Labor adaptation to weather shocks

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Abstract

How do rural households adapt family labor to weather shocks? To answer this question, I matched a panel data on farm households from rural Mozambique with weather shocks, drought and wet episodes, calculated using high resolution precipitation and potential evapotranspiration data and causally estimated labor adaptation responses to weather shocks. I find significant labor adaptation during and following drought and wet episodes. At the extensive margin, contemporaneous drought shocks lead to more engagement in salaried non-agricultural activities, while contemporaneous wet episodes significantly increases self-employment in trade services and small and micro enterprises. I further find that following drought shocks households significantly pull away from fishery, forestry and fauna activities, which are potentially highly vulnerable to drought shocks, while last year's wet spells trigger households to increase their participation in salaried non-agricultural activities. I empirically show that labor adaptation through self-employment in trade services and small and micro enterprises exclusively takes place locally, while salaried non-agricultural activities involve migration, both domestic and international. Finally, I show that there are heterogeneities in labor adaptation responses based on land holding, head's education and labor endowment.

JEL Codes: Q54, O15, J22, J61
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1. Introduction

An overwhelming majority of rural households in sub-Saharan Africa work on on-farm agriculture. Income from this activity constitutes the lion's share of total household income. In spite of this, 98% of agriculture in the region is rain-fed making it the most vulnerable region to climate-related risks than anywhere else in the world (Parry (2007), Cline (2008), IPCC (2014)). The fact that formal insurance is incomplete and credit markets are thin in these parts of the globe leave households to experience significant declines in income and consumption in the wake of extreme climate conditions that significantly affect agricultural production. These effects on income and consumption are not just temporary but might well persist in the long-term leading to poverty persistence (Dercon *et al.* (2005), Clarke and Dercon (2009)), unless otherwise appropriate risk management strategies are put in place. To shield themselves from shocks, rural households use informal risk sharing schemes, but these schemes are shown not to be feasible in dealing with covariate risks, like climate shocks, which affect an entire network (Townsend (1994), Dercon (2002)). Due to this, households rely on self-insurance schemes, which includes adaptation to these covariate shocks, to smooth their income and consumption.

While there is a growing literature assessing rural households' different on-farm adaptation[1] options to climate-induced risks (see for example, Kurukulasuriya et al. (2006), Seo and Mendelsohn (2008), Bryan et al. (2009), Deressa et al. (2009), Di Falco et al. (2010), World Bank (2010), Salazar-Espinoza et al. (2015)) and other climate risk management mechanisms like holding spatially separated plots of land (Townsend (1994)), depleting productive assets (Rosenzweig and Wolpin (1993), Fafchamps et al. (1998), Kazianga and Udry (2006)), engaging in low-risk and low-return investments (Rosenzweig and Binswanger (1993), Morduch (1995), Zimmerman and Carter (2003)), and marrying out of daughters to spatially distant households (Rosenzweig and Stark (1989)), labor adaptation has not been well documented in the literature. Given family labor is one of the most important resources owned by rural households in developing countries, studying how farmers adapt labor is of particular importance to understand their coping capabilities and help policy design under the ever increasing occurrence of climate shocks.

[1] On-farm adaptations include irrigation, altering planting dates, changing and diversifying crop varieties, planting trees and soil conservation. Farmers also change livestock species as an adaptation strategy.

To shed light on this, I combined a two wave panel data for the year 2001/2 and 2004/5 on 2936 small and medium-sized farm households[2] from 407 villages across all 10 rural provinces[3] of Mozambique with weather shocks, drought and wet episodes, calculated using high resolution gridded precipitation and potential evapotranspiration data and address three main questions: (1) Do rural households adapt family labor to weather shocks by engaging in other activities which are potentially less vulnerable to climate risks? I study labor adaptation as an *ex post*[4] adaptation strategy to weather shocks, and hence it is possible for some adaptation options to take some time to materialize following shocks. To account for this, I included both the current and one year lagged indicators for climate shocks. (2) Do they adapt locally or migrate to adapt? And (3) are there heterogeneities in labor adaptation between different groups of households? I investigate this later question along three lines: land holding, education and labor endowment.

Rural Mozambique makes an interesting setting to investigate these research questions because agriculture is the main source of household income but predominantly rainfed, the country is among the most vulnerable African countries to weather shocks and there exists substantial rural off-farm and non-farm labor market activity.[5] The timing of the two surveys is also very helpful as 2004/5 is generally a more drought year in the country compared to year 2001/2 (Mather et al. (2008)), providing sufficient variation in the variables of interest across years in addition to the cross-sectional variation among villages.[6]

I start by documenting how different labor market activities and shock coping mechanisms are disrupted due to weather shocks. Then, I model the simultaneous decision regarding which labor market activities to take up and where to undertake them, within the village or migrate outside the village to adapt, during and following climate shocks as a collective decision by a household[7], and hence the unit of analysis is a farm household. All the outcome variables refer to a household's

[2] Characterization of small and medium-sized farm households follows the definition by the Ministry of Agriculture of Mozambique. According to the ministry, they are defined as those having less than 50 hectares of cultivated land, a herd of 100 heads of cattle, 500 goats, sheep, pigs etc., and 20, 000 fruit trees. Farms having at least equal to the stated number for any of the categories are large-sized farms and are not included in the survey.

[3] The only province that is not included in the sample is Maputo city which is not a rural province.

[4] There is a small but growing literature assessing labor adaptation responses to *ex ante* climate risk like Rose (2001) and Dillon et al. (2011). The fact that *ex ante* risk is time invariant makes it not amenable for household fixed effects specification, which is the preferred specification in this study. So, this paper focuses on *ex post* responses.

[5] Section 2 discusses these and other relevant contexts of the rural economy in Mozambique.

[6] I confirm this notion in section 4 by objectively measuring extreme climate conditions.

[7] Labor market participation is commonly modeled as a household decision (see for example, Rose (2001)). Specifically with respect to migration, the "New Economics of Labor Migration" emphasizes that labor migration is a collective decision by a household (Stark and Bloom, 1985).

allocation of at least one family labor to any of the categories of activities, implying that I study labor adaptation decisions to climate shocks at the extensive margin. To get rid of all time invariant household and village specific observable and unobservable factors which might bias the results, all regressions are estimated as household fixed effects regression. Another econometric concern that needs to be taken care of in all specifications is the potential cross-sectional correlation among households within a village regarding the two decisions. To account for this, I clustered the standard errors for all regressions at the village level, lowest possible cluster. The survey consists of 407 villages and each of the villages having few number of households, on average less than 8 households, makes clustering the standard errors at this level pretty much commendable (Wooldridge (2010)).

Several interesting results emerge from my analysis. Drought shocks lead to significant negative effects on net household income, and the most vulnerable activities responsible to this are crop agriculture, self-employment income and remittance income. However, wage income appears not to be vulnerable to drought shocks. Wet spells generally do not have any effect on labor market outcomes, but significantly reduces remittance incomes. Taken together, the effects of droughts and wet episodes on remittance income suggests that the main source of remittance income spans within the village. Livestock income remains unaffected by both of the climate shocks, and the results with regard to drought shocks suggests these activities don't provide support to households to recover from income shocks due to droughts.

Households significantly adapt family labor during and following drought and wet episodes. At the extensive margin, I find that households engage more on salaried non-agricultural activities during drought shocks. On the other hand, contemporaneous wet episodes significantly increases self-employment in trade services and facilitates establishment of new small and micro enterprises. One period following drought shocks, households significantly pull away from fishery, forestry and fauna activities, suggesting this labor activity is the most vulnerable self-employment activity to drought shocks, while following wet spells households significantly increases their participation in salaried non-agricultural activities. I empirically show that labor adaptation through self-employment in trade services and small and micro enterprises exclusively takes place locally, while salaried non-agricultural activities involve migration, both domestic and international.

