Does crop diversity contribute to dietary diversity? Evidence from integration of vegetables into maize based farming systems in Tanzania

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Abstract

Maize is one of the most important staple foods that is critical to food security and livelihoods of farmers in sub-Saharan Africa. Although maize is important staple crop for ensuring food security, it cannot ensure nutritional security. To provide and ensure an adequate supply and greater variety of nutritional foods within a farm household, cropping patterns and farming systems must be diversified to include micronutrient-rich vegetables and fruit crops, particularly traditional African species. Vegetables provide nutritional benefits and increase household incomes for smallholders, and are thus an excellent complement to staple crops for addressing food and nutritional security. The objective of this study is to ascertain if an increased diversity of crops in farmers' fields leads to increased diversified diets or otherwise. This underlying objective is analyzed with a multiple linear regression model from a primary survey of 300 farm households selected from 10 villages in the Babati, Kongwa and Kiteto districts of Tanzania. Results show that farm diversity does not have a positive and significant effect on dietary diversity after controlling for other covariates. However, variables such as households size, level of education, monthly expenditure on food, irrigated area, proportion of vegetables consumed from own household production and control of household income by female decision makers were found to have strong association with dietary diversity.

Keywords Farm Diversity, Dietary Diversity, Vegetables, Maize

JEL code **Q10, Q180, I130**

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I Introduction

Lack of dietary diversity is undoubtedly the major cause of micronutrient malnutrition in sub-Saharan Africa (FAO, 2013a; 2013b and Thompson and Meerman, 2013), including Tanzania (Mazengo et al. (1997). Imbalanced diets resulting from consumption of mainly high carbohydrate based-diets also contribute to productivity losses (Weinberger, 2004) and reduced educational attainment and income (Alderman et al, 2006). Consequently, micronutrient malnutrition is currently the most critical for food and nutritional security problem (Ruel, 2003; Behrman, 1993; Horton and Ross, 2003) as most diets are often deficient in essential vitamins and minerals. In Tanzania, most rural and urban households consume mainly staples as their main food, which are high in carbohydrates, but low in nutrients and vitamins (Leach and Kilama, 2009). Staple food items might increase energy availability but do not improve nutritional outcomes if not consumed in conjunction with micro-nutrient rich foods (Johns and Eyzaguirre, 2007; Kennedy et al, 2007). Farmers' engagement in production and marketing of staple food items might also improve household income but not a direct propionate reduction in malnutrition. Higher household incomes tends to improve nutritional outcomes but at a much slower rate (FAO, 2012 and Ruel, 2003). Vegetables in general, and traditional African vegetables in particular, are rich in micronutrients and other health-promoting phytochemicals; nutrient-dense vegetables complement staple foods and improve the nutritional quality of diets (Weinberger and Swai, 2006). Integrating micronutrient-rich foods such as vegetables, fruits and livestock products into diets has been found to be most practical and sustainable way to alleviate micronutrient deficiency (Ali and Tsou, 1997). Consumption of diverse vegetables have been found to significantly improves nutrition (Settle and Garba, 2011) through access to diverse mineral, micronutrient and vitamin-rich products (Hounsome et al., 2008; Uusiku et al., 2010). Integrating vegetables into maize-based farming systems as a means to augment income is appropriate due to their high farm gate values (Balasubramanian et al., 2007). According to Jones et al. (2014) households in developing countries are often limited to one or two starchy stable foods and may be especially lacking in micronutrient-rich fruits, vegetables and animal-source foods and hence, it is necessary to have more diversified food basket to ensure balanced diets so as to enhance nutrition. The authors conclude that more diverse production systems may contribute to more diverse households diets for farming communities. Reducing the prevalence of micronutrient deficiencies will not be sustainable if food consumption is not diversified (Underwood, 2000). Nutritional security focuses on not only on availability and accessibility to food, it is utilization of diversified quality food and hence dietary diversity can be an important measurement tool for nutritional quality of diet and status (Keding et al. 2012; Kennedy et al, 2007; Savy et al, 2005; Torheim et al, 2004; Hatloy et al, 1998). In addition, Hoddinott and Yohannes (2002) highlighted that dietary diversity is strongly associated with household per capita income and energy availability, The authors, further conclude that dietary diversity could be useful indicator for food security., but additional research is needed to validate and test alternative indicators for different purpose (Ruel, 2003). To achieve increased dietary diversity in Tanzania, it is necessary to extensively promote mixed cropping as a means of integrating farming systems, particularly with micro-nutrient traditional African vegetable crops.

