



2018-01

## Structural Transformation of African Agriculture and Rural Spaces

### Diversify more or less? Household resilience and food security in rural Nigeria

Sènakpon F. A. Dedehouanou  
John McPeak



partnership for  
economic  
policy

pep



# Diversify more or less? Household resilience and food security in rural Nigeria

## Abstract

We provide new findings of rural livelihood diversification in Nigeria, using panel data from the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). To a large extent, the patterns and the implications of livelihood diversification have been analysed using cross sectional data and a narrow definition of food security in previous studies. In some cases, analysis has been conducted in the absence of shock experiences. We find that some results about the determinants of income diversification in cross sectional analysis also hold true in the panel data setting, while others are only revealed due to the panel nature of the data set. We find that the relationship between wealth and income diversification in rural Nigeria is best categorized as upward sloping with diminishing marginal effect rather than a U shape or an inverted U shape as found in previous studies. We also find that income diversification favours food accessibility, food availability and food utilisation, and therefore resilience capacities overall. We do not find any evidence of income diversification in mitigating or aggravating the impact of shocks, as shock experiences appear to negatively affect food security in spite of income diversification.

**Keywords:** Rural household, Livelihood diversification, Food security, Shocks, Nigeria.

## Authors

**Sènakpon F. A. Dedehouanou**

Faculty of Economics,  
University of Abomey Calavi (UAC),  
Cotonou, Benin

**John McPeak**

Department of Public Administration and  
International Affairs, Syracuse University,  
New York, United States

## Acknowledgements

This working paper is based on the PEP-Structural Transformation of African Agriculture and Rural Spaces 'STAARS' Project-05, carried out with financial support from the Government of Canada through the International Development Research Centre (IDRC). Other partners of the STAARS consortium include the African Development Bank (AfDB), the African Economic Research Consortium (AERC), the CGIAR Research Program on Policies, Institutions and Markets (PIM), Cornell University and the World Bank. PEP receives core funding from the Department for International Development (DFID) of the United Kingdom (or UK Aid) and the IDRC.

The authors gratefully acknowledge funding support from the International Food Policy Research Institute under the CGIAR Research Program on Policies, Institutions and Markets.

## Table of contents

<b>I.</b>	<b>Introduction</b>	<b>p.1</b>
<b>II.</b>	<b>Data and definition of food security indicators</b>	<b>p.3</b>
<b>III.</b>	<b>Patterns and dynamics of livelihood diversification strategies in rural Nigeria</b>	<b>p.5</b>
<b>IV.</b>	<b>Methodology</b>	<b>p.11</b>
<b>V.</b>	<b>Results and discussion</b>	<b>p.14</b>
<b>VI.</b>	<b>Conclusions</b>	<b>p.24</b>
	References	p.26
	Appendix	p.29

## Tables and figures

Table 1: Descriptive statistics on food security indicators	p.4
Table 2: Transition probabilities in income sources for rural households (%)	p.7
Table 3: Initial capital endowments by income diversification transition between survey waves	p.10
Table 4: Regression results of determinant of income diversification	p.15
Table 5: Income diversification and food security indicators: regression results	p.17
Table 6: Income diversification and composite measures of food security indicators	p.21
Table 7: Income diversification transitions and food security - nearest-neighbor matching	p.23
Figure 1: Distribution of total household revenue by income sources in rural Nigeria	p.6

## I. Introduction

In recent years, rural livelihood diversification has become an important policy issue and this is reflected in the increasing attention it has gained in reports and scholarly articles. Most of the farm households in rural sub-Saharan Africa are involved in a form of non-farm activity as part of a rural livelihood strategy to diversify income sources (Webb, 2001). The literature mentions diversification of the income generation strategies of households as an important adaptation strategy for risk coping and risk management (Ellis, 2000; Murata & Miyazaki, 2014). Barrett, Reardon and Webb (2001) highlight the importance of analysing diversification behavior or household's livelihood strategies that may guide effective policies interventions in alleviating rural poverty and vulnerability. Empirical studies in developing countries have intensively analyzed the determinants of diversification under several forms and identified their effects on household well-being. Yet the form of diversification strategy in rural areas identified by most studies is defined through categorical variables representing households' participation in any non-farm income activities. Loison (2015) presents a review of the literature and indicates that studies show mixed findings about the causes and consequences of rural smallholders practicing livelihood diversification in sub-Saharan Africa.

