Rain, Impatience and Investment in Soil Conservation: Panel Data Evidence from the Highlands of Ethiopia

Salvatore Di Falco (University of Geneva, Switzerland)

Peter Berck (University of California, Berkeley, USA),

Mintewab Bezabih (London School of Economics, UK)

and

Gunnar Kohlin (university of Gothenburg, Sweden)

Abstract: This paper investigates the role of rainfall and its variability on the implementation of soil conservation strategies 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 rainfall variability reduces effort in soil conservation and increases farmers' elicited impatience. Future patterns of increased rainfall variability may thus reduce the possibility of private investment in soil conservation both by directly reducing the investment in conservation and by increasing farmers' impatience. We also provide evidence that impatience measures are not stable and not fixed in a developing country context. Behavioural parameters respond to climatic shocks.

Introduction

Ethiopia 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. In this paper we investigate determinants of investment in soil conservation activities. We consider rainfall and its coefficient of variation. We also investigate how farmers' impatience is affected by and change in exogenous factors that also has implication for investment in soil conservation.

The understanding of soil conservation investments is of paramount importance. The reduction or loss of biological or economic productivity (land degradation) of rain-fed cropland is one of the major environmental problems in Sub Saharan Africa. Soils that lack nutrients do not adequately support plants growth. Environmental degradation and poverty in developing countries form a nexus in which resource degradation, caused by heavy dependence on natural resources and agricultural stagnation, leads to deepening poverty and further dependence on ecologically fragile environments (Mellor, 1988; Dasgupta, 1993; Dasgupta and Maler, 1994). This has very serious implications in terms of food security and development. The highlands of Ethiopia are a prime example. The country has one of the highest rates of soil nutrient depletion in Sub-Saharan Africa (Stoorvogel and Smaling 1990; Grepperud 1996; Shiferaw and Holden, 1997). It has been estimated that it loses 4.2 tonnes of fertile soil per hectare per year (Hurni, 1993; Teklewold and Kohlin; 2011).[1] Ethiopian agriculture is almost completely dependent on

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[1] Tolerable soil loss, defined as the maximum level of soil erosion permitting a high level of crop productivity to be sustained economically and indefinitely is 1–16 t/ha/year (Hurni 1983a,b). Annually

rainfall, which is quite variable. Rainfall variability exacerbates soil loss by reducing the moisture holding ability of soil. This also directly contributes to low crop yields. With poor and variable agricultural yields, the majority of Ethiopia's rural people are food insecure (Devereux 2000).[2]

The adoption of soil conservation measures may buffer against these negative conditions. Farmers improve the retention of soil nutrients and optimize water availability on their plots through drainage or soil bundings (bunds) (Kassie *et al.* 2012). 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.[3] Its role can be particularly relevant in the context of rain fed agricultural systems, characterized by weather variablility. Notwithstanding their importance for food security and 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? Several

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Ethiopia looses over 1.5 billion tons of topsoil from the highlands by erosion. This could have added about 1–1.5 million tons of grain to the country's harvest. During the dry season wind erosion is severe in arid and semiarid regions. In the rainy season water erosion and tillage erosion removes soil layers and carries them away from farmer's fields to bodies of water or other land, which results in the loss of valuable nutrients that are necessary for crops to grow.

[2]Ethiopia has experienced at least five major national droughts since 1980, along with dozens of localized ones (World Bank 2008b). These cycles of drought create poverty traps for many households, constantly consuming any build up of assets and increase in income. Evidence shows that about half of all rural households in the country experienced at least one major drought during the five years preceding 2004. The evidence also suggests that these shocks are a major cause of transient poverty. That is, had Ethiopian households been able to smooth consumption, then poverty in 2004 would have been at least 14 per cent lower, which translates into 11 million fewer people falling below the poverty line (Dercon 2009).

[3] 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).

factors have been identified as barriers to soil conservation investment in Africa.[4] 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).

In this paper we present reduced form results and contribute to the existing literature in two ways. First, we add to the literature on adoption of conservation technologies by estimating the causal effect of rainfall and its variability on the implementation of soil conservation measure such as the construction of stone and soil bunds. We estimate the *direct* effect of rainfall and its variability on investment in soil conservation. We say total effect, because rainfall can affect investment in many ways, among them: changing the profitability of the investment, changing the profitability of alternative investments, and changing income. 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. We run experiments with the same household in two different points in time. We find that rainfall variability

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[4] 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.[5] 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).[6] 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

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[5] 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).

[6] 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.

schemes. The elicitation procedure maps remarkably well into with this real life measure of impatience.[7]

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 adverse 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

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[7] No real pay off was given to farmers playing the game. Our experimental measure should therefore be considered hypothetical. This result provides further evidence on the possible use of hypothetical measures in 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.

