Effect of Land Policies and Women Empowerment on Nutrition: Panel Data Evidence from Malawi

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By

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Abstract

There is growing interest in the productivity impacts of land tenure regularization and separately in nutritional outcomes of increased agricultural productivity. Nonetheless, there is minimal scientific evidence on the linkages between land tenure security and nutrition. This paper analyses the impact of land tenure security of households and women on maize productivity, agricultural income and nutrition (household dietary diversity, micronutrient dietary diversity, food consumption scores, calorie, Vitamin A, Iron and Zinc intake). Using nationally representative panel data from Malawi, the study reveals that land tenure security has a positive and statistically significant influence on household and women headed household's agricultural income and negative and statistically significant influence on household and women headed household's maize productivity. In addition, the study found that land tenure security of households and women headed households is positively and significantly associated with calorie, Vitamin A, Iron and Zinc intake. The relationship between land tenure security and dietary diversity is positive but not statistically significant. However, land tenure security is inversely associated with food consumption scores both for households and female headed households. Thus, we can expect the registration of customary land under the new land laws to accelerate women's empowerment and household nutrition in Malawi significantly.

Keywords: *Land policies, nutrition, household dietary diversity, calorie intake, micronutrients, women empowerment*

1. Introduction

While much effort has been put into reducing food and nutrition insecurity through improving agricultural productivity in the past decade, the prevalence of undernourishment in Africa has increased from 16.9% in 2015 to 18.0% in 2019 and from 19.5% in 2015 to 20.6% in Sub-Saharan Africa (FAO et al., 2021). Severe food insecurity has increased from 20.4% to 24.9% within the same period due to dwindling agricultural productivity (FAO et al., 2021). Dwindling yield per unit of land is primarily due to high population growth and increasing cases of land-based conflicts (Peters and Kambewa, 2007; Place and Otsuka, 2001a). Land tenure regularization has been identified as one element that facilitates agricultural productivity and food and nutrition security (Chirwa, 2008; Holden and Ghebru, 2016; Mendola and Simtowe, 2015). Unfortunately, over 70% of arable land in the developing world and about 99% in Malawi are not tenure formalized (USAID, 2021). Increasing population densities and pressure on land in Sub-Saharan Africa (SSA), particularly in developing countries like Malawi, enhance the policy relevance of food and nutrition impacts of land tenure regularization. There is, thus, a growing interest in the nexus between the productivity impacts of land tenure regularization and nutritional outcomes (Espinosa, 2014; Holden and Ghebru, 2016). Nonetheless, there is minimal scientific evidence on the linkages between land tenure security and nutrition.

This paper analyses the effect of land tenure security of households and women on household agricultural productivity, particularly maize productivity and nutrition in Malawi. A positive impact of land tenure security on the nutrition status of households will influence the accelerated implementation of the recently approved land laws, particularly customary land regularization in the case of Malawi. The focus on women in this study presents an exciting way to look at the effect of land tenure security on nutrition because women produce most of the food globally, yet they hold only about 32% of the farms (Aberman et al., 2015; USAID, 2021).

This paper offers several additions to existing literature. First, researchers have tried to develop a framework for understanding the causal relationship between land tenure security, and food and nutrition security but with limited empirical evidence. The limited empirical evidence around the world is, in part, due to the disconnect between research, policy, and programs on land tenure on one hand and food security on the other. Some studies that have attempted to establish this linkage claim that land tenure research does not integrate food security, let alone nutrition elements, in

data collection systems and vice-versa (Holden and Ghebru, 2016). Nonetheless, there is a growing need to bring these systems together to enhance our understanding of the linkages between land tenure and food and nutrition security. The current study uses LSMS data with land tenure and food consumption information in the same dataset and helps understand the land tenure and nutrition nexus.

Secondly, most studies that have considered land tenure security have linked tenure security to food security without considering how tenure security affects the nutritional outcomes of households. Even at the food security level, empirical studies have found mixed evidence of the impact of land tenure security on food security outcomes of households. For example, studies on the land redistribution program in Malawi (e.g., Luwanda, 2015; Mendola & Simtowe, 2015) found that land tenure security improved the food security status of participating households. However, other studies, e.g. (Chirwa, 2008), found that the changes in welfare associated with the land redistribution program in Malawi were mainly derived from financial resources accessed under the program than the change in land tenure itself.

Thirdly, studies that have examined the link at the food security level have used non-conventional impact assessment techniques (e.g., Kamoyo et al., 2017; Luwanda, 2015; Matchaya, 2009). Chirwa, (2008); and Mendola & Simtowe, (2015) seem to be the only studies that have employed standard impact evaluation techniques in Malawi. However, neither study examined the link between land tenure security and nutrition and did not use nationally representative data. Lawry et al., (2017) noted that the linkage between land tenure security and nutrition is best studied using nationally representative panel data. However, the absence of such data with land tenure and nutrition information in most countries, Malawi inclusive, limits such analyses. Banerjee & Iyer, (2005) and Holden & Ghebru, (2013) are the few studies that have analyzed the impact of land tenure on development and poverty reduction, respectively, using nationally representative panel data. The current study uses panel data that allows us to control for potential confounders in estimating causal effects.

Estimates of the study confirm that household land tenure security has a positive but not statistically significant influence on crop productivity and a positive and statistically significant influence on agricultural income. In addition, the study finds a statistically significant influence of household land tenure security on calorie, Vitamin A, Iron and Zinc intake. Furthermore, the study shows that land tenure security of female headed households has a positive but not statistically significant influence on crop productivity. More importantly, tenure secure female headed households as associated with significant calorie, Vitamin A, Iron and Zinc intake than tenure insecure female headed households.

This paper is organized as follows: First, the evolution of land tenure in Malawi is described. Second, tenure security and insecurity are contextualized. Third, the study's objectives, the conceptual framework for understanding causal linkages between land tenure security and nutrition, the data used in the study, and the empirical strategy are presented. Finally, the study results are discussed, and conclusions and policy implications are drawn.

Evolution of land tenure in Malawi

The 1965 Land Act of Malawi classified land into public and private land. Private land is owned, held, or occupied under a freehold, leasehold, or customary title. A freehold estate is a piece of land held in perpetuity and has a Certificate of Claim. Freeholds originated in the colonial era and were designed to expropriate land to colonial settlers through private title. A leasehold is a piece of land for which a lease has been granted. Customary land is land used for the benefit of the community within traditional land management areas. Developments in the land sector necessitated updating the land law, and by 2016, the government enacted nine land-related laws. Significant changes in the new land laws include the prohibition of granting freehold titles and converting any such lands to leasehold titles. In addition, the current law provides for the registration of customary land as private land, which was not possible before.

In 2017, the Ministry of Lands, Housing, and Urban Development (MoLHUD) established a Land Reform Implementation Unit (LRIU) to pilot five critical land-related laws to inform national rollouts. However, at the time of preparing this article, the Ministry had not yet issued secure land rights on customary estates. Data on farm households with secure customary land rights were not available. Nonetheless, a few farm households have private land rights, especially in estates.

Tenure security and insecurity

In the strictest definition of land tenure security, customary land was not secure before the Land Bill was enacted in 2016. As indicated by Lovo, (2016), at the time of enacting the Land Bill in 2016, most of Malawi's land was under the customary system in which chiefs granted land-use rights, and transfer was through inheritance. The current law provides for the transfer of customary land through traditional land committees. It is expected that such tenure security will bring farmers confidence to invest more in their land.

However, some researchers have argued that the presence of title does not make any difference if the absence thereof does not lead to feelings of insecurity among farmers. Particularly, Place and & Otsuka, (2001) noted that even though titles are essential, land use rights in Malawi are well established to ensure that farmers are more tenure secure. In addition, Broegaard, (2005) noted that a farmer's perception of security over land matters for long-term investment decision making over land. Therefore, perceived tenure security is a composite concept of farmers' assessment of tenure situation and their fears for future land disputes. Ege, (2017) defined tenure insecurity as the risk of being evicted from a parcel of land. Such threats to land tenure security include disputes over boundaries, inheritance settlements, access rights and way of passage, land grabbing and invasion by the landless, and government expropriation.

The current study does not test whether tenure security perceptions in the absence of tenure documents affect farm investments. The focus is in testing whether the presence of a tenure security document affects agricultural productivity and nutrition.

2. Methodology

Conceptual framework

There is a vast literature on agriculture's contribution to nutrition (see Aberman et al., 2015; Chung, 2012; Fan & Pandya-Lorch, 2012; Headey, 2013; Headey & Hoddinott, 2016; Meerman, 2018; Rammohan & Pritchard, 2014). Of these, the most extensive conceptual framework was developed by Hoddinott, (2012). The current study adapts this framework into a simple, easy-to-follow framework to highlight the linkages between land tenure security and nutrition.

Hoddinott's (2012) conceptual framework describes how agriculture contributes to nutrition via three components: setting, resources, and processes associated with agricultural production. The setting includes physical, social, economic, legal, and governance settings. Of interest in the current study is the legal setting, which are the rules of the game (formal and informal laws, including land laws) shaping households' economic decision-making. Resources include time and capital. Capital includes physical capital like land upon which agricultural production takes place. It also includes human capital like knowledge and skills. Agricultural production processes are influenced by the setting and resources, including the soil fertility status and availability of land for cultivation. We refer the reader to Hoddinott (2012) for fuller details on these components. The interest in the current study is in tracking how changes in land tenure systems translate to nutrition outcomes.

Three main pathways through which land tenure security influences nutritional outcomes can be traced: 1) Agricultural production, 2) land markets, and 3) women empowerment. The effect on agricultural production comes from investments in sustainable land management which increase agricultural productivity and production. Nkonya, Mirzabaev, & von Braun (2016) demonstrate that land tenure security is necessary for sustainable land management. Secure land tenure incentivizes farmers to invest in sustainable land management practices, including conservation agriculture. Such investments lead to improvements in the soil condition, resulting in improved crop production and productivity. High crop productivity has positive effects on food availability and nutrition. Increased crop productivity and production result in the consumption of diverse and quality food from own production or the markets for land-constrained households (Ali et al., 2014; Goldstein et al., 2018; Savath et al., 2014).

In addition, farmers with surplus crop output can sell to the market and earn income to buy more diverse and nutritious foods. Land tenure security also creates incentives for investing in irrigation (Besley, 1995; Kirk and Tuan, 2009). This, in turn, increases crop production and household income, translating into improved households' nutrition status. Furthermore, changes in agricultural production technology, including zero tillage and mulching, lower the intensity of labor for cultivation, weeding, and fertilizer application, which are good for nutrition.

Secondly, land tenure security opens opportunities to transact in land markets. It affects household nutrition via two routes: 1) through increased household income resulting from renting out land or the sale of land which can be used to purchase diverse and quality foods; and 2) through renting in of land for the production of diverse and high-quality foods. Land can also be used as collateral to secure credit for production inputs (Besley, 1995; Kirk and Tuan, 2009).

Thirdly, land tenure security impacts nutrition indirectly through women empowerment. Alkire et al., (2013) developed the Women Empowerment in Agriculture Index (WEAI) and defined women empowerment as a composite index of women's control over production resources, income, leadership, and time. This study focuses on women's control over land as a proxy for women's empowerment. Odeny, (2013) points out that land is an issue for women. There is a direct relationship between securing land access, having land rights, achieving food security, and overcoming poverty. Women produce more than 80% of the food, yet they control only one percent of the land. In addition, FAO (2011) estimated that crop yields would increase by 20% to 30%, and the number of undernourished people in the world would decrease by 12% to 17% if women had the same access to production resources as men. FAO (2011) also shows that women with secure access to land decrease the incidence of food insecurity by 36% and increase food expenditure and educational attainment. Furthermore, children born to mothers who own land are 10% less likely to be sick and 33% less likely to be severely underweight.

There is a bi-direction relationship between improved nutrition status of households and agricultural productivity, particularly labor productivity. Well-nourished households become more productive on the farm where manual labor is involved than malnourished households Aberman et al., (2015).

Data

Nutrition security indicators are best measured at the individual level than at the household level (Aberman et al., 2015). For instance, the Integrated Household Survey (IHS) questionnaire for Malawi questions whether any household member consumed a particular type of food in the past seven days. If the answer to the question is yes, that household is qualified to have eaten that food, when in actual sense, it may just be one individual who ate the food. Examining nutrition at the household level conceals vital information about the nutrition of individuals. However, this apparent importance of examining nutrition at the individual level

is constrained by the high cost of collecting nutrition information. In addition, the Demographic and Health Survey (DHS), which is the traditional source of nutrition information, is not linked to agriculture and land tenure information and hence does not collect information on nutrition and agriculture in the same survey. The only reliable data source is the IHS, even though it does not provide nutrition information at the individual level.

The IHS has detailed consumption data that can be used to estimate dietary diversity and calorie consumption. The survey also collects detailed information on land tenure security and has specific questions on land acquisition, land ownership, land disposition, conflicts over land, and how they are settled. This information allows for examining the gender dynamics of land tenure and how they influence nutritional outcomes.

The study uses the Integrated Household Panel Survey (IHPS 2010-2019) of the National Statistical Office (NSO) to understand the time-varying nature of land tenure security as households register their pieces of land and some sell registered pieces of land.

Table 1: Analytical samples used in the analysis

Year	2010	2013	2016	2019	Total
Tenure insecure farm households	1,271	1,262	1,246	1,081	4,860
Tenure secure farm households	10	8	65	221	304
Total	1,281	1,270	1,311	1,302	5,164

Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

The full sub-sample of farming households for the four-panel years was 7,078. This figure included households split from the original panel households because they have probably married and started their own families. They, therefore, had the same original household ID across the years but were given new IDs in the panel years. These households were dropped to maintain consistency with the panel data structure.

Empirical strategy

The study uses a random-effects probit model to understand the determinants of land tenure security among households and female-headed households, specifically as expressed in equation (1)

$$TS_{it} = \theta + \beta X_{it} + \mu_{it} + \varepsilon_{it} \quad [1]$$

TS_{it} is a dummy indicator variable of tenure security, and βX_{it} is a vector of observable time-variant characteristics. θ is a time constant intercept, μ_{it} captures the individual effect and ε_{it} is the time-varying idiosyncratic error term

The study estimates a four wave panel data fixed effects model of the following generalized form:

$$Y_{it} = \theta_t + \beta X_{it} + \beta_i TS_{it} + \mu_i + \varepsilon_{it} \quad [2]$$

Where *i* indexes individuals and *t* indexes time. θ_t is the time-variant intercept, X_{it} is a vector of observable characteristics that affect the outcome variable (maize productivity, agricultural income, household dietary diversity, micronutrient dietary diversity, food consumption scores, calorie intake, Vitamin A intake, Iron intake, and Zinc intake) and may be correlated with the treatment variable. TS_{it} is the treatment variable representing household tenure security; μ_i is the unobserved heterogeneity, and ε_{it} is the time-varying idiosyncratic error term.

The study conducted a Hausman specification test to test whether the model would be best fitted using random or fixed effects. The tests, as shown in appendix table 1 and appendix table 2, show that in both the household and female-headed household equations, the maize productivity, agricultural income, household dietary diversity, micronutrient dietary diversity, food consumption score, and Vitamin A equations were best fitted using the fixed effects model. However, calorie, Iron, and zinc intake equations were best fitted using the random-effects model.

Effect of land tenure security on count outcome variables (household dietary diversity, micronutrient dietary diversity scores, food consumption scores)

The study uses equation 2 to estimate a panel fixed effects Poisson regression model because of the count variable nature of dietary diversity and food consumption scores. A 12-food group household dietary diversity score (HDDS) was used to analyze the effect of land tenure security on household dietary diversity. The 12 food groups are cereals, roots, tubers; pulses, legumes, nuts; vegetables; fruits; meat and poultry, fish and seafood, eggs; milk and dairy products; oil and fats; sugar, honey, and sweets; and miscellaneous foods, including condiments. The index was computed from the seven-day recall period of all foods consumed by a household.

In addition, the study computed a 16-food group micro-nutrient sensitive dietary diversity score to understand the effect of land tenure security on micronutrients. The 16 food groups are cereals; roots and tubers; dark green leafy vegetables; orange vegetables; other vegetables; Vitamin A fruits; other fruits; red meat; white meat; eggs; fish; pulses, legumes, and nuts; milk, milk products, oil/fats; sugar; and miscellaneous foods.

Nutritionists consider dietary diversity an indicator of food security and not nutrition per se. Therefore, a nutrition-oriented indicator, Food Consumption Score (FCS), was included in the analysis. A Food Consumption Score is an indicator composed of dietary diversity, food consumption frequency, and relative nutritional importance of food. The dietary diversity score is computed from 8 food groups: cereals and tubers, pulses, vegetables, fruits, meat and fish, milk, and sugar and oil. These food groups are recorded on a seven-day recall period. In addition, the indicator

captures the number of days a household consumes each food group within the seven days. Each food group is then weighted based on the nutrition composition. The food consumption score is a positive count variable with a minimum value of 0 and a maximum value of 112. The reader should refer to WFP (2008) for further details on FCS construction.

The study tested the presence of unobserved heterogeneity in

> *Effect of land tenure security on continuous outcome variables (Maize productivity, agricultural income, calorie intake, Vitamin A intake, Iron intake, and Zinc intake).*

The study estimates equation [2] to understand the effect of land tenure security on continuous outcomes of interest, including maize productivity, agricultural income, calorie intake, Vitamin A intake, Iron intake, and Zinc intake. Maize productivity has been estimated as kilograms of maize harvested per hectare of land. Agricultural income has been constructed as income earned from the sale of crops, livestock and livestock products, and fish.

Considering that each food item has a specific amount of nutrients it provides to the human body, the household nutrient consumption variables (calorie, Vitamin A, Iron, and Zinc) are constructed by converting food quantities eaten by households on a seven-day dietary recall into standard kilogram equivalents taking account of edible portions in each food item. The kilograms of food eaten is converted into calories, Vitamin A, Iron, and Zinc quantities using nutrient conversion factors. The study relied on food composition tables, particularly for Malawi (see (Malawi Government, 2020). Following Ecker and Qaim (2011), the study put a bound on the calorie intake of 0 and 5000 and considered any household consuming more than 5000kcal per capita per day as an outlier.

Furthermore, the tolerable upper intake level for Vitamin A is 3000mcg/day, for Iron is 45mg/day and for Zinc is 40mg/day. As such, the study removed from the analysis all outliers in that respect.

> *Effect of women's land tenure security on outcomes of interest (maize productivity, agricultural income, household dietary diversity scores, micronutrient dietary diversity scores, food consumption scores, calorie intake, Vitamin A intake, Iron intake, and Zinc intake).*

Access to productive resources increases women's rights and nutritional status (Malapit and Quisumbing, 2015). As a result, women with tenure security are hypothesized to make better production and investment decisions than those with limited land rights. In this paper, the analysis Outcome equation 2 is estimated where the treatment variable is land tenure security of female-headed households with a value of 1 for tenure secure female-headed households and 0 otherwise.

3. Results

Descriptive statistics

Table 2 shows descriptive statistics for the study sample to provide context for the study findings. The study shows that, in general, tenure secure households have statistically significantly larger household sizes than tenure insecure households. Large household sizes were also observed in 2010 and 2019 for tenure secure households.

The study also shows significantly higher tenure secure male-headed households than tenure secure female-headed households—the result holds for the full sample, 2016 and 2019 sub-samples. In terms of education level, tenure secure households have significantly higher levels of education than tenure insecure households.

Regarding access to credit, the study finds that tenure-secure households have a higher access to credit than tenure-insecure households. Access to credit has a bi-direction influence on land tenure security. Farmers can use the tenure documents as collateral for credit. In the same vein, farmers can use credit to purchase pieces of land and secure them.

Furthermore, the study finds that tenure secure households cultivated slightly larger pieces of land than tenure insecure households. This is related to landholding sizes even though the study did not establish a statistically significant difference in landholding between tenure secure households and tenure insecure households. The mean land holding size for the whole panel stands at 1.4 hectares for tenure secure households and 1.3 hectares for tenure insecure households.

Regarding the quality of soil among tenure secure and tenure insecure households, the study finds no significant difference in the quality of soils found among tenure secure and tenure insecure households. Therefore, it is not surprising that tenure secure households did not have higher maize productivity than tenure insecure households. We expected farmers to take soil improvement seriously once they have tenure security. However, this is not the case.

Table 3: Descriptive statistics

Variable	Obs	All		2010		2013		2016		2019	
		treated	Untreated	treated	Untreated	treated	Untreated	treated	Untreated	treated	Untreated
		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Household size	5,164	5.9***	5.2	6.1***	4.9	5.4	5.4	5.6	5.4	6.0***	5.1
Household head sex (1=Male, 0=Female)	5,145	0.8**	0.7	0.9	0.8	0.8	0.8	0.8*	0.7	0.8***	0.7
Household head age	5,145	48.4	46.1	42.9	42.6	39.6	45.5	45.0	47.6	50.0	49.2
Household head marital status	5,143	1.8	1.9	1.8	1.8	2.0	1.8	1.9	1.9	1.8	2.0
Household head education level (1=none, 2=PSLC, 3=JCE, 4=MSCE, non-uni diploma, 5=uni diploma, 6 post grad degree)	5,118	2.1***	1.4	1.0	1.1	2.5**	1.5	1.2**	1.1	2.4***	1.8
Access to credit (1=Yes, 0=No)	5,164	0.3***	0.2	0.1**	0.1	0.6	0.2	0.3	0.3	0.3*	0.3
Total cultivated land (ha)	5,148	2.1*	1.8	0.8	1.7	1.6*	2.0	2.4	1.8	2.0	1.9
Total landholding (ha)	5,148	1.4	1.3	0.8	1.2	1.9	1.3	1.4	1.3	1.4	1.4
Soil quality (1=good, 2=fair, 3=poor)	5,148	1.4	1.5	1.8	1.5	1.4	1.6	1.5	1.5	1.4	1.4
Crop production value (MK)	2,331	96,257.81**	74,183.52	141,591.3***	36,504.05	158,988.8*	188,482**	122,134.3**	245,562.9	62,316.61*	47,927.02
Qnty maize produced (kg)	3,737	790.4	593.7	893.9	620.1	993.7	683.3	879.8	532.4	595.0**	300.8
Maize productivity (kg/ha)	4,806	757.1	1,486.0	2,445.3	1,755.0	3,138.2	2,190.2	1,796.5	1,426.0	281.6	413.2
Crop value productivity (MK/ha)	2,330	84,244.8	88,777.9	257,176.9	33,557.1	81,026.9	99,161.6	129,713.0	135,595.1	62,138.3	83,966.9
Agricultural income (MK)	5,164	42,456.4***	28,785.1	49,260.1**	14,543.0	70,340.2**	32,053.0	57,052.4**	37,674.0	36,846.3	31,469.5

continued next page

Table 3 Continued

Variable	Obs	All		2010		2013		2016		2019	
		treated	Untreated	treated	Untreated	treated	Untreated	treated	Untreated	treated	Untreated
		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Total household income (MK)	5,164	113,8841***	366,532.2	267,320.0	145,523.2	837,459.1**	303,883.9	1,063,353***	490,718.2	1,211,389***	556,383
Distance to district boma	5,162	20.8	32.2	89.3	55.9	17.9	23.5	16.6***	24.0	19.1***	23.8
Distance to nearest all-weather road	5,162	5.9***	8.8	5.0	8.8	6.6	8.8	5.4**	8.9	6.0***	8.5
HDDS	5,164	9.4***	8.1	9.8**	8.2	**10.6	8.4	8.2**	7.4	9.8***	8.3
msHDDS	5,164	11.3***	9.7	11.4**	9.8	12.9***	10.1	10.0**	8.9	11.6***	9.9
FCS	2,686	54.4***	43.7	-	-	-	-	51.1***	41.7	55.5***	43.9
KCAL	5,164	2356.7***	1787.3	1380.5	1312.4	908.8	1906.3	1975.5*	1788.4	2561.4***	2257.2
Vitamin A (mcg/day)	4,760	1007.6***	582.6	490.2	422.7	703.4	609.3	625.9	522.3	1179.7***	838.3
Iron (mg/day)	5,164	20.8***	23.7	14.4	19.3	14.0	19.7	22.1	21.6	25.0**	22.9
Zinc (mg/day)	4,494	16.5***	13.0	6.8	10.5	12.6	13.6	14.7	13.8	17.5***	15.3

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

The study estimated the value of agricultural production from different crops grown by the household. The value of agricultural production provides a whole picture of the farming enterprise than looking at the productivity of an individual crop. The study shows that tenure secure households have a higher value of agricultural production than tenure insecure households. The value of agricultural production is a function of output quantity and prices. It may be likely that tenure secure households grow higher-value crops than tenure insecure households. High levels of education among tenure secure households lead to knowledge of markets that enhance their ability to sell their commodities at higher prices than tenure insecure households.

Furthermore, the study estimated agricultural income from various farming enterprises, including crops, livestock and livestock products, and fish/aquaculture enterprises. This is income earned from the sale of various agricultural produce and products. It is different from the value of agricultural production, which is a function of agricultural output and price. The study reveals that tenure secure households have higher agricultural incomes than tenure insecure households.

In the same vein, the study estimated household income as a function of agricultural income, enterprise income, time-labor income, and other household income. The study finds that tenure secure households have higher household incomes than tenure insecure households.

Distance to the district boma for tenure secure households was, in general, not significantly different from that of tenure insecure households, except in the 2019 sub-sample. Nevertheless, the study finds that tenure secure households had shorter distances to the nearest all-weather roads in general and for the 2016 and 2019 sub-samples. Interestingly, this implies that the easier it is to get to the road, the higher the likelihood that households would travel to seek registration of their lands.

In terms of nutrition, the study finds that tenure secure households have significantly higher dietary diversity scores, micronutrient dietary diversity scores, and food consumption scores than tenure insecure households. WFP, (2008) categorizes FCS into the following groups if the population under study is assumed not to consume sugar and oil daily:

a. Poor food consumption: 0 to 21

b. Borderline food consumption: 21.5 to 35

c. Acceptable food consumption: > 35

According to these criteria, both tenure secure and tenure insecure households achieve acceptable food consumption.

The descriptive statistics also reveal that tenure secure households have higher per capita caloric, Vitamin A, Iron, and Zinc intake than tenure insecure households in the full sample and the 2019 sub-sample.

The study used maize to understand crop productivity effects of land tenure security because it is the most widely grown crop among the tenure secure and tenure insecure households. The study results reveal that land tenure security improves crop productivity, as evidenced by relatively higher maize productivity among tenure secure households relative to tenure insecure households. These findings are consistent with findings reported by Mendola & Simtowe, (2015), who found that tenure security increased agricultural output in a land redistribution program in Malawi.

Determinants of household land tenure security

The first step of the empirical analysis was determining which variables are the strongest predictors of land tenure security. The study shows that the size of the household, the gender of the household head, age of the household head, education level of the household head, household income, and distance of the nearest all-weather road are strong predictors of household land tenure security. The household size is positively related to the likelihood of having land tenure security among farming households. The result suggests that larger households may desire to secure a piece of land for their children or dependents to reduce the likelihood of land-based conflict in case of the death of parents.

Table 4: Determinants of household land tenure security

Variables	Coefficient	se
Household land tenure security		
Year		
2013	-0.431*	(0.223)
2016	0.662***	(0.171)
2019	1.407***	(0.172)
Region		
Central	0.0934	(0.1240)
South	-0.2086	(0.1302)
Household size	0.0567***	(0.0174)
Household head sex	0.357**	(0.142)
Household head age	0.0331*	(0.0186)
Household head age squared	-0.000334*	(0.000179)
Marital status of household head		
Polygamous, married, or non-formal union	0.0876	(0.141)
Separated	0.101	(0.215)
Divorced	-0.320	(0.237)
Widowed or widower	0.393**	(0.171)
Never married	0.247	(0.444)

continued next page

Table 4 Continued

Variables	Coefficient	se
Household head education level		
Primary school leaving certificate	0.0672	(0.202)
Junior certificate of education	0.0533	(0.287)
Malawi school certificate of education	0.585**	(0.257)
Non-University Diploma	0.751*	(0.456)
University Diploma or Degree	0.139	(0.650)
Post-Graduate Degree	1.790***	(0.571)
Access to credit	0.110	(0.0818)
Household land holding (ha)	0.0174	(0.0313)
Household income	3.56e-09**	(1.66e-09)
Distance to district boma	-0.00352	(0.00223)
Distance to nearest road	-0.0156***	(0.00477)
lnsig2u	-1.504***	(0.452)
Constant	-3.774***	(0.499)
Observations	5,098	
Number of HHID	1,476	

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

The study has also found that male households heads tend to have a higher propensity to secure their pieces of land than female household heads. The age variables imply that younger household heads have a higher likelihood of securing their pieces of land than order household heads. The study also finds an interesting result that widowed household heads tend to secure their pieces of land more than those whose spouses are still alive, divorced, or separated. This can be explained by the fact that widowed household heads, particularly women, would seek to avoid land grabbing by relatives and other people. The study further finds that the education level of the household head is positively associated with land tenure security. This implies that educated household heads easily understand the benefits of securing their pieces of land compared to uneducated household heads.

Furthermore, the study shows that household income is positively associated with land tenure security because securing a piece of land is costly. They are transaction costs associated with getting a signed letter from a chief to prove land ownership and engaging government officials to obtain a lease certificate.

Finally, the study shows that the distance to the district boma and the nearest all-weather road is important for land tenure security. As highlighted above, government officials in the Ministry responsible for lands need to be engaged for a piece of land to be given a lease certificate. Long distances to this important office discourage households from registering their lands.

Effect of land tenure security on maize productivity and agricultural income

The first effect of land tenure security is shown in increased land-based investments, particularly improvements in soil fertility management practices, resulting in improved crop productivity (Kirk & Tuan, 2009; Lovo, 2016; Nkonya et al., 2016; Ali et al., 2014). Table 4 below shows that land tenure security positively but not statistically significantly increases maize productivity among tenure secure households compared to tenure insecure households. This is not surprising, as other studies have similarly found that land tenure does not affect crop productivity (Carter et al., 1991; Pender et al., 2003; Place and Migot-Adholla, 1998).

Table 5: Effect of land tenure security on maize productivity and agricultural incomes

	(1)	(2)	(3)	(4)
	Maize productivity (kg/ha)		Agricultural income (MK)	
VARIABLES	**coef**	**se**	**coef**	**se**
Household land tenure security	-745.1***	(98.64)	10,215***	(3,263)
Household size	6.288	(15.63)	1,714***	(513.6)
Household head sex	288.5***	(102.1)	2,295	(3,413)
Household head age	-23.57***	(3.101)	319.0***	(103.4)
Marital status of household head				
Polygamous	-3.282	(104.9)	-702.3	(3,569)
Separated	-138.6	(134.2)	-3,495	(4,502)
Divorced	-326.5**	(136.4)	-1,042	(4,584)
Widowed or widower	138.2	(124.7)	-3,794	(4,164)
Never married	-745.8**	(374.6)	14,015	(10,607)
Education level of household head				
Primary school leaving certificate	175.6	(109.9)	2,867	(3,596)
Junior certificate of education	401.7***	(143.3)	363.8	(4,590)
Malawi school certificate of education	299.4*	(163.4)	-1,956	(5,308)
Non-University Diploma	834.8**	(353.7)	11,836	(11,355)
University Diploma or Degree	238.4	(569.0)	4,342	(15,816)
Post-Graduate Degree	-878.2	(622.8)	-1,858	(20,036)
Access to credit	-9.061	(56.10)	4,035**	(1,858)
Access to extension	83.92*	(45.77)	8,846***	(1,527)

continued next page

Table 5 Continued

	(1)	(2)	(3)	(4)
	Maize productivity (kg/ha)		Agricultural income (MK)	
VARIABLES	**coef**	**se**	**coef**	**se**
Soil quality				
Fair	82.12*	(47.45)	-4,866***	(1,579)
Poor	-41.15	(81.00)	-8,121***	(2,733)
Total amount of fertilizer applied (kgs)	0.0195	(0.0790)	7.055***	(2.730)
Total household cultivated area (ha)	-65.17***	(8.955)	1,537***	(303.1)
Average annual amount of rainfall (mm)	1.306**	(0.533)	62.04***	(17.64)
Distance to the nearest all-weather road	0.100	(7.278)	374.8	(243.8)
Constant	851.4*	(472.5)	-58,332***	(15,644)
Observations	4,529		4,896	
R-squared	0.099		0.054	
Number of HHID	1,433		1,471	

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

The study estimated agricultural incomes from the sale of crops, livestock, livestock products and fish to better understand the effect of tenure security on agricultural production. The results reveal that tenure security is positively and significantly associated with agricultural income. This result agrees with results found in Zambia by (Smith, 2004).

Effect of land tenure security on households' dietary diversity scores, micronutrient dietary diversity score, food consumption scores, Calorie, Vitamin A, Iron, and Zinc intake

The study estimated the effect of land tenure security on household dietary diversity scores, micronutrient dietary diversity scores, food consumption scores, calorie, Vitamin A, Iron, and Zinc intake of agricultural households in Malawi. The results show that land tenure security has a positive but not statistically significant effect on household dietary diversity scores. The same is true for micronutrient dietary diversity scores. The association between land tenure security and food consumption scores is negative and statistically significant.

Nevertheless, the study should positive and statistically significant influence of land tenure security on calorie, Vitamin A, Iron, and Zinc intake. This implies that tenure secure households tend to grow foods rich in calories, Vitamin A, Iron, and Zinc or indeed use most of their farm and non-farm income to purchase foods rich in these nutrients.

Table 6: Effect of land tenure security on household dietary diversity, scores micronutrient household dietary diversity scores, food consumption scores, calorie, Vitamin A, Iron, and Zinc intake

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Treatment	0.0260	0.0233	-0.0249*	311.7***	287.2***	1.690**	2.187***
	(0.0255)	(0.0233)	(0.0142)	(71.17)	(54.84)	(0.728)	(0.512)
Household size	0.000736	0.000997	-0.00419	-142.2***	-36.03***	-1.243***	-1.140***
	(0.00445)	(0.00407)	(0.00332)	(8.240)	(8.845)	(0.0867)	(0.0613)
Household head sex	0.0461	0.0436	0.0473**	77.57	-61.03	0.334	-0.0599
	(0.0296)	(0.0271)	(0.0222)	(62.49)	(58.25)	(0.667)	(0.467)
Household head age	-0.00611	-0.00506	-0.0264***	13.80**	27.77***	0.130*	0.136***
	(0.00412)	(0.00376)	(0.00349)	(6.975)	(7.896)	(0.0742)	(0.0520)
Household head age squared	3.59e-05	2.66e-05	0.000217***	-0.111	-0.215***	-0.00116	-0.00107**
	(3.99e-05)	(3.63e-05)	(3.32e-05)	(0.0677)	(0.0754)	(0.000719)	(0.000503)
Household head marital status							
Polygamous	-0.0168	-0.00688	0.0793***	-92.02	-70.93	0.449	-0.0621
	(0.0301)	(0.0275)	(0.0227)	(65.26)	(58.89)	(0.661)	(0.484)
Separated	-0.00820	-0.00686	-0.00126	28.67	-22.50	0.636	0.463
	(0.0389)	(0.0355)	(0.0275)	(95.74)	(77.75)	(1.003)	(0.707)
Divorced	-0.00264	0.00427	0.101***	93.88	166.1**	-1.031	0.192
	(0.0401)	(0.0366)	(0.0277)	(92.36)	(78.00)	(0.979)	(0.683)
Widowed or widower	0.0176	0.0166	0.0500*	62.31	8.869	-0.336	-0.334
	(0.0365)	(0.0333)	(0.0284)	(77.74)	(71.11)	(0.823)	(0.580)
Never married	-0.0298	-0.00960	-0.194***	19.09	172.6	2.570	1.840
	(0.0881)	(0.0803)	(0.0701)	(213.6)	(199.7)	(2.359)	(1.638)

continued next page

Table 6 Continued

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Household head education level							
Primary school leaving certificate	0.0498*	0.0558**	0.0695***	238.1***	88.84	0.912	1.128*
	(0.0288)	(0.0262)	(0.0268)	(82.38)	(60.42)	(0.869)	(0.616)
Junior certificate of education	0.0507	0.0506	0.0700	328.3***	110.9	-1.501	0.416
	(0.0374)	(0.0343)	(0.0464)	(109.1)	(77.72)	(1.218)	(0.850)
Malawi school certificate of education	0.0455	0.0405	0.00405	395.7***	100.7	1.724	3.261***
	(0.0403)	(0.0366)	(0.0587)	(123.9)	(90.25)	(1.334)	(0.895)
Non-University Diploma	0.102	0.112	0.161	-7.946	320.6	0.0562	-0.634
	(0.0825)	(0.0746)	(0.114)	(277.4)	(208.0)	(2.933)	(2.079)
University Diploma or	0.0398	0.0521	0.185	647.8*	442.7	3.292	-3.447
Degree	(0.106)	(0.0957)	(0.151)	(390.8)	(291.1)	(4.548)	(3.170)
Post-Graduate Degree	0.120	0.119	0.159	181.1	-315.4	3.851	1.436
	(0.141)	(0.128)	(0.125)	(421.1)	(343.2)	(4.524)	(3.158)
Access to credit	0.0292*	0.0271*	0.0228**	78.68**	-12.81	0.497	0.477
	(0.0153)	(0.0140)	(0.0108)	(39.30)	(30.66)	(0.406)	(0.291)
Total land holding (ha)	0.0142**	0.0152***	0.0111**	73.60***	32.39***	0.501***	0.466***
	(0.00590)	(0.00538)	(0.00448)	(14.03)	(11.81)	(0.149)	(0.104)
Log of household income	0.0158***	0.0148***	0.0123***	109.3***	45.68***	0.644***	0.574***
	(0.00407)	(0.00372)	(0.00315)	(9.248)	(7.907)	(0.0951)	(0.0686)
Distance to district boma	0.000747***	0.000700***	0.00327***	-6.255***	-1.408**	-0.0269***	-0.0309***
	(0.000284)	(0.000260)	(0.000583)	(0.690)	(0.573)	(0.00721)	(0.00522)

continued next page

Table 6 Continued

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Constant				924.3***	-486.2**	16.89***	8.995***
				(187.8)	(201.5)	(1.971)	(1.408)
Observations	4,777	4,777	2,366	4,163	4,504	3,723	4,253
Number of HHID	1,349	1,349	1,155	1,428	1,450	1,385	1,433
R-squared					0.067		

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

The study reveals a statistically significant inverse relationship between household size and calorie, Vitamin A, Iron, and Zinc intake. This implies that larger households compete for within-household food, resulting in decreased intake of these nutrients.

Another interesting finding from these results is that landholding size is positively and significantly associated with dietary diversity, food consumption scores, calorie, Vitamin A, and Iron and Zinc intake.

The study also finds that household income is positively and statistically significantly associated with all the nutrition indicators (dietary diversity scores, micronutrient dietary diversity scores, food consumption scores, calorie, Vitamin A, Irion, and Zinc intake. The income variable suggests a positive relationship between household income and land holding size. This relationship suggests that richer households (with more land) consume more nutritious foods than do poor households. In addition, the results show that the effect size of household income on nutrition indicators is larger than that of landholding size, implying that household income is important for household nutrition.

Furthermore, the study finds that longer distances to the district boma are negatively and significantly associated with low consumption of calories, Vitamin A, Iron, and Zinc.

Determinants of land tenure security among female-headed households

The study now focuses on whether women's control over land significantly influences households' nutrition. The analysis first identifies the determinants of land tenure security among female-headed households.

The year dummy variables reveal that more female-headed households started securing their pieces of land as time went on. This is important as it denotes progress in implementing land laws in Malawi. Female household heads from the central region were positively associated with the likelihood of tenure security than those in the southern region, even though not statistically significant. Furthermore, younger female household heads are likely to be more tenure secure than older female household heads.

Being widowed is positively and statistically significantly associated with land tenure security among female-headed households. The study also finds a positive and statistically significant relationship between tenure security and household income. However, the distance to the district boma and nearest all-weather road is inversely related to the likelihood of female-headed households being tenure secure.

Table 7: Determinants of land tenure security among female-headed households

Variables	(1)	(2)
	Coefficient	se
Female household head tenure security		
Year		
2013	-0.460*	(0.245)
2016	0.619***	(0.190)
2019	1.399***	(0.190)
Region		
Central	0.1191	(0.1445)
South	-0.1769	(0.1521)
Household size	0.0572***	(0.0209)
Household head age	0.0480**	(0.0235)
Household head age squared	-0.000497**	(0.000230)
Household marital status		
Polygamous	0.141	(0.145)
Separated	-0.443	(0.522)
Divorced	0.00840	(0.393)
Widowed or widower	0.791***	(0.306)
Never married	0.0665	(0.678)
Household head education level		
Primary school leaving certificate	0.118	(0.219)
Junior certificate of education	0.00247	(0.320)
Malawi school certificate of education	0.426	(0.296)
Non-University Diploma	0.255	(0.616)
University Diploma or Degree	0.494	(0.710)
Post-Graduate Degree	0.787	(0.836)
Access to credit	0.0562	(0.0934)
Total landholding (ha)	0.00742	(0.0353)
Household income	2.83e-09	(1.76e-09)
Distance to district boma	-0.00426*	(0.00257)
Distance to nearest all-weather road	-0.0172***	(0.00542)
lnsig2u		
Constant	-3.664***	(0.590)
Observations	3,757	
Number of HHID	1,265	

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

Effect of land tenure security of female-headed households on maize productivity and agricultural income

Table 8 estimates the effect of land tenure security of female household heads on maize productivity and agricultural annual income. The results reveal an inverse relationship between land tenure security of female-headed households and maize productivity. Nevertheless, there is a positive and statistically significant relationship between land tenure security of female-headed households and annual agricultural incomes.

The results also reveal an inverse relationship between land size and agricultural productivity, as reported by Adesina and Djato (1996) and Deininger and Castagnini (2006), implying that smaller farmers are more efficient than large farms. However, large farms are positively and significantly associated with agricultural income. Furthermore, access to credit and extension are positively and significantly associated with agricultural income.

Table 8: Effect of land tenure security of female-headed households on maize productivity and agricultural income

Variables	(1)	(2)	(3)	(4)
	Maize productivity (kg/ha)		Log of agricultural income	
	coef	se	coef	se
Female head land tenure security	-644.5***	(119.6)	0.321**	(0.151)
Household size	14.41	(20.88)	0.0552**	(0.0271)
Household head age	-42.26***	(4.960)	0.0540***	(0.00687)
Household head marital status				
Polygamous	-77.50	(126.8)	-0.108	(0.164)
Separated	-337.9	(337.2)	-0.0367	(0.557)
Divorced	-174.3	(330.3)	-0.445	(0.512)
Widowed or widower	98.29	(291.0)	-0.0629	(0.388)
Never married	-597.4	(623.4)	1.888**	(0.773)
Household head education level				
Primary school leaving certificate	120.1	(133.6)	0.0952	(0.173)
Junior certificate of education	305.3*	(169.2)	-0.0940	(0.216)
Malawi school certificate of education	283.5	(185.1)	-0.346	(0.265)
Non-University Diploma	764.2*	(401.9)	1.031*	(0.618)
University Diploma or Degree	296.8	(605.2)	0.716	(0.681)
Post-Graduate Degree	-384.2	(825.4)	-0.407	(1.397)
Access to credit	-3.658	(69.82)	0.219**	(0.0868)
Access to extension	109.3*	(58.18)	0.480***	(0.0756)

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Table 8 Continued

Variables	(1)	(2)	(3)	(4)
	Maize productivity (kg/ha)		Log of agricultural income	
	coef	se	coef	se
Soil quality				
Fair	12.86	(60.55)	-0.0654	(0.0778)
Poor	-72.64	(105.9)	-0.215	(0.145)
Quantity of fertilizer applied (kgs)	-0.0190	(0.0876)	8.94e-05	(0.000111)
Total cultivated land area (ha)	-67.43***	(10.58)	0.0331**	(0.0129)
Average amount of rainfall (mm)	1.514**	(0.671)	0.000735	(0.000819)
Distance to nearest all-weather road	-0.762	(8.898)	0.0268**	(0.0133)
Constant	1,779***	(596.7)	5.697***	(0.744)
Observations	3,344		2,595	
R-squared	0.108		0.114	
Number of HHID	1,214		1,047	

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

Effect of land tenure security of female-headed households on household dietary diversity scores, micronutrient dietary diversity score, food consumption scores, calorie, Vitamin A, Iron, and Zinc intake

Table 9 shows that tenure security of female-headed households has a positive but not statistically significant effect on household dietary diversity scores and micronutrient sensitive dietary diversity scores. The results also show a negative but statistically insignificant relationship between tenure security of female-headed households and food consumption scores.

The study found a positive and statistically significant relationship between female-headed households' land tenure security and calorie, Vitamin A, Iron, and Zinc intake regarding nutrient intake.

Table 9: Impact of land tenure security of female-headed households on household calorie intake

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Female head land tenure security	0.0163	0.0178	-0.0113	241.2***	254.8***	1.436*	1.553***
	(0.0293)	(0.0268)	(0.0167)	(77.83)	(61.77)	(0.790)	(0.562)
Household size	-0.00236	-0.00239	-0.000626	-137.6***	-44.93***	-1.295***	-1.100***
	(0.00560)	(0.00512)	(0.00448)	(9.550)	(11.21)	(0.0990)	(0.0705)
Household head age	-0.000461	0.000582	-0.0297***	13.82	42.65***	0.122	0.153**
	(0.00606)	(0.00555)	(0.00567)	(8.680)	(11.92)	(0.0902)	(0.0644)
Household head age square	-3.46e-05	-4.86e-05	0.000252***	-0.117	-0.369***	-0.00113	-0.00123*
	(6.06e-05)	(5.55e-05)	(5.59e-05)	(0.0857)	(0.119)	(0.000886)	(0.000635)
Household head marital status							
Polygamous	-0.0149	-0.00421	0.0653**	-95.55	-44.33	0.317	-0.221
	(0.0340)	(0.0310)	(0.0269)	(66.89)	(66.00)	(0.667)	(0.492)
Separated	-0.0426	-0.0387	-0.0176	240.1	-128.6	2.081	1.064
	(0.0852)	(0.0778)	(0.0554)	(216.8)	(186.4)	(2.600)	(1.651)
Divorced	-0.0243	-0.0254	0.0618	105.5	409.0**	-2.741	0.290
	(0.0880)	(0.0810)	(0.0523)	(228.8)	(188.4)	(2.542)	(1.635)
Widowed or widower	0.0618	0.0625	-0.0430	429.2**	115.0	2.525	1.066
	(0.0788)	(0.0719)	(0.0685)	(167.6)	(157.9)	(1.852)	(1.260)
Never married	-0.0555	-0.0884	-0.481***	-301.4	-374.4	-1.342	-0.587
	(0.139)	(0.128)	(0.101)	(263.2)	(314.2)	(2.860)	(2.027)

continued next page

Table 9 Continued

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Household head education level							
Primary school leaving certificate	0.0401	0.0471	0.000276	177.5*	46.70	0.224	0.895
	(0.0333)	(0.0304)	(0.0342)	(91.31)	(67.88)	(0.959)	(0.676)
Junior certificate of education	0.0449	0.0482	0.0494	316.1***	152.1*	-1.800	0.192
	(0.0417)	(0.0382)	(0.0492)	(114.4)	(85.50)	(1.289)	(0.891)
Malawi school certificate of education	0.0541	0.0494	0.0233	351.4***	90.79	1.678	2.861***
	(0.0443)	(0.0403)	(0.0649)	(127.1)	(96.72)	(1.368)	(0.922)
Non-University Diploma	0.0915	0.112	0.0974	139.6	336.3	1.258	-0.637
	(0.0911)	(0.0825)	(0.136)	(295.7)	(219.5)	(3.168)	(2.205)
University Diploma or Degree	0.0623	0.0611	0.113	926.8**	667.6**	0.465	-1.919
	(0.119)	(0.108)	(0.160)	(456.9)	(331.7)	(5.782)	(3.817)
Post-Graduate Degree	0.136	0.121	0.103	486.0	-118.2	5.482	4.031
	(0.170)	(0.154)	(0.145)	(456.2)	(381.5)	(4.985)	(3.404)
Access to credit	0.0273	0.0243	0.0635***	63.76	-5.750	0.276	0.317
	(0.0179)	(0.0164)	(0.0128)	(44.14)	(35.27)	(0.455)	(0.326)
Total land holding (ha)	0.0161**	0.0174***	0.0134**	69.59***	28.45**	0.566***	0.397***
	(0.00667)	(0.00608)	(0.00521)	(15.20)	(13.39)	(0.161)	(0.113)
Household income (MK)	0.0158***	0.0148***	0.0220***	110.9***	45.76***	0.646***	0.563***
	(0.00494)	(0.00452)	(0.00395)	(10.49)	(9.600)	(0.108)	(0.0772)
Distance to district boma	0.000672**	0.000584*	-0.000452	-6.397***	-1.233*	-0.0275***	-0.0327***
	(0.000331)	(0.000302)	(0.000688)	(0.758)	(0.664)	(0.00789)	(0.00569)

continued next page

Table 9 Continued

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HDDS	msHDDS	FCS	Kcal	Vitamin A	Iron	Zinc
Constant				986.7***	-810.1***	17.78***	8.725***
				(216.6)	(278.9)	(2.221)	(1.609)
Observations	3,428	3,428	1,563	3,130	3,370	2,802	3,179
Number of HHID	1,024	1,024	768	1,204	1,232	1,152	1,207
R-squared					0.075		

*** p<0.01, ** p<0.05, * p<0.1
Source: Author's analysis of Malawi IHPS (2010-2019) dataset.

4. Discussion

The current study has established a positive but not statistically significant relationship between household land tenure security and maize productivity. The same holds for tenure security of female-headed households. Similar studies on land tenure equally fail to establish a positive relationship between land tenure security and agricultural productivity (see Carter et al., 1991; Pender et al., 2003; Place and Hazell, 1993; Place and Migot-Adholla, 1998; Place and Otsuka, 2002). Even in land redistribution programs, beneficiary households' farms are not more productive than non-beneficiary farms (Chirwa, 2008). However, other studies have found evidence of improved productivity from land tenure security (see (Deininger and Jin, 2006; Nkonya et al., 2016). It seems likely that in countries with weak extension systems, farmer knowledge of soil conservation is poor; hence tenure secure and tenure insecure households equally do not invest in improving the condition of the soils. For example, a study by Ragasa and Comstock, 2019 in Malawi shows that only six percent of farmers adopt residue soil cover and zero/minimum tillage, 41% adopt crop residual incorporation and eight percent adopt agroforestry practices. In addition, the current study found 27% of farm households across the panel years applied organic manure.

Moreover, the current study has found no significant difference in the soil quality between tenure secure and tenure insecure households. Place and Otsuka, (2002) suggest that farm management practices are independent of tenure systems. As such, the mechanism by which tenure security impacts a household's nutrition is not as direct from a farm efficiency point of view.

However, the current study established a positive relationship between tenure security and agricultural income. The study establishes a similar finding for female-headed households. Other studies also report similar findings on the relationship between land tenure security and agricultural income or profits (see Mendola and Simutowe 2013, Jayne et al. 2003, and Nkonya et al. 2005). To understand how tenure security influences farm profits, Chirwa, (2006) shows that large farms are associated with crop commercialization. Therefore, it is not surprising that tenure secure households in the current study cultivated significantly large pieces of land compared to tenure insecure households, hence having higher agricultural incomes than tenure insecure households.

The study also notes the inverse relationship between landholding and productivity. The cultivated land size was inversely and significantly related to maize productivity but positively related to agricultural income. Many studies have documented this

inverse relationship between landholding and productivity (Nkonya et al., 2016; Pender et al., 2003; Place and Hazell, 1993). However, other studies have found a positive relationship between landholding and productivity (see (Carter et al., 1991; Dorward, 1999)

The effect of land tenure security of households and female-headed households was positively but not statistically significantly associated with household dietary diversity and micronutrient household dietary diversity scores.

The current study has established a positive and statistically significant relationship between household land tenure security, female-headed household land tenure security and calorie, Vitamin A, Iron and Zinc intake. In Ethiopia, a study by Holden and Ghebru, (2013) found a positive and statistically significant relationship between land tenure and calorie intake. Unfortunately, no studies have looked at the effect of land tenure security on Vitamin A, Iron, and Zinc intake.

Furthermore, household income was a significant determinant of all nutrition-related variables in the model, including dietary diversity, food consumption scores, calorie, Vitamin A, Irion, and Zinc intake. At the same time, the study shows that household land is positively and significantly associated with these nutrition indicators even though the effect size is less than that of household income.

On the relationship between distance to the district boma and nutrition variables in the models, Holden and Ghebru, (2013) show that weak market integration strengthens the link between own food production and nutrition. This implies that households in communities with strong market integration use the income to eat nutritious food rather than rely on their food production.

Moreover, the relationship between landholding size and nutrition indicators in the household and female-headed household models implies that some farmers still rely on their food production to achieve food security and nutrition. However, it seems likely that the effect of land tenure security on nutrition is channeled through the income effect either from the sale of production output or non-agricultural income.

5. Policy implications

The current study suggests that achieving food and nutrition security amidst increasing pressure on land and land conflicts will require concerted efforts to improve agricultural productivity. The study has clearly demonstrated that positive nutritional impact of land tenure regularization would not be achieved without parallel efforts in improving agricultural extension to stimulate investments in soil improvements.

In addition, the study shows that land tenure security has a positive effect on the nutrition of households, particularly in female-headed households. There is, therefore, a need to accelerate the implementation of land reform to enhance women's empowerment that leads to improved nutrition.

There is a need to strengthen the income-earning opportunities of households, whether from farming or off-farm, because household income is a chief determinant of household nutrition.

5. Conclusion

In conclusion, this study has revealed that land tenure security is inversely related to maize productivity but positively and significantly associated with agricultural income. The study also found an inverse relationship between cultivated land size and maize productivity. Nonetheless, there is a positive and statistically significant relationship between land tenure security and agricultural income and cultivated land size. This implies a commercial orientation of tenure secure households compared to tenure insecure households.

In addition, the study did not establish any significant relationship between land tenure security and the quality of the soil. This shows that tenure secure households do not necessarily consider the presence of tenure security as an incentive to seriously invest in soil improvements. This is attributed to weak agricultural extension systems such that both tenure secure and tenure insecure households do not invest in soil improvements.

Interestingly, the study reveals that tenure security of households and female-headed households significantly influences calorie intake, Vitamin A intake, Iron intake, and Zinc intake. Within the same models, household income was strongly associated with Vitamin A intake, Iron intake, and Zinc intake. This implies that more of the nutrition effect of land tenure security is channeled through the income effect than the productivity effect.

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Appendix A

Appendix table 1: Hausman specification tests for household outcome equations

	Maize productivity eq.	Agricultural income eq.	HDDS eq.	msHDDS eq.	FCS eq.	Calorie eq.	Vitamin A eq.	Iron eq.	Zinc eq.
chi2(20) =	173.11	75.31	124.96	162.55	520.98	24.74	52.39	23.47	22.29
Prob > chi2 =	0.0000	0.0000	0.0000	0.0000	0.0000	0.2588	0.0002	0.3196	0.383

Appendix table 2: Hausman specification tests for Female household outcome equations

	Maize productivity eq.	Agricultural income eq.	HDDS eq.	msHDDS eq.	FCS eq.	Calorie eq.	Vitamin A eq.	Iron eq.	Zinc eq.
chi2(24) =	165.28	95.28	65.38	85.08	194.32	27.49	41.37	26.27	18.62
Prob > chi2 =	0.0000	0.0000	0.0000	0.0000	0.0000	0.122	0.0033	0.1571	0.5466

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