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Does Land Reform Improve Soil Health and Household Food Security in Malawi? Insights from Smallholder Farmers.

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Does Land Reform Improve Soil Health and Household Food Security in Malawi? Insights from Smallholder Farmers.

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Abstract.
Land reforms play a critical role in enhancing tenure security among smallholder farmers in Malawi. This study examines the impact of land registration on household food security and soil health restoration, providing new insights into the broader outcomes of Malawi's land reform initiatives. Using observational data from 506 smallholder households, the analysis employs an Endogenous Switching Regression model to account for both observed and unobserved factors that may influence participation in land registration. Recognizing that food distribution within households is often unequal, the study adopts multiple proxies to capture the multidimensional nature of food security, including the Women's Dietary Diversity Score, Children's Dietary Diversity Score, Household Food Insecurity Access Scale, and Household Food Insecurity Experience Scale. The results reveal that land registration significantly improves both food security and soil health among smallholder farmers. Moreover, household and farm characteristics, such as the age of the household head, membership in farmer groups, landholding size, and adoption of sustainable land management practices, further enhance these household welfare outcomes. The study concludes that scaling up targeted land reform programs, alongside the promotion of complementary sustainable land management practices, can substantially strengthen food security and improve soil health in Malawi's smallholder farming systems.

Keywords: Food security, land registration, soil health restoration, Customary Land Act, tenure security.

Introduction

Achieving Sustainable Development Goals (SDGs) 1 and 2, ending poverty, hunger, food insecurity, and all forms of malnutrition by 2030, remains a central global objective. Yet, progress has been uneven and slow. Globally, one in eleven people experiences food insecurity, and the situation is more severe in sub-Saharan Africa, where one in five people faces hunger (FAO, 2022). This deviation from global targets has been exacerbated by multiple, interlinked challenges. Ongoing conflicts have disrupted agricultural production, markets, and food supply chains (WFP, 2024); climate change continues to damage crops and livestock systems (FAO, 2023); and economic instability, particularly through inflation and rising input costs, has restricted access to affordable and nutritious food (World Bank, 2018; World Bank, 2025).

Malawi exemplifies these challenges. Despite being an agrarian economy, the country faces persistent and worsening food insecurity, ranking among the most affected nations in sub-Saharan Africa. Between 2010 and 2020, the prevalence of food insecurity rose by nearly 50% (NSO, 2020). According to the Malawi Vulnerability Assessment Committee (MVAC), about 3.8 million people were acutely food insecure in 2023, a 64% increase from 2021 levels. Several factors contribute to this crisis. Economic constraints, including currency devaluation and persistent inflation, have reduced household purchasing power and increased the cost of imported agricultural inputs such as fuel, fertilizers, and pesticides, particularly affecting cereal production in the Central and Northern regions (Moyo & Chirwa, 2025). Demographic pressure, combined with the predominance of smallholder agriculture and limited adaptive capacity to climate shocks, further intensifies vulnerability (Salima et al., 2023; Chirwa et al., 2024). The devastation caused by Tropical Cyclone Freddy in 2023, resulting in widespread flooding and landslides across 15 southern districts, led to significant crop losses, livelihood disruptions, and infrastructure damage, further constraining national food availability (FSIN, 2024, Pangapanga et al., 2022).

Among the structural constraints accelerating Malawi's food insecurity crisis is the challenge of insecure land tenure. Insecure land rights undermine productivity and discourage long-term investment in sustainable land management and soil fertility restoration. Farmers without formalized land rights are unable to use land as collateral for credit, limiting access to essential agricultural inputs such as fertilizers and improved seeds. This disincentive contributes to soil degradation and declining fertility. For instance, nitrogen fertilizer efficiency has dropped from 9.6 kg to 2 kg of output per kg of fertilizer between 1984 and 2022 (Burke et al., 2022), while national soil acidity has worsened, with an average pH decline of 0.68 units and a 10% topsoil loss (Omuto et al., 2018).

Recognizing these challenges, the Government of Malawi enacted the Customary Land Act (2016) to formalize the management of customary land and strengthen land governance, particularly in rural areas (Chikaya-Banda & Chilonga, 2021; Zuka, 2019). The Act provides a framework for registering customary land under the Registered Land Act, granting formal recognition and legal protection to individuals, families, and communities. Secure tenure is expected to enhance investment in land improvements (Deininger et al., 2019), reduce disputes (Melesse & Bulte, 2015), and promote equitable access to land resources (Deininger, 2021). Furthermore, the Act ensures fair compensation for land acquired for public purposes, recognizing both the intrinsic and developmental value of land. Collectively, these provisions aim to improve land governance, strengthen land markets, and incentivize sustainable land management, thereby enhancing agricultural productivity and socio-economic development. However, despite the potential of these reforms, empirical evidence on their actual impacts, particularly on soil health and household food security, remains limited and requires systematic investigation (Bae, 2021).

Although several studies have examined the implications of land registration and tenure security in Malawi (e.g., Deininger, 2021; Chikaya-Banda & Chilonga, 2021; Zuka, 2019; Peters, 2010; Melesse & Bulte, 2015; Holden et al., 2009; Holden & Ghebru, 2016; Kishindo, 2004; Place & Otsuka, 2001; Matchaya, 2009), most have focused on productivity, investment behavior, or land dispute resolution. To date, no study has comprehensively analyzed the joint effects of land registration on soil health and food security outcomes among smallholder farmers in Malawi. Given that food security is multidimensional, encompassing availability, access, utilization, and stability, this study employs multiple indicators to capture its complexity. These include the Child Dietary Diversity Score (CDDS), Women's Dietary Diversity Score (WDDS), Household Food Insecurity Experience Scale (HFIES), and Household Food Insecurity Access Scale (HFIAS). To assess soil health, the study uses a composite proxy reflecting household-level soil management practices, such as the application of soil amendments (lime, organo-mineral fertilizers, and biochar), agroforestry tree planting (e.g., Gliricidia, Tephrosia, and Faidherbia albida), and conservation techniques (e.g., legume intercropping, crop rotation, mulching, and minimum tillage). Households employing all three categories of practices are considered to maintain healthier soils.

