The Mitigating Impact of Land Tenure Security on Drought-induced Food Insecurity: Evidence from Rural Malawi

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Abstract

This paper explores household variation in land tenure security and drought shocks across villages to investigate the extent to which land tenure systems matter in households' capacity to cope with adverse impacts of weather shocks for agricultural dependent households in rural Malawi. Our findings reveal that land tenure security cushions the effects of drought regimes on food security. Further, we establish access to credit facilities for farm investment purposes as the underlying channel that mediates the impact of drought shocks on food insecurity. The results of this study reinforce the growing consensus that property rights through land tenure security are associated with improved agricultural productivity and consequently household food security.

Keywords: Food security, Rainfall shocks, Land tenure security, Agricultural productivity

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1 Introduction

Promoting agricultural productivity to ensure food security has been a major public policy issue in developing countries in recent years. Despite the enormous efforts by the governments, both national and international, evidence shows that the number of chronically undernourished people worldwide increased from 777 million in 2015 to 815 million in 2016. This trend is pervasive in the sub-Saharan African (SSA) region, with rising food insecurity over the last decade (FAO, 2014b), and accounting for a significant proportion of global cases of household food insecurity. Since 1990-92, about 42 million were added to the total number of undernourished people in SSA with an estimated 217.8 million in 2014-16 compared to 176 million in 1990-92 (FAO, 2015). This pattern is driven by the poverty statistics associated with this region compared to the rest of the World[1].

A majority of poor households in SSA depend on smallholder agricultural practice for their livelihoods. In many cases, enhanced productivity and growth of the agricultural sector in aggregate leaves many smallholders behind in poverty; and food security can remain a problem even for those that have increased productivity. More importantly, sustainable agricultural productivity of these households is hampered by the variability of weather and climate with the smallholder agrarian households the worst hit by this (Asfaw and Braun, 2004; Fussel, 2010; Skoufias et al., 2011; Levine and Yang, 2014; and Asfaw and Maggio, 2017)[2].

Besides climate and weather variability, land tenure insecurity can inhibit agricultural productivity and food security among agrarian households. When land rights are insecure, the motivation to invest on the land is likely to be low. These behaviours can have consequences that lead to a decrease in agricultural productivity and food insecurity (Besley, 1995; Potts, 2006; Woodhouse, 2006; Deininger et al. 2009; Linkow, 2016; and Lovo, 2016).

In light of the above, this paper investigates the interplay between drought regimes, land tenure security and food security in Malawi. To investigate this relationship, we use two waves of household data, namely the Integrated Household Survey (IHS) for 2013 and 2016. The first motivation for focussing the research context on Malawi can be linked to an important reference from the World Bank (2010) statistics where Malawi emerged as the 12th most exposed country to the effects of climate change. This vulnerability is likely explained by the country's historical climate distribution, which is characterised by frequent environmental shocks such as droughts and floods (Chinsinga, 2013).

Second, structural economic conditions exacerbate this vulnerability. For example, Malawi's agricultural sector contributes nearly 37 per cent to the country's GDP, with subsistence smallholders producing 75 per cent of Malawi's total agricultural output using a production system that is predominantly rain-fed with limited irrigation (Chirwa and Quinion, 2005). Moreover, according to the Global Food Security Index (GFSI), Malawi ranks 105/113 countries on overall food security index with a breakdown of 105, 101 and 106 in terms of affordability, availability and quality/safety of food respectively (GFSI, 2016). These features typically explain why micro and macro food security indices in Malawi may be highly elastic to rainfall shocks especially droughts. This situation leaves Malawi highly susceptible to chronic food insecurity (Harrigan 2008).

Third, in Malawi, there are locality-level variations in household land tenure security through village headship plot allocation programs and inheritance systems. Customs and traditions strongly complement formal land tenure rights through the inheritance systems practised across villages, which affect efficient food production attributable to agricultural practice. For instance, the attendant effect of patrilineal or matrilineal systems on productivity through land ownership tenures which results from customs and traditions is unclear from the literature. Also, the inheritance system in practice plays a significant role in the institution of marriage across communities thereby determining the expected traditional union for couples – patrilocal or matrilocal. Hence, the customary gender-biased inheritance practices prevalent in the community could indirectly affect productivity, given the extent of land tenure security (Peters and Kambewa, 2007; Peters, 2010; Lovo, 2016; Berge et al. 2014).

The objectives of this study are threefold: (i) To investigate the mitigating role of land tenure security in the relationship between droughts and household food security in Malawi. This stems from the evidence that consider land tenure security as associated with food security (Besley and Burgess, 2000; Deininger et al., 2009; Ghebru and Holden, 2013; Mendola and Simtowe, 2015). (ii) To investigate whether the mitigating role of land tenure security on the impacts of drought on food security fully compensates for the adverse effects. (iii) To investigate whether the mitigating role of land tenure security on the impacts of drought on food security differs between matrilineal societies and patrilineal societies. This objective is motivated by existing evidence that suggests the inheritance rights of patrilineal and matrilineal system to be potential source of land tenure insecurity (Peters, 2010; Mueller et al., 2014).

The paper contributes to the growing literature on the impact of rainfall shocks on household outcomes (welfare) (Jayachandran, 2006; Yang and Choi, 2007; Björkman-Nyqvist, 2013; Levine and Yang, 2014; and Asfaw and Maggio, 2017), by investigating the role of land tenure security in mitigating rural households against drought shocks. The paper's novel approach in examining the mitigating role of land tenure security in the relationship between drought and household food security distinguishes it from the existing literature.

The paper proceeds as follows. Section 2 presents conceptual framework of climate shocks, land tenure and food security. Section 3 discusses related literature to the study. We present data and empirical strategy in section 4. Section 5 presents the results of the study and section 6 concludes the paper.

2 Conceptual Framework

Land tenure entails how access is granted to rights to use, control, and transfer land, as well as associated responsibilities and restraints (FAO, 2002). While a number of studies have examined the nexus between weather-induced shocks and agricultural productivity, the roles of land tenure security in mitigating against climate risk are less well studied. Broadly speaking, the theoretical link between land tenure security and the mitigation of weather-induced shocks can be understood under the following headings.

2.1 Channel One

Land tenure security is being considered as part of social protection and safety net for agrarian households (Mahadevia 2011; Holden and Gebru, 2016). Land tenure security has been found to be important in drought-prone areas because it provides an incentive for landholders to invest in adaptation measures such as sustainable pasture use, use of irrigation systems and development of drought-resistant crops (FAO, 2011; Lokonon, 2018). The propensity for smallholders to invest in adaption measures is largely influenced by the certainty with which land rights are held and recouping investments from the land ((Jacoby and Minten, 2007; Goldstein and Udry). This is known as assurance effect of secure land rights.

Smallholder households with stronger land rights are more likely to invest in natural resources or environment management practices such as tree planting, fallowing, erosion control, and mulching (agroforestry). These practices reduce the exposure of land to climatic shocks (Deininger, 2003; FOA, 2002; Place, 2009; Higgins et al., 2017; Meinzen-Dick et al., 2019)[3]. For instance, in Bangladesh, evidence shows that adverse shocks have insignificant impacts on households with joint land and asset holdings (Quisumbing et al., 2018). Moreover, secure land rights can enhance access to capital through the use of land as collateral or allow landholders to lease or sell the land in event of profitable opportunity or in response to adverse income shocks in order to raise income. The benefits of security of one plot may spill over to other plots owned by the same household and provide opportunities to diversify to non-agricultural livelihoods (Besley, 1995; Deininger and Castagnini, 2006; Deininger and Jin, 2006)[4]. Therefore, we identify the first channel as adoption of climate resilient measures that help smallholders to mitigate the effect of drought.

