Production diversification, dietary diversity and food poverty: Empirical evidence from Ethiopia and Tanzania

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Abstract

This paper investigates the role of production diversification for dietary diversity in smallholder agriculture. We use the Living Standards Measurement Study dataset of the World Bank from Ethiopia and Tanzania. We show that production diversification contributes to dietary diversity of farm households. Furthermore, we show that the effects of production diversification and proportion of purchased food on the dietary diversity of the household significantly varies across families who are in food poverty, and the food secure families. Diversified farming systems can contribute to improve the food security and dietary diversity, especially if targeted towards nutritionally rich food production schemes.

Keywords: dietary diversify, production diversification, poverty

1. Introduction

Food insecurity and malnutrition are among the key challenges in sub-Saharan Africa and the developing world (KENNEDY et al., 2003, GODFRAY et al., 2010). In a predominantly agrarian economy, the wide array and spectrum of challenges in the agricultural production system itself and the complexity of production and consumption decisions at the household level have a large impact on the improvement of food and nutrition security of smallholder farmers (EHUI and PENDER, 2005, WENHOLD et al., 2007). As a response, improving agricultural productivity and the linkage of agricultural production with food security and nutrition quality has been a central issue of development policies in the region (ALLEN, 2003, HADDAD, 2000). This stems from the role that the agricultural sector plays as the primary source of food and nutrition (HAWKES and RUEL, 2006), and for its contribution as the main source of livelihood for the majority in the developing world and sub-Saharan Africa (BARRETT et al., 2001, EHUI and PENDER, 2005, WORLD BANK, 2008).

Smallholder farmers often rely on own farm production to meet the household dietary requirements. Hence, improving farm productivity is likely to enhance the food security situation of the household (GODFRAY et al., 2010, EVENSON and GOLLIN, 2003, MINTEN and BARRETT, 2008). For example, as EVENSON and GOLLIN (2003) document, Green Revolution contributes to a substantial reduction of poverty and food security with the productivity growth of smallholders. Conversely, inadequate food production and low level of agricultural productivity can lead to household food insecurity, malnutrition and micro-nutrient deficiency (SHARIFF and KHOR, 2005, MELLO et al., 2010, DJURFELDT et al., 2005). These forms of malnutrition can lead to poverty through loss of productive human capacity and capital (VICTORA et al., 2008). Breaking the cycle often requires an integrated agricultural development and nutrition interventions. As a response, agricultural production and productivity improvement strategies together with nutrition-sensitive development packages have got growing support and attention in global nutrition and poverty alleviation programs (HERFORTH, 2010, WRIGHT, 2011, RUEL and ALDERMAN, 2013).

There are a number of pathways in which agriculture can contribute to improve the nutrition status of the farming family. The first one is the contribution of agricultural productivity growth for improving the nutrition status of the household with increased income. There is a growing literature that document the implication agricultural productivity growth for food security and welfare (WENHOLD et al., 2007, BEZU et al., 2014, EHUI and PENDER, 2005, THORNE-LYMAN et al., 2010). The second one is the role of agriculture in improving nutritional quality with the production of nutrient rich food (HODDINOTT, 2012). An important contribution of agriculture in this aspect is the role of farm production diversity for the dietary diversity of farm households (HODDINOTT and

YOHANNES, 2002, HODDINOTT et al., 2014, THORNE-LYMAN et al., 2010). JONES et al. (2014) and SIBHATu et al. (2015) for instance show that farm production diversification can improve the dietary diversity of households in the developing world.

Interestingly, as NTWENYA et al. (2015) highlight in their case study in Tanzania, the situations of families in the food poverty can be different from the situations of the food secure households. They indicate that households in food poverty can have high risk of inadequate dietary diversity. A household in food poverty, struggling to meet the calorie requirements for the family members, might have lower propensity to look for options of diversifying diets. Nonetheless, the literature that demonstrates the interplay of production diversification with food poverty and dietary diversity of households is scarce. The empirical evidence gets even scarcer when it comes to sub-Saharan Africa and the developing world. And most importantly, those are the places with subsistence production systems where one can expect a strong interrelation between farm production diversification, dietary diversity and food poverty. Furthermore, it is in such a context that integrated agricultural development, nutrition and health packages can bring a significant contribution to better livelihoods.