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.

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 two rounds of the survey, 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 asked the farmers about their soil conservation effort. 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). These bunds 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. 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.

Farmers reported that weather shocks were very important in determining their welfare. Drought and floods affected a substantial portion of the sample: 27% of households report that they experienced an environmental shock in the two years before the first survey round, and 38% before the second round.

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 asking farmers: would you prefer a payment of 50 Ethiopian Birr today and 65 Ethiopian Birr in the next year? Would you prefer 50 Ethiopian Birr today or 80 Ethiopian Birr in the next year?[8] We interpret the choice of the immediate payment as "impatient."[9] 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 *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).[10] Incentive compatible measures of behaviour, besides being more expensive than hypothetical ones, are not easy to implement in developing country context.[11] 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). Moreover, a growing body of economics literature indicates that hypothetical measures map

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

[9] This interpretation is due to Ashraf, Karlan and Yin (2006).

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

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

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).

While hypothetical measures of behavior are not a *perfect substitute* of real stakes ones,[12] they are definitively source of important behavioural information (Dohmen et al., 2011). To validate the use of a hypothetical measure of time preference, 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. This, therefore, justify an elicitation procedure that does not depends on incentive-compatible experiment.

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[12] 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)

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 with 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 Em, which is just 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 give 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.

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 $E[m(L) R(L)] = Em\ ER + cov(m,R) = 1$.

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.

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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 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.

Econometric strategy

The main objectives of the empirical analysis are to assess the causal relationship rainfall, and its variability, on both soil conservation and on the rate of time preference. We argue that climatic factors are crucial determinants of both the rate of time preferences and investment decisions because the majority of rural households in Ethiopia are rain-fed. 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.

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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]

We estimate two equations. Equation (1) presents the causal relationships between rainfall variables and time allocated in building soil conservation structures. Equation (2) presents the relationship between the rainfall variables and the rate of time preferences.

$$Soil\ Conservation_{ht} = \alpha_0 + \alpha_1\ rain_{ht} + \alpha_2 rain\ variability_{ht} + \beta_1 X_{ht} + u_{ht} \qquad (1)$$

$$Impatience_{ht} = \alpha_3 + \alpha_4 rain_{ht} + \alpha_5 rain\ variability_{ht} + \beta_2 X_{ht} + v_{ht}, \qquad (2)$$

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.

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[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.

We use a fixed effect panel data estimator and add time fixed effects. This allows controlling for time invariant characteristics of the household as well as for household invariant time effects such as policies that may have affected this area in the period covered by the dataset.

Discussion of the results

Table 3 reports the estimation results of equation (1). Column 1 reports the regression of time spent on conservation measures on annual rainfall and its coefficient of variation, computed across months in the observation year. There are 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 and its coefficient of variation 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.

More rainfall is positively correlated with time spent in building conservation structures. The estimated elasticity is not trivial. An increase of 10% in rainfall increases the conservation effort by 36%. The estimated coefficient for rainfall variability is negative and statistically significant in all the specifications. An increase of 10% in the coefficient of variation decreases the time spent in conservation activities by 15%. This is an interesting result. Among the other controls, only household size displays a statistically significant coefficient. The larger the size of the household the higher the time spent in conservation. This seems quite intuitive in this type of agriculture. We are

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in the context of small (typically less than one hectare) self-subsistence farms. Farmers do not hire more labour on the market and therefore household members are the key providers of labour. To see if last season rainfall had some impact on this year outcome variable we added a lagged variable for rainfall. We find that is not statistically significant. We also controlled for other possible sources of shocks. 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 not 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]

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

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[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.

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
Rainfall	Annual rain in mm	1201	166	102	2294
Rainfall CV	Coefficient of variation	0.1	0.034	0.05	0.56
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

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 and its coefficient of variation per village and year

Village	Rain in 2005	Coefficient of Variation (CV) in 2005	Rain in 2007	Coefficient of variation (CV) in 2007	Change in Rainfall (in %)	Change in CV (in %)
Amanuel, East Gojam	1181.93	0.065	1294.73	0.051	9.5	-21.5
D.Elias, East Gojam	1181.93	0.065	1294.73	0.051	9.5	-21.5
Kebi, East Gojam	1167.96	0.067	1281.32	0.056	9.7	-16.4
Wolkie, East Gojam	1180.38	0.066	1293.88	0.052	9.6	-21.2
Telma, East Gojam	1418.7	0.122	1506.2	0.144	6.2	18.0
Sekla, East Gojam	1351.18	0.12	1440.26	0.154	6.6	28.3
Kete, South Wollo	986.82	0.006	1239.05	0.01	25.6	66.7
Godguadi, South Wollo	1016.61	0.07	1244.51	0.1	22.4	42.9
Amba, South Wollo	1091.23	0.1	1244.88	0.11	14.1	10.0
Yamed, South Wollo	1015.23	0.07	1244.03	0.1	22.5	42.9
Addis me, South Wollo	1081.1	0.1	1237.86	0.12	14.5	20.0
Chorisa, South Wollo	1074.33	0.09	1243.26	0.11	15.7	22.2
Indood, South Wollo	990	0.066	1237.9	0.1	25.0	51.5

