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ABSTRACT

Do Households Where Women Own Land Fare Better for Food Security? Evidence for Tanzania

This paper aims to study the relationship between women's land ownership and household food security in Tanzania, using data from three waves of the Tanzanian National Panel Survey. The analysis focuses on the Household Dietary Diversity Scale (HDDS) as a measure of food security, and we categorize land ownership by gender and whether it is solely or jointly owned. Additionally, we examine the impact of the gendered division of crop cultivation on household food security, distinguishing between cash crops and food crops. We estimate several fixed-effects specifications and perform a heterogeneity analysis to disentangle the effects of women's land ownership across households with varying levels of dependence on home-produced food. The findings reveal that women's land ownership significantly influences household dietary diversity. Specifically, women's sole ownership of food crops and joint ownership of cash crops have positive effects on household food security, especially for households reliant on purchased food. These results underscore the importance of women's ownership of income-generating crops in enhancing food security. Overall, this research provides valuable insights for policymakers, emphasizing the significance of women's land ownership in driving household food security in Tanzania. By uncovering the positive impacts of women's land ownership, the study highlights the importance of gender equity in agricultural systems and the potential for women's empowerment to foster sustainable development and food security.

JEL Classification: O12, Q15
Keywords: gender equity, food security, land ownership, Tanzania

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1. Introduction

Despite significant efforts by national governments and the international community to fight food insecurity, the number of people suffering from hunger continues to rise. In 2020, approximately 10 percent of the global population was undernourished, with more than one third located in Africa. Tanzania, although experiencing improvements in recent years, still faces challenges in ensuring a healthy and diversified diet, with nearly 60 percent of households unable to afford nutritious food. Additionally, an estimated 14.3 million Tanzanians experienced food insecurity in 2020 (FAO et al., 2021).

Women play a crucial role in achieving food security, both in terms of agricultural production and family consumption. They represent nearly 53 percent of the agricultural labor force in Sub-Saharan Africa (International Labour organization [ILO], 2019) and play a significant role in feeding their families (Guyer 1980; Haddad & Hoddinot 1994; Hopkins et al., 1994; Quisumbing et al. 1995; Kennedy & Peters 1992; Malapit & Quisumbing, 2015; Palacios-Lopez et al., 2017). However, women in agriculture face numerous economic constraints, including unequal access to land, inputs, paid work, and information (Alkire et al., 2013; Akter et al., 2017). These constraints contribute to the well-documented gender productivity gap in agriculture (Peterman et al., 2011; Ali et al., 2014; Oseni et al., 2015; Doss, 2018; Singbo et al., 2021).

Given the importance of food security and gender equality, governments, NGOs, and donor agencies are increasingly prioritizing these issues on their policy agendas. The United Nations' 2030 Agenda for Sustainable Development, in particular, calls for a global partnership to eradicate hunger and address gender inequality (SDG 2 and 5 - United Nations, 2015).

So far, research on women's land ownership and on the role of women for food security has progressed through distinct strands of literature. To contribute to this body of knowledge, our study aims to address two key questions: first, does food security improve in households where women own land? Second, do women enhance food security more effectively through the ownership of cash crops or food crops?

Women typically have fewer land rights than men within households, and female-headed households often face even greater limitations (Agarwal, 1994; Ossome, 2014). Efforts have been made in some countries to promote gender equality in land rights, such as Ethiopia's land tenure reform and Rwanda's successful land tenure reform initiative (Muchomba, 2017; Ali et al., 2014). In Tanzania, legal reforms have aimed to transition from customary to private property rights, recognizing gender equity and women's rights to own and use land (Peterman, 2011). However, traditional practices and male dominance still pose challenges to women's access to land rights.

Existing literature has explored the relationship between women's land ownership and household food security from various perspectives. Women's land rights have been linked to increased agricultural productivity, intra-household decision-making power, and access to credit (Udry, 1996; Duflo, 2012). Evidence suggests that women's empowerment and economic resources are primarily used to feed their families (Kennedy & Peters, 1992; Hopkins et al., 1994; Gladwin et al., 2001; Sraboni et al., 2014). Therefore, women's land rights have the potential to enhance household food security (Allendorf, 2007; Doss, 2006). However, the gendered division of crop cultivation in Sub-Saharan Africa, where men focus on cash crops (income generating farming) while women on food crops (subsistence farming), adds complexity to this relationship (Hoddinott & Haddad, 1995; Duflo

& Udry, 2004; Carr, 2008; wa Gĩthĩnji et al., 2014; Muthini et al., 2020; Malapit et al., 2015; Chegere & Stage, 2020; Olabisi et al., 2021).

Progress in this research area also depends on gender-specific land ownership measurements. Early studies used ethnographic data to assign crops by gender (Hoddinott & Haddad, 1995; Duflo & Udry, 2004). These studies highlighted the need for improved data on the extent of women's land ownership compared to men's, including sole or joint ownership (Doss et al., 2014; Doss et al., 2015; Alkire et al., 2013). Exploiting recent advances in data collection on the gendered structure of land ownership, we try to fill the gaps.

To advance the understanding of the mechanisms underlying the relationship between women's land ownership and household food security, this study conducts a comprehensive analysis that integrates the various strands of literature. Utilizing three waves of data from the Tanzanian National Panel Survey (NPS, 2008, 2010, 2012), we employ fixed-effects linear models. Household food security is measured using the Household Dietary Diversity Scale (HDDS) indicator, widely recognized as a proxy for food access and household nutrition. We analyze the land ownership structure within households, considering the sex of the owner and sole or joint ownership. Moreover, we examine the heterogeneity of the relationship based on household dependence on own consumption versus market-purchased food and the gendered division of crop cultivation.

By investigating these interdependent issues, our research contributes to the existing body of knowledge on women's land ownership and household food security. Additionally, it addresses a critical research gap by examining this relationship specifically in the Tanzanian context.

The main findings of our study suggest that women's land ownership significantly influences household dietary diversity. In particular, the sole ownership of food crops by women and joint

ownership of cash crops with men emerge as important factors, underscoring the need for policy measures that incentivize and support women in these endeavors.

The remainder of this paper is organized as follows: Section 2 provides the contextual background of the study in Tanzania; Section 3 outlines the data and methodology employed; Section 4 presents the empirical results; and finally, Section 5 concludes the paper.

2. Gender, Food Security and Land Policies in Tanzania

Despite significant economic growth, food security remains a concern in Tanzania. The malnourishment rate among children under five is above the African average, with 31.8 percent suffering from chronic malnutrition (WFP, 2022). Households' diets lack diversity and nutritive food, and local production accounts for 95 percent of the country's food availability (URT, 2017).

The Government has targeted the agricultural sector as a major strategy to eliminate poverty and food insecurity. The Tanzania Development Vision 2025 reaffirms agriculture as an engine of growth and encourages private sector investment in the sector, representing a notable policy innovation. However, past challenges in implementing food security plans, such as bureaucracy, resource scarcity, capacity limitations, and accountability issues, need to be addressed. Special efforts are required to reach marginalized participants, particularly women (USAID, 2013). An interesting randomized control experiment focused on women in ten villages in Eastern Tanzania to study the association between vegetable home gardening and women's dietary diversity and household food security. The experiment showed positive effects after one year, but the benefits disappeared after three years (Blakstad et al., 2022).

