Weather variability and food consumption

Evidence from rural Uganda

Sara Lazzaroni[1]

[1] Dipartimento di scienze economiche e sociali, Università Cattolica del Sacro Cuore, Piacenza, Italy

sara.lazzaroni@unicatt.it

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Summary

This multidisciplinary study considers the impact of short-term weather variations on food consumption of 488 rural households in Uganda. We combine World bank LSMS households panel data with data on rainfall, number of rainy days, maximum and minimum temperatures in the period 2005/06-2009/10. Triangulating the findings of the econometric model with qualitative interviews and the analysis of the agricultural sector recent developments, we argue that households are involved in ex-ante smoothing strategies while land and reduction of non-consumption expenditures seem to partially offset adverse rainfall variations.

Keywords: weather variability; risk; food consumption; Uganda.

JEL Classification codes: I31; O12; O44; Q12; Q14.

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1. INTRODUCTION

In the wake of the current debate on the effects of climate change on poor households in developing countries, the analysis of the effects of shorter term climatic shocks on households welfare and households coping strategies still permeates academic discussions on the role of risk, shocks and vulnerability as perpetrators of poverty. As entrepreneurs and proponents of agricultural development have agreed, individuals and households in developing countries, would be more affected from changes in weather patterns due to their high degree of vulnerability (Cooper et al., 2008: 25) combined with their high dependence on the rain-fed agricultural sector (Skoufias et al., 2011: 2). On the other side, to the extent that individuals and households are able to appropriate or develop technologies and adjust their behavior to mitigate the impacts of weather changes, they can cope or, as the literature on climate change states, *adapt*, to climatic shocks (Nordhaus, 1993: 14). Hence, a review of the multiple channels through which climatic shocks can affect households welfare is needed to assess the state of art, while case-specific analyses need to be as comprehensive as possible to understand the set of behavioral and technical changes that households adopt to counteract welfare losses.

Building on these premises, this paper discusses the chain of direct and indirect effects of short-term weather variations on rural households welfare engaging with the findings of other disciplines (biology, medical science, agrarian studies) and referring to the existing microeconomic literature on the impact of weather variability on selected welfare indicators. This discussion is then used as a framework to analyze the effects of rainfall, number of rainy days, maximum and minimum temperatures short-term variability on households food consumption in Uganda. Increasing concerns about the adverse effects of climate change (Magrath, 2008; NAPA, 2007), exacerbating the already assessed high vulnerability to weather changes of rural households in the country (MAAIF, 2010; Okori et al., 2009) and recent food security issues (Shively and Hao, 2012) motivate our analysis. The households panel dataset is provided by the World Bank Living Standard Measurement Study (LSMS) on Uganda covering the period 2005/06-2009/10. We concentrate on households that have reported living in rural areas to specifically focus on the rural dimension of the consequences of climatic shocks. Households interviewed in the same season in both rounds only are analyzed to rule out seasonal patterns in the outcome variable. We merge the LSMS subsample with rainfalls and temperatures recordings made by the Department of Meteorology at the Ugandan Ministry of Water and Environment (UDOM). Finally we discuss the results of the empirical model in light of the theoretical framework and the analysis of the context of Uganda combining qualitative and qualitative methodologies and focusing on how households coped with weather variations in order to insure and/or improve their welfare in the period 2005/06-2009/10. We show that short term weather variations seem to have some adverse effects on food consumption, especially in the case of higher temperatures. Household land ownership seems to mitigate adverse variations in precipitations amount (rainfall millimeters) depending on the size of both the rainfall variation and land owned. Moreover, if food consumption doesn't seem to be highly affected by rainfall variations, we find that non consumption expenditures such expenditures on funerals and social functions, and outgoing remittances would experience 5 to 20 percent reductions respectively in the case of a 10% decrease in precipitations. Triangulating the findings of the econometric analysis with the findings of the agricultural sector performance review we argue that households are also involved in *ex-ante* smoothing strategies that help to reduce adverse effects of weather variability on food consumption.

The relevance of this work is threefold. First of all, in line with the existing literature on climatic shocks in developing countries (Dercon, 1996; Kazianga and Udry, 2006) the paper provides further evidence that poor households in rural areas *do* adjust to climatic shocks with anthropogenic and behavioral changes. Second, we use different approaches ranging from qualitative to quantitative analysis and move on the boundaries of different disciplines (economics, biology and agriculture) to sustain the results. Finally we exploit a dataset and focus on a context (Uganda) not much explored as far as the relationship between food consumption and weather variations is concerned.

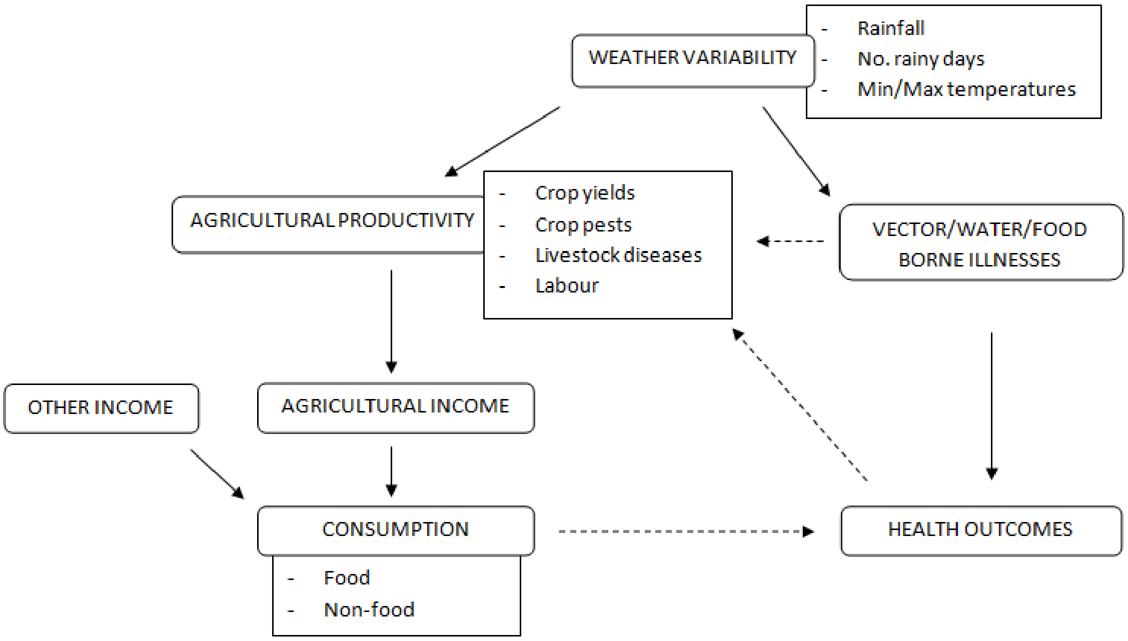
The remainder of this paper is organized as follows. Section 2 contextualize climatic shocks in the literature on shocks in developing countries and analyze the channels through which they affect households welfare. The possible coping and adapting strategies are briefly introduced. Section 3 describes the socio-economic and weather characteristics of rural households in Uganda while Section 4 discusses the empirical model. Section 5 presents the data and Section 6 reports the results. Section 7 triangulates the findings of the different studies and methodologies considered in the paper and concludes.

2. THEORETICAL FRAMEWORK

2.1. Climatic shocks and welfare impacts

Within the field of development economics and in connection with the study of the determinants of poverty, much of the emphasis has been put on the role of risk, shocks and vulnerability. In their work on Ethiopia, Dercon *et al.* generally defined shocks as "adverse events that lead to a loss of household income, a reduction in consumption and/or a loss of productive assets" (Dercon et al., 2005: 5). Among the various types of shocks we concentrate on climatic shocks due to their acknowledged importance in determining households welfare (Dercon, 2004; Kazianga and Udry, 2006; Tol, 2009). Climatic shocks can be classified into simple and complex extreme events (IPCC, 2001). Higher maximum and minimum temperatures (with the connected increase of hot days and heat waves) and the increase in the intensity of precipitation events are examples of extreme simple events or, in our analysis, weather variations as referred to the usual pattern of weather indicators. Increasing occurrence of droughts and floods, especially when precipitations are associated with El Niño events, or storms and tropical cyclones and more variability in the monsoon season are examples of extreme complex events but in this work we do not explicitly separate the analysis of the two kinds of extreme events because complex events can be considered nothing but simple extreme events that occur in a more disruptive way, due to their particular duration and temporal shape (Anderson, 1994: 555). In the analysis of climatic shocks impact on households welfare, we follow the approach of Skoufias *et al.* (2011) and discuss some aspects of rural households welfare, referring to Figure 1 to visualize the chain of effects. The solid lines represent direct effects while the dashed lines represent indirect effects.

Figure 1 Weather variability and its impact on household welfare.



Source*:* Adapted from Skoufias *et al.* (2011).

First of all, the close connection of the agricultural sector with the natural system and the importance of agriculture in developing countries make the impact of adverse weather variations potentially harmful for rural households and for the performance of the entire economy. In the short-term weather variations have a direct impact on the agricultural productivity and income because higher temperatures and changing rainfall patterns are likely to modify the hydrological cycle, ultimately affecting crop yields and total factor productivity (IPCC, 2001: 31). For example, weather changes have short-term effects on crop yields through changes in temperatures when they exceed the optimal thresholds at which crops develop (Lansigan *et al.*, 2000; Prasad *et al.*, 2008). Similarly, mismatches between the amount of water received/required and its potential evapotranspiration during the growing and harvesting seasons, and the timing of the water stresses faced by the crops, affect the agricultural productivity (Otegui *et al.*, 1995; Wopereis *et al.*, 1996). On the other side, when water comes or does not come in extreme quantities (floods or droughts) its potential impact can be very high due to the losses of lives and infrastructures (IPCC, 2001: 29). An instability or a decrease in agricultural income will have effects on food consumption (as share of production or income) depending on the subsistence nature of the agricultural activity or on the price of the purchased products. When the agricultural activity is of subsistence the effect on consumption is through the quantities produced while in the case of market-oriented activity the effect can be both through quantities and prices. According to the

Agricultural Household Model there could be a positive net effect on households income and then consumption in the case of market-oriented agriculture (Singh et al., 1986) but this does not seem to apply in Uganda due to the prevalence of subsistence agriculture[1]. The impact of decreased income will affect different types of consumption in different ways. Generally, food consumption is likely to decrease less than non-food consumption (Skoufias and Quisumbing, 2005), in some cases depending on household characteristics such as the sex of the income earner (Duflo and Udry, 2004). Moreover, despite no effects on yields, erratic weather can stress the crops and lower the quality of the harvest, pushing the household to purchase out of home produced food.

The indirect (dashed arrows) impacts of weather changes are mainly on agricultural productivity and come primarily from two channels. First, there is a direct effect on the development of vector/water/food-borne diseases, altering the parasites life cycles because weather variations can provide particular conditions that allow pathogens already existing in the environment to develop and spread or make their life longer than their usual historic range (Anderson et al., 2004: 540). Piao *et al.* (2010) show in a recent study on China that changed local ecology of water borne and food borne infective diseases can cause an increase in the incidence of infectious diseases and crop pests. This applies to parasites affecting human beings as well, leading to the second indirect effect of weather variability on agricultural productivity. Individuals are affected in different ways by changes in illness and death rates as well as injuries and psychological disorders due to higher temperatures or complex extreme events such as floods and storms (McMichael and Haines, 1997). For instance, vector-borne diseases sensitive to weather changes such as the mosquitoes responsible of malaria and yellow fever, and diarrhea and other infectious diseases are likely to increase due to the prolonged range and activity of pathogens (Haines et al., 2006: 2104). Then, the productivity of the labor force, especially in the agricultural sector, is potentially highly affected (see for example the work of Badiane and Ulimwengu (2012) on the incidence of malaria on agricultural efficiency in Uganda).

