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Livelihood Diversification and Vulnerability to Poverty in Rural Malawi[1]

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Abstract

Climate variability, associated with farm-income variability, is recognized as one of the main drivers of livelihood diversification strategies in developing countries. Analysing determinants of livelihood diversification choices, to better understand household strategic behaviour in the event of climatic risks and other shocks, is important for the formulation of development policies in developing countries highly dependent on rain-fed agriculture, like Malawi. We use geo-referenced farm-household-level data collected in 2010-11 to investigate how climatic variability influences the pattern of diversification that farmers adopt, and the impacts of these choices on welfare. To do so we apply the "vulnerability to expected poverty" approach which measures the future level of poverty taking into consideration the role of risk and uncertainty. The analysis considers the effect of policies and institutions such as fertilizer subsidies, extension services, safety-net and credit on diversification choices. The results show that higher levels of climate risk generally increase the likelihood of diversification across labour, cropland and income, suggesting the importance of diversification as a response to constraints imposed by increased risk. In contrast, we find that in areas with favourable average rainfall conditions households are more likely to diversify income, suggesting diversification as a response to opportunities. In terms of welfare, the analysis performed on the components of vulnerability to poverty provides evidence that climatic variables are key determinants of both components of vulnerability (expected consumption and its variance). Fertilizer subsidies are found to be significant in diversification choices for all dimensions and also particularly effective in reducing vulnerability to poverty in high variability environments although the same does not hold for extension. Looking at differences across gender, we find that women labour diversification is less responsive than men's, resulting in a lower positive impact on expected consumption per capita.

Key words: Climate change, diversification, impact, Malawi

JEL Classification: Q01, Q12, Q16, Q18

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1. Introduction

The latest figures from FAO report that over 214 million people in Sub-Saharan Africa (SSA) suffer from chronic hunger (FAO, IFAD and WFP, 2014). 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% in 2010) (World Bank, 2010). In recent years, the goals of poverty alleviation and of achieving food security in SSA have been in the forefront of national and international policy agendas. The pathway to food security in many of these countries depends heavily on the growth and development of the agricultural sector, which is the dominant sector in their economies (World Bank, 2008).

Agriculture, by its very nature, is highly dependent on weather patterns, and given the very high number of people dependent on rain-fed agriculture in SSA, the implications of weather variability for poverty and vulnerability are easy to imagine. Recent evidence suggests that global climate change is likely to increase the incidence of natural hazards, as well as the variability of rainfall, temperature and other climatic parameters (IPCC, 2012). As a result, it is expected that all aspects of food security may be potentially affected by climate change, including food availability, access, utilization, and stability (e.g., Challinor *et al.*, 2010; IPCC, 2014).

Malawi is ranked as one of the world's twelve most vulnerable countries to the adverse effects of climate change (World Bank, 2010), and subsistence farmers are expected to suffer from climate-related stressors in a number of ways. These include increased exposure to extreme climate events, such as droughts, dry spells and floods, in addition to erratic and unreliable rainfall (Chinsinga, 2012). Given that agricultural production remains the main source of income for most rural communities, the increased risk of crop failure, associated with increased frequency of extreme climate events, poses a major threat to food security and poverty reduction. Adaptation of the agricultural sector to the adverse effects of climate change is thus an important priority, to protect and improve the livelihoods of the poor and to ensure food security (Bradshaw, Dolan and Smit, 2004; Wang *et al.*, 2009; Asfaw *et al.*, 2014).

Households exposed to the risks of weather and other shocks thus have significant incentives to devise strategies to adapt or cope with the effects of climate variability (e.g., Morton, 2007; Howden *et al.*, 2007). Livelihood diversification strategies, including crop, labour and income diversification, are important in these contexts, although the motivations and outcomes may vary significant. For the poorest, who have the least capacity to effectively manage risk, diversification may be a response to constraints imposed upon them by increasing climate risk. In this sense they are pushed into diversification by lack of alternatives for risk coping. In contrast, wealthier households may be pulled into diversification by the existence of welfare increasing diversification options, as well as their own capacity to access them.

In this paper, we investigate factors that affect the household's decision to diversify in cropland, labour and income, and the subsequent implications for household welfare measured by vulnerability to poverty and its components, with a particular focus on the role of different measures of climate variability. We apply the "vulnerability to expected poverty (VEP)" approach developed by Chaudhuri, Jalan and Suryahadi (2002) and Calvo and Dercon (2003) to provide a forward looking measure of poverty. Standard poverty analysis makes statements about deprivation after the veil of uncertainty has been lifted but the term 'vulnerability' has been used as a tool to remark that uncertainty and risk do matter. The main idea of VEP is to produce a measure capable of foreseeing ex-ante level of poverty taking into consideration the role of risk and uncertainty (Calvo and Dercon, 2003). We use geo-referenced farm-household-level data collected in 2010-11 for a nationally-representative sample in Malawi, from the Third Integrated Household Survey (IHS3) implemented by the Central Statistical Office of Malawi with the World Bank. This dataset is matched to historical measures of temperature and rainfall variability as proxies for weather expectations. We also combine the dataset with administrative data on policy-relevant institutions serving rural areas that can mitigate production risks, including extension services, credit providers, government-subsidized fertilizer, and government social safety-net programs.

Besides the policy implications that can be derived from the investigation of these issues, we focus on the effect of climate variability for two major reasons. The growing availability of high-quality geo-referenced data on weather allows for an important and exogenous component of risk to be measured and included in empirical models. Second, although weather 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 covariance makes weather an important determinant of income variability, which is likely to influence welfare, especially for rain-fed-dependent farm households in developing economies. Thus, by giving particular attention to climatic variability (both long-term and short-term), as a proxy for expectations about future uncertainty, we address three main questions. First, we test how long-term climate pattern, such as a) mean rainfall, b) coefficient of variation in rainfall, along with short-term rainfall anomalies, measured the deviation of rainfall for 2009-10 from its long-term average, affect the diversification choices of rural households. Second, we investigate whether climatic variability affects household welfare measured by vulnerable to poverty and its components, namely expected consumption and variance of consumption. Third, we further test the hypothesis that policy-relevant mechanisms can be effective means of reducing the negative welfare effects of local climate variability both directly and indirectly by increasing diversification strategies.

The analyses of the impact of push factors, particularly measures of long-term climate variability, are rarely taken into account in past studies. The present study contributes to filling this gap by looking at the effects of climatic shocks on a number of diversification strategies put in place by rural households in Malawi, using historical rainfall and its variability instead of less effective measures of risk such as the level of rainfall of the current or preceding period or the deviation from its mean (e.g., Ersado, 2003; Nhemachena and Hassan, 2007; Dimova and Sen, 2010). Past studies have also not disentangled the role of gender in affecting household level diversification decisions, which we address by gender differentiated analysis of the diversification decision. The present study also introduces novelty to this literature by looking at the role that institutions and policies can play in promoting desirable diversification, and avoiding diversification strategies that reduce welfare. Very few studies include policy-relevant variables in the analysis of diversification strategies[2] and even fewer investigate their interactions with climatic terms (e.g., Bandyopadhyay and Skoufias, 2013).

The remainder of the paper is organized as follows: in section 2, the most recent literature on diversification and climate variability in developing countries is reviewed and discussed. In section 3, an overview of climate variability and livelihood diversification in Malawi is provided. Data sources, survey sample composition and descriptive statistics are presented in section 4. In section 5, the conceptual framework and analytical methods are presented, with an emphasis on the empirical models and hypotheses under investigation. Econometric results are presented and discussed in section 6. Section 7 concludes with the key findings and policy implications of the study.

2. Diversification and climate variability in developing countries

Diversification in rural environments can be seen as a dynamic adaptation process in response to threats and opportunities, by which farmers can manage risk as well as gain extra income and resources, securing their livelihoods and improving their standard of living (Ellis, 1999; Ellis *et al.*, 2003). Rural households traditionally rely on diversified income portfolios (Reardon, 1997; Reardon *et al.*, 1998). Non-farm earnings in developing countries constitute around 35-50% of rural-household incomes (Reardon *et al.*, 2006; Haggblade *et al.*, 2009), and this percentage tends to be even higher for Sub-Saharan countries

[2] These are often limited to simple indicators of credit access and/or infrastructure status at the village or community level (e.g., Ersado, 2003; Babatunde and Qaim, 2009; Asmah, 2011).

(Ellis, 1999) where livelihood diversification is very commonly observed (Ellis, 2009; Barrett, Reardon and Webb, 2001; Davis *et al.*, 2010).

The literature on household motivations for livelihood-diversification strategies indicates that both push and pull factors determine the levels and types of diversification, depending on farmers' endowments and off-farm opportunities as well as other exogenous factors. Key push factors driving households towards diversification are: 1) managing risk (including market and price risks) and income variability, 2) adapting to heterogeneous agro-ecological production conditions, and 3) adapting to changing weather conditions (Lipper, Cavatassi and Keleman, 2010; Cavatassi, Lipper and Winters, 2012).

Climate variability, associated with farm-income variability, is recognized as one of the main drivers of diversification in developing countries. Engaging in activities that are less susceptible to disruption from climate impacts is one way for rural households to manage uncertainty surrounding the future effects of climate change on agricultural production (Newsham and Thomas, 2009). Mortimore and Adams (2001) include biodiversity in crop cultivation and livelihood diversification among five major elements of adaptation of dryland farmers in north-east Nigeria in the aftermath of the Sahel Drought. Ersado (2003) finds that Zimbabwean households with a more diversified income base were better equipped to withstand the unfavourable welfare impacts following the financial and weather shocks experienced by the country in the early 1990s. Using data from a farm survey undertaken in 1999-2000 in one of the driest regions of Ethiopia, Di Falco and Chavas (2009) conclude that on-farm diversification, in the form of crop-genetic diversity, enhanced productivity and reduced the risk of crop failure, and that these beneficial effects become of greater value in degraded land. Macours, Premand and Vakis (2012) present experimental evidence for a program in Nicaragua, which aimed to improve the risk-management capacity of rural households exposed to weather shocks from changes in rainfall and temperature patterns, through income diversification. Their results show that households that received a full package of interventions diversified economic activities and gained better protection from shocks, besides having higher average consumption levels. Bandyopadhyay and Skoufias (2013) combine data from a number of sources to show that self-employment in agriculture is negatively associated with high local rainfall variability in rural Bangladesh.

Diversification may, thus, be considered as a deliberate household strategy to smooth incomes or to manage risks, or it may be an involuntary response to crisis to cope with shocks (Bryceson 1996, 1999; Delgado and Siamwalla 1999; Toulmin *et al.*, 2000; Barrett, Reardon and Webb, 2001). Hence, diversification provides a safety-net for the rural poor, while the rural rich can use it as a means of asset accumulation (Ellis, 1998). In regions where rainfall variability is high, households may decide ex-ante to diversify their income to manage the risk of possible shocks. Alternatively, they can be induced, or even forced, to diversify ex-post by the same negative effects of climatic shocks (e.g., harvest shortfalls).

Diversification, as a risk-management and shock-coping strategy, may yield lower average welfare outcomes, but should lead to more income security when an extreme event does occur (Barrett, Reardon and Webb., 2001; Bandyopadhyay and Skoufias, 2013). In this sense, climate and other risks push households into diversification (Barrett, Reardon and Webb., 2001; Ellis, 2004; Reardon *et al.*, 2006). For instance, working off the farm could potentially reduce household food production due to the competition for family labour between farm and off-farm work (e.g., Huang *et al.*, 2009; Pfeiffer, López-Feldman and Taylor, 2009). Additional factors that can push households to diversify include diminishing factor returns (e.g., diminishing returns to land productivity as population increases), credit constraints, imperfect or missing factor markets, and high output-market transactions costs that disfavour specialization (Barrett, Reardon and Webb., 2001; Reardon *et al.*, 2006; Lay, Nahrloch and Omar Mahmoud, 2009).