Heterogeneity test results reveal that land rich households significantly pull away from the most vulnerable activities during drought shocks, i.e., from crop agriculture and forestry, fishery and fauna activities. Although there are no differences in participation in salaried non-agricultural activities during drought shocks, land rich households will subsequently pull away from these activities following drought shocks and also following wet episodes. Given salaried non-agricultural activities are mainly undertaken by migrating outside the village, the results imply that land rich households engage only in short term migration and do return to the village after drought shocks. These results suggest that inherited wealth plays a crucial role to cope with risks. These households also engage more on self-employment activities in trade services during wet episodes. More educated households appear to significantly pull away from small and micro enterprises during drought shocks, while engage more on self-employment in trade services and forestry, fishery and fauna activities during wet episodes. Following drought shocks, these households engage more on salaried non-agricultural activities. Labor rich households participate more on salaried non-agricultural activities due to contemporaneous drought shocks.

This paper adds value to the existing literature in several ways. First, it contributes to the literature related to migration as an *ex post* risk management strategy to climate shocks. This literature is more geared towards studying permanent migration and international migration (Rosenzweig and Binswanger (1993), Halliday (2006), Feng. et al. (2010), Dillon et al. (2011), Gray and Mueller (2012a,b), Gray and Bilsborrow (2013), Mueller et al. (2014), Kubik and Maurel (2016)). Although these studies are relevant to draw conclusions about permanent migration, this type of migration is not easily accessible to rural households in Sub Saharan Africa due to various reasons including liquidity constraints to finance migration costs (Kleemans (2014)), inability to pay for labor in place of migrants (Zezza et al. (2011)), and low returns to migration arising from low access to social networks and other language and skill related barriers at the destination (Chiswick and Miller (2003)). Moreover, most of these studies don't identify whether the purpose of migration is for work or other reasons (see for example, Dillon et al. (2011), Kubik and Maurel (2016), Dou et al. (2016)). Members of rural households migrate for a variety of reasons, and not all migrations are equally important as a risk management strategy for the migrant sending households, or more specifically as an adaptation to extreme climate conditions.[8] I address these shortcomings from the earlier literature by constructing the migration variable in such a way that it includes short-term domestic migration, that spans as small as one month, in addition to permanent and international migration. Moreover, migrants in this study are exclusively work related migrants. I also have information on the type of activities they are undertaking at the destination which opens a room to classify migrants into a rich set of categories of labor activities.

[8] Gray and Wise (2016) disentangles labor migration from other forms of migration. Although the unit of analysis is a household in this study, this study don't rely on household fixed effects regression. They only included district fixed effects implying that the results are potentially biased due to time-invariant household characteristics that are not controlled for in the regression.

Second, this paper also contributes to the literature related to income diversification as a risk management tool against climate shocks in rural areas of developing countries. This literature mostly uses a binary measure of off-farm labor participation (Rose (2001), Haggblade et al. (2007), Deichmann et al. (2009), Mueller and Quisumbing (2011), Dimova et al. (2015), Mathenge and Tschirley (2015)). Different off-farm activities have different sets of risks and marginal returns compared to on-farm agriculture. Hence, a more compelling and policy-wise relevant analysis can be obtained through rich classification of all the available off-farm labor adaptation options. I add value on this capitalizing on the sufficient list of activities from the survey. In this regard, there are papers which provide sufficient classification of activities including Cunguara et al. (2011), Skoufias et al. (2016) and Dou et al. (2016). The former two studies are cross-sectional implying the results are not potentially well identified owning to lack of randomness of climate variables at a cross-section. All of these studies also do not distinguish whether labor adaptation is local or involves migration.[9] I add on these two points by using panel data, which enables me to control for both location and time fixed effects and hence guarantee the randomness of variables used to define weather shocks, and differentiating whether labor adaptation is taking place within the village or involves migration.

Traditionally, the literature on the impacts of extreme climate conditions relied very much on respondents' self-reported assessments of extreme climate conditions. Recent studies are using more objectively measured indicators of extreme climate condition although they are mostly based on a single climate variable of either rainfall or temperature.[10] Agricultural incomes depend on a multitude of climate factors, and hence characterizing extreme climate conditions using just a single climate variable is less sound (Rose (2001), Vicente-Serrano et al. (2010)). In light of this, I contribute to the existing literature by characterizing the relative dryness (drought) and wetness (flood) using water balance which is the difference between precipitation and potential evapotranspiration following the climatology literature (Vicente-Serrano et al. (2010), Beguería et al. (2014)), whereby the latter is calculated taking into account the effect of temperature, wind speed, vapor pressure and cloud cover (Harris et al. (2014)).

The rest of the paper is organized as follows. Section 2 discusses agriculture, rural labor market activity and climate condition in Mozambique. Section 3 presents data and summary

[9] Dou et al. (2016) includes migration as an outcome variable in addition to the different categories of labor activities. But, this variable do not differentiate whether migration is work related or not.

[10] Exceptions in this regard are Mueller et al. (2014) and Kubik and Maurel (2016).

statistics. Section 4 presents the empirical strategy and I present and discuss the main results in Section 5. Section6 presents a variety of robustness checks. Section 7 concludes.

2. Background

The Mozambican economy has achieved an impressive growth over the past two decades (World Bank (2010)). The agricultural sector has played a major role behind this overall all economic growth, and it continues to be one of the important sectors in the economy absorbing over 70% of the population (World Bank (2010), Jones and Tarp (2015)) and being at the heart of addressing poverty in the country (Arndt et al. (2012), Arndt et al. (2015)). In spite of the sector's contribution to these and other key development indicators, almost all (over 99.8%) the farms are owned by smallholder (small and medium-sized) farmers cultivating 90.7% of the total cultivated land (Deininger and Xia (2016)). These farmers operate on a very fragmented land, on average holding less than 1.5 hectares (World Bank (2006), Arndt et al. (2012), Arndt et al. (2015)) with majority of them cultivating on one or less hectares (Arndt et al. (2012)).

There are also some more concerns with regard to agricultural development in the country. First, the growth in the sector is achieved mainly through agricultural land expansion, but not improved productivity. Agricultural productivity is quite low with, for instance, productivity of maize, the most important staple crop, being 1.4 tons per hectare which is far below the potential productivity of 5 - 6.5 tons per hectare (Howard et al. (2003)), and aggregate agricultural productivity has been stagnant since then until near present (Arndt et al. (2012), Deininger and Xia (2016)). One of the major reasons behind this is low level of adoption of productivity-enhancing agricultural technologies. In this respect, of the total smallholder farmers, not more than 12% use improved seeds, 5% use fertilizers, 7% use pesticides, and 4% use tractors over the period 2002-2014 (Deininger and Xia (2016)). World Bank (2010) also estimates that not more than 0.5% of the total cropland is irrigated, which is almost entirely used by sugarcane farms and the rest of it by rice and vegetable farms. Although recent estimates show less than 18% of the country's agriculturally suitable land is being cultivated for crop production and there still remains large potential to boost agriculture through land expansion, modernization of the sector is something that needs to be taken seriously. The second and perhaps the most important concern is lack of sufficient attention from the policy sphere in the country to improve smallholder productivity (Arndt et al. (2006), Arndt et al. (2012)).

Although labor market activity in Mozambique (and to a greater extent in rural areas) is dominated by smallholder farming (Jones and Tarp (2015)), there is substantial off-farm and non-farm labor market activity in rural parts of the country. With respect to off-farm agricultural labor, over 15.5% and 17.6% of farm households hired seasonal labor to work on their farms in exchange for cash, kind or both in 2002 and 2005, respectively. Similarly, 2.2% and 1.8% of farm households hired permanent labor in 2002 and 2005, respectively (Jones and Tarp (2013)). A significant portion of farm households also allocate at least one family labor in non-farm labor activities. In this respect, Mather et al. (2008) estimates 57% and 70.2% of farm households engage in either wage-employment or self-employment in non-farm activities in 2002 and 2005, respectively. This led to off-farm and non-farm activities to constitute significant portion of farm household income with off-farm agricultural labor income making up 2% and 3.7% of total farm household income in 2002 and 2005, respectively. And non-farm income constitutes 22.4% and 30.5% of total household income in 2002 and 2005, respectively (Mather et al. (2008)). Farm households are also increasingly using labor migration as a livelihood diversification strategy (World Bank (2006), Jones and Tarp (2013)), which might have led to increased receipt of remittances from 2002 to 2005 (Mather et al. (2008)).