Land rights are a central issue in Tanzania, and the government is undertaking legal reforms to transition from customary tenure to private property rights (Rwegasira, 2012; Bourguignon, 2018). Women's rights to land are relatively well supported in the formal legal framework, providing for equal rights and prohibiting discrimination based on sex (Government of Tanzania Constitution 1977). The Land Act and Village Land Act recognize customary law while requiring its consistency with the non-discrimination clause of the Constitution (Hallward-Driemeier & Hasan, 2012). Gender equity is emphasized, granting women co-ownership rights and the individual right to acquire, hold, sell, and use land (Peterman, 2011).

Land grabbing has become a significant concern in Tanzania since 2005, leading to land dispossession for rural smallholders as land formalization and acquisition for investment increase (Nelson et al., 2012; Engström et al. 2022). The government prepared the Strategic Plan for the Implementation of the Land Laws in 2005 and revised it in 2013 to better support the country's social, economic, and environmental development. However, shortcomings, such as the non-gender-neutral views of village councils in the implementation of the law, prompted a review of the land policy starting in 2016, with efforts to address gender equity issues and improve legal clarity on matters like inheritance.

Joint ownership, typically acquired after marriage, is the most common way for women to access land rights. Inheritance as daughters or widows is another means for women to inherit rights (Genicot & Hernadez-de-Benito, 2022). Nevertheless, this framework reinforces patrilineal practices and customary laws, favoring men who hold greater rights to land as de facto heads of households. Women's rights often pass through their male relatives, leaving them vulnerable in this context.

3. Data and Methods

We draw our data from the three waves of the NPS (National Panel Survey) of Tanzania conducted during 2008-2009, 2010-2011, and 2012-2013 (National Bureau of Statistics 2009, 2011, 2013). This representative household panel survey gathers information on various topics, including agricultural production, non-farm income-generating activities, consumption expenditure, and other socio-economic characteristics. The attrition rate for the survey is relatively low, at 3.9 percent.

We select all households that responded to the Agricultural Questionnaire and were present in at least two of the three waves. This process results in an unbalanced panel comprising 1,992 households, with 1,459 households present in all waves and 533 households present in two waves.

3.1 Land ownership

Notwithstanding the growing evidence on the positive effects of women's land rights on various development objectives (Argawal, 1994; Peterman, 2011; Bhaumik, 2016; Muchomba, 2017; Dillon & Voena, 2018; Meinzen-Dick et al., 2019), there is still a need for improvement in measuring the dimension of women's land ownership.

Information on land ownership can be reported or documented and categorized at the plot or individual level. For gender analysis, land ownership can be distinguished as (1) solely owned by a woman, (2) solely owned by a man, (3) jointly owned by a couple, or (4) jointly owned by people who are not a couple. Defining ownership based on the sex of the owner(s) avoids complications in identifying "couples" or "people not in a couple" in extended households (Doss et al., 2015). Research for Uganda indicates that joint ownership can be more empowering for women than sole

ownership of a less valuable asset, challenging the notion that sole ownership is a better indicator of empowerment (Doss et al., 2014).

In this paper, we analyze land ownership at the household level, using reported information on plot ownership by sex, drawn from the Agricultural Questionnaire. The household is considered a landowner if it owns at least one plot or shares ownership[1]; otherwise, it is classified as a "Landless household." Based on this information, we construct the household structure of land ownership by gender.

For preliminary insights, we create the dummy variable "Woman landowner," taking a value of 1 if there is at least one woman in the household who solely owns or jointly owns land with a man (0 otherwise). To further understand the role of women's land ownership, we distinguish between "Woman sole landowner" and "Man sole landowner."

Figure 1. Household structure of land ownership by gender

[1] For each plot households were asked what was the ownership status (owned/used free of charge/ rented in/ shared – rent / shared – owned) and who in the household owns this plot.

Figure 1 illustrates the land ownership structure at the household level and the corresponding women land ownership dummy variables.

For a deeper understanding, we consider the ownership structure using the number of plots. We create the continuous variables "N. of plots WM/solely owned by women" (number of plots owned jointly with a man or by women only), "N. of plots solely owned by women" (number of plots owned by women only), "N. of plots WM jointly owned" (number of plots jointly owned with a man), and "N. of plots solely owned by men" (number of plots owned by men only). We also consider the ownership structure using the acres owned, resulting in a comprehensive set of variables describing the household land ownership structure by the number of plots/acres and gender.

Table 1 presents the summary statistics of these variables. Overall, women are less likely to be landowners than men, and on average, they own fewer and smaller plots.

Table 1 Household land ownership structure by gender.

	2008-09		2010-11		2012-13		Total	
Land ownership variables	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Dummies								
At least one "Woman landowner" (joint with a man or sole)	0.48	0.50	0.54	0.50	0.55	0.50	0.52	0.50
At least one "Woman sole landowner"	0.21	0.41	0.22	0.41	0.22	0.41	0.22	0.41
At least one "Man sole landowner"	0.48	0.50	0.41	0.49	0.39	0.49	0.42	0.50
Landless household	0.09	0.29	0.10	0.30	0.09	0.29	0.09	0.29
Number of plots								
N. of plots WM/solely owned by women	1.00	1.35	1.21	1.46	1.28	1.57	1.17	1.47
N. of household plots	2.00	1.34	2.09	1.45	2.20	1.56	2.10	1.45
N. of plots solely owned by women	0.39	0.90	0.42	0.96	0.42	0.95	0.41	0.93
N. of plots solely owned by men	0.99	1.31	0.87	1.35	0.91	1.44	0.92	1.37
N. of plots WM jointly owned	0.51	1.15	0.68	1.31	0.75	1.47	0.65	1.33
Acres								
Acres WM/solely owned by women	2.17	5.31	2.87	9.7	3.18	9.06	2.75	8.32
Acres of household plots	5.22	18.11	5.34	12.53	6.28	17.23	5.62	16.08
Acres solely owned by women	0.61	3.25	0.74	4.19	0.88	6.91	0.75	5.04
Acres solely owned by men	3.03	17.23	2.45	8.55	3.06	14.61	2.84	13.85
Acres WM jointly owned	1.57	4.40	2.14	8.67	2.31	6.18	2.01	6.70
N. Obs.	1,719		1,848		1,798		5,365	

3.2 Food security

We measure food security using the Household Dietary Diversity Score (HDDS), a widely used index in the food security literature and by international organizations. HDDS serves as a well-established proxy for food access, availability, dietary quality, and nutritional adequacy (Ecker 2018; Fongar et al., 2019; Verger et al., 2019). Consistent with recent literature on food security in Sub-Saharan Africa (Muthini et al., 2020; Olabisi et al., 2021), we select HDDS as our dependent variable.

To compute this indicator, we utilize the information from the "Consumption of food over the past one week" section of the Household Questionnaire. HDDS is calculated as the number of different food groups consumed by the household during the 7-day recall period (Kennedy et al., 2011). The survey includes twelve food groups: cereals; white tubers and roots; legumes and legume products; nuts and seeds; vegetables and vegetable products; fruits; meat; eggs; fish and fish products; milk and milk products; sweets, sugars, and syrups; oils and fats; and spices, condiments, and beverages. The HDDS score ranges from 0 to 12.

Additionally, we use the HDDS threshold, computed based on the dietary patterns of wealthier households (i.e., households in the third tercile of expenditure), following the approach of Swindale & Bilinsky, 2006. This threshold serves as a target level of HDDS, assuming that households will diversify their food expenditures as their incomes rise.

Table 2 presents the average values of the continuous HDDS indicator, showing approximately 8 for all households and 9.3 for households in the third expenditure tercile. The percentage of households above the HDDS threshold has seen fluctuations over the years, increasing from 23 percent in 2008 to 28 percent in 2010, then decreasing to 23 percent in 2012.

