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List of abbreviations and acronyms

AQ	Agriculture Questionnaire
COV	Coefficient of Variation
CQ	Community Questionnaire
ECMWF	European Centre for Medium-Range Weather Forecasts
FAO	Food and Agriculture Organization of the United Nations
GLS	Generalized Least Square
HQ	Household Questionnaire
NOAA	National Oceanic and Atmospheric Administration
SI	Seasonality Index
SSA	sub-Saharan Africa
UNHS	Uganda National Household Survey
UNPS	Uganda National Panel Survey
ARC2	Africa Rainfall Climatology version 2
SLM	Sustainable Land Management

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Abstract

This paper evaluates the effects of weather/climate shocks on various measures of household welfare using a nationally representative panel data from Uganda National Panel Survey (UNPS) together with a set of novel climate variation indicators. We estimated generalized least square (GLS) random effects and quintile regression models to address the research questions. Our results point towards a consumption and income smoothing behaviour by the households since: we obtain very few significant results with respect to climate/weather shock variables together with highly significant effects of the socio-demographic and wealth control variables. We also investigate if different shocks definitions, i.e the reference period used to define the shock, modifies our results. The latter are robust since the coefficients and the signs do not change with the reference period. We further test the hypotheses that policy-relevant mechanisms can be effective means of mitigating the negative welfare effects. For instance access to credit services and use of sustainable land management practices enables the households to contain the negative effects of climate shock on per capita food consumption from own produced crops but not the case for some of the outcome variables.

Keywords: Climate change, adaptation, impact, multivariate probit, instrumental variable, Ethiopia, Africa

JEL Classification: Q01, Q12, Q16, Q18

1. Introduction

Reducing food insecurity continues to be a major public policy challenge in developing countries. Nearly about 843 million people worldwide are undernourished, and the absolute numbers tend to increase further (FAO, 2013). Unlike almost all other regions of the world, food insecurity in sub-Saharan Africa (SSA) has been rising over the last decade. The share of people living on less than $1.25 a day in this region started to decrease only from 2008, though it still remains the highest in the world (48.2 percent in 2010 according to World Bank, 2010). In recent years, poverty alleviation and achieving food security in SSA has been in the forefront of the national and international agenda. As the economies of many African countries and the livelihood of the majority of the poor within them depend on agriculture, the pathway to food security in these countries depends on the growth and development of that sector made through research and technological improvements. However, a significant proportion of the population in these countries that relies on agriculture is highly vulnerable to variability in weather and climate as well as to pests, pathogens and market related factors like price volatility.[1]

Recent evidence suggests that global climate change is likely to increase the incidence of environmental disasters, increase the variability of rainfall and temperature, and involve other climatic parameters such as seasonal pattern change and the increase of extreme weather events (IPCC, 2013). Studies have shown that climate and weather variability have negative impacts on the welfare of households relying on agriculture in many regions through potential increases in yield variability and crop failures and reduction in average yields in the longer term (e.g. IPCC, 2014; Challinor *et al.*, 2010). Climate change affects food production directly through changes in agro-ecological conditions and indirectly by affecting the growth and the distribution of incomes, and thus the demand for agricultural products Martin L. Parry and Hanson (2007). According to the IPCC report all aspects of food security are potentially affected by climate change, including food access, utilization, and price stability (IPCC, 2014). Reducing the vulnerability of agricultural systems to climate change is thus an important priority for agricultural development in order to protect and improve the livelihoods of the poor and to ensure food security (Bradshaw *et al.*, 2004; Wang *et al.,* 2009).

There is an emerging economic literature concerning climate-economy relationships which has largely been sparked by a desire to inform the global community of the potential consequences of global climate change.[2] Most of this literature is concerned with

[1] Recent literature often distinguishes between weather and climate, where the word climate is reserved to describe the distribution of outcomes which may be summarized by averages over several decades (long periods of time) while weather refers to a particular realization from that distribution (Dell *et al.*, 2013). In other words, the difference between weather and climate is basically a matter of time. Weather is the condition of the atmosphere over a short period of time, while climate is the behaviour of the atmosphere over a relatively long period of time.

[2] The idea of using climate measures as explanatory variables in explaining the economic performance is an old one (Fisher, 1925; Wright, 1928). The advantage of using climate variables, as noted by (Angrist and Krueger, 2001), is that they are exogenous and random in most economic applications and thus in some settings allows researchers to statistically identify the causal effect of one variable on an economic outcome of interest.

establishing linkages between these outcomes of interest and weather using data at aggregated levels (e.g. country, district, and municipality) including through cross-country studies. In general, the evidence shows a strong and negative relationship between temperature and economic outcome indicators (e.g., Dell *et al.,* 2009; Nordhaus, 2006); Dell *et al.,* 2013). In developing countries, Schlenker and Lobell, 2010) find negative impacts from bad weather shocks (higher temperature) on yields for Sub-Saharan Africa. Similarly, Guiteras (2009) for India and Feng *et al.* (2010) for Mexico estimate that higher temperatures reduce agricultural output. Not completely in line with the previous studies, Welch *et al.* (2010) estimate for Asian countries that higher minimum temperature reduces yields, whereas higher maximum temperature increases yields. As regards precipitations, Levine and Yang (2014) find using a panel of Indonesian districts a positive relationship between rainfall and rice production. Other studies obtain the same relationship for developing countries when testing other hypotheses (Paxson, 1992; Jayachandran, 2006; Choi and Yang, 2007; Hidalgo *et al.,* 2010).

In summary, past studies generally predict economically and statistically significant negative impacts of hotter temperatures on agricultural output, and these impacts are more pronounced in African countries where the level of irrigation is extremely low. Uganda, like many other sub Saharan countries, relies heavily on the agricultural sector and consequently the economic impact of weather and climate change is crucial for small-scale farmers' food security and welfare (Mendelsohn *et al.,* 2006; Mendelsohn and Dinar, 2009). Usually, agricultural production is completely dependent on rainfall (approximately 85 percent of the Ugandan population is vulnerable to climate change (Uganda Bureau of Statistics, 2012) and is widely based on the adoption of traditional technologies. In response to a change in climate, farmers may alter their use of inputs including fertilizers, change their mix of crops, or even decide to use their farmland for another activity (e.g., a housing complex). Since many smallholder farmers in SSA in general and Uganda in particular view climate/weather variability as a primary source of risk (Barrett *et al.*, 2007), understanding the welfare implication of climate variability is important for policymakers if policies aiming to reduce the associated risk and thus mitigate adverse consequences are to be effective and welfare enhancing. In countries where the agricultural sector is largely based on smallholders and dominates the economy, the main linkages between weather/climate and welfare go directly through agriculture, and when the latter is based on rain-fed subsistence agriculture, this link has substantial implications for food security and welfare. Not only are the average incomes of smallholders low, but also they tend to be highly volatile due to income shocks resulting from climate/weather fluctuations.

In this paper, we evaluate the effects of weather/climate shocks on household welfare in rural Uganda. Besides the important policy implications that can be derived from the investigation of these issues, we focus on climate/weather-related risk for two additional reasons. First, the growing availability of high quality geo-referenced data on weather makes this important and exogenous component of the environment riskiness measurable, along with the related household's response. Second, although it is not the only exogenous factor affecting income and consumption of rural households, it is spatially covariant. As pointed out by Rosenzweig and Binswanger (1993), this feature makes it an important determinant of income variability that is most likely to influence welfare, especially in developing economies. The goal of this study is, therefore, to provide a comprehensive analysis of the impact of weather risk on rural households' welfare and, to this aim, we use a nationally

representative panel data on Ugandan households together with a set of novel weather variation indicators based on interpolated gridded and re-analysis weather data that capture the peculiar features of short term (weather) and long term (climate) variations in rainfall and temperature. In particular, we estimate the effects of weather/climate shocks on a rich set of welfare indicators (i.e. total consumption expenditure, total food expenditure, share of food expenditure, total income and daily calorie intake) and investigate the extent to which they vary according to a different definition of the shock. Where the effect of climate/weather variability has a significantly negative effect on household welfare, we further test the hypotheses that policy-relevant mechanisms can be effective means of mitigating the negative welfare effects of local climate variability both directly and indirectly. We consider four factors that can be altered by policy action, which include access to extension services, access to credit, sustainable land management practices (SLM), and the size of the farm. Finally, since fluctuations in weather patterns may have a heterogeneous impact on different household profiles, we investigate this heterogeneity along the quintiles of the considered outcome indicators. It should be noted that different definitions of what a climatic or weather shock can be used. The latter can be defined as departures from long or short run averages or as peaks in the maximum or minimum values of rain or temperature. Furthermore the departures can be computed overt time or over space. In this paper we try to asses not only if the shock has impact on the household welfare but also if the impact changes according to different definitions of shock. In particular, we consider four different definitions of shock, according to the reference period with respect to which the climatic variables have been computed, namely the past 25, 10, 5 and 3 years with respect to the year *t* for which survey data is available (*t* = 2010, 2011). Our results show that in the case of the Ugandan household it seems that the different definition of the shocks has no impact on the outcome variables. The low significance of the shock variables point toward consumption smoothing behaviour by the household, whose welfare level is not affected by the weather shocks.

The rest of the paper is organized as follows. Section two provides an overview of agricultural production in Uganda. Data sources, variable construction and descriptive results are presented in section three. The forth section presents the conceptual framework and analytical methods with emphasis on empirical models and hypothesized relationships. Econometric results are presented and discussed in section five. Section six concludes by presenting the key findings and the policy implications.

2. Country background

Uganda is located on the East African plateau and lies almost completely within the Nile basin. Although situated close to the equator, it has diverse climate patterns due to the country's unique bio-physical characteristics influenced by several large rivers, bodies of water, and mountain ranges to the east and west. Rainfall varies throughout the country: from rain spread throughout the year in the south, with heavy rains in the Rwenzori mountainous region in the southwest and rains falling from March to June and November/December near Entebbe on the northern shore of Lake Victoria. In the north, a dry season emerges from November to February in Gulu; the northeastern Karamoja region has the driest climate and is most susceptible to drought.

In mid-2012 the population of Uganda was estimated to be 34.1 million (Uganda Bureau of Statistics, 2012) with one of the highest annual population growth rates in the world at

3.2 percent, with an increasing trend. It also has the second highest total fertility rate in the world, with 6.2 children born per woman in 2011 (Uganda Bureau of Statistics, 2011b). The population is young, with a median age of 15 years (CIA, 2009). Uganda continues to be one of the poorest nations in the world, with 24.5 percent of the population living on less than $1.25 a day (World Bank, 2012). Poverty fell between 2005- 2006 and 2009-2010 from 31.1 percent to 24.5 percent of the national population, i.e., from 8.5 million to 7.5 million people. Social indicators for health reflect how the country continues to struggle in addressing poverty. According to the 2002 census, life expectancy was estimated to be 50.4 years (Uganda Bureau of Statistics, 2011b); the infant mortality rate was approximately 54 deaths per 1 000 live births (according to the 2011 Uganda Demographic Health Survey, and 352 women die per 100 000 births (Uganda Bureau of Statistics, 2011b).

Approximately 41 percent (Uganda Bureau of Statistics, 2012) of the land is cultivated (9 percent in permanent crops). The World Bank reported that 0.20 hectares per person was arable in 2009 and between 1980 and 2011 arable land increased from 53.5 to 70.4 percent of the total land area (World Bank, 2011). Land pressure to cultivate has steadily increased over the last two decades, and given the consistent and strong population trend is expected to continue. Cultivated land is encroaching on the protected areas and is projected to become a bigger problem as land pressure increases, gradually diminishing forest cover and the ecological services that forested ecosystems provide. According to the latest data available from the Uganda National Bureau of Statistics (UBoS) (Uganda Bureau of Statistics, 2011a) Uganda had about 3.95 million agricultural households of which about 20 percent are female headed, with about 19.3 million persons living in agricultural households. The Western Region with 28.5 percent had the highest percentage of agricultural households followed by the Eastern Region (28.1 percent) while the Central Region had the least (21 percent). Over 7 000 000 parcels are cultivated by Ugandan households and the vast majority is owned by the agricultural households, with 8 million people working permanently in agriculture. Maize, beans, banana (Food), cassava and sweet potatoes were the crops grown by most of the agricultural households in the country, with each grown by over one million households. Of these five major crops, maize carried the day with over 1.5 million agricultural households growing the crop. The Eastern Region had the highest number of agricultural households that grew maize (578 000), cassava (373 000) and sweet potatoes (356 000) while the Western Region led in the number of agricultural households that that grew beans (696 000) and banana-food (696 000). Within the Central Region, most agricultural households grew banana-food (460 000), followed by maize (410 000), beans (366 000) and cassava (279 000). These crops are mainly grown using local seeds and only about 26 percent of agricultural households practiced shifting cultivation. Shifting cultivation is a farming practice whereby a particular piece of land is cultivated for some years and then abandoned for a period sufficient to restore its fertility by natural vegetative growth before being re-cultivated.

3. Data and variables description

We use two main sources of data in our analysis: socio-economic data from Uganda National Panel Survey (UNPS) and historical re-analysis data on rainfall and temperature from the National Oceanic and Atmospheric Administration (NOAA) and the European Centre for Medium-Range Weather Forecasts (ECMWF), respectively. The UNPS, implemented by the UBoS, is part of the Living Standards Measurement Study-Integrated

Surveys on Agriculture, a series of nationally representative household panel surveys that assembles information on a wide range of topics, with a strong focus on agriculture and rural development. The survey collects information on socio-economic characteristics, production activities in agricultural, livestock and fisheries sectors, non-farm income generating activities and consumption expenditures. The sample for the 2009-10 UNPS was designed to revisit some of the very households that participated in the 2005/06 Uganda National Household Survey (UNHS). Households were tracked and re-interviewed using identification particulars available in the 2005-06 UNHS. Out of the 7 400 households interviewed during the UNHS 2005-06, about 3 200 households were selected for the 2009-10 UNPS.

During data collection, households that had migrated to known places were followed-up and re-interviewed based on the contact information provided by knowledgeable persons: out of the 3 123 original households, 2 607 were tracked and interviewed. Similarly, the 2010-11 UNPS was designed starting from the UNHS 2005-06. Out of the 3 123 households that were originally sampled for Wave I of the UNPS, a total of 2 607 households were successfully interviewed. In the second wave a detailed fisheries module was added. Both samples were designed to be representative at the national, urban/rural and main regional levels (North, East, West and Central regions). Both waves make use of three main questionnaires to collect data: a Household Questionnaire (HQ) collecting information on household composition, educational attainment, health, labour market participation, non-farm and social activities[3]; an Agriculture Questionnaire (AQ), administered to any household that has engaged in any farming or livestock activities, in which data are collected at both the plot and crop levels on inputs, production and sales; and a Community Questionnaire (CQ) administered to a group of local leaders determined by the field supervisors and designed to collect information about the community where the selected households are located.

One of the main reasons to use the two consecutive waves and not the 2005-2006 one was mainly driven by the fact that starting from the UNPS 2009-10 a comprehensive agriculture module is also included, which will be administered annually to all households in the main sample identified during the main interview as being involved in crop and/or livestock or fishery production. The Agriculture Questionnaire will allow, among other things, for the estimation of land area, both owned and cultivated, and detailed production cost for selected crops. The 2009-10 UNPS was undertaken from September 2009 to August 2010, while the second wave of the UNPS and was conducted from November 2010 to October 2011. The analysed sample in the first wave consists of 2 492 households (1 943 households in rural areas and 549 urban areas). The second consists of 2 216 households (1 859 households in rural areas and 346 urban areas).

3.1 Weather fluctuations and climate shocks

Our data on rainfall and temperatures come from the daily ARC2 (Africa Rainfall Climatology version2) database. Rainfall (measured in millimetres of rain) and temperature (measured in Celsius degrees) data are summed at decadal (10-days) values and corrected for possible

[3] Data on labour, education, and health status are collected at the individual level

missing daily values at county level. The ARC2 rainfall (max*temperature) database contains data at a spatial ground resolution of 1/10 of degree for African countries for the period 1983-2012 (1989-2010). As reported by Novella and Thiaw (2013) the benefits of ARC2 include a high-resolution long-term data set, with minimal, continuous inputs that minimize bias and error, with availability in near real-time.

Uganda is characterized by a hotter northern region, where the average max temperature is approximately 5 degrees more in the south (see Figure 21) while total rainfall is more abundant in the central areas (see Figure 22) although the coefficient of variation is higher in the norther region. Preliminary analysis of Uganda’s climatic characteristics showed that the characteristics of an area do not change if we change the reference period used to define the shock (i.e. if an area has a high rain volatility with the 25 years reference period the same is generally true for the 3 years reference period). The north is characterized by both higher temperatures and higher variations of temperatures but the difference between the first and the last quintile of the maximum temperature distribution is only 8 degrees, leading to a small variability of the maximum temperature Coefficient of Variation.

We construct a series of intra- and inter-seasonal indicators to measure both the level and variability of rainfall and maximum temperature for the specific planting and harvesting calendar for the main crops in Uganda from January to June. This enables us to highlight relevant differences between weather fluctuations and climate shocks as they represent essentially different phenomena and are expected to have different welfare implications (see for example Deschenes and Greenstone, 2007 and Fisher *et al.,* 2012).[4] Indeed, while intra-seasonal indicators measure weather fluctuations, or the short-term variation within the same cropping season, inter-seasonal indicators allow the measurement the climate in a specific area, or the variation of weather in that area for a specified reference period. As discussed in section 4, permanent climate shocks may cause farmers to alter the activities they conduct on their land. For example, they might switch crops because their income would be higher with an improved high-yield crop, or they might adopt specific land practices to mitigate the adverse impact of the permanent change. In order to investigate how different definitions of the reference period may affect the results, we construct both the intra- and inter-seasonal indicators with respect to different reference periods, namely the past 25, 10, 5 and 3 years.

Of special note is that we consider an intra-seasonal measure of rainfall seasonality that allows to the characterization of a specific county according to the rainfall seasonality pattern. In particular, we consider a discrete version of the Seasonality Index (SI) following the qualitative classification of degrees of seasonality suggested by Walsh and Lawler (1981). The resulting discrete indicator is equal to 1 if the continuous index is less than 0.4, indicating those enumeration areas in which precipitations are equally distributed over the cropping season; it is equal to 2 when the continuous index is greater or equal to 0.4 and less than 1, indicating those enumeration areas in which precipitations can be defined as seasonal; and it is equal to 3 when the continuous index is greater than 1, indicating those enumeration areas in which almost all rain falls in 1-3 months.

[4] It is worth noting that to the extent that the distributions of weather fluctuations and climate shocks are similar, the distinction between the two becomes negligible.

In what follows, we denote with RP the reference period, SS the survey cropping season, and with *t* = 2009*,* 2010 the year for which survey data on outcome measures and controls is available. As for precipitation, we consider the following indicators:

Inter-seasonal measures

1. the between-years average of SS precipitation totals computed for the RP (*R*1); For example, the average total rainfall in the cropping season computed over the 25,10,5,3 years span before the survey period;

2. the between-years standard deviation of SS precipitation totals computed for the RP (R2); for example, the standard deviation of the average total rainfall in the cropping season computed over the 25,10,5,3 years span before the survey period;

3. ratio of the between-years Coefficient of Variation (COV). For example, the between-years COV is computed as the ratio between *R*2 and *R*1 for a given reference period. COV is computed for the past 10, 5 and 3 years (past with respect to the year *t* for which survey data is available) over the 1983-2012 between-years COV (*R*3).

Intra-seasonal measures

1. we computed the Walsh and Lawler (1981) Seasonality Index (SI) for the year t and then constructed a dummy variable equal to 1 if the SI changed class with respect to the reference period class;[5]

2. the SS precipitation shortfall in year t computed with respect to the between years average of SS precipitation totals for the RP (R5). For example, how much less rain fell in the year t cropping season compared to average of the 25,10,5,3 previous ones.

As for temperature, we consider the following indicators

Inter-seasonal measures

1. the between-years average of the SS average maximum temperature computed for the RP (*T*1); For example, the average maximum temperature in the cropping season computed over the 25,10,5,3 years span before the survey period;

2. the between-years standard deviation of the SS average maximum temperature computed for the RP (T2); For example, the standard deviation of the average maximum temperature in the cropping season computed over the 25,10,5,3 year span before the survey period.

Intra-seasonal measures

1. the number of dekades (10 days) in which the maximum temperature have exceeded the SS average maximum temperature computed for the RP (T3).

[5] We reduced the classes proposed in Walsh and Lawler (1981) to 3 equable, seasonal and extreme

3.2 Outcome measures and other controls

As for households' welfare indicators, we consider *i*) per capita daily calories intake, *ii*) per capita food expenditures, *iii*) food expenditure's share (over total expenditures), *iv*) per capita gross total income, *v*) per capita total expenditures and *vi*) value of own produced crops. Our measure of income includes agricultural and non-agricultural wages, self-employment wages, revenues from own-produced crops, revenues from livestock and revenues from private and public transfers.