Mozambique has a diverse climatic condition which is mostly arid and semi-arid in the south and southwest, sub-humid and humid in the center, and sub-humid in the north (World Bank (2006)). The main rainy season runs from October to March in the south and from November to March in the center and north (Silva et al. (2015)). Annual rainfall ranges from 400 to 1000 mm in the south, 1000 to 1200 mm in the center and 1000 to 1800 mm in the north (World Bank (2006)). The country is highly vulnerable to extreme climate conditions (World Bank (2006; 2010), Arndt et al. (2011)), ranking the third most vulnerable African country to multiple weather-induced risks (UNISDR (2009)). Droughts and floods are the most common weather-related risks (World Bank (2006; 2008; 2010)), with the former being the most frequent disaster in the country (World Bank (2010)). Southern and central regions of the country are particularly vulnerable to droughts with drought frequency of 7 in 10 and 4 in 10 years, respectively. Floods also occur most frequently in southern and central regions of the country, but also along river basins, in low-lying regions, and in areas with underdeveloped drainage systems. Although less frequent compared to droughts, floods in Mozambique can last for several months and become disastrous. For instance, the flood in 2000 was the worst flood over 50 years in the country, killing and displacing over 800 and 540, 000 people, respectively (World Bank (2010)). In addition to these, weather-induced shocks have had serious effects on the performance of agriculture and the national economy of Mozambique (World Bank (2010)). Projected climate conditions show that the frequency and intensity of these shocks will increase, implying they will continue to be a setback for the Mozambican economy. Arndt and Thurlow (2015) predicted a 4%, and possibly up to 10%, lower agricultural value added in

Mozambique by 2050 due to climate change compared to a "no climate change" scenario if appropriate adaptations are not put in place. This points to the importance of understanding how farmers in rural Mozambique adapt to changes in climate. And family labor being one of the most important resources of the rural economy, adapting family labor to changes in climate remains to be the integral part of the overall adaptation by farm households.

3. Data and Summary Statistics

The empirical analysis in this study is undertaken by combining two different datasets. The first one is a two wave panel household survey for the year 2001/2 and 2004/5 from *Trabalho de Inquérito Agrícola* (TIA) on Mozambican small and medium-sized farm holdings.[11] It is collected by the Ministry of Agriculture of Mozambique in collaboration with Michigan State University. The 2001/2 survey sample households were drawn from the year 2000 agricultural census using stratified, clustered sampling design with the aim of making it representative of small and medium-sized farm households for each of the 10 rural provinces and all agro-ecological zones of the country. The 2001/2 -2004/5 panel data is the first nationally representative panel survey in Mozambique (Mather et al. (2008)). It contains information on various characteristics of farm households including household demographics, employment conditions, access to services, land holding, agricultural production and sale, self-reported occurrence of natural disasters, indicators of well-being and food security, and diseases (morbidity). Using this survey, I constructed a balanced panel of 2936 households residing in 407 villages[12] in all provinces of the country for which village centroid GPS coordinates are available in the community survey, a supplement to the household survey. Important to the objectives of this study, the survey has a rich list of over 25 salaried and self-employment activities in addition to on-farm agriculture. This list is based on information from previous cross-section TIAs and hence includes all the important activities in the rural economy of the country. Moreover, it provides the option to households to specify themselves if they are undertaking anything that is not included in the list. Capitalizing on this I constructed appropriate categories of activities based on similarities in risks and returns involved, which will eventually serve as outcome variables in this study. These categories are: on-farm agriculture, salaried

[11] The TIA (and since 2012 Inquérito Agrícola Integrado (IAI)) survey has been conducted since 1996 and has 10 surveys thus far in 1996, 2002, 2003, 2005, 2006, 2007, 2008, 2012, 2014 and 2015. These surveys are all nationally representative (representative at the provincial and agro-ecological levels) of small and medium-sized farm households in the country. The sample households in 2002 were re-interviewed in 2005, and I use these TIAs to exploit the panel nature of the survey, while the rest of the surveys are cross-sectional.

[12] Location of villages will be shown on a map.

agricultural activities, salaried non-agricultural activities, self-employment in trade services, self-employment in small and micro enterprises, and self-employment in forestry, fishery and fauna activities.

Households have the option of undertaking any of the salaried employment and self-employment activities either locally or elsewhere by sending out at least one household member to other villages, provinces or countries.[13] These two locations involve different costs, risks and returns even for the same type of activity. I accounted for this by differentiating each of the categories of activities whether they are undertaken locally or elsewhere. For the same reason, I also differentiated the activities which are significantly undertaken outside the village whether it is within or outside the country, i.e. involve domestic or international migration. Summary statistics for the aforementioned outcome variables and other controls is presented in Table 1.

The second data is gridded monthly precipitation and potential evapotranspiration (PET)[14]. It comes from the Climate Research Unit (CRU) of University of East Anglia, Norwich, UK. The community survey of TIAs include village centroid GPS coordinates. I matched these coordinates with the corresponding grid cells of the CRU data to pull the relevant values for the two climate variables for each village.[15] The gridded data has a high spatial resolution of 0.5 degrees latitude and longitude (Harris et al. (2014)). It contains the two variables, among others, from year 1901 to near present, but the actual years used in this study spans from 1971 to 2005. This period is chosen based on two criteria: (1) It should be long enough so that it is insensitive to recent shocks. In this regard, Mckee et al. (1993; 1995) recommends to use at least a 30 years monthly data in order to appropriately characterize climate shocks. (2) And the number of years should not be so many so that calculation of extreme climate conditions will not miss out recent averages incase the long-run mean of climate variables change (Burke et al. (2013)). Moreover, the object of interest in this paper being to estimate how farmers allocate labor when agricultural productivity is adversely hit by weather shocks, the relevant weather condition is the one during the main agricultural growing season. The main growing season in rural Mozambique runs from October to March in the south and from November through March in the north (Silva et al. (2015)). For consistency purposes, I used values for the two climate variables from October through March.

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[13] The survey doesn't provide the location of fishery, forestry and fauna activities. So, with regard to location based differences in labor adaptation, I focus on the other four categories of activities other than on-farm agriculture.

[14] More information on how PET is calculated can be found from Harris et al. (2014).

[15] This implies that climate variables vary only across villages for a survey year. However, the survey includes 407 villages providing sufficient variation in these variables for the study. This is further complemented by the variation in these variables over time.

Using the two climate variables, characterization of extreme climate conditions is based on an extended version of the Standardized Precipitation Index (SPI) called the Standardized Precipitation Evapotranspiration Index (SPEI) (Vicente-Serrano et al. (2010), Beguería et al. (2014)) on a six months scale over the main growing period defined above. The SPI has been extensively used as a drought (Mckee et al. (1993, 1995)) and flood (Seiler et al. (2002)) monitoring in the climatology literature. The main drawback of the SPI is the use of only precipitation to characterize climate conditions. The SPEI extends the SPI in that it is based on water balance, the difference between precipitation and potential evapotranspiration (PET) (Vicente-Serrano et al. (2010), Beguería et al. (2014)). PET is calculated based on monthly maximum, minimum and average temperature and in addition wind speed, vapor pressure and cloud cover (Harris et al. (2014)), and hence this makes SPEI to take into account the effect of all these climate variables in defining the evaporative demand which will eventually be subtracted away from precipitation to define water balance. This is a big improvement over the SPI in defining climate conditions since evaporation and transpiration could consume up to 80% of rainfall (Abramopoulos et al. (1988)). Using water balance data, calculation of SPEI involves: (1) Fitting the water balance data for each village into a log-logistic distribution. The water balance data in this study are positively skewed and fitting it into such a distribution takes care of non-normality of it. (2) Then, transforming it into a standard normal distribution with zero mean and standard deviation of unity. This allows comparability of SPEI values between villages, since all villages have the same mean after the transformation (Mckee et al. (1993, 1995), Vicente-Serrano et al. (2010), Beguería et al. (2014)). Then, drought shocks are defined as dry periods with SPEI values less than -0.5[16], and wet episodes are defined conversely as wet periods with SPEI values greater than 0.5. Summary statistics of these climate shocks is also included in Table 1.