2.2 Channel Two

A number of studies have shown that production risks (e.g. climate variability) is an important determinant of smallholders' investment decision on adoption of modern technologies or inputs (Dercon and Christiaensen, 2011; Lamb, 2003; Mukasa, 2018)[5]. Farmers in SSA are risk averse due to the high prevalence of production risks and this has often led to low rate of adoption of modern technologies such as chemical fertilisers, improved seeds, and pesticides (Mukasa, 2018).

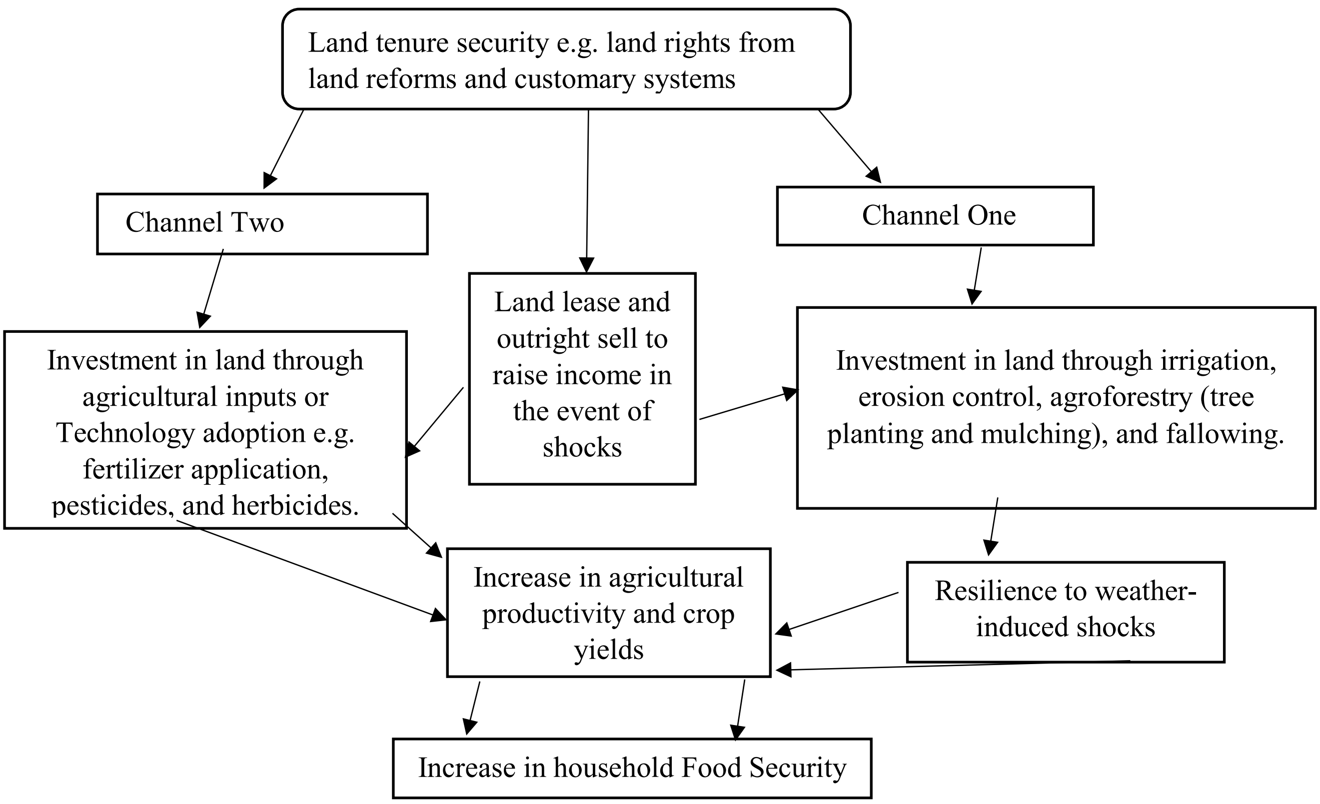
One common theoretical and empirical explanation for the low rate of adoption of modern technologies in the presence of high production risks is the lack of access to formal credit and insurance schemes that could help mitigate loss to farmers in the event of crop failure, droughts and pest infestations (Karlan et al., 2014; Mukasa, 2018).

Given this context, our proposition is that, secure land rights can provide access to insurance and credit to smallholders, albeit, in some cases informally. The first mechanism stems from secure land rights providing access to capital through the ability to use a land as collateral (Besley, 1995; Deininger and Castagnin, 2006). The second mechanism relates to how land rights allow an investor or smallholder to rent or sell the land in event of profitable opportunity or in response to adverse income shock (Besley, 1995; Deininger and Jin, 2006).

From both mechanisms above, secure land rights can lead to relaxing of credit and insurance constraints, and smallholders will have enhanced incentives to invest in modern forms of technology adoption, such as use of new crop varieties, fertilizer, pesticides and herbicides. This can lead to increased agricultural productivity and food security.

Considering the above arguments, secure land rights creates a pathway for increased agricultural productivity and food security, through investment of labour and resources on the land. It is important to note that, activities of Channel One and Channel Two in figure 1 below can occur simultaneously on the same plot. These theoretical relationships, summarised in Holden and Ghebru (2016), have been expanded by authors in figure 1 below:

Figure 1: Land Tenure Security, Mitigation of Shocks and Food Security



Source: Authors.

Figure 1: Relationship between weather-induced shocks, land tenure security and food security

3 Empirical literature

This section discusses two strands of empirical evidence for the research. The first aspect of the evidence focuses on studies on land tenure security and food security. In an attempt to strengthen land tenure security in developing countries, various reforms such as land titling programs, tenancy reforms, radical land reforms, customary tenure reforms (for example in Malawi, Tanzania and Uganda), and land redistribution have been implemented. The reforms were done in-line with commonly held belief that land tenure security can stimulate investment and agricultural productivity (Besley, 1995).

While the reforms were successful in enhancing land tenure security in some settings, evidence has shown that, land tenure reforms in other settings often led to 'elite capture of land' and marginalisation of the poor and minority groups. This indicates more access to land by the wealthy (Barrows and Roth, 1989; Roth, 1993; Platteau, 1996; Benjaminsen et al., 2009; Aryal and Holden, 2011; Simtowe et al., 2012).

There is mixed evidence on the effects of land tenure security on investment and agricultural productivity. Some studies in Latin America, Africa and Asia, found positive investment impacts of land titling (Feder, 1988; Alston et al., 1995; Lopez, 1997; Deininger and Chamorro, 2004; Deininger et al., 2008; Lovo, 2016). Other studies on land titling in Africa have found no evidence of the impacts of investment (Migot-Adholla et al., 1994; Pinckney and Kimuyu, 1994).

Few existing studies investigate the direct effect of land tenure security on other measures of household welfare (such as food security and poverty). Ghebru and Holden (2013) found that the land certification program in Ethiopia resulted in increased food production and food access for the poor female-headed households who sharecropped out their land. Similar result was obtained on the impact of land reforms on poverty in India (Deininger et al., 2008; and Besley and Burgess, 2000). Among agrarian households, Maxwell and Wiebe (1998) argue that a reduction in, or outright loss of access to land leads directly to a reduction in income and access to food.

The second part of this literature review comprises of evidence on weather shocks and household welfare. Weather risks such as floods, droughts, frost and hailstorms can have significant impacts on agricultural productivity and food security of agrarian households. The literature on the impact of weather and climate variability on household welfare abound with evidence from developing countries' perspectives (Jayanchandran, 2006; Nordhaus, 2006; Yang and Choi, 2007; Dell et al., 2009; Schlenker and Lobell, 2010; and Björkman-Nyqvist, 2013). For instance, some selected studies in developing countries including Schlenker and Lobell (2010) found negative impacts of bad weather shocks (higher temperature) on yields for SSA. Similarly, Guiteras (2009) for India and Feng et al. (2010) for Mexico estimate that higher temperature reduces agricultural output. With a slightly different result, other studies (e.g. Welch et al., 2010) show that for Asian countries, higher minimum temperature reduces yields, whereas higher maximum temperature increases yields. With regard to rainfall precipitation, Levine and Yang (2014), using a panel of Indonesian districts, found a positive relationship between rainfall and rice production.