The novelty of this study lies in its integrated analysis of land registration, soil health, and household food security within the context of Malawi's ongoing land reform agenda. While previous research has extensively examined the relationship between land tenure security and agricultural productivity, investment incentives, or land dispute resolution (e.g., Deininger, 2021; Holden & Ghebru, 2016; Peters, 2010), few have explored how formalization of customary land rights translates into biophysical and welfare outcomes. Specifically, no existing study has empirically assessed the joint effects of land registration on soil health restoration and food security outcomes among smallholder farmers. This research therefore bridges an important empirical and policy gap by linking land reforms to ecological sustainability and household resilience. Furthermore, by employing an endogenous switching regression (ESR) model, the study advances methodological rigor in estimating causal effects while addressing selection bias inherent in non-random participation in land registration. The multidimensional measurement of food security using dietary diversity and food insecurity experience indices, combined with a composite proxy for soil health, also offers a comprehensive and context-sensitive framework for understanding the nexus between institutional reforms and household resilience in Malawi.

Evolution of Land Reforms in Malawi.

The evolution of land reforms in Malawi reflects a complex historical trajectory shaped by colonial legacies, post-independence political dynamics, and contemporary efforts to promote equitable access and tenure security. Under British colonial rule, established in 1891 through the declaration of the Nyasaland Protectorate, land became a tool of economic and political control. The colonial administration formalized settlers' rights to acquire land from indigenous communities through the issuance of Certificates of Claim, thereby creating large European estates for export-oriented crops such as tea and tobacco (Zuka & Matinga, 2016). This process alienated local populations from their ancestral land and fueled widespread land disputes. To mitigate growing tensions, the colonial government established land commissions in 1920, which recommended the demarcation of land reserves for indigenous communities, albeit on the condition that such measures did not compromise labor availability for European estates.

Further consolidation of colonial land control came with the 1951 Land Ordinance, which legitimized the tenure systems derived from treaties, agreements, and conquests, and categorized all land into public, private, or customary. This tripartite classification entrenched unequal land ownership patterns and institutionalized colonial authority over indigenous tenure systems. Following independence in 1964, the new government inherited deeply inequitable land regulations. Land remained central to Malawi's development agenda, as it was the primary productive resource and source of livelihoods (Chisinga, 2008). However, early post-independence reforms reinforced, rather than dismantled, existing inequalities. The 1965 Land Act and the 1967 Land Acquisition Act allowed the state to take control of customary land, redistributing it to a new class of black estate farmers to replace white settler dominance (Zuka & Matinga, 2016; Kanyongolo, 2008; Harrigan, 1995). These acts consolidated political patronage and perpetuated exclusion, while rapid population growth further reduced average landholding size from 1.53 hectares to 0.8 hectares per capita, intensifying land scarcity and rural poverty.

The transition to multiparty democracy in 1994 reignited debates on land reform, this time framed around social justice, poverty reduction, and equity (Chisinga, 2008). Widespread recognition emerged that the roots of land inequality lay in colonial expropriation and postcolonial mismanagement (Silungwe, 2015). During this period, concerns also grew over the misuse of authority by traditional leaders, who often distributed customary land in a manner that disadvantaged poor and marginalized households. In response, the notion of registering user rights under customary tenure gained traction as a safeguard against dispossession by both the state and traditional elites (Chikaya-Banda & Chilonga, 2021).

In the same year, the Bretton Woods institutions, through the Highly Indebted Poor Countries (HIPC) Programme, urged Malawi to adopt new land laws as part of structural adjustment and debt relief conditions. These proposals emphasized that customary tenure systems were too insecure to support efficient land markets or promote investment (World Bank, 1981; Spooner, 1988). The recommended reforms aimed to formalize and register customary land rights to improve tenure security and attract investment. However, these initiatives gained limited traction, as the government ranked land reform low on its list of agricultural priorities and allocated no significant budgetary support (Jenkins & Tsoka, 2003).

A major breakthrough came in 2016, when Parliament adopted a comprehensive package of land reforms, supported by the World Bank. This led to the enactment of the National Land Policy and the Customary Land Act (2016), which repealed the outdated Customary Land (Development) Act and dissolved local land boards. The new legislation decentralized customary land administration, formalized land titling, and established community-level land committees and tribunals to improve transparency and reduce the excessive control previously exercised by traditional authorities. These reforms represented a paradigm shift in Malawi's land governance framework, emphasizing equity, accountability, and sustainable management.

To implement the reforms, pilot projects launched in 2019 targeted both patrilineal districts (Karonga, Mzimba, Rumphi, and Kasungu) and matrilineal districts (Nkhotakota, Mchinji, Phalombe, and Chikwawa). These pilots were designed to test the adaptability of land registration processes within diverse cultural contexts and to assess their impact on tenure security, agricultural investment, and food security. Early evidence suggests that formal land registration enhances farmers' confidence in investing in sustainable land management practices, thereby improving soil health, agricultural productivity, and household food security.

Methodology

Conceptual Framework

Conceptually, this study assumes that land certification and titling enhance food security in Malawi by strengthening tenure security, promoting investments in soil health practices, and increasing agricultural productivity. Under the 2016 Customary Land Act, land certification provides legal recognition of ownership and use rights, thereby reducing the risk of encroachment or expropriation by private entities or the state (Holden et al., 2013). Secure tenure empowers smallholder farmers with confidence and authority to make long-term investments in their land, such as applying organic and mineral fertilizers, lime, and biochar; planting agroforestry trees like *Tephrosia* and *Faidherbia albida*; and adopting conservation practices, including minimum tillage, mulching, and crop rotation. These sustainable land management practices enhance soil fertility, improve land productivity, and strengthen the resilience of farming systems. Moreover, land certification enables farmers to use their titled plots as collateral to access agricultural credit, which can be invested in inputs such as improved seeds, fertilizers, and pesticides. By facilitating access to both resources and credit, land certification supports productivity growth that can directly improve household food availability and, through commercial production, expand the local food supply. Consequently, the framework underscores the transformative role of secure land rights in fostering sustainable agricultural intensification and advancing food security outcomes in Malawi's smallholder sector (Zuka & Matinga, 2016).

Theoretical Framework

As developed by McFadden (1974), we model household decisions regarding land registration through certification and titling. Theoretically, the study suggests that rational households will opt to register land if the expected gain from registering land exceeds that of maintaining the current situation. Households are more inclined to register land when the anticipated benefits enhance tenure security, reducing risks of disputes or expropriation (Holden et al., 2013). Secure tenure promotes investments in soil health, such as applying organic and mineral fertilisers, lime, biochar, or planting agroforestry trees (e.g., Tephrosia, Faidherbia albida), and adopting conservation agriculture practices like minimum tillage and mulching. These investments improve soil fertility and agricultural productivity, directly supporting household food security through increased subsistence production or market surplus. Furthermore, titled land can serve as collateral for loans, facilitating access to inputs like fertilisers, seeds, and pesticides, thus further boosting productivity.