Panel (c) of Table 1 show that household heads are mostly male with an average age being in the middle of forties. The household heads education is on average 3 years in 2001/2 and 2 years in 2004/5. The average household size is relatively stable across the two surveys with around six people, close to half of them being members aged 15 and 59 years old. Households own around two plots of land whose aggregate area is on average around 2.3 hectares in 2001/2, while they own around four plots of land and the total size measured in hectares is around 2.4 in 2004/5.

[16] The same cut-off point is used by Salazar-Espinoza et al. (2015) to define droughts based on SPI. However, Rose (2001) defined rainfall shocks as any deviation from long run mean. In light of this, I used the whole continuum of values of SPEI as a water balance shock.

The outcome variables are presented in panel (a) of Table 1. It shows that almost all rural households work on on-farm agriculture, but opportunities to work on activities other than on-farm agriculture are considerably large. In 2001/2, about 19% of households have small and micro enterprises and around 11% of households engage in self-employment in trade services. They also work on salaried employment with around 12% of them in non-agricultural activities and 7% in agricultural activities. Participation in each of these off-farm activities is even larger in 2004/5, whereby the largest growth is in self-employment in small and micro enterprises followed by salaried agricultural activities. In both years, most of these activities are undertaken locally within the village except for non-agricultural activities whereby most of households undertake these activities by sending at least one household member elsewhere outside the village. The statistics shows that majority of the households engage in forestry, fishery and fauna activities.

The other variables of interest are proxies of extreme climate conditions, drought and wet episodes. Panel (b) of Table 1 presents these variables for each of the survey years and one lagged period. The statistics shows that the growing season during 2004/5 was mostly dry compared to 2001/2 with over 74% and 41% of households experiencing drought shocks, respectively. However, almost 10% households experienced wet episodes in these two years. Year 2003/4 is also a dry year with over 60% of households hit by drought shocks, while less than 2% of households experienced wet episodes. On the other hand, the growing season in 2000/1 is characterized by excess water balance with over 85% households experiencing wet episodes while less than 1% of households were hit by drought shocks. The descriptive result for this year is not surprising given that the country experienced one of the worst floods over 50 years in this period which led to loss of many lives and displacement of over half a million people (World Bank (2010)).

4. Empirical Strategies

The goal of this paper is to investigate how households adapt family labor in the wake of income shocks due to extreme climate conditions. Hence, I start the empirical analysis by investigating how vulnerable are different activities to climate shocks based on the following specification:

$$Y_{ht} = \alpha + \beta D_{ht} + \theta W_{ht} + \delta X_{ht} + \gamma \, YR_t + C_h + \varepsilon_{ht} \qquad \ldots \ldots (1)$$

where h indexes the household and t indexes year (2004/5 or 2001/2). Y_{it} is the dependent variable which takes household income or incomes from other shock coping mechanisms. D_{ht} and W_{ht} are dummy variables indicating whether household h experienced drought and wet episodes in year t, respectively. X_{ht} is a vector representing time-varying socio-economic variables of the household including household (including household size, land size in hectares, number of plots, etc.) and household head (including head's age, gender, and education). YR_t is a year fixed effect which takes 1 if it 2004/5 and 0 otherwise. This variable is included to capture the general trends in the outcome variables that resulted from the changes in living conditions over time. C_h is a variable capturing observed and unobserved household fixed effects. ε_{ht} is a statistical noise term. $\alpha, \beta, \theta, \delta$ and γ are parameters to be estimated. The coefficients of interest are β and θ which measures the effects of contemporaneous drought and wet episodes, respectively, on incomes.

Once time (YR_t) and location (C_i) fixed effects are controlled for in equation (1), the climate shock variables (DD_{ht} and FF_{ht}) are random. The main objective being estimating the effect of these variables on incomes, randomness of these variables has two effects: (1) Controlling for other exogenous variables (X_{it}) do not have any additional value. Hence, in the basic regression, I don't include these variables. In a separate regression, I show the robustness of the main results to inclusion of additional such controls. (2) It is possible to run a linear regression model although the outcome variable is binary so long as the object of interest is to study the difference in the outcome variable between households who experienced shocks and who don't (Angrist and Pischke (2009)), which further makes it possible to employ fixed effects regression. All regressions are therefore household fixed effects regression whereby all observed and unobserved time invariant household (C_h) and village characteristics drops out.

Another econometric concern that needs to be dealt with in all regressions of the form in equation (1) is the potential cross-sectional correlation among households within a village regarding incomes, other coping mechanisms and household decisions on which labor activity to take up and where to undertake it. To account for this, I clustered the standard errors for all regressions at the village level, which is the lowest available cluster, across years. The survey covers 407 villages and each of the villages having few number of households, on average less than 8 households, makes clustering the standard errors at this level pretty much commendable (Wooldridge (2002)).

I next estimated labor adaptation responses to climate shocks. Taking advantage of the gap in between the two surveys, I included not only the contemporaneous climate shocks but also one year lagged shock variables. These variables are included in order to take account of the fact that adapting towards some of the labor activities might take some time to materialize once exposed to climate shocks. To this end, I estimated a slightly different version of (1) as specified below:

$$L_{ht} = \alpha + \sum_{j=0}^{1} \beta_{t-j} D_{ht-j} + \sum_{j=0}^{1} \theta_{t-j} W_{ht-j} + \gamma\, YR_t + C_h + \varepsilon_{ht} \qquad \ldots\ldots (2)$$

where L_{ht} the dependent variable which in this case is an indicator variable whether household h allocates at least one family labor to a particular category of labor activity at time t. D_{ht-j} and W_{ht-j} includes one year lagged drought and wet episodes, respectively, in addition to the current shocks. The other variables are as defined before. The coefficients of interest are β_{t-j} and θ_{t-j}. The coefficients β_t and θ_t measure the effects of current year drought and flood episode, respectively, on various labor market participations. The coefficients β_{t-1} and θ_{t-1} measure the effects of one year lagged drought and wet episodes, respectively, on a multitude of labor market participations.

To account for the different risks and returns involved with respect to where households are undertaking the adaptation, I next disaggregated whether adaptations into different activities are local which refers to adaptation within the village or involve migration if the adaptation is undertaken outside the village and estimated equations of the form in equation (2). Whenever adaptations involve migrating outside the village, I further disaggregated them into whether they involve domestic or international migration and estimated the same specification as in equation (2).

Similar to (1), the preferred estimation for all regressions based on equation (2) is household fixed effects estimation which takes care of all time invariant observed and unobserved household and village characteristics. Due to the randomness of indicators of climate shocks, other time variant household characteristics are not included in the main results. The disturbance terms are allowed to be correlated within a village but remain independent across villages and over time similar to equation (1).

I next assessed the heterogeneities in labor adaptation responses between different groups of households along three lines: land holding, education and labor endowment. To accomplish this, I classified the households into two categories based on the median value of each of the three variables. The rational for using land holding is that land rich households have better capability to mitigate risk through inherited wealth (Rosenzweig and Stark (1989)). Head's education is used on the assumption that better educated households will have better employment opportunities outside on-farm agriculture both within and outside the village. The rational for using labor endowment is that labor availability makes participation in other labor activities easier. For empirical estimation, I interacted these variables with the climate shock indicators, and these interaction variables are added to the main regressions in equation (2) above which then becomes:

$$L_{ht} = \alpha + \sum_{j=0}^{1} \beta_{t-j} D_{ht-j} + \sum_{j=0}^{1} \theta_{t-j} W_{ht-j} + \sum_{j=0}^{1} \eta_{t-j} (D_{ht-j} * I) + \sum_{j=0}^{1} \zeta_{t-j} (W_{ht-j} * I) + \gamma\, YR_t + C_h + \varepsilon_{ht} \quad \dots (3)$$

where "I" is a dummy variable indicating whether a household head's education is above the median heads' education. And it is defined analogously when land holding and dependency ratio are used. The other variables are as defined before. The coefficients of interest are η_{t-j} and ζ_{t-j}. The significance of these coefficients imply heterogeneity in labor adaptation responses to drought and wet episodes, respectively, at time $t-j$ based on the particular "I" under consideration. Similar to the regressions in equations (1) and (2), the preferred estimation for equation (3) is household fixed effects and the disturbance terms are allowed to be correlated within a village, but remain independent across villages.