Table 2 Household dietary diversity score: level and threshold.

Variables	2008-09		2010-11		2012-13		Total	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
HDDS	7.93	1.91	8.37	1.81	7.93	2.07	8.10	1.94
HDDS in 3° exp. tercile	9.23	1.60	9.51	1.42	9..21	1.66	9.32	1.57
N. of households above the HDDS threshold (0/1 dummy)	0.23	0.42	0.28	0.45	0.23	0.42	0.25	0.43
Observations	1,729		1,860		1,839		5,428	

Figure 2 illustrates that households predominantly consume cereals, vegetables, legumes, tubers, and spices and beverages. Furthermore, Table 3 highlights that households with at least one woman landowner have significantly higher consumption of vegetables, eggs, and oils compared to households with only male landowners, who tend to have higher values for cereals, fruit, fish, milk, and sugar. This descriptive evidence suggests that women and men land ownership might be associated with different patterns of food consumption, thus motivating our research question.

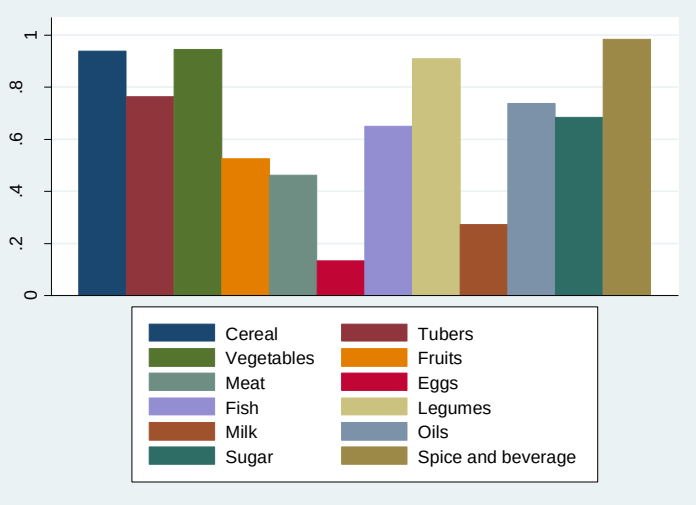


Figure 2. Percentage of households by food group consumption over the past week

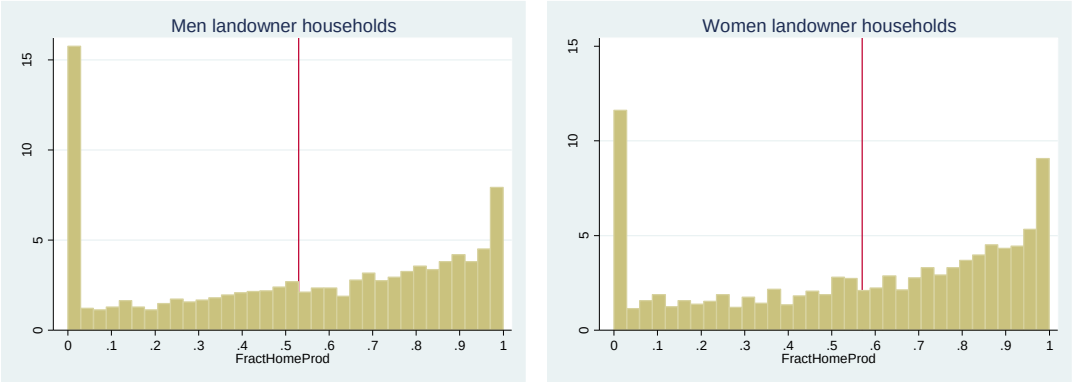
Table 3 Mean difference of consumption of food groups by gender of landowner over the past week.

Food groups	Man sole landowner Mean	Woman landowner (sole or joint with a man) Mean	Mean Difference
Cereals	0.96	0.94	0.02**
Tubers	0.78	0.77	0.01
Vegetables	0.95	0.96	-0.01*
Fruits	0.54	0.52	0.02*
Meat	0.46	0.47	-0.01
Eggs	0.12	0.15	-0.03***
Fish	0.70	0.62	0.07***
Legumes	0.92	0.92	-0.00
Milk	0.29	0.26	0.03*
Oils	0.73	0.76	-0.02**
Sugar	0.71	0.68	0.03**
Spices and beverages	0.99	0.99	-0.00
Obs.	2551	2814	

3.3 Home produced food consumption and food and cash crop production

The evidence on the relationship between food security and home-produced food versus market-purchased food, referred to as direct own consumption versus indirect income effects, is mixed. For instance, Chegere & Stage (2020) find that in Tanzania, the HDDS increases when households diversify their agricultural production, while the effect of market-purchased food is unclear. Ecker (2018) finds in Ghana that food security improvements are mainly due to the direct effect of own consumption of produced foods rather than an indirect income effect. On the other hand, Dillon et al. (2015) present a different conclusion for Nigeria, showing a positive although small elasticity of food security with respect to revenues from production. Similarly, Sibhatu & Qaim (2017) for Ethiopia and Olabisi et al. (2021) for Nigeria find that purchased foods have a larger role in dietary diversity than home-produced food. As a result, it becomes relevant to consider the use of land owned in terms of food and cash crop production. In Sub-Saharan Africa, men and women grow different crops (Duflo, 2012; Udry, 1996), and interestingly, some evidence suggests that women's control over income from cash crops significantly increases the share of the household budget allocated to food (Malapit et al., 2015; Hoddinott & Haddad, 1995; Duflo & Udry, 2004; Doss, 2006; Muthini et al., 2020).

To address the relationship between food security, women's land ownership, own consumption, and purchased food, we interact the fraction of food consumed from own production over the total food consumption, referred to as *FractHomeProd*, with the gendered structure of land ownership. Figure 3 shows that households where there is at least one woman landowner depend more on own production than other households. This mean difference is statistically significant and may suggest a fundamental role of food crops for the food security of women landowner households.



Note: red line shows the mean value of the variable.

Figure 3. Distribution of the fraction of food consumed from own production over the total food consumption (FractHomeProd) by women's land ownership.

Furthermore, Figure 3 reveals that approximately 13 percent of households purchase all the food they consume. Another 3.5 percent show an extremely low *FractHomeProd*, ranging from 0.0004 to 0.1, with a mean value of 0.013. We therefore create the dummy variable HPFC, which takes value one if more than 10 percent of the household consumption comes from own production and zero otherwise. To account for these features, we conduct a heterogeneity analysis by terciles of *FractHomeProd*.

Table 4 Home produced food consumption and thresholds.

	Obs.	Mean	Std. Dev.	Min	Max
HHs that produce more than 10% of their consumption	5365	0.83	0.37	0	1
Terciles of *FractHomeProd*					
• 1 tercile	1548	0.10	0.11	0	0.34
• 2 tercile	1896	0.57	0.12	0.34	0.77
• 3 tercile	1921	0.90	0.07	0.77	1

Regarding the distinction between cash and food crops[2], Table 5 shows that household production primarily focuses on food crops, with 50 percent of food crop plots either jointly or solely owned by women. In contrast, cash crop plots are mainly solely owned by men. The number and area of plots confirm this evidence.

Table 5 Cash and food crop production by land ownership structure.