However, households weigh these benefits against costs such as registration fees, administrative burdens, and time, which can be considerable in Malawi's resource-limited context. The decision to register land can be expressed mathematically as:

$$R_i^* = U_{iR} - U_{iNR} > 0 \quad (1)$$

where R_i^* is a latent variable representing the net utility of registration for a household, U_{iR} is the utility of registering land, and U_{iNR} is the utility of the status quo (unregistered land). The household registers if $R_i^* > 0$. Further, R_i^* can be presented as a function of observable characteristics, as defined in equation 2, where (β) is a vector parameter to be estimated, (X_i) is a vector of explanatory variables (e.g., household income, land size, access to credit, education, gender, cultural tenure system), and (ε_i) is the error term capturing unobserved factors.

$$R^*{}_i = \beta X_i + \varepsilon_i \text{ with } R^*{}_i = \begin{cases} 1 \; if \; \mathrm{R}_i > 0 \\ 0 \;\; otherwise \end{cases} \quad (2)$$

Empirical Strategy.

We hypothesize that some households will choose to register their land while others will not (Rosenbaum, 1994; Gertler et al., 2011; Guo & Fraser, 2010; Rubin & Imbens, 2015). Consequently, the impact of land registration or reform can be identified by comparing the outcome variables between registered and non-registered households, allowing for a robust estimation of the causal effects of land certification on key outcomes such as food security and soil health. In non-random studies, such as those by Pangapanga-Phiri et al. (2021), Tufa et al. (2022), Mgomezulu et al. (2023), and Chirwa et al. (2024), households may self-select into treatment and control groups, indicating the potential presence of self-selection. Consequently, when comparing outcome variables, farmers with prior advantages in observable characteristics may exhibit better outcomes, potentially leading to biased and inconsistent estimates if ordinary least squares (OLS) methods are employed.

Various methods e.g., (Pangapanga-Phiri et al., 2022); Mgomezulu et al., 2024; Tione et al., (2025); Moyo & Chirwa (2025) have been adopted to derive unbiased estimates using non-experimental data. These methods consist of propensity score matching (PSM), inverse probability weighted regression adjustment (IPWRA), instrumental variable (IV), and endogenous switching regressions. Among these, a propensity score matching (PSM) technique has been widely used to address self-selection bias in impact evaluation (Tufa et al., 2019). In addition, PSM is adopted under situation where decisions are influenced by observable factors such as access to markets (Chirwa et al, 2024), access to extension services(Mgomezulu et al., 2023). However, there could be unobserved characteristics that could influence the decision to register land, such as farmers' utility preferences, farmers' skills, and innovativeness (Lokshin & Zurab Sajaia, 2004). Hence, using PSM could yield biased and inconsistent estimates due to the presence of unobserved heterogeneity. Secondly, farmers may self-select, and their decision to adopt these technologies could influence outcomes like dietary diversity score, and food consumption score. In this context, the study employs the Endogenous Switching Regression (ESR) to assess the impact of land registration on soil health and food security.

According to Lokshin & Zurab Sajaia, (2004), an ESR method can be applied in two steps to evaluate the impact of implementing land registration. The first step involves applying a probit regression model to ascertain the likelihood of participating in land registration. The second stage examines the relationships between the observable traits of farmers who registered their lands and the outcome variables. The two separate regimes are given as follows.

$Y_{iR}^{*} = \beta_{iR}X_{iR} + v_{iR}$ if $G_i = 1$ for land registration in regime 1 (3)
$Y_{iNR}^{*} = \beta_{iNR}X_{iNR} + v_{iNR}$ if $G_i = 0$ for those that did not register in regime 2 (4)

The latent variable Y_{iR}^{*} represents the likelihood that a farming household will register their land. The vectors X_{iR}, and X_{iNR}, represent production socioeconomic and institutional regressors for treatment and control, β_{iR} and β_{iNR} represents a vector of parameters that need to be estimated for both adopters and non-adopters, and v_{iR} , v_{iNR} represents the stochastic error term. Due to selection bias and endogeneity, the study assumes non-zero values of correlation between $v_{iN}$and v_{iA}. Further, the study assumes that the three errors, thus, ε_i, $v_{iN}$and v_{iA} have a trivariate normal distribution with zero mean and variance covariance structure presented as follows.

$$\text{Covariance } (\varepsilon_i, v_{iN}, v_{iA}) = \begin{Bmatrix} \sigma_{\varepsilon}^2 & \sigma_{R\varepsilon} & \sigma_{NR\varepsilon} \\ \sigma_{R\varepsilon} & \sigma_{R}^2 & \sigma_{NR} \\ \sigma_{NR\varepsilon} & \sigma_{NR} & \sigma_{NR}^2 \end{Bmatrix} \quad (5)$$

where σ_{ε}^2, σ_{R}^2, and σ_{NR}^2 are variances of the error terms in the selection equation and outcome models for adopters and non-adopters. Further, $\sigma_{A\varepsilon}$ is the covariance between ε_i, and v_{iA} and $\sigma_{N\varepsilon}$ is the covariance between $\varepsilon_i$and v_{iN}. Since Y_A^* and Y_N^* do not occur at the same time, the covariance between v_{iN}, and v_{iA} is undefined. This results into the mean values of the truncated error terms being presented as:

$E[v_R | \, G = 1] = \sigma_{A\varepsilon} = \sigma_{R\varepsilon}\gamma_R$ (6)
$E[v_{NR} | \, G = 0] = \sigma_{N\varepsilon} = \sigma_{R\varepsilon}\gamma_{NR}$ (7)

In the first stage, γ_R and γ_{NR} can be estimated and included in the outcome equations for treatment and control groups if an exogenous instrument relevant to the situation is provided. For the proper design of the ESR model, the selection model must have at least one variable that influences the decision to register land but does not affect the outcome variable (FCS, WDDS, CHDDS, and HFIAS). The impact of land registration can be modelled by estimating the FCS, HDDS and HFIAS under observed and counterfactual scenarios. In the observed scenario, the expected value of the outcome variables (FCS, WDDS, CHDDS and HFIAS) for adopters (Y_{iA}^*) can be expressed as:

$$E[Y_R^*|\ G = 1] = \ \beta X_R - \sigma_{A\varepsilon}\gamma_A \quad (8)$$

Households that registered their land may behave differently from an average household with the same characteristics due to unobserved characteristics. Hence, $\sigma_{A\varepsilon}\gamma_A$, in the equation above, takes selection bias consideration. The expected outcome (FCS, WDDS, CHDDS and HFIAS) for adopters had they decided not to register land is modelled as follows:

$$E[Y_{NR}^*|\ G = 1] = \ \beta X_{NR} - \sigma_{NR\varepsilon}\gamma_R \quad (9)$$