Finally, the malnutrition effects on human capital are one of the most explored phenomena following lower food productivity through the food consumption effects of weather vagaries (de la Fuente and Dercon, 2008). Malnutrition affects adults and children in different ways. Adverse consequences in the short-term

[1] This argument is further supported by Benson *et al.* (Benson et al., 2008). The authors analysed the mechanism of global and regional prices transmission and its welfare effects in Uganda suggesting that not many would benefit from rising food prices. In fact, only 12 to 27% of the population seems to be a net seller of food.

can be brought about through the impact on productivity on the workplace. Children's future performances in school and work are affected in long-term, instead, depending on the choices in the allocation of the food to the different components of the household (Skoufias et al., 2011: 6). Then, in connection with problems of food security and malnutrition, lower BMI and labor productivity for the adults and children stunted growth or low grade completion are examples of the indirect consequences of a reduction of household income and consumption on individual health (Dercon and Krishnan, 2000; Alderman *et al.*, 2006; Yamano *et al.*, 2005). In conclusion, we emphasize that the explored effects will take place in different degrees, depending on the *ex-ante* and *ex-post* coping mechanism that households are able to put in place.

2.2. Coping mechanisms and adaptation

Households can adopt two kinds of risk coping strategies: income smoothing and consumption smoothing (Morduch, 1995: 104). Income smoothing consist of decisions concerning production, employment and the diversification of the economic activities. On the production side, rural households can chose different types of crops to be cultivated and input intensities (Morduch, 1995: 104). However, despite ensuring a certain amount of income, these strategies can have also adverse effect on households final welfare. For example, Dercon (1996) found that the absence of developed markets for credit, combined with the lack of accessibility to off-farm labor, gave the incentive to cultivate low-risk, low-return crops (sweet potatoes) to rural households in Shinyaga District of Tanzania. A poverty trap of low-income and assets ownership, induced low-risk, low-return crop choices and hence low-income and assets accumulation seemed to capture households in the area (Dercon, 1996). Analogously, intercropping (that combines mixed cropping with field fragmentation) or adoption of new production technologies (like high-yielding varieties-HYV and fertilizers) can lower the risk of the agricultural activity. Behavioral norms and households specific characteristics would play a further important role in the decision process (Foster and Rosenzweig, 1995).

On the other side, consumption smoothing comprises decisions regarding borrowing and saving, selling or buying non financial assets, modifying the labor supply and making use of formal/informal insurance mechanisms (Bardhan and Udry, 1999: 95). For example, Paxon (1992) found that household in Thailand were able to use savings to compensate for losses of income due to rainfall shocks, hence leaving consumption unaffected. Dercon (2004) showed that 342 households in rural Ethiopia were able to partially offset the risk of food consumption losses from shocks at the household level (idiosyncratic shocks) thanks to the allocation of the risk within the village, leaving the aggregate rainfall shocks uninsured. We will discuss the decisions about labor supply below in the analysis of the case of Uganda where they have been tested by Kijima *et al.* (2006).

Income and consumption smoothing differ in the time horizon over which they deal with shocks. Income smoothing is aimed to prevent or mitigate the effects of shocks before they occur while consumption smoothing is concerned with the effects of shocks after they have taken place. Then, potentially no effects of shocks could be found if households engaged into one (or more) of these mechanism, so in the discussion of the impact of weather variability in Uganda we have to take into account two aspects. First, lack of irrigation systems, the use of traditional practices and the recent higher weather variability could have pushed households to put in place *ex-ante/ex-post* measures. Hence we explore the performance of the agricultural sector, for most households are employed in it and a big framework of modernization of this sector was launched in 2000 (MAAIF, 2010: 27). Second, being weather variations a country-level exogenous shock to households in Uganda, if the chain of weather effects on agricultural productivity and income is not "compromised" by coping strategies, the coefficients on the weather variables in the econometric analysis should significantly affect food consumption. However, the weather deviations recorded have a certain variability on regional and synoptic station area level, then adverse food consumption in areas affected by climatic shocks could be compensated by the production obtained in other areas of the country. Notwithstanding this remark, the subsistence nature of the agricultural activity in the country constitutes a deterrent from considering weather variations a sort of idiosyncratic shock in a country-level analysis.

3. WEATHER VARIABILITY AND WELFARE IN UGANDA

3.1. Background

Uganda is a landlocked country classified by the World Bank as a low income nation. Poverty in Uganda is high but declining in recent years. The percentage of population living with or less than 2$ a day (PPP) declined from 86% of the mid-nineties to about 76% in 2006, reaching 65% in 2009 (World Bank, 2011). As Table 1 and 2 show, although the agricultural sector share of total GDP decreased during the years, the country is still highly reliant on agriculture for the generation of its income, the agricultural sector employing more than 60% of the labor force (World Bank, 2011).

Table 1 Per capita GDP (constant 2000 USD) and value added per sector (% GDP).

	1990-1994	1995-1999	2000-2004	2005-2010
GDP per capita (constant 2000 UDS)	193.99	239.11	273.38	345.13
Agriculture value added (% GDP)	52.40	43.41	26.61	24.60
Industry value added (% GDP)	12.72	17.17	23.22	25.75
Services value added (% GDP)	34.88	39.42	50.17	49.65

Source: World Bank (2011b)

Table 2 Employment per sector (% of total employment)[1].

	2002	2005	2009
Agriculture	65.50	71.60	65.60
Industry	6.50	4.50	6.00
Services	22.00	23.20	28.40

Source: World Bank (2011b)
[1] Data on employment per sector are available only for the years presented in the table when a national household survey was conducted.

The country is particularly vulnerable to weather changes and, more generally, to climatic shocks due to individuals and households high dependence on rain-fed agriculture (Mubiru et al., 2012: 1). Rough estimates on the disaster profile of Uganda drawn from the Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Leuven, Belgium[2] show that droughts and floods are the phenomena that mostly have affected the Ugandan population (EM-DAT, 2012). More than 10% of Ugandans are exposed to the risk of droughts and the country is listed as 19th out of 184 countries in the human exposure ranking for this type of hazard (ISDR, 2009). The National Adaptation Plan of Action elaborated in 2007 summarizes the five channels through which climate change is impacting on Uganda's development, confirming the approach of the theoretical

[2] EM-DAT contains essential core data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to present. It is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. This database contains information about disasters in the world that satisfy at least one of the following criteria: 10 or more people reported killed, 100 or more people reported affected, declaration of a state of emergency or call for international assistance. Earthquakes, floods, droughts, extreme temperature events and landslides are some of the phenomena recorded in the sample.

framework outlined in the previous section. In particular, the rain-fed agricultural sector that is the backbone of the Ugandan economy has suffered from high weather instability due to the no longer predictable pattern of rainfall (Mubiru et al., 2012). Even in the best case in which the quantity of millimeters of rain is the same during the rainy and dry seasons, the distribution of the rain is concentrated in fewer days, shortening the rainy season (Magrath, 2008: 3). Hence, food prices, food security and income stability are altered, making poor households even more vulnerable (NAPA, 2007: 12) especially considering the decrease in the amount of farmland per person due to rapid population growth rate (Funk et al., 2012). Moreover, the importance of food expenditures as the prevailing share of households expenditures (Table 3) makes food consumption expenditures a good indicator of households welfare to be analyzed in the case of shocks.

Table 3 Consumption expenditures data 2005/06-2009/10.

	Rural Uganda (UBOS-NHS)		488 households (LSMS sub-sample)	
	05/06	09/10	05/06	09/10
Household total expenditures[1]	176,600	197,500	174,958	195,560
Per capita total expenditures[1]	33,150	38,200	29,959	30,556
Shares of households expenditures by item groups (%)[2]				
Food, drink and tobacco	50.00	51.00	55.66	52.34
Food			(91)	(91)
Beverages and tobacco			(6)	(5)
Restaurants			(3)	(4)
Non durable			30.75	31.56
Rent, fuel Energy	15.00	15.00	(52)	(50)
Non-durable and personal goods[3]	4.00	5.00	(12)	(9)
Transport and communication	6.00	7.00	(11)	(16)
Health and medical care	8.00	6.00	(23)	(22)
Other services[3]	2.00	3.00	(2)	(3)
Semi durable			11.41	13.82
Clothing and footwear	4.00	3.00	(36)	(30)
Furniture, carpet, furnishing			(9)	(8)
Household appliances and equipment			(5)	(10)
Glass/table ware, utensils			(4)	(3)
Education	8.00	7.00	(42)	(45)
Services not elsewhere specified			(4)	(4)
Non-consumption	3.00	3.50	2.17	2.28
Outgoing remittances, gifts and other transfers			(47)	(46)
Funerals and other social functions			(36)	(43)
Other (taxes, pensions, subscriptions, interests)			(17)	(11)

Source: Author's elaborations on UBOS-NHS (National Households survey) and LSMS Uganda household panel 2005/06-2009/10.

[1] Adjusted for regional inflation, base year 2005.

[2] UBOS reported classification is slightly different from the more detailed breakdown allowed by the data in the LSMS dataset. For the LSMS dataset we report in brackets the shares of expenditures in the four expenditures aggregates by type and durability of items.

[3] In UBOS classification Non-durable and personal goods share include semi-durable furniture, households appliances and utensils while Other services includes Services not elsewhere specified

3.2. Uganda's climate and recent changes: time-series analysis and qualitative studies

Uganda's climate is influenced by the Inter-Tropical Convergence Zone, whose position varies over the year: from October to December it goes to the southern part of the country while from March to May it returns in the northern part (McSweeney et al., 2007: 1). Consequently, the prevalent rainfall pattern is bimodal with the aforementioned two rainy seasons, with rains falling with the north-easterly winds coming from the Indian Ocean. On the other side, in the northern part of Uganda, the moisture coming from the Congo basin makes the period between the first and second rainy season close enough to form a unique rainy season (Mubiru et al., 2012: 2). Projections made with the Global Circulation Model for the future climate indicate an increase in annual rainfall, especially in the months of October, November and December (McSweeney et al., 2007: 3). The two agricultural seasons are composed by a dry season and a rainy season. The first agricultural season goes from December to May, December-January-February being the first dry season in which the fields are prepared after the harvest for the coming first rainy season from March to May. The second agricultural season starts in June with the harvest and preparation of fields until August, leading to the second planting season from September to November (Asiimwe and Mpuga, 2007: 10) (see Figure 2 for a graphical representation of the agricultural cycle). As Asiimwe and Mpuga (2007) reported, the crop cycle highly depends on the rains onset because irrigation is not very common in the country.

A recent report from OXFAM, made mainly through qualitative interviews, highlights the fact that climatic changes are taking place in Uganda and their impact is affecting the lives of the people. In fact, the country is experiencing more erratic rainfall in what used to be the traditional rainy season (March to May/June), with the result that droughts are more frequent and crop yields and plant varieties are decreasing. On the contrary, the rainfall in the short rainy season (October to December) have become more intense and devastating, often being the cause of floods, landslides and soil erosion (Magrath, 2008: 1). Moreover, during the latest twenty years there has been an increase in the average monthly temperatures. As mentioned in the report, the Executive Director of the Karughe Farmers Partnership in the Kasese district stated in one of the interviews:

> "Because of the current weather changes the yields have completely gone down. We used to have much more rainfall than we are having now, that's one big change, and to me this area is warmer than 20 years ago. Until about 1988 the climate was okay, we had two rainy seasons and they were very reliable. Now

the March to June season in particular is not reliable, which does not favor the crops we grow. Rain might stop in April. Because of the shortened rains you have to go for early maturing varieties and now people are trying to select these. That's why some local varieties of pumpkins and cassava that need a lot of rain, even varieties of beans, have disappeared. We need things that mature in two months - maize needs three months of rain to grow so two months is not enough. Coffee isn't doing badly, but it's not doing well either – not like the 1970s when we harvested lots." (Magrath, 2008: 7).

