strategies and the other indirect, by making farmers more impatient and hence less willing to put in place investment (Duflo *et al.,* 2011).

Climate change for Ethiopia is projected to lead to a more variable climate. Our findings imply that increased weather variability under climate change would lead to increased land degradation due to reduced investments in soil conservation. Further research is however needed to investigate differential impacts of shocks on RTP, to more precisely identify whether certain households could be vulnerable to entering dynamic paths toward low-wealth equilibria at higher asset levels than other households.

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Table 1 Descriptive statistics

Variable	Definition	Mean	Std Dev	Min	Max
Time Conservation	Number of Person days worked	6.67	14	0	150
Impatience	Elicited impatience	1.106	0.46	0	1.36
Long rainy season (2004, 2006)	Rain in mm	1201	166	102	2294
Short rainy season (2004, 2006)	Rain in mm	0.1	0.034	0.05	0.56
Short rainy season 2007	Rain in mm				
SPI					
SPEI					
Theft shock	Reported theft (1= Yes; 0= otherwise)	6%			
Death in the family	Reported death in the family (1= Yes; 0= otherwise)	20%			
Financial shock	Reported financial shock (1= Yes; 0= otherwise)	16%			
HH size	Number of members of HH	6.366	2.35	1	19
Age	Age of HH head	51	15.5	16	105
Land	Size of operating plots in hectares	1.65	1.03	0.3	5
Tenure security	Do you expect that your land endowment will not change in the future (1= Yes; 0= otherwise)	33%			
Temperature	Average annual temperature	11	4.8	2.5	20
Iddir	Contribution to Iddirs (in ETB)	6.3	12.91	2.5	19.8

	p50	Mean	Min	Max	RTP	p50	Mean	Min	Max	RTP	
Amanuel, East Gojam	140.4	139.1	132.3	140.4		220	228.5	211.9	222.08		
D.Elias, East Gojam	139.6	143.2	132.2	167.6		211.9	221.6	183.6	276.8		
Kebi, East Gojam	118.7	122.2	118.7	142.5		231.7	234.4	178.2	286.7		
Wolkie, East Gojam	139.6	139.3	101.6	146.6		221.5	222.4	101.4	276.8		
Telma, East Gojam	111.5	110.2	78.4	111.5		196.4	196.5	154.1	264.1		
Sekla, East Gojam	111	111.2	78.7	130.9		205.1	205.2	181.60231.7			
Kete, South Wollo	176.2	174.4	115.4	176.2		84.3	106.3	84.28	286.7		
Godguadi, South Wollo	176	173	103	179		84.3	84.2	67.6	97.7		
Amba, South Wollo	140	140	72	172							
Yamed, South Wollo	172.7	157.8	97.7	172.7							
Addis me, South Wollo	106.5	105.8	94.7	107.2							
Chorisa, South Wollo	106.5	120.3	102.1	157							
Indood, South Wollo	180.2	177.5	153.8	180.1							

Table 2. How the elicited impatience explains real behaviour?

Dependent variable: Contribution to Iddir (rosca)	
Impatience	1.9**
	(0.951)
Time effects	Yes
N	1526
Fixed effects estimator. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Constant not reported.	