Therefore, the impact of land registration on food security is the difference between the two equations above; thus, the average treatment effect on treated (ATT) is presented as follows.

$$ATT = E[Y_R^*|\ G = 1] - E[Y_{NR}^*|\ G = 1] = \ X(\beta_R - \beta_{NR}) + (\sigma_{R\varepsilon} - \sigma_{NR\varepsilon})_{\gamma_R} \quad (10)$$

The ESR can have large standard errors; hence, it is necessary to test for endogeneity in explanatory variables. Following (Wooldridge, 2015), endogeneity and weak instrument tests are presented as follows:

$$Y_i^* = \beta_i X_i + v_i \quad (11)$$
$$Y_i^* = Z_i \Upsilon_i + \varepsilon_i \quad (12)$$

where equation (11) is the structural form and equation (12) is the reduced form. Hence, the study tests the null hypothesis that $\Upsilon_i = 0$ in the reduced form against the alternative that $\Upsilon_i \neq 0$. Rejecting the null hypothesis implies the presence of endogeneity and necessitates the use of a strong instrument.

Description of Outcome Variables

Measuring food security is a multidimensional process, meaning that no single indicator can fully capture all the aspects of sustainability, availability, access, utilization, and stability. This study identifies several indicators as proxies for food security: the Child Dietary Diversity Score (CDDS), the Women's Dietary Diversity Score (WDDS), the Household Food Insecurity Experience Scale (HFIES), and the Household Food Insecurity Access Scale (HFIAS). Recognizing that food distribution is not equal within households, we consider minimum dietary diversity for both women of reproductive age (18-64 years) and children aged 6-59 months. The Household Dietary Diversity Score (HDDS) serves as a valuable indicator of food access, as it measures the quality of food available to households rather than just the quantity.

The Women's and Children's Dietary Diversity Scores are calculated as follows:

$$DDS = \sum_i H_i \ \ i = 1,2,3 \dots ,0 \quad (13)$$

where H_i represent the food group consumed, and each food group is represented by a binary value where 1 indicates that a household consumed a particular food group and 0 indicates that it did not. For example, a household with a Dietary Diversity Score of 10 would have consumed every food group within the last 24 hours. The relevant food groups include fish and meat, pulses, eggs, fats and oils, cereals and grains, fruits and vegetables, dairy, roots and tubers, sugars, and condiments. The WDDS and CDDS measure dietary diversity for women (15–49 years) and children (6–23 months), respectively, based on the consumption of nine and seven food groups in the past 24 hours, with higher scores indicating greater dietary diversity and improved nutritional outcomes (FAO, 2016).

The Household Food Insecurity Access Scale (HFIAS), developed by FANTA, assesses household food insecurity over the past 30 days. A higher HFIAS score indicates greater food insecurity. The scale includes nine questions, with households responding based on their experiences in the last four weeks: "seldom" (once or twice), "sometimes" (three to ten times), and "often" (more than ten times). Scores range from 0 (food secure) to 27 (maximum insecurity), with higher scores indicating food insecurity (Maxwell et al., 2014). The Food and Agriculture Organization (FAO) created the Household Food Insecurity Experience Scale (FIES) to measure food insecurity as part of monitoring the Sustainable Development Goals (SDGs). The FIES survey includes eight questions aimed at determining whether, during a certain period, the respondent has experienced specific conditions that suggest a reduced ability to access food (FAO, 2016).

Soil health is assessed using a binary proxy variable indicating whether a household adopts a comprehensive soil health package, defined as the simultaneous implementation of three practices: agroforestry, cultural practices, and soil amendments. Agroforestry includes planting nitrogen-fixing trees (e.g., *Gliricidia sepium or Faidherbia albida*) to enhance soil fertility and structure. Cultural practices encompass crop rotation and intercropping with legumes, which improve soil nutrient content and reduce erosion. Soil amendments involve applying organic inputs (e.g., compost, manure) to enhance soil organic matter and microbial activity. Households are classified as adopting the soil health package (1) if they implement all three practices concurrently, and non-adopting (0) otherwise. This composite measure reflects a holistic approach to soil health, capturing long-term investments in sustainable land management influenced by land registration.

Study Area

This study was conducted in the Mikalango and Mwansambo Extension Planning Areas (EPAs) within Nkhotakota and Chikwawa districts in Malawi, selected to represent contrasting land tenure systems. Nkhotakota is predominantly matrilineal, where land rights are typically inherited through the female line, while Chikwawa is predominantly patrilineal, with land rights passed through the male line. These districts were chosen to capture variations in local land governance, which influence land registration, food security, and soil health outcomes. Data were collected by the Centre for Agricultural Research and Development (CARD) from 512 households using a structured questionnaire administered via Survey Solutions. A stratified random sampling technique was employed to select households within the two EPAs, followed by simple random sampling to ensure representativeness across tenure systems.

Results and Discussion.

Summary of Household Characteristics.

Table 4.1 presents descriptive statistics comparing the socioeconomic, agricultural, and institutional characteristics of households with registered and unregistered land. The results reveal significant differences, supporting the hypothesis that land certification affects tenure security, agricultural investment, and food security. The average age of household heads was 46.9 years, with registered households slightly older (47.6 years) than unregistered households (45.6 years), although this difference was not statistically significant ($p = 0.160$). The majority of households (80.6%) were male-headed, with no significant gender difference between the groups ($p = 0.987$). Literacy rates were higher among registered households, with 75.4% literate in Chichewa and 23.1% in English; these differences were significant at the 1% level. Education levels also differed significantly ($p < 0.001$), with registered household heads averaging 5.8 years of schooling compared to 4.6 years for unregistered households. Household sizes were similar across both groups. Land holdings averaged 2.6 acres overall, with registered households owning significantly larger parcels (2.9 acres) than unregistered households (1.9 acres), a significant difference at the 1% level.