On the other hand, livelihood diversification is considered an important strategy in the transition from subsistence to more commercial agriculture, and from poverty to higher levels of wellbeing (Pingali and Rosegrant, 1995). In this context, livelihood diversification strategies result from pull factors, such as higher wage rates and higher returns to entrepreneurial activities, which should be associated with greater economic efficiency and higher aggregate output (Bandyopadhyay and Skoufias, 2013). Economies of scope also favour diversification, as does having the ability to allocate labour to take advantage of seasonality in labour demand and the ability to diversify cropping patterns to make the most of heterogeneous land quality (Barrett, Reardon and Webb, 2001; Di Falco and Chavas, 2009). Taking advantage of pull factors often requires that the household and its members have certain assets, particularly given thin financial markets (Block and Webb, 2001). Wealthier households can more easily finance entrepreneurial activities, and more educated members have access to a wider range of job opportunities (Barrett, Reardon and Webb., 2001). Good access to markets and infrastructure, as well as proximity to urban areas, are also associated with diversification patterns (Lanjouw, Quizon and Sparrow, 2001; Fafchamps and Shilpi, 2003, 2005; Deichmann, Shilpi and Vakis, 2008; Babatunde and Qaim, 2009; Davis *et al.*, 2010; Losch, Freguingresh and White, 2011). Given these considerations, diversification of activities associated with push factors may result in lower returns and lower consumption in comparison to farm households that diversify due to pull factors (Bandyopadhyay and Skoufias, 2013).

Considering that both push and pull factors govern the household decision to allocate labour and land, it is important to investigate which of these factors plays a more vital role in the diversification choice of households and their members. Identifying which set of factors is the main driver of diversification by rural households will provide insight into the role of diversification, as a decision of necessity and survival to escape from poverty and food insecurity on the one hand, or as a choice and opportunity for improving standards of living on the other (Dimova and Sen, 2010). In particular, this latter type of evidence makes further investigation of diversification strategies desirable, in order to identify the design of policies that explicitly take into account household diversification behaviours as possible determinants of their future level of welfare (Barrett, Bezuneh and Aboud, 2001).

Almost all of the empirical evidence on rural households in SSA suggest that pull factors dominate, so that wealthier households with more educated members located in more densely populated areas are more diversified in terms of labour and income, whereas poorer farmers are more crop diversified, but less diversified in terms of income and labour (Newman and Canagarajah, 2000; Barrett, Reardon and Webb, 2001; Canagarajah, Newman and Bhattamishra, 2001; Lanjouw, Quizon and Sparrow, 2001; Babatunde and Qaim, 2009; Dimova and Sen, 2010; Asmah, 2011). Though more difficult to establish due to endogeneity issues, the empirical evidence also suggests that more diversified households have higher incomes and greater consumption per capita (Ersado, 2003; Babatunde and Qaim, 2009; Asmah, 2011).

3. Climate change and livelihood diversification in Malawi

In Malawi, agriculture is an important component of the economy; employing 85% of the labour force, accounting for about 39% of Gross Domestic Product (GDP), and providing 83% of foreign exchange earnings (Chirwa and Quinion, 2005; Chinsinga 2008). The agricultural sector is further divided into two subsectors: estates and smallholder farmers, which have very different characteristics and which perform very differently. The latter accounts for over 90% of total farms corresponding to 78% of cultivated land, which generates about 75% of total agricultural output (Chirwa and Quinion, 2005; Tchale, 2009). How Malawi's economy performs thus depends largely on how its smallholder farmers perform. It is on this agricultural subsector that this paper focuses its attention. Average farm size is about 2.7 acres, although more than 72% of smallholder farms are less than 2.5 acres, which is too small to achieve food self-sufficiency. Benin *et al.* (2008) find that Malawi is the third most densely populated country in SSA (at 1 rural people per acre of agricultural land) after Rwanda (1.7 people per acre) and Burundi (1.2 people per acre). There is a single growing season lasting between November and May, and a dry season that spans between June and October. During the dry season, only some farmers are able to make use of residual moisture in valley floors (*dambos*) in order to continue cultivation (in what are called *dimba* fields) during the dry season (Climate Change Knowledge Portal, The World Bank).[3]

The principal crops grown in Malawi are maize, cotton, tobacco, groundnut wheat, coffee, rice, sugarcane and pulses. A significant feature is the dominance of maize in farming systems. It is estimated that more than 70% of the arable land is allocated to maize production (GoM, 2006). According to Dorward *et al.* (2008), the share of farmers growing maize varies from 93% to 99% in the country's main regions. However, even though maize is the dominant crop among smallholder farmers, over the last two decades maize productivity has been unstable. Only 10% of maize growers are net sellers, with as high as 60% being net buyers (Dorward *et al.*, 2008). Thus, while agriculture and maize are critically important to the livelihoods of most Malawians, the overall productivity performance raises serious concerns about long-term viability (World Bank, 2010).

The Welfare Monitoring Survey (WMS) conducted in 2010 (ILO, 2010) defines Malawi as one of the least diversified economies in the world. It finds that 84% of the working population is employed in agriculture; 7% in wholesale and retail, including marketing and tourism; and only 1% in manufacturing and construction. An earlier, more detailed, nationally-representative survey conducted in 2008 (FinScope, reported in ILO, 2010), also finds that of the adult population, only 10% are not involved in agriculture, with the remaining share working solely on agriculture (46%) and on agriculture plus other activities (40%)

In terms of income sources, the FinScope survey, which also collected data on both primary and secondary sources of income, reports that about 50% of the households mainly derive their income from agriculture and another 25% from a second source. For contract labour (called *ganyu*), there is a large discrepancy between the WMS and FinScope survey results, likely due to seasonality and to the way in which labour is defined[4]. The former reports that *ganyu* is the main source of income for 15% of households and the second for 13%, whereas according to the WMS, *ganyu* is the main source of income for only 1% of people. Privately owned businesses are common, providing income for over 20% of households (13 and 8%), for the main and secondary sources respectively). Finally, a total of 15% of individuals receive a salary or wages, whereas other sources of income altogether do not reach 10% (ILO, 2010).

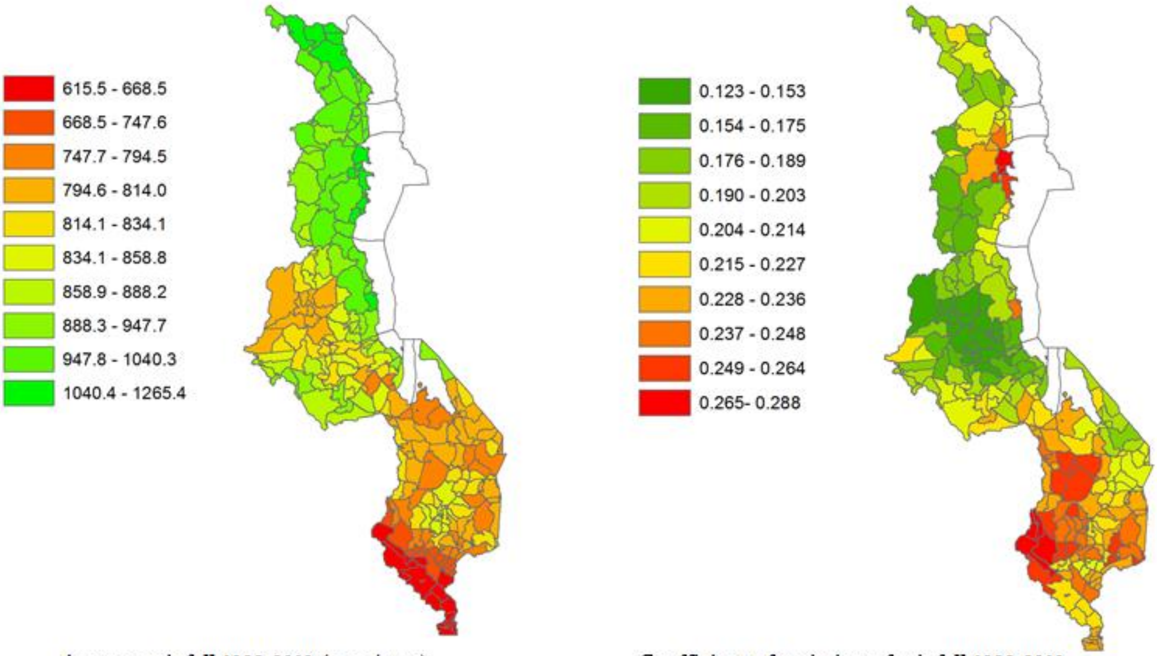
Predicted climate-change impacts in Malawi are likely to affect smallholders who depend on rainfall (Denning *et al.,* 2009). A synthesis of climate data by the World Bank indicates that in the period 1960 to 2006, mean annual temperature in Malawi increased by 0.9°C (World Bank, 2012). This increase in temperature is concentrated in the rainy summer season (December–February), and is expected to increase further. Long-term rainfall trends are difficult to characterize due to the highly variable inter-annual rainfall pattern in Malawi. It should be also noted that assessments of climate-change impacts on Malawian agriculture are highly variable across agro-ecological zones (Boko *et al.,* 2007; Seo *et al.*, 2009). Figure 1 shows the geographic distribution of long-term average and coefficient of variation of rainfall by Enumeration Area (EA) and illustrates that the Northern provinces experience relatively higher levels of rainfall, on average, as compared to the Southern and Central provinces. While across the three regions there are fairly distinct rain and climate regimes, the same is not the case for the coefficient of variation of rainfall. As the figure shows, while the Northern region has more favourable rainfall conditions, farmers are exposed to significant variability within the region. Farmers in the Southern provinces are particularly vulnerable to weather conditions given the lower amount of average rainfall combined with the highest rainfall variability. Finally, in the Central region long-term average rainfall is higher than in the South but lower than in the North although the region reports the lowest rainfall variability. The socio-economic impacts of such climatic variables on smallholder farmers are a function of their adaptive capacity and of their coping strategies (Morton, 2007). It is important to note that, for the most part, 2009-10 was a

[3] Last accessed 10 November 2014 at: http://sdwebx.worldbank.org/climateportal/index.cfm?page=country_historical_climate&ThisRegion=Africa&ThisCCode=MWI.

[4] Employment is defined as at least one hour of work during 7 days preceding the survey (ILO, GoM, 2010).

normal year with respect to rainfall, with the exception of some villages in the Central and Southern regions where rainfall was higher than the average.

Figure 1. Long-term average and coefficient of variation (CoV) of rainfall (1983-2010)



Average rainfall 1983-2010 (mm/year) **Coefficient of variation of rainfall 1983-2010**

Including climate-change into agricultural and development planning is therefore of crucial importance for a country highly exposed to climatic events and with agriculture constituting its economic cornerstone. The government of Malawi has been putting in place a range of policy programs to address challenges associated with climate change. The National Adaptation Programme of Action (NAPA), formulated in 2006, is one of the key climate-change policy documents (GoM, 2006; Chinsinga, 2012). In the agricultural sector, the Ministry of Agriculture and Food Security has attempted to operationalize NAPA priorities through the Agriculture Sector Wide Approach (ASWAp) that identifies several strategies, including diversification, meant to increase the resilience of communities in rural areas to the adverse effects of climate change (GoM, 2008; Chinsinga, 2012). In its second implementation phase, currently being formulated, the ASWAp is also seeking to harmonize the Malawian Farm Input Subsidy Program (FISP) with the Agricultural Development Program–Support Project (ADP-SP) and the Green Belt Initiative to promote more sustainable and climate-robust agricultural development in the country through improving input-use efficiency. With the implementation of the ASWAp, the government of Malawi has increased its budget share for agriculture from 6.1% in the period 2000–05 to 15.9% for 2006–09 which aims to increase further to 24% by 2015. In 2012-13, the budget was close to 20% of the national public expenditures while FISP accounts for nearly 65% of the total Ministry of Agriculture and Food Security (MoA) annual budget (budget statement 2012). However, the high costs of the FISP contribute to recent financial constraints in the country (Holden and Lunduka, 2012). The promotion of sustainable land management can be one way to ease the financial pressure of subsidizing fertilizer, by providing alternative sources of nutrients, as well as improving the efficiency of inorganic inputs.

4. Data and variable construction

4.1 Data

For the purpose of addressing the issues described above, we use three types of data: 1) socio-economic household data from the Malawi Third Integrated Household Survey (IHS3); 2) historical data on rainfall and temperature from the National Oceanic and Atmospheric Administration (NOAA) and the European Centre for Medium Range Weather Forecasts (ECMWF); and 3) community and administrative data on institutions.