This paper presents new evidence on the determinants of livelihood diversification and the relationship between diversification and food security in rural Nigeria. The motivations of the paper are as follows. First, a brief review of the data collected by the Nigeria National Bureau of Statistics as part of the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA 2010) – revealed that diversification of income sources is a norm in rural Nigeria. Four out of five rural households are engaged in some agricultural activity yet tend to be involved in other activities as well. About 60% of the agricultural households also have a non-farm enterprise, and 20% of them have at least one member that reports some wage employment. This raises the question of whether the degree or the level of diversification matters in rural households' livelihood strategy or not. We use a continuous definition of diversification and we construct an income diversification index that encompasses both the magnitude and the number of income sources. Dimova and Sen (2010) stress the

appropriateness of using household income diversification – as opposite to discrete indicator variables for different types of income portfolios - as it makes no assumption that a higher degree of diversification is necessarily related to greater household engagement in more remunerative non-farm activities.

Second, previous cross sectional studies have analysed either the determinants of household income diversification or the relation between diversification and household incomes or poverty reduction, in rural Nigeria (Babatunde & Quaim, 2009; Awotide, Awoyemi, Diagne, Kinkingnihoun & Ojehomone, 2012; Oluwatusin & Sekumade, 2016). These studies deal with the potential endogeneity of diversification through econometric methods. Yet the cross sectional nature of the data limits the ability to disentangle household innate characteristics such as attitudes to risk from other household observable characteristics (Dimova & Sen, 2010). We take advantage of the large panel dimension of our data that allows us to account for unobserved household level heterogeneities.

Third, there is mixed empirical evidence on the relationship between income diversification and income, or wealth level. Research findings from Indonesia present evidence showing that rural income diversification is higher among poorer compared to richer households (Schwarze & Zeller, 2005). The opposite has been observed in Mali and Ethiopia (Abdulai & Crolerees, 2001; Block & Webb, 2001). In this paper, we investigate the pattern of the relationship between income diversification and wealth. We use a quadratic specification to investigate whether a U-shaped, an inverse U-shaped, or other pattern for income diversification exists over the range of wealth in the case of rural households in Nigeria. The scarce literature on this issue for sub-Saharan countries leaves the nature of this relationship as an open empirical question to be tested (Loison, 2015).

Lastly, we also add to the literature by examining the association between income diversification and different food security indicators, and the capacity of income diversification for mitigating the impact of shocks to food security. We complement the analysis by examining the relationship between income diversification transitions into higher and lower levels and food security. Few studies on income diversification that have used panel data have focused on

household calorie consumption or households' consumption expenditure (Block & Webb, 2001; Bezu, Barrett & Holden, 2012). We account for different dimensions of food security with regard to the dynamics of income diversification. We argue that our empirical approach to the question of income diversification will help develop further insights into the interaction between livelihood diversification and household food security in sub-Saharan countries.

## **II. Data and definition of food security indicators**

We use data from the 2010-2011 and 2012-2013 GHS-Panel Surveys implemented by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank. These are panel surveys carried out under the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project in Sub-Saharan Africa. About 4,700 households in rural and in urban areas were interviewed in the first round and resurveyed in the second round. The sample is representative at the national level as well as at the urban and rural levels. In this paper, we use the sample of rural households. After removing observations with missing values, we finally consider a total of 5,858 observations, making a balanced panel of 2,929 rural households for each of the two survey rounds.

The survey included three instruments: the household questionnaire, the agriculture questionnaire, and the community questionnaire. The different modules of the questionnaires contain information on socio-demographic characteristics of the households, the different types of economic activities, and other information that allow the calculation of the variables used in this study. Particularly relevant in this study are variables related to household income sources and indicators of food security. Income related information allows us to investigate the degree of diversity in the income generation profile for each household interviewed.