Table 4.1: Descriptive statistics

Variable Name	Variable Description	Total (N=506) (100%)	Land Registered (n=325) (63%)	Did not register the land (n=181) (37%)	Test
Age	Age of the household head in years	46.866 (15.475)	47.588 (15.311)	45.569 (15.724)	0.160
Gender	Gender of the household head	0.806 (0.396)	0.806 (0.396)	0.806 (0.397)	0.987
Literacy in Chichewa	If the household head can read or write in the Local language	0.711 (0.454)	0.754 (0.431)	0.635 (0.483)	0.005
Literacy in English	If the household head can read or write in English	0.190 (0.392)	0.231 (0.422)	0.116 (0.321)	0.002
Education	The highest class of education that the household head reached	5.374 (3.412)	5.794 (3.415)	4.619 (3.284)	0.000
Household size	Number of persons living in the same house	5.318 (1.766)	5.391 (1.795)	5.188 (1.712)	0.216
Farmer group	Is the household head a member of any farmers' group, association, or company?	0.350 (0.478)	0.414 (0.493)	0.238 (0.427)	0.000
Solar Panel	Do you have a solar panel?	0.359 (0.480)	0.352 (0.478)	0.372 (0.485)	0.655
Land size	The land size of the main land parcel	2.558 (1.843)	2.906 (2.018)	1.933 (1.259)	0.000
Vetiver grass	If the household has vetiver grass as a soil and water conservation measure	0.690 (0.463)	0.748 (0.435)	0.586 (0.494)	0.000
Crop rotation with legumes	If the household practices crop rotation with legumes	0.486 (0.500)	0.540 (0.499)	0.389 (0.489)	0.000
Intercropping with legumes	If the household practices intercropping with legumes	0.310 (0.463)	0.336 (0.473)	0.261 (0.440)	0.080
Minimum tillage	If the household practices minimum tillage	0.062 (0.240)	0.043 (0.204)	0.094 (0.293)	0.022
Tephrosia	If the household has Tephrosia as an agroforestry tree	0.032 (0.177)	0.044 (0.206)	0.011 (0.105)	0.044
Faidherbia albida	If the household has Faidherbia albida as an agroforestry tree	0.224 (0.417)	0.256 (0.437)	0.167 (0.374)	0.021

Mixture of Organic Manure and inorganic fertilizer	If the household applies a mixture of manure and inorganic fertilizer on their main land parcel	0.213 (0.410)	0.243 (0.430)	0.160 (0.368)	0.029
Soil Erosion	Is soil erosion a major problem on this plot	0.443 (0.497)	0.403 (0.491)	0.514 (0.501)	0.016
Access to extension and advisory services	Access to extension advisory	1.147 (0.354)	1.123 (0.329)	1.189 (0.393)	0.047
Farmer organisation	If the farmer uses the farmer organization as a source of extension and advisory services	0.144 (0.352)	0.124 (0.330)	0.188 (0.392)	0.082
Household Food Insecurity Access Scale	Household Food Insecurity Access Scale	11.093 (7.567)	9.560 (6.980)	13.845 (7.816)	0.000
Household Dietary Diversity Score	Household Dietary Diversity Score for children under 5 years	3.327 (1.748)	3.656 (1.888)	2.826 (1.374)	0.000
Household Dietary Diversity Score	Household Dietary Diversity Score for women aged 18 to 64 years	4.140 (1.964)	4.474 (2.087)	3.553 (1.569)	0.000
Household Food Insecurity Experience Scale	Household Food Insecurity Experience Scale	5.200 (2.977)	4.778 (3.088)	5.956 (2.607)	0.000

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Participation in farmer organizations was substantially higher among registered households, with 41.4% compared to 23.8% for non-registered households (p < 0.001), suggesting that land registration enhances access to networks and resources. Registered households were also significantly more likely to adopt agricultural practices that promote soil health. For instance, 74.8% used vetiver grass for soil conservation, compared to 58.6% of non-registered households (p < 0.001). Crop rotation with legumes was practised by 54.0% of registered households versus 38.9% of non-registered households (p < 0.001), while intercropping with legumes was slightly higher among registered households at 33.6%, compared to 26.1% in non-registered households (p = 0.080). Additionally, the use of soil-improving species such as Tephrosia was more common among registered households (4.4% vs. 1.1%, p = 0.044), as was Faidherbia albida (25.6% vs. 16.7%, p = 0.021). Registered households also more frequently employed mixed organic and inorganic fertilizers, with 24.3% adoption compared to 16.0% among non-registered households (p = 0.029). Overall, these results highlight that land registration is associated with greater engagement in sustainable and productivity-enhancing agricultural practices.

Unregistered households reported greater use of minimum tillage practices, with 9.4% employing this method compared to 4.3% of registered households (p = 0.022), potentially reflecting resource constraints among unregistered households. Soil erosion was also less prevalent among registered households, affecting 40.3% versus 51.4% of unregistered households (p = 0.016), suggesting more effective land management practices among those with registered land. Registered households consistently exhibited superior food security outcomes. The Household Food Insecurity Access Scale (HFIAS) score was lower for registered households at 9.6 compared to 13.8 for unregistered households (p < 0.001), indicating reduced food insecurity. Similarly, Household Dietary Diversity Scores (HDDS) were higher among registered households, with children under five scoring 3.7 versus 2.8 for unregistered households (p < 0.001), and women aged 18–64 scoring 4.5 compared to 3.6 (p <

0.001). The Household Food Insecurity Experience Scale (HFIES) also reflected improved outcomes for registered households, with scores of 4.8 versus 6.0 for unregistered households ($p < 0.001$). These findings collectively indicate that land registration is associated with better land management and enhanced food security.

Weak instrument and Endogeneity test.

The study's selection of instrumental variables (IVs) is guided by both theoretical considerations and prior research. Three proxy variables are employed as IVs: (i) farmers' perception that land registration confers legal ownership, (ii) farmers' perception that land registration reduces the risk of land disputes, eviction, and expropriation, and (iii) farmers' perception that land registration encourages investment in their land, with confidence in future returns. These variables are chosen because they are strongly correlated with the likelihood of a farmer registering land but are plausibly exogenous to food security outcomes (WDDS, CDDS, HFIAS, HFIES) and soil health, affecting them only indirectly through land registration. To ensure the validity of these instruments, the study adheres to standard econometric principles by conducting robustness checks, including tests for endogeneity and weak instruments, with the zero first-stage test employed to assess instrument strength. As shown in Table 4.2, both the Anderson-Rubin test and Wald test are significant at a 1%. Following the reduced form econometric estimation, we reject the null hypothesis that the instruments are weak and land registration is exogenous. This suggests the presence of endogeneity, and the instruments used are strong.