The source of socio-economic data is the Malawi IHS3 survey, which was conducted from March 2010 to March 2011.[5] The IHS3 survey is a nationally-representative sample survey designed to collect information on various aspects of community and household composition, characteristics and socio-economic status, as well as agriculture-specific production characteristics. The final sample includes a total of 12,271 households, which provides district-level representativeness and a reasonable level of precision for information on socio-economic and agricultural indicators. We restrict our analysis to rural households only which brings the sample size to about 8,000 households. The total number of observations used varies across the estimations due to missing information. For instance, the male labour diversification index is created for 6552 observations, mainly due to the fact that many female-headed households (~25% of households) do not have adult males in the household.

All sampled households were administered the multi-topic Household Questionnaire, and a separate Agriculture Questionnaire. The survey team also administered a community-level survey, which captured data related to collective action, access to information, and to infrastructure, including access to markets and roads among other information.[6]

Table 1 presents descriptive statistics for the main variables of interest for this study. Of the household-related variables, the average household head is middle aged (43 years) male (about 75% of households are headed by men) with very little education (4.8 years on average). The average family is fairly balanced in gender (1.1 gender ratio) and composed of about 4 members and with a dependency ratio of 1.1. The average sampled household has very limited access to agricultural implements and consumer durables compared to maximum observed indices in the sample which indicates a high inequality in the distribution of asset ownership (given the agricultural implement access index of 0.37 and the wealth index of -0.50). The average farm size is about 2.48 acres.

Since the IHS3 survey data are geo-referenced at household and EA levels (768 EAs in IHS3), with latitude and longitude coordinates obtained through hand-held global-positioning system (GPS) devices, we are able to merge the socio-economic data with climate data. Climate data are collected from secondary sources for historical rainfall and temperature. Rainfall data are extracted from the Africa Rainfall Climatology version 2 (ARC2) of the National Oceanic and Atmospheric Administration's Climate Prediction Centre (NOAA-CPC) for each dekad (*i.e.,* 10-day intervals) covering the period of 1983-2010. ARC2 data are based on the latest estimation techniques on a daily basis an d have a spatial resolution of 0.1 degrees (~10km).[7] Temperature data are surface temperature measurements for each dekad for the period 1989 to 2010 obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF) at a spatial resolution of 0.25 degrees (~28km).[8] As mentioned earlier, we use long-term as well as short-term (proxying a shock) variables. For the former, we focus on long-term mean rainfall, which is 850 mm per year, as well as the coefficient of variation of rainfall over the period 1983-2010, which corresponds to a variation of 0.21, at national level. With regards to short-term climatic variables, we construct a measure of rainfall anomaly. It is computed as the difference between the total amount of rainfall in the 2009-10 rainy season from the long-term average rainy-season rainfall, divided by the latter.

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[5] At the time of this study, panel data was not available for the analysis.

[6] Detailed description of the survey instruments and sampling strategy is found in the Malawi IHS3 Basic Information Document. Last accessed 21 October 2014 at:http://siteresources.worldbank.org /INTLSMS/Resources/3358986-1233781970982/5800988-1271185595871/IHS3.BID.FINAL.pdf.

[7] Average of a 10km radius buffer of the dekadal sum of daily values per enumeration area centroid. For more details on ARC2 algorithms, see: http://www.cpc.ncep.noaa.gov/products/fews/AFR_CLIM/AMS_ARC2a.pdf

[8] Point extraction per enumeration area centre point of values of average of a 50km radius buffer of dekadal values.

Table 1. Descriptive summary of selected variables

	Mean	Std. Dev.	Min	Max
Climate variables				
CoV of Nov-May rainfall 1983-2010	0.211	0.035	0.123	0.288
Average of Nov-May rainfall 1983-2010 (dm)	8.5	1.065	6.096	12.654
Anomaly of Nov-May rainfall 2009-10	-0.086	0.092	-0.369	0.2
Household socio-demographic				
Age of household head (years)	42.965	16.738	15	110
Gender of household head (1=male)	0.748	0.434	0	1
Household size (Adult Equivalent [AE])	3.886	1.828	0.97	15.68
Household head highest level of education in years	4.848	3.94	0	19
Sex ratio	1.126	1.009	0	8
Dependency ratio	1.105	0.946	0	11
Number of household members hospitalized in the past 12 months	0.176	0.439	0	7
Household wealth				
Wealth index	-0.502	1.37	-1.45	12.053
Agricultural implements access index	0.374	1.378	-3.272	8.265
GPS based land size (acre)	2.479	2.571	0	44.35
Community characteristics				
In migration in the community (1=yes)	0.54	0.498	0	1
Out migration in the community (1=yes)	0.13	0.336	0	1
Irrigation scheme in the community (1=yes)	0.202	0.401	0	1
Road density in 10 km radius ('000 metres)	9.546	2.537	0	11.274
Number of months main road was passable by a lorry	9.696	3.539	0	12
ln(price of fertilizer [MKW/kg]/price of maize [MKW/kg])	1.121	0.836	-2.708	5.339
ln(wage rate for casual labour [MKW/day]/price of maize [MKW/kg])	1.63	1.161	-3.401	6.032
Institutions				
Number of agricultural extension and development officers in the district	9.546	3.9	0	22
Number of microfinance institutions in the district	2.813	1.639	0	6
Fertilizers distributed per household in the district (MT)	1.269	0.518	0.305	2.249
ln(MASAF wages paid in 2008-09 season [million MKW/household[)	0.004	0.002	0.001	0.013
Welfare indicators				
ln(total real consumption expenditure per household)	10.713	0.652	8.556	13.564
Diversification indices				
Margalef index of labour diversification, all adults	0.043	0.072	0	0.372
Margalef index of labour diversification, male adults	0.039	0.071	0	0.721
Margalef index of labour diversification, female adults	0.018	0.053	0	0.379
Margalef index of cropland diversification	0.148	0.121	0	0.826
Margalef index of income diversification	0.199	0.105	0	0.527

Lastly, we supplement these data with the community level data of the IHS by collecting survey and administrative data on farmer-relevant institutions. This capture issues related with access to information and infrastructure (including market and roads in addition to irrigation schemes and migration flows), as well as primary administrative data, for a number of government and non-government institutions, relevant for understanding enabling factors towards livelihood diversification strategies at the household level, focusing on information available at a centralized (district) level. This includes data on subsidized fertilizer distributed by district (proxy for government input support), number of agricultural extension and development officers by district (proxy for access to extension services), number of micro finance projects and institutions by district (proxy for credit availability) and total cash paid out in 2008-09 in exchange of labour from the Malawi Social Action Fund (MASAF)[9] (proxy for access to government social safety net program). For this paper most of the policy variables (hereafter defined as policy action variables) are obtained from this primary collected dataset.

The combination of the three data sets, allows us to create a unique data set to analyse if crucial factors such as climate and institutional variables play a role in household diversification decisions and if these, in turn, affect vulnerability to poverty.

4.2 Diversification indices

In the Malawian context, diversification can take place within the farm sector (diversifying into different crops, livestock, natural-resource-related activities or working on other farms) and/or in the non-farm sector (diversifying into non-farm activities such as wage employment, self-employment, transfers, rents). As discussed in section 2 above, diversification can be either a deliberate household strategy to smooth incomes or to manage risks, or it may be as a response to opportunity by the existence of welfare increasing diversification options (e.g., Barrett and Reardon, 2000; Barrett, Reardon and Webb, 2001; Ellis, 2005). Several studies analyse diversification using a vector of income shares associated with different income sources (e.g., Lay, Mahmood and M'mukaria, 2008; Davis *et al.*, 2010). For our study, we construct Margalef indices to measure household-livelihood diversification. The Margalef index (*MI*) is computed according to the following formula: $D_i = \frac{(S_i - 1)}{\ln(N_i)}$, where N_i is the total population count over all farmer-managed units of diversity options and S_i is the number of farmer-managed units of diversity for household i (namely, a count). The index has a lower limit of zero if only one unit of diversity is observed. These indices are calculated for land and labour as the two major resources of rural households, as well as for overall income. Using these indices allows us to capture a multi-dimensional perspective of household-diversification behaviour (Barrett and Reardon, 2000). [10] Table 2 shows *MI* formula's components by dimension of livelihood diversification.

Table 2. Components of Margalef index formula by dimension of livelihood diversification

	S	***N***
Cropland	Total number of crop types planted	Total area planted over all crop types
Labour	Total number of working activities performed by adult household members	Total person-hours per year worked by adult household members in all working activities
	Total number of working activities performed by adult male household members	Total person-hours per year worked by adult male household members in all working activities
	Total number of working activities performed by adult female household members	Total person-hours per year worked by adult female household members in all working activities
Income	Total number of household income sources	Total gross household income from all income sources

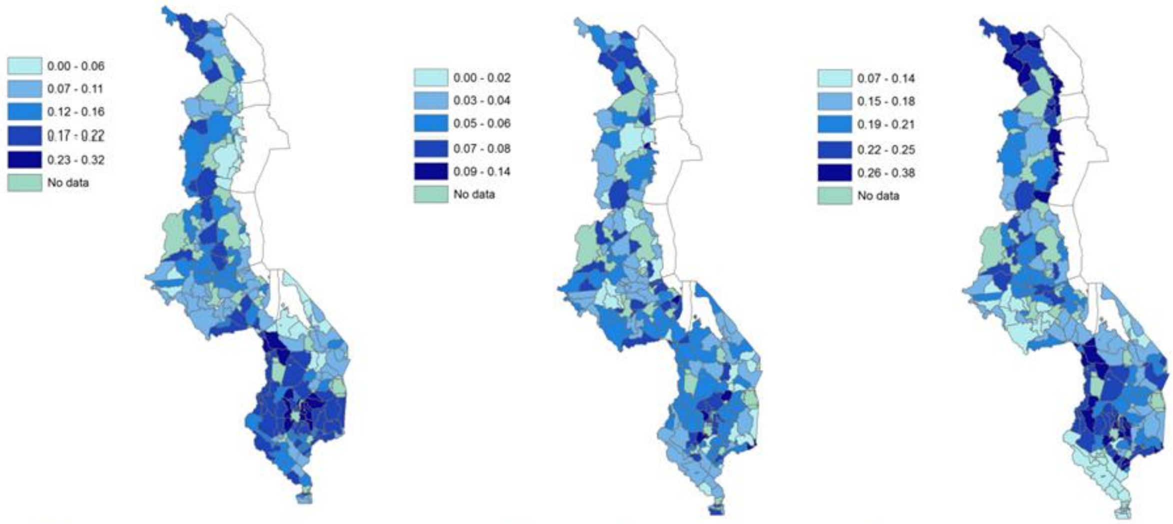
[9] The Malawi Social Action Fund (MASAF) is a project designed to finance self-help community projects and transfer cash through safety-net activities.

[10] We also constructed Berger-Parker and the Shannon-Weaver indices for land, labour and income but because the results obtained from the three specific indices to measure diversification are qualitatively very similar across cropland, labour and income, here we present results obtained using only the Margalef index. The decision to use the Margalef indices is mainly driven by the goodness of fit of the data (*i.e.*, R-square perform better for the Margalef compared to the other indices). Full estimation results for the two remaining diversification indices are available from the authors upon request.

To construct the land diversification index we use information on the number of crop types planted[11] and the area allocated during the 2009-10 agricultural season[12]. Household labour diversification is assessed with respect to the time (measured in person-hours per year)[13] allocated to three main working activities: on-farm, off-farm wage labour and self-employment in household enterprise[14]. Labour diversification indices are computed separately for males, females and the total members of the household aged more than 14 years. As to income diversification, we follow the FAO Rural Income Generating Activities (RIGA) project methodology and distinguish between nine main sources of aggregate household income[15]: farm agricultural wage, off-farm non-agricultural wage, on-farm livestock income, on-farm temporary and permanent (including trees) crop income[16], on-farm fishery income, income from self-employment in household enterprise, public and private transfers, and income from other non-labour sources.[17] Although being aware that the use of net figures would be the most appropriate choice, the presence of negative values in the net income variables led us to use gross income shares.

Figure 2 shows the distribution of labour, cropland and income diversification patterns across Malawian EAs. It is interesting to note that labour diversification does not show a clear pattern across Malawi. Cropland and income diversification tend to be higher in the central-South and income diversification is particularly low in the southern-most part of the country.