As for controls, we consider a set of socio-demographics including age, gender, marital status of the household head, as well as household size, average years of education and dependency ratio. In order to control for income and consumption smoothing strategies, we consider access to the credit market and the adoption of Sustainable Land Management (SLM) practices (e.g. maize-legume intercropping, soil and water conservation practices, and the use of organic fertilizer) defining as adopters the households that have treated at least one plot with these practices, irrespective of the area covered.[6] Dummies for extension advice and smallholders are also included. As for wealth indicators, we include a wealth index based on durable goods ownership and housing conditions and dummies for the ownership of radio and mobile phone. We also include land related characteristics collapsed at the household level, such as the hectares of cultivated land and if the land is irrigated. In order to control for external shocks, we include dummies for the death and illness of at least a household's member. To control for transaction costs, we consider the distance from home to markets and hospitals as well as if the household is a small landholder or not.

3.3 Descriptive analysis

Table 1 reports the summary statistics for the both the outcome variables and the sociodemographic controls for the two waves considered in the study. As for control variables, we observe small differences between the households across the two (consecutive) waves. For both samples about a third of the households are female-headed or are headed by a single person. Household size slightly decreased between wave 1 and wave 2 from 5.4 to 4.8, as did the average age of household head from 47.1 to 46.7. The within-household dependency ratio remained stable at 1.5 across the two waves while we observe a drop in the wealth index, from .47 in 2009-10 to -.25 in 2010-11. Agricultural production in Uganda is characterized by a large majority of smallholders, more than 70 percent of the sample, in mainly rain-fed areas. Only 1 percent of the households have irrigated land in both waves, and few households use sustainable land management practices (around 10 percent in 2009-10 and 2010-11). About a third of the households received extension services, i.e. the application of scientific research and new knowledge to agricultural practices through farmer education, in 2009/10 while only 20 percent of the households had been reached in 2010-11. With regards to access to credit, around 60 percent of the sample had no access to any kind of credit, with a high risk of being financially constrained.

[6] We are aware of the potential endogeneity of these controls, but no causal inference is made based on them.

4. Conceptual framework and methodology

Following Dercon *et al.* (2005) we define shocks as “adverse events that lead to a loss of household income, a reduction in consumption and/or a loss of productive assets.” In this study, we focus on climatic shocks due to their role in determining household welfare (see, among the others, Dercon, 2004; Kazianga and Udry, 2006; Tol, 2009). In particular we investigate whether long or short-term climate shocks, i.e. calculated with respect to different reference periods, have a different impact on welfare variables. In order to analyse the impact of climatic shocks on welfare, we follow the conceptual framework proposed in Skoufias *et al.* (2011).

In this framework, the environment affects consumption mainly through its impacts on current agricultural production or income. This implies that weather shocks have a short-term direct impact on the agricultural production (and consequently on the agricultural income), since higher temperatures and highly variable rainfall patterns are likely to change the hydrological cycle, ultimately affecting crop yields and total factor productivity. 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 (see for instance Lansigan *et al.* (2000) or Prasad *et al.* (2008) on rice and sorghum respectively). Similarly, mismatches between the amount of water received and required along the growing and harvesting seasons, and the timing of the water stresses faced by the crops, affect agricultural productivity (see for example Wopereis *et al.* (1996) on rice or Otegui *et al.* (1995) on maize. On the other side, when water comes or does not come in extreme quantities, its potential impact can be very high due to the losses of lives and infrastructure, as in the case of floods (IPCC, 2001). A decrease in agricultural income will then, affect 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 and in the case of market-oriented agriculture there could be a positive net effect on households income and subsequently on consumption (Singh *et al.*, 1985). A decrease in 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 (for example the sex of the income earner as in (Duflo and Udry, 2004). Moreover, even when the yield is more or less the same, 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 impacts of weather shocks 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). For example, Piao *et al.* (2010) have shown 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. The research has highlighted that 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 diarrhoea and other infectious diseases are likely to increase due to the prolonged range and activity of pathogens (Haines *et al.*, 2006). Then the productivity of the labour force, especially in the agricultural sector, is potentially highly affected. 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 variability (de la Fuente and Dercon, 2008). Malnutrition affects adults and children in different ways. Adverse consequences in the short-term can be brought about through the impact on productivity of adults on the workplace. Summarizing, it is worth emphasizing that the climatic adverse effects will take place depending on whether households are able to put in place effective *ex-ante* and/or *ex-post* coping measures. The latter are essentially represented by income and consumption smoothing (Morduch, 1995).

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 change input intensities (Morduch, 1995). 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 labour, gave the incentive to cultivate low-risk, low- return crops (sweet potatoes) to rural households in the Shinyaga District of Tanzania. A poverty trap of low-income and asset ownership, induced low-risk, low-return crop choices and hence low-income and asset accumulation seemed to capture the 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. Behavioural norms and households specific characteristics can 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 labour supply and making use of formal/informal insurance mechanisms (Bardhan and Udry, 1999). For example, Paxson (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, instead, that households in 342 rural communities in Ethiopia were able to 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. These two strategies differ in the time horizon over which they deal with shocks. Income smoothing is generally aimed at preventing or mitigating the effects of shocks before they occur, while consumption smoothing is concerned with the reduction of these effects after they have taken place. It is worth noting that, potentially, no effects of climatic shocks could be found in the case where households effectively engaged into one (or more) of these strategies. However, if coping strategies are not effective or are not

enough to provide an insurance against the aforementioned adverse effects, we expect to find a significant evidence of the aforementioned adverse impacts on food consumption.

5. Econometric strategy

The goal of our econometric analysis is to assess whether and how weather fluctuations and climate shocks affect households income and expenditure decisions. Furthermore, we want to verify if these effects, if present, are sensible to different shock definitions. In particular, we want to test if shocks defined over different time periods (25, 10, 5 and 3 years) have a different impact on the outcome variables. To this aim, we estimate the following model:

$$y_{it} = \alpha_i + R_{it}\delta + T_{it}\gamma + X_{it}\beta + \varepsilon_{it} \quad (1)$$

where

$$\begin{aligned} \boldsymbol{R}_{it}\boldsymbol{\delta} &= \frac{1}{R_{1,it}}\delta_1 + R_{2,it}\delta_2 + \left(\frac{1}{R_{1,it}}\right)^2\delta_3 + R_{2,it}^2\delta_4 + \frac{R_{2,it}}{R_{1,it}}\delta_5 + 1\{R_3 > 1\}\delta_6 + \\ &+ 1\{R_4 < 1\}\delta_7 + 1\{R_4 > 1\}\delta_8 + 1\{0 < R_5 \leq p_{33}\}\delta_9 + 1\{p_{33} < R_5 \leq p_{66}\}\delta_{10} + \\ &+ 1\{R_5 > p_{66}\}\delta_{11} \end{aligned}$$

and

$$\begin{aligned} \boldsymbol{T}_{it}\boldsymbol{\gamma} &= \frac{1}{T_{1,it}}\gamma_1 + T_{2,it}\gamma_2 + \left(\frac{1}{T_{1,it}}\right)^2\gamma_3 + T_{2,it}^2\gamma_4 + \frac{T_{2,it}}{T_{1,it}}\gamma_5 + 1\{p_{25} < T_3 \leq p_{50}\}\gamma_6 + \\ &+ 1\{p_{50} < T_3 \leq p_{75}\}\gamma_7 + 1\{T_3 > p_{75}\}\gamma_8 \end{aligned}$$

where the outcome variable y_{it} is represented by a bundle of welfare indicators described in section 3.1 and 3.2, $\boldsymbol{R}_{it}$ and $\boldsymbol{T}_{it}$ represent precipitation and maximum temperature related variables, and $\boldsymbol{X}_{it}$ represents control variables which may affect the level of the considered outcome variables and includes information on household structure, household assets and idiosyncratic shocks for a detailed description).

For the specification of the precipitation and temperature variables in model (1), we allow for non-linear effects in different ways. First, intra-annual measures are included in the model as a series of percentiles dummies (variables *R*5 and *T*3).[7] As for the discretized SI we include a dummy, equal to 1 if the county in which the household is located has experienced a bottom-up shock in the rainfall pattern, i.e. from the case in which precipitations are equally distributed to the one in which almost all rain falls in 1-3 month. Second, for inter-annual measures we recognize that, since the COV is just an interaction between the inverse of the

[7] It is worth noting that the percentiles of the R_5 variable used to construct the dummies included in the regressions have been computed considering only the counties with a positive value of R_5, i.e. counties with a strictly positive rainfall shortfall. This means that the reference category is represented by those counties in which there have not been rainfall shortfall in the SS growing season.

mean and standard deviation, it has to be included in the model along with its components, which are indeed the variable of interest in our analysis, i.e. the inter-annual level and variability of precipitations and temperature. As the model would require inclusion of the variables that comprise it as first-order terms, including the COV alone is likely to mix the effect of first and second moments of the precipitation and temperature distributions (the mean and the standard deviation) that may have independent effects on the considered outcome measures. Moreover, the scale-invariance property of the COV is too restrictive in our context. As in Kronmal (1993), we argue that the true impact of weather variability could be confounded by that of the precipitations level in a model in which only the COV is used as explanatory variable. Hence, we consider a quadratic polynomial which also includes the interaction of the first and the second moment of the between-years rainfall and maximum temperature distribution, i.e. $\frac{R2,it}{R1,it}$ and $\frac{T2,it}{T1,it}$. Finally, in order to allow for its meaningful interpretation, the ratio of the RP average rainfall COV over its long run average (R_3) has been included as a dummy variable equal to 1 when the ratio is greater than 1.

Model (1) allows one to test the hypothesis that households are unable to completely mitigate the negative effects of weather and/or climate shocks. As mentioned before, we consider four different specifications of model (1) according to the reference period with respect to which the climatic variables have been computed, namely the past 25, 10, 5 and 3 years with respect to the year *t* for which survey data is available (*t* = 2009, 2010).[8] Moreover, we investigate the impact of relevant policy variables in order to test if they are effective in reducing the negative welfare effects of weather and climate shocks. To this aim, we interact the weather and climatic variables with a dummy equal to 1 in the presence of adoption of SLM practices, extension advices and access to credit.

Further, in order to investigate the effect of the weather and climatic variables on different household profiles, especially the poorest ones, we conduct a Quantile Regression (QR) analysis based on pooled data. It is worth noting that median regression is more robust to outliers than classical mean regression, and it can be viewed as semi-parametric as it avoids assumptions about the parametric distribution of the error process. Thus, since OLS can be inefficient if the errors are highly non-normal, QR is more robust to non-normal errors and outliers. QR also provides a richer characterization of the data, allowing us to consider the impact of a covariate on the entire distribution of the outcome variables, not merely on its conditional mean.[9]

As for the appropriate functional form for the weather variables, a common approach measures these variables in levels (e.g. degrees Celsius for temperature or millimetres for precipitation). In a panel set-up, the identification thus comes from deviations in levels from the mean. Another common approach, aimed at revealing non-linear effects, considers the weather realizations falling into different bins. The key advantage lies in avoiding functional

[8] We have performed a preliminary analysis in order to avoid collinearity and other specification issues. All estimated models and collinearity diagnostics are available upon request.

[9] Furthermore, QR is invariant to monotonic transformations, such as the logarithmic transformation, so that the quantiles of $h(y_{it})$, a monotone transformation of y_{it}, may be translated back to y_{it} simply using the inverse transformation.

form specifications since this method is relatively non-parametric and it is well suited in presence of high-resolution data.

6. Empirical results

In this section, we present the evidence obtained by the estimation of model (4.1) by the Generalized Least Squares random effects approach for each of the outcomes discussed in section 3.3.[10] Our empirical results are presented in the form of elasticities computed at covariates means taking into account the fact that our model specification includes second-order terms for some of the covariates. This implies that the coefficients for continuous variables report the percentage change in the outcome variable for a 1 percent change in the explanatory variable, while coefficients for the dummy variable report the percentage change in the outcome variable if the dummy changes from zero to one. Results are reported in Annex 1, Table from 2 to 7 for the regressions without the interactions with the policy variables and from Table 14 to 25 for the interacted policy variables.

In general we obtain very few significant results which on one side may be explained by the imprecision associated with the very small length of our panel, while on the other side it might point towards a consumption and income smoothing behaviour by the households, whose welfare level is not affected by the weather shocks. Given the significant effect of the socio-demographic control variables, reported in the appendix (Tables from 8 to 13), the second explanation seems plausible. As for income the results we obtain are in line with our expectation and with the international consensus: we observe a stable negative and significant relationship of household size and a positive and significant relationship with the average years of education. Household income is positively affected by the size of the land operated and by irrigation, increasing the outcome variable as in many empirical studies in developing countries. From a policy perspective access to credit and to extension services play a very important role, with an estimated elasticity of 11 percent and 14 percent (respectively) while SLM practices have no significant effect on income.

Consumption-related variables such as the number of people in the household negatively affects all the outcome variables while education positively affect per capita food expenditures and per-capita total expenditures. No significant relationship is observed for these controls with own-produced crop value, food expenditure share and daily calories intake. This might imply that while more ”general” consumption variables do depend on the level of education, when we consider outcomes that are more related to subsistence the role of education disappears. This result is consistent with the expectations presented in section 3.3. The dummy for irrigation and the size of the land operated exhibit the expected positive and significant effect, with the access to irrigation displaying the higher elasticity (22 percent for total food expenditure and 43 percent for own produced crop value). Like in the income regression we observe a strong and positive effect from access to credit and extension services.

[10] The choice of the random effect estimator is mainly driven by the short length of the panel and by efficiency consideration

Turning to the analysis of the weather shocks Figure 1 plots the marginal effect of the rainfall average on per capita gross total income for different reference periods. We observe a positive effect for the 25 and 5 years reference period while a negative relationship is observed for the 3 year reference period. With regards to the different shocks definition, reported in Table 2, the reference period used to define the shock does not matter since the coefficients and the signs do not change with the reference period. Extreme values of rain variability have a negative effect on households total income for the 3 years reference period, as shown in Figure 6. Higher average temperatures, if computed over 25 or 10 years, have a negative impact on the outcome variable (Figure 10) while long term temperature variability is bell shaped, with a positive effect for small deviations from the trend and a negative effect for bigger deviations (Figure 12). Defining the temperature shocks over different time periods changes the magnitude of the effect but not its sign (Table 2), with a positive significant effect for the long term temperature variability that affects all the quartiles of the income distribution, as shown in Figure 14. Figure 15 and 16 show that the positive effect of higher temperature is positive, significant and increases with the income quartile, when the reference period is 10 or 5 years. Correlated with the results reported in Table 14 highlight the fact that the adoption of sustainable land management practice significantly ensures the households against negative rain shocks while household that do not engage in SLM practices are more affected by higher temperature shocks, when measured by the first moment of the distribution.

Food related outcome variables (per capita food expenditures, both total and own produced crop value, and the share of expenditures dedicated to food) exhibit very weak relationships with the shock variables, across all reference periods. Nonetheless, while shock variables exhibit no effect on per-capita food expenditure (Table 3), the value of own produced crop is negatively affected by the shocks. Since both outcome variables are evaluated at market prices we interpret this a sign of consumption shooting behaviour: when facing a decrease in the value of their production, households turn to markets in order restore their consumption levels. As shown Figure 7 rain variability negatively affects per capita food expenditures for all reference periods except the 3 year period, while rising average temperature seems to positively affect the outcome variable but the coefficients are never significant, nor are those related to temperature variability (Figure 13 and 11). Pooled quantile regressions show a negative and significant impact of the temperature variability computed over the longer reference periods on lower quantiles of the outcome variable distribution (Figure 17, 18) while the effect is no longer significant for shorter reference periods. Access to credit services and SLM practices enables the households to contain the negative effects of higher short term rain and temperature variability on per capita food expenditures computed using only the value of own produced crops, but we observe no significant relationship between the average level of rain and this outcome variable for all reference periods as shown in Figure 2. The same is true for the variability of rain as seen in Figure 8. Again, different shock definitions, for both rain and temperature, do not change the impact on the value of own produced crops as shown in Table 4 with the coefficient remaining either non significant (e.g. rain) or maintaining the same sign (e.g. temperature).

Figures from 19 and 20 show the results of the pooled quantile regressions for share of expenditures dedicated to food. The effect of the shock variables, no matter the definition, on the outcome is almost never significant but it is worth noting that the relationship does

not change across different quantiles, remaining flat around zero. This implies that irrespective of the shock definition and of the position of the household in the food expenditures distribution both rain and temperature shocks have no effect. Furthermore, moving to panel analysis, the share of expenditures dedicated to food seems not to be affected by the long term average level of rain, (Figure 4), while short term average rainfall has a positive, but not significant, impact on the food share. Again, using different shocks definition does not change the impact on the outcome variable (Table 6 for both rain and temperature).

Another welfare related outcome variable we analyse is per-capita daily calories intake. We observe a negative and significant relationship between the amount of daily calories consumed by the household members and the average level of rain, except for the 25 years average level (Figure 5). Except for the latter reference period the sign and the magnitude of the effect do not depend on various shock definitions. Rain variability does not have a significant effect on the outcome variable. Higher average temperatures have a slight positive impact on the daily calories intake while temperature variability has a non significant impact as shown in Table 7. Per capita total expenditures are positively affected by the average level of rainfall, except when the latter is computed over 3 years, but the effect is never significant (Figure 3). Table 5 shows that the outcome is not influenced by different shock definitions. Rain variability (Figure 9) seems to have a positive effect on the outcome variable. Long term average temperature has no effect on total expenditures while short term average temperature has a positive but not significant effect.

Thus the evidence points towards the presence of both income and consumption smoothing. The latter results is in line with previous studies on the effects of weather shocks on Ugandan agricultural households (e.g. Bosco Assiimwe and Mpuga (2007)) whose authors found that “households are engaged in consumption smoothing to mitigate the impact of shocks on welfare”. The aforementioned study did find some evidence of a significant effect on weather shocks on income but the coefficients and level of significance are smaller in the case of the rural-only subsample.

7. Conclusion

In this paper, we evaluate the effects of weather/climate shocks on household welfare (i.e. total consumption expenditure, total food expenditure, share of food expenditure, total income and daily calorie intake) using a nationally representative panel data on Uganda households together with a set of novel weather variation indicators based on interpolated gridded and re-analysis weather data that capture the peculiar features of short term (weather) and long term (climate) variations in rainfall and temperature. Our paper also attempts to further investigate to which extent the effects vary according to a different definition of the shock i.e., calculated with respect to different reference periods. Where the effect of climate/weather variability has a significantly negative effect on household welfare, we further test the hypotheses that policy-relevant mechanisms can be effective means of mitigating the negative welfare effects of local climate variability both directly and indirectly. We consider four factors that can be altered by policy action which includes access to extension services, access to credit, sustainable land management practices (SLM), and the size of the farm. Finally, since fluctuations in weather patterns may have a

heterogeneous impact on different household profiles, we investigate this heterogeneity along the quintiles of the considered outcome indicators.

In general we obtain very few significant results with respect to climate/weather shock variables which on one side may be explained by the imprecision associated with the very small length of our panel, while on the other it might point towards a consumption and income smoothing behaviour by the households, whose welfare level is not affected by the weather shocks. Given the significant effect of the socio-demographic and wealth control variables the second explanation seems plausible. With regards to the different shocks definition, the reference period used to define the shock does not matter since the coefficients and the signs do not change with the reference period. Different policy action variables have also heterogeneous impact across different outcome variables in terms of the mitigating the negative impact of climate/weather shocks. For instance access to credit services and use of sustainable land management practices enables the households to contain the negative effects of higher short term rain and temperature variability on per capita food consumption from own produced crops but not the case for some of the outcome variables.