A special interest in this paper is to explore the role of production diversification for dietary diversity of households, by integrating the food poverty situation. Using a cross-section data of rural households from Ethiopia and Tanzania from LSMS-ISA (2011), we show that production diversification is an essential element in improving the dietary diversity of farm households. Furthermore, we also show that this effect significantly varies for households in food poverty and the food secure households, and the effect of production diversification is stronger for the food secure households.

This paper is organized as follows. The next section illustrate the data and empirical approach used in this paper. The results of the study are presented in section 3. In section 4, we discuss and conclude the findings.

2. Data and Empirical Approach

2.1. Production diversification, dietary diversity and food security measurements

In what follows, we illustrate the measurements and approaches that have used in this paper for important variables in the analysis including the level of production diversification, dietary diversity and food security. These variables are constructed from the food balance sheet that farm households consume in a week.

Dietary diversity is conceptualized as the sum of unique foodstuff consumed in a specified period of time. A variety of approaches employed in empirical literature to measure dietary diversity. The choice of the approach mostly depends on the relative abundance of some food types, dietary habits and culture of the society, availability of data and the level of processing and other socio-economic elements (FAO, 2007, JONES et al., 2014, PELLEGRINI and TASCIOTTI, 2014, SIBHATU et al., 2015). The simple food count index and the food diversity index are commonly applied in empirical literature.

The simple food count index is a simple count of all the food items consumed by the household, while the household food diversity score ($HDDS$) measures the count of the food groups the household consumed in a certain period of time. We adopt the latter for this paper, as the simple food count index fails to capture whether the household gets different micro-nutrients (SWINDALE and BILINSKY, 2006, JONES et al., 2014, SIBHATU et al., 2015). We use eleven food groups (cereals,

roots and tubers, vegetables, fruits, meat, eggs, pulses, milk and milk products, oils and fats, sugar, and beverages) and the index has a continuous score that ranges from 0 to 11.

Another important variable in this paper is the food poverty index. This term is often used interchangeably with food insecurity (JONES et al., 2013, FAO_WFP_IFAD, 2012). According to the World Food Summit 1996, food security is defined as a situation that exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1998, FAO, 2002). Food security is a term associated with the "availability of food for all at all times", and deals with both the physical and economic access to food (FAO, 1983, FAO, 2001). The US Department of Agriculture (USDA) also defines food insecurity as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (HAMILTON et al., 1997). There is well-documented evidence on the dimensions of food security (i.e. availability, accessibility and utilization) (FAO, 2002, HODDINOTT and YOHANNES, 2002, SCHMIDHUBER and TUBIELLO, 2007). Despite the varied definitions and conceptualizations, the existing literature incline to agree that food poverty (food insecurity) is a situation when one doesn't meet his (her) nutritional requirements. Food poverty is often measured with in its extremes as a form of undernourishment. Food poverty exists "when caloric intake is below the minimum dietary energy requirement" (FAO_WFP_IFAD, 2012, WHO, 1985).

First, we sum up the calories from food consumed by the household to calculate actual calorie intake (C_actual). Second, we calculate a minimum calorie intake by adding up minimum requirements for each individual in the household (C_min). The minimum calorie requirement of the household (C_min) is dependent on the sex and age composition of the family. In this paper, we use this definition of extreme food poverty[1] and is measured as a binary variable taking one if the household gets the required calorie intake ($C\_min \geq C\_actual$), and zero otherwise[2].

Production diversification is commonly captured with the biodiversity index and aggregated food production index. The former is a simple count of all outputs of crop and livestock in the farm (DI FALCO and CHAVAS, 2009, JONES et al., 2014, SIBHATU et al., 2015). The aggregate food production index measures the sum of the groups of food commodities produced in the household. For the aggregated food production index, we again use the eleven food groups used for developing the food diversity index.