Figure 2. Labour, cropland and income diversification



Labour diversification index **Cropland diversification index** **Income diversification index**

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[11] These include local maize, improved maize, wheat, finger millet, sorghum, pearl millet, tobacco, groundnuts, ground beans, beans, soy beans, pigeon peas, peas, potatoes, rice, cotton, and *nkhwani*.

[12] All indices are constructed using data from both rainy and dry season. The rainy-agricultural season in Malawi conventionally refers to the period November-May, and the dry season refers to the period June-October (Malawi IHS3 Basic Information Document; footnote 6).

[13] We assume an average working days of 8 hours (FAO Rural Income Generating Activities Project).

[14] We did not further distinguish skilled versus unskilled wage labour mainly because of the limited number of observations for jobs that could be considered skilled.

[15] We acknowledge the similarity with labour diversification, but aggregate household income is not necessarily the same since some activities are more remunerative per unit of time than others. The main reason why we have just three categories for labour, but nine for income, is that the income data is more disaggregated.

[16] The concept of temporary crop as opposed to permanent crop is used to differentiate crop production according to the growing cycle.

[17] For additional information see http://www.fao.org/economic/riga/rural-income-generating-activities/en/.

5. Conceptual framework and analytical methods

Using the diversification variables defined in section 4, first we test the determinants of diversification, paying particular attention to potential push and pull factors. Following Van Dusen and Taylor (2005), a linear regression model is used to determine diversity as a function of initial endowments of land, household labour, household characteristics and other push and pull factors, including institutions and climatic variables, on cropland, household labour, women's labour, men's labour and income diversification of the household.

$$D_{ij} = \beta_0 + \beta_1 M_\pi + \beta_2 S_i + \beta_3 W_i + \beta_4 G_\pi + \beta_5 X_d + \varepsilon_i \quad (1)$$

where D_{ij} is the Margalef index for household i for each of the *j* diversification strategies (household labour, women's labour, men's labour, cropland and income), M_π are climatic variables at EA level, S_i are variables reflecting the various household socio-demographic characteristics, W_i include household-wealth indicators, G_π are variables that capture community characteristics at the EA level, and X_d is a vector of institution variables at the "agricultural development division" or district level[18].

As discussed in section 2, the degree to which a livelihood diversification strategy may be adopted by the household to manage risk depends on the households endowments, and thus on its ability to engage in profitable activities, on external factors such as the exposure to shocks, and on the existence of alternative means of ex-ante or ex-post risk coping, as well as on the households own risk preferences (Ellis, 2000). Push factors of household diversification choices are mainly linked to deteriorating conditions in agriculture or livelihood conditions, while pull factors are mainly linked to commercial agriculture and attractive labour market opportunities in the non-farm sector. If pull factors dominate, then livelihood diversification is likely to be more opportunistic, whereas if push factors dominate it is more likely to be a matter of survival or to avoid distress (Dimova and Sen, 2010). We summarize both push and pull factors hypothesized to explain the diversification and resulting welfare outcome under five major categories.

The first set of variables used in the analysis is comprised of climatic variables that characterize the exposure of households to climate-related stresses, and represent push factors. As mentioned in section 4, we use the coefficient of variation of rainfall as a proxy for expectations about future uncertainty. We also include long-term average rainfall as well as the current period rainfall anomaly; the latter to capture farmers' response to current period rainfall shocks. [19] Greater riskiness, reflected in the coefficient of variation of rainfall, is expected to push households to increase diversification, as is the current period anomaly, to the extent that the household can re-allocate resources in response to a rainfall shock.

The second set of variables captures socio-demographic characteristics and include household size, age of the household head, gender of the household head, household composition variables (sex ratio and dependency ratio), and education level of the household head. Family size in terms of adult-equivalent units is a potential indicator of labour supply for both on-farm and off-farm activities, which should favour diversification. On the one hand, older and female-heads, as well as households with higher domestic time requirements may find it more difficult to take advantage of off-farm opportunities when available, but such households may also be more vulnerable to risks, and so the signs on these variables are ambiguous a priori. We expect education to positively affect the diversification decision as more educated family members tend to look for off-farm labour opportunities as well as for a more diversified

[18] We suppress *i* and *j* subscripts for the supra-household variables so that the notation is less cluttered.
[19] We excluded temperature variables from our estimation due to multicollinearity problems with rainfall; high temperatures are highly correlated with low rainfall.

crop production. The third set of variables capturing household wealth include a wealth index[20] based on durable-goods ownership and housing condition, an agricultural-machinery index based on agricultural implements and machinery ownership, and land size. Household wealth is often considered as a pull factor to the diversification decision and as a result we expect a positive sign for these variables. However it can also be the case that wealthy household specialize on few activities to maximize their welfare, thus the sign of these coefficient is an empirical question.

The fourth set of variables considered as main determinants governing the diversification decision are related to community characteristics, particularly transaction costs. Transaction costs have been used as definitional characteristics of smallholder farmers and as a crucial factor responsible for market failures in developing countries (Sadoulet and de Janvry, 1995). However, they pose challenges related to measurement. Therefore, this study uses proxies for transaction costs via observable factors that capture transaction costs, such as distance to district centres, road density, the number of months the main road was passable by a lorry, and output and input prices (*i.e.*, price of fertilizer and agriculture wage labour, deflated by the price of maize). By increasing travel time and transport costs, transaction cost variables are expected to have an influence on diversification. Additionally, we control for other community characteristics, including whether there is an irrigation scheme within the community, and the extent of out-migration captured at the community level, as well as the extent of in-migration.

The last set of variables captures the institutional environment, and includes the density of agriculture extension agents, the number of formal credit sources, the amount of fertilizer distributed per household in the year preceding the survey, and the total amount of social safety net payments made per household. Density of extension agents is at the "agricultural development division" level, which is generally sub-district, and the remaining variables are at the district level. While policy actions by government and donor communities that increase household access to these institutions cannot directly r educe climate variability, extra resources made available through policy actions may help households either moderate the ex-ante climate risk or manage it ex-post, reducing risk management and coping benefits from diversification. On the other hand access to these institutions can also enable households to take advantage of pull factors. For example, access to subsidized fertilizer reduces crop income risk, but may also free up resources that the household can then allocate to different activities. Thus, a priori, the impact on diversification is ambiguous.

After investigating factors associated with diversification, we address our second research question by looking at the effect of climatic variables on the probability that the household becomes vulnerable to poverty, measured by the components of vulnerability to poverty namely expected consumption and variance of consumption, following Chaudhuri, Jalan and Suryahadi (2002). Most previous studies have measured household poverty-status variables such as income and consumption, while taking into account the role of risks a household faces, as well as its ability to mitigate and cope. However, these poverty measures are often subject to measurement error and generally are unable to distinguish whether poverty is transient or deeply structural (Carter and Barrett, 2006). Liverpool-Tasie and Winter-Nelson (2011), note that the asset-based poverty classifications predicts future asset and expenditure poverty status more accurately than expenditure-based measures. As assets and their returns

[20] The household-wealth index is constructed using principal component analysis. In this specific case, the following variables have been included: number of (per-capita) rooms in the dwelling, a set of dummy variables accounting for the ownership of dwelling, mortar, bed, table, chair, fan, radio, tape/CD player, TV/VCR, sewing machine, paraffin/kerosene/electric/gas stove, refrigerator, bicycle, car/motorcycle/minibus/lorry, beer brewing drum, sofa, coffee table, cupboard, lantern, clock, iron, computer, fixed phone line, cell phone, satellite dish, air-conditioner, washing machine, generator, solar panel, desk, and a vector of dummy variables capturing access to improved outer walls, roof, floor, toilet, and water source. The household agricultural-implement-access index is also computed using principal components analysis and covers a range of dummy variables on the ownership of hand hoe, slasher, axe, sprayer, panga knife, sickle, treadle pump, watering can, ox cart, ox plough, tractor, tractor plough, ridger, cultivator, generator, motorized pump, grain mail, chicken house, livestock kraal, poultry kraal, storage house, granary, barn, and pig sty.

are crucial factors that determine the wellbeing of poor households, our paper incorporates the concept of asset poverty as proposed by Carter and Barrett (2006) into expected poverty to better reflect the temporal nature of poverty.

To introduce the asset-based-vulnerability concept we establish a functional relationship between household consumption and total household assets, taking climatic risk explicitly into account. In the absence of panel data, most previous papers have used cross-sectional data to estimate the vulnerability to poverty of a household as per estimation procedures proposed by Chaudhuri, Jalan and Suryahadi (2002). Using a similar approach, we specify the consumption of household i given by:

$$\ln(C_i) = \gamma_0 + \gamma_1 M_\pi + \gamma_2 S_i + \gamma_3 W_i + \gamma_4 G_\pi + \gamma_5 X_d + \gamma_6 (M_\pi * X_d) + u_i \quad (2)$$

where $\ln(C_i)$ is the log of per adult equivalent consumption M_π, S_i, W_i, G_π and X_d are variables defined above including a number of assets that are likely to shape a household's future well-being such as human, physical, natural and social capital. We also include a term to capture the interaction between climatic variables and institutional variables, to determine whether such institutions act as buffers to consumption, effectively ameliorating impacts of climate shocks on consumption. Allowing for the error term from the OLS regression, u_i, to be heteroskedastic, following Chaudhuri, Jalan and Suryahadi (2002) and Christiaensen and Subbarrao (2005), we use a three-step feasible generalized least square (FGLS) procedure to recover the unbiased estimates of conditional expected consumption per capita $(E(\ln(C_i)|X_i))$ and the conditional variance of consumption $(V(ln(C_i)|X_i))$, a method first proposed by Just and Pope (1979).

We note that the three-step procedure allows us to examine which factors affect expected consumption as well as the variance of consumption, both of which determine a household's vulnerability to poverty. So, we are particularly interested in factors that increase expected consumption and reduce the variance of consumption.

Finally we undertake exploratory analysis to look at the correlation between diversification and household welfare. Due to potential multicollinearity problems between the three diversification indices (*i.e.*, labour, cropland and income), we introduce the diversification variables consecutively as well as simultaneously, e.g.:

$$\ln(C_i) = \varphi_0 + \varphi_1 M_\pi + \varphi_2 S_i + \varphi_3 W_i + \varphi_4 G_\pi + \varphi_5 X_d + \varphi_6 (M_\pi * X_d) + \varphi_7 D_{ij} + v_i \quad (3)$$

and then apply the same three-stage least squares procedure.

6. Econometric results

6.1 Determinants of diversification

Table 3 presents results from the OLS estimates of the determinants of labour, cropland and income diversification. The results show that the coefficient of variation of rainfall generally leads to greater diversification across labour, cropland and income indicating that rainfall riskiness is a push factor for these indices. Higher mean rainfall is also associated with greater diversification of income, but not for cropland diversification, as one would expect, nor for labour. This indicates that more favourable average rainfall conditions are a pull factor that enables households to secure income from a wider range of sources. A higher rainfall anomaly experienced in the last season reduces income diversification, indicating that households cannot respond quickly to current shocks. It is important to point out that, during that particular season, the anomaly itself was generally moderate, since the rainfall in that year was "close to" normal across Malawi. This suggests that households are not pursuing diversification strategies, in terms of crops and income, to manage moderate shocks.

Results also show that households with older heads are generally less diversified. Male-headed households have higher total labour diversification, but have less diversified income sources and cropland use. Wealthier households, in terms of cropland, agricultural assets, and education, have greater levels of diversification, indicating that these are all pull factors. The one exception is the wealth index based on consumer durables, which has a negative effect on cropland and income diversification. With respect to transactions costs, only the number of months that the main road was passable by a truck has a statistically significant impact, being positive in total labour, male labour and income, indicating that lower costs favour labour and income diversification. An irrigation scheme, which should be associated with less risky crop production, decreases labour and cropland diversification, as expected.

With respect to institutions, results show that the availability of extension has a positive impact on all diversification measures, indicating that extension information acts as a pull factor, enabling farmers to take advantage of both on and off-farm opportunities. Availability of fertilizer subsidies per capita also increases cropland and income diversification. Availability of social safety nets and credit – both of which can help farmers to cope with poor weather ex post – reduce cropland diversification; credit availability also reduces income diversification. On the other hand, credit availability also increases labour diversification, indicating that such availability helps farmers secure off-farm income sources. The negative impact on income diversification and positive impact on labour diversification is likely driven by the fact that income diversification includes five different on-farm income sources, whereas labour diversification only has one on farm labour category.