Table 3. Rainfall per village and year

Village	**2004**				**2006**			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Amanuel, East Gojam	103.5	6.32	100.57	117.68	198.88	7.6	182	202
D.Elias, East Gojam	122.25	12.84	106.44	149.13	179.47	10.72	136.55	188.1
Kebi, East Gojam	120.54	5.07	114.1	138.43	196.18	10.36	164.74	212.1
Wolkie, East Gojam	112.13	10.1	86.17	149.13	186.22	7.41	146.72	188.1
Telma, East Gojam	175.01	13.70	97.67	192.28	139.1	14.02	135.96	210.9
Sekla, East Gojam	173.22	16.93	99.95	177.5	171.85	8.05	147.2	197.62
Kete, South Wollo	71.16	9.76	25.33	114.1	173.21	14.59	122.42	212.1
Godguadi, South Wollo	70.47	4.74	51.35	71.86	165.09	20.61	86.1	171.05
Amba, South Wollo	52.03	6.88	37.69	106.71	109.21	11.4	106.9	201.22
Yamed, South Wollo	54.22	14.86	42.64	155.63	119.55	14.83	105.9	201.22
Addis me, South Wollo	100	3.22	77.73	110.31	179.2	4.81	177.21	207.7
Chorisa, South Wollo	91.14	14.86	67.59	110.31	157.4	32.1	84.24	194
Indood, South Wollo	51.6	5.4	49.01	67.58	105.44	11.66	86.1	113.23

Table 3a. Rainfall and its coefficient of variation. Standard deviation between and within decomposition

		Std. Deviation	Min	Max
Long rainy season	Between	88.62	27.43	415.29
	Within	50.31	11.19	285.53

Short rainy season	Between	31.29	68.72	197.91
	Within	37.11	61.86	191.81

Table 4. Time allocated for conservation and rate of time preferences – Panel IV estimator.

Dependent variables: Time allocated to conservation				Number of oxen
Variables	(2)	(3)	(4)	(5)
Impatience	-9.357**	-10.57***	-10.43**	-0.387*
	(3.942)	(3.930)	(4.124)	(0.215)
Short Rain	0.0142	0.0125	0.0179	-0.00191*
	(0.0189)	(0.0195)	(0.0203)	(0.00106)
Long rain	0.00148	-0.000736	-0.00335	-0.000782
	(0.0220)	(0.0231)	(0.0240)	(0.00125)
Theft shock		-0.948	-1.443	-0.0129
		(2.045)	(2.119)	(0.111)
Death in the family		0.911	1.532	0.0939
		(1.269)	(1.374)	(0.0717)
Financial shock		0.648	1.442	-0.140*
		(1.362)	(1.466)	(0.0765)
Temperature		-0.122	-0.0921	-0.000780
		(0.120)	(0.129)	(0.00672)
HH size			2.261**	-0.0183
			(1.060)	(0.0553)
Age			0.113	0.0184**
			(0.149)	(0.00779)
Land			0.00341	0.0632*
			(0.654)	(0.0342)
Tenure security			-0.716	0.0952
			(1.140)	(0.0595)
Time effects	Yes	Yes	Yes	Yes
Village effects	No	Yes	Yes	Yes
N	1526	1448	1306	1306

Significance codes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ Standard errors in parentheses. Constant not
Reported. Instrument relevance (based on (4)): Partial R-squared of excluded instruments: 0.08. Test of excluded instruments: F(1, 637) = 56.46.

Table 5. Time allocated for conservation. Different climate variables. Panel IV estimator

Dependent variable: Time allocated to conserve ation		
	(1)	(2)
Impatience	-7.74***	-6.22**
	(3.18)	(3.2)
SPI – Long	-4.741**	
	(1.929)	
SPI - Short	-0.917	
	(1.452)	
SPEI - Long		-6.813***
		(1.777)
SPEI - Short		-0.943
		(1.153)
Theft shock	-1.091	-1.014
	(2.065)	(2.055)
Death in the family	1.514	1.511
	(1.338)	(1.331)
Financial shock	1.506	1.475
	(1.427)	(1.418)
Temperature	-0.0902	-0.0922
	(0.126)	(0.125)
HH size	2.146**	2.128**
	(1.039)	(1.033)
Age	0.105	0.0994
	(0.144)	(0.143)
Land	0.211	0.245
	(0.642)	(0.640)
Tenure security	-0.455	-0.425
	(1.128)	(1.121)
Time Effects	Yes	Yes
Village Effects	Yes	Yes
N	1306	1306
Standard errors in parentheses. Significance codes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$		