A large body of literature have studied the association between dietary diversity and child growth and other nutritional indicators (see for example Ruel, 2003; Arimond and Ruel, 2004). The conclusion from these studies is that there is a strong association between child dietary diversity and nutritional status after controlling for socioeconomic characteristics of households. The authors argued that dietary diversity serves as a proxy for determining diet quality and hence dietary diversity can be used as an indicator of diet quality. However, additional research is required to test and validate alternative dietary indicators for different purposes. Some studies measured determinants of income from farm and non-farm activities (see for example Barrett et al, 2001; Reardon, 1997 and Reardon et al, 1992) and crop diversity (see for example Zeller et al, 1998; Birkhaeuser et 1991; walker et al 2004; Joshi et al, 2006 and Birthal et al, 2012). However, these studies focused mainly on evaluating one of two indicators (i.e., farm diversity or dietary diversity) at a time, but it is important to understand the causal linkages between farm diversity and dietary diversity.

More recently some studies have attempted to establish the linkage between land use or cropping pattern and dietary diversity of households (Thompson and Meerman, 2010; Pellegrini and Tasciotti 2013; Smale et al, 2013). Apart from these studies, Herforth (2010) and Jones et al (2014) examined the relationship between farm diversity and dietary diversity among households in African countries and concludes that there is a strong relationship between dietary and farm diversity. Herforth (2010) specifically examined these relationship in Tanzania and Kenya. The author concluded that crop diversity was significantly related to dietary diversity and was also more closely related to consumption of household from own produced food than consumption of market purchased food. However, there are some limitations in the aforementioned recent studies. Firstly, there is a potential for limitations in the interpretation of results stemming from unmeasured confounding factors. Jones et al (2014) for example used multiple linear regression model to analyze the interlinks between farm production diversity and household dietary diversity. Although the authors found a positive relationship between the two constructs, the constant term in their regression results was highly significant, indicating the possibility of improving the model by identifying more potential unmeasured covariates, given the high level of data aggregation associated with nationally representative household survey data as used by the authors. Second, the data used for analysis does not account for the proportion of consumption of own household produced food and associated seasonal effects. Therefore, this paper aims at filing these identified gaps in the literature while also focusing specifically on uniqueness of vegetable integration within maize-based farming systems by analyzing the possible effects on dietary diversity after controlling for potential covariates for the study locales in Tanzania.

Other than the recent studies earlier enumerated, there has been virtually scanty research work to examine the causality between cropping diversity and dietary diversity in the context of sub-Saharan. As a contribution to the on-going discourse and growing body of literature on the linkages between agriculture-nutrition-health nexus, it would be interesting to see how smallholders respond to different transitional changes in this discourse and the associated changes in the cropping production and consumption decisions using detailed household level survey data for capturing information on production and consumption decisions that are specific to identified locales as opposed to the high level of aggregation from national survey data. Most particularly, how are smallholders benefiting from increased crop diversity through inclusion of micro-nutrient rich vegetables from the nutrition view point. The purpose of this study is to ascertain if an increased diversity of crops in farmers' fields leads to more diverse diets for the households. We hypothesize that: (i) large-scale farmers have more diverse dietary patterns; (ii) higher level of education of farmers' leads to positive and significant association with dietary diversity (iii) increased diversity of crops in farmers' fields leads to more diverse diets of the households, and (iv) decision making and control of income by female headed households leads to increase dietary diversity. These hypotheses were tested using multiple linear regression model by controlling other covariates in the model.

II Data and Methods

Survey Design and Data Sources

Extension officers from the agricultural departments in respective districts and opinion leader from the respective villages collaborated to provide lists of farmers who cultivate maize and vegetables from the various communities, and samples were selected randomly from the lists. Farmers were categorized into "vegetable cum maize based households" and "only maize-based households." Farmers designated as vegetable cum maize based households grew vegetables, maize and other staples, whereas only maize-based households were those that cultivated maize and other staple crops with no vegetables. To correct bias among these two groups, we randomly selected an equal proportion from each group—15 farm households from each category, making a total of 30 farm households per village. Overall, 300 farm households that cultivated maize and vegetables in each of the 10 villages selected from the Babati, Kongwa and Kieto districts in Tanzania (Table 1) were surveyed from July to August, 2013 using a structured questionnaire. The survey was done in three stages: pre-pilot, pilot, and main survey. Wards and villages were selected through a multi-stage sampling approach. Meetings were held with officials of the horticultural and agricultural departments in the respective study areas to identify the blocks and villages where major areas had been under maize, vegetable cultivation.

