Efficiency and equity of customary land tenure systems in farmland allocation and implications for well-being

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Abstract

This paper examines the role of customary tenure systems in redistributing land resources within the context of developing countries, which face challenges such as market imperfections and land idleness. Specifically, it scrutinizes the scenario in Malawi, where the farmland market is underdeveloped, and land acquisition predominantly occurs through customary tenure systems. Using data from the National Integrated Household Panel Survey, the study employs a combination of stochastic frontier analysis (SFA) and fixed effects techniques. Research findings indicate that farmland allocation by chiefs is inefficient and does not promote equity, while land tenure through inheritance is relatively efficient and associated with equity in farmland redistribution. Furthermore, the study reveals that customary land tenure systems and land tenure through sales and rental markets have similar welfare impacts in terms of crop production and sales values.

Keywords: Customary; Land tenure; Stochastic frontier; Farming ability; Efficiency, Equity
JEL Codes: D13, O13, Q15, R14

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1 Introduction

Land property rights, as fundamental institutional arrangements, govern individual interactions and encompass attributes like exclusivity, inheritability, transferability, and enforcement mechanisms (Feder and Feeny, 1991; Alchian and Demsetz, 1973). These rights dictate the legitimacy of exclusive resource use, identify the entities in possession and regulate various land-related activities, from hunting and gathering to cultivation, grazing, mineral extraction, and tree utilization (Feder and Feeny, 1991). Land property rights can be acquired through sales and rental markets or customary land tenure. Proponents of the former argue that its efficiency is based on flexible land rights transfer through market-driven transactions governed by formal legal systems, ensuring clear and enforceable property rights. This promotes economic activities, investments, and access to credit. Conversely, advocates of customary land tenure perceive its efficiency in land allocation due to its reliance on local knowledge and traditions, considering factors such as soil quality, water access, and historical land use patterns (Roth and McCarthy, 2013; Ostrom, 1990; De Soto, 2002).

While there is vast empirical evidence supporting the economic efficiency of rental and sales markets, there is limited evidence for the efficiency of customary land tenure. The available literature for customary land tenure mainly focuses on its role in risk insurance and safety nets rather than on its efficiency in farmland allocation. Proponents of land property rights through rental and sales markets argue that permanence and full tradability are the factors that drive this efficiency because they enable the full utilization of resource productivity, allowing landowners to maximize profits or sell to those who can. Consequently, land tenure through sales and rental markets contributes to increased household earnings and equitable land distribution (Han et al., 2021; Holden et al., 2010; Kijima and Tabetando, 2020; Chamberlin and Ricker-Gilbert, 2016). These scholars consider customary land tenure systems inefficient because they are constrained by cultural

and restrictive factor which are not flexible in transferring property rights. However, their argument assumes perfect markets, which may not hold in developing countries dominated by customary land tenure systems as well as associated with information and credit market imperfections. On the other hand, recently, many observers suggest that rapid private land ownership through formal titling programs under sales or rental markets may not be the sole or best approach to ensure Land Tenure Property Rights (LTPR) and foster equitable economic growth. For instance, USAID policy advocates for "secure enough" principles, emphasizing scalable land tenure security aligned with affordability, sustainability, and a continuum of rights (Roth and McCarthy, 2013). The policy identifies various alternatives to formal land titling that can enhance land tenure security without the potential pitfalls of sales and rental market-based systems, which can exacerbate inequality. These alternatives include recognizing customary rights through policy and legal measures, issuing certificates to secure usufruct, management, and inheritance rights, or implementing community titling (Arko-Adjei, 2011; Bassett, 2005; Roth and McCarthy, 2013; Toulmin, 2009).

Therefore, this paper aims to empirical assess the efficiency hypothesis under customary land tenure systems and their impact on household welfare. It employs the screening model, which involves self-selection through contractual choices, to assess the hypothesis. The screening model operates under the premise that market failures make it challenging to predict the farming abilities of land seekers in advance, as distinguishing between those with high and low farming abilities is difficult before actual crop harvesting (Akerlof, 1978; Stiglitz, 1974). In contexts characterized by asymmetric information, self-selection by land tenure systems serves as a signal regarding the farming abilities of land seekers. The paper classifies customary land tenure systems into two categories: inherited farmland and farmland allocated by village leaders or employers, to assess their efficiency in farmland allocation.

The study makes a novel contribution to the available literature concerning customary

land tenure. Instead of focusing on its commonly researched aspects like risk insurance and safety nets, this paper examines the efficiency of the customary land tenure system in farmland allocation. Additionally, the paper contributes empirically to alternative policies for land rental or sales markets to ensure Land Tenure Property Rights (LTPR) in Sub-Saharan African countries. These policies encompass customary rights through policy and legal measures, issuing certificates to secure usufruct, management, and inheritance rights, or implementing community titling. Such measures have been recommended to foster equitable economic growth without the potential pitfalls of sales and rental market-based systems.

The study draws upon data from Malawi's Integrated Household Panel Survey (IHPS), administered by the National Statistical Office (NSO). IHPS runs concurrently with the Integrated Household Survey (IHS) program, tracking changes in poverty levels, socio-economic conditions, and agricultural characteristics over time. The baseline IHPS, conducted in 2010 alongside IHS-3, comprised 3,104 households. The research employs a multifaceted approach, combining a Cobb-Douglas stochastic frontier model to estimate farming ability or farmers' effort, which serves as an explanatory variable in subsequent logistic regression analysis. Finally, fixed effects are used to assess the welfare effects of customary land tenure systems.

The study's findings reveal that, on average, smallholder farming households in Malawi operate with significant inefficiencies, as the gap between their actual output and the maximum feasible output (farming ability = 1) is substantial. The average farming ability score is 0.087, ranging from 0 to 0.84. Furthermore, the results indicate that households with higher farming ability tend to acquire farmland through inheritance, whereas those with lower farming ability are more inclined to land allocation by chiefs or employers. Likewise, the inherited farmland tenure system promotes equity in farmland allocation, while farmland acquired through chiefs does not. These findings may be explained by the fact that inherited farmland tenure promotes equity through the national land

policy, ensuring equal rights for both genders and facilitating the direct transfer of land to children on an equal basis. Meanwhile, inefficiency of farmland allocation by chiefs may be attributed to its association with political influence, selling land to individuals outside the community, and the presence of informal markets. Furthermore, the farmland rental market is associated with higher farming ability, aligning with previous literature in Malawi and other sub-Saharan African countries (Chamberlin and Ricker-Gilbert, 2016; Jin and Jayne, 2013; Deininger and Mpuga, 2010). In contrast to existing literature, the farmland sales market is linked to low levels of farming ability. This discrepancy may be explained by the underdevelopment of credit markets and the selling of farmland to meet immediate household needs, such as medical bills (Kishindo, 2004). In terms of welfare effects, both inherited land tenure and land tenure allocated by chiefs or employers have no differential impacts on crop production and sales values compared to farmland tenure through sales and rental markets.

The subsequent chapters look at the background information, theoretical and empirical literature reviews, data sources, identification methodologies, and the conclusion.

2 Background

Land in Malawi is categorized into three forms, namely public, private, and customary (Kishindo, 2004; GoM, 2002; Tsutomu, 2008). The government owns public land and, in some instances, delegates management to the traditional authorities. Government land includes national parks, forest and game reserves, conservation areas, and government farms. The second category of private land covers the land with tenure security under freehold, leasehold title, or obtained through colonial governors with a certificate of claim, such as commercial estate land for tea, sugar, and tobacco. Lastly, customary land is acquired and held under the customary law of each ethnic group and constitutes about 69% of the total land area in Malawi (Tsutomu, 2008). Households from every

village are entitled to access and use a piece of land subject to the availability of free land and compliance with traditions and customs. Under the land act, the right to public and customary land is bestowed upon the president, who delegates control and administration to the minister of lands. Upon trust, the minister also delegates control and administration of customary land to chiefs who are empowered to allocate land in compliance with customary laws (Kishindo, 2004). Thus, chiefs ensure customary land is distributed equitably among the villagers and preserved for future generations (Ibid). When a household migrates permanently to other villages, the land is returned to the community for possible allocation to other land seekers. For permanent village residents, the land rights remain in the household and can be passed on along the family generations. Apart from allocation by the village chief, indigenous land tenure can be acquired within the family through inheritance, gifts, or as payment for lobola. Land rights acquired through inheritance depend on the lineage of a specific ethnic group. In patrilineal societies, inherited land rights are primarily transferred from father to son, while in matrilineal societies, land rights are transferred from mother to daughter (Tsutomu, 2008; Kishindo, 2004).