5. Results

This section is structured into two sub-sections. In the first section, I investigate the effects of weather shocks on agricultural income, other incomes and shock coping mechanisms based on equation (1). In the next section, I analyze labor adaptation responses to weather shocks based on equations (2) and (3). I assess responses to contemporaneous and lagged weather shocks, location based differences in responses to shocks and heterogeneities in responses based on land holding, head's education and labor endowment.

5.1. Income shocks and other shock coping mechanisms

In this section, I present results on how weather shocks disrupt incomes from different labor market activities and other shock coping mechanisms with the aim of distinguishing the differences in vulnerability of different labor market activities to weather shocks and the effects on other shock coping mechanisms. In panel (a) of table 2 I present results of the impacts of climate shocks on total net household income, total net crop income and wage income. The effects of climate shocks on total net household income can be interpreted as the effect that a household's all available self-insurance and informal insurance schemes cannot buffer. In panel (b) of table 2 I present results of the impacts of weather shocks on self-employment income, remittance income and livestock income. The latter two groups of incomes are collectively referred as shock coping mechanisms.

The results reveal that drought shocks lead to significant declines in total net household income, and the result is robust for inclusion of a wide range of other controls (columns 1 and 2). This effect mainly comes from significant declines in incomes from crop agriculture (columns 3 and 4) and self-employment labor activities (columns 7 and 8), making them the most vulnerable labor market activities to drought shocks. Transfers from other households also declines significantly during drought shocks. However, wage income remains unaffected by drought shocks, suggesting that salaried labor activities are less vulnerable to drought shocks. On the other hand, wet spells appear not to have any effect on incomes from different labor market activities and total net household income. However, remittance income significantly declines during these wet spells. The significant decline in remittance incomes both in drought periods which significantly reduce total net household incomes and in the wake of wet spells which doesn't affect aggregate net household incomes suggests that the source of these incomes is largely within the village. In the former case, drought being a covariate shock affects the entire network within the village and hence reducing the ability of households to send out transfers, while in the latter case wet spells having no effects on labor incomes do not necessitate sending out transfers to other households within the village.

In spite of the differences in vulnerability to drought shocks, both shock coping mechanisms, remittances and selling livestock, don't provide insurance to households when hit by drought shocks which led to significant declines to household incomes. Salaried employment activities also don't provide recovery to households in times of drought shocks although it is not vulnerable to drought shocks. This suggests that households whose incomes are mainly dependent on salaried employment activities have lesser income risks due to shocks and hence diversifying labor activities to these activities can reduce income risks due to drought shocks, but will not help households recover from weather shocks.

5.2. Labor adaptation responses

Table 3 presents the main estimation results for households' labor adaptation responses to weather shocks. Labor adaptation results are reported for six disaggregated categories of activities: self-employment in (on-farm) agriculture, salaried agricultural activities, salaried non-agricultural activities, self-employment in trade services, self-employment in small and micro enterprises and self-employment in fishery, forestry and fauna activities. The results reveal that households significantly adapt family labor during and following drought and wet episodes. This result is at the odds with the findings of Dou et al. (2016) in East Africa in which they show rural workers are non-responsive to temperature shocks. However, other studies from Asia (Kochar (1999), Rose (2001), Gray and Mueller (2012a,b)) show results in line with this study, whereby workers adapt to different climate shocks.

At the extensive margin, I find that contemporaneous drought shocks lead to a 5% points more engagement in wage employment in non-agricultural activities. Households also adapt family labor to contemporaneous wet episodes through a 10% and 7% more engagement in self-employment activities in trade services and small and micro enterprises, respectively. The fact that households adapt labor during these periods which don't result in aggregate income or crop income losses suggests that they do so not only to reduce risk but also to maximize incomes. In terms of medium term labor adaptation responses, I find that households reduce their labor market participation in forestry, fishery and fauna activities by 12% points to last year's drought shocks, implying that this labor market activity is among the vulnerable activities to drought shocks but takes some time to completely pull away from the sector. Wet spells from one lagged year also triggers households to increase their participation in salaried non-agricultural activities 5% points more.

I next explore whether these adaptations are taking place locally or involve migrating outside the village. Table 4 reports these results for all categories of labor market activities except on-farm agriculture, which can be undertaken only locally, and forestry, fishery and fauna activities for which the survey doesn't provide the location of activities. The results show that labor adaptation through self-employment in trade services and small and micro enterprises during wet spells is exclusively takes place within the village. Households also adapt to last year's drought shocks locally by increasing participation in salaried non-agricultural activities. Households' labor adaptation through more engagement in salaried non-agricultural activities during drought shocks and following last year's wet spells is, however, undertaken by migrating outside the village. This result supplements the small but growing literature which shows that different climate shocks leads to more migratory responses (see for example, Rosenzweig and Binswanger (1993), Halliday (2006), Feng. et al. (2010), Dillon et al. (2011), Gray and Mueller (2012a,b), Gray and Bilsborrow (2013), Mueller et al. (2014), Kubik and Maurel (2016)) by specifically assessing migration for work-related purposes. In addition, most of the aforementioned studies focused on international migration. I empirically show that (in table 5) domestic migration is equally important as international migration to labor adaptation to drought shocks through engaging in salaried non-agricultural activities.

The results further show that households don't adapt family labor to weather shocks by engaging in salaried agricultural activities (column 2 of table 3), neither locally nor by migrating outside the village (column 1 and 2 of table 4). Contrary to these results, World Bank (2006; 2008) argues theoretically that *ganho-ganho* is one of the coping strategies to climate shocks in rural Mozambique. Specifically, World Bank (2008, p.49) writes:

> In rural areas (of Mozambique), coping usually includes casual day labor—often referred to locally as *ganho-ganho*—on someone's farm in exchange for food or money. Although *ganho-ganho* is also practiced in normal times, it takes on

particular importance as a coping strategy in times of shocks and stress, when few regular activities are available to the poor.

Before outlining the above, World Bank (2008, p.48) writes that weather related shocks (such as floods and droughts) are among the most important shocks in rural Mozambique. World Bank (2006) also writes that *ganho-ganho* is the main coping mechanism in rural Mozambique in the wake of climate shocks although at lower payments compared to normal times. Motivated by these and the fact that the survey question for salaried agricultural activities over the past 12 months right before the survey is framed as "Agriculture (cropping or livestock) including *ganho-ganho*?", I empirically assessed if this customary risk sharing system, i.e. *ganho-ganho*, provides employment to households in times of weather shocks. To this end, I assessed if households increase local participation in household farms as salaried laborers (to capture *ganho-ganho*) and not on large farms nor employed by other economic agents (like factories, NGOs, government and others). The results show that households donot use *ganho-ganho* to adapt family labor to weather shocks (Table 6). Instead, they significantly pull away from salaried agricultural activities in large farms following both drought and wet episodes. The result on *ganho-ganho* is in line with the discussions on informal risk sharing networks (for example, Townsend (1994), Dercon (2002)) where in times of weather shocks the whole network in the village will breakdown and hence can't provide support to households to recover from shocks.

Table 7, 8 and 9 report heterogeneity test results in labor adaptation to weather shocks. This test is undertaken based on three different variables of interest: land holding, head's education and labor endowment. The results reveal that land rich households significantly pull away from the most vulnerable activities, i.e. crop agriculture and forestry, fishery and fauna activities, during drought shocks compared to land poor households. Although there are no differences in participation in salaried non-agricultural activities during drought shocks, land rich households will subsequently reduce their participation in these activities following drought shocks and also following wet episodes. Given salaried non-agricultural activities mainly takes place by migrating outside the village, the results imply that land rich households engage only in short-term migration and do return to the village after drought shocks. These results suggest that inherited wealth plays a crucial role to cope with risks so that land rich households engage only in short term migration while land poor households engage in long term migration. Land rich households also engage more on self-employment activities in trade services during wet episodes compared to land poor counterparts. This suggests that asset rich households do easily diversify activities to maximize household incomes. More educated households appear to significantly pull away from small and micro enterprises during drought shocks, while engage more on self-employment in trade services and forestry, fishery and fauna activities during wet episodes compared to less educated households. Following drought shocks, these households engage more on salaried non-agricultural activities suggesting educated households have better employment opportunities in the non-agricultural sector. Labor rich households participate more on salaried non-agricultural activities due to contemporaneous drought shocks compared to labor poor households implying that labor availability is an important factor to adapt to drought shocks.