The absence of complete formal markets for credit and insurance among poor agrarian households, which have the capacity to mitigate the impact of covariate shocks left rural households vulnerable to adverse shocks (Binswanger and Rosenzweig, 1986). In order to cushion the impacts of covariate shocks, most poor households often rely on informal coping mechanisms such as assets and income diversification strategies. Evidence has shown, however, that the informal coping mechanisms are limited in their capacity to cushion risk, mainly because of the correlation between these mechanisms and production shocks (Dercon, 2001).

Access to secure land tenure can have a sustainable mitigating impact that can support the welfare of poor agrarian households (Holden et al., 2008; Holden and Ghebru, 2016). Existing empirical evidence found a connection between egalitarian land distribution and household welfare. With the perceived capacity of land as reliable asset, this study will investigate the shock-cushioning capacity of land possession/security to preserve food security during periods of drought shocks in Malawi.

4 Data sources and empirical methodology

4.1 Data sources

This study uses household and plot-level data provided by the Integrated Household Panel Survey (IHPS) 2013 and the Fourth Integrated Household Survey (IHS4) 2016/2017 for Malawi. The data consists of partly longitudinal survey structure where the same households are re-interviewed across the two waves while at the same time expanding the sample of households in the second wave. These surveys were conducted by the Government of Malawi through the National Statistical Office, with the support of World Bank. The survey collects information on 4000 households for 2013 and 12,447 households for 2016/2017 across the entire country and provides information on various rainfall and temperature measures in the geospatial data relating to seasonal variation of weather. Other plot-specific information relating to agricultural productivity includes the topographic and vegetation indicators of household plot characteristics.

To measure local rainfall shocks, we rely on rainfall data from terrestrial precipitation: the 1900 – 2017 gridded monthly time series (version 5.01), from the University of Delaware's (UDel) Center for Climatic Research. The dataset provides estimates of monthly precipitation on a 0.5° by 0.5° grid covering terrestrial areas across the globe for the period 1900–2017. Rainfall estimates are based on climatologically-aided interpolation of available weather station information. The data have been compiled and made available by Matsuura and Willmott (2018). We use the GPS information provided for each locality referenced as enumeration area in the IHPS and IHS4 respectively for 2013 and 2016/2017 waves to access the UDel's rainfall repository by matching each locality to the four closest weather stations in order to obtain rainfall data for the years spanning 1900 and 2017.

We establish rainfall deviation and shocks based on the previous theories. For food shock/nutrition pathway, we rely on rainfall deviation and shocks emanating from the harvest realisations from cultivation during the agricultural seasons for rural households who predominantly depend on harvests for sustenance. By extension, this model captures the income shock pathway of the harvest variation from rainfall shocks. This pathway requires a lag period (an interval) between the planting season and harvesting season which determines the level of household food security before future harvesting seasons. It is important to break linear shock into basic shock components due to evidence of asymmetric impacts emanating from either side of the shock spectrum. The basic approach is the use of quantified negative and positive deviations to measure the potentially asymmetric impacts from either side of the shock spectrum (Sekhri and Storeygard 2015). This is closely followed by use of stage-wise thresholds to characterise shock depths and intensities (Comfort 2016). Following Comfort (2016), we model village-level drought shocks using percentile thresholds of the historical precipitation pattern for each locality. This is similar to the use of standard deviation movements of seasonal rainfall patterns (Rocha and Soares 2015 and Riley 2018). We construct thresholds of drought indicators (low rainfall shock dummies) capturing stepwise drought shocks which enable us to examine cumulative impact of these on food security while disregarding the flood component used in some studies[6].

Wide-range drought shocks – 50th percentile drought shock threshold

$$\text{Drought shock\_50}_{lt-1} = \begin{Bmatrix} 1 \text{ if rainfall within locality is below 50th percentile of norm} \\ 0 \text{ if rainfall within locality is above 50th percentile of norm} \end{Bmatrix} \quad (1)$$

Mid-range drought shocks – 30th percentile drought shock threshold

$$\text{Drought shock\_30}_{lt-1} = \begin{Bmatrix} 1 \text{ if rainfall within locality is below 30th percentile of norm} \\ 0 \text{ if rainfall within locality is above 30th percentile of norm} \end{Bmatrix} \quad (2)$$

Extreme drought shocks – 15th percentile drought shock threshold

$$\text{Drought shock\_15}^{7}{}_{lt-1} = \begin{Bmatrix} 1 \text{ if rainfall within locality is below 15th percentile of norm} \\ 0 \text{ if rainfall within locality is above 15th percentile of norm} \end{Bmatrix} \quad (3)$$

Where the norm represents the average historical yearly precipitation of the locality over 30 years.

We focus on land tenure security questions consistent across the two panel waves, similar to Ma et al. (2016); Owoo and Boakye-Yiadom (2015); and Rao et al. (2016). We restrict our analysis to questions directed to land (or garden) ownership rights and dispute. This sort of questions directly captures land tenure security and varies at the household level. The questions we explore include a measure for title ownership and authority to sell land to capture control over land use; and land dispute to capture existing concerns regarding land security that may affect investment patterns or plans. We construct a measure of land tenure security that combines this variety by indexing households that indicate secure land tenure in at least one of the questions. We create an indicator variable specified as 1 for any tenure security obtained from the above questions and zero otherwise. This simplistic approach for tenure security index facilitates easy interpretation of results while also capturing the diverse roles of land tenure security options for rural households. For the food security indicators, we follow Beegle et al. (2017) by using the quantified food security outcomes, alongside other subjective measures, in our analysis[8].

4.2 Summary statistics

Table 1 below presents the summary statistics of the variables of interest in the regression set up. Average household size is approximately 5, average age of household head is 43 years, and 26 percent of the household heads are women. For general expenditure patterns, log. of real per capita (food) expenditure are 6 and 5.7 respectively. Subjective food security measures show that 47 percent of the sample households reported food insecurity in the previous week while 51 percent reported food dissatisfaction in the previous month. Next, we examine the standardised food insecurity measures. Food security score is at an average of -3 while the mean food resilience index is -6.

Table 1: Summary statistics

Variables	Mean	Std. dev.
Demographic statistics		
HH size	5.039	2.326
Gender of HH head	0.262	0.440
Age of HH head	43.215	16.342
Food security measures		
Expenditure (Total & food)		
Natural log of real per-capita expenditure	5.982	0.952
Natural log of real per-capita food expenditure	5.685	1.018
Subjective food insecurity indicators		
food insecure (in the previous week) - indicator	0.468	0.499
dissatisfaction with food indicator (in the previous month)	0.507	0.500
Standard food insecurity measures		
Food security score	-2.743	1.427
Food resilience	-6.154	8.067
Food consumption score	49.522	18.526
Food consumption score (indicator)	0.764	0.425
Rainfall shock		
Drought shock (50th percentile threshold)	0.956	0.205
Drought shock (30th percentile threshold)	0.415	0.493
Drought shock (15th percentile threshold)	0.080	0.272
Land tenure security (HHs)		
Land tenure index[9]	0.949	0.220
Title (Deed) ownership	0.016	0.124
Authority to sell land	0.596	0.491
Dispute free land	0.896	0.305
Mechanisms		
Household irrigation (indicator)	0.019	0.135
Household credit for food consumption (natural log)	0.751	2.457
Community extension service (indicator)	0.369	0.483

Notes: Summary statistics are computed from a panel of two waves of Malawi Living Standard Measurement Study – Integrated Survey on Agriculture (LSMS-ISA) for 2013 and 2016/17. Summary statistics pertain to rural HHs only including 3,058 observations. Land tenure index is a combination of three mutually inclusive measures below it. Expenditure (Total & food) are measured in \$US. Household credit for food consumption are measured in Malawi Kwacha. Drought shocks are computed as indicator variables from equations 1 – 3.