The Malawi National land policy 2002 allows customary land to be registered and protected by law. It encourages all communities, households, and individuals who hold customary land to register it as private estates with tenure rights. Again, the policy aimed to establish private leasehold estates while maintaining ownership of the customary landholder and formalized the roles of chiefs and household heads to allow for orderly and transparent land transactions (Kishindo, 2004; GoM, 2002). In order to operationalize the policy, the Malawi National Assembly passed ten new and amended land-related bills into law in 2016 to ensure tenure security and equitable access to land (NPC, 2021). For more details and chronological order of the land reform process from 1993 to 2016, when the parliament passed the ten amended and new land-related bills into law, see Appendix 1.2. The new land reforms allow individuals or households to formally register their

customary land and call for decentralization of the structures for land registration and transfers. Before the enactment of the bills into law, about 4.7 million hectares of land in Malawi were untitled. Insecure land tenure resulted in the low income generated by the government from land rent and an increase in some land-related disputes. The estimates show that about 15 out of every 100 households registered land disputes, and about 20% of the households were afraid that their land might be grabbed or encroached on (NPC, 2021; Msukwa et al., 2021). Therefore, the new land laws are envisaged to improve land tenure security, increase access to credit, reduce investment uncertainty, land transaction costs, and land conflicts, and increase government revenue.

3 Literature review

In the screening model of farmland rental arrangements, entrepreneurial ability determines the allocation of output under rent contracts, sharecropping contracts, and wage labor due to adverse selection. The choice of arrangement reveals information about entrepreneurial ability, with the most-able farmers opting for fixed rent contracts, the least-able for wage labor, and those with average ability for sharecropping. Productivity does not significantly differ between sharecropped and rented plots; instead, the focus is on the distribution of output between landowners and renters. Rent-in individuals, with higher entrepreneurial ability, receive more income/output than sharecroppers, while wage laborers earn less. Rent-out individuals with lower ability prefer rent contracts, sharing profits with sharecroppers (Akerlof, 1978; Stiglitz, 1974; Hallagan, 1978). Farmland rental arrangements act as both a screening mechanism and a matching system for different landowners and tenants. The agricultural ladder hypothesis suggests that workers progress from wage labor to sharecropping and then renting, responding to capital accumulation (Hallagan, 1978)

Farmland tenure is a critical aspect of agricultural systems, with a predominant fo-

cus on rental and sales markets in existing literature. Sub-Saharan African countries, including Malawi, Zambia, Uganda and Kenya have been extensively studied to understand how land sales and rental markets contribute to efficiency and equity in farmland allocation (Kijima and Tabetando, 2020; Chamberlin and Ricker-Gilbert, 2016; Lunduka et al., 2010; Jin and Jayne, 2013). Studies in Uganda and Kenya, particularly by Kijima et al. (2020), reveal that land markets facilitate the efficient transfer of farmland from land-abundant to landless households with higher farming ability. This efficiency is further supported by findings indicating that purchased and rented-in farmland in Sub-Saharan African countries is associated with higher productivity than inherited land (Kijima and Tabetando, 2020; Deininger and Mpuga, 2010; Chamberlin and Ricker-Gilbert, 2016). However, the impact on poverty reduction varies between countries, emphasizing the need for context-specific analyses (Kijima and Tabetando, 2020). Malawi provides additional insights, where farmland rental markets demonstrate efficiency by transferring land from low-ability to high-ability households but generate mixed results on welfare impacts (Chamberlin and Ricker-Gilbert, 2016). In Zambia and Malawi, rental markets are prevalent, with positive returns to renting in land observed, particularly for larger producers. However, the impacts of renting out land are mixed, with negative returns in Malawi and negligible returns in Zambia, highlighting the evolving nature of land rental market participation in sub-Saharan Africa (Chamberlin and Ricker-Gilbert, 2016).

Again, a decade-long study in Kenya and Uganda explores factors influencing rural households' participation in land rental and sales markets. While both countries demonstrate efficiency in transferring land from lower to higher farming ability households, challenges persist, suggesting the need for context-specific strategies to maximize the benefits of land market participation (Kijima and Tabetando, 2020). Literature has also shown that different land tenure arrangements are not equally efficient. For example, (Ip and Stahl, 1978) found that sharecropping, fixed rental, wage cultivation, and owner cultivation are not equally efficient in resource allocation. Their study argues that land

reform measures redistributing land to owner-cultivators enhance agricultural production efficiency and resource allocation, contributing to the economic development of less developed countries.

Studies on cropland rental and sales markets outside Africa have also revealed their growth and contribution to improving land use efficiency. However, concerns arise regarding the insignificant benefits for the poor and the likelihood of land being transferred to wealthier households (Nguyen et al., 2021). Policy implications include addressing administrative barriers, supporting farmers, encouraging non-farm sector development, and providing targeted support for the poorest rural population. Again, an investigation into the impact of land rental decisions on household income in rural areas of Jiangsu Province, China, indicates that lessor households experience lower total income, while lessee households in lower income groups gain the most from land rentals. The study calls for careful consideration of local market dynamics in shaping policy interventions (Zhang et al., 2018). These findings align with the recent prevailing perspective on securing land tenure and fostering economic growth that challenges the idea that rapid private ownership through formal land titling is the exclusive solution. For instance, the USAID policy advocates for a "secure enough" approach, prioritizing affordability, sustainability, and a continuum of rights. Under the policy, various alternatives exist to enhance land tenure security without worsening inequality, including recognizing customary rights, issuing certificates for usufruct, management, or inheritance rights, and implementing community titling (Bassett, 2005). Empirical evidence suggests that a more flexible tenure model, preserving elements of customary tenure, may be preferable, especially in systems with overlapping property rights like free-grazing livestock systems. Such rights act as insurance, and gradual transitions provide beneficiaries with time to understand the process, allowing for the development of complementary institutions and a potentially more equitable distribution of strengthened land tenure and property rights (Niamir-Fuller et al., 1999; Roth and McCarthy, 2013; Toulmin, 2009; Arko-Adjei, 2011). Several countries

including ***Malawi*** have adopted alternative systems maintaining elements of customary tenure. Namibia, for example, is developing an incremental approach building on customary rights, offering a continuum of rights through occupancy licenses and certificates of occupancy. In Ghana and Botswana, land boards with traditional leaders or elected officials play a role in decision-making and the implementation of the land registration process. Mexico's 1992 land reform involved community voting on issues like communal resource allocation (Roth and McCarthy, 2013). Another recent model is the Community Land Trust (CLT), where communities own the land, and individuals own improvements like houses. Retaining state ownership and control over some land is also considered, potentially facilitating economies of scale and ensuring land access for marginalized individuals under a liberalized tenure system (Arko-Adjei, 2011; Deininger and Bresciani, 2001).