6. Robustness Checks

In this sub-section, I conducted two robustness checks of the main results presented in the previous section. These robustness checks are related to the definition of drought and wet episodes used thus far. In the first robustness exercise, I used the whole continuum of the Standardized Precipitation Evapotranspiration Index (SPEI) values instead of the binary measures based on cut-off points. Specifically, all positive values referring to positive water balance deviations from the long-run mean are used to define wet episodes and conversely negative values are used in absolute value terms to define drought periods. Higher values refer to more severe drought and wet episodes. In the second exercise, instead of the above mentioned index, I calculated the long-run mean of water balance based on the precipitation and potential evapotranspiration data from 1971 through 2005 and used a simple measure of the number of standard deviations above the long-run mean of water balance to define wet periods and below the long-run mean to define drought periods. Similarly, higher standard deviations imply more severe drought and wet episodes. The results, not reported here, remain unchanged.

7. Conclusions

Income and consumption of rural households in sub-Saharan Africa face substantial risks from different sources. One of the important sources of risk comes from weather shocks since the main economic activity in this region is rain-fed agriculture. To shield themselves from these risks, households use a variety of adaptation strategies. However, how households use family labor as a risk management strategy to weather shocks has not been very well documented in the literature. This paper sheds light on this self-insurance scheme by matching a panel survey on Mozambican small and medium-sized farm households with indicators of weather shocks, drought and wet episodes, calculated using geo-referenced high resolution precipitation and potential evapotranspiration data.

The results of household fixed effect regressions reveal significant labor adaptation responses during and following drought and wet episodes. At the extensive margin, contemporaneous drought shocks lead to more engagement in salaried non-agricultural activities, while contemporaneous wet episodes significantly increases self-employment in trade services and small and micro enterprises. I further find that following drought shocks households significantly pull away from fishery, forestry and fauna activities, which are potentially highly vulnerable to drought shocks, while last year's wet spells trigger households to increase their participation in salaried non-agricultural activities. I empirically show that labor adaptation through self-employment in trade services and small and micro enterprises exclusively takes place locally, while salaried non-agricultural activities involve migration, both domestic and international. Finally, I show that there are heterogeneities in labor adaptation responses based on land holding, head's education and labor endowment.

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Table 1: Summary Statistics: Outcome Variables

	Survey Year					
	2002			2005		
Variables	Obs	Mean	Sd	Obs	Mean	Sd
Panel (a): Outcome Variables						
Self-Employment (SE) in Agriculture (Ag)	2,936	0.990	0.097	2,936	0.995	0.069
Wage Employment (WE) in Ag	2,936	0.073	0.259	2,936	0.177	0.382
Adapt Locally	2,936	0.050	0.219	2,936	0.146	0.353
Migrate to Adapt	2,936	0.023	0.150	2,936	0.034	0.181
WE in non-agriculture (NAg)	2,936	0.118	0.322	2,936	0.156	0.363
Adapt Locally	2,936	0.035	0.184	2,936	0.058	0.234
Migrate to Adapt	2,936	0.087	0.282	2,936	0.103	0.303
SE in Trade Services (TS)	2,936	0.115	0.319	2,936	0.168	0.374
Adapt Locally	2,936	0.077	0.267	2,936	0.135	0.342
Migrate to Adapt	2,936	0.042	0.200	2,936	0.039	0.194
SE in Small and Micro Enterprises (SMEs)	2,936	0.195	0.396	2,936	0.306	0.461
Adapt Locally	2,936	0.170	0.376	2,936	0.275	0.447
Migrate to Adapt	2,936	0.027	0.163	2,936	0.036	0.186
SE in Forestry, Fishery and Fauna activities	2,936	0.946	0.226	2,936	0.799	0.401
Panel (b): Shock Variables						
Drought (t)	2,936	0.410	0.492	2,936	0.736	0.441
Wet spell (t)	2,936	0.100	0.301	2,936	0.105	0.306
Drought (t-1)	2,936	0.008	0.090	2,936	0.600	0.490
Wet spell (t-1)	2,936	0.851	0.356	2,936	0.015	0.120
Panel (c): Other Controls						
Male head	2,936	0.783	0.412	2,936	0.753	0.431
Age head (years)	2,936	42.878	14.522	2,936	45.275	14.480
Head Education (years)	2,936	2.752	3.785	2,936	2.066	2.651
# of HH members aged 15 to 59	2,936	2.622	1.583	2,936	2.740	1.800
# of male HH members aged 15 to 59	2,936	1.216	0.910	2,936	1.275	1.035
# of female HH members aged 15 to 59	2,936	1.407	1.034	2,936	1.465	1.131
HH size	2,936	5.503	3.140	2,936	5.807	3.448
Land size (hectars)	2,936	2.329	3.999	2,888	2.425	2.783
# of plots	2,936	2.418	1.328	2,936	4.176	1.234
HH owns a bike	2,936	0.286	0.452	2,928	0.369	0.482
HH used animal traction (12M)	2,936	0.162	0.369	2,928	0.003	0.052
HH received extension services (12M)	2,936	0.158	0.365	2,928	0.178	0.382
HH is a member of farmer's association	2,936	0.047	0.212	2,928	0.080	0.272

Notes: Obs=Number of observations, Sd=Standard Deviation, HH= household, 12M= during the last 12 months. All outcome variables are values referring to participation in the last 12 months. Adapt Locally= refers to adaptation within the village. Migrate to adapt= at least one household member migrates outside the village to adapt.

Table 2: Income Shocks and Other Shock Coping Mechanisms

Panel (a) Net Total Income, Crop Income and Wage income	(1) Income	(2) Income	(3) Crop Income	(4) Crop Income	(5) Wage Income	(6) Wage Income
Drought (t)	-2527.159***	-2879.788***	-1375.564***	-1192.498***	278.224	-125.784
	(851.942)	(991.396)	(464.324)	(427.726)	(343.589)	(293.957)
Wet spell (t)	4738.786	5353.333	1642.387	1471.798	-436.315	-29.153
	(4572.378)	(5998.456)	(1313.615)	(1309.598)	(947.576)	(656.855)
Constant	11739.864***	-2451.183	5049.713***	1872.872	2240.263***	680.936
	(438.617)	(4257.429)	(255.135)	(1196.101)	(157.962)	(1434.133)
Mean of the outcome variable	12, 277	12, 277	4,878.894	4,878.894	2,647.302	2,647.302
R-squared	0.0093	0.0393	0.0061	0.0207	0.0047	0.0217
Panel (a) Other Incomes and Shock Coping Mechanisms	**(7) SE Income**	**(8) SE Income**	**(9) Remittance**	**(10) Remittance**	**(11) Livestock Income**	**(12) Livestock Income**
Drought (t)	-1352.689*	-1466.681*	-337.186*	-340.757**	260.727	246.942
	(716.689)	(777.453)	(175.185)	(167.840)	(244.805)	(263.763)
Wet spell (t)	4525.916	5328.798	-1252.556**	-1594.242**	251.061	165.805
	(4270.597)	(5303.342)	(579.506)	(619.841)	(261.943)	(255.167)
Constant	2744.082***	-4535.561	841.706***	-25.994	861.687***	-454.277
	(377.079)	(2950.448)	(108.866)	(1176.264)	(76.522)	(898.341)
Mean of the outcome variable	3,213.276	3,213.276	651.6131	651.6131	884.0098	884.0098
R-squared	0.0070	0.0252	0.0062	0.0172	0.0008	0.0032
Controls	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes
N	5872	5824	5872	5824	5872	5824

Notes: This table estimates the impact of weather shocks on household incomes other coping mechanisms. The outcome variable in regressions (1) and (2) is total household income, (3) and (4) is crop income, (5) and (6) is wage income, (7) and (8) is self-employment income, (9) and (10) is remittance income, and (11) and (12) is livestock income. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Standard errors are reported in parenthesis. Standard errors are clustered at the village level. Controls include age, sex and education of household head, household size, land size in hectares, number of plots, indicators for bike ownership, use of animal traction, use of extension services and membership in farmers' association. FE=fixed effect, HH=Household, N=Number of observations. The last four rows are for both panels (a) and (b). Incomes are all expressed (in real terms) in 2005 *Meticais da Nova Familia* (MTN).