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Annex 1 – Tables[11]

Table 1: Summary statistics of selected variables (rural households' subsample)

	Wave 1			Wave 2		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Total gross income per capita (1000s Ugandian Sh)	1869	624.54	714.71	1752	705.86	877.05
Value of own produced crops per capita	1874	132.66	115.63	1747	125.75	124.29
Food expenditure per capita (1000s Ugandian Sh)	1862	307.63	203.26	1734	355.53	259.5
Yearly total expenditure per capita (1000s Ugandian Sh)	1855	935.88	1555.79	1745	1147.59	1767.63
Share of food expenditure	1846	.52	.24	1750	.51	.23
Daily Calories Intake	1854	2574.42	2048.64	1756	2440.34	2094.05
Female hh's head	1936	.28	.45	1855	.29	.45
Single hh's head	1943	.31	.46	1859	.33	.47
hh's size	1936	5.43	2.88	1855	4.77	2.6
hh's age	1808	47.13	15.13	1700	46.7	15.57
hh's avg yrs of education	1943	5.47	2.21	1859	5.61	2.27
hh's Dependency Ratio	1936	1.55	1.2	1855	1.51	1.22
Land operated	1804	2.55	2.35	1667	2.62	2.42
Irrigation (1=yes)	1943	.01	.1	1859	.01	.11
Home-mkt distance (Km)	1943	5.48	4.04	1859	6.29	6.94
Home-Hospital distance (Km)	1943	22.98	11.68	1859	26.57	18.88
Wealth Index	1914	.47	1.87	1815	-.25	1.3
Radio tenure (1=owned)	1914	.62	.48	1815	.64	.48
Cell. tenure (1=owned)	1914	.42	.49	1815	.5	.5
Death of HH Member (1=occurred)	1943	.04	.2	1859	.03	.17
Illness of HH Member (1=occurred)	1943	.13	.33	1859	.11	.31
SLM practices (1=Yes)	1943	.1	.29	1859	.09	.29
Access to extension services	1943	.27	.44	1859	.2	.4
Access to credit	1943	.43	.49	1859	.4	.49
Smallholders (1=yes)	1943	.73	.45	1859	.71	.45
AEZ==Busoga Farming System	1943	.13	.33	1859	.11	.32
AEZ==Eastern Highlands	1943	.06	.25	1859	.07	.26
AEZ==Eastern Savannah	1943	.1	.3	1859	.11	.31
AEZ==Karamoja	1943	.04	.2	1859	.04	.2
AEZ==Lake Albert Crescent	1943	.13	.33	1859	.11	.31
AEZ==Northern Farming System	1943	.11	.31	1859	.13	.34
AEZ==South Western Highlands	1943	.05	.21	1859	.04	.2
AEZ==West Nile Farming System	1943	.1	.31	1859	.12	.32
AEZ==Western Range Lands	1943	.12	.33	1859	.1	.31

[11]all tables are based on authors' elaborations

Table 2: Per-capita total gross income. Elasticities (at means). Reference Period (RP), Between-years (B), Average (AVG), Standard Deviation (SD), Survey growing season (SS).

Rainfall								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	-0.119		-0.102		-0.044		0.335	
RP-B-SD	0.021		-0.063		-0.005		0.059	
SI shock: equable → extreme	-0.028		-0.024		-0.004		-0.056	
SS Shortfall - 2^{nd} quartile	0.051		0.005		0.026		-0.020	
SS shortfall - 3^{rd} quartile	0.112	*	0.095		0.131	**	0.111	*
SS shortfall - 4^{th} quartile	0.126	*	0.118		0.111		0.129	*
RP-B-COV / 1983-2012 B-COV			-0.105		-0.004		0.100	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	2.929	***	1.926		1.262		0.032	
RP-B-SD	0.708	***	0.357		0.358	*	-0.066	
SS # Dekads > RP-AVG - 2^{nd} quartile	0.061		0.038		0.170	**	0.004	
SS # Dekads > RP-AVG - 3^{rd} quartile	0.068		0.154	**	0.312	***	0.168	*
SS # Dekads > RP-AVG - 4^{th} quartile	0.255	***	0.248	***	0.319	***	0.207	**
R^2	0.262		0.263		0.262		0.264	

Table 3: Per-capita food expenditure

Rainfall					
	25 years	10 years	5 years		3 years
Inverse of RP-B-AVG	-0.286	-0.059	-0.007		0.073
RP-B-SD	-0.113	-0.018	-0.002		0.014
SI shock: equable → extreme	-0.013	0.007	-0.003		0.001
SS Shortfall - 2^{nd} quartile	-0.008	0.006	0.036		-0.003
SS shortfall - 3^{rd} quartile	0.025	-0.015	0.053		0.026
SS shortfall - 4^{th} quartile	0.051	-0.022	-0.009		-0.033
RP-B-COV / 1983-2012 B-COV		-0.082	-0.041		0.070
Maximum temperature					
	25 years	10 years	5 years		3 years
Inverse of RP-B-AVG	0.544	-0.157	0.179		-0.044
RP-B-SD	0.202	-0.008	0.105		-0.037
SS # Dekads > RP-AVG - 2^{nd} quartile	-0.001	-0.005	0.047		-0.040
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.015	0.045	0.139	**	0.017
SS # Dekads > RP-AVG - 4^{th} quartile	0.054	0.021	0.086		-0.040
R^2	0.353	0.352	0.354		0.353

Table 4: Value of own produced crops

	Rainfall							
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	0.116		0.107		-0.341	*	-0.024	
RP-B-SD	0.019		-0.068		-0.066		-0.015	
SI shock: equable → extreme	0.006		0.019		0.021		0.022	
SS Shortfall - 2^{nd} quartile	-0.020		0.004		0.065		0.018	
SS shortfall - 3^{rd} quartile	0.055		-0.035		-0.009		-0.044	
SS shortfall - 4^{th} quartile	0.085		-0.155	**	-0.137	**	-0.138	**
RP-B-COV / 1983-2012 B-COV			0.036		-0.016		0.065	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	-0.939		-1.462		1.320	**	0.193	
RP-B-SD	-0.430	**	-0.562	**	0.185		-0.185	*
SS # Dekads > RP-AVG - 2^{nd} quartile	0.005		-0.032		-0.018		-0.060	
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.068		-0.041		-0.057		-0.183	**
SS # Dekads > RP-AVG - 4^{th} quartile	0.055		-0.046		-0.030		-0.159	*
R^2	0.220		0.216		0.218		0.217	

Table 5: Per-capita total expenditure

	Rainfall							
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	-0.647		-0.329		-0.074		0.215	
RP-B-SD	0.077		-0.018		0.274	***	0.102	**
SI shock: equable → extreme	0.006		0.042		-0.001		0.009	
SS Shortfall - 2^{nd} quartile	-0.028		-0.068		-0.099		0.003	
SS shortfall - 3^{rd} quartile	0.040		-0.002		0.074		-0.049	
SS shortfall - 4^{th} quartile	-0.024		-0.110		0.010		0.006	
RP-B-COV / 1983-2012 B-COV			-0.218	*	0.035		0.092	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG	-0.091		1.355		-1.597		-1.174	
RP-B-SD	0.470		0.533		0.206		-0.089	
SS # Dekads > RP-AVG - 2^{nd} quartile	0.040		0.086		0.255	***	-0.000	
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.072		0.111		0.274	**	0.123	
SS # Dekads > RP-AVG - 4^{th} quartile	0.091		0.129		0.225	**	-0.007	
R^2	0.233		0.234		0.236		0.234	

Table 6: Food expenditure's share

Rainfall	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG	-0.007	0.057	-0.153	-0.194 **
RP-B-SD	0.054	0.065	-0.046	-0.031 *
SI shock: equable → extreme	-0.005	-0.011	-0.009	-0.005
SS Shortfall - 2^{nd} quartile	-0.016	0.005	0.013	-0.008
SS shortfall - 3^{rd} quartile	-0.020	-0.039	-0.046	-0.000
SS shortfall - 4^{th} quartile	0.018	0.023	-0.059 *	-0.031
RP-B-COV / 1983-2012 B-COV		0.018	-0.045 *	0.007
Maximum temperature	**25 years**	**10 years**	**5 years**	**3 years**
Inverse of RP-B-AVG	0.305	-0.416	0.682 *	0.396
RP-B-SD	-0.112	-0.177	0.053	0.036
SS # Dekads > RP-AVG - 2^{nd} quartile	-0.014	-0.028	-0.049	-0.001
SS # Dekads > RP-AVG - 3^{rd} quartile	0.008	-0.020	-0.085 **	-0.041
SS # Dekads > RP-AVG - 4^{th} quartile	0.027	0.031	-0.029	0.024
R^2	0.252	0.252	0.254	0.251

Table 7: Per-capita daily calories intake

Rainfall	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG	-0.086	0.453 **	0.308	0.334 **
RP-B-SD	-0.201	0.085	-0.073	-0.008
SI shock: equable → extreme	-0.000	0.030	0.017	-0.003
SS Shortfall - 2^{nd} quartile	-0.071 *	-0.048	0.007	-0.061
SS shortfall - 3^{rd} quartile	-0.071	-0.112 **	-0.034	0.002
SS shortfall - 4^{th} quartile	-0.183 **	-0.108 *	-0.019	-0.059
RP-B-COV / 1983-2012 B-COV		-0.037	0.058	-0.085
Maximum temperature	**25 years**	**10 years**	**5 years**	**3 years**
Inverse of RP-B-AVG	-0.196	-1.679 *	-0.856	-0.944
RP-B-SD	0.180	-0.204	-0.066	-0.080
SS # Dekads > RP-AVG - 2^{nd} quartile	0.021	0.001	0.017	-0.108 *
SS # Dekads > RP-AVG - 3^{rd} quartile	0.053	0.065	0.086	-0.139 *
SS # Dekads > RP-AVG - 4^{th} quartile	0.072	-0.093	-0.009	-0.248 ***
R^2	0.319	0.318	0.321	0.320

Table 8. Per capita total gross income

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG	-2.1998		0.4024		-0.2939		0.2016	
RP-B-SD	-0.0147		0.0360	**	0.0090		0.0065	*
Inverse of RP-B-AVG^2	0.3710	*	0.0710		0.0628		0.0090	
RP-B-SD^2	0.0000		-0.0001	***	-0.0001	**	-0.0000	*
RP-B-COV	0.0059		-0.0083	*	0.0014		-0.0013	
SI shock: equable → extreme	-0.0452		-0.0060		0.0043		-0.0170	
SS Shortfall - 2^{nd} quartile	0.0085		0.0238		0.0626		0.0557	
SS shortfall - 3^{rd} quartile	0.0637		0.1079	**	0.1661	***	0.1376	**
SS shortfall - 4^{th} quartile	0.1065		0.0276		0.0289		0.0486	
RP-B-COV / 1983-2012 B-COV			-0.0140		0.0091		0.0988	
Maximum temperature								
Inverse of RP-B-AVG	1.0330		0.8336		-0.3034		-0.5748	*
RP-B-SD	26.0909	*	37.0136	**	4.2146		-5.5496	
Inverse of RP-B-AVG^2	-0.0096		-0.0069		0.0046		0.0071	*
RP-B-SD^2	-5.1667	**	-10.6464	***	-1.7191		0.6173	
RP-B-COV	-0.5312	*	-0.7527	**	-0.0727		0.1309	
SS # Dekads > RP-AVG - 2^{nd} quartile	0.0758	*	0.0293		0.0649		0.0226	
SS # Dekads > RP-AVG - 3^{rd} quartile	0.0544		0.1205	*	0.2443	***	0.1150	
SS # Dekads > RP-AVG - 4^{th} quartile	0.1513	**	0.1442	*	0.2244	***	0.1663	*
Controls								
Female hh's head	0.0218		0.0152		0.0185		0.0158	
Single hh's head	-0.0735		-0.0701		-0.0772		-0.0753	
hh's size	-0.1341	***	-0.1341	***	-0.1344	***	-0.1344	***
hh's age	-0.0026	**	-0.0026	**	-0.0025	**	-0.0026	**
hh's avg yrs of education	0.0336	***	0.0328	***	0.0333	***	0.0343	***
hh's Dependency Ratio	-0.0759	***	-0.0748	***	-0.0731	***	-0.0737	***
Land operated	0.0482	***	0.0484	***	0.0474	***	0.0485	***
Irrigation (1=yes)	0.1827	*	0.1991	*	0.1853	*	0.1663	
Home-mkt distance (Km)	-0.0002		-0.0003		0.0007		-0.0002	
Home-Hospital distance (Km)	-0.0011		-0.0010		-0.0008		-0.0010	
Wealth Index	0.0704	***	0.0717	***	0.0705	***	0.0682	***
Radio tenure (1=owned)	0.1951	***	0.1926	***	0.1867	***	0.1933	***
Cell. tenure (1=owned)	0.3278	***	0.3289	***	0.3351	***	0.3378	***
Death of HH Member (1=occurred)	-0.0257		-0.0269		-0.0296		-0.0267	
Illness of HH Member (1=occurred)	0.0235		0.0186		0.0174		0.0230	
SLM practices (1=Yes)	0.0264		0.0232		0.0241		0.0274	
Access to extension services	0.1438	***	0.1424	***	0.1385	***	0.1414	***
Access to credit	0.1149	***	0.1101	***	0.1142	***	0.1080	***
Smallholders (1=yes)	0.0221		0.0232		0.0212		0.0262	
AEZ==Busoga Farming System	-0.3195	***	-0.2023	**	-0.1171		-0.1511	*
AEZ==Eastern Highlands	-0.3810	*	-0.3036	**	-0.0995		-0.2292	*
AEZ==Eastern Savannah	-0.2602	*	-0.0790		0.0343		-0.0320	
AEZ==Karamoja	-0.8421	***	-0.7612	***	-0.6174	***	-0.7126	***
AEZ==Lake Albert Crescent	-0.1561	*	-0.0863		-0.0889		-0.1284	
AEZ==Northern Farming System	-0.6211	***	-0.4192	***	-0.2600	**	-0.3712	***
AEZ==South Western Highlands	-0.2985	***	-0.2878	**	-0.3513	***	-0.4006	***
AEZ==West Nile Farming System	-0.2522	**	-0.2026	*	-0.0447		-0.1517	
AEZ==Western Range Lands	-0.0362		-0.0893		-0.0867		-0.1547	*
Wave2 (1=yes)	0.0854	*	0.0280		0.0844		0.0634	
Constant	-10.6427		-11.8870		17.6829	**	24.4674	***

Table 9. Per-capita food expenditure

	25 years		10 years		5 years		3 years	
			Rainfall					
Inverse of RP-B-AVG	-1.8696		-0.2813		-0.6704	**	-0.3863	**
RP-B-SD	-0.0139		0.0043		-0.0034		-0.0025	
Inverse of RP-B-AVG^2	0.3050	*	0.1094		0.1208	***	0.0775	**
RP-B-SD^2	0.0000		0.0000		0.0000		0.0000	
RP-B-COV	0.0047		-0.0024		0.0017		0.0006	
SI shock: equable $\rightarrow$ extreme	0.0096		0.0421		0.0240		0.0242	
SS Shortfall - 2^{nd} quartile	-0.0126		-0.0096		0.0028		-0.0210	
SS shortfall - 3^{rd} quartile	0.0128		-0.0343		0.0015		-0.0080	
SS shortfall - 4^{th} quartile	0.0793		-0.0365		-0.0620		-0.0743	
RP-B-COV / 1983-2012 B-COV			-0.1342	**	-0.0347		0.0448	
			Maximum temperature					
Inverse of RP-B-AVG	-1.3580	**	-0.4617		-0.1179		-0.3264	
RP-B-SD	-17.4500	*	-4.0394		-2.4677		-8.6880	**
Inverse of RP-B-AVG^2	0.0151	*	0.0050		0.0010		0.0031	
RP-B-SD^2	1.5891		-0.7983		0.5097		1.0442	
RP-B-COV	0.4233	*	0.1069		0.0598		0.2031	**
SS # Dekads > RP-AVG - 2^{nd} quartile	-0.0210		0.0063		0.0175		-0.0510	
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.0472		0.0442		0.0809		-0.0146	
SS # Dekads > RP-AVG - 4^{th} quartile	-0.0139		-0.0162		0.0229		-0.0647	
			Controls					
Female hh's head	0.0753	**	0.0785	**	0.0755	**	0.0749	**
Single hh's head	-0.0395		-0.0425		-0.0429		-0.0413	
hh's size	-0.1181	***	-0.1190	***	-0.1186	***	-0.1188	***
hh's age	0.0013		0.0012		0.0013		0.0013	
hh's avg yrs of education	0.0174	***	0.0176	***	0.0174	***	0.0173	***
hh's Dependency Ratio	-0.0292	***	-0.0272	***	-0.0288	***	-0.0281	***
Land operated	0.0117	*	0.0114	*	0.0112	*	0.0115	*
Irrigation (1=yes)	0.2139	***	0.2138	***	0.2151	***	0.2174	***
Home-mkt distance (Km)	-0.0019		-0.0024		-0.0025		-0.0026	
Home-Hospital distance (Km)	-0.0015	*	-0.0014	*	-0.0013	*	-0.0012	
Wealth Index	0.0209	***	0.0229	***	0.0211	***	0.0205	***
Radio tenure (1=owned)	0.1343	***	0.1331	***	0.1301	***	0.1333	***
Cell. tenure (1=owned)	0.1511	***	0.1528	***	0.1539	***	0.1558	***
Death of HH Member (1=occurred)	0.0352		0.0404		0.0376		0.0345	
Illness of HH Member (1=occurred)	0.0340		0.0343		0.0298		0.0336	
SLM practices (1=Yes)	-0.0284		-0.0285		-0.0306		-0.0314	
Access to extension services	0.0794	***	0.0756	***	0.0748	***	0.0752	***
Access to credit	0.0935	***	0.0951	***	0.0930	***	0.0960	***
Smallholders (1=yes)	-0.0937	***	-0.0918	***	-0.0936	***	-0.0890	***
AEZ==Busoga Farming System	-0.1454	**	-0.0879		-0.0523		-0.0962	*
AEZ==Eastern Highlands	-0.4691	***	-0.1710	*	-0.1817	*	-0.2669	***
AEZ==Eastern Savannah	-0.3376	***	-0.2577	***	-0.2138	***	-0.2629	***
AEZ==Karamoja	-0.7416	***	-0.7850	***	-0.8547	***	-0.7927	***
AEZ==Lake Albert Crescent	-0.0748		-0.0019		-0.0146		-0.0401	
AEZ==Northern Farming System	-0.6132	***	-0.4563	***	-0.5281	***	-0.5258	***
AEZ==South Western Highlands	-0.2585	***	-0.1094		-0.2040	**	-0.2359	***
AEZ==West Nile Farming System	-0.1944	**	-0.0650		-0.1276		-0.1501	*
AEZ==Western Range Lands	-0.0358		-0.0250		-0.0407		-0.0816	
Wave2 (1=yes)	0.0768	**	0.0564		0.0340		0.0512	
Constant	45.8662	***	23.5385	*	16.7477	**	21.6064	***

Table 10. Value of own produced crops

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG	-0.6416		1.8788	*	-1.7465	***	-0.9726	***
RP-B-SD	0.0377		0.0417	**	-0.0089		-0.0030	
Inverse of RP-B-AVG^2	0.3250		0.0041		0.3361	***	0.2538	***
RP-B-SD^2	-0.0001	**	-0.0000		-0.0000		0.0000	
RP-B-COV	-0.0014		-0.0204	***	0.0050		0.0010	
SI shock: equable $\rightarrow$ extreme	-0.0406		-0.0117		-0.0080		-0.0121	
SS Shortfall - 2^{nd} quartile	-0.0519		0.0522		0.1250	**	0.0976	
SS shortfall - 3^{rd} quartile	0.0865		0.0493		0.0582		0.0586	
SS shortfall - 4^{th} quartile	0.2217	***	-0.1397	*	-0.1437	**	-0.1115	
RP-B-COV / 1983-2012 B-COV			0.1523	*	-0.0590		0.0956	
Maximum temperature								
Inverse of RP-B-AVG	-1.1841		0.5281		0.6451		0.5135	
RP-B-SD	-10.4646		6.1817		-6.2640		-6.2237	
Inverse of RP-B-AVG^2	0.0134		-0.0072		-0.0086	*	-0.0075	
RP-B-SD^2	-0.8699		-4.9595		1.7905		-0.6943	
RP-B-COV	0.2590		-0.1255		0.1511		0.1523	
SS # Dekads > RP-AVG - 2^{nd} quartile	0.0116		-0.0454		-0.0058		-0.0181	
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.1350	*	-0.1371		-0.1414		-0.2587	**
SS # Dekads > RP-AVG - 4^{th} quartile	0.0021		-0.1332		-0.0646		-0.1901	*
Controls								
Female hh's head	-0.0064		-0.0025		0.0004		-0.0021	
Single hh's head	0.0096		0.0109		-0.0024		0.0036	
hh's size	-0.1078	***	-0.1098	***	-0.1084	***	-0.1092	***
hh's age	0.0040	***	0.0040	***	0.0045	***	0.0042	***
hh's avg yrs of education	0.0069		0.0099		0.0104		0.0075	
hh's Dependency Ratio	-0.0213		-0.0134		-0.0183		-0.0152	
Land operated	0.0257	**	0.0242	**	0.0229	**	0.0231	**
Irrigation (1=yes)	0.4367	***	0.4735	***	0.4437	***	0.4505	***
Home-mkt distance (Km)	-0.0006		-0.0013		-0.0032		-0.0031	
Home-Hospital distance (Km)	-0.0017		-0.0016		-0.0012		-0.0008	
Wealth Index	0.0115		0.0158		0.0083		0.0105	
Radio tenure (1=owned)	0.1464	***	0.1619	***	0.1568	***	0.1637	***
Cell. tenure (1=owned)	0.0285		0.0312		0.0395		0.0409	
Death of HH Member (1=occurred)	-0.1463		-0.1404		-0.1471		-0.1458	
Illness of HH Member (1=occurred)	0.0580		0.0494		0.0410		0.0433	
SLM practices (1=Yes)	-0.0692		-0.0820		-0.0916		-0.0860	
Access to extension services	0.1264	***	0.1226	***	0.1213	***	0.1217	***
Access to credit	0.0649	*	0.0755	**	0.0769	**	0.0785	**
Smallholders (1=yes)	-0.1058	*	-0.1050	*	-0.1113	*	-0.1003	*
AEZ==Busoga Farming System	0.0656		-0.0329		-0.1037		-0.1420	
AEZ==Eastern Highlands	0.0060		0.0695		-0.2054		-0.1391	
AEZ==Eastern Savannah	0.1312		-0.1008		-0.2001		-0.2253	*
AEZ==Karamoja	-0.8744	**	-1.6907	***	-1.5523	***	-1.3500	***
AEZ==Lake Albert Crescent	0.1511	*	0.3057	***	0.3240	***	0.2654	***
AEZ==Northern Farming System	-0.1525		-0.1819		-0.5147	***	-0.4391	***
AEZ==South Western Highlands	0.1530		0.4128	***	0.4828	***	0.5060	***
AEZ==West Nile Farming System	-0.2204	*	0.1094		-0.0318		-0.1394	
AEZ==Western Range Lands	0.0753		0.2015	**	0.3278	***	0.2391	**
Wave2 (1=yes)	0.0245		-0.0468		0.0075		-0.0024	
Constant	35.7808		-1.0039		1.8344		4.4695	