Looking at the heterogeneous impact across gender of household members, it is interesting to note that female and male labour diversification appears to perform similarly for the most part, though the coefficients generally show that female labour is less responsive than male labour. A major difference occurs when the head of household is male, which has a positive impact on male labour diversification but a negative impact on female labour diversification. Household size has no impact on male labour diversification, but a strong and positive impact on female diversification, indicating that women's labour supply off-farm is more constrained by availability of household labour. On the other hand, whether a household member had been hospitalized in the past 12 months has a significant positive impact on male labour diversification, but no impact on female labour diversification. This is consistent with the impact of household size on women's diversification, where fewer members constrain their ability work off-farm.

Table 3. Determinants of diversification and the role of climate variability

	Labour			Land	Income
	Total	Male	Female		
Climate variables					
CoV of Nov-May rainfall 1983-2010	1.570***	1.083***	0.785***	3.946***	3.438***
	(0.378)	(0.396)	(0.243)	(0.767)	(0.623)
Average of Nov-May rainfall 1983-2010 (dm)	0.003	0.005	-0.000	0.005	0.230***
	(0.014)	(0.014)	(0.009)	(0.025)	(0.021)
Anomaly of Nov-May rainfall 2009-10	0.079	0.168	0.077	0.352	-0.755***
	(0.128)	(0.129)	(0.092)	(0.266)	(0.224)
Household socio-demographic					
Age of household head (years)	-0.003***	-0.003***	-0.002***	-0.003***	-0.000
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Gender of household head (1=male)	0.048**	0.181***	-0.170***	-0.115***	-0.066**
	(0.020)	(0.021)	(0.018)	(0.032)	(0.029)
Household size (Adult Equivalent [AE])	0.019***	0.002	0.019***	0.004	0.065***
	(0.005)	(0.006)	(0.004)	(0.008)	(0.007)
Household head highest level of education	0.017***	0.014***	0.004**	0.019***	0.013***
	(0.003)	(0.003)	(0.002)	(0.004)	(0.004)
Sex ratio	-0.003	-0.003	-0.005	-0.008	-0.000
	(0.008)	(0.009)	(0.007)	(0.012)	(0.012)
Dependency ratio	-0.002	0.004	0.005	0.026*	0.005

	(0.008)	(0.011)	(0.007)	(0.015)	(0.012)
Number of household members hospitalized in the past 12 months	0.046**	0.040**	0.020	0.021	0.100***
	(0.019)	(0.020)	(0.016)	(0.033)	(0.026)
Household wealth					
Wealth index	0.088***	0.083***	0.059***	-0.048***	-0.026**
	(0.009)	(0.009)	(0.007)	(0.012)	(0.011)
Agricultural implements access index	0.010	0.013	0.002	0.133***	0.170***
	(0.008)	(0.008)	(0.006)	(0.013)	(0.011)
GPS based land size (acre)	0.001	0.002	0.001	0.189***	0.067***
	(0.003)	(0.003)	(0.003)	(0.011)	(0.006)
Community characteristics					
In migration in the community (1=yes)	0.029	0.027	0.009	-0.084	0.012
	(0.026)	(0.027)	(0.017)	(0.057)	(0.044)
Out migration in the community (1=yes)	0.037	0.032	-0.010	0.004	-0.026
	(0.036)	(0.036)	(0.024)	(0.084)	(0.060)
Irrigation scheme in the community (1=yes)	-0.052**	-0.043	-0.030*	-0.140***	-0.072
	(0.025)	(0.027)	(0.017)	(0.053)	(0.049)
Road density in 10 km radius ('000 metres)	0.004	0.004	0.001	0.010	-0.000
	(0.004)	(0.004)	(0.003)	(0.009)	(0.008)
Number of months road was passable by a lorry	0.007**	0.008***	0.003	-0.004	0.010*
	(0.003)	(0.003)	(0.002)	(0.006)	(0.005)
ln(price of fertilizer [MKW/kg]/price of maize [MKW/kg])	0.027	0.016	0.014	0.134***	0.126***
	(0.020)	(0.020)	(0.013)	(0.036)	(0.034)
ln(wage rate for casual labour [MKW/day]/price of maize [MKW/kg])	-0.010	-0.002	-0.006	-0.070***	-0.147***
	(0.013)	(0.012)	(0.011)	(0.019)	(0.021)
Institutions					
Number of agricultural extension and development officers in the district	0.009***	0.006**	0.004*	0.017***	0.022***
	(0.003)	(0.003)	(0.002)	(0.007)	(0.005)
Number of microfinance institutions in the district	0.019**	0.015**	0.010*	-0.105***	-0.046***
	(0.008)	(0.007)	(0.005)	(0.015)	(0.012)
Fertilizers distributed per household in the district (MT)	-0.021	-0.023	0.012	0.139***	0.110**
	(0.027)	(0.028)	(0.017)	(0.050)	(0.047)
ln(MASAF wages paid in 2008-09 season [million MKW/household])	1.837	6.688	-1.774	-26.823***	12.854
	(4.810)	(5.000)	(3.264)	(9.260)	(8.385)
Constant	-0.196	-0.196	0.035	0.138	-1.525***
	(0.177)	(0.176)	(0.119)	(0.346)	(0.270)
Observations	7,862	6,552	7,327	7,255	7,768
R-squared	0.082	0.075	0.047	0.260	0.200

Note: Robust standard errors in parentheses based on EA level clusters. *** p<0.01, ** p<0.05, * p<0.1.

6.2 Effects of climate risk on household welfare

Table 4 presents results from the OLS estimates of the effects of climate variability on components of vulnerability to poverty (*i.e.*, variability of consumption $(\mathrm{V}(C_i))$ and expected value of consumption $(\mathrm{E}(C_i))$). Results in the "Without interaction" (with policy variables) columns show that consumption per capita is lower in environments with greater climate variability (*i.e.*, the coefficient of variation of rainfall is negative and significant). This is consistent with the hypothesis that rural households facing uninsured weather shocks pursue strategies to reduce risk, even when such strategies have a negative impact on mean consumption. The effect on variance of consumption is however negative which is counterintuitive. Higher mean rainfall is associated with higher per capita consumption. A higher rainfall anomaly experienced in the last season reduces consumption per capita and increases variance of consumption, with an unambiguous increase in the vulnerability to poverty. This result is consistent with the hypothesis that households cannot completely absorb current-period shocks.

In general, those with greater household wealth have higher consumption levels and lower variability of consumption suggesting being less vulnerable to poverty, as expected. Access to institutions such as extension, credit, and fertilizer subsidies all increase per capita consumption. However it's only access to fertilizer subsidies that also reduces variance of consumption, which clearly reduces vulnerability to poverty for all households.

Table 4 also reports results of policy-action variables (in the "Interaction with policy variables" columns) in terms of helping households either to mitigate the ex-ante climate risk or manage them ex-post, reducing the negative effects of high rainfall variability on welfare. The coefficients of interaction terms of rainfall variability with access to extension, credit and fertilizer subsidy are positive though only significant for the fertilizer subsidy. Note that in this specification, the direct impact of fertilizer subsidies is now negative on consumption, though the net effect is positive, indicating that these subsidies are particularly effective in high variability environments. Similarly, the direct impact of the fertilizer subsidy on the variance of consumption increases variance, thought the net impact reduces the variance in consumption in high variability environments. On the other hand, the presence of extension agents is effective in reducing the variance, but overall the impact is ineffective for most of the sample, since it increases the variance of consumption leading to higher vulnerability in high variability environments. The latter indicates a real opportunity to refocus extension activities and information flows in high variability environments so that impacts of the extension system not only increase average outcomes, but also decrease the variance of those outcomes.

Table 4. Effect of climate variability on vulnerability components: variance of consumption and expected consumption per capita

	Without interaction		Interaction with policy variables	
	Variance	Expected consumption	Variance	Expected consumption
Climate variables				
CoV of Nov-May rainfall 1983-2010	-0.349***	-0.984***	-0.622	-2.854***
	(0.132)	(0.192)	(0.522)	(0.757)
Average of Nov-May rainfall 1983-2010 (dm)	0.001	0.050***	0.005	0.040***
	(0.005)	(0.007)	(0.005)	(0.008)
Anomaly of Nov-May rainfall 2009-10	0.238***	-0.608***	0.229***	-0.577***
	(0.047)	(0.067)	(0.049)	(0.070)
Household wealth				
Wealth index	0.003	0.207***	0.003	0.207***
	(0.003)	(0.004)	(0.003)	(0.004)
Agricultural implements access index	-0.015***	0.047***	-0.016***	0.048***
	(0.003)	(0.004)	(0.003)	(0.004)
GPS based land size (acre)	-0.000	0.012***	-0.000	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)
Institutions				
Number of agricultural extension and development officers in the district	0.003***	0.014***	-0.014**	0.010
	(0.001)	(0.002)	(0.006)	(0.009)
Number of microfinance institutions in the district	0.005*	0.028***	-0.019	0.003
	(0.003)	(0.004)	(0.016)	(0.023)

Fertilizers distributed per household in the district (MT)	-0.025***	0.074***	0.105*	-0.147*
	(0.009)	(0.013)	(0.060)	(0.087)
ln(MASAF wages paid in 2008-09 season [million MKW/household])	-0.880	4.297	-3.760	16.097
	(1.806)	(2.624)	(11.604)	(16.700)
Institutions*Climate variables				
Extension service*CV rainfall			0.083***	0.019
			(0.028)	(0.042)
Microfinance*CV rainfall			0.120	0.133
			(0.078)	(0.113)
Fertilizer distributed*CV rainfall			-0.617**	1.054**
			(0.283)	(0.410)
Safety-net*CV rainfall			11.891	-43.975
			(48.162)	(69.501)
Observations	8,009	8,009	8,009	8,009
R-squared	0.019	0.451	0.021	0.452

Full estimation results are in the Appendix, see Table A.1.
Note: Robust standard errors in parentheses based on EA level clusters. *** p<0.01, ** p<0.05, * p<0.1.

6.3 Relation between diversification and household welfare

We conclude our empirical analysis with an exploratory analysis of the extent to which livelihood diversification is a significant pathway by which climate variability affects household welfare. To test this hypothesis, we estimate a structural equation whereby welfare is specified as a function of three diversification indices (*i.e.*, labour, cropland and income)[21] and other factors including climatic variables. Many previous studies have shown that, in the context of subsistence agriculture as is the case of Malawi, climate variability reduces adoption of certain inputs and has a corresponding negative impact on crop yields (e.g., Asfaw *et al.*, 2014), which implies a direct negative effect on consumption per capita if output markets are missing or incomplete. In this paper, we establish that climate variability also has an impact on diversification (see Table 3). Thus, the ultimate impact of climate variability on consumption is through on-farm income (*i.e.*, yields, prices) as well as through diversification. Introducing the diversification indices in our structural equation would then not necessarily mean we would exclude the climate variability variables since these capture additional, non-diversification, effects that we know are important from other studies. We also recognize the potential endogeneity of diversification indices in the structural welfare equation, which ideally, should be accounted for using instrumental variable (IV) techniques.[22] However, due to the concerns about the bias associated with the use of weak instruments and the similarity of results between IV and OLS estimates, we rely on OLS estimation and simply report the unconditional and conditional correlation between diversification and consumption/vulnerability.

[21] Given the potential correlation between the three indices, we have also attempted to introduce the indices sequentially (one index at a time) instead of introducing them simultaneously but the final results don't change.
[22] We have attempted to use the climatic variables (coefficient of variation of rainfall and anomaly) as identifying instruments but the tests (the weak identification test and over identification test) do not support the validity of our identification restrictions. The F-statistic of joint significance of the excluded instruments is less than 10, thus failing the test for weak instruments. The null hypothesis in the case of the over identification test is that the selection instruments are not correlated with the welfare error term and we reject the null in all the cases.