Food purchase proportion is conceptualized in this paper as the amount of food that farm households purchase from the total consumption. This variable is calculated as the proportion of purchased food from the total consumption of food items in the week. The food purchase proportion intuitively capture the reliance of the farm household on own production and purchased food.

2.2. Data and summary statistics

The data used in this study comes from a nationally representative and large pool of datasets derived from the World Bank's Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA); cross-section surveys that encompass households living in rural and small town areas with collected panel data on a range of household and community level characteristics linked to agricultural activity. We use the 2011 round of survey data from Ethiopia and Tanzania (WORLD BANK, 2013). The dataset comprises of information on the household demographic and health, agricultural production, marketing consumption and off-farm activities and many more.

[1] Food poverty in this paper is interchangeably used with food insecurity
[2] See annex 1 for more details

The result of this paper is based on 1140 rural households from 10 regions in Ethiopia and 854 farm households from 21 regions in Tanzania.

Table 1 present the summary statistics of important variables for Ethiopia and Tanzania respectively. The farm households in Tanzania have almost three times as much landholding as households in Ethiopia. The age structure, age dependency ratio and food purchase proportion are also similar among the two countries. Informal cash transfer and off-farm and non-farm income is a lot higher in Ethiopia. When looking at the food and the production diversity index Tanzania has by far more consumption and production diversity as compared to Ethiopia.

Table 1: Descriptive statistics for Ethiopia and Tanzania

Variables	Ethiopia (N=1140) Mean (std. dev.)	Tanzania (N=854) Mean (std. dev.)
Food diversity index (count index)	8.23 (2.54)	8.16 (2.18)
Production diversity (count index)	4.50 (1.89)	6.72 (0.93)
Food purchase proportion (percent)	0.12 (0.08)	0.14 (0.07)
Age of the household head (years)	44.18 (14.05)	47.77 (14.43)
Age dependency ratio[3](proportion)	1.23 (0.86)	1.14 (0.83)
Household literacy (0=illiterate, 1=literate)	0.41 (0.49)	0.74 (0.43)
Land holding (hectares)	1.32 (2.0)	3.35 (5.18)
Distance to population center (kilometers)	46.33 (42.57)	39.34 (43.91)

In Table 2, we present summary of important variables for the households in extreme food poverty and food secure households in Ethiopia and Tanzania. The mean values of food diversity index, the level of production diversification and food purchase proportion are slightly higher for the food secure households in Ethiopia.

In Tanzania, the food diversity index and food purchase proportion are slightly lower for the households in food poverty. Conversely, food secure households in Tanzania have higher levels of production diversification compared to households in food poverty. This might give an indication that dietary diversity might not be necessarily translated in to adequate nutritional intake.

Table 2: Descriptive statistics of the two groups based on food poverty status

Ethiopia	Ethiopia Mean (std. dev.)		Tanzania Mean (std. dev.)	
	Food poverty	Food secure	Food poverty	Food secure
Food diversity index	8.14 (2.58)	8.31 (2.51)	8.65 (2.05)	7.56 (2.18)
Production diversity	4.39 (1.80)	4.58 (1.96)	6.68 (0.94)	6.77 (0.92)
Food purchase prop.	0.11 (0.07)	0.12 (0.25)	0.15 (0.07)	0.12 (0.06)
Age household head	43.78 (14.34)	44.53 (13.88)	47.76 (14.61)	47.79 (14.23)
Age dependency ratio	1.23 (0.84)	1.23 (0.87)	1.11 (0.84)	1.18 (0.81)
Literacy	0.37 (0.48)	0.45 (0.49)	0.77 (0.42)	0.71 (0.45)
Land holding	1.33 (1.48)	1.32 (2.39)	3.56 (5.98)	3.10 (4.00)
Distance	51.74 (48.70)	42.63 (37.76)	38.38 (44.14)	40.50 (43.65)
Observations	457	652	466	388

1. [3] Age dependency ration is the proportion of dependent family members (age of <15 and >64) to the working age population (ages between 15 and 64) in the family.