These claims are supported by a study by Mubiru *et al.* (2012). The authors analyzed historical data about daily rainfall and temperatures and found that there is high variability of the onsets of rainfalls across the country. However, the withdrawal dates remained quite stable, resulting in a shortening of the growing season. The March to May rainy season seems the most affected by variability both in the quantity and distribution of rainfall while the October to December rainy season seems to be stable for the distribution of rains (stable number of rainy days) but with an increasing trend in the amount of rain received. On the other side, even if the pattern of rainfall is on average stable during the dry seasons, the frequency of unusual events within both the dry and rainy seasons has increased (Mubiru *et al.*, 2012; Jennings and Magrath, 2009). Therefore, it could be argued that, given that the major rainfall pattern instability is in the first rainy season (first agricultural season), the production obtained in the more reliable second agricultural season could, to a certain extent, buffer the food consumption along the year. In this case we should not find any impact of the rainfall variables in our model. However, again the subsistence nature of the agricultural activity (see Table 4 and the discussion below) suggests that in the context analyzed households are able to produce in each agricultural season just the amount of products enough to cover the current period. This would be due to both unreliable means for on-farm storage and farmers preferences for selling food immediately after harvest at low prices to satisfy cash needs, unmet because of low savings and access to credit constraints (Kasente et al., 2002; Mpuga, 2010).

Parallel to changes in rainfall patterns, maximum and minimum temperatures changed across the country causing warmer days and nights (Mubiru et al., 2012). The northern and north-east part have been so far the warmest part of the country but the regions that are experiencing higher increases in the temperatures are those in the south-west side, accounting for an increase of about 0.3°C per decade (NAPA, 2007). The magnitude and the path of increase in temperature suggest room for adjustments in the agricultural activity to accommodate these changes using heat-resistant varieties or changing the crop-mix in the areas affected. For instance, intercropping cassava with maize can lower the temperature of the soil and allow higher yields for cassava also thanks to the improved soil moisture and earthworms activity (Olasantan *et al.*, 1996: 149-50). Since maize grows faster and develops high leaf area, cassava can enjoy a lower soil temperature during its first three months of growth, counteracting the rise in temperatures in the ecosystem and giving higher yields. The same mechanism would be brought about by intercropping maize or sorghum with potato and groundnut crops. Hence, in light of the quote from the farmer's interview suggesting some changes in the crops cultivated to face climatic changes, and of the actual advantages of different crop/crop-mix choices, we analyze the pattern of the crops cultivated in the country to better understand the results of the empirical analysis.

3.3. Agricultural sector performance

In Uganda the majority of the population is employed in the agricultural sector for the generation of its income, more than 75% being employed in the subsistence agricultural sector with less than 3% population occupied in the market-oriented agricultural sector. So we can directly analyze the effects of weather deviations on the consumption pattern assuming that the impact of weather variability on food consumption is directly connected with the impact on the agricultural production (consistent with the causality chain displayed in Figure 1)[3].

[3] We could not incorporate the production side in the empirical analysis because of a mismatch between the reference period in the household and agricultural questionnaire. The household questionnaire was conducted across two years, asking for a seven days (or month/year depending on the type of goods considered) recall of consumption expenditures, while the data on the agricultural production were collected taking as reference two specific agricultural seasons for all the households so that we are not able to assign to households data exactly the production data of the season preceding the interviews. For instance, in the second round there are some households for which the household questionnaire was filled in July 2010, hence, to make our analysis of production and consumption in a consistent way, we should consider for them the first agricultural season 2010 (running from December to May, 2010). However, the agricultural questionnaire of that round collected data on agricultural production (inputs and outputs) in the two agricultural seasons of 2009. The high instability of the pattern of climate does not allow us to assume that data on production and weather in the first agricultural season in 2010 can be a good proxy of the first agricultural season 2009. For this reason, we had to make the hypothesis that food consumption is a proxy of the agricultural productivity and income and directly conduct the analysis of food consumption.

Table 4 Distribution of rural household's individuals in Uganda by occupations.

	Full sample NHS (3,123 households)		Study sample (488 households)	
Occupation	2005	2009	2005	2009
Subsistence agricultural and fishery workers				
Subsistence agricultural workers	77.94%	76.87%	79.17%	79.21%
Subsistence animal rearing	2.80%	3.69%	1.93%	3.55%
Subsistence fishery and related workers	0.63%	0.18%	0.43%	0.24%
Market-oriented skilled agricultural and fishery w.	2.60%	2.84%	2.00%	2.70%
Elementary occupations				
Agricultural, fishery and related laborers	3.39%	2.46%	3.00%	2.22%
Other elementary occupations	2.78%	3.78%	2.27%	3.00%
Other job categories	9.86%	10.18%	11.2%	9.08%
Total	100%	100%	100%	100%

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel.

Okori et al. (2009) show that farmers in Lira and Kitgum districts of Northern Uganda perceived decline and wrong timing of rainfall as major causes of decreased food production and consequent famine. Mwerera et al. (2010) find that 89% of the surveyed farmers in Kabale and Nakasongla districts (in Western and Central Uganda respectively) suffered from droughts, leading to 39.2% decrease in crop yield and 35.1% income losses. The effects of variations in rainfall on the income and consumption of households in Uganda were also analyzed by Asiimwe and Mpuga (2007) using the 1999/2000 and 2002/2003 national household surveys and rainfall data from the Statistical Abstract of the Uganda Bureau of Statistics for selected years. Using rainfall deviations from the long-term means[4] they found that the total income of rural household was, on average, reduced by 51.7% in the case of a shock (positive or negative) during the first rainy season. However, the magnitude and significance of rainfall shocks on the consumption of rural households were mixed (significant/insignificant, positive/negative depending on the sign of the shock and the season considered). This seemed to suggest the existence of consumption smoothing strategies (Aiimwe and Mpuga, 2007: 18), however, a caveat in the analysis of the authors could be the inclusion in the long-term mean of the survey years[5].

On the other side, Hisali *et al.* (2011) analyzed the determinants of the choice of adaptation strategies in response to weather adverse events using data from the 2005/06 Uganda National Household Survey. Five

[4] Rainfall changes were measured as the difference between current seasonal rains and the long-term mean, divided by the long term mean, for the planting and harvesting seasons in the six months preceding the date of interview of the household (Asiimwe and Mpuga, 2007: 11)

[5] The estimations could be downward biased in the case the survey years were particularly different from the others. For example, if 1999/2000 was a year of massive rains as compared to the usual rainfall pattern, the long-term mean calculated including the 1999/2000 data would spread the effect of that particular year on the other data, lowering the magnitude of the shock in the analysis and compromising the ability of the model to capture the effects of the shock on the outcome variable.

categories of coping/adaptation strategies were identified: borrowing, modifying the labor supply, decreasing consumption, selling of assets or usage of savings and changing technology or crops. The study suggested that age of the head of the household, credit access, availability of off-farm labor and tenure of land are some of the variables that explain the different choices, depending also on the agro-climatic zone to which households belong. Moreover, Kijima *et al.* (2006) analyzed the role played by off-farm labor in mitigating the effects of excess or shortage of rainfall (covariate) and crop and livestock diseases (idiosyncratic) shocks thanks to a panel of 894 rural households in the period 2003-2005. The results showed an increase in the labor supply only in the case of idiosyncratic shocks and only in the artisanal off-farm labor, especially if the household had lower asset endowments. Both shocks did not have significant impacts on self-employed and regular salaried off-farm jobs, probably reflecting the difficulty in accessing these positions or their more long-term nature. In any case, despite the engagement in more labor of different natures to compensate for the shocks, the extra-income did not seem to be enough to compensate the loss of agricultural income, resulting in a higher probability of falling into poverty for the non-poor in 2003 (Kijima et al., 2006). Since poverty was measured using expenditures per adult equivalent, the result just reported implicitly suggest that, in the case analyzed, households that experienced climatic shocks were not able to smooth consumption with the income obtained from secondary jobs undertaken to that purpose.

Drawing on the literature summarized above we can hypothesize that household could have engaged during the years in *ex-ante* income smoothing strategies such as land extension, crops selection and diversification and the use of fertilizers/pesticides and the analysis of the agriculture sector performance should reveal this. Data on production, yields and harvested area for selected crops (the most important in the country as cash and food crops) are reported in Table 5 for selected years. The agricultural production has generally increased for almost all the crops considered but yields remained fairly stable and the high population growth caused soil erosion and degradation, decreasing per capita production (Pender et al., 2004). The studies by Benin *et al.* (2007), James (2010) and Okoboi et al. (2013) reveal that the government efforts to modernize agricultural practices were only partially effective and the increase in production was mainly due to the progressive extension of land cultivated, especially for staple crops (maize, potatoes, beans). Coffee experienced a decrease in the land cultivated between 2000 and 2010, probably in response to increasing difficulties in obtaining expected yields due to weather variability as claimed by the farmer in the quote previously reported.

Table 5 Production, yields and hectares harvested for selected crops in selected years.

	Production (1000 Tonnes)			Yield (Kg/Ha)			Hectares harvested (1000 Ha)		
	2000	2005	2010	2000	2005	2010	2000	2005	2010
Banana	610	563	600	4519	3976	4196	135	142	143
Beans	420	478	455	601	577	489	699	828	930
Cassava	4966	5576	5282	12384	14408	12728	401	387	415
Coffee	143	158	162	477	601	600	301	263	270
Groundnuts	139	159	172	699	707	732	199	225	235
Maize	1096	1170	1373	1742	1500	1543	629	780	890
Plantains	9428	9045	9550	5900	5400	5618	1598	1675	1700
Potatoes	478	585	695	7029	6802	6814	68	86	102
Sorghum	361	449	500	1289	1527	1515	280	294	330
Sweet potatoes	2398	2604	2838	4321	4414	4577	555	590	620
Population (million)	24.21	28.43	33.42						

Source: FAO (2012) for data on agricultural sector and World Bank (2011) for population data.

Table 6 presents data on production and land allocation for selected crops for the 488 households considered[6]. High value cash crops have traditionally been coffee, tea, cotton, tobacco and banana but, besides banana and coffee, these crops account only for small portions of households agricultural income (Betz, 2009; Kasente et al., 2002). Banana (food) is cultivated both as food and cash crop but its cultivation only partially followed the increasing trend of other major (staple) food crops: maize, cassava, sweet potatoes and beans. Considering the concerns on food security, this increase seems an attempt to insure against food shortages: maize grows fast and can be both eaten or sold if cash is needed, cassava is relatively easy to grow and store, sweet potatoes mature fast, require low labor input (as cassava) while beans are rich in proteins, are the first crop to mature after the dry season and can be stored until the following season (Bagamba et al., 2008; Kasente et al., 2002). Simsim is grown in the same season and agricultural zones of cotton and, due to cotton market unreliability and high export potential of this crop (Nakyagaba et al., 2005), households seems to gradually prefer simsim to cotton. Improved varieties of all these crops could generate higher margins, up to five in the case of cassava (Kraybill and Kidoido, 2009), however underinvestment and wrong incentives given by the government (such as 5% GDP ceiling to expenditures in agriculture and the tax-reduction on hoes) constitute major impediments to the adoption of high-technology inputs and modernization (Hickey, 2013: 202).

[6] The data for the 488 households sample are a good representation of the full sample.

Table 6 Crops cultivated and hectares harvested for selected crops in the Uganda LSMS sample (488 households)[1].