Table 11. Per-capita total expenditure

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG	-2.2280		0.3479		-0.2313		0.1768	
RP-B-SD	-0.0329		0.0160		-0.0001		0.0023	
Inverse of RP-B-AVG^2	0.3111	*	0.0320		0.0655		0.0003	
RP-B-SD^2	0.0001	*	-0.0000		0.0000		0.0000	
RP-B-COV	0.0075		-0.0056		0.0006		-0.0011	
SI shock: equable $\rightarrow$ extreme	-0.0037		0.0311		0.0070		0.0065	
SS Shortfall - 2^{nd} quartile	-0.0183		-0.0375		-0.0242		0.0058	
SS shortfall - 3^{rd} quartile	0.0106		-0.0302		0.0398		0.0164	
SS shortfall - 4^{th} quartile	0.0132		-0.1028	*	-0.0093		-0.0199	
RP-B-COV / 1983-2012 B-COV			-0.0680		0.0130		0.0352	
Maximum temperature								
Inverse of RP-B-AVG	-0.9098		-0.0070		0.0013		-0.1287	
RP-B-SD	-9.6817		9.5091		7.6684		-4.6261	
Inverse of RP-B-AVG^2	0.0101		0.0004		0.0003		0.0009	
RP-B-SD^2	-0.0392		-3.9605		-2.5299	*	1.1440	
RP-B-COV	0.2644		-0.1846		-0.1535		0.0883	
SS # Dekads > RP-AVG - 2^{nd} quartile	-0.0010		0.0515		0.1025	**	-0.0425	
SS # Dekads > RP-AVG - 3^{rd} quartile	-0.0653		0.0822		0.1996	***	0.0229	
SS # Dekads > RP-AVG - 4^{th} quartile	-0.0441		-0.0298		0.0735		-0.0759	
Controls								
Female hh's head	-0.0057		-0.0018		-0.0074		-0.0056	
Single hh's head	-0.0510		-0.0529		-0.0555		-0.0525	
hh's size	-0.1122	***	-0.1131	***	-0.1127	***	-0.1123	***
hh's age	0.0001		-0.0000		0.0002		0.0001	
hh's avg yrs of education	0.0493	***	0.0494	***	0.0477	***	0.0494	***
hh's Dependency Ratio	-0.0633	***	-0.0613	***	-0.0624	***	-0.0619	***
Land operated	0.0246	***	0.0241	***	0.0230	***	0.0236	***
Irrigation (1=yes)	0.1678	*	0.1708	*	0.1734	*	0.1717	*
Home-mkt distance (Km)	-0.0033		-0.0035		-0.0026		-0.0034	
Home-Hospital distance (Km)	-0.0012		-0.0012		-0.0010		-0.0010	
Wealth Index	0.0607	***	0.0635	***	0.0622	***	0.0607	***
Radio tenure (1=owned)	0.1690	***	0.1638	***	0.1601	***	0.1642	***
Cell. tenure (1=owned)	0.4235	***	0.4270	***	0.4309	***	0.4313	***
Death of HH Member (1=occurred)	0.0138		0.0151		0.0140		0.0089	
Illness of HH Member (1=occurred)	0.1609	***	0.1568	***	0.1542	***	0.1568	***
SLM practices (1=Yes)	-0.0002		0.0061		-0.0004		0.0027	
Access to extension services	0.0835	***	0.0797	***	0.0747	**	0.0748	**
Access to credit	0.1294	***	0.1273	***	0.1253	***	0.1276	***
Smallholders (1=yes)	-0.0945	**	-0.0911	**	-0.0869	*	-0.0875	**
AEZ==Busoga Farming System	-0.4163	***	-0.2906	***	-0.1646	**	-0.2412	***
AEZ==Eastern Highlands	-0.6967	***	-0.3821	***	-0.3316	***	-0.4113	***
AEZ==Eastern Savannah	-0.5395	***	-0.3762	***	-0.2562	***	-0.3438	***
AEZ==Karamoja	-1.1877	***	-1.2203	***	-1.2481	***	-1.2913	***
AEZ==Lake Albert Crescent	-0.3210	***	-0.2139	***	-0.2911	***	-0.2518	***
AEZ==Northern Farming System	-0.8088	***	-0.5947	***	-0.5657	***	-0.6476	***
AEZ==South Western Highlands	-0.4977	***	-0.3950	***	-0.5122	***	-0.5072	***
AEZ==West Nile Farming System	-0.5389	***	-0.4468	***	-0.4575	***	-0.4100	***
AEZ==Western Range Lands	-0.0709		-0.0843		-0.1340		-0.1444	*
Wave2 (1=yes)	0.1401	***	0.1156	**	0.0885		0.1689	***
Constant	37.7965	*	11.9455		12.8736	*	17.1277	**

Table 12. Food expenditure's share

	25 years	10 years	5 years	3 years
Rainfall				
Inverse of RP-B-AVG	0.7452	-0.2667	-0.4073	-0.4692 **
RP-B-SD	0.0223	-0.0124	-0.0034	-0.0039
Inverse of RP-B-AVG^2	-0.0678	0.0258	0.0523	0.0695 **
RP-B-SD^2	-0.0001 *	0.0001	-0.0000	0.0000
RP-B-COV	-0.0039	0.0020	0.0014	0.0014
SI shock: equable → extreme	0.0017	-0.0124	0.0019	0.0016
SS Shortfall - 2nd quartile	-0.0070	0.0376	0.0464	-0.0083
SS shortfall - 3rd quartile	-0.0093	-0.0367	-0.0310	0.0186
SS shortfall - 4th quartile	0.0348	0.0547	-0.0624	-0.0391
RP-B-COV / 1983-2012 B-COV		0.0433	-0.0645 *	-0.0017
Maximum temperature				
Inverse of RP-B-AVG	-0.5957	-0.7969	-0.0739	0.0408
RP-B-SD	-11.5015	-20.0748 *	-9.6466 **	-0.7147
Inverse of RP-B-AVG^2	0.0065	0.0082	0.0003	-0.0006
RP-B-SD^2	2.5156	4.8362 *	2.8199 ***	-0.4237
RP-B-COV	0.2318	0.4124 *	0.2007 **	0.0270
SS # Dekads > RP-AVG - 2nd quartile	-0.0173	-0.0611	-0.0725 *	0.0006
SS # Dekads > RP-AVG - 3rd quartile	0.0410	-0.0387	-0.0950 *	-0.0472
SS # Dekads > RP-AVG - 4th quartile	0.0492	0.0190	-0.0150	0.0356
Controls				
Female hh's head	0.0689 **	0.0690 **	0.0704 **	0.0676 **
Single hh's head	-0.0213	-0.0222	-0.0212	-0.0217
hh's size	-0.0102 **	-0.0107 **	-0.0101 **	-0.0107 **
hh's age	0.0007	0.0007	0.0007	0.0007
hh's avg yrs of education	-0.0219 ***	-0.0214 ***	-0.0205 ***	-0.0216 ***
hh's Dependency Ratio	0.0340 ***	0.0340 ***	0.0329 ***	0.0339 ***
Land operated	-0.0122 *	-0.0121 *	-0.0122 *	-0.0121 *
Irrigation (1=yes)	0.0431	0.0374	0.0350	0.0415
Home-mkt distance (Km)	-0.0002	-0.0003	-0.0011	-0.0006
Home-Hospital distance (Km)	-0.0002	-0.0003	-0.0003	-0.0004
Wealth Index	-0.0381 ***	-0.0403 ***	-0.0397 ***	-0.0388 ***
Radio tenure (1=owned)	-0.0316	-0.0272	-0.0280	-0.0296
Cell. tenure (1=owned)	-0.2679 ***	-0.2673 ***	-0.2711 ***	-0.2697 ***
Death of HH Member (1=occurred)	0.0376	0.0395	0.0416	0.0406
Illness of HH Member (1=occurred)	-0.1312 ***	-0.1265 ***	-0.1281 ***	-0.1287 ***
SLM practices (1=Yes)	-0.0550 *	-0.0574 *	-0.0532 *	-0.0557 *
Access to extension services	-0.0266	-0.0247	-0.0222	-0.0219
Access to credit	-0.0454 **	-0.0419 **	-0.0412 **	-0.0411 **
Smallholders (1=yes)	0.0002	-0.0027	-0.0078	-0.0005
AEZ==Busoga Farming System	0.2789 ***	0.1922 ***	0.1199 *	0.1464 **
AEZ==Eastern Highlands	0.2146	0.2455 ***	0.1299	0.1681 *
AEZ==Eastern Savannah	0.2157 **	0.1119	0.0504	0.0765
AEZ==Karamoja	0.4289 ***	0.3790 ***	0.3510 ***	0.4182 ***
AEZ==Lake Albert Crescent	0.2565 ***	0.2029 ***	0.2657 ***	0.2147 ***
AEZ==Northern Farming System	0.2584 **	0.2138 **	0.1018	0.1543 *
AEZ==South Western Highlands	0.2242 ***	0.1817 *	0.2629 ***	0.2387 ***
AEZ==West Nile Farming System	0.3699 ***	0.3749 ***	0.3525 ***	0.2785 ***
AEZ==Western Range Lands	0.0386	0.0271	0.0775	0.0374
Wave2 (1=yes)	-0.0755 **	-0.0497	-0.0743	-0.0801 **
Constant	11.1170	19.5646 *	2.8797	-0.6970

Table 13. Per-capita daily calories intake

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG	-2.8177	**	0.1409		-0.3498		0.2154	
RP-B-SD	-0.0377	**	-0.0090		-0.0078		-0.0002	
Inverse of RP-B-AVG^2	0.3953	**	0.0359		0.0888	*	-0.0043	
RP-B-SD^2	0.0001	*	0.0001		0.0000		0.0000	
RP-B-COV	0.0108	**	0.0003		0.0025		-0.0005	
SI shock: equable → extreme	0.0191		0.0254		0.0126		0.0048	
SS Shortfall - 2^{nd} quartile	-0.0653	*	-0.0775	*	-0.0169		-0.0990	**
SS shortfall - 3^{rd} quartile	-0.0818	*	-0.1038	**	-0.0336		-0.0262	
SS shortfall - 4^{th} quartile	-0.1738	***	-0.1035	*	-0.0461		-0.0558	
RP-B-COV / 1983-2012 B-COV			0.0086		0.0317		-0.0886	*
Maximum temperature								
Inverse of RP-B-AVG	-0.9308		-0.3567		-0.6422	**	0.3821	
RP-B-SD	-7.7673		0.3750		-9.1216		6.8312	
Inverse of RP-B-AVG^2	0.0107		0.0040		0.0070	**	-0.0045	
RP-B-SD^2	0.3902		-0.7231		0.1912		0.7516	
RP-B-COV	0.1983		-0.0218		0.2361	*	-0.1992	*
SS # Dekads > RP-AVG - 2^{nd} quartile	0.0403		-0.0165		-0.0144		-0.1145	**
SS # Dekads > RP-AVG - 3^{rd} quartile	0.0414		0.0553		0.0249		-0.1130	*
SS # Dekads > RP-AVG - 4^{th} quartile	0.0726		-0.0347		-0.0021		-0.1603	**
Controls								
Female hh's head	-0.0144		-0.0080		-0.0151		-0.0073	
Single hh's head	0.0210		0.0167		0.0189		0.0178	
hh's size	-0.1362	***	-0.1369	***	-0.1368	***	-0.1369	***
hh's age	-0.0008		-0.0008		-0.0007		-0.0008	
hh's avg yrs of education	0.0078		0.0072		0.0071		0.0076	
hh's Dependency Ratio	-0.0374	***	-0.0358	***	-0.0375	***	-0.0342	***
Land operated	0.0250	***	0.0242	***	0.0230	***	0.0240	***
Irrigation (1=yes)	0.1651	*	0.1632	*	0.1738	*	0.1828	*
Home-mkt distance (Km)	0.0039	**	0.0039	**	0.0039	*	0.0035	*
Home-Hospital distance (Km)	0.0014		0.0013		0.0012		0.0010	
Wealth Index	0.0176	**	0.0170	**	0.0196	***	0.0202	***
Radio tenure (1=owned)	0.0674	***	0.0659	**	0.0657	**	0.0668	***
Cell. tenure (1=owned)	0.1341	***	0.1416	***	0.1346	***	0.1396	***
Death of HH Member (1=occurred)	0.0981	*	0.1038	**	0.1006	*	0.0915	*
Illness of HH Member (1=occurred)	0.0185		0.0201		0.0227		0.0124	
SLM practices (1=Yes)	0.0247		0.0334		0.0290		0.0297	
Access to extension services	0.0573	**	0.0559	**	0.0562	**	0.0498	*
Access to credit	0.0760	***	0.0705	***	0.0682	***	0.0706	***
Smallholders (1=yes)	0.0028		0.0005		0.0020		0.0025	
AEZ==Busoga Farming System	0.0252		-0.0021		-0.0574		-0.0523	
AEZ==Eastern Highlands	-0.3144	**	-0.0954		-0.2358	**	-0.1986	*
AEZ==Eastern Savannah	0.3093	***	0.2794	***	0.2425	***	0.1924	**
AEZ==Karamoja	-0.2781	*	-0.4960	***	-0.4515	***	-0.7171	***
AEZ==Lake Albert Crescent	-0.1316	**	-0.0396		-0.0952		-0.0035	
AEZ==Northern Farming System	0.1599		0.1868	*	0.0773		-0.0286	
AEZ==South Western Highlands	-0.0303		-0.0175		-0.1501		0.0362	
AEZ==West Nile Farming System	0.1462	*	0.1696	*	0.1905	**	0.2133	***
AEZ==Western Range Lands	-0.2589	***	-0.3047	***	-0.3411	***	-0.2479	***
Wave2 (1=yes)	-0.2446	***	-0.1943	***	-0.2345	***	-0.1619	***
Constant	33.0154	**	16.1792		22.9684	***	0.0051	

Table 14. Per-capita total gross income – interaction with SLM practices dummy. Elasticities (at means).

	25 years	10 years	5 years	3 years
Rainfall				
Inverse of RP-B-AVG				
SLM: no	-0.016	-0.077	0.078	0.357
SLM: yes	-0.899	-0.228	-1.215 **	0.210
SI shock: equable $\rightarrow$ extreme				
SLM: no	0.087	-0.087	0.032	0.055
SLM: yes	-0.505	0.329	-0.182	0.114
SS Shortfall - 2^{nd} quartile				
SLM: no	-0.032	-0.041	-0.030	-0.073
SLM: yes	0.001	0.065	0.140	0.029
SS shortfall - 3^{rd} quartile				
SLM: no	0.156 **	0.139 **	0.157 **	0.151 **
SLM: yes	-0.116	-0.097	-0.059	-0.104
SS shortfall - 4^{th} quartile				
SLM: no	0.128 *	0.131 *	0.128	0.143 *
SLM: yes	0.146	0.215	-0.002	0.135
RP-B-COV / 1983-2012 B-COV				
SLM: no		-0.124	-0.017	0.065
SLM: yes		-0.120	0.065	0.310 *
Maximum temperature				
	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
SLM: no	3.094 ***	2.020	1.270	0.131
SLM: yes	0.785	-0.264	1.371	-1.229
RP-B-SD				
SLM: no	0.749 ***	0.333	0.321	-0.050
SLM: yes	0.282	0.039	0.641 **	-0.466
SS # Dekads > RP-AVG - 2^{nd} quartile				
SLM: no	0.054	0.002	0.140 **	0.010
SLM: yes	0.119	0.231	0.356 *	-0.174
SS # Dekads > RP-AVG - 3^{rd} quartile				
SLM: no	0.080	0.137 *	0.316 ***	0.159 *
SLM: yes	0.049	0.236	0.310 **	0.135
SS # Dekads > RP-AVG - 4^{th} quartile				
SLM: no	0.267 ***	0.213 **	0.295 ***	0.216 **
SLM: yes	0.192	0.410 ***	0.516 ***	-0.037
R^2	0.266	0.269	0.266	0.267

Table 15. Per-capita total gross income – interaction with extension advice dummy. Elasticities (at means).

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG								
Extension advice: no	-0.292		-0.214		-0.085		0.323	
Extension advice: yes	-0.112		-0.083		-0.074		0.284	
SI shock: equable $\rightarrow$ extreme								
Extension advice: no	-0.069		-0.158		-0.078		0.064	
Extension advice: yes	0.024		0.089		0.144		0.042	
SS Shortfall - 2^{nd} quartile								
Extension advice: no	-0.071		-0.077		-0.033		-0.073	
Extension advice: yes	0.082		0.085		0.084		-0.019	
SS shortfall - 3^{rd} quartile								
Extension advice: no	0.098		0.083		0.105		0.139	**
Extension advice: yes	0.132		0.109		0.151		0.031	
SS shortfall - 4^{th} quartile								
Extension advice: no	0.168	**	0.164	**	0.147		0.122	
Extension advice: yes	0.012		0.034		0.024		0.111	
RP-B-COV / 1983-2012 B-COV								
Extension advice: no			0.017		0.016		0.140	
Extension advice: yes			-0.436	**	-0.046		-0.058	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Extension advice: no	3.126	***	1.782		1.275		-0.141	
Extension advice: yes	3.443	**	2.500		1.346		0.846	
RP-B-SD								
Extension advice: no	0.715	***	0.325		0.355		-0.078	
Extension advice: yes	0.810	***	0.469		0.320		-0.014	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Extension advice: no	0.019		0.024		0.187	**	0.052	
Extension advice: yes	0.135	*	0.045		0.146		-0.122	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Extension advice: no	0.069		0.094		0.330	***	0.179	*
Extension advice: yes	0.037		0.243	**	0.284	**	0.144	
SS # Dekads > RP-AVG - 4^{th} quartile								
Extension advice: no	0.234	***	0.231	**	0.333	***	0.235	**
Extension advice: yes	0.327	***	0.269	**	0.322	***	0.158	
R^2	0.267		0.266		0.265		0.266	

Table 16. Per-capita total gross income – interaction with access to credit dummy. Elasticities (at means)

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG								
Access to credit: no	-0.096		0.014		-0.040		0.386	
Access to credit: yes	-0.169		-0.266		-0.086		0.214	
SI shock: equable $\rightarrow$ extreme								
Access to credit: no	0.024		-0.009		0.004		0.073	
Access to credit: yes	-0.010		-0.103		-0.014		0.046	
SS Shortfall - 2^{nd} quartile								
Access to credit: no	-0.078		-0.100		-0.044		-0.127	**
Access to credit: yes	0.023		0.032		0.039		0.006	
SS shortfall - 3^{rd} quartile								
Access to credit: no	0.083		0.095		0.113		0.182	**
Access to credit: yes	0.152	**	0.106		0.162	**	0.028	
SS shortfall - 4^{th} quartile								
Access to credit: no	0.215	***	0.257	***	0.165	*	0.241	***
Access to credit: yes	0.020		-0.037		0.062		0.012	
RP-B-COV / 1983-2012 B-COV								
Access to credit: no			-0.209		-0.008		0.098	
Access to credit: yes			0.002		-0.010		0.083	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Access to credit: no	3.986	***	3.007	*	2.247	**	0.452	
Access to credit: yes	2.060		1.129		0.370		-0.474	
RP-B-SD								
Access to credit: no	0.797	***	0.345		0.406	*	-0.102	
Access to credit: yes	0.615	**	0.439		0.339		-0.040	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Access to credit: no	0.111	*	0.017		0.137		-0.038	
Access to credit: yes	-0.006		0.063		0.197	**	0.036	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Access to credit: no	0.118		0.110		0.289	***	0.136	
Access to credit: yes	0.001		0.208	**	0.326	***	0.209	**
SS # Dekads > RP-AVG - 4^{th} quartile								
Access to credit: no	0.343	***	0.321	**	0.287	***	0.246	*
Access to credit: yes	0.151	*	0.193	**	0.349	***	0.188	*
R^2	0.266		0.268		0.265		0.268	