2.3. Empirical model

The aim of this paper is to analyze the role of production diversification on the dietary diversity of the household. We would also like to explore if the relationship is similar for the households in food poverty and food secure farm households using a cross-sectional data from Ethiopia and Tanzania.

As previous empirical works in sub-Saharan Africa and elsewhere in the developing world highlight, subsistence farms rely on their farm production to satisfy the household consumption requirements (DERCON and KRISHNAN, 2000, YESUF and BLUFFSTONE, 2009, DILLON and BARRETT, 2014, HODDINOTT et al., 2014). Subsistence farmers also purchase some food items from the market. VISWANATH (2012) and HERRADOR et al. (2015) argue that the consumption of high value crops by the producing farm households is often unlikely. For instance, farm households can sell high value crops, and in return, can purchase cheap food items to meet the calorie requirements of members. This requires a joint food consumption model that combines food production and purchase of food stuffs.

We can represent dietary diversity score of the household ($HDDS_i$) as a function of production diversity (PD_i) and food purchase proportion (PP_i) after controlling for other household characteristics (X_i) as:

$$HDDS_i = f(PD_i, PP_i, X_i, \beta_j) + e_i \quad (1)$$

Where $\beta_j$and e_i respectively represent the vector of coefficients associated with each explanatory variables and the error term. We include age, sex and literacy of the household head, age dependency ratio in the household, landholding and regional dummies as control variables in this model.

Furthermore, we would like to explore if the relationship between the dietary diversity and production diversification of households stay the same, when we control for their food security (poverty) situation.

$$HDDS_{i0} = f_0(PD_i, PP_i, X_i, \beta_j) \quad if\ \text{C\_actual}_i < \text{C\_min}_i \quad (2a)$$

$$HDDS_{i1} = f_1(PD_i, PP_i, X_i, \beta_j) \quad if\ \text{C\_actual}_i \geq \text{C\_min}_i \quad (2b)$$

As the dietary diversity of the household is a count index and we expect Poisson distribution in the data, Poisson regression can be employed for the estimation. We use robust standard errors to control for heteroscedasticity problems for the simple Poisson regression estimations. The issue of an unobserved heterogeneity is another important concern in the analysis. In the dietary diversity model, the proportion of purchased food could be endogenous. This could arise when there are unobservable factors that can simultaneously determine dietary diversity decision together with food purchase decision of the household. In this case, instrumental variable Poisson regression approach is appropriate. Furthermore, we calculate bootstrapped standard errors as the IV Poison is estimated using the general method of moments (GMM) approach. A key challenge in the instrumental variable estimation approach is to find valid instruments. These instruments should be strongly correlated with the endogenous variable, and should only influence the dietary diversity of the household through their effect on the purchased food proportion. We use distance from the nearest population center as instrument for the percentage of food purchase.

3. Results

3.1. Production diversification and dietary diversity

Table 3 presents the poison and instrumental variable Poisson regression results for Ethiopia and Tanzania. In models 1 and 3, we present the simple Poisson regression model. Models 2 and 4 we present results of the IV Poisson regression model. The instruments used in models 2 and 4 are strong (see annex 2 and 3).

Table 3: Determinants of dietary diversity for Ethiopia and Tanzania

Explanatory Variables	Ethiopia (N=1140)		Tanzania (N=854)	
	Model 1 (Poisson reg.)	Model 2 (IV reg.)	Model 3 (Poisson reg.)	Model 4 (IV reg.)
Production diversity	.215***(.009)	.147***(.065)	.029***(.008)	.034***(.011)
Food purchase prp.	1.41***(.201)	2.928**(1.405)	2.517***(.115)	4.142*** (1.041)
Household head sex	.012 (.027)	.007 (.032)	-.021 (.017)	-.044 (.026)
Age of the head	.001**(6.5e-04)	.001*(7.3e-04)	2.8e-04 (4e-04)	.001 (6e-04)
Dependency ratio	-.001 (.011)	-.005 (.013)	-.004 (.007)	-.002 (.012)
Literacy	.005*(.003)	.005 (.004)	.005***(.001)	-6.1e-05 (.003)
Land holding	-5.1e-07 (6e-07)	-9.6e-07 (1.2e-06)	.005***(.001)	.006***(.002)
Regional dummies	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis are robust standard errors for model 1 and 3, and bootstrapped standard errors for models 2 and 4. *, ** and *** indicate statistical significance at 10%, 5% and 1% probability.