Methodological Framework

Measurement of Dietary Diversity

The study tested the hypotheses that, increased diversity of crops in farmers' fields using the dietary diversity score, with a higher score is expected to lead to an increased diversity of diets among households members. Consequently, a number of studies have constructed dietary diversity scores (Kant et al., 1993; Drewnowski et al., 1997; Drescher et al., 2007; Jones et al., 2014). Dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for the nutritional adequacy of individual micronutrient diets (Ruel, 2003; Kennedy et al, 2007). Our study estimated a dietary diversity score based on FAO guidelines (FAO, 2011). The dietary diversity scores described in these guidelines consist of a simple count of food groups[1] that a household or an individual has consumed over the preceding 24 hours recall period. However, currently no international consensus exists on which food groups to include in the scores (FAO, 2011). Therefore, 16 food groups were constructed based on local food consumption (West et al, 1988). Individual dietary diversity scores aim to reflect nutrient adequacy, whereas the Household Dietary Diversity Score (HDDS) is a snapshot of the economic

[1] See Appendix for the detailed food group category that was considered for our study

ability of a household to access a variety of foods (FAO, 2011). Results from previous studies have showed that, an increase in dietary diversity is associated with socioeconomic status and household food security measured in terms of household energy availability (See for example, Jones et al, 2014; Yuan-Ting et al, 2012; Thorne-Lyman et al, 2009; Faber et al, 2009; Migotto, Mauro, 2006; Abdulai and Aubert 2004; Ohiokpehai, Omo 2003; Hoddinot and Yohannes, 2002; Hatloy et al., 2000) and monthly per capita caloric availability from non-staples for all households (Hoddinot and Yohannes, 2002) and household expenditure (Thorne-Lyman et al, 2009).

Measurement of Farm Diversity

We used two different measurement of variables such as crop count and Simpson's Index (Simpson, 1949) to measure farm diversity in agricultural sessions (both dry and rainy seasons). The crop count constructed based on sums the total number of different crop species cultivated by the households in crop year (i.e., March, 2012 to Feb, 2013). Whereas, Simpson's Index describes evenness of distributed area under cultivation for different crop species in cropping pattern. The crop species counts and Simpson's Index were used in ecological and biodiversity literature (Herforth, 2010; Falco and Perrings, 2003; Meng et al, 2000; Lyson and Welsh, 1993; Magurran, 1988). Based on these measurement variables, many literature to identify the factors that influences farm diversity (Nagarajan, 2005; Benin et al, 2004). Particularly in African region, Shaxson and Tauer (1992) measured determinants of crop diversity in Malawi.

Analytical Framework

Based on the identified gaps from recent literature on the causal relationship between farm diversity and dietary diversity (Herforth, 2010; Torheim et al, 2004; Jones et al, 2014), this paper examine the effect of crop diversity on dietary diversity of farm households, by estimating the following model through multiple linear regression model using cross-section data collected through primary survey. The reason for using multiple linear regression model is to control other covariates (i.e individual and household characteristics, land ownership, irrigation, regional effects, non-farm income, expenditure on food and non-food items) while we estimate net effect of farm diversity on dietary diversity.

Y_i = *f*(individual characteristics, household characteristics, agricultural characteristics, farm diversity, regional dummies. i = 1,.....N (Number of farm households)

Y_i is a Household dietary diversity score (HDDS). The individual characteristics includes gender, level of education, age, decision making capacity. Household characteristics includes monthly per capita expenditure on food and non-food items, size of households in terms of number of people live in households. In addition to the above mentioned variables, we also explored other variables in the model specified namely income from non-farm activities, ownership of Television and Radio, dependency ratio and perception about nutritional benefits. Agricultural characteristics includes net cultivated area, irrigated area, proportion of total vegetables consumed from own production. Farm dietary includes two type of measurement variables namely crop count and Simpson's Index. Finally, regional dummies also been included.