These recent approaches draw their basis from the fact that the transformation of African economies and societies is undergoing changes due to demographic growth, urbanization, economic monetarization, livelihood diversification, and cultural change. Customary land tenure systems have evolved in response to these shifts, with varied impacts on authority and land rights (Chauveau, 2007). Therefore, the need for an alternative formalization strategy in customary areas is emphasized, focusing on flexible tenure and adapting Land Administration Systems (LAS) to local contexts. To this effect, Arko-Adjei (2011) proposed conceptual models for customizing LAS to the institutional framework of customary tenure in peri-urban areas, advocating for community participation and the recognition of indigenous knowledge. These recent perspectives challenge the prevailing assumption that private, individual tenure is the most effective means of ensuring property rights security. Instead, in sub-Saharan Africa, customary tenure systems prioritize community membership and collective control, challenging the universal applicability of private tenure (Mattingly, 2013). However, the efficiency of customary land tenure has been limitedly researched upon in sub-Saharan Africa, despite undergoing transformation

to improve tenure security.

4 Data and Identification strategy

4.1 Data

The study uses the Integrated Household Panel Survey (IHPS) data from Malawi's National Statistical Office (NSO). The IHPS is conducted alongside the Integrated Household Survey (IHS) program to capture trends in poverty, social-economic, and agricultural characteristics of individuals and households over time. The first IHPS (baseline) was conducted in 2010 alongside the IHS-3 with a total sample of 3,104 households. The surveys are based on stratified sampling criteria with a total of 6 strata. Firstly, sample selection is representative of the three regions of Malawi and then further divided into rural and urban strata. Later in 2013, the first follow-up survey was conducted, covering a total sample of 4,000 households. The sample increased due to household members' split away and new household formation. The third wave was conducted in 2016 alongside IHS4, but the sample size was scaled down to 1,989 due to budgetary constraints. The last wave of IHPS was conducted in 2019 with a combined sample from the third wave and split-off individuals and their new households. The fourth wave covered a total of 3,104 households. This study only uses the first three IHPS waves because the fourth wave of 2019 did not capture data/information on land tenure through sales and rental markets.

4.2 Identification strategy

The study uses a combination of different strategies to estimate the level of farming ability and factors that determine households' participation in customary land tenure systems. Firstly, the paper estimates the farming ability/farmers' effort using a Cobb-Douglas stochastic frontier model, which is then used as an explanatory variable in the

second model. This estimation technique has been widely used in farmland rental market studies where entrepreneurial ability is estimated as the time-invariant component of the Cobb-Douglas function using fixed effects at the household level (Chamberlin and Ricker-Gilbert, 2016; Kijima and Tabetando, 2020; Jin and Deininger, 2009). The fixed-effects stochastic frontier model uses the Marginal Maximum Simulated Likelihood Estimation (MMSLE) technique. Unlike other stochastic frontier panel data models, the MMSLE partials-out household time-fixed heterogeneity to obtain a non-negative random component for household farming efficiency. The approach is also superior to the traditional true fixed effect estimation technique because it gives consistent variance estimates even if there is incidental parameters problem due to an increase in the number of observations while periods remain fixed (Belotti and Ilardi, 2018; Kumbhakar and Wang, 2010; Wang and Ho, 2010). The augmented Cobb-Douglas stochastic frontier function is specified as follows:

$$ln(Q_{ijt}) = \alpha_0 + \sum_{i=1}^{N} \beta ln(Z_{ijt}) + \beta_q \chi'_{ijt} + v_{ijt} - \mu_{ijt} \tag{1}$$

Where Q_{ijt} is the total value of crop production for household i from plot j during the rainy season of year t, Z_{ijt} represents factor inputs which include the total area of plot j cultivated by household i at time t, fertilizer applied and labor input by household i at time t, captured by the adult equivalents (Chamberlin and Ricker-Gilbert, 2016). χ'_{ijt} represents a vector of household characteristics such as gender, age, and years of education for the household head, adult equivalent, annual rainfall total rainfall and temperature. It takes 1 if the household applied fertilizer and 0 otherwise. v_{ijt} is a normally distributed error term, and μ_{ijt} is a one-sided, strictly non-negative term representing farming ability (Belotti and Ilardi, 2018). The sign of the μ_{ijt} term is positive or negative depending on whether the frontier describes a cost or production function respectively. Depending on the estimator used, fixed-effect stochastic frontier models allow the underlying mean and

variance of the farming ability (as well as the variance of the idiosyncratic error) to be expressed as functions of exogenous covariates (Ibid., 2013).

The second part of the analysis uses the estimated level of entrepreneurial ability ($\hat{\mu}_{ijt}$), obtained from equation (1) as an explanatory variable in the Ordinary Least squares (OLS) estimator of farmland tenure systems choice represented by equation (2) below.

$$LT_{ijt} = \theta_1 \hat{\mu}_{ijt} + \theta_2 ln(PA_{ijt}) + \chi^{'}_{ijt} + \epsilon_{ijt} \tag{2}$$

Where LT_{ijt} represents dummies for inherited farmland tenure, farmland allocated by chiefs or employers, rented/borrowed farmland and purchased farmland, taking 1 if the household participated in the land tenure system and 0 otherwise. $\hat{\mu}$ is the estimated level of farming ability from equation (1), PA_{ijt} is the plot area for the household. χ'_{ijt} represents a vector of household and farm plot characteristics such as adult equivalent, household head education, age and sex, migration of the household member, access to credit/loan, death of an adult household member, and Geo-location variables, soil quality, and type. ϵ_{ijt} is the error term. The p-values on the coefficients of equation (2) are obtained using bootstrapping to account for the two-step estimation process because we are using estimates from equation (1) to generate $\hat{\mu}_{ijt}$. θ_1 represents the coefficient of interest that shows whether the level of farming ability determines participation in customary land tenure systems. Though we are primarily interested in the sign of θ_1, studies have shown that it is likely to be biased downwards (Chamberlin and Ricker-Gilbert, 2016; Zhang et al., 2018) because other time-invariant variables such as soil quality measures and risk aversion are not partialled-out from the estimated α. This study overcomes this problem by including soil type and quality for the plot, as well as the level of crop diversification captured by the number of crops grown by the household in a farming season, to control for other time-invariant variables. For interpretation, when θ_1 is greater than 0 in the model means that the farmland tenure system leads to efficiency in land allocation by transferring

land from less efficient farmers to highly efficient farmers, and if less than 0, the opposite holds. As with other studies on farmland markets, this study uses averages of household-level time-variant variables called the Mundlak-Chamberlain (MC) device. The technique is done in case the unobserved time-fixed household-level covariates are correlated with the household-level time-constant averages (Chamberlin and Ricker-Gilbert, 2016; Kijima and Tabetando, 2020; Woodridge, 2010).

Thirdly, to estimate the differential welfare effects between customary land tenure systems and land tenure through sales and rental markets, I estimate equation (3) using household-plot fixed-effect models. The use of household fixed effects partials-out household level time-fixed covariates such as entrepreneurial ability, which are likely to covary with farmland rental arrangement decisions and household income.

$$ln(Y_{ijt}) = \pi_1 IT_{ijt} + \pi_2 CET_{ijt} + \pi^* \chi_{ijt}^{'} + \nu_{jt} + \tau_t + \epsilon_{ijt} \tag{3}$$

Where Y_{ijt} represents crop production and sales values, IT_{ijt} represents a dummy for inherited farmland while CET_{ijt} represents a dummy for farmland allocated by chiefs or employers. The dummies take a value of 1 for land inherited and farmland allocated by chiefs or employers, respectively, and 0 otherwise (indicating land tenure through sales and rental markets). χ'_{ijt} represents a vector of control variables such as total farmland area for the household, soil quality and type of the farmland, household labor availability (adult equivalent), household head sex, gender, and age. ν_{jt} and τ_t represent regional and year fixed effects, respectively while ϵ_{ijt} is the error term.

5 Descriptive statistics and empirical results

5.1 Descriptive statistics

The study uses data from the Integrated Household Panel Surveys (IHPSs) conducted in 2010, 2013, and 2016. Table 1 provides descriptive statistics for balanced panels with 3804 observations. Descriptive statistics encompass variables related to household demographic characteristics, customary land tenure systems, rainfall indicators, geolocation variables, and soil characteristics of farm plots. Due to substantial skewness and large maximum numbers in certain variables, such as crop production and sales values, with minimal mean values, logarithms are employed to normalize these variables.