Mean food consumption score is 50 with over 76 percent of households having above essential food consumption score in the sample. While the subjective food security indicators show below average food satisfaction, food consumption score metrics indicate that households are generally above average food security benchmarks. Wide-range drought shock affects 96 percent of households with only 8 percent affected by extreme drought shock. 94.9 percent own one or other form of security on land (see endnote 8 for discussion on variation). Only 1.6 percent own title deeds, whereas 59.6 and 89.6 percent respectively have authority to sell land and do not have any dispute concerns regarding land. Household land tenure distribution of this nature underpins the aggregative method for land tenure used in this paper to more effectively capture informal tenure security in rural SSA. Only 1.9 households participate in irrigation activities in the past planting season. Log of food credit in the past 12 months amounts to Kwacha 0.8. Approximately 36.9 percent households have access to community extension services over the same period.

4.3 Empirical methodology

This paper investigates whether land tenure security mitigate the impact of drought shocks on food security in Malawi. The study adopts identification strategy similar to Björkman-Nyqvist (2013); and Yang and Choi (2007), and exploits the exogenous variations in seasonal precipitation pattern to investigate the causal impact of drought shocks on households' food security. The primary focus of the study is to model the interaction of land tenure security on the relationship between drought shocks and households' food security as follows:

$$FS_{ht} = \boldsymbol{\delta}_t + \boldsymbol{\phi}_h + \mathrm{TS}_{ht} + \boldsymbol{\beta}_1(\text{Drought shock\_15}_{lt-1}) + \boldsymbol{\tau}_1(\text{Drought shock\_15}_{lt-1}\text{ X TS}_{\text{ht}}) + \boldsymbol{\beta}_2(\text{Drought shock\_30}_{lt-1}) + \boldsymbol{\tau}_2(\text{Drought shock\_30}_{lt-1}\text{ X TS}_{\text{ht}}) + \boldsymbol{\beta}_3(\text{Drought shock\_50}_{lt-1}) + \boldsymbol{\tau}_3(\text{Drought shock\_50}_{lt-1}\text{ X TS}_{\text{ht}}) + X'_{ht}\ \boldsymbol{\beta}_4 + \varepsilon_{ht} \quad (4)$$

Where FS_{ht} denotes food security measures for household *h* at time *t*. δ_t and $\boldsymbol{\phi}_h$ represent year and household fixed effects respectively. TS_{ht} is an indicator variable for land tenure index measure representing all the three possible formal and/or informal tenure measures indicated in the data section. Also, parameters $\boldsymbol{\beta}_i$ denote the direct effects of drought shocks (using different thresholds) on household food security, while $\boldsymbol{\tau}_i$ capture parameters of interest – the interactions between land tenure security status of the household (TS) and drought shocks. Evaluating threshold level relationship between interaction of coefficient estimates from $\boldsymbol{\beta}_i$ and $\boldsymbol{\tau}_i$ is the underlying basis for equation 4. Lastly, X'_{ht} denotes household and community covariates used as controls in the estimation and ε_{ht} is the error term which is assumed to be normally distributed. The error term is assumed to be iid between villages but correlated within villages; hence we cluster the standard errors at the village level for all estimations.

We use a variety of outcome measures including subjective food security indicators from the questionnaire and standardized food security measures constructed using the World Food Program Guidelines (WFPG). Results for both self-reported food security and standardised measures are reported on the Table 2. Food insecurity in the last week is a binary outcome while the standardized WFPG's food security measures namely food security score, food resilience and food consumption score are all continuous outcomes. In addition, we create a binary choice outcome using the applicable threshold for sufficient food intake within the household to capture an indicator for food consumption score. Controls include household characteristics such as household size, income status and credit facility; the demographic characteristics of HH head (including gender, age and education level). In addition to this, we include household yield storage from the agricultural survey as an additional covariate in all regressions to capture the usage of accumulated grain savings as buffers against shocks; adoption of irrigation at the household level and community level access to extension service to capture potential support against drought regimes. Community socioeconomic characteristics included in controls are indicator variables for availability of telephone stall, pharmacy, health clinics, banks, SACCO and aid group for insecticides, HIV intervention and school feeding programs. We also control for a politician coming from a locality as an important political representativeness of each community.

An important aspect to consider in our analysis is the variation in land tenure security across households in Malawi. From the historical context of land acquisition in Malawi for majority of smallholder farmers, evidence shows that majority of land tenure relations are governed by local customs and land acquisition are mostly through inheritance, especially the smallholder farmers that comprises about 80 percent of the farming population (Mkandawire, 1983; Kishindo, 1993; Peters, 1997).

The predominance of customary laws over land tenure allows for, to a large extent, an established land use rights in Malawi. Due to absence of developed formal market for land, cultivation rights and transfer of land are mostly through village headmen and inheritance (Peters and Kambewa, 2007; Lovo, 2016). As a result of growing population over the years, demand for land increased and it led to the emergence of an informal rental market which allowed for land borrowing between relatives. In recent years, however, the informal rental market allowed for informal renting agreements between non-relatives on a season-long basis (Peters, 2010).

In light of the above, land tenure security in Malawi is likely to vary across villages because of the influence of customary laws (that vary among villages) in land transfer and inheritance. One possible limitation of our analysis is the lack of exogenous variation in land tenure across villages which may impact agricultural outcomes. Therefore, our interaction terms in equation 4 may not be interpreted as causal mitigating impact of land tenure security on weather-induced food insecurity. Nevertheless, our results provide important insights from a policy perspective based on the pattern of association between land tenure security and weather-induced food insecurity in Malawi.

5 Results

5.1 The role of land tenure security in mitigating risks of drought shocks on food security

Table 2 presents the results of the interaction of land tenure security with drought shocks. We use a singular index for combined informal tenure security measures available in the household questionnaire to capture potential role of both mode of land acquisition and transfer; and perception of farmers' access to yields following cultivation during agricultural season. This approach is relevant within the rural setting as it captures the two main elements of tenure security associated with rural households in the conceptual framework. The household's land title ownership represents land tenure security on mode of acquisition while authority to use land for transaction purposes or sell it with dispute context of land both depicting the perception of farmers on access to yields. Panels A and B present coefficient estimates on diverse food security sub-categories including subjective (reported) food insecurity and standardised food security measures respectively. Each regression includes the three drought thresholds and their interaction terms including a separate indicator for land tenure security. In general, drought coefficient estimates for all outcome variables are consistent with the expected signs.

In Panel A, the main results for subjective food insecurity measures include a measure for food security concern indicator variable capturing a period of past week[10]. The results represented in columns (1) shows that both the 15th and 50th percentile drought thresholds impact this food security measure with the interaction terms simultaneously showing that land tenure security helps mitigate the accompanying risks. An incidence of extreme drought shock (15th percentile threshold shock) increases the incidence of food insecurity concerns by 37.9 percentage point for weekly food insecurity. The interaction term shows a negative association between interacted shock and food security of around 50.2 percentage point. Coefficient estimates are significant at 5 per cent and above. Similar pattern is repeated for the wide-range shock (50th percentile threshold shock) which increases the incidence of food insecurity concerns by 44.9 while the interaction term is associated with a decline of 44.2 percentage points. Both estimates are significant at the 1 per cent level.