The measurement of food security has been developed and extensively discussed in the literature. It has been argued that availability, access, utilization, and stability are now widely accepted as the four pillars of food security (Upton, Cissé & Barrett, 2016). We use primarily four indicators to capture these first three pillars of food security (see Table 1). The first

indicator captures the sense of food accessibility: this is a measure of per capita food expenditures. The second indicator uses the definition of food availability in terms of quality: the nutrient stock defined as the number of days the household reported it had to limit the variety of food eaten in the seven days prior to the survey. The third indicator uses the definition of food availability in terms of quantity: the nutrient stock defined as the number of days the household had to limit portion size at meal times in the seven days prior to the survey. The last indicator uses the definition of food utilization: the dietary diversity defined as the number of different food group categories consumed by households in the seven days prior to the survey<sup>1</sup>. Table 1 shows that there are significant differences between the two rounds in food accessibility and food availability. In the econometric analysis, we include year dummies in the model to account for some events that may occur in the second wave to cause these differences. In addition, we consider two alternative composite measures of food security indicators.

**Table 1: Descriptive statistics on food security indicators**

<b>Pooled (waves 1 and 2 of survey)</b>	<b>Obs.</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
Annual Food expenditures p.c. (10,000 Naira)	5,778	8.125	7.15	0.087	113.576
Dietary diversity (number of food groups)	5,829	7.583	1.989	1	11
Nutrient stock (quality) – days	5,858	0.742	1.415	0	7
Nutrient stock (quantity) – days	5,858	0.493	1.15	0	7
<i>Wave 1 (2010/2011)</i>					
Annual Food expenditures p.c. (10,000 Naira)	2,869	8.933	7.634	0.112	96.22
Dietary diversity (number of food groups)	2,902	7.654	2.034	1	11
Nutrient stock (quality) – days	2,929	0.555	1.196	0	7
Nutrient stock (quantity) – days	2,929	0.354	0.95	0	7
<i>Wave 2 (2012/2013)</i>					
Annual Food expenditures p.c. (10,000 Naira)	2,909	7.328	6.542	0.087	113.576
Dietary diversity (number of food groups)	2,927	7.514	1.942	1	11
Nutrient stock (quality) - days	2,929	0.93	1.583	0	7

<sup>1</sup> Food availability, food accessibility and food utilization are three interlinked dimensions of the food and nutrition status of a household. Food availability is a measure of the amount of food physically available for households. Household-level food accessibility is realized when a household has the opportunity to obtain sufficient food quantity and quality. In addition to the quantity of food, food utilization also includes the quality of the diet. Food accessibility is a necessary but not a sufficient condition to ensure an adequate food and nutrition status while the realization of food availability is a necessary but not sufficient condition for the realization of food access (see Pieters, Guariso & Vandeplass, 2013).

Nutrient stock (quantity) - days	2,929	0.632	1.307	0	7
----------------------------------	-------	-------	-------	---	---

Note. 1 US Dollar = 156.15 Nigerian Nairas (at the end of 2012) and 152.25 Nigerian Nairas (at the end of 2010).