Table 1: Descriptive statistics

Variable	N	Mean	SD	p25	p50	p75	Min	Max
Crop production value (Malawi Kwacha)	3804	53534.459	651513.262	4000	15000	39000	0	30240000
Plot area (acres)	3804	1.41	16.481	.41	.75	1.22	0	685.35
Crop sales value (Malawi Kwacha)	3804	25750.364	900964.63	0	0	2800	0	55500000
Plot soil type	3804	1.972	0.768	2	2	2	0	3
Plot soil quality	3804	1.26	0.672	1	1	2	0	2
Extent of plot soil erosion	3804	1.562	0.856	1	1	2	1	4
Total inorganic fertilizer applied (kgs)	3804	37.415	66.103	0	0	50	0	1100
Inherited farmland	3804	.599	0.490	0	1	1	0	1
Chief/employer allocated farmland	3804	.256	0.437	0	0	1	0	1
Rented/borrowed farmland	3804	.096	0.295	0	0	0	0	1
Purchased farmland	3804	.047	0.211	0	0	0	0	1
Distance to agricultural market (kms)	3804	25.979	14.349	15	27	36	0	67
Distance to the paved road (kms)	3804	16.582	6.306	2	6.615	14	0	36
Plot distance from the household (kms)	3804	1.37	5.715	.1	.5	1.1	0	248.6
Annual total rainfall (mm) – last season	3804	877.285	140.665	779	836	952	615	1386
Annual total rainfall (mm) – current season	3804	767.452	57.326	657	742	828	529	1131
Annual average temperature ($0^c * 10$)	3804	214.796	18.005	202	213	225	193	263
Annual precipitation (mm)	3804	1010.714	188.661	892	941	1148	795	1843
Credit or loan access (=1)	3804	.2	0.400	0	0	0	0	1
Adult equivalents	3804	3.925	1.599	2.86	3.701	4.845	.76	12.755
Number of crops planted (/season)	3804	1.35	0.572	1	1	2	1	4
Household head age (years)	3804	44.792	15.766	32	42	55	16	106
Household head education (years)	3804	1.283	0.800	1	1	1	0	7
Male Household head (=1)	3804	.749	0.433	0	1	1	0	1

The units of measurement include crop production and sales values in the local currency, Malawi kwacha; plot area in acres; geolocation variables in kilometers (kms); rainfall in millimeters (mm); and fertilizer in kilograms (kgs).

5.2 Empirical results

5.2.1 Estimation of farming efficiency/ability

This section of the analysis estimates a Cobb-Douglas stochastic frontier model and derives the post-estimate of farming ability for use as an explanatory variable in the participation model. Plot area, the amount of inorganic fertilizer applied, adult equivalents, and the age of the household head are positively and significantly related to crop production value. Specifically, a 1% increase in the size of farm plots, the amount of fertilizer applied, and adult equivalents increases crop production value by 0.62%, 0.10%, and 0.56%, respectively. The results align with existing theory and literature from sub-Saharan African countries (Deininger and Mpuga, 2010; Jin and Jayne, 2013; Chamberlin and Ricker-Gilbert, 2016).

Table 2: Fixed-effects Cobb-Douglas stochastic frontier model

VARIABLES	**Log crop production value**	**P-value**
Log plot area (acres)	0.6167***	(0.0001)
Log total inorganic fertilizer (kgs)	0.1013***	(0.0016)
Log adult equivalent	0.5647*	(0.0623)
Log annual rainfall (mm)- previous season	-1.7035**	(0.0151)
Log population density	-0.4331	(0.4653)
Log annual temperature ($0^c * 10$)	0.3747	(0.9636)
Household head age (years)	0.0123*	(0.0936)
Household head education (years)	0.0739	(0.4688)
Male household head (=1)	0.0397	(0.8625)
Year & Regional fixed effects	YES	
U-sigma Constant	5.8577***	(0.0000)
V-sigma Constant	0.8925***	(0.0000)
N	3804	

*Standard errors in parentheses clustered at household level. * p < 0.10, ** p < 0.05, *** p < 0.01.*

On the other hand, a 1% increase in total rainfall in the previous season (survey production season) results in a reduction of approximately 1.7% in crop production value. This can be attributed to severe flooding experienced in Malawi during the years of IHPSs due to heavy rains, leading to widespread devastation, including crop washout and nutrient

leaching. The floods impacted various districts, displacing thousands of people and causing significant damage to infrastructure and crops[1]. Additionally, an increase in the age of the household head by one year leads to a significant increase in crop production value by 1.2%. This may be attributed to the experience, knowledge, access to resources, and social capital accumulated by older household heads.

Finally, population density per square kilometer, annual average temperature, education, and sex of the household head do not affect the value of crop production. However, both the sex and education of the household head are positively related to crop production value. The next step involves analyzing factors that determine households' decisions to participate in customary land tenure systems, with the estimated farming ability from the Cobb-Douglas production function included as an explanatory variable.

The predicted farming ability scores represents the ratio of actual crop production output to the maximum attainable crop production output. The post-estimation mean farming ability score is 0.08 and ranges from a minimum of 0 to a maximum of 0.83. This indicates that, on average, smallholder farming households in Malawi exhibit significant inefficiency in crop production, with the mean deviation from the maximum feasible output (farming ability = 1) being substantial.

5.2.2 Determinants of household participation in customary land tenure systems

The section analyzes the determinants of household participation in customary land tenure systems using the OLS estimator, incorporating the Mundlak-Chamberlin device. To preserve the dependence structure of the data, as farming ability is an estimated variable from the Cobb-Douglas stochastic frontier model, we employ block bootstrapping at the household level for a more accurate estimation of parameters, standard errors, and

[1]https://climateknowledgeportal.worldbank.org/country/malawi/vulnerability

confidence intervals (Brummund and Merfeld, 2022). The estimates provided in Table 3 suggest that participation in all land tenure systems is not determined by the level of farming ability. However farmland tenure through chiefs or employers is negatively associated with the level of farming ability. Though not significant, households with lower farming ability are more likely to acquire farmland from chiefs and the phenomenon might be driven by political influence, corruption behavior of the chiefs and existence of informal markets for customary land (Kishindo, 2004). Similarly, farmland allocated by employers is often not on a demand basis, as the farmland is predetermined for the occupants of the house. On the other hand, while most existing literature from Malawi and other sub-Saharan African countries (Deininger and Mpuga, 2010; Jin and Jayne, 2013; Chamberlin and Ricker-Gilbert, 2016) found that land sales and rental markets are efficient in allocating farmland, this study finds no significant effects of the levels of farming ability on the likelihood of households participating in the respective land tenure systems.

In terms of equity in farmland allocation, the results indicate that inherited farmland tenure is associated with efficiency in land reallocation, i.e., the likelihood of households participating in inherited land tenure decreases as landholding size increases. Consequently, households with smaller landholding sizes have a higher probability of participating in inherited land tenure, thereby increasing their chances of acquiring farmland and promoting equitable farmland allocation. Again, in the context of inherited land tenure, marriage serves as a significant avenue for land access and to address inequalities, the National Land Policy advocates for the registration of individual and family titles. The policy ensures equal rights for both genders and facilitates the direct transfer of land to children, emphasizing that all offspring should inherit land and real property from their parents on an equal basis (Kishindo, 2004).