In Panel B, there is no significant estimated impacts of extreme drought shocks or the interaction terms on standardised food security measures. However, columns (2) – (4) report significant coefficient estimates for both the wide-range drought shock and its interaction term. The direct impact of drought results into reduction in the food security measures of -1.344 units, -5.672 units and -35.8 percentage points respectively for food security score, food resilience and food consumption indicator respectively. The interaction term coefficient estimates indicate that the land tenure security is associated with cushioning the impact of drought shocks by increasing the standardised measures by

1.831 units, 4.253 units and 21.0 percentage points respectively. While the coefficient estimates of the interaction term for weekly food insecurity indicator and food security score equals and overcompensates for the adverse effects of drought shocks respectively, food resilience and food consumption score present weaker results. This pattern can be interpreted to mean that the relative effectiveness (mitigating role) of land tenure security differs based on the measure of food security. The main interpretation of the results on Table 2 is that households with land tenure security benefit from its mitigating role when faced with wide-range drought shocks compared to households without secure land tenure. The findings of this paper are consistent with studies that established a positive relationship between land tenure security, agricultural productivity and food security (Chand and Yala, 2009; Holden and Ghebru, 2016; Godfray et al., 2010; Lambin and Meyfroidt, 2011; Holden et al., 2009).

In general, the results demonstrate the persistence of the mitigating role for wide-range drought shock measure relative to just extreme drought shock and the mid-range drought shock. This pattern is important for the structural design of droughts in the literature. It is important to allow the econometric model of the impact of drought reflect unique question design rather than adopt usual drought measures in the literature[11]. It is important to note that while plausibly exogenous variation of drought may enable causal interpretation of drought variables, coefficient estimates from the interaction terms are only associations. Hence, the comparison of these results are restricted to associations rather than causal.

Table 2: Interactive role of informal land tenure security on the impacts of drought shocks on food security outcomes in Malawi.

	Dependent variables:			
	Panel A: Subjective food insecurity	Panel B: Standardised food security measures		
	Food insecurity concern indicator (week)	Food security score	Food resilience	Food consumption score (indicator)
VARIABLES	(1)	(2)	(3)	(4)
Land tenure index	0.342***	-1.609***	-3.785***	-0.095
	(0.093)	(0.291)	(1.125)	(0.059)
Drought shock (15th percentile threshold)	0.379**	-0.182	-1.671	0.169
	(0.162)	(0.635)	(2.572)	(0.407)
15th percentile drought X land tenure index	-0.502***	0.390	2.852	-0.305
	(0.157)	(0.608)	(2.521)	(0.427)
Drought shock (30th percentile threshold)	-0.165	0.090	-0.266	0.119
	(0.131)	(0.422)	(1.942)	(0.087)
30th percentile drought X land tenure index	0.192	0.077	-0.627	-0.086
	(0.128)	(0.393)	(2.049)	(0.091)
Drought shock (50th percentile threshold)	0.449***	-1.344***	-5.672***	-0.358***
	(0.120)	(0.350)	(2.066)	(0.123)
50th percentile drought X land tenure index	-0.442***	1.831***	4.253**	0.210**
	(0.110)	(0.356)	(1.655)	(0.087)
Constant	0.078	-1.583***	1.042	1.094***
	(0.137)	(0.391)	(2.210)	(0.111)
Household FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	2,316	2,187	2,314	2,309
R-squared	0.186	0.261	0.224	0.107

Notes: Table 2 reports coefficient estimates for drought shocks and interaction terms with land tenure index. Land tenure index represents an indicator variable for a combination of informal land tenure security measures including title ownership, dispute-free land possession and authority on use of land for transaction purposes (including sales) by the HHs. Drought shocks are computed for seasonal local precipitation levels lower than the 30-year norm's 15th, 30th and 50th percentiles respectively with each measured as an indicator variable assigned 1 if the seasonal precipitation level of an area is lower than the percentile threshold historical level of precipitation; and zero otherwise. Each drought shock is interacted with the land tenure index in the regression process. The specification also includes a separate indicator variable for the land tenure index variable (equation 4). Dependent variables used in the estimation are defined as follows. Panel A reports results of subjective food security measures using an indicator variable for food security concerns within the HH in the past week and food dissatisfaction in the past month. The food insecurity indicators are assigned 1 for HH who face food security concerns or are dissatisfied within this period and 0 otherwise. Dependent variables in Panel B utilizes the standard World Food Program Guidelines' (WFPG's) measures of food security to compute food security score, food resilience and food consumption scores respectively. Method used to calculate each dependent variable in Panel B is outlined in the data section of the paper. The food consumption score outcome is an indicator variable for food consumption score measure using a threshold of 35 as cut-off for availability of sufficient food; where food consumption scores higher than 35 are considered as acceptable food consumption level and are assigned 1; whereas values lower than 35 are assigned 0. Coefficient estimates from the indicator outcomes are from linear probability model (LPM) regressions which are similar to estimates of the marginal effects from panel logistic regressions. Each column includes all household and year fixed effects and all controls. Controls include household characteristics such as household size, income status and credit accessibility; the demographic characteristics of HH head (including age, gender and education level). In addition to this, we include household yield storage from the agricultural survey as an additional covariate in all regressions to capture the usage of accumulated grain savings as buffers against shocks; adoption of irrigation at the household level and community level access to extension service to capture potential support against drought regimes; and community socioeconomic characteristics such as availability of telephone stall, pharmacy, health clinics, banks, SACCO and aid group for insecticides, HIV intervention and school feeding programs. We also control for a politician coming from a locality as an important political representativeness of each community. Observations are restricted to HHs living in the rural areas only. Robust standard errors (clustered at the enumeration area level) are reported in parentheses. ***, ** and * represent significance at 1 percent, 5 percent and 10 percent levels respectively.

Results in Table 2 suggests that land tenure security plays an important role in mitigating the impact of drought-induced food insecurity and welfare deterioration in rural Malawi[12]. One striking feature of the results is the lack of significant results for the extreme and mid-range drought shocks while results persist for the wide-range drought shock across outcomes. This pattern signals that land tenure security is only reliable source of mitigating role for wide-range nature of shock relative to extreme to mid-range drought shocks. This evidence highlights the importance of an adoption of open-ended shock coverage in the literature (Sekhri and Storeygard 2014, Comfort 2016) rather than focus on extreme components only. Also, an approach focusing on the extreme shocks only may evade results from the mid-range to wide-range shocks similar to the findings in this paper. The pattern of mitigating roles for informal land tenure security depicts the sort of incomplete insurance mechanisms documented in the literature (Dercon 2001).

Another important characteristic of our results is the impacts of drought on food security outcomes and the persistent mitigating role of land tenure security for them. The former suggests that there may be two mechanisms for the impact of drought on household welfare. One mechanism is through agricultural income shocks where household expenditure pattern is affected as a result of income from harvest[13]. More importantly, the comparative nature of estimates between food security and other adopted welfare outcomes suggests that the food expenditure component of the household expenditure is more affected by the income shock following the harvesting season. Another mechanism is the direct food shock as a result of lean harvest. Households may share yields into market and storage components after harvest seasons leading to differential impacts depending on the household priority.

We also check for balanced demographic characteristics across secure and insecure land tenure security households. Appendix Table 3 presents test for equality of means for covariates used in Table 2. The Z-values from all the variables suggest equality of means across the two groups of HHs. Similar results are obtained for dichotomised categories using each category in the land tenure security composition namely ownership of title deeds, HH dispute-free land and authority to sell land (results available from the authors upon request). This pattern is consistent with balanced characteristics expected for HHs across tenure security and provides additional support for the identification assumption of parallel trends required for a difference-in-difference approach in equation (4).

5.2 Channels of the mitigating role of land tenure between drought and food security

There are two main channels through which land tenure security mitigates food insecurity generated by weather shocks. Farmers may take proactive measures to invest on land prior to and/or during planting seasons. Since having land tenure security gives the farmer the authorisation to invest on farmlands, this could compensate for potential adverse effects in the future by helping to build farm resilience. These include farm irrigation and other land conservation methods[14]. Another way is the reactive measure afterwards adverse impacts of droughts. In this case, farmers affected by weather shocks could experience low harvest and face food insecurity which they can mitigate by borrowing if they have tenure security. An underlying assumption of the latter is that while holding a land title may be perceived as a formal collateral, having an authority to sell lands and/or having dispute-free land both translate to informal collateral respectively.