Table 5. Effect of diversification on vulnerability components: variance of consumption and expected consumption per capita

	Labour, total		Labour, males and females		Cropland		Income		All three indices	
	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption
Diversification indices										
Margalef index of labour diversification, all adults	0.013	0.718***							0.152**	0.679***
	(0.055)	(0.079)							(0.059)	(0.086)
Margalef index of labour diversification, male adults			0.033	0.784***						
			(0.061)	(0.091)						
Margalef index of labour diversification, female adults			0.014	0.556***						
			(0.084)	(0.123)						
Margalef index of cropland diversification					-0.048	0.246***			-0.010	0.168***
					(0.036)	(0.053)			(0.037)	(0.054)
Margalef index of income diversification							-0.188***	0.406***	-0.155***	0.351***
							(0.039)	(0.057)	(0.043)	(0.063)
Climate variables										
CoV of Nov-May rainfall 1983-2010	-0.337**	-1.042***	-0.308**	-1.303***	-0.244*	-1.051***	-0.334**	-1.072***	-0.252*	-1.202***
	(0.132)	(0.193)	(0.143)	(0.213)	(0.136)	(0.199)	(0.133)	(0.195)	(0.135)	(0.200)
Average of Nov-May rainfall 1983-2010 (dm)	0.001	0.050***	0.002	0.057***	-0.003	0.046***	0.005	0.039***	0.000	0.036***
	(0.005)	(0.007)	(0.005)	(0.008)	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)	(0.007)
Anomaly of Nov-May rainfall 2009-10	0.237***	-0.611***	0.211***	-0.664***	0.214***	-0.651***	0.224***	-0.579***	0.204***	-0.625***
	(0.047)	(0.067)	(0.050)	(0.074)	(0.048)	(0.069)	(0.048)	(0.068)	(0.049)	(0.070)
Household wealth										
Wealth index	0.005	0.200***	0.002	0.186***	0.003	0.201***	0.003	0.208***	0.001	0.193***
	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.005)
Agricultural implements access index	-0.015***	0.047***	-0.013***	0.064***	-0.011***	0.067***	-0.013***	0.041***	-0.008**	0.064***
	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)

GPS based land size (acre)	-0.001	0.012***	0.000	0.015***	0.001	0.011***	0.001	0.010***	0.002	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Institutions										
Number of agricultural extension and development officers in the district	0.003**	0.013***	0.003**	0.012***	0.003***	0.014***	0.003***	0.013***	0.003***	0.013***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Number of microfinance institutions in the district	0.006**	0.026***	0.003	0.025***	0.006**	0.028***	0.004	0.030***	0.005**	0.028***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Fertilizers distributed per household in the district (MT)	-0.027***	0.080***	-0.027***	0.062***	-0.016*	0.060***	-0.024**	0.068***	-0.019*	0.055***
	(0.009)	(0.013)	(0.010)	(0.015)	(0.010)	(0.014)	(0.009)	(0.013)	(0.010)	(0.014)
ln(MASAF wages paid in 2008-09 season [million MKW/household])	-0.514	4.013	-2.160	2.534	-0.758	4.168	-0.170	3.548	0.108	3.670
	(1.801)	(2.624)	(1.901)	(2.863)	(1.844)	(2.679)	(1.814)	(2.659)	(1.832)	(2.695)
Observations	7,862	7,862	6,017	6,017	7,255	7,255	7,768	7,768	7,023	7,023
R-squared	0.019	0.455	0.016	0.448	0.018	0.434	0.023	0.453	0.019	0.443

Full estimation results are in the Appendix, see Table A.2.

Note: Robust standard errors in parentheses based on EA level clusters. *** p<0.01, ** p<0.05, * p<0.1.

As discussed in the earlier sections, diversification due to push factors can lead to worse welfare outcomes. On the other hand, diversification due to pull factors can lead to better welfare outcomes. The ultimate effect of diversification on welfare thus depends on the weight of these two factors. The OLS results show that higher climate variability increases diversification, but also leads to lower, though more stable, consumption. We also find positive impacts of household capital and access to institutions on both diversification and consumption per capita, which are consistent with this hypothesis. Results from Table 5 also show that the correlation between all three measures of diversification (*i.e.*, labour, cropland and income) and consumption per capita are positive, indicating that pull factors outweigh push factors in current consumption levels. Income diversification is also negatively correlated with consumption variability and thus unambiguously reducing vulnerability to poverty. Labour and cropland diversification both lead to higher current consumption with no impact on the variance of consumption, and thus lead to lower levels of vulnerability. Finally, in terms of differences across gender, the positive effect of diversification on expected consumption is higher for male than female labour, and the difference is statistically significant. This is consistent with earlier results from Table 3 where we see that female labour diversification is less responsive than men's.

7. Conclusions and policy implications

This paper investigates factors that influence labour, cropland and income diversification decisions by smallholder rural households, and the subsequent impacts on their welfare, with a particular focus on the impact of climate variability. We distinguish between "push" and "pull" factors influencing diversification, with the former referring to constraints forcing diversification, and the latter to enabling conditions that incentivize diversification. We use geo-referenced farm household-level data collected in 2010-11, from a nationally-representative sample in Malawi, via the Third Integrated Household Survey (IHS3). This dataset is combined with historical measures of temperature and rainfall variability as proxies for current weather expectations. We also merge the dataset with administrative data on policy-relevant institutions serving rural areas that can mitigate production risks, including extension services, credit providers, government-subsidized fertilizer, and government social safety-net programs.

The analysis generates three important findings relevant for the emerging body of literature on diversification and climate risk: 1) climate variability related effects as well as a number of pull factors are important determinants of the diversification options farmers choose, and these effects are quite heterogeneous across gender lines, 2) both climate as well as institutional factors are important determinants of expected consumption and variance of consumption, and 3) income diversification has the strongest positive association with higher expected consumption and lower variance of consumption compared to labour and land diversification.

The first finding is based on the analysis of various climate related variables over time and space for Malawi which indicate highly heterogeneous distribution of effects even within a relatively small country. These climate effects have important impacts on farmer diversification choices and ultimately on their welfare. The results show that long-term climate variability increases the likelihood of household diversification across labour, cropland and income, indicating that rainfall riskiness is an important push factor for all three measures of diversification. On the other hand, contrary to our expectation, more favourable average rainfall conditions are found to pull households towards securing income from a wider range of sources. Recent period climatic shocks are associated with a reduction in income diversification, indicating that households cannot respond quickly to them. Variables associated with household's wealth, are also key pull factors. In particular, labour diversification is higher where consumer durables are higher, whereas cropland and income diversification are higher where agricultural assets are higher. In terms of policy relevant institutions, a larger presence of extension agents at the district level favours diversification across all dimensions. Labour diversification is also favoured by better access to credit, whereas fertilizer subsidy programs increase both land and income diversification.

Our second major set of findings relates to whether climatic variability affects household welfare and weather policy-relevant mechanisms can be an effective means of mitigating the negative welfare effects of local climate variability both directly and indirectly by affecting diversification strategies. Our results show that climatic variables are key determinants of both expected consumption per capita and its variance. In particular, long-term rainfall variability has a strong and unambiguously negative impact on rural households' vulnerability. Fertilizer subsidies are found to be particularly effective in increasing expected consumption and reducing its variance in high variability environments. In contrast, we find that extension, safety nets and credit are not effective in mitigating the negative impacts on stability of consumption in high variability environments.

The third major area of findings from this paper relate to the association between diversification choices and household welfare. The results suggest that policy interventions that enable farmers to pursue income diversification opportunities should be prioritized, since income diversification has the strongest positive association with higher current consumption per capita and lower vulnerability to poverty. We find that access to extension and fertilizer subsidies have the strongest positive impacts on income diversification of the institutions considered in the analysis. Additionally, both extension and fertilizer subsidies mitigate the negative effects of rainfall variability on expected consumption, but only fertilizer subsidies lead to more stable incomes. This is an important finding in the context of ongoing discussions about the reform of fertilizer subsidy programs in the country. Our findings indicate that the impacts of the subsidy program are broader than may be realized, and it will be important to ensure that the effects of the program on facilitating income diversification and reducing risks to consumption are maintained in a reformed program. The findings also suggest that there is scope to improve extension packages, by explicitly incorporating information on practices that not only increase expected welfare outcomes but also reduce fluctuations in the face of climatic shocks.

In comparison, social safety-net payments have limited or no impact on any of the diversification indices, and similarly, limited or no impact on expected consumption nor on the variance of consumption. On the other hand, results show that recent period shocks reduce diversification and consumption per capita and increase variance of consumption in the future. This indicates that government social safety-net programs are not adequately addressing the consumption risks imposed by climatic shocks and thus implies the need for improved program design to address this issue.

Access to credit, which is relatively limited, increases consumption per capita, but also decreases the stability of consumption. It also leads to greater labour diversification, but not to greater income diversification. This result suggests that policies and programs aimed at expanding the delivery of credit, as with extension, should explicitly incorporate the risks farmers face in order to expand income diversification opportunities without destabilizing incomes. Similarly, insurance and credit schemes need to take better account of household exposure to shocks and vulnerability.

Finally, looking at differences across gender, we found that women are less responsive to pull factors in diversifying labour, and thus we see lower impacts of diversification on expected consumption per capita. There are two conclusions to be drawn from this result: first gender differentiated analysis is important to understand the full dynamics of diversification and secondly, we need to better understand the gender specific push and pull factors for diversification to design adequate policy responses.

References

Asfaw, S., McCarthy, N., Lipper, L., Arslan, A., Cattaneo, A. & Kachulu, M. 2014. *Climate variability, adaptation strategies and food security in Malawi.* ESA Working Paper No. 14-08. Rome, FAO.

Asmah, E.E. 2011. Rural livelihood diversification and agricultural household welfare in Ghana. *Journal of Development and Agricultural Economics* 3(7): 325-334.

Babatunde, R.O. & Qaim, M. 2009. Patterns of income diversification in rural Nigeria: determinants and impacts. *Quarterly Journal of International Agriculture* 48: 305-320.

Bandyopadhyay, S. & Skoufias, E. 2013. *Rainfall variability, occupational choice, and welfare in rural Bangladesh.* Policy Research Working Paper 6134. Washington, DC, World Bank.

Barrett, C.B. & Reardon, T. 2000. *Asset, activity, and income diversifications among African agriculturalist: Some practical issues.* Project report. USAID BASIS CRSP.

Barrett, C.B., Bezuneh, M. & Aboud, A. 2001. Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. *Food Policy* 26(4): 367-384.

Barrett, C.B., Reardon, T. & Webb, P. 2001. Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics and policy implications. *Food Policy* 26(4): 315-331.

Benin, S., Thurlow, J., Diao, X., McCool, C. & Simtowe, F. 2008. *Agricultural growth and investment options for poverty reduction in Malawi.* Discussion Paper 794. Washington, DC, International Food Policy Research Institute.

Bezabih, M. & Sarr, M. 2012. Risk Preferences and Environmental Uncertainty: Implications for Crop Diversification Decisions in Ethiopia. *Environmental & Resource Economics* 53(4): 483-505. European Association of Environmental and Resource Economists.

Block, S. & Webb, P. 2001. The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy* 26(4): 333-350.

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo & P. Yanda, 2007. Africa. *In* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, eds. *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK, 433-467.

Bradshaw, B., Dolan, A. & Smit, B. 2004. Farm-level adaptation to climatic variability and change: crop diversification in the Canadian prairies. *Climatic Change* 67(1): 119-141.

Bryceson, D. 1996. Deagrarianization and rural development in Sub-Saharan Africa: A sectoral perspective. *World Development* 24(1): 97-111.

Bryceson, D. 1999. African rural labour, income diversification and livelihood approaches: A long-term development perspective. *Review of African Political Economy* 26(80): 171-189.

Canagarajah, S., Newman, C. & Bhattamishra, R. 2001. Non-farm income, gender, and inequality: evidence from rural Ghana and Uganda. *Food Policy* 26(4): 405-420.

Carter, M.R. & Barrett, C.B. 2006. The economics of poverty raps and persistent poverty: An asset-based approach. *Journal of Development Studies* 42(2): 178-199.

Cavatassi, R., Lipper, L. & Winters, P. 2012. Sowing the seeds of social relations: social capital and agricultural diversity in Hararghe Ethiopia. *Environment and Development Economics* 17(S5): 547-578.

Challinor, A., Simelton, W., Fraser, E., Hemming, D. & Collins, C. 2010. Increased crop failure due to climate change: assessing adaptation options using models and socio-economic data for wheat in China. *Environmental Research Letters* 5(3): 034012.