Production diversity significantly and positively influence the dietary diversity of the household across these different models in Ethiopia and Tanzania. The coefficient of production diversification declines from 0.21 in the simple Poisson approach to around 0.15 in the IV approach in Ethiopia. Despite the change in the magnitude of the coefficients, increase in production diversification contributes to dietary diversity of households. In the same way, production diversification improves the dietary diversity of households (β=0.03) in Tanzania. In Tanzania, there is a slight improvement in the effect of production diversification when we control for unobserved heterogeneity in the estimations.

Furthermore, an increase in the purchased food proportion leads to an improvement in dietary diversity of farm households in Ethiopia and Tanzania. The effect of food purchase proportion on dietary diversity of farm households gets stronger in both countries when we control for unobserved heterogeneity through an IV Poisson estimations (Model 2 and model 4).

In addition, some of the control variables in the model influence the dietary diversity of the household. While age and the education level of the household head are significant determinants of dietary diversity in the Poisson regression approach, only education level of the household head is significant determinant of dietary diversity in the IV Poisson regression method in Ethiopia. In Tanzania, education level of the household head and landholding significantly determine the dietary diversity of the household. From these, only the landholding of the household remain significant after we control for unobserved heterogeneity.

3.2. Production diversification, food security and dietary diversity

In what follows, we classify the sample in to two groups in both countries: the food secure ones and households in food poverty and re-run the analysis. In table 4, we report the estimation results for Ethiopia. In model 5 and 7, we report the results of the simple Poisson regression for the food secure and food insecure households. In models 6 and 8, we show IV Poisson regression results for the two groups. Here again, the instruments significantly associated with the endogenous variable (annex 2).

Table 4: Heterogeneous effect across different groups in Ethiopia

Explanatory Variables	Food insecure (N=457)		Food secure (N=652)	
	Model 5 (Poisson reg.)	Model 6 (IV reg.)	Model 7 (Poisson reg.)	Model 8 (IV reg.)
Production diversity	.192***(.018)	.023 (.137)	.225***(.011)	.219***(.070
Food purchase prp.	1.778***(.352)	5.226*(2.685)	1.231***(.246)	1.400 (1.629)
Household head sex	-.003 (.038)	-.015 (.048)	.034 (.039)	.032 (.047)
Age of the head	.001 (.001)	.001 (.002)	.001 (.001)	.001 (.006)
Dependency ratio	-.011 (.019)	-.029 (.031)	.005 (.014)	.006 (.017)
Literacy	.004 (.006)	-4.1e-04 (.010)	.007*(.004)	.007 (.006)
Land holding	2.9e-07 (6e-07)	-1.4e-06 (2e-06)	-7.0e-07 (8e-07)	-7.5e-07 (1e-06)
Regional dummies	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis are robust standard errors for model 1 and 3, and bootstrapped standard errors for models 2 and 4. *, ** and *** indicate statistical significance at 10%, 5% and 1% probability.

In Ethiopia, an increase in production diversification improves the dietary diversity of the food insecure household in the simple Poisson regression. Nonetheless, this effect is not there anymore when we control for unobserved heterogeneity with the IV Poisson approach. This shows that production diversification might not necessarily improve the dietary diversity of food insecure households in Ethiopia. Table 4 also show that production diversification contributes to improved dietary diversity for the food secure households. Overall, these results show that the effect of production diversification on dietary diversity of food secure households is stronger than the food insecure households. This effect is consistent across the two estimation approaches.

In the same way, an increase in food purchase proportion do significantly improve the dietary diversity of the food insecure households in Ethiopia. The effect gets stronger when we control for unobserved heterogeneity in the estimation. On the other hand, the effect of purchased food proportion erodes away for the food secure households with the instrumental variable approach. Overall, while the food insecure households seem to rely more on purchased food to improve their dietary diversity, the food secure households depend on their farm production diversity to diversify their diet.