Next, we explore the role of household credit facilities and irrigation practice in our results to understand the potential channels by using credit and irrigation measures as outcome variables to investigate the channels in a modest specification where tenure security, wide-range drought shock (50th percentile threshold) and an interaction term are included as explanatory variables[15]. Table 3 presents the coefficient estimates of land tenure security to evaluate the mitigating role of droughts in Panels A and B respectively for credit access and irrigation. Results from columns 1 and 2 of Panel A demonstrate that land tenure households have greater likelihood of borrowing for food for households exposed to drought shocks. Estimated coefficient suggests that there is a likelihood for an 18.3 percentage point increase in the credit facilities accessed by secured household during the drought periods. Similar result is presented for the amount of credit and both are significant at 1 per cent level. In Table 3 Panel B, tenure security coefficient estimates for irrigation practice within household and exposure to extension service within the local community are each nuance and not statistically significant. This pattern strongly indicates a credit/borrowing pathway for the mitigating impact of shocks on food security in a manner not revealed for irrigation. We utilise additional variables from the agricultural questionnaire to further explore the role of farm investment to mitigate the negative impacts of shocks alongside land tenure security.

Table 4 presents results for intermediate outcomes including investment on land, perennial ownership of crops and agricultural output/productivity. Results in Table 4 Panel A reveals that tenure security increases the likelihood for use of pesticides and number of weeding weeks within the planting season. Similarly, Table 4 Panel C shows that tenure secure households are more likely to sell part of their harvest and have greater sales. Tables 3 and 4 provide mixed evidence in support of effectiveness of land tenure as both proactive and reactive measures that are deemed complementary in mitigating the risks of food security impacts from droughts in Malawi. While other channels in Tables 3 and 4 have equivalent suitability across drought thresholds, irrigation methods may be likely associated with the linkage of land tenure to food security for extreme drought shocks which lacks persistent results in this paper.

Table 3: Impacts of land tenure security on household credit and irrigation outcomes.

	Dependent variables:			
	Panel A: Credit		Panel B: Irrigation indicators	
	Indicator	Ln(credit)	Irrigation practice	Extension service
VARIABLES	(1)	(2)	(3)	(4)
Land tenure index	0.183**	1.705**	0.011	-0.133
	(0.092)	(0.836)	(0.011)	(0.096)
Constant	0.090	0.577	-0.046	0.329**
	(0.066)	(0.569)	(0.036)	(0.144)
Household FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	2,316	2,316	2,501	2,316
R-squared	0.081	0.080	0.030	0.158

Notes: Table 3 reports coefficient estimates informal tenure security for credit and irrigation variables. Regression includes land tenure index, 50th percentile drought and the interaction of both. Panel A presents results for indicator and natural logarithm of the amount of household food related credit facilities in the past twelve months in columns (1) and (2) while Panel B reports results for indicator variables for household irrigation practice and access to extension service within the same period. Indicator variable in column 1 is designated 1 if the household access credit facility for consumption; 0 otherwise Indicators in columns 3 and 4 are assigned 1 if household practice irrigation or have access to any extension service within the last season; 0 otherwise. Coefficient estimates from the indicator outcomes are from linear probability model (LPM) regressions which are similar to estimates of the marginal effects from panel logistic regressions. Each column includes household and year fixed effects and all controls. See Table 2 for a list of covariates used as controls in the estimation. Note that controls exclude relevant outcome variable in each case. Observations are restricted to HHs living in the rural areas only. Robust standard errors (clustered at the enumeration area level) are reported in parentheses. ***, ** and * represent significance at 1 percent, 5 percent and 10 percent levels respectively.

Table 4: Impacts of land tenure security on land investments, perennial crop cultivation and agricultural outputs.

	Dependent variables:				
	Organic	Inorganic	Pesticides	No. of weeding weeks	week1 weeding level
VARIABLES	(1)	(2)	(3)	(4)	(5)
PANEL A: Investments on land					
Land tenure index	-0.170	-0.012	0.054**	1.178***	0.395
	(0.200)	(0.088)	(0.026)	(0.396)	(1.096)
Constant	0.326	0.659***	0.059	1.708*	4.761***
	(0.224)	(0.074)	(0.052)	(0.936)	(1.372)
Observations	2,590	2,590	2,590	2,590	2,590
R-squared	0.035	0.038	0.055	0.215	0.279

PANEL B: Perennial (Tree) Crops	Dependent variables:				
	Plant permanent crop	Sell permanent crop	Store permanent crop	Natural log of recent permanent crop planted	Natural log of permanent crop sold
	(1)	(2)	(3)	(4)	(5)
Land tenure index	-0.104	-0.006	-0.038	-0.197	-0.103
	(0.324)	(0.034)	(0.033)	(0.128)	(0.323)
Constant	0.116	-0.119	-0.002	0.156	-1.207
	(0.370)	(0.090)	(0.051)	(0.259)	(0.765)
Observations	2,590	2,590	2,590	2,590	2,590
R-squared	0.054	0.075	0.051	0.069	0.076

PANEL C: Agricultural output and productivity	Dependent variables:				
	Sold harvest	Value of harvest sold			
	(1)	(2)			
Land tenure index	0.397***	3.804***			
	(0.081)	(0.854)			
Constant	0.371***	3.881***			
	(0.124)	(1.232)			
Household FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓
Observations	2,590	2,590			
R-squared	0.068	0.073			

Notes: Table 4 above reports the coefficient estimates of land tenure index on intermediate outcomes directly. PANEL A reports estimates for investments in land during the planting season. Regression includes land tenure index, 50th percentile drought and the interaction of both. PANEL A Columns 1 – 3 are all indicator variables for application of organic fertilizer, inorganic fertilizer and pesticides during the cultivation seasons respectively. PANEL A columns 4 & 5 are the number of weeks of engagement of weeding activities during the planting season and the weeding level accomplished within the first week respectively. PANEL B presents results for cultivation of perennial crops where columns 1 – 3 are indicator variables for cultivation of any permanent crop, and sales/storage of permanent crops in the past twelve months. PANEL B columns 4 & 5 are the natural logarithm of permanent crops planted and sold within the same time period. PANEL C reports coefficient estimates for agricultural output and productivity which includes an indicator variable for selling any harvest from seasonal crop cultivation and the natural logarithm of harvest sold. Coefficient estimates from the indicator outcomes are from linear probability model (LPM) regressions which are similar to estimates of the marginal effects from panel logistic regressions. See Table 2 for a list of control variables. Each column includes all controls. Observations are restricted to HHs living in the rural areas only. Robust standard errors (clustered at the enumeration area level) are reported in parentheses. ***, ** and * represent significance at 1 percent, 5 percent and 10 percent levels respectively.

5.3 Heterogeneous impacts between matrilineal and patrilineal societies

In Malawi, land transfers through inheritance are based on customary tenure systems that vary across villages and are mostly influenced by marriage and residency practices (Peters, 2010; Berge et al. 2014; Lovo, 2016). The system of land tenure is defined based on the matrilineal and the patrilineal system of inheritance (Peters 2010; Berge et al., 2014). Both in patrilineal and matrilineal arrangements, the death of the household head can trigger the risk of expropriation by the deceased's relatives because the wife/husband loses the rights to the property, e.g. land (Peters 2010; Berge et al., 2014; Asfaw and Maggio, 2017).

This informal lineage-based and gender-biased landholding constitutes another source of land tenure insecurity which can affect investment incentives and agricultural productivity in Malawi. For instance, Kishindo (2010) conducted targeted interviews in Kachenga village of Balaka district of Malawi; the findings show that men in matrilineal-matrilocal villages are less willing to make long-term investments. Therefore, gender-biased land tenure system could have implications on agricultural productivity and food security.