Chaudhuri, S., Jalan, J. & Suryahadi, A. 2002. *Assessing household vulnerability to poverty from cross-sectional data: A methodology and estimates from Indonesia.* Discussion Paper No. 010252, New York, USA, Columbia University.

Chinsinga, B. 2008. *Exploring the politics of land reforms in Malawi: A case study of the Community Based Rural Land Development Project (CBDRLDP).* IPPG Discussion Paper No. 20. Manchester, UK, University of Manchester.

Chinsinga, B. 2012. *The political economy of agricultural policy processes in Malawi: A case study of the fertilizer subsidy programme.* Future Agricultures Consortium Working Paper 39. Brighton, UK.

Chirwa, P. & Quinion, A. 2005. Impact of soil fertility replenishment agroforestry technology adoption on the livelihoods and food security of smallholder farmers in central and southern Malawi. *In* Sharma, P. & Abrol, V., eds., *Crop Production Technologies*. Rijeka, Croatia, InTech.

Christiaensen, L. & Subbarao, K. 2005. Towards an understanding of household vulnerability in rural Kenya. *Journal of African Economies* 14(4): 520-558.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E.J., Zezza, A. & DiGiuseppe, S. 2010. A cross-country comparison of rural income generating activities. *World Development* 38(1): 48-63.

Deichmann, U., Shilpi, F. & Vakis, R. 2008. Spatial specialization and farm-nonfarm linkages. World Bank Policy Research Working Paper No. 4611. Washington, DC, World Bank.

Delgado, C. & Siamwalla, L. 1999. Rural economy and farm diversification developing countries. *In* G. H. Peters, & J. von Braun, eds. *Food security, diversification and resource management, refocusing the role of agriculture*. International Associations of Agricultural Economists. Brookfield, USA, Ashgate.

Denning, G., Kabambe, P., Sánchez, P., Malik, A., Flor, R., Harawa, R., Nkhoma, P., Zamba, C., Banda, C., Magombo, C., Keating, M., Wangila, J. & Sachs, J. 2009. Input subsidies to improve smallholder maize productivity in Malawi: Toward an African green revolution. *PLoS Biology* 7(1): 2-10.

Dercon, S. 2002. Income risks, coping strategies, and safety nets, *World Bank Research Observer* 17(2): 141-166.

Di Falco, S. & Chavas, J.P. 2009. On crop biodiversity, risk exposure, and food security in the highlands of Ethiopia. *American Journal of Agricultural Economics* 91(3): 599-611.

Dimova, R. & Sen, K. 2010. *Is household income diversification a means of survival or a means of accumulation? Panel data evidence from Tanzania.* Brooks World Poverty Institute Working Paper No. 12210. BWPI, University of Manchester.

Dorward, A., Chirwa, E., Boughton, D., Crawford, E., Jayne, T., Slater, R., Kelly, V. & Tsoka, M. 2008. Towards Smart Subsidies in Agriculture? Lessons from Recent Experience in Malawi. *Natural Resource Perspectives* 116. London, UK, Overseas Development Institute.

Ellis, F. 1998. Household strategies and rural livelihood diversification. *Journal of Development Studies* 35(1): 1-38.

Ellis, F. 1999. Rural livelihood diversity in developing countries: evidence and policy implications. *Natural Resource Perspectives* No. 40. London, UK, Overseas Development Institute.

Ellis, F. 2000. *Rural livelihoods and diversity in developing countries*. Oxford, UK, Oxford University Press.

Ellis, F. 2004. *Occupational diversification in developing countries and the implications for agricultural policy.* Programme of Advisory and Support Services to DFID (PASS).

Ellis, F. 2005. *Small-farms, livelihood diversification and rural-urban transitions: strategic issues in Sub-Saharan Africa.* Paper prepared for the Research Workshop on "The Future of Small Farms", Withersdane Conference Centre, Wye, Kent, UK, 26-29 June.

Ellis, F. 2009. Small-Farms, Livelihood Diversification and Rural-Urban Transitions: Strategic Issues in Sub-Saharan Africa. In *The Future of Small Farms: Proceedings of a Research Workshop*, Wye, UK, 26-29 June. Washington, DC, International Food Policy Research Institute.

Ersado, L. 2003. *Income diversification in Zimbabwe: Welfare implications from Urban and Rural Areas.*, FCND Discussion Paper No. 152. International Food Policy Research Institute, Food Consumption and Nutrition Division

Fafchamps, M. & Shilpi, F. 2003. The spatial division of labour in Nepal. *The Journal of Development Studies* 39(6): 23-66.

Fafchamps, M. & Shilpi, F. 2005. Cities and specialisation: evidence from South Asia. *The Economic Journal* 115(503): 477-504.

FAO, IFAD and WFP (Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development and World Food Programme). 2014. *State of Food Insecurity in the World 2014: Strengthening the enabling environment for food security and nutrition.* FAO, Rome.

GoM (Government of Malawi) 2006. Malawi growth and development strategy 2006-2011, Ministry of Economic Planning and Development, Lilongwe.

GoM. 2008. Agricultural Development Programme (ADP), Lilongwe, Ministry of Agriculture and Food Security.

Hirano K. & Imbens, G. 2004. The propensity score with continuous treatments. *In* A. Gelman & X.L. Meng, eds. A*pplied Bayesian modeling and causal inference from incomplete-data perspectives*, New York, USA, Wiley.

Holden, S. & Lunduka, A. 2012. Do fertilizer subsidies crowd out organic manures? The case of Malawi. *Agricultural Economics* 43(3): 303-314.

Holden S. & Shiferaw, B. 2004. Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: a bio-economic model with market imperfections. *Agricultural Economics* 30: 31-49.

Howden, S. M., Soussana, J., Tubiello, F. N., Chhetri, N., Dunlop, M. & Meinke, H. 2007. Adapting agriculture to climate change. Proceedings of the National Academy of Sciences of the United States of America (PNAS) 104: 19691-19696.

Huang, J., Wu, Y. & Rozelle, S. 2009. Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labour market linkages in China. *Agricultural Economics* 40(2): 203-218.

IHS (Integrated Household Survey, Malawi). 2012. *Household socio-economic characteristics report.* National Statistical Office, Lilongwe, Malawi.

IPCC (Intergovernmental Panel on Climate Change). 2012. *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley, eds., Cambridge, UK, and New York, USA, Cambridge University Press.

IPCC. 2014. *Working Group II contribution to the IPCC Fifth Assessment Report Climate Change 2014: Impacts, Adaptation, and Vulnerability.*

ILO (International Labour Organisation). 2010. *Employment diagnostic analysis on Malawi.* Prepared for the Government of Malawi by Professor Dick Durevall and Dr. Richard Mussa, with assistance from the International Labour Organisation. Geneva, Switzerland.

Lanjouw, P., Quizon, J. & Sparrow, R. 2001. Non-agricultural earnings in peri-urban areas of Tanzania: evidence from household survey data. *Food Policy* 26(4): 385-403.

Lay, J., Mahmood, T.O. & M'mukaria, G. M. 2008. Few opportunities, much desperation: The dichotomy of non-agricultural activities and inequality in Western Kenya. *World Development* 36(12): 2713-2732.

Lay, J., Nahrloch, U. & Omar Mahmoud, T. 2009. Shocks, structural change, and the patterns of income diversification in Burkina Faso. *African Development Review* 21(1): 36-58.

Lipper, L., Cavatassi, R. & Keleman, A. 2010. The contribution of Plant Genetic Resources for Food and Agriculture to food security and sustainable agricultural development. *The Second State of the World of Plant Genetic Resources for Food and Agriculture*. FAO, Rome.

Little, P. D., Stone, M.P., Mogues, T., Castro, P. & Negatu, W. 2006. Moving in place: drought and poverty dynamics in South Wollo, Ethiopia. *Journal of Development Studies* 42(2): 200-225.

Liverpool-Tasie, L.S.O. & Winter-Nelson, A. 2011. Asset versus consumption poverty and poverty dynamics in rural Ethiopia. *Agricultural Economics* 42(2): 221-233.

Losch, B., Freguingresh, S. & White, E. 2011. *Rural transformation and late developing countries in a globalizing world: a comparative analysis of rural change*. Final Report of the RuralStruc Program, Revised Version, Washington, DC, World Bank.

Macours, K., Premand, P. & Vakis, R. 2012. *Transfers, diversification and household risk strategies: experimental evidence with lessons for climate change adaptation.* Policy Research Working Paper 6053, Washington, DC, World Bank.

Mortimore, M.J. & Adams, W.M. 2001. Farmer adaptation, change and crisis in the Sahel. *Global Environmental Change* 11(1): 49-57.

Morton, J.F. 2007. The impact of climate change on smallholder and subsistence agriculture. Proceedings of the National Academy of Sciences of the United States of America (PNAS) 104: 19680-19685.

Newman, C. & Canagarajah, S. 2000. Non-farm employment, poverty, and gender linkages: evidence from Ghana and Uganda. Policy Research Working Paper 2367. Washington, DC, World Bank.

Newsham, A. & Thomas, D. 2009. *Agricultural adaptation, local knowledge and livelihoods diversification in north-central Namibia.* Tyndall Working Paper 140.

Nhemachena, C. & Hassan, R. 2007. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No. 00714. Washington, DC, International Food Policy Research Institute.

Pingali, P. & Rosegrant, M. 1995. Agricultural commercialization and diversification: processes and polices. *Food Policy* 20(3): 171-185.

Pfeiffer, L., López-Feldman, A. & Taylor, J.E. 2009. Is off-farm income reforming the farm? Evidence from Mexico. *Agricultural Economics* 40(2): 125-138.

Reardon, T. 1997. Using Evidence of Household Income Diversification to Inform Study of the Rural Nonfarm Labour Market in Africa. *World Development* 25(5): 735-747.

Reardon, T., Berdegué, J., Barrett, C.B. & Stamoulis, K. 2006. Household Income Diversification into Rural Nonfarm Activities. *In* S. Haggblade, P. Hazell & T. Reardon, eds. *Transforming the Rural Nonfarm Economy*. Baltimore, MA, USA, Johns Hopkins University Press.

Reardon, T., Stamoulis, K., Balisacan, A., Cruz, M.E., Berdegue, J. & Banks, B. 1998. Rural Nonfarm Income in Developing Countries. Special Chapter in *The State of Food and Agriculture 1998*. Rome, FAO.

Rosenzweig, M.R. & Binswanger, H.P. 1993. Wealth, weather risk and the composition and profitability of agricultural investments. *Economic Journal* 103(416): 56-78.

Sadoulet, E. & de Janvry, A. 1995. Behavior and Welfare Under Risk. In *Quantitative Development Policy Analysis*, Baltimore, MD, USA, Johns Hopkins University Press.

Seo, S., Mendelsohn, R., Dinar, A., Hassan, R. & Kurukulasuriya, P. 2009. A Ricardian analysis of the distribution of climate change impacts on agriculture across agro-ecological zones in Africa. *Environmental and Resource Economics* 43(3): 313-332.

Simtowe, F.P. 2010. Livelihoods diversification and gender in Malawi. *African Journal of Agricultural Research* 5(3): 204-216.

Smale, M., ed. 2006. *Valuing crop diversity: on-farm genetic resources and economic change*. Wallingford, UK, CABI Publishing.

Tadross, M., Suárez, P., Lotsch, A., Hachigonta, S., Mdoka, M., Unganai, L., Lucio, F., Kamdonyo, D. & Muchinda, M. 2009. Growing-season rainfall and scenarios of future change in southeast Africa: implications for cultivating maize. *Climate Research* 40: 147-161.

Tchale, H. 2009. The efficiency of smallholder agriculture in Malawi. *African Journal of Agricultural and Resource Economics* 3(2): 101-121.

Toulmin, C., Leonard, R., Brock, K., Coulibaly, N., Carswell, G. & Dea, D. 2000. *Diversification of livelihoods: evidence from Mali and Ethiopia.* Research Report 47, Brighton, UK, Institute of Development Studies.

Van Dusen, M.E. & Taylor, J.E. 2005. Missing markets and crop diversity: evidence from Mexico. *Environment and Development Economics* 10(04): 513-531.

Wang, J., Mendelsohn, R., Dinar, A. & Huang, J. 2009. *How do China's farmers adapt to climate change?* Paper presented at the International Association of Agricultural Economics Conference, Beijing, August 2009.