III Results

Table 2 shows that dietary diversity and farm diversity by various covariates. The overall dietary diversity shows that on an average there are seven type of food groups that a household consumed over the preceding 24-hour recall period at the time of survey. Among the districts, Babati showed higher dietary diversity compared to the overall mean of all the 3 districts. Whereas, Kiteto and Kiongwa show lower score compared to Babati and overall mean value of dietary diversity. Results for Kongwa in comparison to Babati are not significantly different from each other. Farm diversity in Kongwa district differs significantly from Babati district, whereas Simpson's Index does not vary significantly across districts. Further, we investigated dietary and farm diversity across tercile of monthly per capita expenditure (low, middle and high). Dietary and farm diversity significantly differs in all three tercile groups (i.e., low, middle and high). We also investigated pattern of dietary diversity and farm diversity among the tercile of monthly per capita expenditure on food and non-food items. The results shows that both farm and dietary diversity significantly differs among terciles. However, this was not clear in the case of Simpson's Index, while varying across tercile but with no statistically significant changes. The dietary diversity score is higher for the farmers who have secondary level education and above. It also shows significant differences across level each education category. Clearly, farmers who have attained a higher educational level, might have better knowledge about dietary intake and hence their dietary diversity score is significantly different and higher from farmers who do not have comparatively higher education qualifications. It clearly indicates that dietary and farm diversity does vary in across individuals, households characteristics and factor endowments and hence investigating these covariates along with farm diversity on dietary diversity is an important.

In order to understand the effect of farm diversity on dietary diversity, we examined the correlation among dietary and farm diversity. The dietary diversity score strongly correlated with crop count ($P<0.0001$) but not with Simpson's Index (Table 3). However, crop count and Simpson's Index are strongly correlated with each other with a measured correlation matrix of efficient 0.62. Further we also estimated a bivariate regression to test the relationship between dietary diversity and farm diversity in two different measures (Table 4). Results indicate that dietary diversity is significantly and positively influenced by crop count but did not show a significant impact with the Simpson's Index as it refers number of crops and also distribution of area cultivated under various crops. It indicates that dietary diversity can be increased by increasing number of crops rather than evenly distribution of area under those crops might not be an issue.

In addition, we have used multiple linear regression model to control the effect of other covariates on dietary diversity in order to capture the net effect of farm diversity (Table 5). To this end, two different models on the effect of farm diversity on dietary diversity were estimated. The first model, we examined the effect of crop count on dietary diversity by controlling for other covariates. In model 2, we replaced the independent variable, Simpson's Index with crop count. Both crop count and Simpson's index were not significantly associated with dietary diversity after controlling other covariates in the both models. There are other covariates which includes individual, household characteristics and factor endowments. Variables such as number of people lives in the households, monthly per capita expenditure on food, Net cultivated under irrigated area for all crops, proportion of total vegetable consumed from own production and decision making and control of income by female headed households have strong influence on dietary diversity.

These variables positively and significantly influenced dietary diversity in both models 1 and 2 at less than 5 percent probability level. Given that illiteracy negatively and significantly influenced a farmer's dietary diversity, it presupposes that when a farmer receives better education, his/her dietary diversity score would increase. In addition, the district dummies did not shown significant impact on dietary diversity at the 5 percent probability level, but did at the 10 percent probability level. Particularly farmers located in the Babati district have higher dietary diversity compared to farmers located in Kongwa district. We also explored an interaction effect among selected independent variables such as female decision making and level of education. Among first and second model, we have classified into two category with and without interaction effect. After we introduced interaction effect between level of education and female decision making at home in the model, interaction variable found to be highly statistically significant relationship with dietary diversity, but level of education turns out to be insignificant which implies role of female in the decision making along with her level of education plays important role on dietary diversity.

Furthermore, we have examined the association between farm diversity and specific food group category consumed by households using multiple linear regression function (Table 6). Two models were estimated whereby crop count and Simpson's Index were considered as dependent variables in two different models. Among the two estimated models, crop count model got a better goodness of fit in comparison with the Simpson's Index following an evaluation of the R-square and other model statistics. As part of the field survey, the frequency of specific group of food consumed in a 7 day re-call period by households was also been collected. The group of food item included maize, rice, exotic vegetables, traditional vegetables, fruits, legumes, meat and meat products and milk. A regression analysis was also conducted on this data accordingly to estimate its causal linkages with farm diversity. Results indicate that maize and rice have positive and significant relationship with farm diversity at the 5 per cent probability level, whereas, other food group items such as vegetables and meat product does not show any significant relationship with it.