Table 3: Households' labor adaptation responses to weather shocks

	(1)	(2)	(3)	(4)	(5)	(6)
	SE_Ag	WE_Ag	WE_NAg	SE_TR	SE_SMEs	SE_FFF
Drought (t)	0.003	-0.024	0.048***	0.015	0.001	0.008
	(0.005)	(0.022)	(0.015)	(0.017)	(0.023)	(0.033)
Wet spell (t)	-0.001	0.007	-0.003	0.100*	0.074**	0.005
	(0.013)	(0.032)	(0.049)	(0.052)	(0.034)	(0.035)
Drought (t-1)	0.000	-0.012	0.014	0.013	-0.027	-0.123***
	(0.005)	(0.023)	(0.016)	(0.019)	(0.025)	(0.033)
Wet spell (t-1)	0.006	-0.026	0.054***	0.029	-0.03	0.029
	(0.008)	(0.022)	(0.019)	(0.031)	(0.024)	(0.030)
Constant	0.984***	0.104***	0.052***	0.074***	0.213***	0.919***
	(0.008)"	(0.020)	(0.018)	(0.026)	(0.023)	(0.030)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes
PR-squared	0.0023	0.0548	0.0166	0.0196	0.0416	0.1139
Number of villages	407	407	407	407	407	407
N	5872	5872	5872	5872	5872	5872

Notes: This table estimates households' labor adaptation to weather shocks. SE_Ag=Self-employment in (on-farm) Agriculture, WE_Ag=Wage employment in agricultural activities, WE_NAg=Wage employment in non-agricultural activities, SE_TR=Self-employment in trade services, SE_SMEs=Self-employment in small and micro enterprises, and SE_FFF=Self-employment in forestry, fishery an d fauna activities. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Standard errors are reported in parenthesis. Standard errors are clustered at the village level. FE=fixed effects, HH=Household, N=Number of observations.

Table 4: Location based differences in households' labor adaptation to weather shocks

	(1) WE_Ag L	(2) WE_Ag M	(3) WE_NAg L	(4) WE_NAg M	(5) SE_TR L	(6) SE_TR M	(7) SE_SMEs L	(8) SE_SMEs M
Drought (t)	-0.024	-0.002	0.01	0.041***	-0.003	0.014	0.004	-0.002
	(0.022)	(0.008)	(0.012)	(0.013)	(0.015)	(0.009)	(0.022)	(0.009)
Wet spell (t)	0.008	0.006	-0.008	0.029	0.075*	0.031	0.064**	0.005
	(0.026)	(0.015)	(0.029)	(0.039)	(0.041)	(0.028)	(0.030)	(0.029)
Drought (t-1)	-0.009	-0.004	0.022*	-0.008	0.007	0.01	-0.018	-0.013
	(0.023)	(0.009)	(0.012)	(0.014)	(0.018)	(0.010)	(0.023)	(0.010)
Wet spell (t-1)	-0.033	0.005	0.015	0.028*	0.021	0.003	-0.032	0.000
	(0.021)	(0.009)	(0.014)	(0.014)	(0.024)	(0.015)	(0.021)	(0.013)
Constant	0.088***	0.019**	0.019	0.044***	0.053**	0.031**	0.189***	0.028**
	(0.019)	(0.008)	(0.013)	(0.014)	(0.021)	(0.014)	(0.021)	(0.013)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PR-squared	0.0541	0.0027	0.0089	0.0088	0.0240	0.0020	0.0395	0.0021
Number of villages	407	407	407	407	407	407	407	407
N	5872	5872	5872	5872	5872	5872	5872	5872

Notes: This table estimates households' labor adaptation to weather shocks based on where they undertake the adaptation, i.e. locally or elsewhere through migrating. WE_Ag=Wage employment in agricultural activities, WE_NAg=Wage employment in non-agricultural activities, SE_TR=Self-employment in trade services, SE_SMEs=Self-employment in small and micro enterprises, and SE_FFF=Self-employment in forestry, fishery an d fauna activities. L=Adapt locally. M=Migrate to adapt. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Standard errors are reported in parenthesis. Standard errors are clustered at the village level. FE=fixed effects, HH=Household, N=Number of observations.

Table 5: Adaptation outside the village through salaried non-agricultural activities

	(1) WE_NAg M Domestic	(2) WE_NAg M International
Drought (t)	0.023**	0.019**
	(0.012)	(0.007)
Wet spell (t)	0.027	0.017
	(0.031)	(0.021)
Drought (t-1)	0.004	-0.017
	(0.012)	(0.011)
Wet spell (t-1)	0.004	0.031
	(0.011)	(0.020)
Constant	0.050***	-0.013
	(0.011)	(0.019)
Year FE	Yes	Yes
HH FE	Yes	Yes
PR-squared	0.0042	0.0135
Mean of the dependent variable	0.0718665	0.0243529
Number of villages	407	407
N	5872	5872

Notes: This table estimates households' labor adaptation outside the village in salaried non-agricultural activities to weather shocks disaggregated based on whether it involves domestic or international migration. WE_NAg=Wage employment in non-agricultural activities. M=Migrate to adapt. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Standard errors are reported in parenthesis. Standard errors are clustered at the village level. FE=fixed effects, HH=Household, N=Number of observations.

Table 6: Local labor adaptation through salaried employment in agricultural activities

	(1) WE_Ag L USKS	(2) WE_Ag L USKL	(3) WE_Ag L SK
Drought (t)	-0.015	-0.006	-0.005
	(0.020)	(0.006)	(0.004)
Wet spell (t)	0.005	0.009	-0.005
	(0.026)	(0.005)	(0.006)
Drought (t-1)	0.008	-0.012**	-0.005
	(0.021)	(0.006)	(0.005)
Wet spell (t-1)	-0.018	-0.015***	-0.003
	(0.019)	(0.006)	(0.003)
Constant	0.062***	0.020***	0.008***
	(0.018)	(0.005)	(0.003)
Year FE	Yes	Yes	Yes
HH FE	Yes	Yes	Yes
R-squared	0.0523	0.0045	0.0031
Mean of the dependent variable	0.0860014	0.0080041	0.005109
Number of villages	407	407	407
N	5872	5872	5872

Notes: This table estimates households' labor adaptation outside the village in salaried non-agricultural activities to weather shocks disaggregated based on whether it involves domestic or international migration. WE_NAg=Wage employment in non-agricultural activities. M=Migrate to adapt. USKS= Unskilled labor employed by small/household farms. USKL= Unskilled labor employed by large farms. SK=Skilled labor employed by the government, NGOs, factories, etc. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. Standard errors are reported in parenthesis. Standard errors are clustered at the village level. FE=fixed effects, HH=Household, N=Number of observations.