Variable	Mean	Std. Dev.	Min	Max
Dummies				
HH cultivating food crops	0.97	0.16	0	1
HH cultivating cash crops	0.36	0.48	0	1
Food crops				
• At least one "Woman landowner"	0.50	0.50	0	1
• At least one "Woman sole landowner"	0.21	0.40	0	1
• At least one "Man sole landowner"	0.40	0.49	0	1
• WM jointly landowners	0.30	0.46	0	1
Cash crops				
• At least one "Woman landowner"	0.16	0.37	0	1
• At least one "Woman sole landowner"	0.06	0.24	0	1
• At least one "Man sole landowner"	0.15	0.36	0	1
• WM jointly landowners	0.10	0.30	0	1
Number of plots				
Food crops				
N. of plots cultivated with food crops	2.48	1.83	0	18
N. of plots WM/solely owned by women cultivated with food crop	0.94	1.22	0	10
N. of plots solely owned by women cultivated with food crop	0.35	0.83	0	8

[2] We code the crops into food and cash using the crop codes supplied by the Tanzanian NPS 2012-2013 agricultural questionnaire.

N. of plots solely owned by men cultivated with food crop	0.74	1.13	0	9
N. of plots WM jointly owned cultivated with food crop	1.17	2.18	0	20
Cash crops				
N. of plots cultivated with cash crops	0.71	1.29	0	16
N. of plots WM/solely owned by women cultivated with cash crop	0.24	0.67	0	8
N. of plots solely owned by women cultivated with cash crop	0.09	0.41	0	8
N. of plots solely owned by men cultivated with cash crop	0.22	0.59	0	6
N. of plots WM jointly owned cultivated with cash crop	0.31	1.12	0	16
Acres				
Food crops				
Acres cultivated with food crops	5.88	13.44	0	605
Acres WM/solely owned by women cultivated with food crop	1.98	5.31	0	204
Acres solely owned by women cultivated with food crop	0.59	3.95	0	204
Acres solely owned by men cultivated with food crop	2.15	11.24	0	605
Acres WM jointly owned cultivated with food crop	1.17	2.18	0	20
Cash crops				
Acres cultivated with cash crops	1.79	5.82	0	140
Acres WM/solely owned by women cultivated with cash crop	0.63	2.90	0	70
Acres solely owned by women cultivated with cash crop	0.15	1.46	0	70
Acres solely owned by men cultivated with cash crop	0.58	2.68	0	80
Acres WM jointly owned cultivated with cash crop	0.31	1.12	0	16
Obs.	5365			

3.4 Other control variables

Table 6 presents the descriptive statistics of the remaining control variables, including household, household head, land, and farm characteristics. We also control for region and month of interview dummies to account for spatial distribution and seasonality.

Table 6 Descriptive statistics of the control variables.

Variable	Mean	Std. Dev.	Min	Max
Household characteristics				
HH size	5.60	3.05	1	55
Annual HH Expenditure (Tz. Shillings)	2,620,024	2,545,656	120,400	5.98e+07
Annual HH Expenditure Terciles:				
• 1 tercile	1,037,419	378,957	120,400	1,875,798
• 2 tercile	2,078,174	508,991	1,238,860	3,419,400
• 3 tercile	4,845,378	3,447,693	2,153,100	5.98e+07
Household head characteristics				
Age	49.25	15.37	19	107
Woman	0.23	0.42	0	1
Married	0.77	0.42	0	1
Widow	0.13	0.33	0	1
Primary school	0.62	0.48	0	1
Secondary school	0.09	0.28	0	1
University	0.00	0.04	0	1
No Education	0.27	0.44	0	1
Land and farm characteristics				
Land quality	2.415	0.553	1	3
Fertilizer	0.30	0.46	0	1
Irrigation	0.04	0.19	0	1
Pesticides	0.14	0.34	0	1
Extension service	0.15	0.36	0	1
Home distance (Km)	4.33	20.01	0	550
Market distance (Km)	10.00	14.37	0	518
Street distance (Km)	2.13	3.44	0	75
Livestock	0.42	0.49	0	1
Poultry	0.59	0.49	0	1
Urban area	0.13	0.34	0	1
Year 2010	0.34	0.47	0	1
Year 2011	0.34	0.47	0	1
Obs.	5365			

3.5 The model

We estimate a series of specifications of our model. As a first synthetic indicator of the role of women's land ownership for household food security, we estimate the coefficient of a dummy variable coded one when at least one woman in the household solely or jointly owns a plot with a man. Then we deepen this relationship by exploiting all the available information on the ownership structure by gender in terms of the number of plots. Moreover, to consider the role of women's land ownership for food security acquired through both own consumption and income from agriculture, we account for the fraction of home-produced food consumption and distinguish between owned plots cultivated with food and cash crops.

Our dependent variables Y_{it} for household *i* in year *t* are the continuous HDDS indicator and its threshold dummy for the probability of having a good HDDS. To tackle the unobserved heterogeneity problem, we estimate fixed effects models with linear regressions for both continuous and dichotomous dependent variables.[3]

The resulting model with *ownership dummies* is the following:

$$Y_{it} = \beta_0 + \beta_1 Woman\ landowner_{it} + \beta_2 HPFC_{it} + \beta_3 K_{it} + z_i + u_{it} \quad (1a)$$

where the reference group for $Women\ landowner_{it}$ —at least one woman in the household is the sole owner of one piece of land or owns land jointly with a man—is *Man sole land owner*; $HPFC_{it}$ is a dummy acquiring value 1 when the household consumes more than 10 percent home-produced food ; K_{it} are all other control variables including region, month and year dummies; z_i are

[3] We choose this model rather than logit fixed effect model because the latter is subject to the incidental parameters problem.

household fixed effects and u_{it} is the robust error term clustered at household level. Adding the interaction between $Women\ land\ owner_{it}$ and $HPFC_{it}$, the model becomes:

$$Y_{it} = \beta_0 + \beta_1 Women\ land\ owner_{it} + \beta_2 Women\ land\ owner_{it} * HPFC_{it} + \beta_3 HPFC_{it} + \beta_4 K_{it} + z_i + u_{it} \quad (1b)$$

where $\beta_1 + \beta_2$ in turn, the effect of women's land ownership in households consuming home-produced food and the effect of women's land ownership in households where the fraction of own produced food consumption is higher than 10 percent.

The model with the land ownership structure expressed in terms of *Number of owned plots* by owner's gender in the household, including interaction terms, is the following:

$$\begin{aligned} Y_{it} = \beta_0 &+ \beta_1 N.of\ plots\ WM/solely\ owned\ by\ women_{\ it} \\ &+ \beta_2 N.of\ plots\ WM/solely\ owned\ by\ women_{\ it} * HPFC_{it} \\ &+ \beta_3 N.of\ plots\ solely\ owned\ by\ men_{\ it} + \beta_4\ N.of\ plots\ solely\ owned\ by\ men_{\ it} * HPFC_{it} \\ &+ \beta_5 HPFC_{it} + \beta_6\ K_{it} + z_i + u_{it} \end{aligned} \quad (2)$$

where $N.of\ plots\ owned\ by\ women_{\ it}$ is the number of plots solely or jointly owned with men in the household.