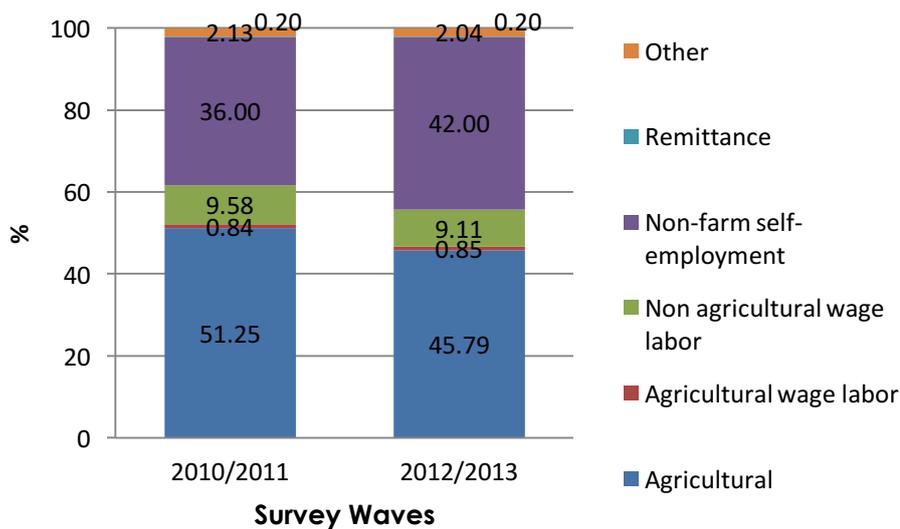
Source. Authors' calculations using LSMS-ISA data for Nigeria.

### III. Patterns and dynamics of livelihood diversification strategies in rural Nigeria

For the most part, rural households in our sample derive their income from combining agricultural activities with other non-agricultural activities. Income generating activities were calculated using a sectoral classification - agriculture and non-agriculture - and a functional classification - wage and self-employment (Barrett et al., 2001). Income generating activities are thus categorized as being either, agricultural self-employment, agricultural wage, non-agricultural wage, or off-farm self-employment. Agricultural self-employment income is calculated as the revenue minus the costs from cultivation and livestock keeping. The total revenue is the sum of the revenues from the commodities harvested and revenues from the sale of animals, meat or animal products. Agricultural costs consist of costs related to hired labor, agricultural inputs (fertilizer, pesticide, seeds, transports, tractor service, maintenance, and other) and animal costs. Some households in the sample also derive their income, in total or in part, from sources other than income generating activities. These are incomes from international remittances and other income from property rental, interest bearing savings accounts, or other returns on investment. Total household income is adjusted using a consumer price index (2010=100) to make information from the two rounds of the data directly commensurable. Note that about 15% of households in our sample had a negative total income after the imputation of costs for non-labor income generating activities. As such, we use the measure of total revenue instead of total income to compute diversification. This is commonly done in the literature when confronting the issue of negative net income. In our case, negative net income data points render the diversification index non-interpretable which can be avoided by using revenue data instead.

The general trend stemming from the data shows that households were intensively involved in agricultural production such as growing crops and maintaining livestock, complemented mostly with off-farm activities such as self-employment and non-agricultural wage employment (see Figure 1). Remittances and agricultural wage labor are present, but not as a particularly high share of the overall income generation profile<sup>2</sup>. However, none of the rural households in our sample derived their income from all six sources represented in Figure 1. The maximum number of income sources observed in our sample was five. For the 2,929 households considered in the first wave (second wave) of the survey, 44.21% (37.49%) relied on one source of income only, followed by 43.80% (50.73%) that relied on two income sources, and 11.99% (11.78%) that relied on more than two income sources.

**Figure 1: Distribution of total household revenue by income sources in rural Nigeria**



*Note.* Other means revenue from property rental, interest bearing savings account, or other returns on investment.

Another observation from the data is that, irrespective of the survey round, agriculture is the dominant source of income for households that reported only one income source. Irrespective of the survey round, at least 74% of these one-income households were exclusively

<sup>2</sup> Note that the question in the survey asked for international remittances, so we are unable to investigate the importance of domestic remittances.

focused on agricultural activities in contrast to at least 19% and 4% who respectively reported all their income from self-employment and non-agricultural labor. For households reporting two sources of income, the dominant pattern was agricultural income that was complemented by self-employment (at least 75% of households, irrespective of the survey round). The next most common two-income strategy revealed by the data was agriculture complemented by non-agricultural labor (at least 7% of households). This is followed by the combination of self-employment with non-agricultural labor (at least 6% of households).