Table 5: Heterogeneous effect across different groups in Tanzania

Explanatory Variables	Food insecure (N=466)		Food secure (N=388)	
	Model 9 (Poisson reg.)	Model 10 (IV reg.)	Model 11 (Poisson reg.)	Model 12 (IV reg.)
Production diversity	.034***(.009)	.037***(.012)	.025*(.013)	.042*(.023)
Food purchase prp.	2.11***(.129)	2.598**(1.225)	3.27***(.210)	5.974***(1.612)
Household head sex	.008 (.018)	-.005 (.033)	-.056*(.029)	-.052 (.034)
Age of the head	2.0e-04 (6e-04)	3.2e-04 (.001)	3.5e-04 (.001)	.001*(7.1e-04)
Dependency ratio	-.009 (.009)	-.007 (.013)	-.003 (.012)	-.016 (.020)
Literacy	.004***(.001)	.002 (.004)	.005***(.002)	-3.5e-04 (.004)
Land holding	.003**(.001)	.003 (.002)	.009***(.003)	.012***(.004)
Regional dummies	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis are robust standard errors for model 9 and 11, and bootstrapped standard errors for models 10 and 12. *, ** and *** indicate statistical significance at 10%, 5% and 1% probability.

Table 5 presents the result of the simple Poisson regression and the IV Poisson regression approach for the food insecure (Model 9 and 10) and food secure households (Model 11 and 12) in Tanzania. We confirm that an increase in production diversification can help to improve the dietary diversity of both the food secure and food insecure farm households in Tanzania. The effects of production diversification gets stronger when we control for unobserved heterogeneity through an IV estimator. Furthermore, the effect of production diversification varies in magnitude across the two groups in Tanzania. While the coefficient of production diversification is 0.035 (Model 10) in the case of food insecure households, the effect gets stronger (=0.042) for the food secure households.

Table 5 also show that an increase in the food purchase proportion enhances the dietary diversity of the two groups in Tanzania. In the same way to the case of production diversification, the effect of purchased food proportion gets stronger for the food secure households. This might be due to the fact that food secure households are more likely to purchase different mix of food compared to the food insecure households in Tanzania. Conversely, the food insecure households might tend to purchase high calorie cereals to meet the energy requirements that contribute less to dietary diversity.

4. Discussion and conclusion

Food insecurity, malnutrition and micro-nutrient deficiency are among the key challenges in the developing world. As the majority rural poor make their living from agriculture, an improvement in the sector is expected to substantially contribute to improve these challenges. Furthermore, most smallholder farmers rely on their production to meet the consumption requirements. With this regard, production diversification (production of variety of grains, vegetables, animal products etc.) can contribute to improved dietary diversity of the household.

This paper empirically investigates the implication of production diversification on dietary diversity across the food secure and food insecure households using cross section data from Ethiopia and Tanzania. We found out that production diversification plays a crucial role for the dietary diversity of farm households. This result is in line with the previous empirical findings in the developing world (JONES et al., 2014, SIBHATU et al., 2015). In subsistence farms, where the proportion of marketed surplus is significantly low and their participation in purchase of food items is limited, the diversity of own production is rather crucial for own consumption (DERCON and KRISHNAN, 2000, DILLON and BARRETT, 2014, HODDINOTT et al., 2014). Attempts that are targeted towards encouraging smallholder farmers to produce more variety of crops and livestock products at the farm level can also improve the dietary diversity of the family members. These interventions can contribute to the improvement of the food and nutritional security of households and dietary diversity, especially if targeted towards nutritionally rich food production schemes.

Dietary diversity can also come from the likelihood of diversifying diet from purchased food. We confirm that an increase in the purchased food proportion significantly improves the dietary diversity of the farm household. JONES et al. (2014) underlined the role of relative market orientation in production to improve the dietary diversity of households in rural Malawi. Especially in times when the farm household is engaged in specialized high value commodities, the role of the local food market will be crucial. Recent studies demonstrated that the consumption of high value cereals like *Teff* in rural Ethiopia is quite low with the increase in demand from urban consumers (VISWANATH, 2012, HERRADOR et al., 2015). This implies that improved market access to smallholder households and enhanced market integrations across regions can play a vital role in the food and nutrition security in SSA.