Table 17. Per-capita total gross income – interaction with smallholders dummy. (Elasticities at means)

Rainfall	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Smallholders: no	-1.017	*	-0.017		-0.023		0.393	
Smallholders: yes	0.049		-0.124		-0.052		0.323	
SI shock: equable → extreme								
Smallholders: no	-0.894	*	-0.354	*	-0.282	**	0.064	
Smallholders: yes	0.241		0.025		0.062		0.055	
SS Shortfall - 2^{nd} quartile								
Smallholders: no	-0.096		-0.066		-0.049		-0.118	
Smallholders: yes	-0.014		-0.013		0.014		-0.045	
SS shortfall - 3^{rd} quartile								
Smallholders: no	0.088		0.153	*	0.068		0.024	
Smallholders: yes	0.112	*	0.086		0.151	**	0.146	**
SS shortfall - 4^{th} quartile								
Smallholders: no	0.162		0.101		0.118		0.160	
Smallholders: yes	0.107		0.131		0.108		0.138	*
RP-B-COV / 1983-2012 B-COV								
Smallholders: no			-0.195		0.047		0.035	
Smallholders: yes			-0.082		-0.028		0.107	
Maximum temperature	**25 years**		**10 years**		**5 years**		**3 years**	
Inverse of RP-B-AVG								
Smallholders: no	2.147		1.637		1.861		0.105	
Smallholders: yes	2.862	**	2.077		1.109		-0.090	
RP-B-SD								
Smallholders: no	0.595	**	0.178		0.393		-0.215	
Smallholders: yes	0.683	***	0.406		0.351	*	-0.034	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Smallholders: no	-0.224	**	-0.031		0.029		-0.121	
Smallholders: yes	0.130	**	0.052		0.228	***	0.051	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Smallholders: no	-0.138		0.034		0.220	**	0.149	
Smallholders: yes	0.094		0.206	**	0.351	***	0.175	*
SS # Dekads > RP-AVG - 4^{th} quartile								
Smallholders: no	0.017		0.123		0.243	**	0.070	
Smallholders: yes	0.295	***	0.304	***	0.355	***	0.250	**
R^2	0.268		0.266		0.266		0.265	

Table 18. Per-capita total expenditure – interaction with SLM practices dummy. Elasticities (at means)

Rainfall	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
SLM: no	-0.529	-0.156	0.104	0.359
SLM: yes	-1.315 *	-1.365 **	-1.457 **	-0.839 *
SI shock: equable $\rightarrow$ extreme				
SLM: no	0.115	0.020	0.281 ***	0.119 **
SLM: yes	-0.230	-0.109	0.255	0.030
SS Shortfall - 2^{nd} quartile				
SLM: no	0.004	0.040	-0.009	0.009
SLM: yes	0.009	0.009	0.030	-0.010
SS shortfall - 3^{rd} quartile				
SLM: no	0.060	0.045	0.103	-0.031
SLM: yes	-0.062	-0.276 *	-0.093	-0.144
SS shortfall - 4^{th} quartile				
SLM: no	-0.013	-0.102	0.060	0.022
SLM: yes	-0.120	-0.104	-0.398 *	-0.084
RP-B-COV / 1983-2012 B-COV				
SLM: no		-0.261 *	0.061	0.065
SLM: yes		-0.004	-0.140	0.246
Maximum temperature	**25 years**	**10 years**	**5 years**	**3 years**
Inverse of RP-B-AVG				
SLM: no	0.095	1.261	-1.763	-1.249
SLM: yes	0.303	0.661	-0.332	-0.567
RP-B-SD				
SLM: no	0.531 *	0.517	0.136	-0.114
SLM: yes	0.221	0.359	0.623 *	0.120
SS # Dekads > RP-AVG - 2^{nd} quartile				
SLM: no	0.060	0.084	0.246 ***	0.002
SLM: yes	-0.108	0.073	0.284 *	-0.015
SS # Dekads > RP-AVG - 3^{rd} quartile				
SLM: no	-0.040	0.134	0.265 **	0.114
SLM: yes	-0.256	-0.046	0.253	0.128
SS # Dekads > RP-AVG - 4^{th} quartile				
SLM: no	0.120	0.115	0.165	-0.042
SLM: yes	-0.010	0.255	0.613 ***	0.144
R^2	0.235	0.237	0.238	0.234

Table 19. Per-capita total expenditure – interaction with extension advice dummy. Elasticities (at means)

Rainfall	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Extension advice: no	-0.834	*	-0.428		-0.093		0.196	
Extension advice: yes	-0.619		-0.298		-0.098		0.124	
SI shock: equable → extreme								
Extension advice: no	0.019		-0.090		0.316	***	0.115	**
Extension advice: yes	-0.076		0.160		0.160		0.065	
SS Shortfall - 2^{nd} quartile								
Extension advice: no	-0.032		0.003		-0.030		0.002	
Extension advice: yes	0.081		0.119		0.053		0.010	
SS shortfall - 3^{rd} quartile								
Extension advice: no	0.075		0.003		0.103		-0.047	
Extension advice: yes	-0.055		-0.004		-0.023		-0.070	
SS shortfall - 4^{th} quartile								
Extension advice: no	0.007		-0.064		0.051		0.006	
Extension advice: yes	-0.078		-0.180		-0.061		-0.016	
RP-B-COV / 1983-2012 B-COV								
Extension advice: no			-0.122		0.090		0.060	
Extension advice: yes			-0.457	**	-0.089		0.182	
Maximum temperature	**25 years**		**10 years**		**5 years**		**3 years**	
Inverse of RP-B-AVG								
Extension advice: no	-0.115		1.405		-2.544	**	-1.440	
Extension advice: yes	0.194		2.005		0.510		-0.437	
RP-B-SD								
Extension advice: no	0.520		0.546		0.075		-0.098	
Extension advice: yes	0.345		0.704		0.443		-0.056	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Extension advice: no	0.030		0.042		0.215	***	-0.011	
Extension advice: yes	0.026		0.175		0.395	***	0.026	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Extension advice: no	-0.056		0.063		0.303	**	0.164	
Extension advice: yes	-0.157		0.184		0.231	*	-0.008	
SS # Dekads > RP-AVG - 4^{th} quartile								
Extension advice: no	0.134		0.132		0.259	**	0.024	
Extension advice: yes	-0.083		0.067		0.100		-0.134	
R^2	0.238		0.237		0.241		0.235	

Table 20. Per-capita total expenditure – interaction with access to credit dummy. Elasticities (at means)

Rainfall	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Access to credit: no	-0.560		-0.186		-0.098		0.255	
Access to credit: yes	-0.743		-0.590		-0.287		-0.057	
SI shock: equable → extreme								
Access to credit: no	-0.063		-0.029		0.237	*	0.101	*
Access to credit: yes	0.341		0.029		0.248	**	0.104	
SS Shortfall - 2nd quartile								
Access to credit: no	-0.120		-0.092		-0.131	*	-0.128	
Access to credit: yes	0.150		0.177	**	0.137		0.142	*
SS shortfall - 3rd quartile								
Access to credit: no	0.151		0.094		0.068		0.059	
Access to credit: yes	-0.104		-0.106		0.075		-0.199	
SS shortfall - 4th quartile								
Access to credit: no	0.132		0.060		0.140		0.144	
Access to credit: yes	-0.215		-0.299	**	-0.148		-0.159	
RP-B-COV / 1983-2012 B-COV								
Access to credit: no			-0.307	*	0.028		-0.072	
Access to credit: yes			-0.154		0.028		0.237	
Maximum temperature	**25 years**		**10 years**		**5 years**		**3 years**	
Inverse of RP-B-AVG								
Access to credit: no	1.137		2.533		-0.385		-0.456	
Access to credit: yes	-2.543		0.485		-2.780	**	-2.083	*
RP-B-SD								
Access to credit: no	0.590	*	0.610	*	0.346		-0.052	
Access to credit: yes	0.105		0.542		0.059		-0.123	
SS # Dekads > RP-AVG - 2nd quartile								
Access to credit: no	0.031		-0.004		0.161	*	-0.097	
Access to credit: yes	0.002		0.140		0.335	***	0.091	
SS # Dekads > RP-AVG - 3rd quartile								
Access to credit: no	-0.046		-0.002		0.226	*	0.069	
Access to credit: yes	-0.169		0.169		0.311	**	0.162	
SS # Dekads > RP-AVG - 4th quartile								
Access to credit: no	0.057		0.116		0.207	*	0.043	
Access to credit: yes	0.086		0.134		0.252	*	-0.006	
R^2	0.239		0.240		0.243		0.239	

Table 21. Per-capita total expenditure – interaction with smallholder dummy. Elasticities (at means)

	25 years		10 years		5 years		3 years	
Rainfall								
Inverse of RP-B-AVG								
Smallholders: no	-1.573	**	-0.618		-0.175		0.178	
Smallholders: yes	-0.501		-0.264		-0.148		0.212	
SI shock: equable → extreme								
Smallholders: no	-0.649		-0.278		0.291	*	0.062	
Smallholders: yes	0.199		0.018		0.250	**	0.098	**
SS Shortfall - 2^{nd} quartile								
Smallholders: no	0.135		0.118		0.118		0.155	
Smallholders: yes	-0.036		0.017		-0.032		-0.037	
SS shortfall - 3^{rd} quartile								
Smallholders: no	0.031		0.058		-0.075		-0.366	**
Smallholders: yes	0.033		-0.011		0.095		0.040	
SS shortfall - 4^{th} quartile								
Smallholders: no	-0.220		-0.364	**	-0.104		-0.309	
Smallholders: yes	0.005		-0.028		0.024		0.081	
RP-B-COV / 1983-2012 B-COV								
Smallholders: no			0.021		0.232	**	0.012	
Smallholders: yes			-0.337	**	-0.043		0.095	
Maximum temperature								
	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Smallholders: no	0.170		0.760		-2.829	**	-0.574	
Smallholders: yes	-0.203		1.308		-0.991		-1.452	
RP-B-SD								
Smallholders: no	0.510		0.400		-0.208		-0.238	
Smallholders: yes	0.468		0.517		0.403		-0.085	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Smallholders: no	-0.161		-0.058		0.020		-0.213	*
Smallholders: yes	0.093		0.143		0.348	***	0.068	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Smallholders: no	-0.025		0.011		0.023		0.146	
Smallholders: yes	-0.123		0.158		0.349	***	0.095	
SS # Dekads > RP-AVG - 4^{th} quartile								
Smallholders: no	0.156		0.188		0.263	*	-0.072	
Smallholders: yes	0.069		0.128		0.223	*	-0.006	
R^2	0.240		0.239		0.244		0.238	

Table 22. Per-capita daily calories intake – interaction with SLM practices dummy. Elasticities (at means)

	25 years	10 years	5 years	3 years
Rainfall				
Inverse of RP-B-AVG				
SLM: no	-0.093	0.387 **	0.279	0.346 **
SLM: yes	-0.048	1.126 ***	0.655	0.462
SI shock: equable $\rightarrow$ extreme				
SLM: no	-0.176	0.098	-0.062	0.003
SLM: yes	-0.539	0.006	-0.124	-0.083
SS Shortfall - 2^{nd} quartile				
SLM: no	0.012	0.037	0.022	0.008
SLM: yes	-0.111	-0.048	-0.016	-0.056
SS shortfall - 3^{rd} quartile				
SLM: no	-0.073	-0.103 **	-0.042	-0.015
SLM: yes	-0.069	-0.208	0.064	0.107
SS shortfall - 4^{th} quartile				
SLM: no	-0.177 **	-0.102	-0.014	-0.046
SLM: yes	-0.264	-0.143	-0.085	-0.134
RP-B-COV / 1983-2012 B-COV				
SLM: no		-0.031	0.070	-0.080
SLM: yes		-0.140	-0.048	-0.047
Maximum temperature				
	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
SLM: no	-0.339	-1.774 *	-1.090 *	-1.117 *
SLM: yes	1.509	-1.904	0.633	0.450
RP-B-SD				
SLM: no	0.196	-0.166	-0.092	-0.078
SLM: yes	0.161	-0.633 *	0.005	-0.116
SS # Dekads > RP-AVG - 2^{nd} quartile				
SLM: no	0.016	-0.003	-0.007	-0.121 *
SLM: yes	0.070	-0.041	0.204	-0.025
SS # Dekads > RP-AVG - 3^{rd} quartile				
SLM: no	0.050	0.048	0.064	-0.146 *
SLM: yes	0.063	0.118	0.246 **	-0.055
SS # Dekads > RP-AVG - 4^{th} quartile				
SLM: no	0.065	-0.109	-0.041	-0.268 ***
SLM: yes	0.100	-0.057	0.216	-0.073
R^2	0.323	0.323	0.325	0.325

Table 23. Per-capita daily calories intake – interaction with extension advice dummy. Elasticities (at means)

Rainfall				
	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
Extension advice: no	-0.082	0.434 **	0.278	0.322 *
Extension advice: yes	-0.257	0.394	0.289	0.238
SI shock: equable → extreme				
Extension advice: no	-0.245	0.032	-0.098	-0.013
Extension advice: yes	-0.176	0.244	0.014	0.013
SS Shortfall - 2^{nd} quartile				
Extension advice: no	0.000	0.041	0.029	0.010
Extension advice: yes	0.003	0.001	-0.016	-0.046
SS shortfall - 3^{rd} quartile				
Extension advice: no	-0.062	-0.076	-0.065	0.024
Extension advice: yes	-0.076	-0.207 ***	0.046	-0.034
SS shortfall - 4^{th} quartile				
Extension advice: no	-0.108	-0.053	0.019	-0.037
Extension advice: yes	-0.359 ***	-0.235 ***	-0.046	-0.108
RP-B-COV / 1983-2012 B-COV				
Extension advice: no		-0.037	0.067	-0.091
Extension advice: yes		-0.048	0.075	-0.087
Maximum temperature				
	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
Extension advice: no	-0.155	-1.260	-0.707	-0.951
Extension advice: yes	0.401	-2.090	-1.416	-0.561
RP-B-SD				
Extension advice: no	0.169	-0.135	-0.019	-0.073
Extension advice: yes	0.333	-0.282	-0.276	-0.011
SS # Dekads > RP-AVG - 2^{nd} quartile				
Extension advice: no	-0.001	0.041	0.015	-0.083
Extension advice: yes	0.059	-0.117	-0.017	-0.167
SS # Dekads > RP-AVG - 3^{rd} quartile				
Extension advice: no	0.055	0.085	0.109	-0.113
Extension advice: yes	0.042	0.006	-0.019	-0.212 *
SS # Dekads > RP-AVG - 4^{th} quartile				
Extension advice: no	0.100 *	-0.047	0.015	-0.199 **
Extension advice: yes	-0.023	-0.247 **	-0.142	-0.416 ***
R^2	0.324	0.322	0.325	0.323

Table 24. Per-capita daily calories intake – interaction with access to credit dummy. Elasticities (at means)

Rainfall	25 years	10 years	5 years	3 years
Inverse of RP-B-AVG				
Access to credit: no	-0.381	0.335	0.236	0.290 *
Access to credit: yes	0.250	0.653 ***	0.368 *	0.408 **
SI shock: equable $\rightarrow$ extreme				
Access to credit: no	-0.461 **	-0.033	-0.095	0.024
Access to credit: yes	0.152	0.259 *	-0.058	-0.041
SS Shortfall - 2^{nd} quartile				
Access to credit: no	0.014	0.056	0.033	0.034
Access to credit: yes	-0.016	-0.011	-0.003	-0.044
SS shortfall - 3^{rd} quartile				
Access to credit: no	-0.090	-0.042	-0.033	0.020
Access to credit: yes	-0.067	-0.203 ***	-0.035	-0.023
SS shortfall - 4^{th} quartile				
Access to credit: no	-0.155 *	-0.105	-0.023	-0.068
Access to credit: yes	-0.235 **	-0.102	-0.005	-0.044
RP-B-COV / 1983-2012 B-COV				
Access to credit: no		-0.035	0.036	-0.122
Access to credit: yes		-0.057	0.089	-0.037
Maximum temperature	**25 years**	**10 years**	**5 years**	**3 years**
Inverse of RP-B-AVG				
Access to credit: no	-0.346	-1.771	-0.818	-1.265 *
Access to credit: yes	0.254	-1.675	-0.905	-0.510
RP-B-SD				
Access to credit: no	0.267	-0.160	0.015	-0.041
Access to credit: yes	0.139	-0.275	-0.138	-0.101
SS # Dekads > RP-AVG - 2^{nd} quartile				
Access to credit: no	0.060	0.018	0.019	-0.050
Access to credit: yes	-0.027	-0.024	0.030	-0.173 **
SS # Dekads > RP-AVG - 3^{rd} quartile				
Access to credit: no	0.157 **	0.060	0.116	-0.072
Access to credit: yes	-0.083	0.055	0.054	-0.210 **
SS # Dekads > RP-AVG - 4^{th} quartile				
Access to credit: no	0.115 *	-0.080	0.020	-0.216 **
Access to credit: yes	0.032	-0.123	-0.041	-0.283 ***
R^2	0.324	0.321	0.323	0.322

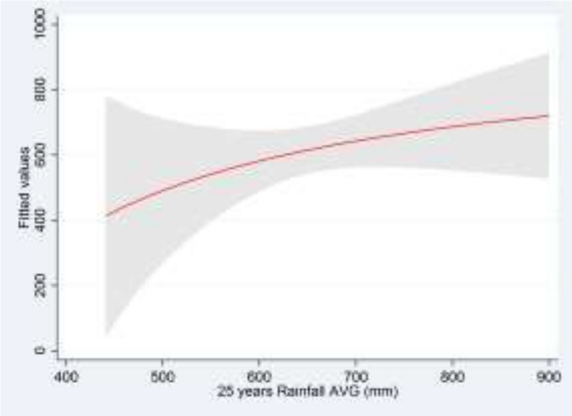
Table 25. Per-capita daily calories intake – interaction with smallholders dummy. Elasticities (at means)

Rainfall	25 years		10 years		5 years		3 years	
Inverse of RP-B-AVG								
Smallholders: no	-0.329		0.249		0.186		-0.044	
Smallholders: yes	-0.057		0.457	**	0.307		0.385	**
SI shock: equable → extreme								
Smallholders: no	-0.329		-0.074		-0.092		-0.017	
Smallholders: yes	-0.184		0.135		-0.073		-0.009	
SS Shortfall - 2^{nd} quartile								
Smallholders: no	0.015		0.003		0.022		-0.016	
Smallholders: yes	-0.006		0.036		0.017		0.001	
SS shortfall - 3^{rd} quartile								
Smallholders: no	-0.130		-0.110		0.083		0.025	
Smallholders: yes	-0.056		-0.103	**	-0.076		-0.014	
SS shortfall - 4^{th} quartile								
Smallholders: no	-0.237	**	-0.252	**	-0.060		-0.173	
Smallholders: yes	-0.165	**	-0.072		-0.006		-0.042	
RP-B-COV / 1983-2012 B-COV								
Smallholders: no			0.111		0.036		-0.126	
Smallholders: yes			-0.089		0.064		-0.072	
Maximum temperature	**25 years**		**10 years**		**5 years**		**3 years**	
Inverse of RP-B-AVG								
Smallholders: no	0.173		-3.456	**	-1.070		-0.251	
Smallholders: yes	-0.313		-1.195		-0.720		-1.169	*
RP-B-SD								
Smallholders: no	0.185		-0.652	**	-0.246		0.002	
Smallholders: yes	0.179		-0.076		-0.012		-0.111	
SS # Dekads > RP-AVG - 2^{nd} quartile								
Smallholders: no	-0.025		-0.256	**	-0.063		-0.188	*
Smallholders: yes	0.027		0.066		0.038		-0.081	
SS # Dekads > RP-AVG - 3^{rd} quartile								
Smallholders: no	-0.010		-0.216	*	-0.093		-0.267	**
Smallholders: yes	0.064		0.152	**	0.146	**	-0.088	
SS # Dekads > RP-AVG - 4^{th} quartile								
Smallholders: no	-0.121		-0.371	**	-0.043		-0.297	*
Smallholders: yes	0.114	**	-0.016		0.011		-0.222	**
R^2	0.322		0.323		0.326		0.323	

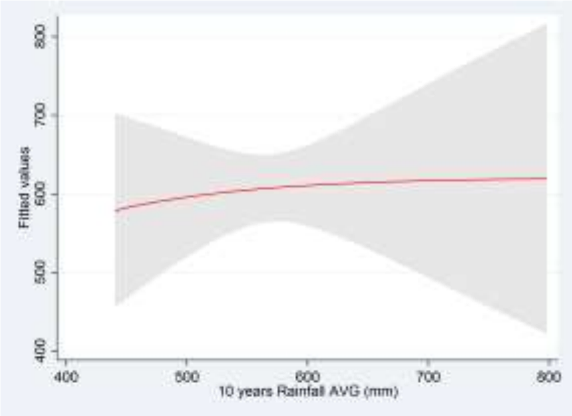
Annex 2 – Figures[12]