Table 4.2: Endogeneity test and weak instrument test for the validity of instrumental variables

Test	Statistic	p-value
AR	Chi2 (3) =11.63	0.000
Wald	Chi2 (3) = 33.14	0.000

Determinants of Land registration among smallholder farmers in Malawi

Table 4.3 reports the estimates from the endogenous switching regression model (ESRM), examining the determinants of land registration and its effects on food security and dietary outcomes, including HFIAS, HFIES, CDDS, and WDDS, for households that registered their land versus those that did not. Across all model estimates, the parameter $\sigma_{R\varepsilon}$, capturing the correlation between unobservable in the land registration and outcome equations, was statistically significant. This indicates initial differences between households that registered land and those that did not generate self-selection into land registration. The joint independence test further reveals significant differences in the HFIAS, HFIES, CDDS, and WDDS functions between registered and unregistered households, highlighting variation in the impact of factors such as the age of the household head, membership in farmer groups, land size, crop rotation with legumes, intercropping with legumes, and the use of vetiver grass for soil and water conservation. These findings underscore the advantages of the ESR over a simple treatment effect model, as it explicitly accounts for endogeneity and selection bias, providing more reliable estimates of the impact of land registration on household outcomes.

The selection equation results (Columns 4, 6, 8, 10, 12 in Table 4.3) indicate that both the age of the household head and membership in farmer groups significantly increase the likelihood of land registration. Specifically, a one-year increase in age raises the probability of registering land, suggesting that older household heads, with greater experience and awareness of tenure benefits, prioritize securing land for future generations, especially in contexts with weak customary land systems. This finding aligns with Gedefaw (2023), who reported that older household heads in Ethiopia were more likely to adopt sustainable land management practices, and with Samim et al. (2025), who found that age influences the adoption of climate-smart agricultural practices under secure tenure in Afghanistan. Similarly, membership in farmer groups enhances the probability of land registration, likely by improving awareness of legal frameworks such as Malawi's Customary Land Act and providing access to training, resources, and information on the benefits of formal tenure, including reduced land disputes. Nahayo et al. (2017) support this, noting that farmer group participation in Rwanda significantly boosts adoption of land management practices through knowledge sharing and resource access, which can extend to decisions about land registration. Collectively, these results underscore the importance of both individual characteristics and social networks in shaping formal land tenure decisions.

Table 4.3: Results from Endogenous switching regression models.