Nonetheless, the effect of production diversification or proportion of purchased food on the dietary diversity of the household significantly varies across the food secure and food insecure families. This

is an important finding as most existing empirical evidences argue that an increase in the level of production diversification leads to dietary diversity. We show that, the effects of production diversification vary a lot across the food secure and the food insecure groups. And, production diversification might not necessarily improve the dietary diversity of the food insecure households as they should first meet the calorie requirements of their members. Poor rural households, who often struggle to acquire the required diet, will rather have smaller propensity to diversify their diets. Hence, it is vital to improve the overall farm productivity that helps to improve the food security situation to bring about change in dietary diversity. Attempts targeted to improve the dietary diversity status and food security of rural households in sub-Saharan Africa can benefit from integrated agricultural development interventions and initiatives. Future research on the type of diets and micro nutrients that the rural poor and food insecure farm households lack is vital to adequately target agricultural production and nutrition interventions.

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Supplementary annex

Annex 1: Energy requirement by age and sex compositions

Age (years)	Male	Female
	Children	
0-6 months	585	585
6 to 12 months	960	960
1-3	1250	1250
3-5	1510	1510
5-7	1710	1710

7-10	1880	1880
	Boys and girls	
10-12	2170	1925
12-14	2360	2040
14-16	2620	2135
16-18	2820	2150
		If pregnant +200
	Active age	
18-60	2944	2140
		2240 (if pregnant)
		2640 (if lactating)
>60	2060	1830

Source: WHO, 1985

Annex 2: First stage IV Poisson gmm approach for food purchase proportion for Ethiopia

Explanatory Variables	Full sample Model 2 (IV reg.)	Food insecure Model 6 (IV reg.)	Food secure Model 8 (IV reg.)
Production diversification	.044***(.001)	.045***(.002)	.043***(.002)
Household head sex	2.7e-04 (.004)	.003 (.006)	-.005 (.007)
Age of the head	4.6e-04 (.001)	8.8e-06 (1.5e-04)	1.3e-04 (1.5e-04)
Dependency ratio	.002 (.002)	.003 (.002)	.001 (.002)
Literacy	4.5e-04 (.001)	.001 (.001)	3.1e-04 (7.8e-04)
Land holding	1.9e-07***(7.0e-08)	4.5e-07***(1.4e-07)	1.4e-07 (8.4e-08)
Distance population center	-1.6e04***(3.9e-05)	-1.6e-04***(5.4e-05)	-1.9e-04***(6.0e-05)

Notes: The numbers in parenthesis are standard errors. *, ** and *** indicate statistical significance at 10%, 5% and 1% probability.

Annex 3: First stage IV Poisson gmm approach for food purchase proportion for Tanzania

Explanatory Variables	Full sample Model 4 (IV reg.)	Food insecure Model 10 (IV reg.)	Food secure Model 12 (IV reg.)
Production diversification	-.003 (.003)	-.002 (.004)	-.003 (.004)
Household head sex	.012**(.005)	.017**(.008)	-2.9e-04 (.006)
Age of the head	-2.6e-04*(1.6e-04)	-2.1e-04 (2.3e-04)	-3.0e-04 (1.9e-04)
Dependency ratio	-.003 (.002)	-.006*(.035)	.003 (.003)
Literacy	.002***(3.4e-04)	.002***(5.5e-04)	.002***(3.8e-04)
Land holding	-6.2e-04*(3.7e-04)	-7.0e-04 (4.7e-04)	-7.8e-04 (.001)
Distance population center	-1.1e-04**(5.5e-05)	-1.6e-04**(8.4e-05)	-4.1e-05 (6.5e-05)

Notes: The numbers in parenthesis are standard errors. *, ** and *** indicate statistical significance at 10%, 5% and 1% probability.