IV Discussion

The Pearson-correlation matrix shows that crop count significantly correlated with dietary diversity, whereas Simpson's Index was not correlated. Further we examined the relationship between farm and dietary diversity by using a bivariate model. The bivariate model also showed similar results. But these bivariate model does not control other covariates and hence we measured the effect of farm diversity on dietary diversity by controlling for other possible confounding factors such as individual, household characteristics and factor endowments. After controlling for the other covariates, farm diversity did not have a significant association with dietary diversity. However, other covariates showed strong association with dietary diversity. For example, household size has a strong relationship with dietary diversity. Household size was measured through simple count of household members. Level of education also has a strong influence on dietary diversity. It indicates that dietary diversity of households can be increased by improving farmers' level of education. Monthly per capita expenditure on food is positively associated with dietary diversity. If households have greater expenditure on food, it leads to higher diversification in their diet as well. Net cultivated area under irrigated has positive relationship with dietary diversity. This implies that irrigated area can be a proxy for farmers who have productive land with irrigation facilities considered to be more endowed with land and water resources suitable to enhance crop productivity. Typically in the study locale, large number of farmers particularly smallholders depend on unirrigated lands, whereas large farm-scale farmers have access to irrigation and hence one can hypotheses that those who cultivate their crops under irrigation area are considered to be more resource endowed and can cultivate more crops and diversify their income sources. Therefore, farmers who cultivate their crop under irrigation are more likely to have positive relationship with dietary diversity. Control over income by female farmers have positive effect on dietary diversity. It clearly shows that when women at home control over income and make decisions, they will have a much better tendency to increase their dietary diversity. Our results are not in conformity with those found by some other authors (Jones et al 2014; Herforth, 2013) who have studied the relationship between these two constructs. The divergent results may be attributed to the observance of a non-significant constant error term in our model in our attempt towards the development of a more robust model specification.

In spite of the interesting findings of this study, it was worth mentioning a couple of limitations such as seasonal effect on dietary diversity and limited sample size. For example Keding et al, 2012; Keding, 2010; Keding, 2007) shown evidence that dietary diversity influenced by farm diversity in different crop seasons.

V **Conclusion and Policy Considerations**

This paper ascertain if an increased diversity of crops in farmers' fields leads to increased diversified diets or otherwise. We conclude that crop diversity does not influences dietary diversity in our study region by controlling other covariates in the multiple linear regression model. It clearly indicates that except crop diversity, there are other variables have strong effect on dietary diversity in farm households in our study regions. First, most importantly, proposition of total vegetable consumed from own production determines the dietary diversity significantly. The possible reasons behind, farmers might be particular about quality and preference of the vegetables that they consumed. They are assured about their quality as it is produced by them and also they can have on their own choice. It might allow them to get more varieties of vegetables and also better quality as well. Second, decision making by female where female have control over income to spend influences dietary diversity significantly. We also found that if female decision makers have better education, their dietary diversity is better than that of female decision makers with lower level of education. Third, we also found that farmers those who cultivate their crop under irrigated area have better dietary diversity as they do have access to water and land which can provide better yield. Finally, household size and monthly per capita expenditure also influences dietary diversity positively. In sum, first, vegetable production for own consumption must be encouraged. Second, level of education needs to be improved particularly women farmers who will be acting as a decision makers at home. Finally, access to irrigation needs to be improved.

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Table 1: Sample Distribution by Region and District

Region/District	Babati	Kiteto	Kongwa	Total
Regions				
Manyara	120	90	0	210
Dodoma	0	0	90	90
Total	120	90	90	300