Table 3: Determinants of household participation in customary land tenure (OLS)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Predicted farming ability	0.0117	-0.0211	-0.00318	0.0171
	(0.0429)	(0.0381)	(0.0300)	(0.0248)
Log plot area (acres)	-0.0348*	0.0384**	-0.0375***	0.0350**
	(0.0206)	(0.0176)	(0.0124)	(0.0155)
Number of crops planted (/season)	0.0773***	-0.0196*	-0.0419***	-0.0151**
	(0.0138)	(0.0114)	(0.00955)	(0.00649)
Log annual total rainfall (mm) - Last season	-0.180**	0.193**	-0.0239	-0.0139
	(0.0903)	(0.0866)	(0.0512)	(0.0442)
Household head age (years)	0.00112	-0.000628	-0.00137**	0.000811**
	(0.000971)	(0.000910)	(0.000625)	(0.000398)
Household head education (years)	-0.0352***	-0.00683	0.0256***	0.0136*
	(0.00999)	(0.00719)	(0.00825)	(0.00697)
Male household head (=1)	-0.0182	-0.0154	0.0307***	0.00259
	(0.0178)	(0.0154)	(0.0110)	(0.00869)
Log adult equivalent	0.00493	-0.00530	0.0105	-0.00297
	(0.0416)	(0.0390)	(0.0259)	(0.0190)
Credit or loan access (=1)	-0.0176	-0.0150	0.0256*	0.00831
	(0.0183)	(0.0146)	(0.0136)	(0.00969)
Log population density	0.00447	-0.0192	-0.00440	0.0258
	(0.0413)	(0.0391)	(0.0359)	(0.0222)
Log distance to paved road (kms)	0.0227	-0.0330	0.00752	0.00802
	(0.0444)	(0.0370)	(0.0290)	(0.0236)
Log annual total temperature ($0^c * 10$)	1.765	-0.879	-0.312	-0.589
	(1.378)	(0.835)	(0.581)	(1.216)
Observations	3,804	3,804	3,804	3,804
R-squared	0.281	0.344	0.037	0.021

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and regional fixed effects; and MC device.*

On the other hand, farmland allocated by chiefs or employers is not only associated with low farming ability but also does not promote equitable allocation of farmland. Households with larger landholding sizes are more likely to participate in farmland acquisition through chiefs at 5% significance level, thereby diminishing the chances for land-poor households to acquire farmland, further exacerbating the inequality in farmland distribution. Chiefs, entrusted with overseeing land without claiming ownership, act as the access point to un-allocated customary land, ensuring equitable distribution for the current generation while preserving it for the future.

However, the Land Act's allocation of land rights to the president and control authority to the Ministry of Lands empowers politicians to override chiefs, leading to decisions on customary land without accountability. This led to the proliferation of tobacco estates, converting around 400,000 hectares of customary land in 1970's and 80's to leasehold tenure. Again, Chiefs, at times influenced by bribes, facilitate the transfer or clandestine sale of un-allocated land to outsiders, depriving the community of a crucial land source for new households. The informal market for customary land further exacerbates the issue, allowing ineligible individuals, primarily rural businessmen, retired workers, and affluent immigrants, to acquire land, circumventing customary rules and disadvantaging community members with fewer financial resources (Kishindo, 2004)

While land rental markets promote equitable allocation of farmland, land sales markets do not. A 1% increase in logged plot area reduces the odds ratio of participation in rented or borrowed farmland by 3.8%, while increasing the likelihood of participation in purchased farmland tenure by 3.6%, and both coefficients are significant at a 1% and 5% significance levels, respectively. Land-abundant households exhibit a higher likelihood of acquiring more farmland compared to land-poor households under the land sales market—a major concern for USAID policy advocates (Roth and McCarthy, 2013). This may be exacerbated by financially constrained households that sell their land to generate funds necessary for addressing immediate financial requirements, including covering medical expenses and repaying loans (Kishindo, 2004). The diversification of crops, as represented by the number of crops planted by the household in a farming season, significantly and positively affects the likelihood of participation in inherited farmland, while it does not affect the likelihood of participating in farmland allocated by chiefs or employers.

Education of the household head emerge as significant determinants of participation in inherited farmland tenure systems, though with opposite effects, while the sex and age of the household head does not. An increase in the household head's education by 1 year decreases the odds ratio of household participation in the inherited land tenure system

by 0.04%, which may be attributed to shift to off-farm income generating activities such as formal employment. Farmland allocated by chiefs or employers is not affected by any of the household head characteristics. The results from the OLS regression with regional fixed effects consistently align with the logistic results presented in Appendix 2 and OLS results with district fixed effects presented in Appendix A4.

5.2.3 Household welfare effects analysis

This chapter examines the welfare effects of customary land tenure systems on crop production and sales values in comparison to land tenure through sales and rental markets. Table 4 presents results of the comparison, where land sales and rental markets form the base category. In Model (1), we estimate the welfare differential impacts based on crop production value, while Model (2) examines the welfare differential impacts based on crop sales value in Malawian local currency (Malawi kwacha). Both inherited land tenure and land tenure acquired through chiefs or employers show no significant difference in the value of crop production compared to land tenure through rental and sales markets. Inherited and land tenure through chiefs exhibit a positive differential welfare impact on crop production value compared to land tenure through sales and rental markets, while they show a negative differential welfare impact on crop sales values compared to land tenure through sales and rental markets, though not significant.

The control variables that have a significant impact on the value of crop production and crop sales include plot size, amount of fertilizer applied, annual rainfall amount for the previous season,age and education of the household head. An increase in plot area leads to a significant increase in both crop production and sales values by 0.78% and 0.61%, respectively. This is in line with theoretical perspectives where an increase in farm size allows the household to increase production, holding other factors constant, thereby increasing the proportion of crop sales out of the total production. Intriguing results are observed on the effect of annual rainfall amounts from the previous season, where we

observe a negative significant effect on crop production value. This can be attributed to the fact that during the survey years, the country experienced heavy rains that destroyed crops through floods and leaching, thereby reducing the crop production value.

Table 4: Welfare effects analysis - customary vs. sales and rental markets (FE)

VARIABLES	**(1)** **Log crop production value (Malawi kwacha)**	**(2)** **Log crop sales value (Malawi kwacha)**
Inherited farmland (=1)	-0.211	-0.268
	(0.265)	(0.297)
Chief or employer allocated farmland (=1)	-0.485	-0.249
	(0.313)	(0.335)
Log plot area (acres)	0.780***	0.612**
	(0.197)	(0.246)
Log adult equivalent	0.896**	0.314
	(0.382)	(0.412)
Log total inorganic fertilizer applied (kgs)	-0.507***	0.231***
	(0.0702)	(0.0716)
Log total annual rainfall (mm) – last season	-1.069	0.729
	(0.955)	(0.783)
Log total inorganic fertilizer * Fertilizer crops	0.785***	-0.199***
	(0.0686)	(0.0723)
Credit or loan access (=1)	0.159	-0.194
	(0.194)	(0.214)
Log plot distance from household (kms)	0.453***	0.172
	(0.129)	(0.165)
Household head age (years)	0.0125	-0.0178*
	(0.00942)	(0.00954)
Household head education (years)	-0.0476	0.0904
	(0.115)	(0.130)
Male Household head (=1)	0.143	0.567**
	(0.280)	(0.272)
Observations	3,804	3,804
R-squared	0.448	0.450

*Standard errors in parentheses clustered at household-plot level *** p<0.01, ** p<0.05, * p<0.1.*

Other control variables: *Soil type and quality; extent of plot soil erosion; year and regional fixed effects*

Lastly, an increase in the household head's age by 1 year significantly reduces crop sales value by 1.8%, while having no significant effect on crop production value. As individuals age, they may experience a decline in physical health and stamina, which

could impact their ability to engage in agricultural activities such as planting, harvesting, and transporting crops to the market. This reduced capacity could lead to lower crop yields and ultimately reduced sales value. On the other hand, the education level of the household head significantly reduces crop production value but has no effect on crop sales value. According to the data summary statistics, the maximum number of years of education for the household head is 7 years, indicating that all household heads only attained primary school education. Hence, there is no significant positive impact on crop production value. However, this may also be explained by a shift in occupation to off-farm income-generating activities as someone attain more years of education, thereby reducing crop production value. Despite the fixed-effects technique mitigating bias from unobserved time-invariant covariates and controlling for more variables, including soil type and quality of the plots, and proxies such as the death of an adult household member and the total amount of rainfall in the previous year, as proposed by Chamberlin & Ricker-Gilbert (2016), the analysis may still suffer from omitted variable bias, which is the weakness of this analysis.