Further disentangling the land ownership into the number of plots solely owned by women, jointly owned by women and men, and solely owned by men, our model becomes:

$$\begin{aligned} Y_{it} = \beta_0 &+ \beta_1 N.of\ plots\ solely\ owned\ by\ women_{it} + \beta_2 N.of\ plots\ WM\ jointly\ owned_{it} \\ &+ \beta_3 N.of\ plots\ solely\ owned\ by\ men_{it} + \beta_4\ N.of\ plots\ solely\ owned\ by\ women_{it} * HPFC_{it} \\ &+ \beta_5 N.of\ plots\ WM\ jointly\ owned_{it} * HPFC_{it} \\ &+ \beta_6 N.of\ plots\ solely\ owned\ by\ men_{it} * HPFC_{it} + \beta_7 HPFC_{it} + \beta_8 K_{it} + z_i + u_{it} \end{aligned} \quad (3)$$

As mentioned, we estimate an alternative specification where we distinguish the number of plots cultivated with cash and food crops. The former approximates a source of income from farm output sold, while the latter a source for own consumption.

$$Y_{it} = \beta_0 + \beta_1 N.of\ cash\ plots\ WM/solely\ owned\ by\ women_{\ it} + \beta_2 N.of\ food\ plots\ WM/solely\ owned\ by\ women_{\ it} + \beta_3 N.of\ cash\ plots\ solely\ owned\ by\ men_{\ it} + \beta_4\ N.of\ food\ plots\ solely\ owned\ by\ men_{\ it} + \beta_5\ K_{it} + z_i + u_{it} \quad (4)$$

We estimate equation (4) also disentangling the number of plots solely owned by women, jointly owned by women and men, and solely owned by men.

Finally, we perform a heterogeneity analysis, distinguishing households with low, middle, and high dependence on own-production food consumption. We approximate these household categories by dividing our sample into terciles of *FracHomeProd* and we estimate equation (1a) and (4) with the complete structure.

4. Results

Table 7, 8, and 9 present the estimated coefficients of Eq. 1, 2, and 3, respectively. In columns 1 and 2, the dependent variable is the continuous HDDS indicator, while in columns 3 and 4, it is the HDDS threshold—a dummy coded 1 when the household has good dietary diversity. For both the continuous and threshold HDDS, the model has been estimated without interaction terms (col. 1 and 3) and with interactions with the *HPFC* dummy (col. 2 and 4).

Table 7 shows the estimated coefficients of ownership dummies (Eq. 1a and 1b). The coefficient of the dummy $Women\ land\ owner$ is positive and significant on the HDDS threshold

outcome variable (col. 3 and 4), indicating that women's land ownership plays a relevant role in achieving the target level of dietary diversity. As for households buying all their food, women's land ownership has a positive effect on the HDDS threshold. However, for households producing at least 10 percent of their consumption, the estimated effect $\beta_1 + \beta_2$ is slightly lower, suggesting that women's land ownership is less significant among households relying on own-consumption. Additionally, producing cash crops is positively associated with having an HDDS above the target level. On average, HPFC positively affects household dietary diversity, especially for the continuous HDDS outcome variable.

Table 7 Effects of women's land ownership on food security (ownership dummies, FE model).

VARIABLES	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
At least one "Woman landowner"	0.019	0.060	0.043**	0.103***
	(0.063)	(0.158)	(0.018)	(0.039)
At least one "Woman landowner"*HPFC		-0.047		-0.071*
		(0.160)		(0.040)
HPFC	0.224**	0.249**	0.016	0.054*
	(0.088)	(0.119)	(0.023)	(0.032)
Landless	0.103	0.106	0.033	0.037
	(0.176)	(0.177)	(0.039)	(0.040)
HH cultivating food crops	0.292	0.292	-0.014	-0.014
	(0.192)	(0.192)	(0.045)	(0.045)
HH cultivating cash crops	0.111	0.111	0.068***	0.067***
	(0.082)	(0.082)	(0.023)	(0.023)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.169	0.169	0.078	0.079
Number of households	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 presents the estimated coefficients of the specification with the number of owned plots by gender (Eq. 2). This specification reveals the positive role of women's land ownership for

food security. Col. 1 and 2 show that an additional plot owned by a woman solely or jointly with a man increases the HDDS, with a slightly larger effect compared to the number of plots solely owned by men. The significant effect of an additional plot jointly/solely owned by women is lower but still significant for the HDDS threshold, while sole men ownership does not show a significant effect.

Table 8 Effects of Women's land ownership on food security (number of plots, FE model).

VARIABLES	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
N. of plots WM/solely owned by women	0.093***	0.139*	0.013	0.039**
	(0.035)	(0.075)	(0.010)	(0.017)
N. of plots solely owned by men	0.082**	0.208***	-0.002	-0.004
	(0.037)	(0.077)	(0.010)	(0.022)
N. of plots WM/solely owned by women* HPFC		-0.053		-0.030*
		(0.077)		(0.017)
N. of plots solely owned by men* HPFC		-0.143*		0.002
		(0.075)		(0.022)
HPFC	0.215**	0.378**	0.015	0.043
	(0.087)	(0.148)	(0.023)	(0.038)
HH cultivating food crops	0.255	0.262	-0.015	-0.014
	(0.195)	(0.196)	(0.045)	(0.045)
HH cultivating cash crops	0.093	0.103	0.067***	0.067***
	(0.082)	(0.082)	(0.024)	(0.023)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.170	0.172	0.078	0.079
Number of households	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Having established a significant effect of women's land ownership, we further analyze the effects of women's sole ownership versus joint ownership. Table 9 displays the estimated coefficients of Eq. 3. In col. 1, the only significant coefficient of the ownership structure without interactions is that of the *N. of plots solely owned by women*: an additional plot increases the HDDS by 0.180. In col. 2, with the ownership structure interacted with *HPFC*, the coefficient of the *N. of plots solely owned by women* increases to 0.224 for those households only relying on purchased food (the interaction

is not significant). The effect of women's sole ownership persists for the HDDS threshold, with and without the interaction, ranging from about 3 to 5 percentage points in col. 3 and 4.

Table 9 Effects of Women's sole and joint with men land ownership on food security (Number of plots, FE model).

	(1)	(2)	(3)	(4)
VARIABLES	HDDS	HDDS	HDDS_thr	HDDS_thr
N. of plots solely owned by women	0.180***	0.224*	0.033*	0.047*
	(0.060)	(0.132)	(0.017)	(0.026)
N. of plots WM jointly owned	0.027	0.102	-0.005	0.026
	(0.030)	(0.072)	(0.009)	(0.018)
N. of plots solely owned by men	0.026	0.159**	-0.016*	-0.020
	(0.031)	(0.079)	(0.009)	(0.021)
N. of plots solely owned by women*HPFC		-0.053		-0.016
		(0.130)		(0.023)
N. of plots WM jointly owned*HPFC		-0.083		-0.034*
		(0.073)		(0.018)
N. of plots solely owned by men*HPFC		-0.149*		0.004
		(0.077)		(0.022)
HPFC	0.214**	0.394***	0.015	0.036
	(0.087)	(0.152)	(0.023)	(0.037)
HH cultivating food crops	0.281	0.289	-0.009	-0.008
	(0.195)	(0.195)	(0.045)	(0.044)
HH cultivating cash crops	0.100	0.110	0.069***	0.068***
	(0.082)	(0.082)	(0.023)	(0.023)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.171	0.172	0.079	0.081
Number of households	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

These results highlight the importance of exploiting the additional variability of more precise measures of the household land ownership structure to better understand the actual role of women's land ownership. The finding that women's land ownership positively impacts food security is robust across specifications. Table 7 and 8 also indicate a relevant role of women's land ownership in households more dependent on the market.

As mentioned earlier, we also consider the effects of the type of crops produced on the land owned. Table 10 displays the results for Eq. 4, introducing the number of owned plots cultivated with cash and food crops by gender. Considering women's land ownership, both joint and sole, Col. 1 shows that women's cash and food crops ownership have positive and significant effects on the HDDS. Women's joint or sole land ownership of cash crop shows a higher coefficient and affects the probability of having an HDDS above the target level even more significantly (+5 percentage points in col. 3). Sole men ownership is significant and positive for food crops. Further disentangling the gendered structure, women's sole food crops ownership and women's joint cash crops ownership have significant effects on the HDDS, with the former showing the highest coefficient (0.151). As for men, sole food crop ownership is the only significant effect. The positive effects of women's land ownership, for both cash and food crops, hold for the HDDS threshold, with effects of 3 and 5 percentage points, respectively. Overall, these results indicate that women's ownership for both types of crops positively affects the HDDS and its threshold. Specifically, the positive effect of cash crops is amplified through joint ownership with a man, while for food crops, it is through sole ownership.

Table 10 Effects of food and cash crop ownership by gender on food security.

VARIABLES	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
N. plots WM/solely owned by women with cash crop	0.131**		0.051***	
	(0.051)		(0.015)	
N. plots WM/solely owned by women with food crop	0.060*		0.016	
	(0.035)		(0.010)	
N. plots solely owned by men with cash crop	-0.046	-0.052	0.029	0.029
	(0.058)	(0.057)	(0.018)	(0.018)
N. plots solely owned by men with food crop	0.087**	0.066*	0.001	-0.005
	(0.039)	(0.039)	(0.011)	(0.011)
N. plots solely owned by women with cash crop		0.113		0.027
		(0.103)		(0.027)
N. plots solely owned by women with food crop		0.151***		0.049***
		(0.058)		(0.017)
N. plots WM jointly owned with cash crop		0.064**		0.029***
		(0.027)		(0.009)
N. plots WM jointly owned with food crop		0.015		0.003
		(0.019)		(0.005)
HPFC	0.225***	0.225***	0.014	0.014
	(0.087)	(0.087)	(0.023)	(0.023)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.172	0.173	0.080	0.081
Number of households	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.1 Heterogeneity analysis

The evidence provided so far has highlighted the importance of HPFC and the types of crops produced on the plot owned by women. Our estimates indicate that women's land ownership has positive effects, particularly among households that are heavily reliant on the market (Table 7 and 8). Given that the majority of households consume some home-produced food, we conduct a heterogeneity analysis by terciles of the ratio of home-produced food consumption to total food consumption. This allows us to examine the effects of women's land ownership in households with low, middle, and high dependence on home-produced food. However, a drawback of this analysis is

that it results in the exclusion of approximately 20 percent of the sample, as households that change tercile in all years are dropped. Therefore, the results apply to the selected sample of households that either maintain a consistent attitude toward own-produced food consumption over the entire panel period or change it only once.

The most interesting sub-populations are found in the first and third terciles, representing households heavily dependent on the market (col. 1 and 2) and their own consumption (col. 5 and 6), respectively. The second tercile (col. 3 and 4) includes households with an intermediate HPFC, which could lead to offsetting effects. Table 11 confirms the positive role of women's land ownership in the first and third terciles. For households relying on the market, the coefficients of women's joint ownership of cash crops are positive and highly significant, increasing the HDDS by approximately 0.20, and the threshold by approximately 8 percentage points. Regarding households relying on own-consumption, women's sole ownership of food crops increases the HDDS by 0.28. However, this positive effect is not confirmed for the HDDS threshold. Men's sole ownership of food crops also positively impacts the HDDS, but with a smaller and less significant effect.

Table 11 Women land ownership and HDDS by tertiles of the HPFC.

	(1) HDDS	(2) HDDS_thr	(3) HDDS	(4) HDDS_thr	(5) HDDS	(6) HDDS_thr
	1° tertile HPFC		2° tertile HPFC		3° tertile HPFC	
N. plots solely owned by women with cash crop	0.055	0.082	-0.155	-0.029	0.193	0.018
	(0.239)	(0.060)	(0.219)	(0.091)	(0.180)	(0.032)
N. plots solely owned by women with food crop	-0.046	0.013	0.142	0.051	0.280**	0.047
	(0.124)	(0.039)	(0.127)	(0.048)	(0.111)	(0.030)
N. plots WM jointly owned with cash crop	0.203***	0.077***	0.027	0.034	0.066	0.019
	(0.077)	(0.026)	(0.070)	(0.022)	(0.044)	(0.012)
N. plots WM jointly owned with food crop	-0.000	-0.007	0.005	-0.003	0.007	-0.002
	(0.065)	(0.017)	(0.036)	(0.013)	(0.032)	(0.010)
N. plots solely owned by men with cash crop	0.055	0.082	0.071	0.052	-0.067	0.026
	(0.239)	(0.060)	(0.124)	(0.045)	(0.097)	(0.031)
N. plots solely owned by men with food crop	-0.046	0.013	-0.207***	-0.049*	0.111*	-0.002
	(0.124)	(0.039)	(0.068)	(0.025)	(0.063)	(0.020)
Regions	✓	✓	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓	✓	✓
Years	✓	✓	✓	✓	✓	✓
Covariates	✓	✓	✓	✓	✓	✓
Observations	1,019	1,019	1,163	1,163	1,384	1,384
R-squared	0.260	0.182	0.194	0.142	0.194	0.095
Number of hh_code	466	466	526	526	581	581

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2 Robustness check

Despite plot size being widely used in agricultural economics, it is rarely disaggregated by gender (Doss et al., 2015). Since the NPS provides this information, we conduct a robustness check to provide a more comprehensive picture of the effect of women's land ownership by estimating Eq. 1, 2, and 3 using the plot size measured in acres as an alternative explanatory variable.

Overall, these robustness checks confirm the significance of women's land ownership for household dietary diversity and its threshold. In Table 12, it is observed that an additional acre owned by women has a positive impact on HDDS and the probability of achieving good dietary diversity. Furthermore, when examining the interaction of land ownership variables with HPFC, the

previous positive effect is confirmed, particularly among households relying on the market (col. 4). Acres solely owned by men also have a positive effect on the outcome variables, but the impact is less pronounced compared to women's land ownership.

Table 12: Effects of acres of land owned by women on food security, robustness check.

VARIABLES	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
Acres WM/solely owned by women	0.010*	0.022***	0.003**	0.009***
	(0.005)	(0.008)	(0.002)	(0.003)
Acres WM/solely owned by women*HPFC		-0.010		-0.006*
		(0.009)		(0.003)
Acres solely owned by men	0.005	0.017***	0.002**	0.003
	(0.003)	(0.006)	(0.001)	(0.002)
Acres solely owned by men*HPFC		-0.010***		-0.001
		(0.004)		(0.001)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.169	0.170	0.080	0.081
Number of hh_code	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13 confirms the significance of joint ownership of cash crops, but this effect is observed only for the threshold outcome and among households relying on the market. On the other hand, women's sole ownership of food crops has a positive impact on both the household dietary diversity score and its threshold.

Table 13: Effects of acres of food and cash crops owned by women on food security, robustness check.

VARIABLES	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
Acres with cash crops WM/solely owned by women	0.015		0.007***	
	(0.012)		(0.003)	
Acres with food crops WM/solely owned by women	0.006		0.005**	
	(0.006)		(0.002)	
Acres with cash crops solely owned by men	-0.008	-0.011	0.002	0.001
	(0.012)	(0.012)	(0.004)	(0.004)
Acres with food crops solely owned by men	0.002	0.001	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.000)
Acres with cash crops solely owned by women		0.007		-0.002
		(0.023)		(0.007)
Acres with food crops solely owned by women		0.045**		0.020***
		(0.018)		(0.006)
Acres with cash crops WM jointly owned		0.006		0.003**
		(0.006)		(0.001)
Acres with food crops WM jointly owned		0.001		0.001
		(0.003)		(0.001)
HPFC	0.228***	0.229***	0.015	0.015
	(0.087)	(0.087)	(0.023)	(0.023)
Regions	✓	✓	✓	✓
Months of interview	✓	✓	✓	✓
Years	✓	✓	✓	✓
Covariates	✓	✓	✓	✓
Observations	5,342	5,342	5,342	5,342
R-squared	0.169	0.170	0.077	0.080
Number of hh_code	1,970	1,970	1,970	1,970

Note: each specification controls for a common set of covariates (see Table 6). Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Discussion and Conclusions

The existing literature highlights the importance of women's direct participation in agricultural production and decision-making regarding household food expenditure and consumption in achieving better dietary outcomes. However, gender inequality remains pervasive in sub-Saharan Africa, affecting various aspects of human development, including land rights, food security, and gender equality. While the Sustainable Development Goals (SDGs) acknowledge the interconnection between these issues, they have often been studied separately. In this study, we have examined the

relationship between women's land ownership and household food security, considering the gendered measure of land ownership at the household level.

We have addressed the conflicting evidence regarding the contribution of home-produced food versus market-purchased food to household dietary quality, taking into account the importance of women's land ownership. Women's land ownership can influence dietary quality through various pathways, including increased food production for domestic consumption and control over production-related income. Our study has tested these mechanisms and conducted a heterogeneity analysis to explore the relationship's variations based on the household's reliance on own consumption.

Our findings based on Tanzania's context indicate that women's land ownership significantly contributes to household dietary diversity. This effect is particularly pronounced in households that depend on purchased food. Women's sole ownership of land and joint ownership with men both have positive impacts, while sole male ownership yields mixed results.

Furthermore, we have considered the gendered division of agricultural production, with men typically cultivating cash crops and women focusing on food crops. Our analysis demonstrates that women's ownership of both types of crops positively affects the Household Dietary Diversity Scale (HDDS) and the probability of having a good HDDS. Joint ownership of cash crops with men and sole ownership of food crops play crucial roles in improving household food security. The gendered division of crop cultivation may result from gender discrimination in access to input and output markets, limited access to credit, cultural barriers, and women's higher risk aversion. For all these reasons, the higher asset endowment and investments required for cash crop production compared to food crop production in subsistence farming make joint ownership with men an inevitable

condition for women. Our results highlight the crucial role of women's ownership in cash crops for food security, thereby providing an indication for policymakers to address the aforementioned constraints.

The distinction between households with low, intermediate, and high reliance on homegrown food has introduced other novel elements to the interpretation of these results. First, women's pivotal role in subsistence farming, as emphasized in much literature starting from Gladwin et al. (2001), is also linked to women's land ownership. This connection is demonstrated by the most positive impact of women's sole ownership of food crops on the Household Dietary Diversity Score (HDDS) in households that heavily rely on their own consumption. Second, joint ownership of cash crops by men and women appears to have the most significant positive effects on household dietary diversity among households with the lowest reliance on their own consumption, while sole ownership of cash crops by men is never significant. This finding further underscores the critical importance of women owning income-producing crops to enhance food security.

However, it is important to acknowledge certain limitations in our analysis, including potential measurement errors related to land ownership definitions, recall errors in food consumption data, and enumerator biases. The definition of land ownership is not unique, it may be related, among other things, to land access, right to sell the land, the presence of formal documentation. This might be even more complicated in countries, such as Tanzania, where the alignment between land rights and land tenure is often lacking. Additionally, the ownership measure we use may suffer from proxy reporting bias (FAO; The World Bank; UN-Habitat, 2019) and enumerator bias when the responsibility of interpreting the ownership question is left to respondents (Doss et al, 2015). Finally,

our analysis may suffer from the well-known recall errors typical of food consumption data (Naeem et al., 2006).

5.1 Policy implications

Our study's findings hold important policy implications. While some progress has been made in formalizing land rights in sub-Saharan Africa, more comprehensive reforms are necessary. Initiatives that promote joint land ownership with men, such as land titling and certification programs, have demonstrated positive impacts on women's land rights in countries like Ethiopia, Rwanda, and Tanzania (Ali et al. 2016; Djurfeldt, 2020; Holden & Tilahun, 2020). However, all studies emphasize that non-discriminatory principles are not sufficient for bringing about significant changes, and that land tenure reforms should be accompanied by policy interventions focused on women's economic and social empowerment.

Tanzania was an ideal setting for this study due to its ongoing concern about food security. Additionally, it is representative of the gender disparity issue prevalent in many other African countries. Notably, women's land rights and empowerment have become a prominent topic on the government's agenda, as evidenced by the President's commitment "to champion women's economic justice and human rights – especially in land ownership and empowering women in the economy"[4].

Our study underscores the urgent need for policy interventions that address gender disparities in land rights and empower women in agriculture. Governments should support women's land ownership and cash crop farming through integrated policies that promote access to input, output,

[4] See https://landportal.org/news/2021/08/resources-sharing-heed-calls-gender-equality

and financing markets. These activities require specialized training and effective informational campaigns. By recognizing that women are equally capable of growing and selling income-generating crops as men and supporting them in these endeavors, governments and development organizations can make significant strides towards achieving food security and, more broadly, rural poverty reduction in sub-Saharan Africa.

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Supplementary Materials

Table A1 Regions and months of interview

Variable	Mean	Std. Dev.	Min	Max
Months:				
• January	0.093	0.290	0	1
• February	0.080	0.271	0	1
• March	0.068	0.252	0	1
• April	0.058	0.234	0	1
• May	0.090	0.286	0	1
• June	0.072	0.259	0	1
• July	0.091	0.288	0	1
• August	0.097	0.296	0	1
• September	0.055	0.229	0	1
• October	0.092	0.290	0	1
• November	0.101	0.302	0	1
• December	0.103	0.303	0	1
Regions:				
• Dodoma	0.046	0.209	0	1
• Arusha	0.025	0.157	0	1
• Kilimangiaro	0.048	0.213	0	1
• Tanga	0.049	0.215	0	1
• Morogoro	0.042	0.200	0	1
• Pwani	0.019	0.135	0	1
• Dar Es Salama	0.018	0.132	0	1
• Lindi	0.066	0.248	0	1
• Mtwara	0.081	0.272	0	1
• Ruvuma	0.064	0.244	0	1
• Iringa	0.056	0.230	0	1
• Mbeya	0.067	0.250	0	1
• Singida	0.022	0.147	0	1
• Tabora	0.045	0.208	0	1
• Rukwa	0.036	0.187	0	1
• Kigoma	0.040	0.195	0	1
• Shinyanga	0.035	0.183	0	1
• Kagera	0.055	0.228	0	1
• Mwanza	0.031	0.174	0	1
• Mara	0.019	0.138	0	1
• Manyara	0.022	0.147	0	1
• Kaskazini Unguja	0.026	0.160	0	1
• Kusini Unguja	0.014	0.117	0	1

• Mjini/Magharibi Unguja	0.011	0.104	0	1
• Kaskazini Pemba	0.031	0.174	0	1
• Kusini Pemba	0.034	0.180	0	1
Obs.	5439			

Table A2 Effects of Women's sole and joint with men land ownership on food security (Number of plots, FE model).

	(1) HDDS	(2) HDDS	(3) HDDS_thr	(4) HDDS_thr
N. of plots solely owned by women	0.180***	0.224*	0.033*	0.047*
	(0.060)	(0.132)	(0.017)	(0.026)
N. of plots WM jointly owned	0.027	0.102	-0.005	0.026
	(0.030)	(0.072)	(0.009)	(0.018)
N. of plots solely owned by men	0.026	0.159**	-0.016*	-0.020
	(0.031)	(0.079)	(0.009)	(0.021)
N. of plots solely owned by women*HPFC		-0.053		-0.016
		(0.130)		(0.023)
N. of plots WM jointly owned*HPFC		-0.083		-0.034*
		(0.073)		(0.018)
N. of plots solely owned by men*HPFC		-0.149*		0.004
		(0.077)		(0.022)
HPFC	0.214**	0.394***	0.015	0.036
	(0.087)	(0.152)	(0.023)	(0.037)
HH cultivating food crops	0.281	0.289	-0.009	-0.008
	(0.195)	(0.195)	(0.045)	(0.044)
HH cultivating cash crops	0.100	0.110	0.069***	0.068***
	(0.082)	(0.082)	(0.023)	(0.023)
HH size	-0.023	-0.023	-0.004	-0.005
	(0.023)	(0.023)	(0.007)	(0.007)
Age of the HH head	0.008	0.008	0.001	0.001
	(0.015)	(0.015)	(0.003)	(0.003)
Female HH head	0.238	0.275	-0.140	-0.143
	(0.766)	(0.775)	(0.147)	(0.147)
Married	-0.101	-0.105	-0.103**	-0.107**
	(0.201)	(0.201)	(0.051)	(0.051)
Widow	-0.234	-0.249	-0.023	-0.025

	(0.218)	(0.219)	(0.050)	(0.050)
Primary school	-0.025	-0.027	0.017	0.015
	(0.122)	(0.123)	(0.032)	(0.032)
Secondary school	0.253	0.263	0.046	0.039
	(0.240)	(0.243)	(0.089)	(0.088)
2nd tercile of expenditure	0.913***	0.911***	0.117***	0.117***
	(0.075)	(0.075)	(0.019)	(0.019)
3rd tercile of expenditure	1.536***	1.533***	0.274***	0.276***
	(0.094)	(0.095)	(0.026)	(0.026)
Livestock	0.102	0.103	0.051**	0.052***
	(0.071)	(0.071)	(0.020)	(0.020)
Poultry	0.250***	0.250***	0.024	0.023
	(0.067)	(0.067)	(0.018)	(0.018)
Extension services	-0.057	-0.064	-0.011	-0.011
	(0.074)	(0.074)	(0.021)	(0.021)
Market distance	-0.003	-0.004	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)
Home distance	-0.002	-0.002	-0.000	-0.000
	(0.002)	(0.002)	(0.000)	(0.000)
Street distance	-0.009	-0.009	-0.003*	-0.003*
	(0.008)	(0.008)	(0.002)	(0.002)
Quality of the ground	0.056	0.057	0.023*	0.023*
	(0.053)	(0.053)	(0.014)	(0.014)
Irrigation	0.124	0.122	0.090*	0.089*
	(0.165)	(0.166)	(0.051)	(0.051)
Fertilizer use	0.206**	0.211**	0.046**	0.045**
	(0.083)	(0.083)	(0.021)	(0.021)
Pesticide use	0.110	0.109	0.006	0.007
	(0.091)	(0.090)	(0.027)	(0.027)
Urban area	0.493***	0.501***	0.129**	0.128**
	(0.189)	(0.190)	(0.051)	(0.051)
Regions:				
• Dodoma	-1.409***	-1.412***	0.016	0.013
	(0.403)	(0.400)	(0.073)	(0.078)
• Arusha	2.773***	2.770***	0.561**	0.567**
	(0.983)	(0.991)	(0.281)	(0.281)
• Kilimangiaro	1.601***	1.639***	0.277**	0.273*
	(0.588)	(0.588)	(0.141)	(0.141)
• Tanga	3.629***	3.544**	0.942***	0.948***
	(1.370)	(1.392)	(0.282)	(0.285)
• Morogoro	2.757	2.658	0.645*	0.619
	(1.685)	(1.698)	(0.376)	(0.377)
• Dar Es Salam	-0.438	-0.462	-0.002	0.002
	(0.476)	(0.478)	(0.113)	(0.113)
• Lindi	2.740**	3.051**	0.480*	0.481*
	(1.192)	(1.228)	(0.262)	(0.261)

• Mtwara	0.765	0.983	0.221	0.238
	(0.730)	(0.739)	(0.201)	(0.203)
• Ruvuma	-1.185***	-1.142***	-0.277***	-0.289***
	(0.409)	(0.413)	(0.097)	(0.097)
• Iringa	3.464**	3.388*	0.546	0.514
	(1.726)	(1.737)	(0.391)	(0.392)
• Mbeya	5.135***	5.056***	1.823***	1.796***
	(1.939)	(1.954)	(0.435)	(0.436)
• Singida	-0.221	-0.226	0.024	0.026
	(0.433)	(0.434)	(0.105)	(0.105)
• Tabora	1.678***	1.650***	0.026	0.034
	(0.415)	(0.417)	(0.095)	(0.095)
• Kigoma	-0.386	-0.465	-0.254*	-0.245*
	(0.420)	(0.426)	(0.130)	(0.131)
• Kagera	0.623***	0.624***	0.863***	0.866***
	(0.190)	(0.190)	(0.052)	(0.052)
• Kusini Unguja	-0.116	-0.096	-0.388	-0.375
	(1.044)	(1.009)	(0.348)	(0.349)
Months of interview				
• January	-0.416**	-0.412**	0.008	0.009
	(0.171)	(0.171)	(0.047)	(0.047)
• February	-0.655***	-0.660***	-0.014	-0.013
	(0.222)	(0.222)	(0.060)	(0.060)
• March	-0.681***	-0.683***	-0.058	-0.057
	(0.237)	(0.236)	(0.068)	(0.068)
• April	-0.796***	-0.798***	-0.153**	-0.152**
	(0.286)	(0.284)	(0.075)	(0.075)
• May	-0.821***	-0.821***	-0.131*	-0.128*
	(0.282)	(0.281)	(0.075)	(0.075)
• June	-0.600**	-0.598**	-0.105	-0.104
	(0.288)	(0.286)	(0.075)	(0.075)
• July	-0.383	-0.379	-0.042	-0.043
	(0.286)	(0.285)	(0.075)	(0.075)
• August	-0.541*	-0.534*	-0.059	-0.061
	(0.287)	(0.285)	(0.075)	(0.075)
• September	-0.621*	-0.617*	-0.065	-0.066
	(0.324)	(0.322)	(0.087)	(0.087)
• October	-0.687***	-0.678***	-0.037	-0.038
	(0.226)	(0.225)	(0.060)	(0.060)
• November	-0.482***	-0.467***	-0.027	-0.027
	(0.163)	(0.164)	(0.043)	(0.043)
Year: 2010	0.419***	0.421***	0.056***	0.054***
	(0.062)	(0.062)	(0.017)	(0.017)
Year: 2012	-0.087	-0.084	0.008	0.006

	(0.086)	(0.086)	(0.022)	(0.022)
Observations	5,342	5,342	5,342	5,342
R-squared	0.171	0.172	0.079	0.081
Number of hh_code	1,970	1,970	1,970	1,970