Similarly, from our analysis of household's exposure to drought shocks in Malawi, empirical evidence has shown that social and cultural norms could interact with weather events and result in unexpected outcomes (Asfaw and Maggio, 2017). From Appendix Table 5, we find heterogeneous impacts of rainfall shocks and interaction by patrilineal (Chart A) and matrilineal (Chart B) societies separately; where the results are more persistent for the matrilineal societies but nuanced for the patrilineal societies. These results are related to Turner (1999) and Brockhaus and Djoudi (2008). For example, Turner (1999) shows that drought in Niger strengthened women's control over livestock.

6 Conclusion and policy implications

Climate variability has been a major source of threat to agricultural production, food security and livelihoods of vast majority of agrarian households in developing countries. Over the years, there has been efforts by governments – both local and international – to design sustainable policies (directly or indirectly) to help households cope or mitigate the pernicious impacts of weather shocks. In view of this, our study extends the existing literature by evaluating the mitigating role of land tenure security on food security in agricultural dependent regions. Specifically, we explore variations in land tenure security and drought regimes across villages to investigate the extent to which land tenure system matter in households' capacity to cope with negative consequences of climate shocks for rural agricultural dependent households in Malawi.

Our findings reveal that wide-range drought persistently impacts a variety of household food security among rural households in Malawi. More importantly, we investigate the role of land tenure security across households and the capacity to cope with the droughts. The results show a counteracting association of land tenure security on the impact of the drought shocks on food security. Land tenure security arrangements in Malawi are widely diversified across legal, institutional and customary perspectives. These results are consistent with the importance of an extensive strategic land reform similar to those documented in the literature (Deininger et al. 2009) and have important policy direction for government agencies in charge of land management in Malawi. Also, we established a pathway for the mitigating effects of land tenure security as credit access for the purpose of food which we posit may be for investments on cultivation practices to improve farm resilience. The coefficient estimates for matrilineal and patrilineal communities are distributed along outcome variables in a manner that does not suggest any heterogenous roles of land tenure security.

The results suggest that land tenure security can have important policy implications, particularly from the perspective of safety nets. The results of this study reinforce the growing consensus that property rights through land tenure security are associated with agricultural productivity and household food security in rural areas. Even though land acquisition in Malawi is largely and effectively routed through customary tenure systems (inheritance), the need for formal titles to landowners is to enhance security by preventing land grabbing and expropriation by the government. Having formal land titles is often associated with land tenure security, which can lead to increased soil conservation practices and agricultural productivity by the landowners.

This study stresses that land reforms aimed at increasing tenure security and inclusive ownership for land users may improve productivity thereby mitigating the negative impacts of weather shocks and enhancing household welfare among agricultural dependent households. Therefore, land tenure security can be a policy instrument to enhance or change the welfare distribution of households. This can also lead to reduction in poverty by promoting growth and sustainable development in developing countries.

Notes

[1] As of 2012, the share of people living on $1.90 or less a day was 47 percent (501 million people) of SSA's population. This yields 233 million undernourished people in SSA within the same period (World Bank, 2017).
[2] Recent evidence shows that climate and weather variability have deleterious effects on household welfare through crop failures and yields variability. Therefore, climate change can potentially affect all aspects of food security through reduction in food access and utilization, and price instability (IPCC, 2014).
[3] Rural households with secure land tenure could adapt to seasonal variations in climate and conditions through migration to other less-affected areas for the drier months. For example, pastoralists in Mongolia, because of their traditional customary rights allow them to migrate to other range land in case of emergencies (FOA, 2011; Lokonon, 2018).
[4] Secure land tenure could also increase the need for smallholder farmers to use government or agricultural extension services (Meinzen-Dick et al., 2019).
[5] This kind of risk is prevalent in SSA because most of the farms are rainfed and this depends on vagaries of climate (Lamb, 2003).
[6] The focus on drought is strengthened by evidence of strong patterns of drought incidence across localities against weak flood incidence in rural Malawi from the UDEL weather data. For example, no locality reports an indication of extreme flood measure (above 80th percentile precipitation of the historical level) for Malawi in the UDel weather data. Summary of the distribution of self-reported causes of food insecurity in Appendix Table 1 also supports the prevalence of droughts with 50.8 per cent cases as against flood incidence with 4.0 per cent.

[7]An alternative drought shock in standard deviation movements from the literature can be computed using $\text{Drought shock}_{lt-1} = 1 \; if \; \text{Rainfall}_{lt-1} < (\overline{\text{Rainfall}_l} - \text{Rainfall}_l^{SD})$, and zero otherwise.
[8] We examine food security outcomes using the following: (i) subjective food insecurity incidence with the household over a period of one week (ii) food security score (iii) food resilience index: which is the negative of the World Food Program coping strategy index. The index is calculated as the negative of the weighted sum of the number of days in the past seven days that households had to reduce the quantity and quality of food consumed. (iv) a food consumption score is computed following WFP guidelines and aims to capture both dietary diversity and food frequency; it is the weighted sum of the number of days the household ate foods from eight food groups in the last week. The score is calculated based on the sum of weighted number of days in the last week the household ate food from eight food groups: (2 * number of days of cereals, grains, maize grain/flour, millet, sorghum, flour, bread and pasta, roots, tubers, and plantains) + (3 * number of days of nuts and pulses) + (number of days of vegetables) + (4 * number of days of meat, fish, other meat, and eggs) + (number of days of fruits) + (4 * number of days of milk products) + (0.5 * number of days of fats and oils) + (0.5 * number of days of sugar, sugar products, and honey). Spices and condiments are excluded. It has a maximum value of 126.
[9] Our identification strategy utilizes the underlying variation in each tenure security measure between 2013 and 2017. Appendix Table 4 shows that increase in tenure security of approximately 3 percent are determined from an underlying increase in the **authority to sell land** and **lack of dispute on land** of around 4 and 5 percent respectively as against decline in **title ownership** of around 1 percent. Additional summary statistics not presented in the Tables show that households without security in 2013 that have gained tenure security in 2017 account for 6.4% while households who have lost their tenure security in the same period account for approximately 4.0%. This amounts to variation in tenure security of 10.4% among households while those without change over this period represent approximately 90% (89.6% for those with security and 0.4% for those without).
[10] We exclude the household food insecurity question relating to dissatisfaction about household food availability/accessibility in the past month and insecurity during one year in this category to avoid reporting bias associated with memory loss.
[11] Use of only extreme drought shock measures in the current research question would lead to misleading conclusions of the mitigating role of rainfall shocks. Although, we expect extreme shock to impact harvest and food security in our initial set up, the impacts associated with wide-range shock is premised upon the importance of adequate precipitation level during the agricultural season for optimal harvest.
[12] Estimated results are robust to adjustments for multiple hypothesis using the Bonferroni-adjusted tests. Results are available from the authors upon request.
[13] Drought shock is lagged to cover harvests from the previous agricultural season in such a way that income shock will be realised around survey period.
[14] This may reflect in the way of land preparation or crop cultivation.
[15] We focus on the 50th percentile threshold drought shock since this component serves as the main driver of the main results in Table 2. Note that we report only coefficient estimates of land tenure index for channels.

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Appendix

A1: Additional descriptive statistics: subjective food insecurity causes and village characteristics

Appendix Table 1 presents self-reported causes of food insecurity. For the various causes identified in the survey, drought is reported as the most common cause of food insecurity at 51 percent, followed by farm input and expensive food respectively 49.2 and 40.6 percent. Land access is reported only as intermediate causes of food insecurity with 13 percent while all others are regarded as insignificantly associated with food insecurity.

Appendix Table 1: Self-reported cause of food security issues

Variables	Mean	Std. dev.
Drought	0.508	0.500
pest damage	0.024	0.153
land access	0.129	0.335
farm input	0.492	0.500
expensive food	0.406	0.491
transport cost	0.006	0.075
market food reduction	0.031	0.174
flood	0.040	0.195
Others	0.086	0.280

Notes: Summary statistics of the self-reported cause of food insecurity causes is compiled from three diverse causes ordered by level of importance across HH. Summary statistics pertain to rural HHs only. The causes listed above are not mutually exclusive events as HH can specify multiple causes at the same time.