The dynamics of rural household livelihood strategies can also be observed in our data. Table 2 shows the transition probabilities of income sources between survey rounds. For example, of the 1,238 households deriving income from one source in the first wave, 36% and 4% of them moved to two and three income sources in the second wave, respectively. At least 10% of the 1,083 households deriving income from two sources in the first wave moved to an additional income source in the second wave, but 32% fell into the group of a single income based source in the second wave. Similar transitions can be observed for the other income diversification categories. In general, Table 1 reveals that while at lower levels of diversification the majority stayed at the same level of diversification over the two rounds, a significant share of households changed their level of income diversification from wave 1 to wave 2.

**Table 2. Transition probabilities in income sources for rural households (%)**

Number of income sources: wave 2 (2012/2013)

<b>Number of income sources: wave 1 (2010/2011)</b>	<b>1 income source</b>	<b>2 income sources</b>	<b>3 income sources</b>	<b>&gt; 3 income sources</b>	<b>Total (N) %=100</b>
1 income source	60.77	34.52	4.32	0.39	1,295
2 income sources	20.34	67.58	11.22	0.86	1,283
3 income sources	15.82	50.17	29.29	4.71	297
> 3 income sources	5.56	42.59	27.78	24.07	54
Total (N)	1,098	1,486	302	43	2,929

Source: Authors' calculations using LSMS-ISA data for Nigeria.

We complement the analysis of the patterns and the dynamics of rural household livelihood strategies in rural Nigeria by using an indicator that captures dimensions of both the

distribution of income earning from different sources and the number of the income sources (Barrett & Reardon, 2000). We calculate the normalized Herfindahl-Simpson income diversification index ( $D_i$ ) that equals one minus the normalized Herfindahl-Simpson concentration index<sup>3</sup>:

$$D_i = 1 - \frac{\sum_1^N Sh_i^2 - \frac{1}{N}}{1 - \frac{1}{N}}, \quad 0 \leq D_i \leq 1 \quad (1)$$

$N$  is the total number of income sources as defined in Figure 1 and  $Sh$  represents the revenue share of the  $k$ -th income source for household  $i$ . As highlighted above, we use the measure of total revenue to address the issue of negative income. Dependence on a single income source falls to the minimal value of zero and full diversification of income to the maximal value approaches one. The income diversification index we calculate from our sample ranges between 0 and 0.87 with mean 0.23 and median 0.14, indicating that households tend to be relatively concentrated in their sources of income. A similar value of income diversification is found by Oluwatusin and Sekumade (2016) in South Western Nigeria.

Diversification patterns are argued to be an exchange and allocation of assets across activities by a household to achieve an optimal balance between expected returns and risk exposure, conditional on the constraints they face (Barrett et al., 2001). It has also been found that initial asset holdings are important factors for transition into high-return rural non-farm employment (Bezu & Barrett, 2012). In this paper, we identify three different rural household livelihood strategies as per the transition of the income diversification index between the two survey waves. The first group of households are those that stayed at the same level of the income diversification index in both waves 1 and 2 of the survey. The second group consists of those who moved to a lower level of the income diversification index in wave 2 than their level in wave 1. The third group moved to a higher level of the income diversification index in the second wave than their level in wave 1. In contrast to the transitions presented in Table 2, this

---

<sup>3</sup> The Herfindahl-Simpson index normalized by the number of activities compensates for the effect of evenness and dominance.

measure of transitions in the income diversification index accounts not only for changes in the number of income sources, but also for changes in revenue earned from these sources.

In Table 3 we present descriptive statistics for the three groups of the households defined above according to their initial capital endowments as well as the shocks experienced in the first survey round. Human capital and relative labor endowments are reflected in age, the number of laborers, education, dependency ratio, and size of the household. A further relevant factor to consider is the gender of the household head. Physical capital endowments are agricultural landholdings, livestock endowments, and household non-agricultural wealth index. Shocks are self-reported dummy variables indicating whether the household experienced negative events during the last two years prior to the survey; in this case, that is shocks experienced in 2010 and 2011. We differentiate the shocks into idiosyncratic shocks, price shocks, and natural shocks. Idiosyncratic shocks are related to events such as illness, death of a family member, or loss of employment. Price shocks are unexpected price changes of food prices, input prices, and output prices. Natural shocks are natural disasters such as floods, droughts, or pests, non-farm business failure, theft of crops, cash, livestock or other property, or destruction of harvest by fire. These natural shocks are more likely to impact agricultural and livestock production than non-farm business.