Figure 1: Marginal effect of rainfall AVG (mm) on per-capita gross total income by reference period

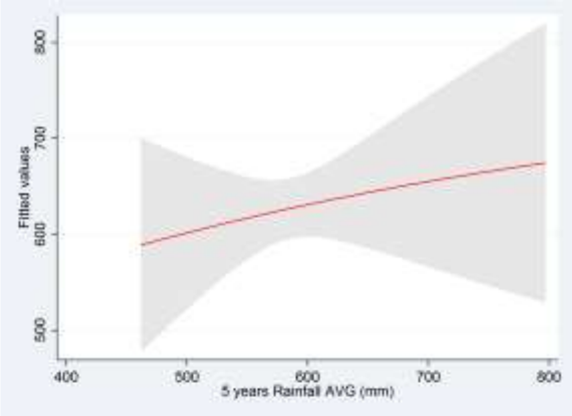
(a) 25 years



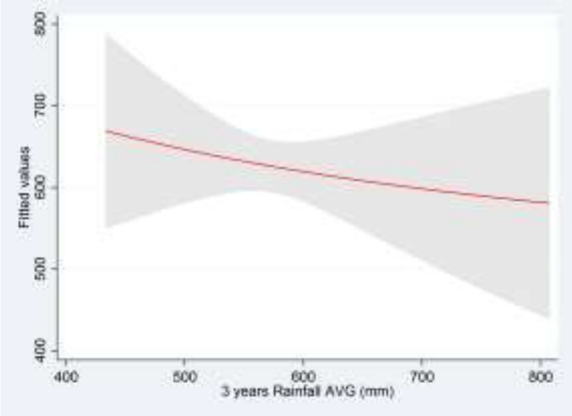
(b) 10 years



(c) 5 years



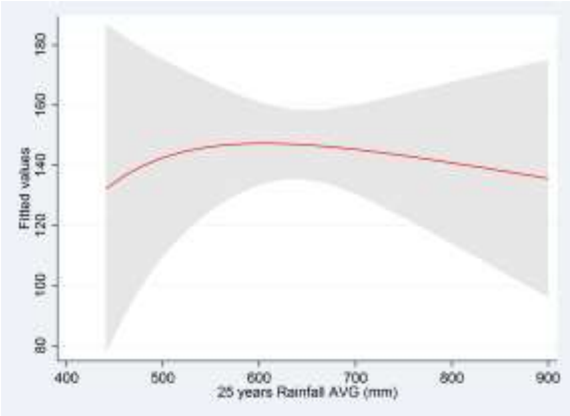
(d) 3 years



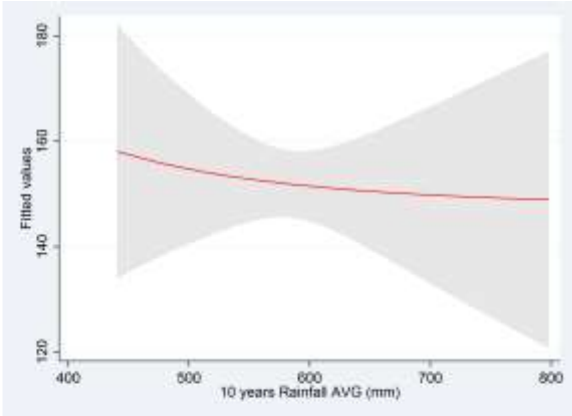
[12] all figures are based on authors' elaborations

Figure 2: Marginal effect of rainfall AVG (mm) on Value of own produced crops by reference period

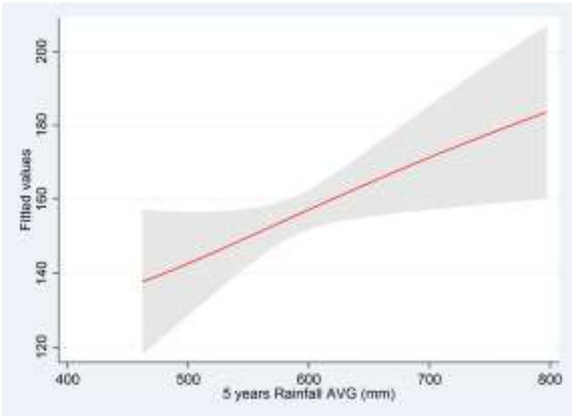
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

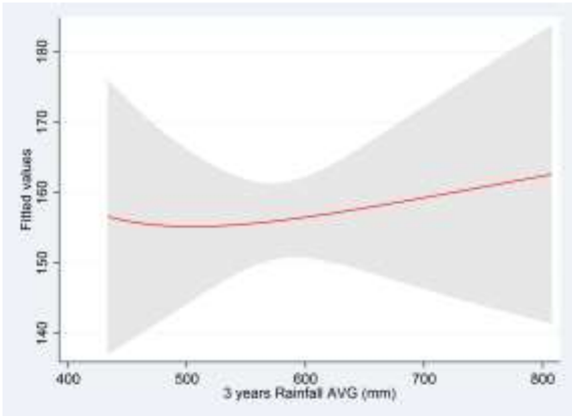
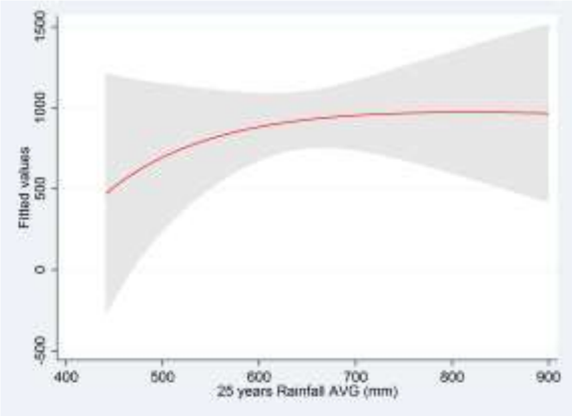
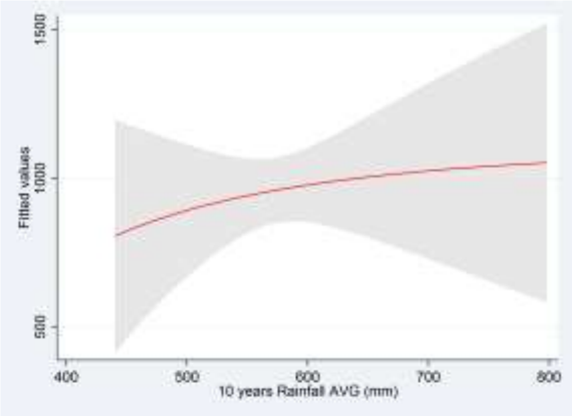


Figure 3: Marginal effect of rainfall AVG (mm) on per-capita total expenditure by reference period

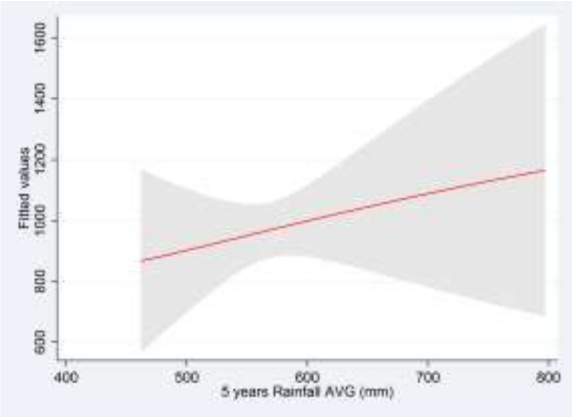
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

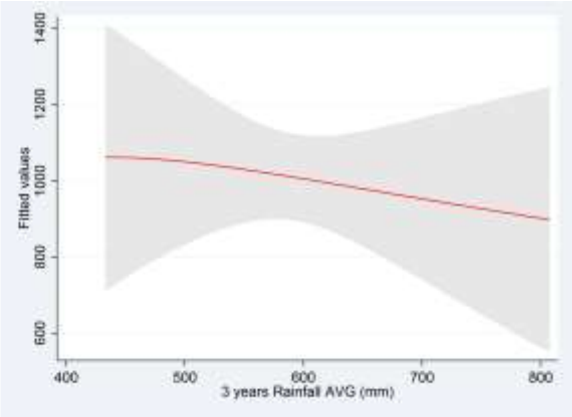
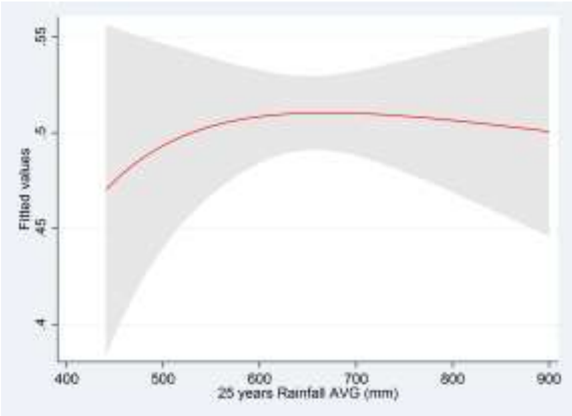
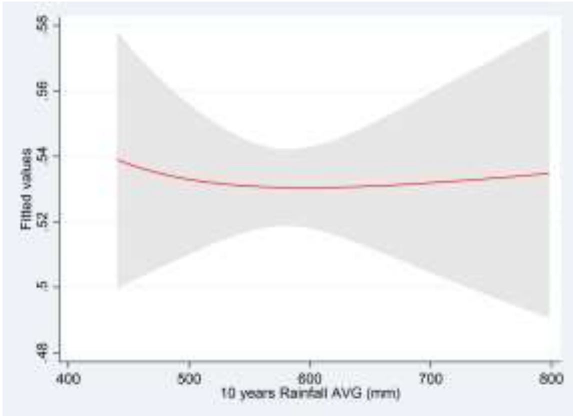


Figure 4: Marginal effect of rainfall AVG (mm) on food expenditure’s share by reference period

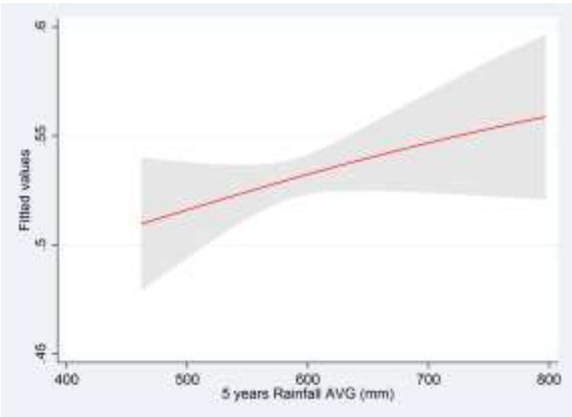
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

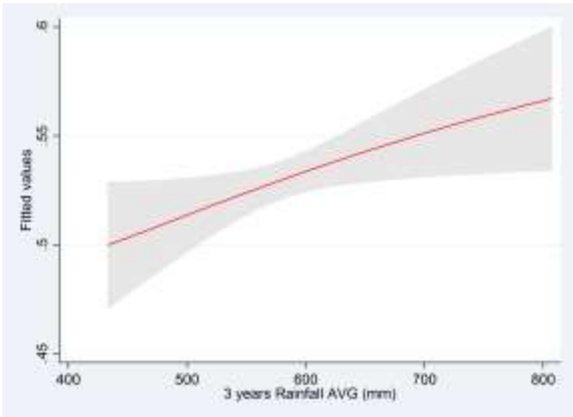


Figure 5: Marginal effect of rainfall AVG (mm) on per-capita daily calories intake by reference period

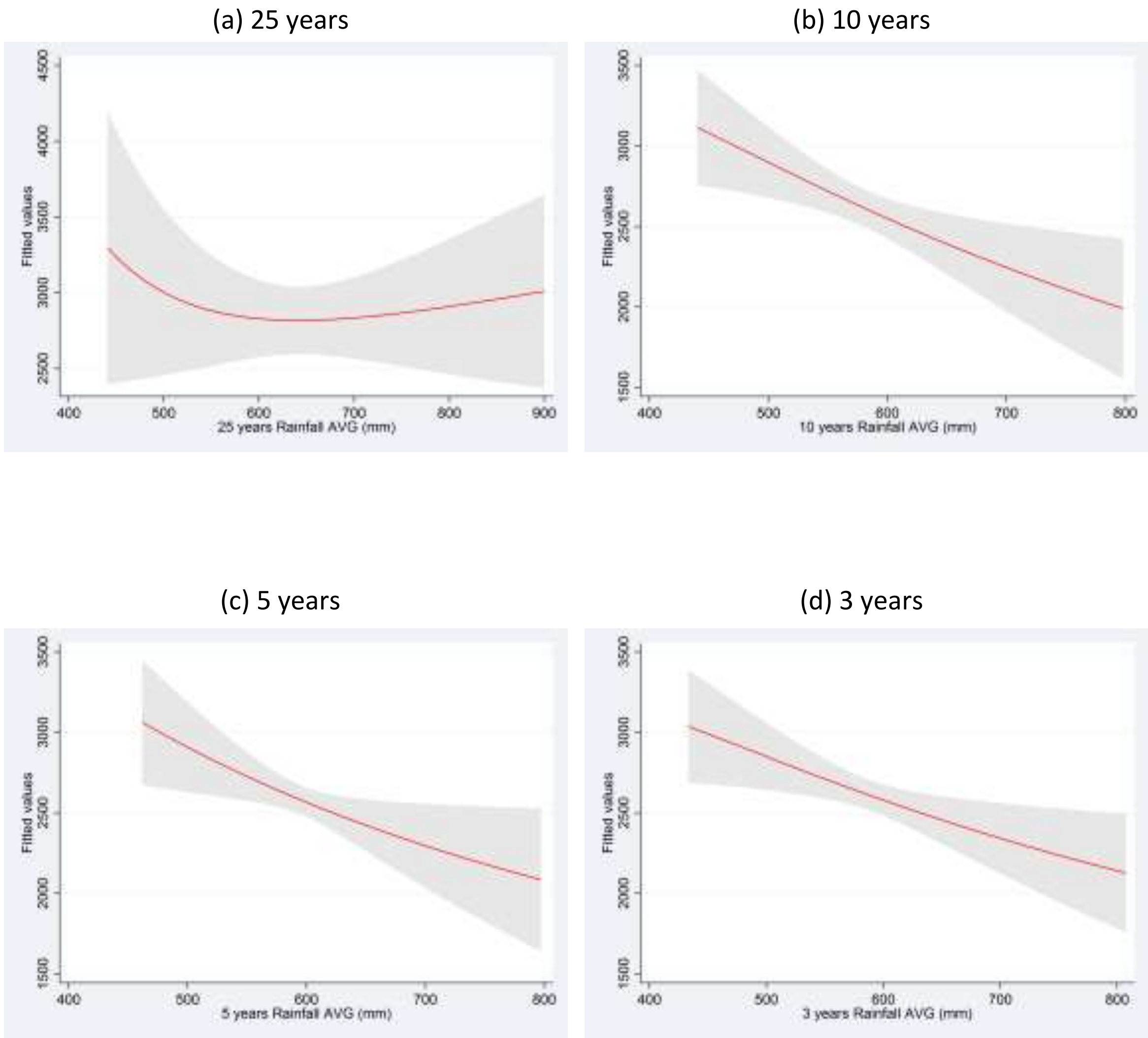


Figure 6: Marginal effect of rainfall SD (mm) on per-capita gross total income by reference period

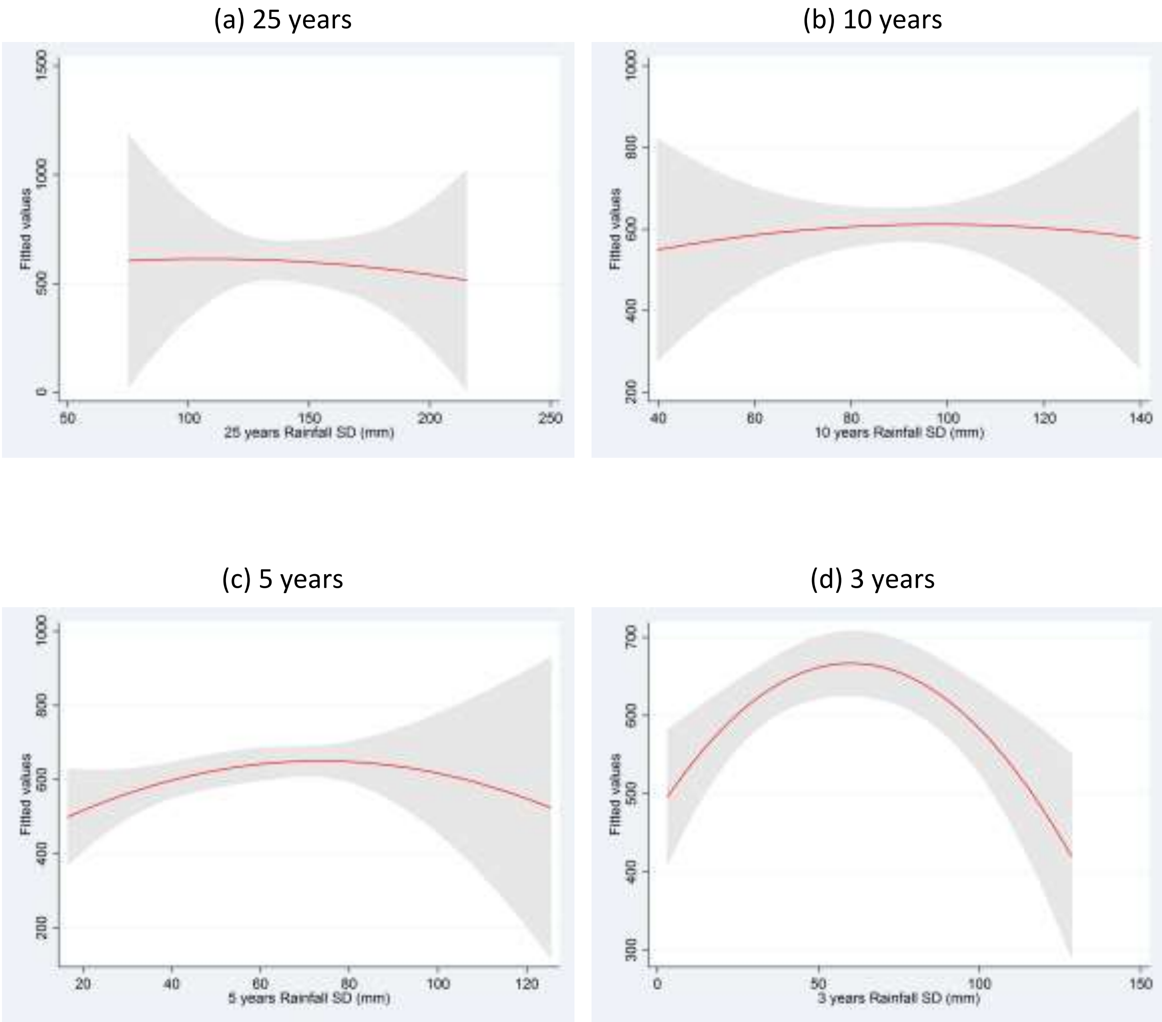


Figure 7: Marginal effect of rainfall SD (mm) on per-capita food expenditure by reference period