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

		Std. Deviation	Min	Max

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Rainfall	Between		13.07	47.81	194.39
	Within		18.67	89.1	163.47
Coefficient of Variation	Between		0.028	0.058	0.355
	Within		0.018	-0.12	0.3

Table 4. Time allocated for conservation, rainfall and coefficient of variation. Fixed effect estimator, different specifications

Dependent variable: Time spent for soil conservation measures							
		(1)	(2)	(3)	(4)	(5)	(6)
Climatic Factors	Rainfall	0.0204**	0.0209**	0.0211**	0.0204**	0.0207**	0.0206**
		(0.00893)	(0.00900)	(0.00922)	(0.00938)	(0.00948)	(0.00950)
	Coefficient of Variation	-105.01***	-104.9***	-100.9***	-101.6***	-101.0***	-100.8***
		(26.46)	(26.53)	(27.24)	(27.56)	(27.67)	(27.70)
Non climatic Shocks	Theft shock		-0.303	-0.634	-0.873	-0.825	-0.770
			(1.912)	(1.992)	(2.043)	(2.050)	(2.060)
	Death in the family		0.841	1.023	1.348	1.358	1.355
			(1.185)	(1.288)	(1.330)	(1.331)	(1.332)
	Financial Shocks		-0.282	0.484	0.630	0.693	0.659
			(1.262)	(1.367)	(1.399)	(1.402)	(1.408)
Time varying controls	HH size			2.060**	2.098**	1.984*	1.964*
				(0.978)	(1.026)	(1.035)	(1.038)
	Age			0.0121	0.0418	0.0339	0.0365
				(0.132)	(0.142)	(0.142)	(0.143)
	Land					0.534	0.538
						(0.623)	(0.624)
	Tenure security					-1.0961	-1.0846
						(1.1032)	(1.1048)
	Rainfall t-1					-0.0231	-0.0222
						(0.0515)	(0.0517)
	Temperature						-0.0373
							(0.125)
	Time effects	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
N		1526	1526	1431	1354	1354	1354
Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; constant not reported							

Table 5. Impatience, rainfall and its coefficient of variation. Fixed effect estimator, different specifications

Dependent variable: Rate of time preference							
		(1)	(2)	(3)	(4)	(5)	(6)
Climatic Factors	Rainfall	-0.000160	-0.000219	-0.000175	-0.000218	-0.000249	-0.000264
		(0.000314)	(0.000316)	(0.000312)	(0.000314)	(0.000316)	(0.000317)
	Coefficient of Variation	3.957***	4.022***	3.815***	3.764***	3.712***	3.729***
		(0.930)	(0.930)	(0.923)	(0.923)	(0.923)	(0.923)
Non climatic Shocks	Theft_shock		-0.0245	-0.0309	-0.0475	-0.0523	-0.0466
			(0.0671)	(0.0675)	(0.0684)	(0.0684)	(0.0687)
	Death in the family		-0.0137	0.0141	0.0227	0.0218	0.0215
			(0.0416)	(0.0436)	(0.0445)	(0.0444)	(0.0444)
	Financial shock		0.0769*	0.0801*	0.0813*	0.0755	0.0721
			(0.0442)	(0.0463)	(0.0469)	(0.0468)	(0.0469)
Time varying controls	HH size			-0.00437	0.00246	0.0131	0.0110
				(0.0331)	(0.0344)	(0.0345)	(0.0346)
	Age			0.00608	0.00601	0.00674	0.00701
				(0.00449)	(0.00475)	(0.00474)	(0.00475)
	Land					-0.0486**	-0.0482**
						(0.0208)	(0.0208)
	Tenure security					0.0438	-0.0452
						(0.0368)	(0.0368)
	Rain t-1					-0.000685	-0.000592
						(0.00172)	(0.00172)
	Temperature						-0.00379
							(0.00416)
	Time effects	Yes	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
	N	1526	1526	1431	1354	1354	1354
Standard errors in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; constant not reported							