Table 2: Dietary Diversity, Crop Count and Simpson's Index by Various Covariates

		Farm Diveristy	
Indicators	**Dietary Diversity**	**Crop Count**	**Simpson's Index**
Overall	7.3 (2.3)	3.3 (1.8)	0.5 (0.2)
By District			
Babati (base)	7.6 (2.3)	3.1 (1.5)	0.5 (0.2)
Kiteto	7.2 (2.1)	3.1 (1.3)	0.4 (0.2)
Kongwa	6.8* (2.2)	3.8* (2.5)	0.5 (0.2)
By Monthly Per Capita Expenditure Tercile			
Low (base)	6.5 (2.3)	2.9 (1.2)	0.5 (0.2)
Middle	7.3* (1.9)	3.4* (1.6)	0.5 (0.2)
High	7.8* (2.3)	3.6* (2.3)	0.5 (0.2)
By Monthly Per Capita Food Expenditure Tercile			
Low (base)	6.5 (2.3)	3.1 (1.6)	0.46 (0.2)
Middle	7.3* (2.2)	3.1 (1.3)	0.47 (0.2)
High	8.0* (2.0)	3.8* (2.3)	0.50 (0.2)
By Monthly Per Capita non Food Expenditure Tercile			
Low (base)	6.7 (2.5)	3.0 (1.3)	0.45 (0.2)
Middle	7.9*** (1.8)	3.5** (2.1)	0.48 (0.2)
High	7.8* (2.3)	3.5** (1.8)	0.50 (0.2)
By Age Group of Respondent			
0-35 years (base)	7.0 (1.9)	3.3 (1.7)	0.5 (0.2)
35-50 years	7.5** (2.2)	3.4 (1.8)	0.5 (0.2)

50 above	6.9 (2.6)	3.2 (1.9)	0.4 (0.3)
By Level of Education			
Illiterate (0 years) (base)	5.7 (3.2)	3.5 (1.6)	0.5 (0.2)
Primary Level (1-5 years)	8.1* (2.3)	4.7 (3.6)	0.5 (0.3)
Secondary Level (5-10)	7.2* (2.1)	3.2 (1.4)	0.5 (0.2)
Higher and Above (10 above)	8.1* (2.6)	3.3 (2.0)	0.4 (0.2)
By Decision Making			
Head Only	7.5** (2.3)	3.3 (1.7)	0.5 (0.2)
All Family Members (base)	7.1 (2.3)	3.3 (1.9)	0.5 (0.2)
By Gender and Decision Making			
Female Head	7.7 (2.1)	2.9 (1.1)	0.4** (0.2)
Male Head (base)	7.2 (2.3)	3.3 (1.9)	0. 5 (0.2)
By Farm Size			
Marginal Farm (0-1 ha) (base)	7.5 (2.6)	3.0 (1.2)	0.5 (0.2)
Small Farm (1-2 ha)	7.3 (2.1)	3.4 (2.2)	0.5 (0.2)
Medium Farm (2-4 ha)	6.9 (1.8)	3.5 (1.5)	0.5 (0.2)
Large Farm (4 ha above)	7.5 (2.5)	3.3 (1.8)	0.5 (0.2)

* $p<0.01$, ** $p<0.05$, *** $p<0.10$

Table 3: Correlation Matrix between Household Dietary Diversity (HDDS) and Farm Diversity (Crop Count; Simpson's Index)

Variables	HDDS	SI	Crop Count
HDDS	1		
SI	0.0195	1	
Crop Count	0.1417*	0.6157*	1

Table 4: Bivariate Regression between Household Dietary Diversity and Farm Diversity

VARIABLES	(1) Dietary Diversity	(2) Dietary Diversity
Crop Count	0.177**	
	(2.471)	
Simpson’s Index (SI)		0.197
		(0.336)
Constant	6.669***	7.162***
	(24.63)	(23.07)
Observations	300	300
R-squared	0.02	0.02

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Multiple Linear Regression Functions: The effect of Farm Diversity on Dietary Diversity