	Pure stand								Intercropped							
	Frequency				Land				Frequency				Land			
Crop name	2004.2	2005.1	2009.1	2009.2	2004.2	2005.1	2009.1	2009.2	2004.2	2005.1	2009.1	2009.2	2004.2	2005.1	2009.1	2009.2
Maize	105	99	126	114	86	83	134	122	312	491	313	214	85	108	104	64
Finger millet	43	35	52	40	21	24	40	18	44	84	37	25	14	33	14	10
Sorghum	54	62	66	81	34	45	59	54	43	80	52	34	13	23	20	9
Beans	53	58	96	79	33	33	58	43	290	328	272	212	93	95	87	60
Groundnuts	45	49	75	40	23	36	81	22	62	112	75	48	19	30	30	8
Soya beans	2	3	12	3	1	2	14	1	14	16	12	13	3	4	5	2
Simsim	38	11	17	52	41	12	16	41	28	20	11	20	15	4	3	7
Sugarcane	8	8	13	15	5	5	10	13	3	6	5	5	1	0	4	4
Cotton	32	4	3	6	36	3	2	6	27	8	2	3	17	3	0	2
Tobacco	2	16	17	-	2	13	11	-	1	-	-	-	0	-	-	-
Irish potatoes	6	9	12	6	2	2	2	1	5	3	3	6	1	0	0	1
Sweet potatoes	179	214	169	183	77	68	94	70	34	82	35	34	8	17	10	10
Cassava	148	217	171	253	100	132	114	188	249	335	249	185	57	67	80	45
Banana food	78	73	74	83	51	49	73	72	217	258	164	172	84	91	68	68
Banana beer	24	25	14	11	21	25	10	9	71	73	30	35	17	16	8	15
Coffee all	34	37	30	40	17	18	27	35	139	155	97	108	35	42	44	40
Cocoa	2	2	4	3	1	2	11	5	4	6	2	3	2	3	0	1
Tea	2	2	-	-	16	21	-	-	-	-	-	-	-	-	-	-
Vanilla	4	4	2	2	2	2	1	1	13	15	-	-	4	3	-	-
Natural pastures	25	24	9	8	909	927	47	43	1	1	-	-	3	39	-	-
Fallow	327	323	72	85	1121	578	134	105	1	4	-	-	0	0	-	-
Bush	37	49	1	4	150	530	8	2	1	-	-	-	0	-	-	-
Plantation trees	19	19	11	7	15	15	10	6	2	4	2	3	0	5	2	2
Other forest trees	1	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-
Other crops	85	82	82	67	226	189	41	35	105	159	137	101	21	35	35	17
Total	1,353	1,425	1,129	1,182	2,991	2,814	998	892	1,666	2,240	1,498	1,221	492	618	514	365

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel.

[1] The LSMS agricultural questionnaire was referred to the second agricultural season 2004 and first agricultural season 2005 in the first round (columns 2004.2 and 2005.1 in the table) while in the second round it was referred to the first and second agricultural season 2009 (columns 2009.1 and 2009.2 in the table).

In Table 7 presenting the prevailing agricultural practices we can note the low use of improved seeds (although increasing), organic and chemical fertilizers and pesticides. Between the two rounds of the survey the most important change can be seen in the land tenure system, following the implementation of the land reform act meant to formalize informal customary rights into freeholds. Moreover, households have increased the labor input from the household members but lowered hired labor to work on the decreased land cultivated (Table 6). We proceed with the explanation of the empirical strategy.

Table 7 Agricultural practices – 488 households sample[1].

	2005/06		2009/10	
Has your household cultivated crops? YES	90.97%		93.42%	
Land tenure – Owned land (YES)	(85.81%)		(91.77%)	
Freehold		5.60%		33.57%
Lasehold		1.62%		1.64%
Mailo		11.21%		3.76%
Customary		80.20%		60.80%
Other		5.60%		33.57%
Land tenure – User rights (YES)	(44.84%)		(39.74%)	
Freehold		4.60%		30.55%
Lasehold		4.60%		6.19%
Mailo		23.02%		6.18%
Customary		64.72%		50.91%
Other		3.07%		5.45%
	2004.2	2005.1	2009.1	2009.2
Seeds used				
Local	93.80%	94.23%		
Improved	6.20%	5.42%		
Mixed	-	0.36%		
Newly purchased seeds			(31.14%)	(18.83%)
Local	-	-	79.70%	80.00%
Improved	-	-	20.30%	20.00%
Use of organic fertilizers (YES)	6.96%	4.54	4.50	3.83
Use of chemical fertilizers (YES)	0.50%	0.87	1.73	0.46
Use of pesticides (YES)	3.41%	1.87	3.84	3.15
Work of household members				
Person days	29	23	37	35
(standard deviation)	(34)		56	46
Work of hired labour (YES)	(22.45%)	(17.99%)	(29.59%)	(31.65%)
Average person days	13	13	6	3
(standard deviation)	(21)	(19)	(23)	(11)

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel.

[1] The LSMS agricultural questionnaire was referred to the second agricultural season 2004 and first agricultural season 2005 in the first round (columns 2004.2 and 2005.1 in the table) while in the second round it was referred to the first and second agricultural season 2009 (columns 2009.1 and 2009.2 in the table).

4. EMPIRICAL MODEL

4.1. Basic model

The impact of weather variability on households food consumption is analyzed using a panel fixed effect model. For OLS to be unbiased and consistent, the error term has to be uncorrelated with the explanatory variables, hence, the strict exogeneity[7] of weather shocks allows us to obtain good estimates of weather variations effects on food consumption. To avoid the omitted variables problem (observed and unobserved variables that are correlated with the error term and the weather deviation variables in the explanation of food consumption) we include a vector of household characteristics able to further explain the outcome variable. Similarly, we include a set of variables to take into account unobserved time-invariant factors that can affect food consumption to control for unobserved fixed heterogeneity (Wooldridge, 2009: 456). First, we control for the synoptic station to which households were assigned because, although the prevalent rainfall and temperature is bimodal across the country, there are some small variations in the weather variables depending on the different latitude, longitude and altitude of the area covered by each synoptic station (see Table 9). Second, we account for the region in which the household was settled because each region in the country has different specific characteristics due different regional poverty dynamics (Deininger, 2003; Okurut et al., 2002). Finally we include fixed effects for the season and round of interview to account for seasonality effects of food consumption and other time-invariant characteristics. Results of separate cross-section estimations could be driven by some specific weather shocks occurring in the year considered while pooling the cross sections do not allow us to control for differences across households, hence we exploit the panel nature of the data at hand to control for household specific unobserved characteristics, allowing for more room to infer causality thanks to the availability of more than one observation per household (Wooldridge, 2009: 11). More information and higher efficiency are some advantages of this methodology together with the higher suitability for the study of the dynamics of change in the variable of interest, accounting also for behavioral changes (Gujarati and Porter, 2009: 637). If the unobserved effects were not correlated with the error term, a random effects model would be better in terms of consistency and efficiency of the parameters estimated because loss of some information lowers efficiency in the case of fixed effects models. However a random effects estimation with clustered standard errors uses the additional orthogonality conditions that the group means are uncorrelated with the idiosyncratic error. Since clusters are of different size and comprehensive of households settled in different regions with different poverty patterns, the additional orthogonality condition is likely to be violated. Testing

[7] The strict exogeneity assumption states that $Cov(\Delta X_{it}, \Delta \varepsilon_{it}) = 0$, in other words, that the explanatory variables are independent from the error term across time. In our case, being the weather shocks likely to be random, once we control

for overidentifying restrictions using the artificial regression approach of Wooldridge (2002: 290-91) to account for heteroskedastic- and cluster-robust standard errors confirms to use fixed effects estimations (p-value 0.000). The model estimated is the following

$$lnFCE_{h,s,r,p,t} = \alpha + \beta lnWV_{h,s,r,p,t-1} + \gamma X_{h,s,r,p,t} + \mu_s + \pi_r + \tau_p + \rho_t + \varepsilon_{h,s,r,p,t} \qquad (1)$$

where $lnFCE_{h,s,r,p,t}$ is the logarithm of the food consumption expenditures for household *h* assigned to the synoptic station s in region *r*, season *p* and year *t*, while $WV_{h,s,r,p,t-1}$ is a vector describing the weather indicators level. $X_{h,s,r,p,t}$ is a vector of household specific characteristics including sex, age, age squared, and education of the head of the household, the size and demographic composition of the household, ownership of house and land (size and number of parcels). μ_s, π_r, τ_p and ρ_t are the synoptic station, region, season and time fixed effects while $\varepsilon_{h,s,r,p,t}$ is the error term. This model is expected to have consistent estimates of the effects of weather variability on food consumption, provided that the unobserved time-invariant fixed characteristics are not correlated to the idiosyncratic error.

4.2. Persistency

The work of Dercon (2004) on shocks in Ethiopia and the relationship between the subsistence nature of the agricultural activity suggest to investigate the persistency of weather deviation effects. Then, we estimate equation (1) adding the persistency term $WD_{h,s,r,p,t-2}$

$$lnFCE_{h,s,r,p,t} = \alpha + \beta_1 lnWD_{h,s,r,p,t-1} + \beta_2 lnWD_{h,s,r,p,t-2} + \gamma X_{h,s,r,p,t} + \mu_s + \pi_r + \tau_p + \rho_t + \varepsilon_{h,s,r,p,t}. \qquad (2)$$

If weather variations have persistent negative effects on food consumption, β_2 should be positive and significant. For example, if the household was interviewed in the second dry season (*t*), a positive and significant β_2 would mean that 1% lower level of weather indicator during the first dry season (*t-2*) would reduce food consumption by the magnitude of β_2.

for them, there should be no correlation of these variables with the error term, then the hypothesis holds and the OLS estimates should be unbiased and consistent.

4.3. Heterogeneity of impacts

According to Skoufias (2011: 20), the average effect of weather variations on the outcome variable may mask differences of impacts between households with different welfare levels depending on the ownership of crucial asset such as the house where the household lives or land. Hence, we estimate equation (1) introducing an interaction term

$$lnFCE_{h,s,r,p,t} = \alpha + \beta_0 WD_{s,r,p,t-1} + \beta_1 (WD_{s,r,p,t-1} \cdot H_{h,s,r,p,t}) + \gamma_1 H_{h,s,r,p,t} + \gamma_2 X_{h,s,r,p,t} + \mu_s + \pi_r + \tau_p + \rho_t + \varepsilon_{h,s,r,p,t} \quad (3)$$

$H_{h,s,r,p,t}$ incorporates the specific household feature that we think important in determining different impacts of weather variations on food consumption. Therefore, β_0 measures the impact of weather variations independently of particular households characteristics while $(\beta_0 + \beta_1)$ measures the combined impact of weather deviations for households with the specific characteristic considered (house or land ownership).

5. THE DATA

5.1. Household data

The analysis of the impact of weather variability on food consumption is conducted using a panel dataset made publicly available by the World Bank Living Standard Measurement Study (LSMS) website. The baseline survey comes from the Uganda National Household Survey (UNHS) conducted in 2005/2006. 3,123 households distributed over 322 enumeration areas (EAs) over the 783 EAs visited by the UNHS were selected by the Uganda National Panel Survey (UNPS) to conduct the interviews in 2009/2010. In coherence with the theoretical framework we consider only rural households interviewed in the same season in both rounds to rule out seasonality in consumption, for a total of 488 households. The dataset contains information on the socioeconomic status of the households, with a detailed module on food, non-durable, semi-durable and non-consumption expenditures. Descriptive statistics for the household variables of interest are reported in Table 8. Since the food consumption data were collected on the basis of a week recall, we make the variable monthly, correct for inflation[8] and we take the logarithm of it.

[8] Data are corrected with monthly CPI - base year 2005 for eight categories of items: food, beverages and tobacco, clothing and footwear, rent fuel and utilities, household and personal goods, transport and communication, education, health entertainment, and other items. Adjustments are made on a regional basis. For Central region we considered CPI calculated outside Kampala in the low income Masaka center while for Western Uganda we took Mbarara recordings.

Table 8 Descriptive statistics of selected variables for rural households in Uganda.

	2005/06			2009/10		
Variable	*N*	Mean	St. Dev	*N*	Mean	St. Dev
Month survey	488	8	1.6525	488	8	2.0737
Year survey	488	2005	0	488	2009	0
Sex Head HH[1] (Female=1)	488	0.2275	0.4196	488	0.2520	0.4346
Age Head HH	488	42.6783	15.2597	488	46.8504	15.5713
Education head of the HH						
(1) Don't know	482	0.0000	0.0000	480	0.0042	0.0645
(2) Never attended school	482	0.1784	0.3833	480	0.2063	0.4050
(3) Some schooling but not completed primary	482	0.4502	0.4980	480	0.4479	0.4978
(4) Completed primary	482	0.1701	0.3761	480	0.1438	0.3512
(5) Completed post primary specialization	482	0.0353	0.1847	480	0.0250	0.1563
(6) Completed junior high	482	0.1286	0.3351	480	0.1313	0.3380
(7) Completed secondary	482	0.0062	0.0791	480	0.0104	0.1016
(8) Completed post secondary specialization	482	0.0290	0.1681	480	0.0292	0.1684
(9) Degree or above	482	0.0021	0.0455	480	0.0021	0.0456
Household size	488	5.8443	3.1349	488	6.3996	3.2937
Share of males 0-5	488	0.1224	0.1439	488	0.0994	0.1269
Share of males 6-11	488	0.0823	0.1150	488	0.1022	0.1150
Share of males 12-17	488	0.0728	0.1176	488	0.0917	0.1312
Share of males 18-64	488	0.2125	0.2015	488	0.1911	0.1844
Share of males >65	488	0.0231	0.1150	488	0.0352	0.1398
Share of females 0-5	488	0.0982	0.1375	488	0.0927	0.1254
Share of females 6-11	488	0.0745	0.1033	488	0.0852	0.1091
Share of females 12-17	488	0.0598	0.1028	488	0.0746	0.1148
Share of females 18-64	488	0.2303	0.1749	488	0.2029	0.1383
Share of females >65	488	0.0240	0.1122	488	0.0249	0.0969
Own house (Yes=1)	488	0.8955	0.3062	483	0.9296	0.2561
No. Rooms	488	3.9918	2.3615	483	2.9379	1.6970
Own land (Yes=1)	444	0.8581	0.3493	462	0.9177	0.2750
Owned parcels size (Ha)	446	5.7250	34.7912	474	4.3094	8.3383
HH monthly food consumption[2]	488	86,024.46	66,432.58	484	87,557.27	69,168.5
HH monthly total expenditures	485	174,957.6	175,729.7	484	195,559.8	194.160.4
Region 1 – Central	488	0.2725	0.4457	488	0.2725	0.4457
Region 2 – Eastern	488	0.2459	0.4311	488	0.2459	0.4311
Region 3 – Northern	488	0.2951	0.4565	488	0.2951	0.4565
Region 4 – Western	488	0.1865	0.3899	488	0.1865	0.3899

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel.
[1] HH stands for household.
[2] Adjusted for monthly regional inflation. 1 USD=1,780 UGX in 2005.

5.2. Weather data

Weather data come from the Uganda Ministry of Water and Environment - Department of Meteorology (UDOM) daily recordings about precipitation and maximum and minimum temperatures for 13 synoptic stations located throughout the country[9]. Table 9 shows the distribution of the synoptic stations in the country. Households are assigned data on the synoptic station on the basis of the proximity to the district of residence (the average distance is 32 Km with a standard deviation of 23 Km). From the monthly weather

For the Northern and Eastern region we averaged the CPI of the two centers in the regions (Arua and Gulu in the Northern region and Jinja and Mbale in the Eastern region).
[9] We preferred national data to NASA data because the width of the NASA grid does not allow for more precision.

data we calculate the relevant weather variables averaging seasonal levels of rainfall millimeters, number of rainy days and maximum and minimum temperatures for the two season preceding the season of interview. Hence, we assign two rainfall and temperature variables for each household, one pertaining to the previous season and one pertaining to the second season back in time.

Table 9 Distribution of synoptic stations across Uganda.

Synoptic Station	Region	Longitude	Latitude	Altitude (meters)	Region Area (sq-Km)
Arua	Northern	30.917	3.05	1280	85,391.7
Gulu		32.283	2.783	1105	
Kitgum		32.883	3.3	940	
Lira		32.933	2.317	1110	
Soroti	Eastern	33.617	1.717	1132	39,478.8
Tororo		34.167	0.683	1170	
Jinja		33.183	0.45	1175	
Kampala	Kampala	32.633	0.25	1200	197.0
Entebbe	Central w/o Kampala	32.45	0.05	1155	61206.3
Mbarara	Western	30.683	-0.6	1420	55,276.5
Masindi		31.717	1.683	1147	
Kasese		30.1	0.183	691	
Kabale		29.983	-1.25	1869	

Source: Author's elaborations based on UDOM (2012) weather data.

Households were interviewed in different seasons so they are assigned different rainfall deviations for a total of 50 observations for every weather indicator in each survey year. In the case the household was interviewed in the second dry season of year *t*, it is assigned firstly the average weather levels calculated in the first rainy season of year *t* and secondly the deviations calculated in the first dry season of *t*, to check for persistence in the weather shocks. This procedure can be made clearer looking to Figure 2 and 3. For example, an household interviewed in June 2005 is assigned firstly the March-April-May 2005 variables and secondly the December-January-February 2004/05 variables.

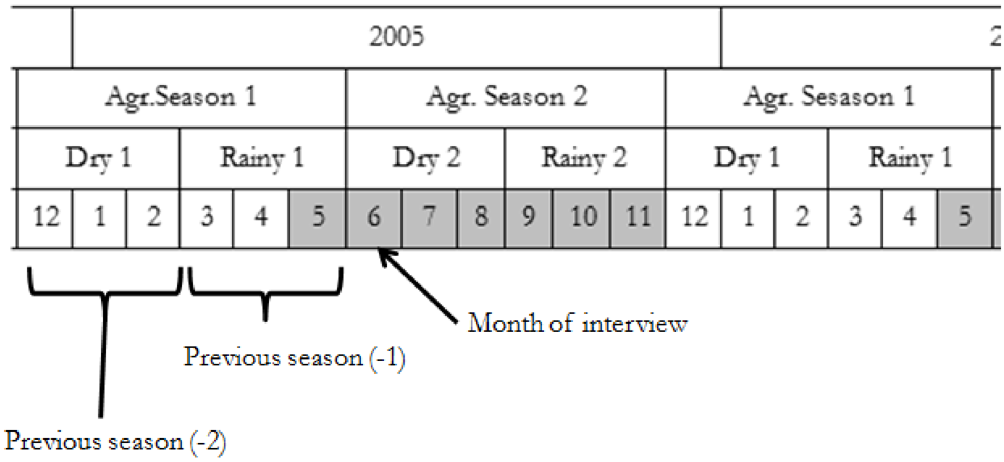
Figure 2 Agricultural cycle in Uganda[1].

Year	2004							2005													2006									
Agr. Season	Agr. Seas 2						Agr.Season 1						Agr. Season 2						Agr. Sesason 1						Agr. Season 2					
Season	Dry 2			Rainy 2			Dry 1			Rainy 1			Dry 2			Rainy 2			Dry 1			Rainy 1			Dry 2			Rainy 2		
Month	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11

Year		2009												2010												2011				
Agr. Season	Agr. Season 1						Agr. Season 2						Agr. Season 1						Agr. Season 2						Agr. Season 1					
Season	Dry 1			Rainy 1			Dry 2			Rainy 2			Dry 1			Rainy 1			Dry 2			Rainy 2			Dry 1			Rainy 1		
Month	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel and Asiimwe and Mpuga (2007).
[1] In light grey we can see the month in which the interviews were conducted.

Figure 3 Example of the mechanism of assignment of weather deviations.



Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel and Asiimwe and Mpuga (2007).

Weather levels descriptive statistics for the first previous season preceding the interview are reported in Table 10, while Table 11 presents weather variables as deviations from their respective 1960-1990 and 1980-2010 long term. Data for the second previous season are reported in Appendix A. In presenting deviations we use the 1960-1990 long term means for rainfall and number of rainy days and the 1980-2000 long term means for temperatures to exclude more recent years that may incorporate the impact of more recent climate change in the country (Skoufias *et al.*, 2011).

Table 10 Descriptive statistics of weather indicators: long-term means and levels in 2005/06 and 2009/10 for the first season preceding the interview.

			Long-term mean[1]		2005/06		2009/10	
Weather variable	Season	N	Mean	St.D.	Mean	St.D.	Mean	St.D.
Rainfall mm	Dry 1	58	48.64	21.87	39.29	23.34	108.71	24.15
	Rainy 1	262	147.31	37.56	150.88	44.18	152.79	46.59
	Dry 2	168	87.64	41.56	98.10	36.64	66.75	38.02
No. rainy days	Dry 1	58	4.64	2.10	3.88	2.14	8.16	2.23
	Rainy 1	262	11.75	2.20	12.31	2.56	11.97	1.56
	Dry 2	168	7.19	3.04	7.88	2.32	5.93	2.72
Max temo. (°C)	Dry 1	58	30.24	2.63	31.35	2.71	29.91	2.77
	Rainy 1	262	28.85	2.08	29.17	1.98	29.24	2.04
	Dry 2	168	27.36	0.98	28.28	1.54	28.86	1.07
Min temp. (°C)	Dry 1	58	16	2.55	17.53	1.92	17.19	2.04
	Rainy 1	262	17.29	2.09	19.15	3.56	18.02	1.75
	Dry 2	168	16.21	1.32	17.14	1.15	17.16	0.92

Source: Author's elaborations from UDOM (2012) weather data.
[1]Long term means are calculated as average weather indicator in the season considered in the period 1960-1990 for rainfall millimetres and number of rainy days and 1980-2000 for maximum and minimum temperatures.

Table 11 Descriptive statistics of weather indicators between 2005 and 2010: weather indicators relative to the long term mean, reported as a percentage deviation for the first previous season and period average[1].

			2005/06		2009/10		2006/07-2009/10	
Weather variable	Season	N	Mean	St.D.	Mean	St.D.	Mean	St.D.
Rainfall mm	Dry 1	58	-18.74	31.00	159.65	92.21	29.34	17.35
	Rainy 1	262	3.04	18.70	2.98	15.64	-7.39	6.82
	Dry 2	168	21.02	34.42	-27.05	19.96	14.52	22.90
No. rainy days	Dry 1	58	-10.32	36.38	91.12	38.41	40.15	33.92
	Rainy 1	262	6.52	21.30	3.40	10.74	-1.57	12.49
	Dry 2	168	18.66	25.79	-19.28	10.73	17.79	18.33
Max temo. (°C)	Dry 1	58	3.71	2.39	-1.05	3.75	0.14	1.70
	Rainy 1	262	1.17	2.88	1.39	2.29	1.17	1.80
	Dry 2	168	3.42	5.10	5.51	2.13	-4.24	10.32
Min temp. (°C)	Dry 1	58	10.94	12.48	8.27	6.50	8.74	9.59
	Rainy 1	262	10.97	15.76	4.80	6.37	3.75	6.80
	Dry 2	168	6.07	6.59	6.26	6.71	4.92	6.93

Source: Author's elaborations based on UDOM (2012) weather data.

[1] Weather indicators assigned to households based on proximity to synoptic station. The reported data are rainfall millimetres, number of rainy days and maximum and minimum temperature in a particular period, relative to the long term mean, expressed as percentage deviation. Yearly indicators are the percentage deviations in the season preceding the interview, as reported in the second column. The five years indicators are the percentage deviations of the average indicator in the period, relative to the long term mean. The long term mean for every indicator, in the three season considered is calculated based on all available observations of the relevant synoptic station in the period 1960-1990 for rainfalls and number of rainy days and 1980-2000 for maximum and minimum temperatures. For example, in the whole sample, rainfall in 2005/2006 was 19% lower than the long term mean.

On average in the country there is high variability in seasonal rainfall precipitations and distribution while temperatures increased all over the country. On average in Uganda minimum temperatures were from 6 to 11% (about 1 to 2 Celsius degrees) in 2005/06 and 5 to 8% higher (0.8 to 1.3 Celsius degrees higher) in 2009/10. Maximum temperatures show a similar increasing pattern, although smaller in magnitude.

6. RESULTS

The results for the impact of weather deviations on food consumption are presented in Tables 12-13. Negative and significant coefficients will mean that weather conditions can have a negative impact on the consumption of food items. We present first the impact of rainfall, then the joint impact of rainfall and number of rainy days, after the effect of temperatures variations only and finally the effect of all the weather deviations combined on the outcome variable for weather variations in the first previous season and finally including persistency terms. The control variables for the odd numbered specifications in the tables are sex, age (also squared) and education of the head of the household, size and demographic composition of the household, ownership and size of the house and a year dummy (taking value one when the year is 2009). The even numbered specifications also include ownership of land (value one when the household owns land) and size of parcels of owned land. Land ownership constitutes a household wealth indicator and then a possible tool to compensate adverse weather variations. If the size of the land owned is bigger, the risk can also be diversified by cultivating different crops or crop mixes in different portions of the owned land[10]. We choose to include these variables only after because for them we have some missing observations that could result in biased estimations.

6.1. Weather variability and persistency

As reported in table 12, on average and controlling for households demographic and economic characteristics rainfall millimeters seem to have positive but insignificant impacts on food consumption. The result is robust to the inclusion of the variables accounting for land ownership and size of the parcels owned but the magnitude of the coefficients of rainfall increases, suggesting that land constitutes a basic insurance asset in case of adverse weather variations. Combining rainfall with number of rainy days brings further evidence that rainfall precipitation and distribution do not affect food consumption. On the other side, temperatures deviations alone seem to adversely affect food consumption always with 1% level of significance. A 5% increase in minimum temperatures would decrease food consumption by more than 3% while the same increase in maximum temperatures would reduce consumption by about 14%. Note that this result seems to be coherent with the understanding of the crops cycle: higher temperatures in a rainy season can prevent the correct development of the crops while the same event during a dry season can dramatically harm the harvest. When temperatures are considered together with rainfall amount and distribution all weather indicator slightly increase in magnitude, but maintaining their sign and level of significance.

Similar results are found when we include the weather deviation related to the second season back in time with respect to the season when the household was interviewed. Only maximum temperatures seem to have persistent effects but the sign is positive suggesting that an increase in temperatures in the second season back in time would increase food consumption while the effect of the same change in the first

[10] It may also be that diversification is brought about by the different location of the parcels in the country. In this case, shocks experienced by the cultivations in every parcels will be different.

[10] Non consumption expenditures are calculated aggregating income tax, property rates (taxes), user fees and charges, local service tax, pensions and social security payments, remittances (including gifts and other transfers), funerals and other social functions, interests on loans and others.

previous period temperature would have a higher negative impact. Besides the negative impact of raising temperatures, estimations including all weather indicators for both periods emphasize the role of rainfall distribution: on average, food consumption decreases by about 3% for a 10% increase in the number of rainy days at conventional levels of significance. This result confirms the description of the interviewee in the OXFAM report (Magrath, 2008): even if on average the millimeters of rain received during the season are the same as they used to be, the problem arises with their distribution. The negative sign of the coefficient for rainy days could be due to some episodes of heavy floods in the country in the years considered (visible in Table 11). Analogously, increases in maximum and minimum temperatures can lead to 1-5% decreases in food consumption while again increasing temperatures in the second period before seem to have positive persistent effects.

6.2. Heterogeneity of impacts

As we argued in the model specification section, the average effect of weather variations on the outcome variable might mask differences of impacts between households with different welfare levels depending on the ownership of crucial assets such as the house or land. Hence, we estimate the model introducing an interaction term to account for the impact of shocks when the household owns the house or land and depending on the size of the land owned. The estimations accounting for land are conducted also following the analysis of the agricultural production where we emphasized an increase of ownership but a decrease in size (and acreage cultivated) of land in the 488 households subsample.

From the results in specification (17) and (18) it seems that house and land ownership *per se* do not mitigate adverse rainfall variations (F-test rejecting the joint significance of the interaction terms or worse negative effects of weather variations when the F-test does not reject the joint significance). However, when we consider the size of parcels of land owned by the household we find that land contributes to lower the negative effects of a decrease in rainfall millimeters depending on the size of both the rainfall variation and land owned. For example, a 3% decrease in rainfall will lower food consumption by about 0.20% if the household owns no land, while if the household owns one hectare of land the rainfall deviation will be completely insured. However, if rainfall decreases by 15% the household will need to have at least 13.5 hectares of land to insure its food consumption.

Table 12 Econometric results, results, fixed effect estimations. Dependent variable: ln Food Consumption Expenditures.

	Rain (-1)	Days(-1)	Max(-1)	Min(-1)	Rain(-2)	Days(-2)	Max(-2)	Min(-2)	Own land	Size land	Const	Rsqr	N	NHH
(1)	0.037										9.726***	0.147	961	488
	(0.060)										(0.524)			
(2)	0.050								0.231**	-0.001	9.156***	0.159	896	472
	(0.060)								(0.093)	(0.001)	(0.569)			
(3)	0.153	-0.193									9.642***	0.151	961	488
	(0.146)	(0.190)									(0.485)			
(4)	0.174	-0.207							0.223**	-0.001	9.03***	0.164	896	472
	(0.154)	(0.194)							(0.096)	(0.001)	(0.556)			
(5)			-2.807***	-0.69***							21.64***	0.173	961	488
			(0.966)	(0.261)							(3.828)			
(6)			-2.761***	-0.743***					0.253***	-0.054	21.10***	0.185	896	472
			(1.008)	(0.275)					(0.092)	(0.001)	(4.047)			
(7)	0.117	-0.277	-3.346***	-0.776***							23.83***	0.181	961	488
	(0.116)	(0.166)	(1.005)	(0.263)							(3.70)			
(8)	0.137	-0.273	-3.117***	-0.793***					0.243***	-0.001	22.43***	0.192	896	472
	(0.125)	(0.177)	(1.011)	(0.298)					(0.094)	(0.001)	(3.865)			
(9)	0.041				-0.026						9.799***	0.148	961	488
	(0.052)				(0.044)						(0.606)			
(10)	0.052				-0.026				0.224***	-0.001	9.24***	0.160	896	472
	(0.055)				(0.048)				(0.088)	(0.001)	(0.64)			
(11)	0.171	-0.219			0.051	-0.152					9.715	0.156	961	488
	(0.138)	(0.190)			(0.082)	(0.121)					(0.530)			
(12)	0.195	-0.240			0.049	-0.157			0.217***	-0.001	9.128***	0.169	896	472
	(0.142)	(0.189)			(0.090)	(0.122)			(0.083)	(0.001)	(0.576)			
(13)			-3.883***	-0.797***			1.884***	-0.100			19.51***	0.180	961	488
			(0.877)	(0.245)			(0.629)	(0.772)			(5.02)			
(14)			-3.887***	-0.836***			1.990***	-0.348	0.265***	-0.001	19.51***	0.194	896	472
			(0.996)	(0.226)			(0.667)	(0.746)	(0.090)	(0.001)	(5.36)			
(15)	0.103	-0.322***	-5.061***	-1.283***	-0.091	0.023	2.134**	-0.005			24.42***	0.198	961	488
	(0.107)	(0.122)	(0.864)	(0.450)	(0.107)	(0.130)	(1.049)	(0.903)			(6.77)			
(16)	0.138	-0.328***	-4.678***	-1.306***	-0.105	0.027	2.166*	-0.387	0.237***	-0.001	23.56***	0.211	896	472
	(0.109)	(0.125)	(0.971)	(0.512)	(0.118)	(0.133)	(1.107)	(0.914)	(0.087)	(0.001)	(6.62)			

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel and UDOM (2012) weather data.

[1] The control variables included in the odd numbered specifications are: sex, age (also squared) and education of the head of the household, size and demographic composition of the household, ownership of the house and number of rooms, year dummy. The even numbered specifications include also the number and size of the owned parcels of land. variables are calculated as natural logarithm of the weather indicator (level) in the first season preceding the interview (-1) or in the second previous season (-2). Robust standard errors clustered by synoptic stations in parenthesis. *, **, *** stand for level of significance at 10, 5 and 1% respectively

Table 13 Econometric results, fixed effect estimations clustered by synoptic station. Dep. var.: ln food consumption expenditures. Heterogeneity of impacts.

House	Own House	Rain(-1)	Days(-1)	MaxT(-1)	MinT(-1)	RainxHouse	DaysxHouse	MaxTXHouse	MinTXHouse	Const	Rsqr	Ftest Rain	Ftest Days	Ftest maxt	Ftest mint
(17)	-0.481	-0.037				0.088				9.57***	0.160	0.707			
	(1.408)	(0.306)				(0.310)				(1.59)					
(18)	0.448	0.539	-0.776			-0.383	0.596			8.48***	0.166	0.448	0.303		
	(1.748)	(0.576)	(0.575)			(0.587)	(0.614)			(1.94)					
(19)	-3.699			-2.678	-2.081			-0.076	1.350	24.66**	0.186			0.049	0.042
	(9.783)			(1.554)	(1.936)			(1.534)	(1.985)	(9.67)					
(20)	-6.695	0.606	-0.858	-4.035	-2.265	-0.483	0.599	0.994	1.480	28.75**	0.196	0.477	0.197	0.031	0.061
	(11.397)	(0.623)	(0.602)	(3.408)	(2.776)	(0.615)	(0.621)	(3.015)	(2.750)	(12.10)					

Own Land	Own land	Size land	Rain(-1)	Days(-1)	MaxT(-1)	MinT(-1)	RainxLand	DaysxLand	MaxTXLand	MinTXLand	Const	Rsqr	Ftest Rain	Ftest Days	Ftest maxt	Ftest mint
(21)	0.615	-0.001	0.126				-0.083				8.76***	0.160	0.350			
	(0.461)	(0.001)	(0.086)				(0.095)				(0.723)					
(22)	-0.053	-0.001	-0.141	0.346			0.347	-0.610			9.166	0.167	0.417	0.242		
	(0.871)	(0.001)	(0.331)	(0.387)			(0.359)	(0.395)			(0.950)					
(23)	-2.206	-0.001			-3.844**	-0.200			1.199	-0.542	23.11***	0.186			0.051	0.005
	(5.062)	(0.001)			(1.73)	(0.919)			(1.433)	(0.721)	(7.00)					
(24)	-2.45	-0.001	-0.134	0.171	-3.886**	-0.548	0.302	-0.491	0.898	-0.224	24.46***	0.196	0.409	0.165		
	(5.29)	(0.001)	(0.257)	(0.315)	(1.851)	(0.881)	(0.289)	(0.323)	(1.454)	(0.653)	(7.266)					

Land size	Own Land	Size land	Rain(-1)	Days(-1)	MaxT(-1)	MinT(-1)	RainxSize	DaysxSize	MaxTXSize	MinTXSize	Const	Rsqr	Ftest Rain	Ftest Days	Ftest maxt	Ftest mint
(25)	0.239**	0.013***	0.068				-0.003***				9.076***	0.167	0.000			
	(0.094)	(0.001)	(0.063)				(0.001)				(0.57)					
(25)	0.231**	0.013	0.195	-0.212			-0.003	0.0001			8.94***	0.171	0.518	0.562		
	(0.096)	(0.027)	(0.170)	(0.203)			(0.011)	(0.010)			(0.60)					
(27)	0.265***	-0.116			-3.024***	-0.284*			0.070***	-0.043***	21.32***	0.193			0.005	0.000
	(0.093)	(0.067)			(1.064)	(0.284)			(0.018)	(0.008)	(4.20)					
(28)	0.26***	-0.146	0.137	-0.271	-3.373***	-0.642*	0.002	-0.011	0.065***	-0.028	22.85***	0.201	0.490	0.284	0.003	0.010
	(0.095)	(0.099)	(0.133)	(0.178)	(1.048)	(0.337)	(0.011)	(0.011)	(0.016)	(0.017)	(4.00)					

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel and UDOM (2012) weather data.