		HFIAS			HFIES			CDDS			WDDS			Soil Health	
	Registered Land	Unregistered Land	Selection Equation	Unregistered Land	Registered Land	Selection Equation	Unregistered Land	Registered Land	Selection Equation	Unregistered Land	Registered Land	Selection Equation	Unregistered Land	Registered Land	Selection Equation
Age of household head	0.0120	-0.0149	0.0117**	-0.0018	0.0049*	0.0115**	-0.0021	-0.0043***	0.0100*	0.0041	-0.0021	0.0099*	-0.0041	0.0027	0.0107*
	(0.025)	(0.042)	(0.005)	(0.003)	(0.003)	(0.005)	(0.002)	(0.001)	(0.005)	(0.003)	(0.001)	(0.005)	(0.008)	(0.003)	(0.005)
Gender of household head	-0.7710	1.1755	-0.1865	0.0316	0.0542	-0.1712	-0.0104	0.1402***	-0.0439	0.1081	0.0539	-0.0434	0.4876*	0.0446	-0.1712
	(1.044)	(1.204)	(0.202)	(0.093)	(0.108)	(0.198)	(0.071)	(0.039)	(0.191)	(0.098)	(0.054)	(0.192)	(0.292)	(0.137)	(0.200)
Literacy in Chichewa	1.4929	2.0212	0.0896	-0.0221	0.1388	0.1630	-0.1160*	-0.0816	-0.0256	-0.0956	-0.1339**	-0.0256	-0.1489	0.4434***	0.1511
	(1.013)	(1.419)	(0.201)	(0.089)	(0.111)	(0.200)	(0.070)	(0.065)	(0.197)	(0.092)	(0.059)	(0.197)	(0.262)	(0.150)	(0.199)
Literacy in English	-1.7274*	-1.1111	0.0621	-0.0088	-0.0118	0.1141	-0.0539	0.0318	0.1165	-0.0310	0.0883	0.1159	-0.2790	0.2739**	0.1434
	(1.023)	(1.449)	(0.224)	(0.097)	(0.123)	(0.228)	(0.112)	(0.054)	(0.222)	(0.130)	(0.057)	(0.224)	(0.424)	(0.131)	(0.241)
Education	-0.0662	-0.7238***	0.0371	-0.0156	0.0096	0.0257	-0.0218*	0.0032	0.0305	-0.0046	0.0069	0.0306	-0.0093	-0.0406**	0.0285
	(0.147)	(0.255)	(0.031)	(0.016)	(0.017)	(0.031)	(0.013)	(0.008)	(0.031)	(0.016)	(0.008)	(0.031)	(0.056)	(0.019)	(0.031)
Household size	0.1696	0.7202*	-0.0478	-0.0029	-0.0053	-0.0514	0.0058	-0.0206**	-0.0472	-0.0160	-0.0032	-0.0476	-0.0782	-0.0307	-0.0545
	(0.216)	(0.392)	(0.042)	(0.021)	(0.021)	(0.044)	(0.016)	(0.010)	(0.042)	(0.028)	(0.012)	(0.042)	(0.064)	(0.031)	(0.043)
Farmer group	-0.9214	0.1737	0.2797*	-0.0028	-0.2852***	0.3106*	-0.0733	-0.0139	0.3094*	0.1103	0.0042	0.3083*	0.0931	-0.1437	0.3022*
	(0.839)	(1.515)	(0.165)	(0.078)	(0.094)	(0.168)	(0.079)	(0.041)	(0.161)	(0.096)	(0.044)	(0.162)	(0.234)	(0.108)	(0.168)
Land size	-0.1039	-0.9766	0.1220***	-0.1024***	-0.0186	0.1422***	0.0227	0.0081	0.1355***	0.0234	0.0165	0.1355***	0.0875	-0.0161	0.1526***
	(0.195)	(0.631)	(0.045)	(0.039)	(0.023)	(0.054)	(0.024)	(0.010)	(0.045)	(0.036)	(0.011)	(0.045)	(0.088)	(0.026)	(0.049)
Crop rotation with legumes	-0.0060	-1.0433	0.4898***	0.2292***	0.0129	0.4680***	0.0780	0.0343	0.5839***	0.0453	0.0538	0.5844***	-0.1872	0.2193*	0.4669***
	(0.885)	(1.115)	(0.155)	(0.074)	(0.093)	(0.161)	(0.064)	(0.036)	(0.157)	(0.087)	(0.049)	(0.157)	(0.271)	(0.122)	(0.160)
Intercropping with legumes	3.3497***	5.8919***	0.6697***	0.1656**	0.1762*	0.7514***	-0.0251	0.0786	0.8387***	-0.0237	0.1483***	0.8376***	0.6343**	0.3785***	0.7711***
	(0.971)	(1.924)	(0.184)	(0.077)	(0.097)	(0.187)	(0.089)	(0.048)	(0.185)	(0.125)	(0.049)	(0.187)	(0.304)	(0.111)	(0.191)
Vetiver Grass	-0.6604	0.9754	0.3301**	0.0256	-0.0381	0.3288**	0.0496	0.0067	0.3305**	-0.0377	0.0077	0.3312**	0.5558*	0.2499	0.3294**
	(1.005)	(1.129)	(0.154)	(0.065)	(0.101)	(0.156)	(0.057)	(0.039)	(0.155)	(0.074)	(0.049)	(0.155)	(0.284)	(0.165)	(0.159)
Faidherbia albida	-0.3614	0.4611	-0.1068	-0.2561**	-0.1629*	0.0126	0.0264	0.0819	-0.0005	0.1615	0.1934***	-0.0013	0.2151	0.6217***	0.0035
	(0.856)	(1.602)	(0.196)	(0.111)	(0.092)	(0.196)	(0.077)	(0.057)	(0.185)	(0.100)	(0.052)	(0.185)	(0.253)	(0.111)	(0.197)
Mixture of Manure and fertilizer	0.3440	5.3568***	-0.0587	0.0825	0.0478	-0.1147	-0.1425	0.0829	-0.0482	-0.1158	0.1256**	-0.0503	0.6741**	0.2469**	-0.1261
	(0.951)	(1.817)	(0.213)	(0.110)	(0.100)	(0.208)	(0.092)	(0.054)	(0.203)	(0.144)	(0.053)	(0.203)	(0.316)	(0.110)	(0.216)
Presence of organisms in the soil	1.6455	0.3198	-0.0948	-0.1511*	0.1445	-0.0799	0.0483	0.0746	-0.1917	0.0367	0.1198	-0.1926	-0.5848	-0.2751	-0.0517
	(2.351)	(1.804)	(0.463)	(0.089)	(0.291)	(0.501)	(0.112)	(0.091)	(0.486)	(0.092)	(0.096)	(0.487)	(0.649)	(0.328)	(0.485)
Soil erosion	-0.3480	0.5163	0.1889	-0.0834	0.0260	0.1611	0.0674	0.0020	0.1963	0.0100	0.0680	0.1952	-0.3962*	-0.1231	0.1495
	(0.820)	(1.235)	(0.154)	(0.074)	(0.096)	(0.161)	(0.061)	(0.045)	(0.156)	(0.080)	(0.045)	(0.157)	(0.218)	(0.109)	(0.160)
Soil quality	1.4669**	1.9297**	-0.1750	0.0613	0.0610	-0.1737	-0.1649***	-0.0819***	-0.1942*	-0.0804	-0.1455***	-0.1938*	-0.4667**	-0.0908	-0.1817
	(0.584)	(0.799)	(0.112)	(0.046)	(0.062)	(0.115)	(0.042)	(0.028)	(0.109)	(0.055)	(0.034)	(0.109)	(0.189)	(0.084)	(0.117)
Flooding	0.8364	0.1455	-0.1161	0.0064	0.0996	-0.0886	-0.0817	-0.0184	-0.1369	-0.0284	-0.0766	-0.1364	0.1020	0.0226	-0.0973
	(0.866)	(1.051)	(0.158)	(0.074)	(0.095)	(0.160)	(0.061)	(0.049)	(0.157)	(0.092)	(0.047)	(0.157)	(0.224)	(0.119)	(0.166)
Access to climate services	-3.5919***	2.6875*	0.2173	0.1834**	-0.1474	0.1930	0.0241	-0.0081	0.1181	-0.1775**	-0.0383	0.1166	0.1106	-0.1256	0.1853
	(1.139)	(1.378)	(0.179)	(0.072)	(0.090)	(0.177)	(0.057)	(0.048)	(0.174)	(0.081)	(0.067)	(0.174)	(0.236)	(0.157)	(0.179)
Legal recognition			0.5462***			0.4801***			0.4783***			0.4803***			0.5056***
			(0.159)			(0.158)			(0.156)			(0.158)			(0.164)
Reduce land disputes			0.8152***			0.7543***			0.6977***			0.7029***			0.7662***
			(0.147)			(0.154)			(0.152)			(0.153)			(0.153)
Willingness to invest			0.6826**												
			(0.320)												
Constant	9.3309***	4.0036	-1.6340***	1.9784***	1.0642**	-1.5420**	1.4250***	1.3774***	-1.3799**	1.2627***	1.5009***	-1.3776**	-0.0348	-0.8926*	-1.5110**
	(3.526)	(3.894)	(0.615)	(0.272)	(0.461)	(0.657)	(0.212)	(0.147)	(0.638)	(0.251)	(0.161)	(0.639)	(0.948)	(0.455)	(0.641)
Observations	437.0000			437.0000			437.0000			437.0000			437.0000		

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

An increase in land size by one acre significantly raises the likelihood of land registration. Larger landholdings, associated with higher economic value and greater exposure to disputes, incentivize farmers to secure formal titles to protect their investments. This finding is consistent with Gedefaw, (2023), who found that larger land holdings in Ethiopia were associated with increased adoption of water-harvesting systems post-registration, reflecting greater incentives for tenure security and soil health investments among farmers with larger plots. Agronomic practices, such as crop rotation and intercropping with legumes, also increase the probability of land registration. These practices, which enhance soil fertility and productivity, indicate that farmers investing in sustainable agriculture are more likely to seek formal tenure to safeguard their long-term investments. Samim et al. (2025) identified intercropping and crop rotation with legumes as climate-smart practices influenced by land tenure security in Afghanistan, suggesting that secure tenure encourages such practices to improve soil health. Similarly, Faye et al., (2025) noted that intercropping with legumes enhances soil fertility in Senegal, with tenure security playing a critical role in adoption.