6 Conclusion

The primary focus of this paper is to identify factors influencing decision-making among farming households in Malawi regarding their participation in customary land tenure systems and the subsequent differential impact on household welfare outcomes compared to land tenure through sales and rental markets. Approximately 69% of Malawi's population still adheres to customary land tenure systems due to the underdevelopment of land sales and rental markets. Contrary to some existing literature (Chamberlin and Ricker-Gilbert, 2016; Jin and Deininger, 2009), results indicate that not all customary land tenures are inefficient in allocating farmland.

While farmland acquired through chiefs or employers proves inefficient in farmland allocation and does not promote equity in farmland distribution, inherited farmland tenure allocates farmland efficiently and equitably, particularly to those with high farming ability and land-poor households. Again, while farmland tenure through rental markets are associated with equity in the allocation of farmland, purchased farmland is significantly associated with inequality in farmland allocation, where land-abundant households are more likely to participate in farmland sales markets. An analysis of welfare effects reveals that both inherited land tenure and land tenure allocated by chiefs or employers do not contribute differently to crop production and sales value compared to land tenure through sales and rental markets. Rental markets are efficient in farmland allocation, whereas sales markets exhibit inefficiency, possibly attributed to limited access to credit, rudimentary land sales markets and informal customary land markets. (Deininger and Xia, 2017; Chamberlin and Ricker-Gilbert, 2016; Kishindo, 2004).

Based on these findings, this paper recommends the following policies for Malawi, which may be applicable to all Sub-Saharan African countries where customary land tenure systems are still predominant. Firstly, promote community engagement by urging policymakers to include local communities, including traditional leaders and farmers, in

the development and implementation of land-related policies. This ensures that policies are aligned with local needs. Secondly, advocate for capacity-building programs to empower local chiefs and community leaders in effective land allocation management, including training in modern practices and conflict resolution. Finally, emphasize the importance of developing or revising legal frameworks that recognize and integrate customary land tenure systems, legitimizing traditional practices while aligning with national development goals.

In summary, our findings provide a comprehensive overview of how customary land tenure systems allocate farmland and impact household welfare outcomes. However, it is essential to note that the data panels have a 3-year gap and do not account for the year of land tenure acquisition. The time lag between acquisition and the survey may affect households' farming ability levels. Therefore, future studies should consider utilizing yearly panel data to observe seasonal dynamics.

References

Akerlof, G. A. (1978): "The market for "lemons": Quality uncertainty and the market mechanism," in *Uncertainty in economics*, Elsevier, 235–251.

Alchian, A. A. and H. Demsetz (1973): "The property right paradigm," *The journal of economic history*, 33, 16–27.

Arko-Adjei, A. (2011): *Adapting land administration to the institutional framework of customary tenure: The case of peri-urban Ghana*, 184, IOS Press Amsterdam, The Netherlands.

Bassett, E. M. (2005): "Tinkering with tenure: the community land trust experiment in Voi, Kenya," *Habitat International*, 29, 375–398.

Belotti, F. and G. Ilardi (2018): "Consistent inference in fixed-effects stochastic frontier models," *Journal of Econometrics*, 202, 161–177.

Brummund, P. and J. D. Merfeld (2022): "Should farmers farm more? Comparing marginal products within Malawian households," *Agricultural Economics*, 53, 289–306.

Chamberlin, J. and J. Ricker-Gilbert (2016): "Participation in rural land rental markets in Sub-Saharan Africa: Who benefits and by how much? Evidence from Malawi and Zambia," *American Journal of Agricultural Economics*, 98, 1507–1528.

Chauveau, J.-P. (2007): *Changes in customary land tenure systems in Africa*, Iied.

De Soto, H. (2002): "Law and property outside the West: A few new ideas about fighting poverty," in *Forum for Development Studies*, Taylor & Francis, vol. 29, 349–361.

Deininger, K. and P. Mpuga (2010): "Land Markets in Uganda 1: What Is Their Impact and Who Benefits?" in *The Emergence of Land Markets in Africa*, Routledge, 131–155.

Deininger, K. and F. Xia (2017): "Assessing effects of large-scale land transfers: challenges and opportunities in Malawi's estate sector," *World Bank Policy Research Working Paper*.

Deininger, K. W. and F. Bresciani (2001): "Mexico'S Ejido Reforms: Their Impact On The Functioning Of Factor Markets And Land Access," .

Feder, G. and D. Feeny (1991): "Land tenure and property rights: Theory and implications for development policy," *The world bank economic review*, 5, 135–153.

GoM (2002): "Malawi National Land Policy. Edited by Physical Planning Surveys Ministry of Lands," *Government of Malawi (GoM), Lilongwe*.

Hallagan, W. (1978): "Self-selection by contractual choice and the theory of sharecropping," *The Bell Journal of Economics*, 344–354.

Han, W., Z. Zhang, X. Zhang, and L. He (2021): "Farmland rental participation, agricultural productivity, and household income: Evidence from rural China," *Land*, 10, 899.

Holden, S. T., K. Otsuka, and F. M. Place (2010): *The emergence of land markets in Africa: Impacts on poverty, equity, and efficiency*, Routledge.

Ip, P. and C. Stahl (1978): "Systems of land tenure, allocative efficiency, and economic development," *American Journal of Agricultural Economics*, 60, 19–28.

Jin, S. and K. Deininger (2009): "Land rental markets in the process of rural structural transformation: Productivity and equity impacts from China," *Journal of comparative economics*, 37, 629–646.

Jin, S. and T. S. Jayne (2013): "Land rental markets in Kenya: implications for efficiency, equity, household income, and poverty," *Land Economics*, 89, 246–271.

Kijima, Y. and R. Tabetando (2020): "Efficiency and equity of rural land markets and the impact on income: Evidence in Kenya and Uganda from 2003 to 2015," *Land Use Policy*, 91, 104416.

Kishindo, P. (2004): "Customary land tenure and the new land policy in Malawi," *Journal of Contemporary African Studies*, 22, 213–225.

Kumbhakar, S. C. and H.-J. Wang (2010): "Estimation of technical inefficiency in production frontier models using cross-sectional data," *Indian Economic Review*, 7–77.

Lunduka, R., S. T. Holden, and R. Øygard (2010): "Land rental market participation and tenure security in Malawi," in *The Emergence of Land Markets in Africa*, Routledge, 112–130.

Mattingly, M. (2013): "Property rights and urban household welfare," *Property Rights and Development Briefing*.

Msukwa, C., J. Burt, and J. Colvin (2021): "Good Governance in Malawi: impact evaluation of the 'Strengthening Land Governance System for Smallholder Farmers in Malawi'project," .

Nguyen, T. T., V. T. Tran, T.-T. Nguyen, and U. Grote (2021): "Farming efficiency, cropland rental market and income effect: evidence from panel data for rural Central Vietnam," *European Review of Agricultural Economics*, 48, 207–248.

Niamir-Fuller, M., M. D. Turner, et al. (1999): "A review of recent literature on pastoralism and transhumance in Africa." *Managing mobility in African rangelands: the legitimization of transhumance.*, 18–46.

NPC (2021): "A Cost-Benefit Note: Implementing the National Land Policy in Malawi - Technical Report, Malawi Priorities, National Planning Commission(NPC)," *Copenhagen Consensus Center (USA) & African Institute for Development Policy (Malawi)*.

Ostrom, E. (1990): *Governing the commons: The evolution of institutions for collective action*, Cambridge university press.