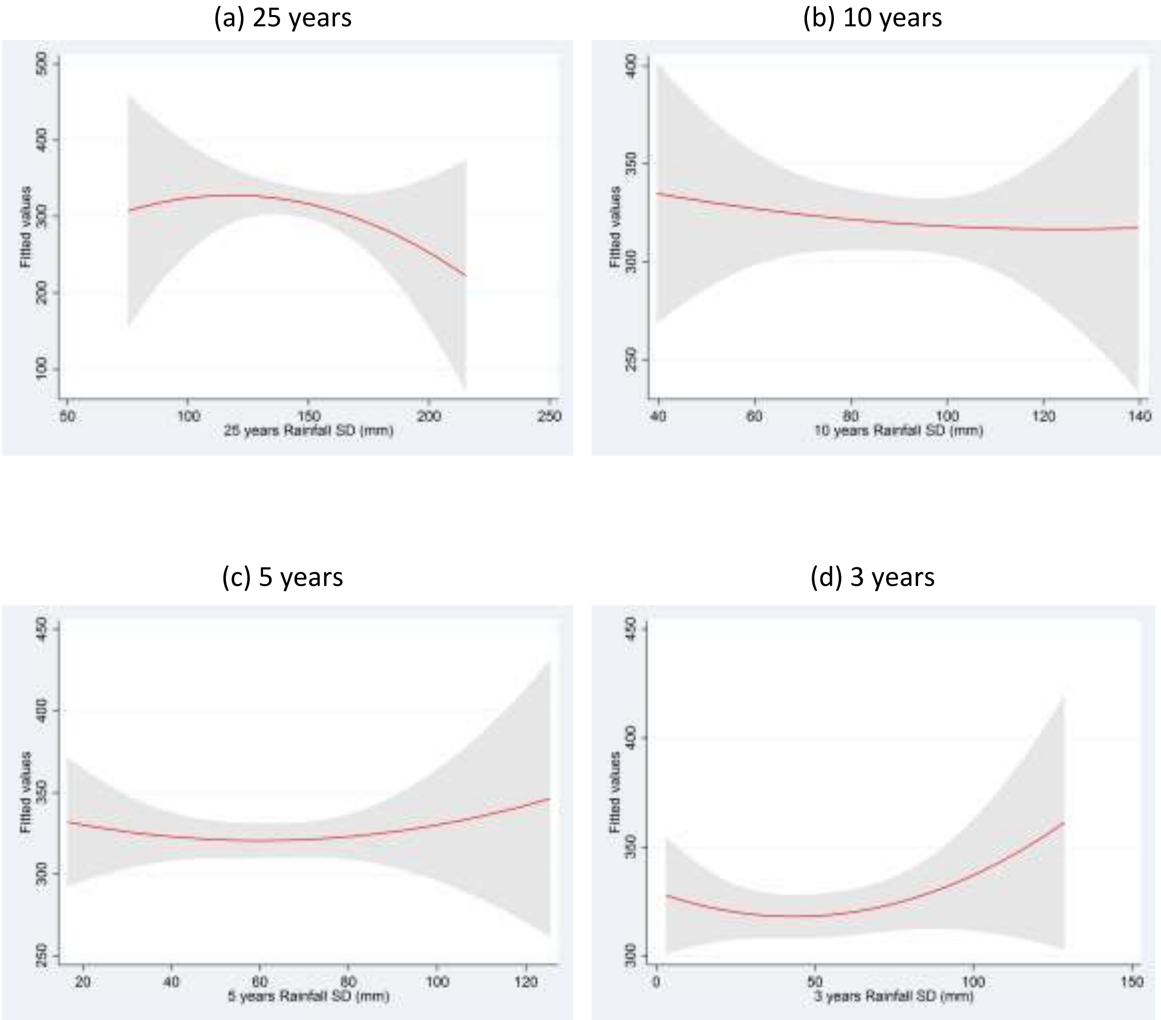


Figure 8: Marginal effect of rainfall SD (mm) on Value of own produced crops by reference period

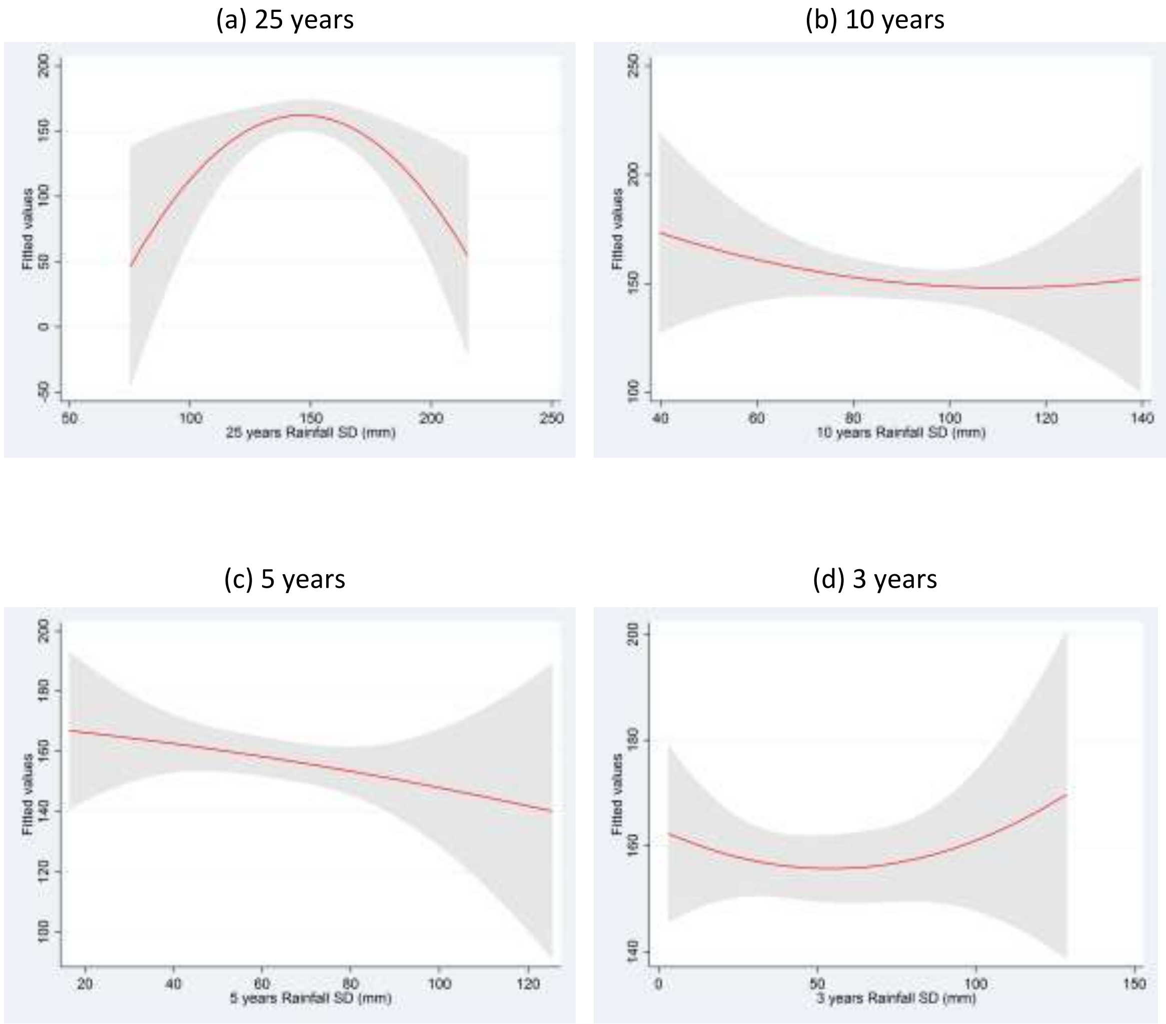


Figure 9: Marginal effect of rainfall SD (mm) on per-capita total expenditure by reference period

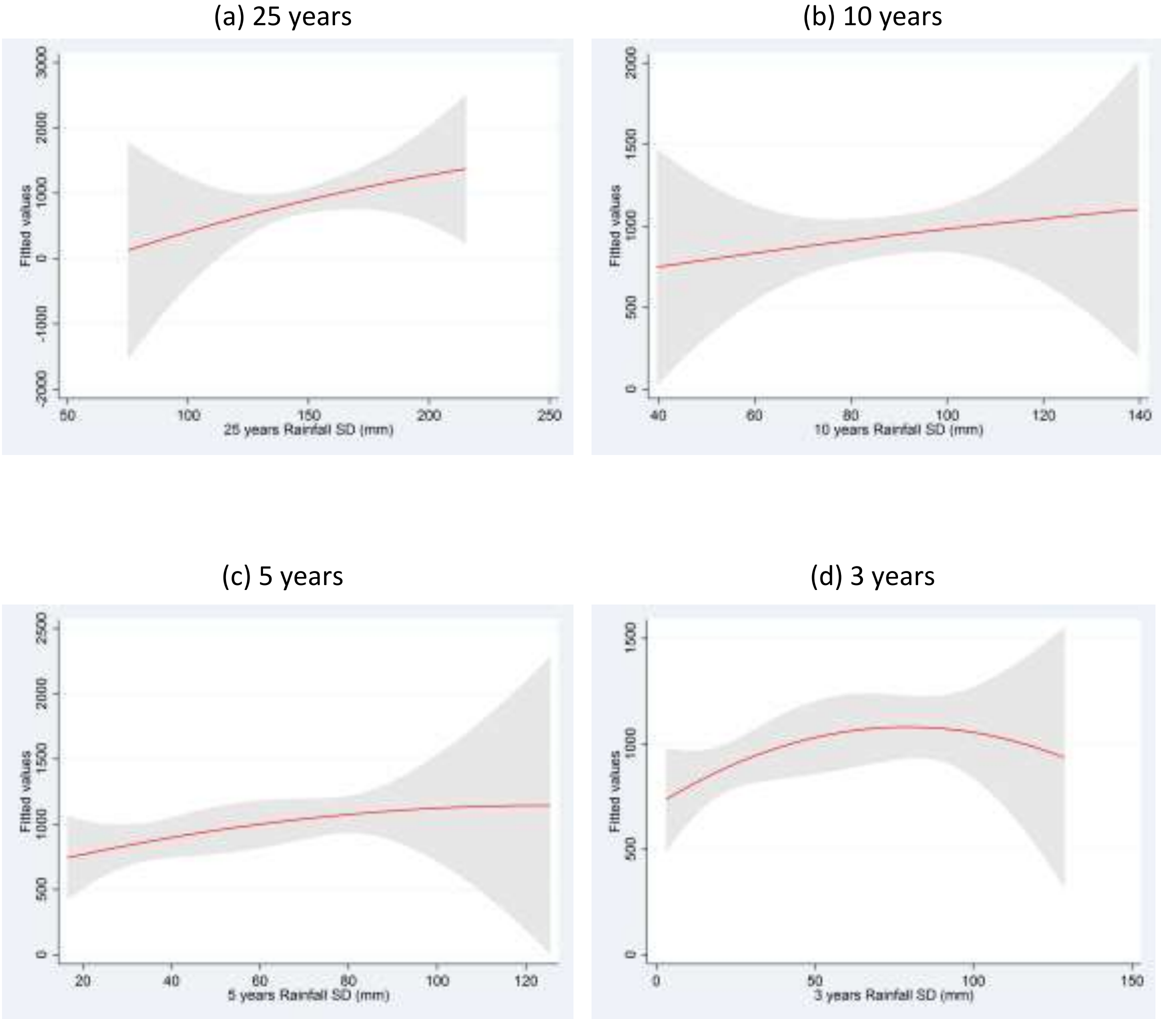
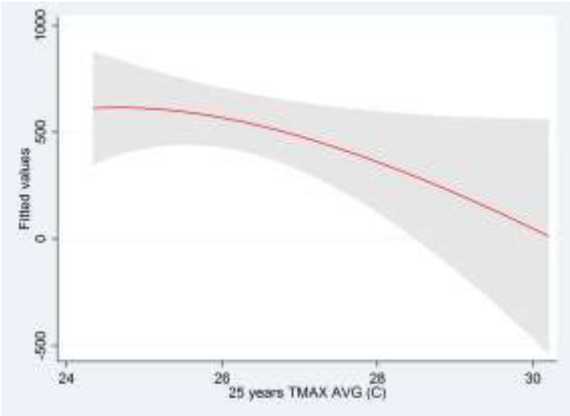
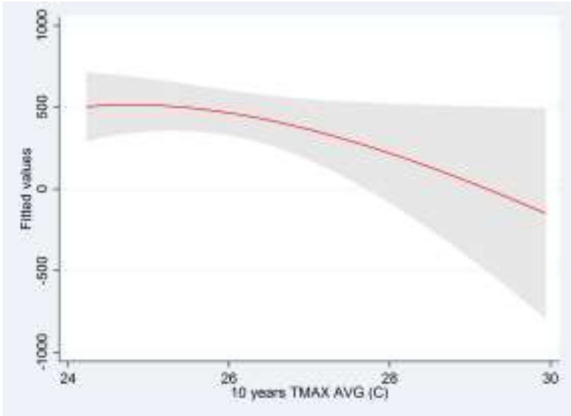


Figure 10: Marginal effect of maximum temperature AVG (_C) on per-capita gross total income by reference period

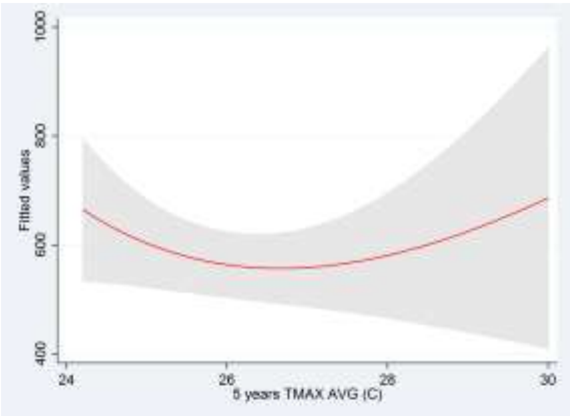
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

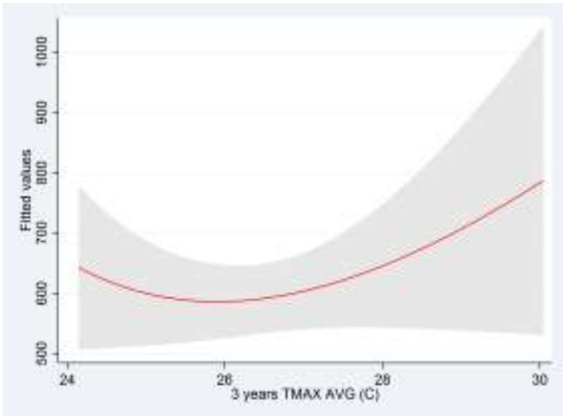
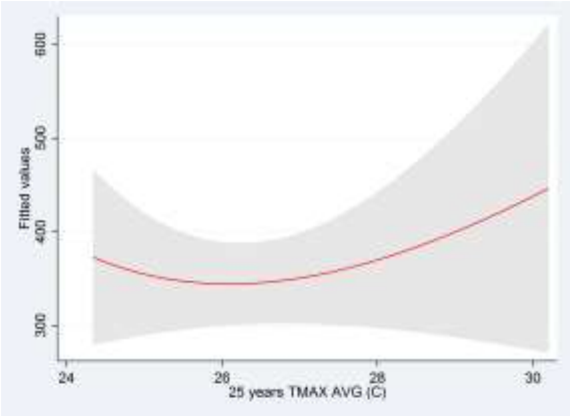
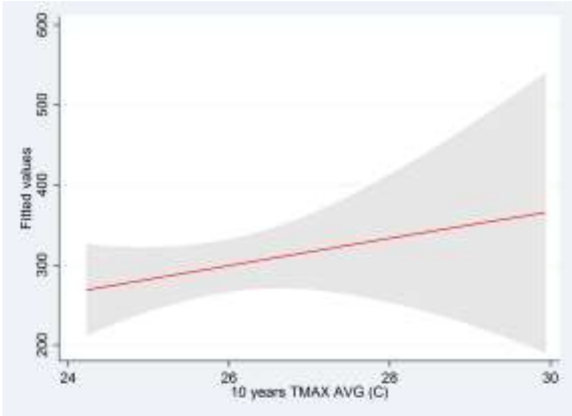


Figure 11: Marginal effect of maximum temperature AVG (_C) on per-capita food expenditure by reference period

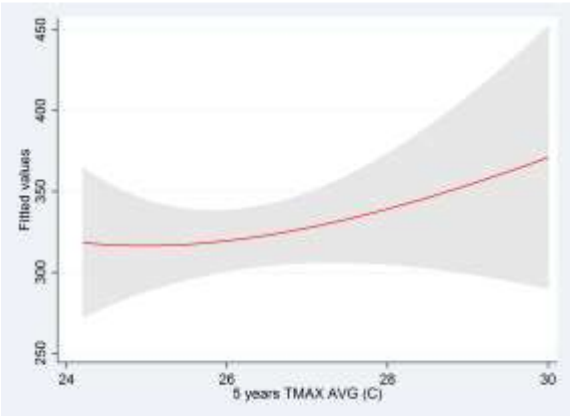
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

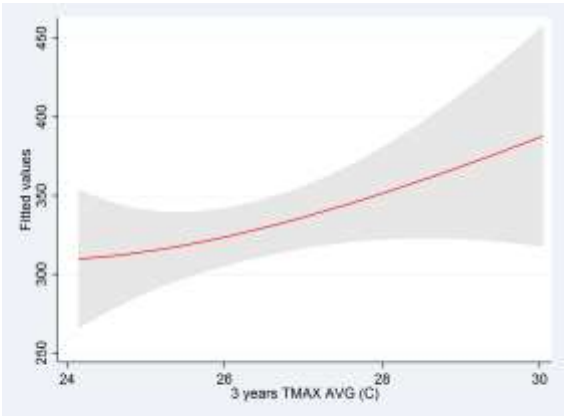


Figure 12: Marginal effect of maximum temperature SD (_C) on per-capita gross total income by reference period

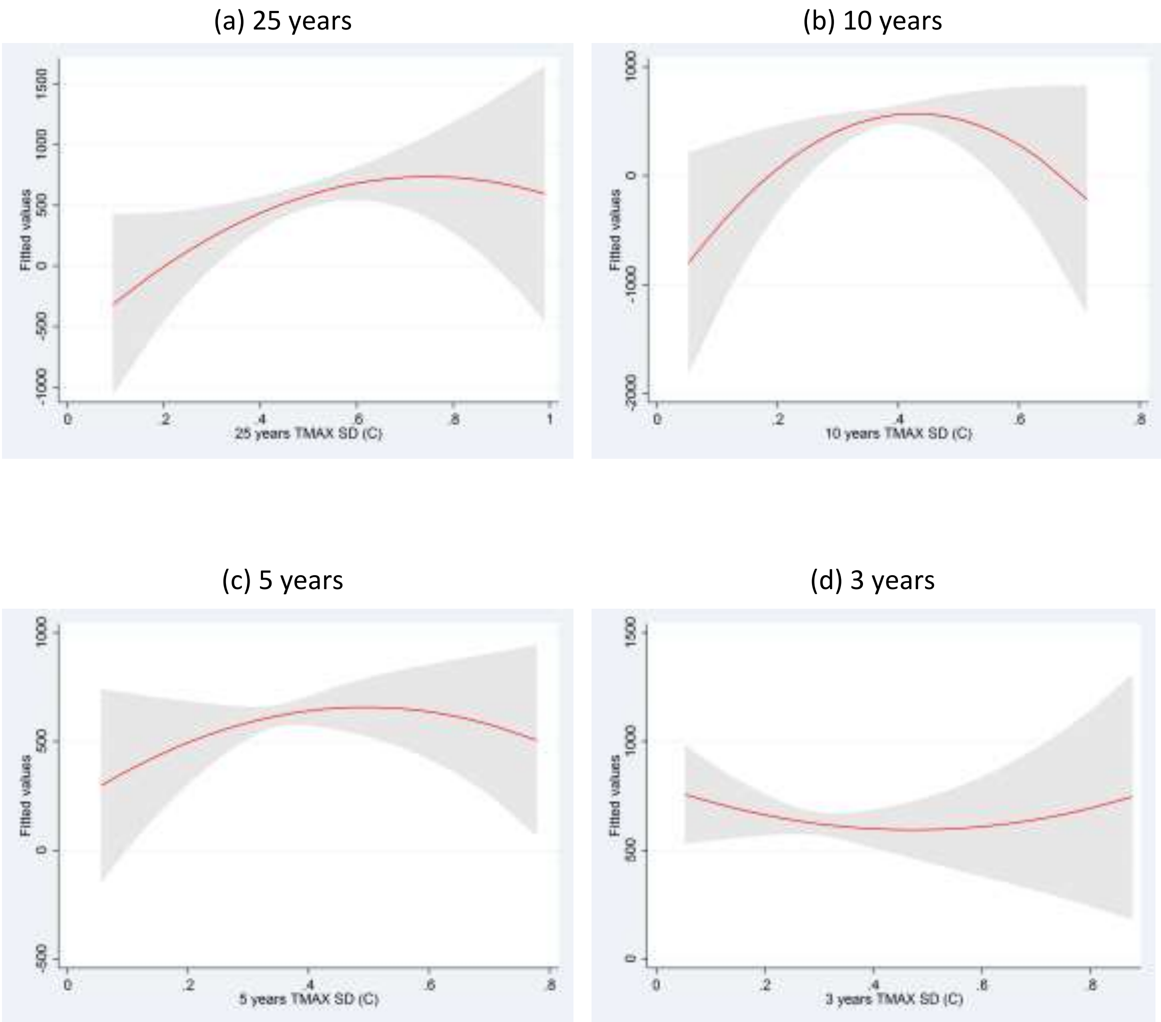
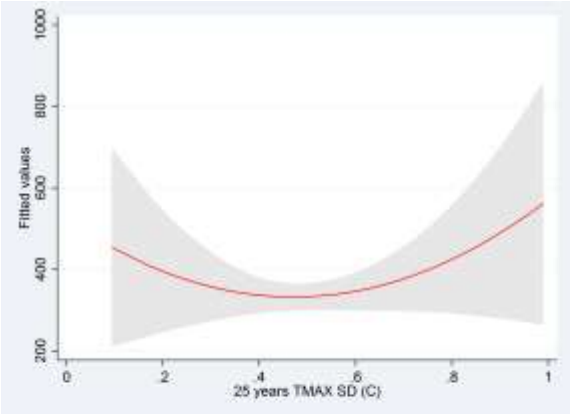
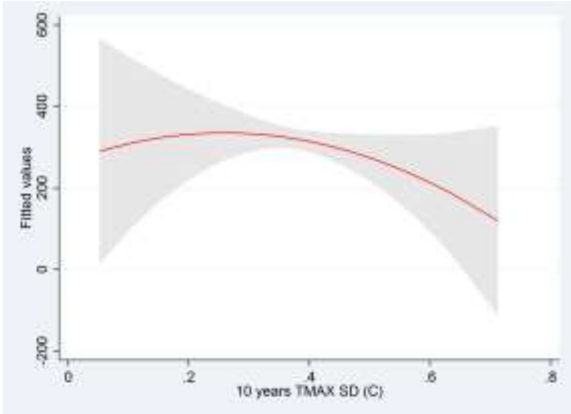