Furthermore, the adoption of soil and water conservation measures, such as planting vetiver grass, significantly increases the likelihood of land registration. This reflects farmers' commitment to long-term land management and soil health, as vetiver grass is an effective erosion-control measure. Despite not being addressed in literature, Samim et al. (2025) and Gedefaw (2023) highlight that soil and water conservation practices are more prevalent under secure tenure, supporting the link between vetiver grass planting and land registration. This finding underscores the potential of land registration to promote sustainable land management practices that enhance soil health.

The Impact of Land registration on household food security and soil health

The study examined the impact of land registration on soil health and food security. As shown in Figure 1, land registration significantly enhances food security. Households with registered land reported HFIAS and HFIES scores of 9.96 and 4.98, respectively, compared to counterfactual scores of 12.50 and 5.81, indicating reductions of 2.54 and 0.83 points, both statistically significant at the 1% level. These findings suggest that formal land registration strengthens household food security, likely by increasing tenure security and encouraging agricultural investment. Land registration also improved dietary diversity: households with registered land achieved WDDS and CDDS of 4.27 and 3.24, respectively, compared to counterfactual scores of 3.25 and 2.74. This represents increases of 1.02 and 0.50 points, both significant at the 1% level, reflecting differences in consumption patterns between women and children within households. Despite these positive effects on food security, land registration had no significant impact on soil health. The difference in soil health outcomes between registered and unregistered households was statistically insignificant, suggesting that registration alone does not directly alter soil management practices. This may be partly due to the slow process of soil restoration and the challenges in its assessment. Improvements from practices such as applying soil amendments (inorganic fertilizers, lime, charcoal, or mixed organic–inorganic fertilizers), agroforestry, or intercropping often take multiple growing seasons to materialize, which may explain the minimal short-term effects observed.

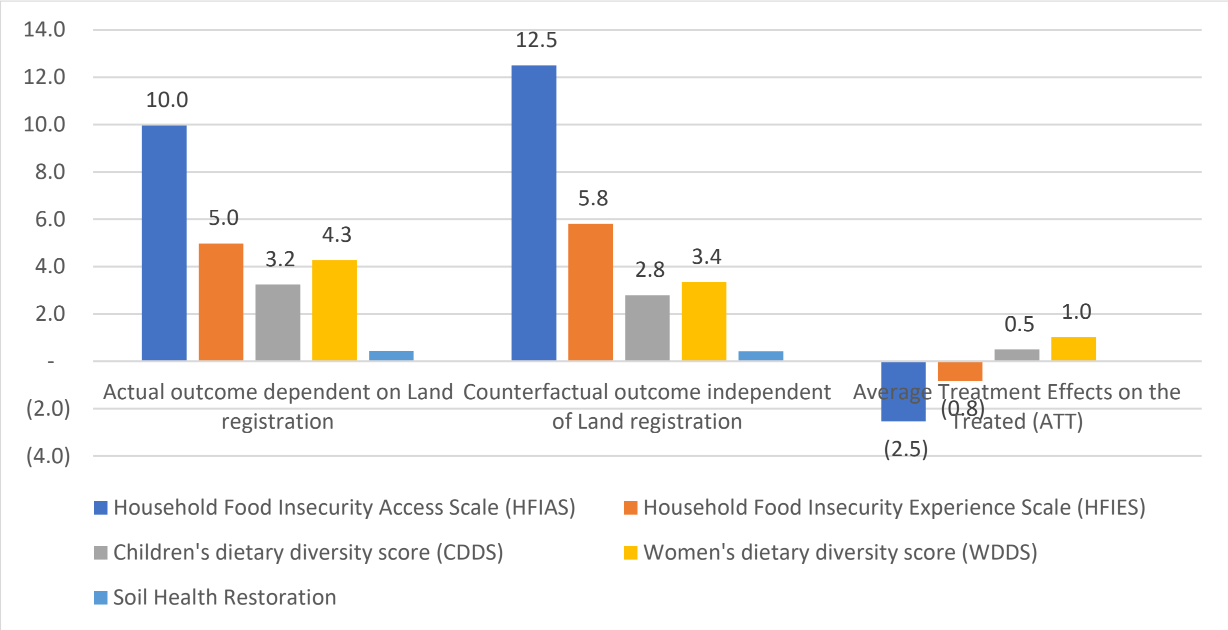

Figure 1: Average treatment effects on the treated of land registration on soil health and food security

Conclusion and Policy Implications

This study examined the implications of land registration on food security and soil health among Malawian smallholder households. Despite recent government and stakeholder efforts, food insecurity remains a persistent challenge in Malawi, undermining efforts to eradicate poverty and achieve zero hunger by 2030. Insecure land tenure exacerbates this crisis by limiting productivity and discouraging investments in soil fertility management. In response, the Government of Malawi introduced the Customary Land Act in 2016, which formalizes the management of customary land and enhances land governance. By enabling individuals, families, and communities to register customary land under the Registered Land Act, the policy aims to strengthen tenure security, reduce land disputes, and incentivize investments in land improvements. However, prior to this study, the effects of land registration on food security and soil health investments remained largely unknown. The findings of this study reveal that factors such as the age of the household head, membership in farmer groups, land size, and adoption of sustainable practices—namely crop rotation with legumes, intercropping, and vetiver grass planting—significantly influence the likelihood of land registration. Importantly, land registration is associated with improved food security outcomes, including reductions in HFIAS and HFIES scores and increases in WDDS and CDDS, highlighting its role in enhancing household dietary diversity.

These results have important policy implications. First, they provide empirical support for scaling up initiatives like the Customary Land Act, aligning with Malawi's 2063 Agenda, which prioritizes sustainable agriculture and poverty reduction. To maximize the benefits of land registration, the study recommends simplifying the implementation of the Customary Land Act, raising awareness of its advantages, and strengthening farmer groups through training, input subsidies, and access to credit. Moreover, integrating sustainable land management practices—such as crop rotation, intercropping, and vetiver grass planting—into land registration programs through extension services and incentives can further boost productivity while encouraging registration. Collectively, these measures can reinforce tenure security, improve food security, and promote sustainable agricultural development in Malawi.

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