[1] Number of observations is 896 and number of households is 472 for all specifications. The control variables included in the specifications are: sex, age (also squared) and education of the head of the household, size and demographic composition of the household, ownership of the house and number of rooms, land ownership and size of land, year dummy. Weather variables (-1) are calculated as natural logarithm of the weather indicator in the season preceding the interview. Robust standard errors clustered by synoptic stations in parenthesis. *, **, *** stand for level of significance at 10, 5 and 1% respectively.

6.3. *Weather variability and other channels*

We tested the effects of rainfall variations replicating specification (1)-(8) using as dependent variables the consumption of non-durable, semi-durable and non-consumption expenditures to check if households lowered other expenditures to maintain food consumption. Rainfall millimeters would lower non-consumption. We report in Table 14 estimates for expenditures for outgoing remittances and funerals and social functions expenditures that together constitute more than 80% of household non-consumption expenditures. Other estimations are available upon request. Remittances, gifts and transfers from the household seem to be very responsive to variations in precipitations: on average, a 10% reduction in millimeters of rain would account for more than 20% decrease of outgoing transfers.

Table 14 Econometric results, results, fixed effect estimations. Other expenditures.

Dependent variable: ln (Remittances, gifts and other transfers)										
	Rain (-1)	Days (-1)	Max t.(-1)	Min t.(-1)	Ownland	Landsize	Const	Rsqr	N	NH
(29)	2.028***						-21.33***	0.141	961	488
	(0.363)						(4.069)			
(30)	2.044***				1.214	-0.014***	-27.65***	0.152	896	472
	(0.350)				(0.920)	(0.003)	(5.011)			
(31)	2.620***	-0.989					-21.76***	0.143	961	488
	(0.909)	(1.158)					(4.24)			
(32)	2.644***	-1.003			1.173	-0.013***	-28.26***	0.154	896	472
	(1.022)	(1.261)			(0.931)	(0.004)	(5.48)			
(33)			-12.592	-10.57**			62.507	0.125	961	488
			(14.114)	(4.278)			(36.51)			
(34)			-14.417	-10.65**	1.500	-0.015***	63.048	0.136	896	472
			(15.067)	(4.307)	(0.985)	(0.004)	(40.880)			
(35)	2.486***	-1.156	-1.968	-8.573***			11.921	0.164	961	488
	(0.943)	(1.153)	(10.988)	(2.582)			(32.904)			
(36)	2.477**	-1.172	-4.090	-8.702***	1.424	-0.014***	13.343	0.176	896	472
	(1.054)	(1.212)	(11.471)	(2.676)	(0.892)	(0.003)	(36.013)			
Dependent variable: ln(Funerals and other social functions)										
	Rain (-1)	Days (-1)	Max t.(-1)	Min t.(-1)	Ownland	Landsize	Const	Rsqr	N	NH
(37)	0.524**						-1.773	0.066	961	488
	(0.210)						(2.382)			
(38)	0.432				1.064*	-0.432**	-4.434	0.081	896	472
	(0.254)				(0.534)	(0.005)	(2.542)			
(39)	1.341	-1.364					-2.37		961	488
	(0.853)	(1.369)					(2.64)			
(40)	1.034	-1.005			1.023*	-0.011**	-5.044	0.084	896	472
	(0.933)	(1.375)			(0.516)	(0.005)	(2.968)			
(41)			-3.127	-1.984			17.19	0.063	961	488
			(6.618)	(3.706)			(17.97)			
(42)			-0.442	-2.046	1.119**	-0.012**	5.178	0.080	896	472
			(6.751)	(3.884)	(0.537)	(0.005)	(17.867)			
(43)	1.310	-1.415	-1.284	-1.58			7.078	0.071	961	488
	(0.845)	(1.274)	(6.696)	(3.478)			(22.27)			
(44)	1.020	-0.995	1.529	-1.634	1.073**	-0.011**	-5.272	0.085	896	472
	(0.934)	(1.405)	(6.725)	(3.671)	(0.518)	(0.005)	(22.293)			

Source: Author's elaborations based on LSMS 2005/06-2009/10 household panel and UDOM (2012) weather data.

[1] The control variables included in the odd numbered specifications are: sex, age (also squared) and education of the head of the household, size and demographic composition of the household, ownership of the house and number of rooms, year dummy. The even numbered specifications include also the number and size of the owned parcels of land. variables are calculated as natural logarithm of the weather indicator (level) in the first season preceding the interview (-1) or in the second previous season (-2). Robust standard errors clustered by synoptic stations in parenthesis. *, **, *** stand for level of significance at 10, 5 and 1% respectively.

Moreover, tests to assess correlation between households engagement in secondary activities and weather variations did not suggest increasing labor activity as a complementary coping strategy.

7. TRIANGULATION OF THE RESULTS AND CONCLUSION

In this paper we focused on the impact of short term weather variations on food consumption highlighting the channels through which rural households in developing countries could be affected. We applied our framework to the context of Uganda to study the impact of weather variability on food consumption. We matched a subsample of the World Bank LSMS panel dataset 2005/06-2009/10 with UDOM weather data concerning rainfall millimeters, number of rainy days and minimum and maximum temperatures.

The results of the empirical model suggest that weather variability would have negative effects on food consumption in Uganda in the case temperatures increased. When considering all the weather indicators together, the adverse impact on the outcome variable would be significant and higher for both temperatures and number of rainy days. On the other side, changes in amount of precipitations do not seem to have high impacts on food consumption. Land ownership and its size seem to partially insure households from rainfall variations while reduction in non-consumption expenditures such as outgoing remittances and social function expenditures seem to absorb the adverse rainfall variations. This being said, recalling the findings of the qualitative study by Magrath (2008) in which a farmer was alluding to some changes in the crops cultivated in response to changes in the pattern of climate, we have a first argument to support the findings of the empirical analysis. Our analysis of the data on agricultural production, yields, area harvested and agricultural practices in the country, suggesting an increase in production and land devoted to staple, again hint that households are trying to preserve their food security from climatic risk through production choices. Triangulating the results we argue that households in Uganda would be involved in *ex-ante* and *ex-post* food-consumption smoothing strategies that would allow them to mitigate, to a certain extent, the risk from climatic shocks.

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REFERENCES

Alderman, H., J. Hoddinott and Kinsey, B. (2006). Long Term Consequences of Early Childhood Malnutrition. *Oxford Economic Papers* 58(3): 450-474.

Anderson, C. (1994). The Aggregate Excess Measure of Severity of Extreme Events. *Journal of research of the National Institute of Standards and Technology* 99(4): 555-561.

Anderson, P.K., Cunningham, A.A., Patel N.G., Morales F.J., Epstein P.R. and Daszak, P. (2004). Emerging Infectious Diseases of Plants: Pathogen Pollution, Climate Change and Agrotechnology Drivers. *Trends in Ecology & Evolution* 19(10): 535-544.

Asiimwe, J.B. and Mpuga, P. (2007). *Implications of Rainfall Shocks for Household Income and Consumption in Uganda.* Nairobi: African economic research consortium (AERC).

Badiane, O. and Ulimwengu, J. (2012). Malaria Incidence and Agricultural Efficiency in Uganda. *Agricultural Economics* 44: 15-23.

Bagamba, F., Burger, K. and Tushemereirwe, W.K. (2008) Banana (Musa spp.) Production Characteristics and Performance in Uganda. International Conference on Banana and Plantain in Africa. Accessed 1 May 2013 <http://www.actahort.org/books/879/879_17.htm>.

Bardhan, P.K. and Udry, C. (1999). *Development Microeconomics: Pranab Bardhan and Christopher Udry.* Oxford [etc.]: Oxford University Press.

Baulch, B. and Quisumbing, A.R. (2011). *Testing and Adjusting for Attrition in Household Panel Data.* London: Cronic Poverty Research Centre.

Benin, S., Nkonya E., Okecho G., Pender J., Nahdy S. and Mugarura, S. (2007). Assessing the Impact of the National Agricultural Advisory Services (NAADS) in the Uganda Rural Livelihoods, *IFPRI Discussion Paper No. 724*. Washington, DC: IFPRI.

Benson, T., Mugarura S. and Wanda, K. (2008). Impacts in Uganda of Rising Global Food Prices: The Role of Diversified Staples and Limited Price Transmission. *Agricultural Economics* 39(s1): 513-524.

Betz, M. (2009). The Effectiveness of Agricultural Extension With Respect to Farm Size: The Case of Uganda. Paper presented at the Agricultural & Applied Economics Association & ACCI Annual Meeting, 26-29 July, Milwaukee, Wisconsin.

Cooper, P., Dimes J., Rao K., Shapiro B., Shiferaw B. and Twomlow, S. (2008). Coping Better with Current Climatic Variability in the Rain-Fed Farming Systems of Sub-Saharan Africa: An Essential First Step in Adapting to Future Climate Change?. *Agriculture, Ecosystems & Environment* 126(1): 24-35.

de la Fuente, A. and Dercon, S. (2008). Disasters, Growth and Poverty in Africa: Revisiting the Microeconomic Evidence. Accessed 15 June 2012 <http://gar-isdr.desinventar.net/gar11/en/bgdocs/GAR-2009/background_papers/Chap3/Fuente-and-dercon--nov-08.doc>.

Deininger, K. (2003). Causes and Consequences of Civil Strife: Micro-level Evidence from Uganda. *Oxford Economic Papers* 55(4): 579-606.

Dercon, S. (1996). Risk, Crop Choice, and Savings: Evidence from Tanzania. *Economic development and cultural change* 44(3): 485-513.

Dercon, S. (2004). Growth and Shocks: Evidence from Rural Ethiopia. *Journal of Development Economics* 74(2): 309-329.

Dercon, S., Hoddinott J. and Woldehanna, T. (2005). Shocks and Consumption in 15 Ethiopian Villages, 1999-2004. *Journal of African Economies* 14(4): 559.

Dercon, S. and Krishnan P. (2000). In Sickness and in Health: Risk Sharing within Households in Rural Ethiopia. *Journal of Political Economy* 108(4): 688-727.

Duflo, E. and Udry, C. (2004). Intrahousehold Resource Allocation in Cote d'Ivoire: Social Norms, Separate Accounts and Consumption Choices. *NBER Working Paper* 10498.

EM-DAT (last update 2011). The OFDA/CRED International Disaster Database. Brussels, Belgium: Université Catholique de Louvain. Accessed 16 June 2012 <www.emdat.be>.

FAO (Last updated 2012). FAOSTAT Database (a webpage of FAO). Accessed 15th October 2012 <http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor>.

Foster, A.D. and Rosenzweig, M.R. (1995). Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *Journal of political Economy* : 1176-1209.

Funk, C., Rowland J., Eilerts G. and White, L. (2012). *A Climate Trend Analysis of Uganda.* U.S. Geological Survey Fact Sheet 2012-3062. Accessed 1 May 2013 < http://pubs.usgs.gov/fs/2012/3062/FS2012-3062.pdf>

Gujarati, D.N. and Porter, D.C. (2009). *Basic Econometrics. Fifth Edition.* Boston [etc.]: McGraw Hill.

Haines, A., Kovats, R.S., Campbell-Lendrum, D. and Corvalán, C. (2006). Climate Change and Human Health: Impacts, Vulnerability, and Mitigation. *The Lancet* 367(9528): 2101-2109.