Figure 13: Marginal effect of maximum temperature SD (_C) on per-capita food expenditure by reference period

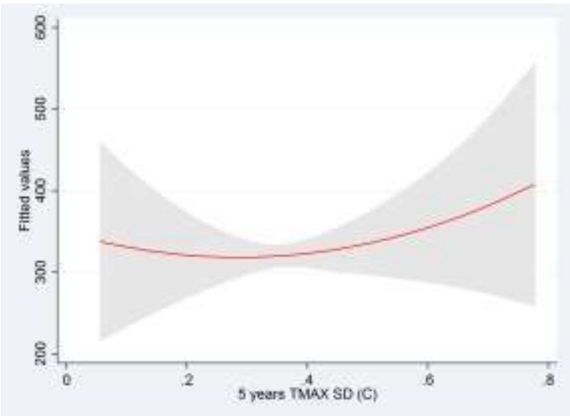
(a) 25 years



(b) 10 years



(c) 5 years



(d) 3 years

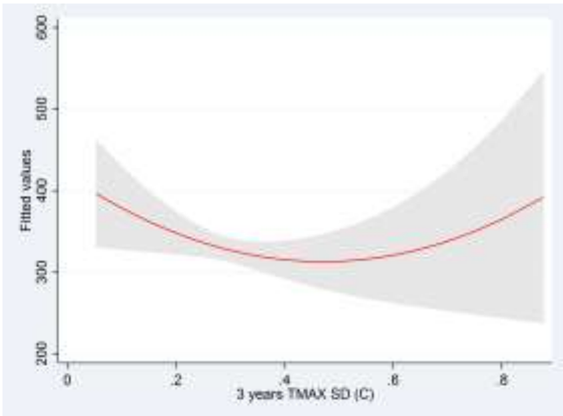


Figure 14: per-capita total gross income - Temperature SD

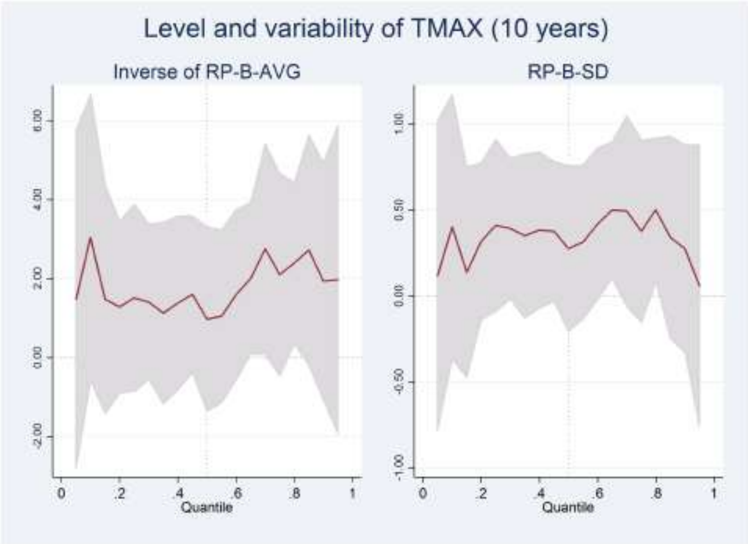


Figure 15: per-capita total gross income - Temperature Dekads

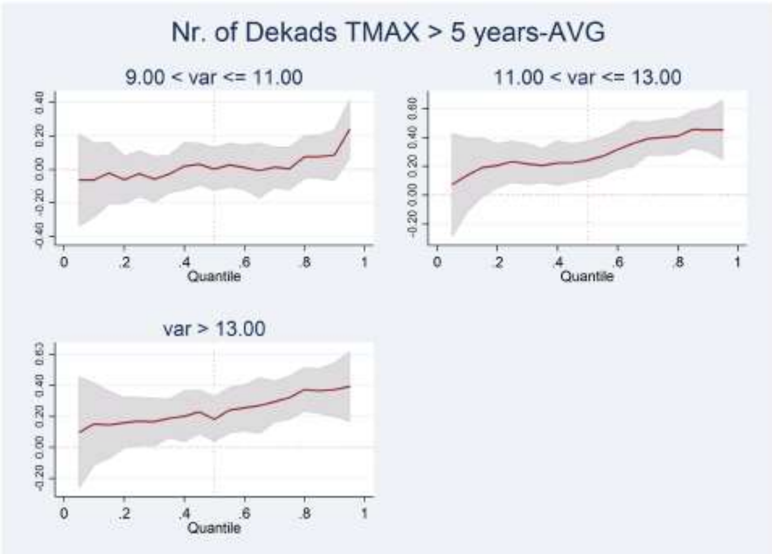


Figure 16: per-capita total gross income - Temperature Dekads

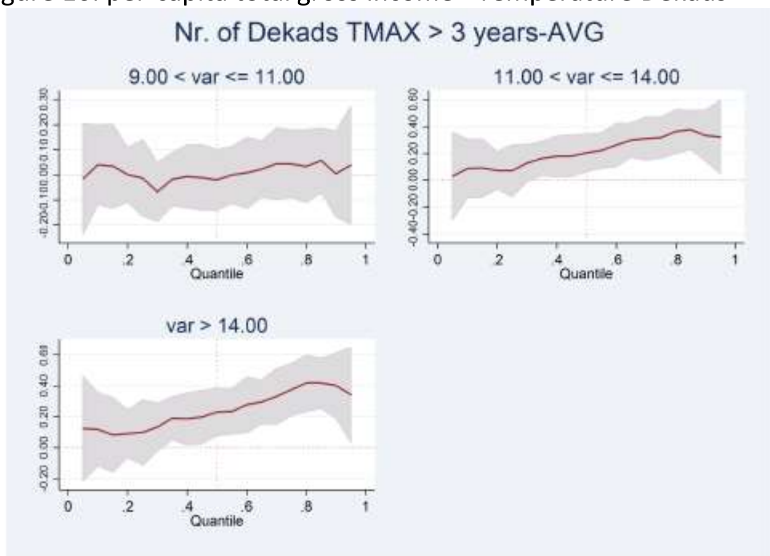


Figure 17: per-capita food expenditure - Temperature SD

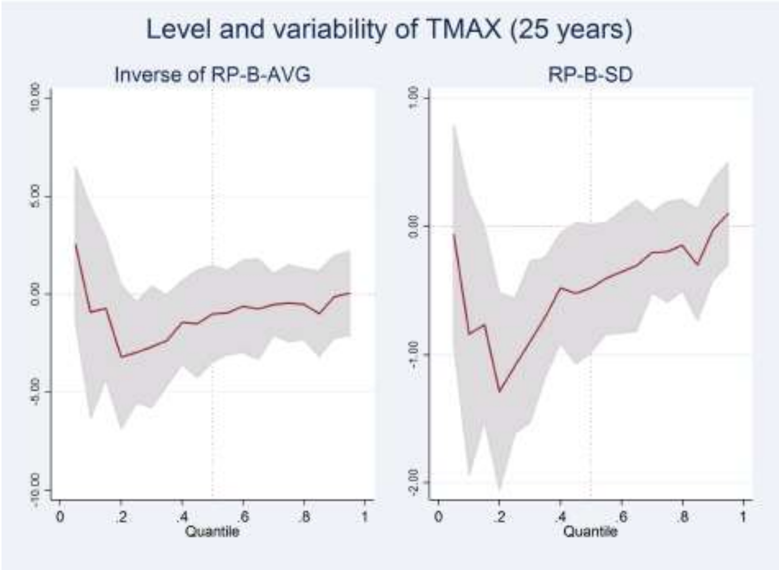


Figure 18: per-capita food expenditure - Temperature SD

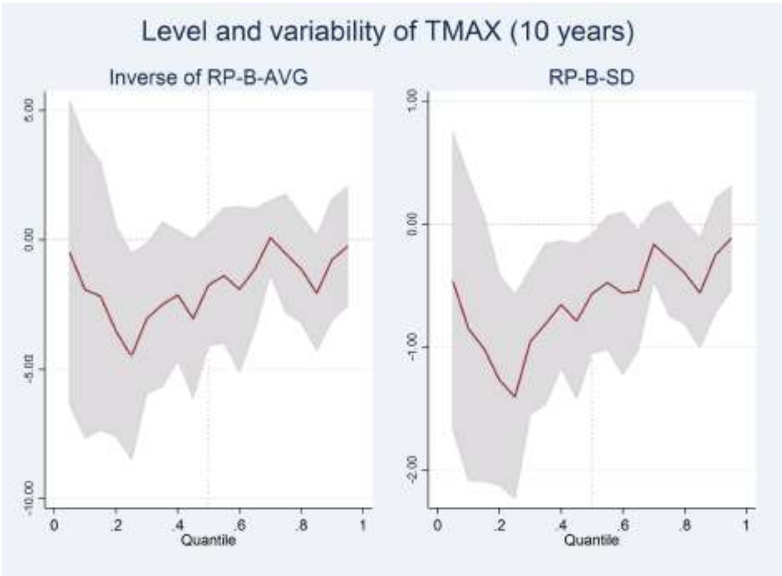


Figure 19: food expenditure’s share - Rain SD

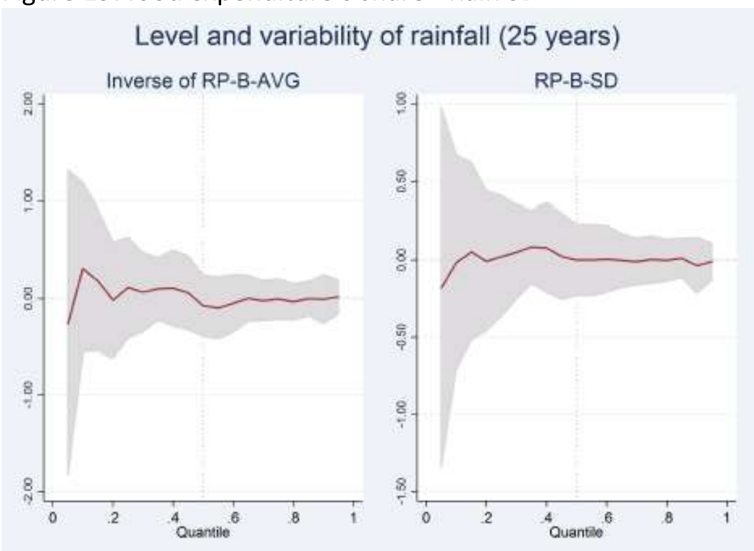


Figure 20: food expenditure's share - Temperature Dekads

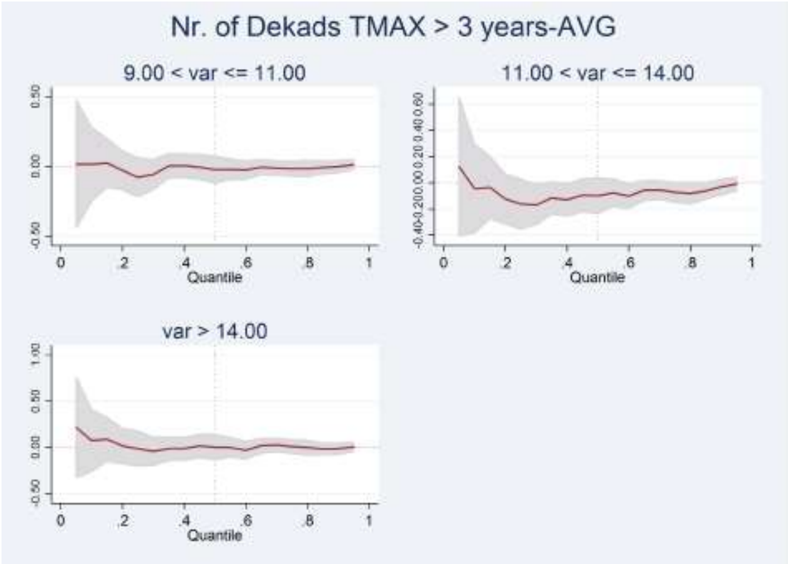


Figure 21: AVG Max Temperature (Average over waves)

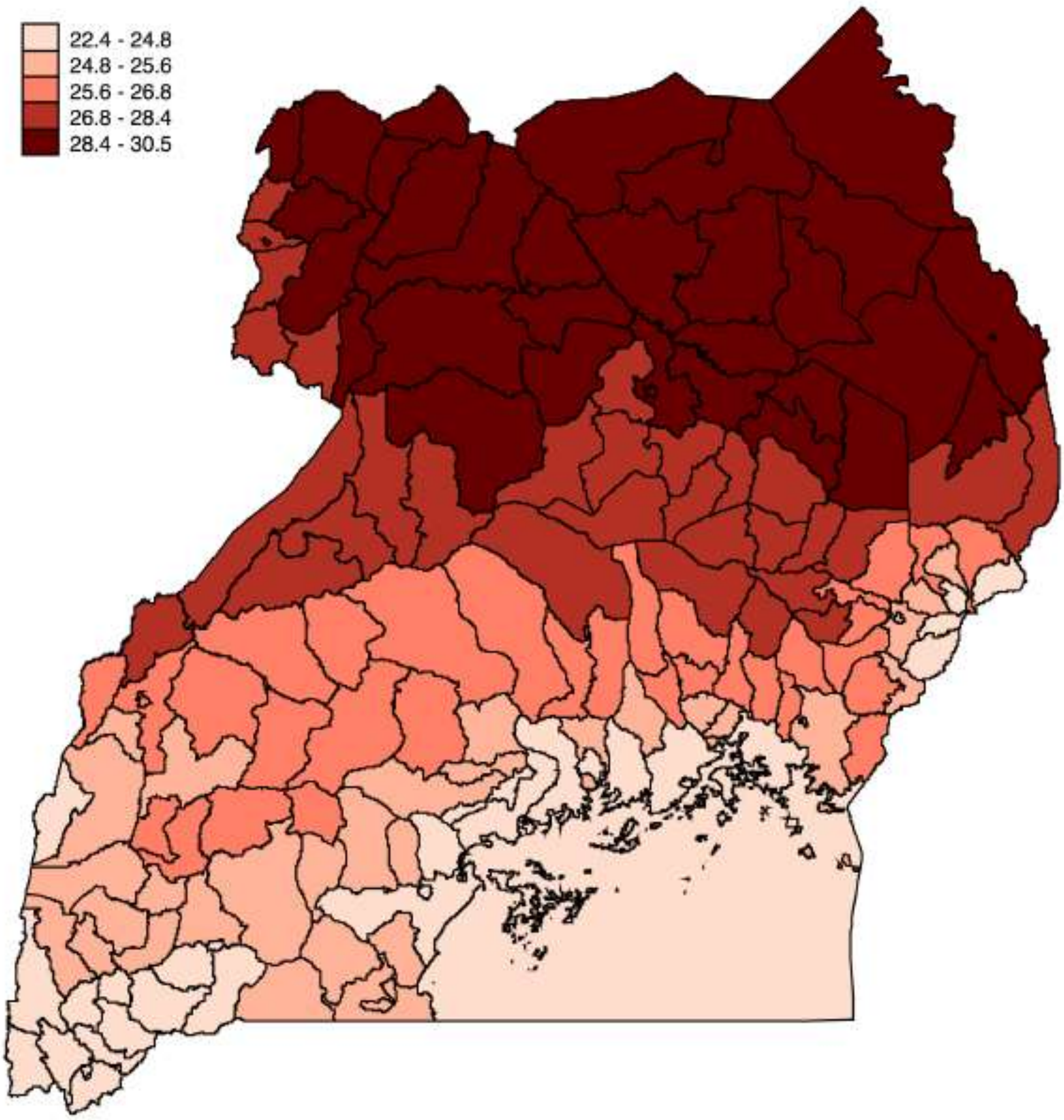
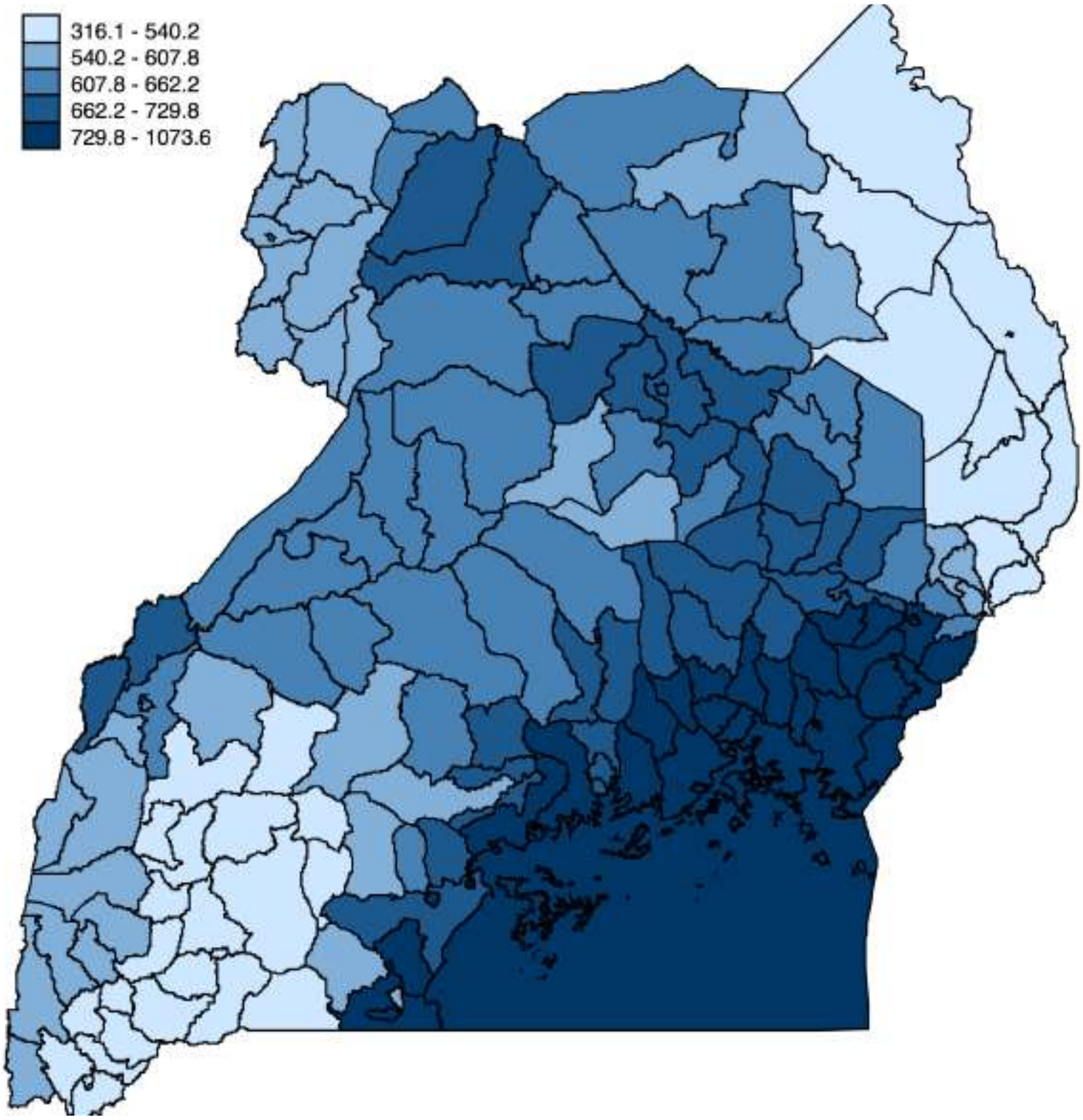


Figure 22: Total Rainfall (Average over waves)



Economics and Policy Innovations for Climate-Smart Agriculture (EPIC)
EPIC is a programme hosted by the Agricultural Development Economics Division (ESA) of the Food and Agriculture Organization of the United Nations (FAO). It supports countries in their transition to Climate-Smart Agriculture through sound socio-economic research and policy analysis on the interactions between agriculture, climate change and food security.

This paper has not been peer reviewed and has been produced to stimulate exchange of ideas and critical debate. It synthetizes EPIC's ongoing research on the synergies and tradeoffs among adaptation, mitigation and food security and the initial findings on the impacts, effects, costs and benefits as well as incentives and barriers to the adoption of climate-smart agricultural practices.

For further information or feedback, please visit:
www.fao.org/climatechange/epic

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