The summary statistics on the distribution of the villages by customary marriage practice and inheritance customs in Appendix Table 2 details marriage customs with priority given to either matrilineal or patrilineal in addition to a secondary customary marriage practice. As expected, matrilineal customary practice is the most prevalent across the villages accounting for 94 percent of all villages. Within the matrilineal category, matrilocal features as secondary marriage practice features in 65 percent villages. Also, 66 percent of communities trace their descents to only mothers while sharing with fathers in additional 20 percent villages. These summary statistics support prevalence of matrilineal and female descent tracing in Malawi.

Appendix Table 2: Customary marriage practice and inheritance customs

Variables	Mean	Std. dev.
Customary marriage practice		
Matrilineal and neolocal	0.067	0.251
Matrilineal and matrilocal	0.652	0.477
Matrilineal and patrilocal	0.221	0.415
Patrilineal and neolocal	0.027	0.161
Patrilineal and patrilocal	0.033	0.179
Inheritance customs		
Father	0.138	0.345
Mother	0.657	0.475
Both	0.204	0.403

Notes: Summary statistics of the customary practice and inheritance customs are all indicator variables representing the proportional contribution of each category. Each case varies at the community/village level. Summary statistics pertain to rural HHs only.

A2: Balanced means test – Household demographic characteristics and community covariates

Appendix Table 3: Test for difference in normalised means in demographic characteristics by HH land dispute experience

Variables	Land insecure HHs		Land secure HHs		Norm-Difference
	Mean	Std. Dev.	Mean	Std. Dev.	
HH size	5.1395	2.6242	5.1100	2.2342	**0.0086**
Income status indicators (with reference to wealth)					
wealthy	0.0388	0.1938	0.0882	0.2837	**-0.1440**
little savings	0.1550	0.3634	0.1133	0.3171	**0.0865**
just able to meet expenses	0.3566	0.4809	0.3559	0.4789	**0.0010**
barely able to meet expenses	0.1705	0.3776	0.2095	0.4071	**-0.0702**
borrow to support	0.2791	0.4503	0.2330	0.4228	**0.0747**
Storage crop (indicator)	0.5969	0.4924	0.5851	0.4928	**0.0169**
Household irrigation (indicator)	0.0233	0.1513	0.0192	0.1374	**0.0197**
Household credit for food consumption (natural log)	0.4958	1.9408	0.7179	2.4016	**-0.0719**
Community extension service (indicator)	0.3577	0.4813	0.3704	0.4830	**-0.0186**
HH head					
Age	42.6357	17.1022	44.3731	16.4099	**-0.0733**
Gender	0.2326	0.4241	0.2823	0.4502	**-0.0804**
Attend school	0.8438	0.3645	0.8289	0.3767	**0.0283**
No education	0.1563	0.3645	0.1719	0.3774	**-0.0299**
Primary	0.7109	0.4551	0.6755	0.4683	**0.0542**
Junior secondary	0.0859	0.2814	0.0847	0.2785	**0.0031**
Senior secondary	0.0469	0.2122	0.0598	0.2372	**-0.0407**
Higher education	0.0000	0.0000	0.0072	0.0844	**-0.0849**
University	0.0000	0.0000	0.0008	0.0290	**-0.0290**
Community covariates					
Community telephone service	0.2481	0.4336	0.2187	0.4135	**0.0489**
Community schooling feeding program	0.2946	0.4576	0.3467	0.4760	**-0.0790**
Community pharmacy	0.8062	0.3968	0.7353	0.4413	**0.1195**
Community healthcare centre	0.2946	0.4576	0.2932	0.4553	**0.0022**

Community clinic	0.4496	0.4994	0.4095	0.4918	**0.0573**
Community insecticide intervention	0.7907	0.4084	0.7917	0.4062	**-0.0018**
Community HIV facility	0.4961	0.5019	0.4818	0.4998	**0.0202**
Community bank	0.1163	0.3218	0.0958	0.2943	**0.0470**
Community SACCO	0.2093	0.4084	0.1928	0.3946	**0.0290**
Community parliamentary representative	0.1705	0.3776	0.1506	0.3577	**0.0384**

Notes: SACCO is an acronym for Savings and Credit Cooperative Organization. Covariate balancing test in the Table above between land insecure HHs (the control group) and land secure HHs (the treatment group) adopts the normalized difference approach in Imbens and Wooldridge (2009) where variables with above a quarter norm-difference are perceived as significantly different between the two groups. The normalized difference is calculated as $norm - diff = \frac{\overline{X_0} - \overline{X_1}}{\sqrt{s_{x,0}^2 + s_{x,1}^2}}$, where s^2denotes the sample variance of x_i.

Appendix Table 4: Distribution of tenure security measures between 2013 and 2017

	Year			
Variable	2013		2017	
	Mean	Std. Dev.	Mean	Std. Dev.
Land tenure index	0.931	0.254	0.964	0.186
Title (Deed) ownership	0.023	0.149	0.010	0.097
Authority to sell land	0.877	0.329	0.913	0.283
Dispute free land	0.570	0.495	0.618	0.486

A3: Heterogeneous results

Appendix Table 5: Heterogenous impacts of main results by patrilineal and matrilineal localities.

	Dependent variables:			
	Panel A: Subjective food insecurity	Panel B: Standardised food security measures		
	Food insecurity concern indicator (week)	Food security score	Food resilience	Food consumption score (indicator)
VARIABLES	(1)	(3)	(4)	(5)
Chart A: Patrilineal localities				
Land tenure index	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Drought shock (15th percentile threshold)	0.879	-12.243***	-42.866**	-0.940
	(0.710)	(3.321)	(18.595)	(0.937)
15th percentile drought X land tenure index	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Drought shock (30th percentile threshold)	-0.489	2.076*	-1.208	0.016
	(0.481)	(1.072)	(4.558)	(0.397)
30th percentile drought X land tenure index	0.298	-0.968*	4.177	-0.131
	(0.471)	(0.545)	(3.406)	(0.226)
Drought shock (50th percentile threshold)	0.220	-0.285	-2.602	-0.448**
	(0.152)	(0.710)	(4.186)	(0.205)
50th percentile drought X land tenure index	-0.282**	0.159	-0.085	0.165
	(0.132)	(0.540)	(3.068)	(0.101)
Constant	0.942*	1.014	16.021	1.620**
	(0.523)	(2.243)	(10.524)	(0.703)
Observations	659	624	659	658
R-squared	0.293	0.423	0.266	0.274
Chart B: Matrilineal localities				
Land tenure index	0.236***	-1.427***	-3.255***	-0.111***
	(0.059)	(0.139)	(0.967)	(0.036)
Drought shock (15th percentile threshold)	0.436*	-0.780	0.933	-0.774***
	(0.244)	(0.895)	(4.988)	(0.163)
15th percentile drought X land tenure index	-0.703***	1.186	3.377	0.694***
	(0.253)	(0.989)	(5.863)	(0.166)
Drought shock (30th percentile threshold)	-0.139	0.348	-0.838	0.070
	(0.154)	(0.439)	(2.641)	(0.103)
30th percentile drought X land tenure index	0.205	-0.394	-0.792	-0.037
	(0.154)	(0.438)	(2.840)	(0.107)
Drought shock (50th percentile threshold)	0.474**	-1.508***	-5.277*	-0.166
	(0.184)	(0.508)	(2.718)	(0.152)
50th percentile drought X land tenure index	-0.365***	1.912***	3.070	0.212**
	(0.104)	(0.302)	(1.958)	(0.092)
Constant	0.008	-1.385**	0.159	0.981***
	(0.179)	(0.534)	(2.776)	(0.142)
Household FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Controls	✓	✓	✓	✓
Observations	1,641	1,547	1,639	1,635
R-squared	0.221	0.307	0.277	0.132

Notes: See Table 2 for notes.