Wiggins, S. 2009. *Transforming the rural nonfarm economy. Opportunities and threats in the developing world.* S. Haggblade, P.B.R. Hazell & T. Reardon, eds. Book review. *Journal of Agrarian Change*, 9(4): 595-598.

World Bank. 2008. *World Development Report 2008: Agriculture for Development.* Washington, DC.

World Bank. 2010. *Social dimensions of climate change: equity and vulnerability in a warming world.* Washington, DC.

World Bank 2012. *Mainstreaming adaptation to climate change and natural resource management.* Washington, DC.

Appendix

Table A.1. Effect of climate variability on vulnerability components: variance of consumption and expected consumption per capita

	Without interaction		Interaction with policy variables	
	Variance	Expected consumption	Variance	Expected consumption
Climate variables				
CoV of Nov-May rainfall 1983-2010	-0.349***	-0.984***	-0.622	-2.854***
	(0.132)	(0.192)	(0.522)	(0.757)
Average of Nov-May rainfall 1983-2010 (dm)	0.001	0.050***	0.005	0.040***
	(0.005)	(0.007)	(0.005)	(0.008)
Anomaly of Nov-May rainfall 2009-10	0.238***	-0.608***	0.229***	-0.577***
	(0.047)	(0.067)	(0.049)	(0.070)
Household socio-demographic				
Age of household head (years)	-0.001**	-0.002***	-0.001**	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Gender of household head (1=male)	-0.012	-0.008	-0.012	-0.009
	(0.010)	(0.014)	(0.010)	(0.014)
Household size (Adult Equivalent [AE])	0.004*	-0.153***	0.004*	-0.152***
	(0.002)	(0.004)	(0.002)	(0.004)
Household head highest level of education in years	-0.003**	0.019***	-0.003**	0.019***
	(0.001)	(0.002)	(0.001)	(0.002)
Sex ratio	-0.005	-0.034***	-0.005	-0.034***
	(0.004)	(0.005)	(0.004)	(0.005)
Dependency ratio	-0.008*	-0.063***	-0.009**	-0.063***
	(0.004)	(0.006)	(0.004)	(0.006)
Number of household members hospitalized in the past 12 months	0.005	0.100***	0.005	0.098***
	(0.009)	(0.012)	(0.009)	(0.012)
Household wealth				
Wealth index	0.003	0.207***	0.003	0.207***
	(0.003)	(0.004)	(0.003)	(0.004)
Agricultural implements access index	-0.015***	0.047***	-0.016***	0.048***
	(0.003)	(0.004)	(0.003)	(0.004)
GPS based land size (acre)	-0.000	0.012***	-0.000	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)
Community characteristics				
In migration in the community (1=yes)	0.040***	0.026**	0.042***	0.029**
	(0.009)	(0.013)	(0.009)	(0.013)
Out migration in the community (1=yes)	0.018	0.017	0.021*	0.021
	(0.012)	(0.018)	(0.012)	(0.018)
Irrigation scheme in the community (1=yes)	0.000	-0.026*	0.005	-0.024*
	(0.010)	(0.014)	(0.010)	(0.014)
Road density in 10 km radius ('000 metres)	-0.002	0.003	-0.001	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Number of months main road was passable by a lorry	0.001	0.009***	0.001	0.008***
	(0.001)	(0.002)	(0.001)	(0.002)
ln(price of fertilizer [MKW/kg]/price of maize [MKW/kg])	-0.025***	0.130***	-0.023***	0.124***
	(0.006)	(0.009)	(0.007)	(0.010)
ln(wage rate for casual labour [MKW/day]/price of maize [MKW/kg])	0.018***	-0.052***	0.019***	-0.049***
	(0.004)	(0.006)	(0.004)	(0.006)

Institutions				
Number of agricultural extension and development officers in the district	0.003***	0.014***	-0.014**	0.010
	(0.001)	(0.002)	(0.006)	(0.009)
Number of microfinance institutions in the district	0.005*	0.028***	-0.019	0.003
	(0.003)	(0.004)	(0.016)	(0.023)
Fertilizers distributed per household in the district (MT)	-0.025***	0.074***	0.105*	-0.147*
	(0.009)	(0.013)	(0.060)	(0.087)
ln(MASAF wages paid in 2008-09 season [million MKW/household])	-0.880	4.297	-3.760	16.097
	(1.806)	(2.624)	(11.604)	(16.700)
Institutions*Climate variables				
Extension service*CV rainfall			0.083***	0.019
			(0.028)	(0.042)
Microfinance*CV rainfall			0.120	0.133
			(0.078)	(0.113)
Fertilizer distributed*CV rainfall			-0.617**	1.054**
			(0.283)	(0.410)
Safety-net*CV rainfall			11.891	-43.975
			(48.162)	(69.501)
Constant	0.348***	10.689***	0.346***	11.158***
	(0.061)	(0.088)	(0.132)	(0.190)
Observations	8,009	8,009	8,009	8,009
R-squared	0.019	0.451	0.021	0.452

Note: Robust standard errors in parentheses based on EA level clusters. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2. Effect of diversification on vulnerability components: variance of consumption and expected consumption per capita

	Labour, total		Labour, males and females		Cropland		Income		All three indices	
	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption	Variance	Expected consumption
Diversification indices										
Margalef index of labour diversification, all adults	0.013	0.718***							0.152**	0.679***
	(0.055)	(0.079)							(0.059)	(0.086)
Margalef index of labour diversification, male adults			0.033	0.784***						
			(0.061)	(0.091)						
Margalef index of labour diversification, female adults			0.014	0.556***						
			(0.084)	(0.123)						
Margalef index of cropland diversification					-0.048	0.246***			-0.010	0.168***
					(0.036)	(0.053)			(0.037)	(0.054)
Margalef index of income diversification							-0.188***	0.406***	-0.155***	0.351***
							(0.039)	(0.057)	(0.043)	(0.063)
Climate variables										
CoV of Nov-May rainfall 1983-2010	-0.337**	-1.042***	-0.308**	-1.303***	-0.244*	-1.051***	-0.334**	-1.072***	-0.252*	-1.202***
	(0.132)	(0.193)	(0.143)	(0.213)	(0.136)	(0.199)	(0.133)	(0.195)	(0.135)	(0.200)
Average of Nov-May rainfall 1983-2010 (dm)	0.001	0.050***	0.002	0.057***	-0.003	0.046***	0.005	0.039***	0.000	0.036***
	(0.005)	(0.007)	(0.005)	(0.008)	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)	(0.007)
Anomaly of Nov-May rainfall 2009-10	0.237***	-0.611***	0.211***	-0.664***	0.214***	-0.651***	0.224***	-0.579***	0.204***	-0.625***
	(0.047)	(0.067)	(0.050)	(0.074)	(0.048)	(0.069)	(0.048)	(0.068)	(0.049)	(0.070)
Household socio-demographic										
Age of household head (years)	-0.001**	-0.002***	-0.001**	-0.002***	-0.000*	-0.002***	-0.001**	-0.002***	-0.000	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Gender of household head (1=male)	-0.011	-0.012	-0.002	0.044**	-0.012	-0.006	-0.013	-0.006	-0.013	-0.008
	(0.010)	(0.014)	(0.013)	(0.020)	(0.010)	(0.015)	(0.010)	(0.014)	(0.010)	(0.015)

Household size (Adult Equivalent [AE])	0.004	-0.152***	0.005*	-0.130***	0.003	-0.150***	0.006**	-0.156***	0.004	-0.153***
	(0.002)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Household head highest level of education in years	-0.003***	0.017***	-0.003***	0.015***	-0.003**	0.016***	-0.002**	0.018***	-0.003**	0.014***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Sex ratio	-0.004	-0.033***	0.004	-0.013**	-0.003	-0.027***	-0.005	-0.034***	-0.001	-0.027***
	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)
Dependency ratio	-0.009**	-0.063***	-0.011**	-0.070***	-0.009**	-0.054***	-0.009**	-0.064***	-0.009**	-0.054***
	(0.004)	(0.006)	(0.005)	(0.008)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)
Number of household members hospitalized in the past 12 months	0.007	0.095***	0.006	0.101***	0.009	0.101***	0.011	0.094***	0.013	0.094***
	(0.009)	(0.013)	(0.009)	(0.013)	(0.009)	(0.013)	(0.009)	(0.013)	(0.009)	(0.013)
Household wealth										
Wealth index	0.005	0.200***	0.002	0.186***	0.003	0.201***	0.003	0.208***	0.001	0.193***
	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.005)
Agricultural implements access index	-0.015***	0.047***	-0.013***	0.064***	-0.011***	0.067***	-0.013***	0.041***	-0.008**	0.064***
	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)
GPS based land size (acre)	-0.001	0.012***	0.000	0.015***	0.001	0.011***	0.001	0.010***	0.002	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Community characteristics										
In migration in the community (1=yes)	0.040***	0.024*	0.034***	0.012	0.039***	0.022*	0.038***	0.028**	0.036***	0.020
	(0.009)	(0.013)	(0.010)	(0.015)	(0.009)	(0.013)	(0.009)	(0.013)	(0.009)	(0.013)
Out migration in the community (1=yes)	0.020*	0.013	0.013	0.010	0.017	0.018	0.018	0.019	0.017	0.019
	(0.012)	(0.018)	(0.013)	(0.020)	(0.013)	(0.018)	(0.012)	(0.018)	(0.012)	(0.019)
Irrigation scheme in the community (1=yes)	0.002	-0.023	-0.004	-0.031**	0.000	-0.018	0.001	-0.022	0.003	-0.011
	(0.010)	(0.014)	(0.010)	(0.016)	(0.010)	(0.014)	(0.010)	(0.014)	(0.010)	(0.015)
Road density in 10 km radius ('000 metres)	-0.002	0.003	-0.001	0.002	-0.001	0.003	-0.002	0.003	-0.001	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Number of months main road was passable by a lorry	0.000	0.008***	-0.000	0.006***	0.001	0.008***	0.001	0.008***	0.001	0.006***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
ln(price of fertilizer [MKW/kg]/price	-0.024***	0.128***	-0.017**	0.138***	-0.029***	0.128***	-0.021***	0.122***	-0.025***	0.118***

of maize [MKW/kg])										
	(0.006)	(0.009)	(0.007)	(0.010)	(0.007)	(0.010)	(0.006)	(0.009)	(0.007)	(0.010)
ln(wage rate for casual labour [MKW/day]/price of maize [MKW/kg])	0.016***	-0.050***	0.014***	-0.050***	0.020***	-0.046***	0.016***	-0.044***	0.015***	-0.037***
	(0.004)	(0.006)	(0.004)	(0.007)	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)
Institutions										
Number of agricultural extension and development officers per household in the district	0.003**	0.013***	0.003**	0.012***	0.003***	0.014***	0.003***	0.013***	0.003***	0.013***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Number of microfinance institutions in the district	0.006**	0.026***	0.003	0.025***	0.006**	0.028***	0.004	0.030***	0.005**	0.028***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Fertilizers distributed per household in the district (MT)	-0.027***	0.080***	-0.027***	0.062***	-0.016*	0.060***	-0.024**	0.068***	-0.019*	0.055***
	(0.009)	(0.013)	(0.010)	(0.015)	(0.010)	(0.014)	(0.009)	(0.013)	(0.010)	(0.014)
ln(MASAF wages paid in 2008-09 season [million MKW/household])	-0.514	4.013	-2.160	2.534	-0.758	4.168	-0.170	3.548	0.108	3.670
	(1.801)	(2.624)	(1.901)	(2.863)	(1.844)	(2.679)	(1.814)	(2.659)	(1.832)	(2.695)
Constant	0.358***	10.673***	0.312***	10.508***	0.330***	10.673***	0.326***	10.755***	0.313***	10.740***
	(0.062)	(0.089)	(0.068)	(0.101)	(0.064)	(0.093)	(0.062)	(0.090)	(0.064)	(0.094)
Observations	7,862	7,862	6,017	6,017	7,255	7,255	7,768	7,768	7,023	7,023
R-squared	0.019	0.455	0.016	0.448	0.018	0.434	0.023	0.453	0.019	0.443

Note: Robust standard errors in parentheses based on EA level clusters. *** p<0.01, ** p<0.05, * p<0.1

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