Hickey, S. (2013). Beyond the Poverty Agenda? Insights from the New Politics of Development in Uganda. *World Development* 43: 194-206.

Hisali, E., Birungi, P. and Buyinza, F. (2011). Adaptation to Climate Change in Uganda: Evidence from Micro Level Data. *Global Environmental Change* 21(4): 1245-1261.

IFRC (Last updated 2012). Hydrological Hazards: Mass Movement Wet (Subsidences, Rockfalls, Avalanches and Landslides). Accessed 5th November 2012 <http://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/definition-of-hazard/mass-movement-wet/>.

IPCC (2001). *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, UK: Cambridge University Press.

ISDR (2009). *Global Assessment Report on Disaster Risk Reduction*. Geneva, Switzerland: United Nations.

James, P.A.S. (2010). Using Farmers' Preferences to Assess Development Policy: A Case Study of Uganda. *Development Policy Review* 28(3): 359-378.

Jennings, S. and Magrath, J. (2009). *What Happened to the Seasons?*. UK: Oxfam.

Kasente, D., Lockwod, M., Vivian, J. and Whitehead, A. (2002). Gender and the Expansion of Non-Traditional Agricultural Exports in Uganda. In Razavi, S. (ed.) *Shifting Burdens, Gender and Agrarian Change under Neoliberalism,* 35-65. United Nations Research Institute for Development. Bloomfield: Kumarian Press.

Kazianga, H. and Udry, C. (2006). Consumption smoothing? Livestock, insurance and drought in rural Burkina Faso. *Journal of Development Economics* 79: 413-446.

Kijima, Y., Otsuka, K. and Sserunkuuma, D. (2008). Assessing the Impact of NERICA on Income and Poverty in Central and Western Uganda. *Agricultural Economics* 38(3): 327-337.

Kijima, Y., Matsumoto, T. and Yamano, T. (2006). Nonfarm Employment, Agricultural Shocks, and Poverty Dynamics: Evidence from Rural Uganda. *Agricultural Economics* 35(3): 459-467.

Kraybill, D. and Kidoido, M. (2009). Analysis of Relative Profitability of Key Ugandan Agricultural Entreprises by Agricultural Profuction Zones. *Uganda Strategy Support Program*, background paper USSP 04. Kampala: IFPRI.

Lansigan, F., De los Santos, W. and Coladilla, J. (2000). Agronomic Impacts of Climate Variability on Rice Production in the Philippines. *Agriculture, Ecosystems & Environment* 82(1): 129-137.

MAAIF (2010). Agriculture Sector Development Strategy and Investment Plan: 2010/11-2014/15. Agriculture for Food and Income Security. Kampala, Uganda: MAAIF.

Magrath, J. (2008). Turning Up the Heat: Climate Change and Poverty in Uganda. UK: Oxfam.

McMichael, A.J. and Haines, A. (1997). Global Climate Change: The Potential Effects on Health', *BMJ* 315(7111): 805-809.

McSweeney, C., New, M. and Lizcano, G. (2007). Uganda. *UNDP Climate Change Country Profiles* 27.

Morduch, J. (1995). Income Smoothing and Consumption Smoothing. *The journal of economic perspectives* 9(3): 103-114.

Mpuga, P. (2010). Constraints in Access to and Demand for Rural Credit: Evidence from Uganda. *African Development Review* 22 (1): 115-148.

Mubiru, D.N., Komutunga, E., Agona, A., Apok, A., Ngara, T., Energy, S.(2012). Characterising Agrometeorological Climate Risks and Uncertainties: Crop Production in Uganda. *South African Journal of Science* 108 (3/4).

Mwerera, R. L., Majaliwa, J. G. M. and Isubikalu, P. (2010). Climate change adaptation strategies among agricultural communities in Uganda: The case of Kabale and Nakasongla districts. Second RUFORUM Biennial Meeting, Kampala, 20-24 September. Entebbe, Uganda.

Nakyagaba, N.W., Ssekabembe, C.K. and Osiru, D.S.O. (2005). An Overview of the Agronomic Constraints to Simsim Production in Uganda. *African Crop Science Conference Proceedings* 7: 1221-1228. Uganda: African Crop Science Society.

NAPA (2007). Uganda National Adaptation Programmes of Action'Republic of Uganda, Ministry of Environment.

Nordhaus, W.D. (1993). Reflections on the Economics of Climate Change. *The Journal of Economic Perspectives* 7(4): 11-25.

Okori, W., Obua, J., and Baryamureeba, V. (2009). Famine Disaster Causes and Management Based on Local Community's Perception in Northern Uganda. *Research Journal of Social Sciences*, 4: 21-32.

Okoboi, G., Kuteesa, A. and Barungi, M. (2013). The Impact of the National Agricultural Advisory Services Program on Household Production and Welfare in Uganda. *Africa Growth Initiative Working Paper 7* (March). Washington: Brookings.

Okurut, F.N., Odwee, J.O.O. and Adebua, A. (2002). Determinants of Regional Poverty in Uganda. *AERC Research Paper*, No. 122. Nairobi, Kenya: African Economic Research Consortium.

Olasantan, F., Ezumah, H. and Lucas, E. (1996). Effects of Intercropping with Maize on the Micro-Environment, Growth and Yield of Cassava. *Agriculture, Ecosystems & Environment* 57(2): 149-158.

Otegui, M.E., Andrade, F.H. and Suero, E.E. (1995). Growth, Water use, and Kernel Abortion of Maize Subjected to Drought at Silking. *Field Crops Research* 40(2): 87-94.

Paxson, C.H. (1992). Using Weather Variability to Estimate the Response of Savings to Transitory Income in Thailand. *The American Economic Review* : 15-33.

Pender, J., Nkoya, E., Jagger, P., Sserunkuuma, D. and Ssali, H. (2004). Strategies to Increase Agricultural Productivity and Reduce Land Degradation: Evidence from Uganda. *Agricultural Economics* 31: 181-195.

Piao, S., Ciais, P., Huang, Y., Shen, Z., Peng, S., Li, J. et al. (2010). The Impacts of Climate Change on Water Resources and Agriculture in China. *Nature* 467(7311): 43-51.

Prasad, P., Pisipati, S., Mutava, R. and Tuinstra, M. (2008). Sensitivity of Grain Sorghum to High Temperature Stress during Reproductive Development. *Crop Science* 48(5): 1911-1917.

Shively, G. and Hao, J. (2012). A Review of Agriculture, Food Security and Human Nutrition Issues in Uganda. *Purdue University Department of Agricultural Economics Staff Paper* 12.

Singh, I., Squire, L. and Strauss, J. (1986). A Survey of Agricultural Household Models: Recent Findings and Policy Implications. *The World Bank Economic Review* 1(1): 149-179.

Skoufias, E. and Quisumbing, A.R. (2005). Consumption Insurance and Vulnerability to Poverty: A Synthesis of the Evidence from Bangladesh, Ethiopia, Mali, Mexico and Russia. *The European journal of development research* 17(1): 24-58.

Skoufias, E., Vinha, K. and Conroy, H. (2011). The Impacts of Climate Variability on Welfare in Rural Mexico. *World Bank Policy Research Working Paper* 5555.

Tol, R.S.J. (2009). The Economic Effects of Climate Change. *The Journal of Economic Perspectives* 23(2): 29-51.

UBOS (2010). The Uganda National Panel Survey 2009/2010. Basic Information Document. Kampala, Uganda: Uganda Bureau of Statistics.

UDOM (2012). Weather data. Entebbe, Uganda: Department of Meteorology, Ministry of Water and Environment of the Government of Uganda.

Wooldridge, J.M. (2002). *Econometric Analysis of Cross Section and Panel Data*. London, UK: The MIT Press.

Wooldridge, J.M. (2009). *Introductory Econometrics: A Modern Approach.* Mason, OH [etc.]: South-Western/Cengage Learning.

Wopereis, M., Kropff, M., Maligaya, A. and Tuong, T. (1996). Drought-Stress Responses of Two Lowland Rice Cultivars to Soil Water Status. *Field Crops Research* 46(1): 21-39.

World Bank (Last updated 2011). World Bank Database. Accessed 30 June 2012 <http://data.worldbank.org/country/uganda>.

Yamano, T., Alderman, H. and Christiaensen, L. (2005). Child Growth, Shocks, and Food Aid in Rural Ethiopia. *American Journal of Agricultural Economics* 87(2): 273-288.

8. APPENDIX A

Table A1 Descriptive statistics of weather indicators: long-term means and levels for the second season preceding the interview (-2) in 2005/06 and 2009/10.

			Long term means[1]		2005/06		2009/10	
Weather variable	Season	N	Mean	St.D.	Mean	St.D.	Mean	St.D.
Rainfall mm	Rainy 2	58	140.13	25.81	137.44	44.19	153.64	15.89
	Dry 1	262	54.46	23.10	45.74	24.92	105.41	39.69
	Rainy 1	168	140.18	37.26	138.79	46.86	119.38	46.44
No. rainy days	Rainy 2	58	10.98	1.13	11.40	1.43	12.81	1.03
	Dry 1	262	5.29	2.14	4.32	2.08	8.30	2.10
	Rainy 1	168	11.33	1.96	11.73	2.79	10.93	1.55
Max temp. (°C)	Rainy 2	58	28.48	1.94	28.67	2.14	28.38	1.91
	Dry 1	262	29.91	2.31	31.25	2.49	29.66	2.59
	Rainy 1	168	28.22	1.38	28.91	1.37	28.71	1.52
Min temp. (°C)	Rainy 2	58	15.88	2.35	16.46	2.08	17.03	1.81
	Dry 1	262	16.41	2.21	17.73	1.80	17.47	1.87
	Rainy 1	168	17.29	1.31	18.15	1.14	17.77	1.11

Source: Author's elaborations from UDOM (2012) weather data.

[1] Long term means are calculated as average weather indicator in the season considered in the period 1960-1990 for rainfall millimetres and number of rainy days and 1980-2000 for maximum and minimum temperatures.

Table A2 Weather indicators between 2005 and 2010: percentage deviations from long-term means[1].

			2005/06		2009/10		2006/07-2009/10	
Weather variable	Season	N	Mean	St.D.	Mean	St.D.	Mean	St.D,
Rainfall mm	Rainy 2	58	-2.00	27.06	159.65	92.21	5.63	5.76
	Dry 1	262	-15.84	29.20	2.98	15.64	28.34	19.07
	Rainy 1	168	-1.55	15.77	-27.05	19.96	-11.5	7.46
No. Rainy days	Rainy 2	58	4.14	10.85	91.12	38.41	7.56	16.49
	Dry 1	262	-12.18	36.75	3.40	10.74	33.65	34.62
	Rainy 1	168	3.83	19.07	-19.28	10.73	-2.35	11.86
Max temp.	Rainy 2	58	0.62	1.79	-1.05	3.75	0.07	1.64
	Dry 1	262	4.53	2.65	1.39	2.29	0.33	1.56
	Rainy 1	168	2.56	5.00	5.51	2.13	1.71	2.01
Min temp.	Rainy 2	58	4.31	8.51	8.27	6.50	11.94	14.50
	Dry 1	262	8.93	9.64	4.80	6.37	6.58	8.02
	Rainy 1	168	5.29	6.61	6.26	6.71	2.09	5.91

Source: Author's elaborations based on UDOM (2012) weather data.

[1] Weather indicators assigned to households based on proximity to synoptic station. The reported data are rainfall millimetres, number of rainy days and maximum and minimum temperature in a particular period, relative to the long term mean, expressed as percentage deviation. Yearly indicators are the percentage deviations in the season preceding the interview, reported in the second column. The four years indicators are the percentage deviations of the average indicator in the period, relative to the long term mean. The long term mean for every indicator, in the season considered is based on all available observations of the relevant synoptic station in the period 1960-1990 for rainfalls and number of rainy days and 1980-2000 for maximum and minimum temperatures.