Roth, M. and N. McCarthy (2013): "Land tenure, property rights, and economic growth in rural areas," *USAID Issue Brief*, 3, 1–15.

Stiglitz, J. E. (1974): "Alternative theories of wage determination and unemployment in LDC's: The labor turnover model," *The Quarterly Journal of Economics*, 88, 194–227.

Toulmin, C. (2009): "Securing land and property rights in sub-Saharan Africa: The role of local institutions," *Land use policy*, 26, 10–19.

Tsutomu, T. (2008): "2. Land Shortage, Customary Law, and Smallholders," *African Rural Livelihoods under Stress: Economic Liberalization and Smallholder Farmers in Malawi*, 21–50.

Wang, H.-J. and C.-W. Ho (2010): "Estimating fixed-effect panel stochastic frontier models by model transformation," *Journal of Econometrics*, 157, 286–296.

Woodridge, J. (2010): "Econometric Analysis of Cross Section and Panel Data, 2nd Edtion," .

Zhang, L., S. Feng, N. Heerink, F. Qu, and A. Kuyvenhoven (2018): "How do land rental markets affect household income? Evidence from rural Jiangsu, PR China," *Land Use Policy*, 74, 151–165.

Appendix

Table A1: Determinants of household participation in farmland tenure systems (OLS – lag farming ability)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Lag predicted farming ability (-1)	0.00849	-0.00483	-8.62e-05	-0.000435
	(0.0471)	(0.0452)	(0.0303)	(0.0232)
Log plot area (acres)	-0.0242	0.0233	-0.0322*	0.0338*
	(0.0252)	(0.0232)	(0.0177)	(0.0174)
Number of crops planted (/season)	0.0813***	-0.0220	-0.0354***	-0.0224***
	(0.0161)	(0.0150)	(0.0109)	(0.00744)
Log annual total rainfall (mm) - Last season	-0.0954	-0.0575	0.0689	0.0802
	(0.123)	(0.114)	(0.0820)	(0.0575)
Household head age (years)	0.00217**	-0.000821	-0.00253***	0.00111**
	(0.00101)	(0.00113)	(0.000781)	(0.000496)
Household head education (years)	-0.0320***	-0.00631	0.0204**	0.0152*
	(0.0110)	(0.00922)	(0.00863)	(0.00783)
Male household head (=1)	-0.0222	-0.0161	0.0443***	-0.00695
	(0.0205)	(0.0190)	(0.0131)	(0.0107)
Log adult equivalent	0.0342	0.0143	-0.0471	-0.000751
	(0.0544)	(0.0519)	(0.0392)	(0.0305)
Credit or loan access (=1)	0.00177	-0.0155	0.00700	0.00649
	(0.0204)	(0.0187)	(0.0146)	(0.0106)
Log population density	0.0229	-0.0336	-0.0215	0.0326
	(0.0593)	(0.0695)	(0.0721)	(0.0403)
Log distance to paved road (kms)	0.0484	-0.0482	-0.0159	0.0153
	(0.0731)	(0.0763)	(0.0820)	(0.0330)
Log annual total temperature ($0^c * 10$)	0.994	0.110	-1.254	0.151
	(1.634)	(1.615)	(2.150)	(0.377)
Observations	2,536	2,536	2,536	2,536
R-squared	0.326	0.332	0.040	0.028

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and regional fixed effects; and MC device.*

Table A2: Determinants of household participation in farmland tenure systems (Logit)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Predicted farming ability	0.286	-0.465	0.254	-0.174
	(0.249)	(0.328)	(0.415)	(0.584)
Log plot area (acres)	-0.214	0.270*	-0.486*	0.650**
	(0.159)	(0.154)	(0.256)	(0.259)
Number of crops planted (/season)	0.512***	-0.152	-0.549***	-0.524**
	(0.105)	(0.0960)	(0.155)	(0.224)
Log annual total rainfall (mm) - Last season	-0.386	-0.327	0.942	2.079
	(0.927)	(0.857)	(1.089)	(1.678)
Household head age (years)	0.00215	0.00598	-0.0317***	0.0367**
	(0.00653)	(0.00719)	(0.0108)	(0.0150)
Household head education (years)	-0.218***	-0.0215	0.166*	0.249*
	(0.0689)	(0.0812)	(0.0905)	(0.129)
Male household head (=1)	-0.184	-0.0110	0.549***	-0.272
	(0.135)	(0.154)	(0.196)	(0.245)
Log adult equivalent	0.210	-0.0724	-0.130	-0.0522
	(0.322)	(0.356)	(0.444)	(0.691)
Credit or loan access (=1)	-0.0775	-0.0399	0.180	0.110
	(0.132)	(0.144)	(0.175)	(0.269)
Log population density	-0.168	0.127	0.0184	0.633
	(0.318)	(0.332)	(0.732)	(0.903)
Log distance to paved road (kms)	-0.259	0.0182	0.429	-0.0960
	(0.453)	(0.471)	(0.714)	(0.797)
Log annual total temperature ($0^c * 10$)	16.23	-3.223	-16.80	4.056
	(13.19)	(13.84)	(22.95)	(11.95)
Observations	3,804	3,804	3,804	3,804
Number of newid	1,268	1,268	1,268	1,268

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and regional fixed effects; and MC device.*

Table A3: Determinants of household participation in farmland tenure systems (Logit – lag farming ability)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Lag predicted farming ability	0.0448	-0.0577	0.0206	-0.255
	(0.308)	(0.288)	(0.439)	(0.943)
Log plot area (acres)	-0.148	0.152	-0.413	0.683*
	(0.174)	(0.154)	(0.314)	(0.407)
Number of crops planted (/season)	0.535***	-0.157	-0.515***	-0.861***
	(0.110)	(0.0989)	(0.174)	(0.309)
Log annual total rainfall (mm) - Last season	-0.622	-0.312	1.253	3.477
	(0.939)	(1.031)	(1.382)	(3.226)
Household head age (years)	0.0129*	-0.00530	-0.0364***	0.0473**
	(0.00679)	(0.00740)	(0.0112)	(0.0216)
Household head education (years)	-0.209***	-0.0460	0.176*	0.349**
	(0.0736)	(0.0813)	(0.0983)	(0.167)
Male household head (=1)	-0.146	-0.106	0.730***	-0.300
	(0.141)	(0.144)	(0.229)	(0.353)
Log adult equivalent	0.229	0.00678	-0.249	-0.404
	(0.343)	(0.342)	(0.569)	(1.073)
Credit or loan access (=1)	0.0159	-0.109	0.0613	0.180
	(0.139)	(0.147)	(0.184)	(0.319)
Log population density	0.136	-0.159	-0.236	1.259
	(0.401)	(0.396)	(1.129)	(1.316)
Log distance to paved road (kms)	0.315	-0.301	-0.172	0.667
	(0.591)	(0.548)	(1.068)	(1.468)
Log annual total temperature ($0^c * 10$)	8.267	-1.672	-8.926	10.54
	(14.88)	(15.89)	(30.83)	(27.04)
Observations	2,536	2,536	2,536	2,536
Number of newid	1,268	1,268	1,268	1,268

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and regional fixed effects; and MC device.*