**Table 3 : Initial capital endowments by income diversification transition between survey waves**

	Total sample (2,929)		Income diversification level: transition from wave 1 to wave 2							
			Stay in the same level (787)		Move to a lower level (976)		Move to a higher level (1,166)			
Initial capital endowments (wave 1)	Mean	SE	Mean	SE	Mean	SE		Mean	SE	
Size of household	6.197	0.06	5.323	0.12	6.508	0.11	***	6.5	0.1	***
Age of household head	49.73	0.32	51.34	0.68	48.75	0.52	***	49.5	0.49	**
Number of labourers	3.044	0.04	2.632	0.07	3.233	0.06	***	3.153	0.06	***
Dependency ratio	1.148	0.02	1.084	0.04	1.133	0.03		1.201	0.03	**
Female-headed HH	13%	0.01	20%	0.02	10%	0.01	***	10%	0.01	***
Years of education of the HH head	4.281	0.11	3.122	0.19	5.099	0.2	***	4.359	0.18	***
Average years of education of the HH	3.117	0.07	2.66	0.13	3.432	0.13	***	3.154	0.11	***
Farm size (ha)	1.254	0.24	0.934	0.13	1.137	0.14		1.551	0.58	
Per capita landholdings (ha)	0.562	0.22	0.298	0.04	0.352	0.05		0.896	0.54	
Units of livestock	3.797	0.24	3.843	0.42	4.061	0.48		3.556	0.35	
(HH non-agricultural) wealth index	-0.63	0.04	-1.21	0.06	-0.36	0.07	***	-0.47	0.08	***
Idio_shock	8%	0.01	9%	0.01	7%	0.01		7%	0.01	
Nature_shock	10%	0.01	9%	0.01	11%	0.01		11%	0.01	
Price_shock	5%	0	5%	0.01	5%	0.01		5%	0.01	

Note. The wealth index is measured as the first principal component of indicators of household asset variables such as vehicles, home characteristics, furniture, and household appliances (see Filmer & Pritchett, 2001). The dependency ratio of dependents to labourers is measured as the number of household members aged 15 or below or above 64, divided by the number of household members aged between 15 and 64.

SE is standard error obtained after mean estimation. Significant mean differences are indicated with \*\*\* p<0.01, \*\* p<0.05, \* p<0.10. The reference category is: Stay in the same level.

Source: Authors' calculations using LSMS-ISA data for Nigeria.

Table 3 presents the average values of the initial endowment and shock experiences overall and then according to groups of households. Comparisons are made using mean comparison tests. The reference group is the group of households that maintained the same level of income diversification index between the two survey waves. Table 3 shows that all groups of households share the same characteristics in terms of initial endowments concerning the livestock units, farm size and experience with different shocks. Yet some significant initial endowment differences still exist between the groups of households.

Compared to households that stayed at the same level of income diversification, the heads of households that moved into a lower or a higher level of income diversification in the second survey wave were younger. Female-headed households were less likely to change strategies than male-headed households, perhaps indicating that gender role constraints make diversification options more rigid for women. On average, both types of household that moved from one level to another had relatively larger initial human capital endowments, compared to households that stayed in the same level of income diversification. They had a significantly higher initial number of members and workers, and initially had more educated members. Regarding initial physical capital, movers were only more initially endowed in terms of non-agricultural wealth. In general, the group of households that moved in a lower and a higher level of income diversification seem to be relatively homogenous in terms of initial human capital endowments in comparison to households that stayed in the same level of income diversification. All types of households were homogenous in terms of initial physical capital endowments and shock experiences, except for non-agricultural wealth.