VARIABLES	(1) Dietary Diversity 1-Without Interaction Effect	(2) Dietary Diversity 1-With Interaction Effect	(3) Dietary Diversity 2-Without Interaction Effect	(4) Dietary Diversity 2-With Interaction Effect
Crop Count	0.0926	0.112		
	(1.236)	(1.516)		
Simpson's Index			-0.272	-0.0674
			(-0.474)	(-0.119)
Female (Dummy: Female=1, Male=0)	-0.483	-2.356**	-0.523	-2.353**
	(-1.285)	(-2.318)	(-1.393)	(-2.301)
Age (years)	-0.0151	-0.0126	-0.0174	-0.0145
	(-1.102)	(-0.934)	(-1.261)	(-1.066)
Household Size (N)	0.144**	0.132**	0.147**	0.135**
	(2.293)	(2.122)	(2.330)	(2.160)
Decision by Head of Household Only (Dummy)	0.186	0.154	0.181	0.147
	(0.613)	(0.511)	(0.595)	(0.486)
Education – Illiterate (Dummy)	-1.703**	-1.049	-1.699**	-1.061
	(-2.501)	(-1.406)	(-2.490)	(-1.415)
Kiteto District	0.192	0.0924	0.0978	-0.00781
	(0.544)	(0.266)	(0.279)	(-0.0226)
Babati District	0.502	0.404	0.435	0.318
	(1.510)	(1.233)	(1.324)	(0.981)
Net Operated Area (Ha)	0.0108	0.0180	0.0120	0.0178
	(0.387)	(0.656)	(0.427)	(0.645)

Ln Per Capita Monthly Food Expenditure	0.760***	0.745***	0.770***	0.754***
	(4.722)	(4.712)	(4.772)	(4.746)
Ln Per Capita Monthly non-food Expenditure	0.0989	0.0856	0.122	0.116
	(0.744)	(0.652)	(0.928)	(0.887)
Net Operated Irrigated Area (Ha)	0.794**	0.702**	0.835***	0.746**
	(2.568)	(2.314)	(2.700)	(2.456)
Proportion of total veg consumed from own production	0.0707***	0.0671***	0.0696***	0.0669***
	(3.600)	(3.490)	(3.509)	(3.437)
Female Decision Maker	1.113**	1.266**	1.089*	1.253**
	(2.018)	(2.327)	(1.966)	(2.287)
Interaction Effect: Female & Level of Education		0.271*		0.264*
		(1.964)		(1.897)
Constant	-2.410	-2.196	-2.187	-2.072
	(-1.250)	(-1.165)	(-1.119)	(-1.083)
Observations	282	278	282	278
R-squared	0.226	0.232	0.222	0.225

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Associations between farm diversity and consumption of specific food groups

	(1)	(2)
VARIABLES	Crop Count	Simpson's Index
Maize	0.155***	0.00908*
	(4.351)	(1.867)
Rice	0.270***	0.0217**
	(3.418)	(2.006)
Exotic vegetables	0.0136	0.00807*
	(0.383)	(1.658)
Traditional Vegetables	0.0267	-0.00310
	(0.674)	(-0.572)
Fruits	-0.00256	0.00464
	(-0.0493)	(0.652)
Legumes	-0.0141	0.000217
	(-0.310)	(0.0349)
Meat and meat products	0.0208	0.00177
	(0.240)	(0.149)
Milk	0.0140	-0.00160
	(0.487)	(-0.407)
Constant	1.425***	0.352***
	(6.199)	(11.19)
Observations	300	300
R-squared	0.256	0.070

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A

No.	Food Group **(mention code from Qn.no)**	Examples
1	Cereals	corn/maize, rice, wheat, sorghum, millet or any other grains or food made from these (e.g. bread, noodles, porridge or other grain products)+insert local foods i.e. *ugali, porridge or paste*
2	White Roots & Tubers	white potatoes, white yam, white cassava, or other foods made from roots
3	Vitamin A Rich Veg & Tubers	pumpkin, carrot, squash, or sweet potato, that are orange inside + other locally available vitamin A rich vegetables (e.g. red sweet pepper)
4	Dark Green Leafy Veg	dark green leafy veg, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach
5	Other Veg	other veg. (e.g. tomato, onion, eggplant)+other locally available veg
6	Vitamin A Rich Fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A rich fruits
7	Other Fruits	other fruits, including wild fruits and 100% fruit juice made from these
8	Organ Meat	liver, kidney, heart or other organ meats or blood-based foods
9	Flesh Meats	beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects
10	Eggs	eggs from chicken, duck, guinea fowl or any other egg
11	Fish & Seafood	fresh or dried fish or shellfish
12	Legumes, Nuts & Seeds	dried beans, dried peas, lentils, nuts, seeds, or foods made from these (e.g., hummus, peanut butter)
13	Milk & Milk Product	milk, cheese, yogurt or other milk products
14	Oils & Fats	oil, fats or butter added to food or used for cooking
15	Sweets	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes
16	Spices, Condiments, Beverages	spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages