Impact of off-farm Employment on Rural Household Food and Nutrition Security: Evidence from the Southern Highland Regions of Tanzania

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Abstract

Despite the rural off-farm economy becoming increasingly important, the question whether off-farm income-generating activities increase household food and nutritional security in Tanzania remains unanswered. The current study explores the issue of off-farm employment by addressing two objectives: (i) to examine the drivers of households' decision to participate in off-farm employment in a high-potential agricultural zone in Tanzania and (ii) to evaluate the impact of off-farm activities on rural households' food security and nutritional security. We use household survey data from the southern highland districts of Mbeya and Songwe regions collected in 2014 and 2016. We employ difference-in-difference and propensity score matching techniques to evaluate the impact of participation in off-farm employment on household food security using three indicators with different recall periods. Results show that more adults per household and a larger farm size stimulated involvement in off-farm activities, while farming experience and livestock ownership had a limiting effect. Participation has a significant impact on food security, but the strength of the effect depends on the specific indicator selected. We recommend that the development of policies and programs that pay more attention to off-farm work can boost rural household income and thus promote food security and nutritional security.

Keywords: Off-farm work; Rural households; Food security; Dietary diversity; Tanzania
JEL Classification Codes: D13, 23, I13, 012

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1. Introduction

Food and nutritional insecurity remain the most serious global health challenges of our time (FAO, 2019). Estimates show that more than 820 million individuals worldwide are food insecure (FAO, 2019). The causes of food insecurity include low adoption of modern farm technologies, inadequate infrastructures for irrigation and reliance on rain-fed cropping methods. In addition, food insecurity is being increased by rapid population growth coupled with low agricultural productivity. Projections have shown that 1.3 billion people of the world's population lacks access to sufficient or suffers from poor nutrition. In Africa, the number of undernourished people in the region increased from 181 million in 2010 to 236 million in 2017 (FAO, 2018). Achieving food security thus remains a key development challenge in most sub-Saharan African (SSA) countries. Farm households are key to this challenge, not only as the main producers of food but also because a substantial share of the food-insecure population depends for the most part on agriculture for food, nutritional security, and income (Dzanku, 2019).

Tanzania is one of the countries in SSA with a high rate of food and nutritional insecurity issues. Estimates show that about 15.7 million people are hungry due to inadequate consumption of calories and energy-proteins (FAO *et al*., 2014). Rapid population growth coupled with low agricultural productivity increases food insecurity. Low adoption of modern farm technologies, inadequate infrastructures for irrigation and reliance on rain-fed cropping methods are among the causes of food insecurity. The Tanzania Household Nutrition Survey of 2015–2016 indicates that the stunting rate in children under the age of 5 years was 35%. Wasting was about 5% (too thin for their age), while 4% were overweight and 14% were underweight. Surprisingly, all three nutritional indicators are highest in children in the major food production areas of the southern highlands, an observation that requires investigation. While the agricultural sector remains the primary employer in rural Tanzania and the major source of income to rural households, its contribution to household food security has declined over time. As a result, farming as the primary source of income fails to furnish a sufficient livelihood to many rural farming households in Tanzania, and households are being forced to look for alternative means of coping with the problem of low and variable income.

One strategy for countering food insecurity is the object of growing interest: rural off-farm employment. Increasingly, engaging in off-farm activities is being seen as a crucial pathway towards mitigating the income shocks and risks associated with farming in rural areas where agriculture is vulnerable to weather **(**Duong *et al*., 2020**)**. Among multiple determinants to improve food and nutritional security, off-farm employment plays a significant role in stabilizing income and promoting consumption of diversified diets, which is termed the income effect (Dzanku, 2019). Rural households can decide to participate in off-farm activities for various reasons: excess labour in the family, seasonality of crop production and demand for more income. In both cases, off-farm income may provide farmers with enough financial resources to purchase farm inputs which can boost agricultural production, finance household expenditures on food and increase food security. On the other hand, liquidity constraints could force farmers to supply off-farm labour at the cost of their own farm production (Dzanku, 2019). In addition, moving away from agriculture makes households more dependent on food purchased at the market, with its fluctuating prices which could potentially harm their food security (Rahman and Mishra, 2020). The relationship between off-farm employment and food security is therefore anything but clear-cut.

The current study explores the issue of off-farm employment by addressing two objectives: (i) to examine drivers predicting households' decision to participate in off-farm employment in a high-potential agricultural zone in Tanzania and (ii) to evaluate the impact of off-farm activities on rural

households' food security. Several studies have analysed the impact of off-farm employment on food security in SSA (*e.g.,* Dzanku, 2019; Babatunde and Qaim, 2010; Zereyesus, 2017). We contribute to these studies in two ways. Our first contribution is the use of food security indicators with different recall periods: (i) the household dietary diversity score for the past 7 days (7 days HDDS); (ii) the household food insecurity access scale (HFIAS) for the past month; and (iii) a binary indicator for whether a household reported facing food insecurity in the past year. While previous literature has used many different indicators for food security, these are generally so-called objective measures based on similar household-level food consumption data with a 7-day recall period (Kuwornu, Owusu, Tsiboe, Zereyesus). Exceptions are Babatunde and Qaim (2010), who complemented 7-day consumption data with child anthropometric data, and Dzanku (2019), who calculated annual potential food supply and asked whether households had reduced the number of meals eaten during the lean season due to lack of food, which is a more subjective measure of food security. Our study uses both objective and subjective indicators with different recall periods to provide additional insights into the intricacies of the relationship between off-farm employment and food security.

Our second contribution to previous literature involves the use of panel data. Generating unbiased estimates of the impact of off-farm employment is complicated due to self-selection of households, especially when only cross- sectional data is available. To the best of our knowledge, the only study using panel data to assess the relationship between off-farm employment and food security for SSA is Dzanku (2019). However, the use of panel data provides a number of significant advantages. It offers the additional option to control for time-invariant differences between participants and non-participants. Also, it enables the use of baseline characteristics in matching. Our study therefore uses panel data for 1,411 farm households in the southern highlands of Tanzania.

The findings of this study are central for making evidence-based policy-making concerning the rural economy, where people are often more nutritionally susceptible and have a greater risk of micronutrient deficiencies. The results of the study will guide strategies to reduce food insecurity and boost the nutritional status of rural households.

The remaining part of this chapter is structured as follows. Section 2 describes the material and methods, section 3 is about results and discussion, and section 4 presents the conclusion and recommendations.

2. Literature Review

Empirical studies have documented two sets of factors motivating rural farming households to participate in off-farm work. First, the push factors that motivate households or individuals to seek supplementary income outside the farm. These push factors play a significant role in SSA where diversification of income sources is primarily responding to challenges facing the rural farm household's production such as weather shocks, high-risk of drought and diseases, seasonal activity, and insufficient income (Atamanov and Van Den Berg, 2012; Reardon *et al*., 2000; Ruben and Clemens, 2000). Second, the pull factors such as better job opportunities and lower risk of off-farm activities attracts people to engage in off-farm work to improve their welfare (Alobo Loison, 2015). Available market and opportunities, infrastructural facilities, and supportive institutions are among the pull factors (Ali and Peerlings, 2012). Human capital, for example, an educational level, largely determines the ability to enter high-skilled off-farm employment (Essers, 2017).

Economic theory suggests that a household allocates labour to the production of commodities that yield higher economic returns. In turn, income generated from these resource allocation decisions may finance household expenditure, including food. Theoretically, an improvement in household food security is a function of own production and food accessed from the market. Due to income obtained from participation in off-farm activities, one could expect a positive association between participation in off-farm, household food security, and diet improvement.

There is growing interest in rural off-farm employment as a crucial pathway to increasing household income and reducing food insecurity to rural households (Do *et al*., 2019; Owusu *et al.*, 2011). Farming as a main source of income fails to support livelihood to most rural farming households in SSA. Economic pressure is the main driver forcing many households to look for alternative means like off-farm activities to cope with the challenges of income variability. Increasingly, off-farm activities have become the mediating strategy to mitigate income shocks and risks associated with farming to rural households' livelihood improvement where agriculture is vulnerable to weather **(**Duong *et al*., 2020**).** Off-farm activities involve individual participation in remunerative work outside the participant's farm**.** Evidence suggests that rural households are instead pulled into the off-farm sector mainly when returns to off-farm employment are higher or less risky than on-farm agricultural production (Babatunde and Qaim, 2010; Duong *et al*., 2020). This off-farm income may provide farmers with financial security to purchase farm inputs to boost agricultural production, finance household expenditure such as food, and increase food security. In this regard, we expect a positive association between off-farm income and household food security.

Available studies document that income generated from off-farm activities yields a positive effect: on agricultural production (Adjognon *et al*., 2017; Alobo Loison, 2015), enables households to have better income (Ahmed and Melesse, 2018), food security and poverty reduction *(*Duong *et al.*, 2020; Dzanku, 2019; Van den Broeck and Kilic, 2018). Moreover, studies have shown that off-farm income enables rural households to overcome credit and risk constraints on agricultural innovations (Bui and Hoang, 2020; Hoang *et al*., 2014; Hossain and Al-Amin, 2019; Sohns and Revilla Diez, 2017). More empirical studies indicate that off-farm income influences household diets because it provides additional purchasing power, thereby improving household food security (Madzorera *et al.*, 2021), and dietary diversity (Babatunde and Qaim, 2010; Owusu *et al.*, 2011; Rahman and Mishra, 2020; Ruben, 2001; Ruben and Clemens, 2000). Evidence shows that off-farm work influences household diets since it diversifies income, provides additional purchasing power and improve household food security (Madzorera *et al*., 2021). Through off-farm earnings, households can increase their food expenditure, thereby improve the household's nutrition status, food security, and dietary diversity (Babatunde and Qaim, 2010; Owusu *et al*., 2011; Rahman and Mishra, 2020; Ruben, 2001; Ruben and Clemens, 2000).

Several studies evident a substitution and complementary effects amongst off-farm employment and agricultural production activities (Kirk *et al*., 2017; Bai et al., 2024). Households with more labour are likely to engage more in off-farm activities, which in turn may affect agricultural production, which is substitution effect (Mondal *et al*. 2021). Off-farm income can be used to finance agricultural production operations, hence increase productivity, which is the complementary effect (Dedehouanou *et al*. 2018; Thinda *et al*. 2020).

The available empirical studies suggests that off farm employment is a viable source of income to rural livelihoods. The coexistence of interaction between off-farm work and agricultural production which is vital to inform policy makers. In cases where the two have complementary effects on each other, rural policies may focus on how to maximize their synergies. Much less is known on the impact of participating in off-farm work on household access to nutrition foods in the leading food producing regions in Tanzania.

3. Material and methods

3.1 Data

This paper used panel household survey data from the southern highland districts of the Mbeya and Songwe regions. The first round of data was collected in December 2014-January 2015. This coincided with a peak in the production season with farmers preparing their fields and planting an assortment of crops. However, some locations were difficult to access due to the rains, which caused severe delays in the data collection process. The second round was collected almost two years later. While we originally intended to collect the second-round data exactly two years after the first round, we opted against this to avoid the complications encountered in the first round. Instead, we collected the data in October-November 2016.

Multistage sampling was used to select the households. First, we sampled four districts: Mbeya Rural and Mbarali from the Mbeya region and Mbozi, and Momba from the Songwe region. These districts were selected for their potential to produce crops such as maize, paddy and beans. In the second stage, we selected 41 wards using the same criteria. In the third stage, we selected 51 farmer organizations spread over the wards. Finally, we randomly selected farming households from each of the membership lists of the farmer organizations for the interviews.

We used two pre-tested structured questionnaires to gather primary data through face-to-face interviews. The trained enumerators used Swahili language to interview the respondents. The first questionnaire was used to interview household heads. Information collected included socioeconomic data on agricultural production of the previous cropping season, such as land size, total land owned, land cultivated, and input used in agricultural production. Moreover, we collected information on access to institutional factors such as distance to output markets. The second questionnaire was administered to the main female adult, often the spouse of the household head. In a situation where the spouse was absent, we interviewed a knowledgeable household member engaged in cooking and well informed on consumption expenditures. In the case of female-headed households, the woman had to answer both questionnaires. Using the female questionnaire, we collected demographic data such as age, gender, marital status, education level, and main occupations of all household members. The occupations included participation in any off-farm income-generating activities, i.e., wage labour or self-employment, such as petty trading. As these questions did not refer to a specific time period, we do not expect the difference in timing between the first and second survey round to have affected the answers to these questions. Moreover, we collected information on total livestock owned by the households, as well as household consumption and food security. As the data on these last two items partly refer to a shorter time period, the timing of the survey may have affected some of the answers, as we will discuss in detail below.

3.2 Measuring food security

The Food and Agriculture Organization (FAO) defines food security as a ''situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life'' (FAO, 2010). Due to the complex nature of the concept, we used three indicators. Each indicator referred to a different time period: a week, a month, or the year before the survey. The most food-insecure period in the research area is February-March, just before the main harvest. Both our surveys rounds took place before this. However, the households interviewed in January in the first round may have already experienced some seasonal food insecurity, which would mean that levels of food security for the indicators with a short reference period were lower in the first round than in the second round.

The first indicator was the Household Dietary Diversity Score (HDDS), which measures economic access to a food. The HDDS was calculated based on household consumption data for the 7 days before the survey. All food items in the questionnaire are classified in 12 food group using FAO guidelines (2011). These food groups are 1) cereals; 2) roots and tubers; 3) vegetables; 4) fruits; 5) meat/poultry; 6) eggs; 7) fish and seafood; 8) pulses/legumes/nuts; 9) milk and dairy products; 10) oils/fats; 11) sugar/honey; and 12) spices, condiments, and beverages. HDDS is then the number of food groups consumed in the reference period.

The second indicator is the Household Food Insecurity Access Scale (HFIAS). The HFIAS is constructed from a short questionnaire that captures behavioral and psychological manifestations of insecure food access (see Appendix 1). The reference period was the 30 days before the survey date (Coates et al., 2007). For each of nine items, the HFIAS questionnaire asks how often a situation occurred: never, rarely (once or twice), sometimes (three to ten times) or often (more than ten times). A score of 0 was recorded for never, 1 for rarely, 2 for sometimes, and 3 for often. The sum of HFIAS points can thus range from 0 for fully food-secure to 27 for maximum food-insecure households, with 0-2 indicating food security, 3-10 moderate food insecurity, and 11-27 severe food insecurity (Coates *et al*., 2007).

Measure three reflects food security on an annual basis: the female questionnaire contained questions on whether the household had experienced food insecurity in the past twelve months. The indicator is simply the binary variable indicating whether this was the case or not. We also asked in which months the household experienced food insecurity. Based on this information, we calculated the number of months that each household faced food insecurity. However, as only 21 % of survey households reported food insecurity, the results for this variable were very similar to the results for the binary variable and we decided to report the latter only.

3.3 Data analysis

To make optimal use of the panel nature of our data, we built on two different approaches to deal with the probable endogeneity of off-farm employment, borrowing heavily from impact assessment methodology. First, we used a first difference approach for the full sample of households. The model was estimated using linear regression and can be expressed as:

$$\Delta Y_i = \beta_0 + \beta_1 \Delta OF_i + \beta_2 X_i + \varepsilon_i, \quad (1),$$

where ΔY_i is a vector measuring the change in food security between the two survey periods for household *i*. ΔOF is the change in off-farm employment status and *X* is a set of controls from period 1, including the lagged outcome indicator. (See Table 1 for a description of the variables.) This approach gives unbiased estimates of the effect of ΔOF on ΔY if cov(ΔOF, ε_i), *i.e.*, there are no unobserved characteristics that affect both ΔY and ΔOF. Potential seasonal differences in food security between baseline and endline are expected to be averaged out.

Table 1: Definition of control variables

Variable	Variable type	Description
Off-farm participation	Binary	A treatment variable whether the household participated working off-farm 1 = participant, 0 = non-participant
Age of household head	Continuous	Age of household head in years
Gender head	Binary	Dummy = 1 if female head of household, 0= Male head of household
Secondary education complete	Binary	Dummy = 1 if the head completed secondary school education, 12 years of schooling, 0 = otherwise
Household size	Continuous	Total number of household members
Dependency ratio	Continuous	The ratio of total inactive labour <15 years of age and >60) and the active working age i.e., between 15 and 60 years
Livestock owned	Continuous	Total number of livestock estimated in Tropical Livestock Unit
Region of respondent	Binary	Dummy = 1 if respondent resided in Songwe region, 0= Mbeya region
Subsistence farming as main occupation	Binary	Dummy = 1 if subsistence farming the main occupation
Farming experience	Continuous	A number of years a household head has engaged in farming activities. This acts as proxy for experience in farming
Land owned	Continuous	Size of land owned by the household in acres
Distance to market	Continuous	Distance in kilometers of a household from the agricultural market

The second approach is propensity score matching (PSM). This approach focuses on food security in period 2. Households in period 2 were divided into two groups, those with and those without off-farm employment. Then, we compared food security between two groups after matching the households using the propensity score, which is the probability of engaging in off-farm employment using a probit model with period 1 characteristics as independent variables. The key underlying assumption is that there are no unobservable characteristics affecting both period 2 off-farm employment and period 2 food security. These estimates will not be affected by potential seasonal differences in food security between baseline and endline.

Whereas estimating the effects of off-farm employment on the full sample has the advantage of using all available information and, in the case of first differences, accounting for both loss and gain of off-farm income, households who already engaged in off-farm activities in 2014 may be

inherently different from those who did not. This would cast doubt on the validity of the underlying assumptions of the two models. We therefore performed a second set of analyses for those households that did not have off-farm employment in period 1. Interpreting engagement in off-farm employment as a non-randomized treatment, we can now make full use of quasi-experimental methods.

The first difference model now reverts to a standard difference-in-differences estimator (DID). DID relies on the availability of data for two groups: the treatment group that receives treatment (Zi=1) and the control group that does not (Zi=0). The intervention is not available in the first period for either group (Di,t=0 = 0|Zi = 1, 0), and it is available for the treated group in the follow-up period (Di,t=1 |Zi = 1) (Villa, 2016). The DID treatment effect is then defined as the difference in the outcome for treated and control units before and after controlling for period 1 characteristics (X) and can be expressed as:

$$DID = E\{\ (Y_{it,=1}|D_{it=1} = 1, Z_i = 1, X_i) - \ E(Y_{it=1}|D_{it=1} = 0, Z_i = 0, X_i)\} - \\ \{E\ (Y_{it=0}|D_{it=0} = 0, Z_i = 1, X_i\ ) - E(Y_{it=0}|D_{it=0} = 0, Z_i = 0, X_i)\} \qquad (2).$$

The regression model used to estimate this equation equals (1), the only difference being that households with off-farm employment in period 1 are excluded.

The key assumption of DID is that, although treatment and comparison groups may have different levels of the outcome prior to the start of treatment, their trends in pre-treatment outcomes are the same. Unfortunately, this assumption can only be tested when more than one observation before treatment is available, which is why we did not rely on this approach alone. As a second approach we again used PSM, but now for the restricted sample.

As a third model, we combined DID and PSM (PSM-DID). PSM-DID controls for both observed covariates and time-invariant unobserved characteristics that may affect both the treatment and the outcome variables (Dehejia, 2005; Villa, 2016). The propensity score from the probit model is used to weigh observations in the DID regression. Econometrically the model is expressed as follows:

$$DID = \{E(Y_{it,=1}D_{it=1} = 1, Z_i = 1) - w_i X\ E(Y_{it,=1}|D_{it=1} = 0, Z_i = 0)\} - \\ w_{it=0}^{t}\ X\ \{E(\ Y_{it=0}|D_{it,=0} = 0, Z_i = \ 1) - w_i X\ E(Y_{it,=0}|D_{it=0} = 0, Z_i = 0)\} \qquad (3),$$

where w_i are the kernel weights.

As a third set of analyses, we intended to calculate DID, PSM and PSM-DID for those farmers who had off-farm activities at baseline. The treatment would then be the loss of off-farm income. Comparing the results for farming gaining off-farm employment in period 2 with those losing off-farm employment in that same period would give an additional robustness check. However, the number of farmers engaging in off-farm employment in period 1 was relatively small and the number of these losing their employment in period 2 was too small for DID and PSM-DID to be taken into further consideration. We did, however, estimate the PSM model for this subset of farmers.

4. Results and discussion

4.1 Summary statistics

Two thirds of the survey households did not engage in off-farm employment in either of the two survey periods (Table 2), and 12 % participated in both periods. Fifteen percent participated only in period 2 (2016), whereas no more than 7 % participated only in period 1 (2014). This implies that there was a substantial increase in off-farm participation between the two years. Restricting the sample to only those households not participating in off-farm activities thus amounts to excluding 19 % of the sample.

Table 2 Number of households participating in off-farm employment per survey year

	Off-farm 2016		
Off-farm 2014	No	Yes	Total
No	936	205	1,141
	(66%)	(15%)	(81%)
Yes	97	173	270
	(7%)	(12%)	(19%)
Total	1,033	383	1,411
	(73%)	(27%)	(100%)

Tables 3a and 3b compare the 2014 characteristics of households with and without off-farm employment in 2016. Looking at the full sample (Table 3a), we see that the group without off-farm employment had higher food security status as measured by all three indicators. This group also had a higher human capital endowment: household heads were more likely to have completed secondary education and had more farming experience, even though they were younger on average. The households with off-farm employment in 2016 owned more land but less livestock on average and were somewhat less likely to define themselves as subsistence farmers, a label deemed appropriate by 96 % of respondents.

Restricting the sample to those households who did not have off-farm employment in 2014 made the two groups more comparable, as expected. Of the three food security indicators, only HFIAS showed a statistically significant difference between the two groups: those who had off-farm employment in 2016 were more food-secure in 2014. Additionally, differences in capital endowments decreased substantially, and the only significant differences remaining were in livestock owned (higher for those without off-farm employment) and farming experience (higher for those with off-farm employment). On the other hand, in 2016 the with and without off-farm groups (Table 3c) are again relatively dissimilar when one considers only those that had off-farm income in 2014. However, this observation is based on a relatively small group of households.

Table 3a Descriptive statistics 2014 (Full sample)

	All		No off-farm 2016		Off-farm 2016		Comparison
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Pr(|T|>|t|)
Food security							
HDDS	7.43	1.53	7.30	1.50	7.78	1.56	0.00
HFIAS	4.18	4.49	4.33	4.58	3.76	4.23	0.03
Food insecurity	0.21	0.41	0.22	0.41	0.17	0.38	0.03
Other							
Off-farm	0.19	0.39	0.09	0.29	0.46	0.50	0.00
Region	0.49	0.50	0.45	0.50	0.60	0.49	0.00
Age head	48.50	13.10	50.26	13.56	43.68	10.33	0.00
Gender head	0.14	0.34	0.13	0.34	0.16	0.37	0.13
Head secondary education	0.10	0.30	0.07	0.26	0.17	0.38	0.00
Head married	0.82	0.38	0.83	0.38	0.82	0.39	0.61
Household size	5.36	2.21	5.30	2.21	5.52	2.19	0.10
Land owned (acres)	6.46	12.79	5.90	10.03	7.99	18.25	0.04
Farming experience	20.07	13.45	22.10	13.82	14.53	10.55	0.00
Dependency ratio	42.42	21.67	43.21	22.34	40.26	19.57	0.02
Livestock (TLU)	0.54	0.58	0.56	0.51	0.50	0.72	0.15
Subsistence farmer	0.96	0.19	0.98	0.14	0.91	0.28	0.00
Distance to market	23.36	32.22	22.79	31.86	24.94	33.19	0.28
Number of observations	1411		1033		378		

Table 3b Descriptive statistics 2014 (No off-farm in 2014)

	All		No off-farm 2016		Off-farm 2016		Comparison
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Pr(|T|>|t|)
Food security							
HDDS	7.27	1.52	7.24	1.49	7.40	1.63	0.19
HFIAS	4.23	4.50	4.37	4.60	3.58	3.92	0.01
Food insecurity	0.22	0.41	0.22	0.42	0.20	0.40	0.38
Other							
Region	0.48	0.50	0.46	0.50	0.55	0.50	0.03
Age head	49.57	13.46	50.70	13.68	44.42	11.06	0.00
Gender head	0.13	0.34	0.13	0.33	0.16	0.36	0.28
Head secondary education	0.07	0.25	0.07	0.25	0.06	0.24	0.63
Head married	0.82	0.38	0.83	0.38	0.79	0.41	0.20
Household size	5.33	2.17	5.28	2.18	5.56	2.13	0.10
Land owned (acres)	6.21	12.51	5.92	10.20	7.52	19.89	0.26
Farming experience	21.56	13.71	22.65	14.01	16.62	11.04	0.00
Dependency ratio	42.59	22.36	42.97	22.68	40.87	20.83	0.20
Livestock owned (TLU)	0.54	0.53	0.56	0.51	0.47	0.59	0.03
Subsistence farmer	0.98	0.13	0.98	0.13	0.98	0.14	0.82
Distance to market	22.66	31.49	22.82	31.75	21.94	30.34	0.71
Number of observations	1141		963		205		

Table 3c Descriptive statistics 2014 (Off-farm in 2014)

	All		No off-farm 2016		Off-farm 2016		Comparison
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Pr(|T|>|t|)
Food security							
HDDS	8.10	1.39	7.88	1.44	8.23	1.35	0.05
HFIAS	3.94	4.47	3.87	4.31	3.98	4.58	0.84
Food insecurity	0.16	0.37	0.21	0.41	0.14	0.35	0.17
Other							
Region	0.57	0.50	0.40	0.49	0.67	0.47	0.00
Age head	43.97	10.32	46.02	11.61	42.82	9.36	0.02
Gender head	0.16	0.37	0.16	0.36	0.17	0.38	0.78
Head secondary education	0.23	0.42	0.09	0.29	0.31	0.46	0.00
Head married	0.83	0.38	0.79	0.41	0.84	0.36	0.32
Household size	5.49	2.33	5.52	2.46	5.47	2.26	0.89
Land owned (acres)	7.53	13.87	5.74	8.27	8.54	16.13	0.06
Farming experience	13.79	10.09	16.88	10.60	12.05	9.38	0.00
Dependency ratio	41.68	18.47	45.49	18.78	39.54	18.00	0.01
Livestock owned (TLU)	0.53	0.76	0.51	0.56	0.54	0.85	0.78
Subsistence farmer	0.87	0.34	0.94	0.24	0.83	0.38	0.01
Distance to market	26.33	35.04	22.46	33.01	28.50	36.05	0.17
Number of observations	270		97		173		

4.2 Determinants of households' participation in off-farm employment

Table 4 presents the estimates for participation in off-farm employment in 2016 as a function of 2014 characteristics. Households from Songwe, one of the two districts, had a higher probability of participating, as did households with more members and a lower dependency ratio. This may reflect the secondary status of off-farm employment in relation to farming: only when sufficient adults are available do the households engage in off-farm activities. Yet, the coefficient of land owned is positive, indicating that, *ceteris paribus,* a larger farm size is associated with higher off-farm employment. The effect is very small though: less than a one percentage point increase per acre owned. The effect of livestock is more substantial; an additional livestock unit is associated with a 13 (full sample) or 25 percentage point decrease in the probability that a household engages in off-farm employment. In addition, households with older heads or heads with more farming experience are less likely to participate in off-farm activities. Secondary education decreases participation, but only for the restricted sample. For the full sample, households with female and married heads were more likely to participate. The same gender effect was observed in Tanzania by Dzanku (2019). In our sample, it seems to be driven by those households who already had off-farm employment in 2014, as the effects disappear in the restricted sample. Contrary to the findings of Beyene (2008) for Ethiopia and Nazir *et al*. (2018) for Pakistan, we found no or negligible effects of distance to the market.

Table 4: Probit model for Off-farm employment in 2016

Variables	Full sample	No off-farm in 2014
Region of respondent, 1= Songwe, 0= Mbeya	0.489***	0.293**
	(0.125)	(0.128)
Age of household head (years)	-0.017***	-0.017***
	(0.004)	(0.004)
Gender of head, 1= female, 0= Male	0.335**	0.066
	(0.146)	(0.136)
Marital status, 1= married, 0 =otherwise	0.467***	-0.108
	(0.132)	(0.144)
Secondary school education of household head	-0.068	-0.271**
	(0.142)	(0.127)
Household size (number)	0.056***	0.063***
	(0.015)	(0.022)
Land owned (acres)	0.007**	0.007**
	(0.003)	(0.003)
Farming experience (years)	-0.020***	-0.013***
	(0.004)	(0.005)
Dependency ratio	-0.005**	-0.004*
	(0.002)	(0.002)
Livestock owned (TLU)	-0.134*	-0.247**
	(0.072)	(0.099)
Subsistence farmer	-1.023***	-0.178
	(0.167)	(0.284)
Distance to market	-0.001	-0.002*
	(0.001)	(0.001)
Constant	1.159***	0.341
	(0.292)	(0.312)
Number of observations	1,411	1,141

4.3 Impact of off-farm employment on rural households' food security

The estimation results are qualitatively robust between estimation methods and subsamples, suggesting that participation in off-farm employment significantly improves food security (Table 5). HDDS increased by 0.4 to 0.7 food groups for the full sample and the no off-farm at baseline sample, depending on the estimation method. This is an increase of 6 to 10 %. For our preferred estimates, the PSM-DID for the restricted sample, the increase is 8%. We found no significant effect of off-farm income for those households who were already engaged in off-farm employment in period 1. This could be due to the small sample size or because these households were better off on average. HFIAS decreased by -0.6 to -1.9, 14 to 45 % (25 % for our preferred estimates). These differences are related to the choice of estimation method, with PSM giving the highest estimates, but also to the choice of sample. In this case it is perhaps surprising that farmers with off-farm income at baseline show the largest effect. When non-significant estimates are included, the probability of being food insecure decreases by 2-8 percentage points, which is substantial at a food insecurity rate of 22 %. However, the coefficient is only marginally significant for two out of six estimates and not for our preferred estimates, so we must be very careful when drawing conclusions from these numbers. The lack of significance could be due to the very rough nature of the indicator. Replacing it by the more detailed number of months that households were food insecure gave very similar results due to the relatively small share of non-zero values. Yet, alternative annual indicators, for example based on HFIAS, could potentially give stronger results.

Table 5: The effect of off-farm employment on food security

VARIABLES	N	HDDS	HFIAS	Food insecure
Full sample	1,411			
First difference		0.440***	-0.629**	-0.024
		(0.140)	(0.310)	(0.034)
PSM		0.696***	-1.519**	-0.062*
		(0.165)	(0.772)	(0.033)
No off-farm at baseline	1,141			
DID		0.596***	-0.943*	-0.078*
		(0.182)	(0.477)	(0.127)
PSM		0.699***	-1.480**	-0.030
		(0.187)	(0.660)	(0.045)
DID with propensity score weights		0.579***	-1.078**	-0.069
		(0.197)	(0.472)	(0.041)
Off-farm at baseline	270			
PSM		0.241	-1.870***	-0.067
		(0.194)	(0.657)	(0.058)

Inference: *** p<0.01; ** p<0.05; * p<0.1(standard errors in parentheses)

In conclusion, while the overall effect of off-farm employment on food security is clearly positive, the strength of the effect depends on the specific measure selected. We find the largest effects for our monthly measure HFIAS. This could be due to the recall period selected, but also to the subjective nature of this indicator compared to the more objective HDDS.

4.4 Matching quality assessment

The reader may recall that period 1 characteristics differed substantially between farmers engaging in off-farm employment in period 2 and those who did not (Tables 3a-c), especially for the full sample, and that we applied matching procedures to overcome these differences. The question is

how well these procedures have worked: are the covariates balanced after matching? We tested this problem using a T-test on the weighted covariates (Rosenbaum and Rubin 1985). We assumed that after matching, covariates would be balanced (Caliendo and Kopeinig 2008).

Table 6 indicates that matching was very effective for all characteristics, except for the baseline food security indicators. Remember that for the full sample, all three indicators were significant at the <1 % or 3 % level. After balancing, balancing of HFIAS was still rejected, but only at 7%, whereas balancing for the other two indicators was rejected at the <1 % level. On the other hand, for the restricted sample, only HFIAS was significantly different between the two groups without weighting. This did not change after weighting, though the significance level decreased from 1 % to 7 %. Hence, matching has significantly improved balancing, though perhaps not as much as desired for the lagged outcome indicators. Based on these results, we would credit the estimates with the restricted samples as having the lowest chance of bias, as anticipated.

Table 6 Balancing of baseline characteristics after weighting

	Full sample Mean			No off-farm at baseline Mean		
Weighted Variables	Control	Treated	Pr(|T|>|t|)	Control	Treated	Pr(|T|>|t|)
HDDS	7.357	7.792	0.000	7.314	7.406	0.414
HFIAS	4.322	3.827	0.072	4.230	3.594	0.068
Months food insecurity	0.612	0.385	0.002	0.551	0.459	0.191
Region	0.517	0.558	0.412	0.530	0.546	0.784
Age head	43.706	44.205	0.542	44.475	44.432	0.959
Gender head	0.152	0.161	0.735	0.155	0.155	0.978
Head secondary education (yes=1)	0.152	0.154	0.956	0.061	0.058	0.816
Head married (yes=1)	0.805	0.808	0.902	0.784	0.787	0.917
Household size	5.465	5.504	0.807	5.503	5.551	0.756
Land owned (acres)	6.554	7.489	0.504	5.736	7.468	0.327
Farming experience	15.184	15.142	0.956	16.675	16.705	0.973
Dependency ratio	41.12	41.246	0.938	41.179	40.768	0.822
Livestock (TLU)	0.499	0.499	0.980	0.480	0.462	0.639
Subsistence farmer	0.921	0.917	0.851	0.986	0.976	0.336
Distance farm to market	23.306	24.382	0.696	21.762	21.834	0.973
Numbers of observations	1033	378		963	205	

5. Conclusion and policy recommendations

This study has investigated the impact of participation in off-farm activities on improving household food and nutritional security. The analysis relied on the panel data collected in 2014 and 2016 in the southern highlands regions of Songwe and Mbeya in Tanzania. Despite the strong agricultural character of the regions, 33 % of survey households engaged in agriculture in either or both of the two years. More adults and a larger farm size stimulated off-farm activities, while farming experience and livestock ownership had a limiting effect. This participation had a significant effect on food security, the strength of which depended on the specific indicator selected. HFIAS was most affected, followed by HDDS. The effects on the very rough annual indicator for food insecurity were mostly insignificant. On the basis of these findings, we suggest

that development of policies and programs that pay more attention to off-farm work can boost rural household income, and thus promote food security and nutritional security.

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Authors Contributions

The corresponding author has contributed substantially to the work, from the conception of the presented idea, data collection and verification, analysis, interpretation, and discussion of results, and drafted the article to the final version of the manuscript. Professor Erwin Bulte and Professor Marrit van den Berg were responsible for revising the paper and approving the final manuscript. The sole author is responsible for all parts of the manuscript.

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Appendix 1: Household Food Insecurity Access Scale

For each of the following questions, consider what has happened in the past 1 month. Please answer whether this happened never, rarely (once or twice), sometimes (3-10 times), or often (more than 10 times) in the past 1 month?
1: Did you worry that your household would not have enough food?
2: Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?
3: Did you or any household member eat a limited variety of foods due to a lack of resources?
4: Did you or any household member eat food that you did not want to eat because a lack of resources for obtaining other types of food?
5: Was there ever no food at all in your household because there were no resources for getting more?
6: Did you or any household member go to sleep at night hungry because there was not enough food?
7: Did you or any household member go a whole day without eating anything because there was not enough food?
8: Did anybody in your household eat a smaller meal than you felt you needed because there was not enough food?
9: Did anybody in your household eat fewer meals in a day because there was not enough food?