Table 7: Heterogeneities in households' labor adaptation to weather shocks based on land holding

	(1) SE_Ag	(2) WE_Ag	(3) WE_Nag	(4) SE_TR	(5) SE_SMEs	(6) SE_FFF
Drought (t)	0.021**	-0.03	0.044**	0.008	0.029	0.043
	(0.009)	(0.030)	(0.019)	(0.022)	(0.032)	(0.040)
Wet spell (t)	-0.014	0.016	-0.053	0.023	0.118**	0.013
	(0.034)	(0.056)	(0.049)	(0.055)	(0.054)	(0.063)
Drought (t-1)	0.007	-0.022	0.050**	0.027	-0.011	-0.130***
	(0.011)	(0.028)	(0.021)	(0.026)	(0.031)	(0.037)
Wet spell (t-1)	0.014	-0.029	0.085***	0.045	-0.038	0.056
	(0.014)	(0.028)	(0.024)	(0.033)	(0.033)	(0.039)
D(t)*Land	-0.035***	0.012	0.008	0.013	-0.053	-0.066*
	(0.010)	(0.037)	(0.025)	(0.027)	(0.037)	(0.039)
W(t)*Land	0.019	-0.013	0.08	0.130***	-0.082	-0.017
	(0.035)	(0.068)	(0.069)	(0.049)	(0.067)	(0.069)
D(t-1)*Land	-0.019	0.024	-0.063**	-0.024	-0.05	0.018
	(0.012)	(0.033)	(0.026)	(0.031)	(0.039)	(0.036)
W(t-1)*Land	-0.011	0.004	-0.054**	-0.021	0.01	-0.041
	(0.011)	(0.033)	(0.026)	(0.028)	(0.035)	(0.031)
Constant	0.982***	0.104***	0.050***	0.071***	0.215***	0.912***
	(0.008)	(0.020)	(0.019)	(0.025)	(0.024)	(0.031)
F-test						
D(t)+D(t)*L=0	6.57**	0.47	7.04***	0.93	0.80	0.43
p-value	0.011	0.494	0.008	0.336	0.3704	0.514
W(t)+W(t)*L=0	2.39	0.01	0.16	8.83***	0.76	0.01
p-value	0.123	0.925	0.694	0.003	0.385	0.909
D(t-1)+D(t-1)*L=0	4.68**	0.00	0.39	0.01	3.65*	9.01***
p-value	0.031	0.956	0.531	0.913	0.057	0.003
W(t-1)+W(t-1)*L=0	0.23	0.89	1.50	0.62	1.06	0.26
p-value	0.634	0.346	0.222	0.431	0.304	0.613
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0114	0.0552	0.0192	0.0208	0.0453	0.1163
Number of villages	407	407	407	407	407	407
N	5872	5872	5872	5872	5872	5872

Notes: This table estimates heterogeneities in households' labor adaptation to weather shocks based on land holding. All the regressions are household fixed effects (linear probability model) regression. Standard errors are reported in parenthesis, which are clustered at the village level. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. D=Drought, W=Wet spell and L=Land.

Table 8: Heterogeneities in households' labor adaptation to weather shocks based on education

	(1) SE_Ag	(2) WE_Ag	(3) WE_Nag	(4) SE_TR	(5) SE_SMEs	(6) SE_FFF
Drought (t)	0.008	-0.015	0.025	0.022	0.038	0.016
	(0.007)	(0.028)	(0.019)	(0.019)	(0.029)	(0.036)
Wet spell (t)	-0.004	0.005	0.041	-0.008	0.073	-0.038
	(0.020)	(0.048)	(0.054)	(0.043)	(0.054)	(0.048)
Drought (t-1)	-0.002	-0.016	-0.01	0.037	-0.034	-0.099***
	(0.007)	(0.028)	(0.019)	(0.023)	(0.031)	(0.036)
Wet spell (t-1)	0.01	-0.031	0.031	0.045*	-0.022	0.033
	(0.012)	(0.028)	(0.024)	(0.027)	(0.032)	(0.034)
D(t)*Educ	-0.01	-0.021	0.046	-0.01	-0.079**	-0.015
	(0.009)	(0.029)	(0.028)	(0.030)	(0.036)	(0.041)
W(t)*Educ	0.004	0.005	-0.084	0.245***	-0.01	0.093*
	(0.033)	(0.049)	(0.054)	(0.091)	(0.065)	(0.053)
D(t-1)*Educ	0.004	0.01	0.052**	-0.055	0.021	-0.056
	(0.012)	(0.030)	(0.026)	(0.034)	(0.041)	(0.038)
W(t-1)*Educ	-0.006	0.012	0.042	-0.015	-0.007	-0.005
	(0.011)	(0.031)	(0.026)	(0.032)	(0.035)	(0.033)
Constant	0.983***	0.103***	0.056***	0.067***	0.209***	0.918***
	(0.009)	(0.021)	(0.018)	(0.021)	(0.023)	(0.030)
F-test						
D(t)+D(t)*E=0	0.07	2.10	10.49***	0.21	1.97	0.00
p-value	0.792	0.148	0.001	0.650	0.162	0.982
W(t)+W(t)*E=0	0.00	0.12	0.56	9.20***	2.81*	2.57
p-value	0.995	0.732	0.454	0.003	0.095	0.109
D(t-1)+D(t-1)*E=0	0.09	0.05	3.81*	0.38	0.15	15.18***
p-value	0.763	0.822	0.052	0.536	0.695	0.000
W(t-1)+W(t-1)*E=0	0.15	0.49	11.98***	0.99	1.21	0.62
p-value	0.696	0.486	0.001	0.321	0.273	0.430
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0035	0.0552	0.0188	0.0242	0.0434	0.1160
Number of villages	407	407	407	407	407	407
N	5872	5872	5872	5872	5872	5872

Notes: This table estimates heterogeneities in households' labor adaptation to weather shocks based on head's education. All the regressions are household fixed effects (linear probability model) regression. Standard errors are reported in parenthesis, which are clustered at the village level. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. D=Drought, W=Wet spells and E=Head's education.

Table 9: Heterogeneities in labor adaptation to weather shocks based on labor endowment

	1	2	3	4	5	6
	SE_Ag	WE_Ag	WE_Nag	SE_TR	SE_SMEs	SE_FFF
Drought (t)	0.004	-0.014	-0.013	0.052**	0.02	-0.013
	(0.012)	(0.036)	(0.025)	(0.025)	(0.044)	(0.061)
Wet spell (t)	0.059	0.047	-0.07	0.056	0.135	0.001
	(0.045)	(0.062)	(0.043)	(0.060)	(0.117)	(0.077)
Drought (t-1)	-0.02	-0.001	0.028	0.012	-0.042	-0.169***
	(0.018)	(0.039)	(0.032)	(0.030)	(0.048)	(0.059)
Wet spell (t-1)	-0.011	0.003	0.031	0.054*	-0.046	-0.018
	(0.019)	(0.044)	(0.038)	(0.033)	(0.050)	(0.058)
D(t)*Labor	-0.002	-0.013	0.072**	-0.044	-0.023	0.024
	(0.013)	(0.038)	(0.034)	(0.032)	(0.046)	(0.050)
W(t)*Labor	-0.07	-0.049	0.083	0.049	-0.072	0.009
	(0.047)	(0.071)	(0.071)	(0.078)	(0.142)	(0.083)
D(t-1)*Labor	0.023	-0.013	-0.016	0.001	0.016	0.053
	(0.019)	(0.040)	(0.037)	(0.036)	(0.051)	(0.050)
W(t-1)*Labor	0.018	-0.034	0.026	-0.027	0.018	0.052
	(0.018)	(0.041)	(0.036)	(0.032)	(0.049)	(0.049)
Constant	0.985***	0.104***	0.052***	0.072***	0.214***	0.920***
	(0.007)	(0.020)	(0.018)	(0.025)	(0.023)	(0.031)
F-test						
D(t)+D(t)*Lb=0	0.22	1.26	10.44***	0.20	0.02	0.13
p-value	0.639	0.263	0.001	0.656	0.901	0.7187
W(t)+W(t)*Lb=0	0.83	0.01	0.05	3.49*	2.01	0.06
p-value	0.362	0.940	0.822	0.062	0.157	0.800
D(t-1)+D(t-1)*Lb=0	0.22	0.32	0.46	0.39	0.91	13.05***
p-value	0.639	0.574	0.499	0.530	0.341	0.000
W(t-1)+W(t-1)*Lb=0	0.87	2.05	8.22***	0.79	1.32	1.38
p-value	0.351	0.153	0.004	0.376	0.2517	0.241
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0049	0.0553	0.0185	0.0201	0.0419	0.1144
Number of villages	407	407	407	407	407	407
N	5872	5872	5872	5872	5872	5872

Notes: This table estimates heterogeneities in households' labor adaptation to weather shocks based on labor endowment. All the regressions are household fixed effects (linear probability model) regression. Standard errors are reported in parenthesis, which are clustered at the village level. Asterisks: *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. D=Drought, W=Wet spells and Lb=Labor