Table A4: Determinants of household participation in farmland tenure (OLS-District FE)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Predicted farming ability	0.0361	-0.0427	0.0170	-0.00737
	(0.0356)	(0.0303)	(0.0253)	(0.0193)
Log plot area (acres)	-0.0322	0.0222	-0.0337**	0.0449***
	(0.0206)	(0.0177)	(0.0132)	(0.0159)
Number of crops planted (/season)	0.0628***	-0.0144	-0.0359***	-0.0110
	(0.0164)	(0.0126)	(0.0113)	(0.00749)
Log annual total rainfall (mm) - Last season	-0.0776	-0.0510	0.0600	0.0637
	(0.122)	(0.109)	(0.0688)	(0.0520)
Household head age (years)	0.000427	0.000564	-0.00195***	0.000883**
	(0.000900)	(0.000945)	(0.000664)	(0.000445)
Household head education (years)	-0.0323***	0.00109	0.0210**	0.00766
	(0.0103)	(0.00778)	(0.00857)	(0.00576)
Male household head (=1)	-0.0212	-0.00329	0.0301***	-0.00556
	(0.0183)	(0.0155)	(0.0115)	(0.00907)
Log adult equivalent	0.0245	-0.00240	-0.0173	0.000307
	(0.0461)	(0.0399)	(0.0282)	(0.0226)
Credit or loan access (=1)	-0.0129	-0.00617	0.0144	0.00537
	(0.0177)	(0.0152)	(0.0131)	(0.0102)
Log population density	-0.0173	-0.00162	0.00212	0.0171
	(0.0424)	(0.0457)	(0.0433)	(0.0274)
Log distance to paved road (kms)	-0.0306	-0.00570	0.0413	-0.00588
	(0.0546)	(0.0503)	(0.0562)	(0.0193)
Log annual total temperature (0c)	1.892	-0.445	-1.659	0.214
	(1.237)	(1.298)	(1.516)	(0.351)
Observations	3,804	3,804	3,804	3,804
R-squared	0.313	0.353	0.072	0.052

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and district fixed effects; and MC device.*

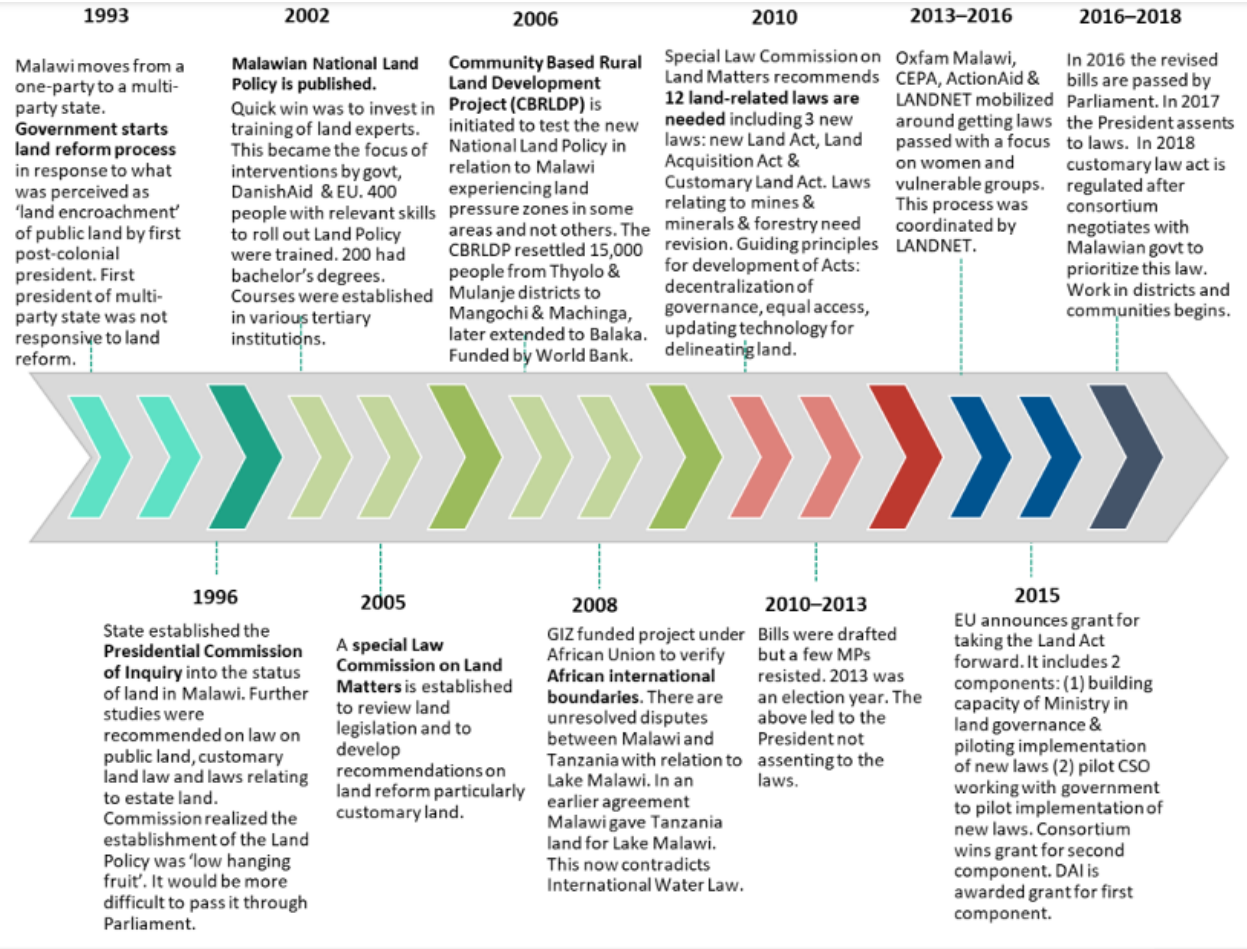
Table A5: Determinants of household participation in farmland tenure (OLS – District FE)

VARIABLES	(1) Inherited farmland. (=1)	(2) Chief/employer farmland. (=1)	(3) Rented/borrowed farmland. (=1)	(4) Purchased farmland. (=1)
Lag predicted farming ability (-1)	0.0115	-0.00958	0.00312	-0.00277
	(0.0487)	(0.0459)	(0.0329)	(0.0231)
Log plot area (acres)	-0.0226	0.0143	-0.0351*	0.0442**
	(0.0264)	(0.0247)	(0.0190)	(0.0180)
Number of crops planted (/season)	0.0843***	-0.0235	-0.0403***	-0.0182**
	(0.0177)	(0.0162)	(0.0129)	(0.00874)
Log annual total rainfall (mm) - Last season	-0.106	-0.0487	0.0691	0.0809
	(0.128)	(0.113)	(0.0750)	(0.0575)
Household head age (years)	0.00194*	-0.000618	-0.00244***	0.00105**
	(0.00100)	(0.00116)	(0.000776)	(0.000490)
Household head education (years)	-0.0318***	0.00373	0.0142*	0.0107
	(0.0112)	(0.00951)	(0.00846)	(0.00704)
Male household head (=1)	-0.0209	-0.0143	0.0411***	-0.00698
	(0.0208)	(0.0193)	(0.0132)	(0.0104)
Log adult equivalent	0.0242	0.00446	-0.0228	-0.00513
	(0.0560)	(0.0516)	(0.0405)	(0.0305)
Credit or loan access (=1)	0.00160	-0.0166	0.00855	0.00646
	(0.0207)	(0.0200)	(0.0137)	(0.0109)
Log population density	0.0575	-0.0284	-0.0692	0.0396
	(0.0667)	(0.0700)	(0.0692)	(0.0436)
Log distance to paved road (kms)	0.0667	-0.0327	-0.0618	0.0266
	(0.0769)	(0.0717)	(0.0728)	(0.0345)
Log annual total temperature (0c)	1.051	-0.304	-1.209	0.477
	(1.729)	(1.774)	(2.199)	(0.426)
Observations	2,536	2,536	2,536	2,536
R-squared	0.347	0.351	0.069	0.060

*Bootstrap standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Other control variables: *Household member migration; adult death in the household; soil type and quality; extent of plot soil erosion; year and district fixed effects; and MC device.*

Figure A1: Land reform process since multiparty state in 1993)



Adopted from NPC (2021): "A Cost-Benefit Note: Implementing the National Land Policy in Malawi - Technical Report, Malawi Priorities, National Planning Commission(NPC)," Copenhagen Consensus Center (USA) African Institute for Development Policy (Malawi).