#### **IV. Methodology**

To begin our regression analysis, we first examine explanatory factors associated with income diversification in rural Nigeria by estimating the following model:

$$\begin{aligned}
Income\_diversification_{ht} = & + \beta_1 Wealth_{ht} \\
& + \beta_2 Wealth\ square_{ht} \quad (1) \\
& + X_{ht} + T + u_h + e_{ht}
\end{aligned}$$

where  $T$  is the time fixed-effect for the survey round.  $u_h$  is the household ( $h$ ) random effect and  $e_{ht}$ , the error term. Control variables included in  $X$  are those commonly used in income diversification literature and are observable covariates that might affect the household livelihood diversification strategies in the year  $t$ . These variables are human capital endowments, idiosyncratic factors and community related variables controlling for household access to resources (reported more fully in Table A1 in the appendix). Regional dummies are also included in  $X$  matrix to account for environmental or geographic conditions. The dependent variable is the normalized Herfindahl-Simpson income diversification index defined above.

We are particularly interested in testing the relationship between income diversification and wealth, as an inverted U-shape has been identified in the literature where diversification is a risk coping strategy for the poorer and a risk management strategy for the wealthier. However, as previously discussed, it has also been found that a U-shape could characterize this relationship, where the poor are too constrained to diversify, the middle of the wealth distribution diversify, and the wealthy specialize. We use the variable wealth and its square instead of household income to reduce the measurement error bias from the income, and also because of the permanent and ex ante nature of wealth that is less subject to endogeneity than income (Barrett & Reardon, 2000; Sahn & Stifel, 2003; Démurger, Fournier & Yang, 2010). The wealth variable is measured as an index that is the first principal component of indicators of household asset variables such as vehicles, home characteristics, furniture, and household appliances (see Filmer & Pritchett, 2001).

We use a random-effects tobit estimation to account for the censored nature at zero of the income diversification index, as a large share of the sample is completely concentrated in one income source. In addition, we apply the Mundlak transformation (Mundlak, 1978) to the

random-effects tobit regression, to account for the potential endogeneity of wealth. This method allows for correlation between the household random effect  $u_h$  and this independent variable by including an additional covariate in the model (1); that is, the mean of the wealth variable and its square across each year, that is:

$$u_h = \varphi \bar{Y}_l + v_h \quad (2)$$

The individual random effect  $u_h$  is a function of a component that is correlated to the potentially endogenous variables  $Y$  – wealth and its square – and a pure error term  $v_h$  that is not correlated to the explanatory variables.  $\bar{Y}_l$  is the average of  $Y_l$  across the time and the coefficient  $\varphi$  is the statistical correlation corrector factor.

Following this analysis, we are also interested in exploring the impact of income diversification on household food security. Given that there may be different ways of interpreting why households adopt different income generating profiles, we seek to identify different kinds of food security outcomes that are associated with different diversification profiles. We estimate the impact of income diversification on different food security indicators through the following model:

$$\begin{aligned} Food\_security_{ht} = & \beta_1 Income\_diversification_{ht} \\ & + \beta_2 Shock_{ht} \\ & + \beta_3 Income\_diversification_{ht} * Shock_{ht} \\ & + Z_{ht} + T + u_h + \hat{e}_{ht} \end{aligned} \quad (3)$$

In equation (3), we include shocks experienced by households and their interaction with income diversification to estimate the resilience capacities of rural livelihood diversification strategies. As such, income diversification in the model is a capacity indicator that may facilitate recovery following an exogenous shock.  $\beta_1$  may be interpreted as the effect of household level capacities on welfare - food security - without shocks.  $\beta_2$  is interpreted as the effect of shocks on welfare without household level resilience capacities and  $\beta_3$ , is the combined effect of household level capacities and shocks (2) in mitigating or aggravating the impact of shocks.

We use random-effects regressions - for continuous outcomes - and random-effects Poisson regressions - for count outcomes - according to the nature of the food security indicators defined in the data section. We apply the Control Function (CF) approach for all regressions by estimating model (3) with the residual  $\hat{\epsilon}_{ht}$  from the estimation of model (1) added as an explanatory variable (Smith & Blundell, 1986; Smale, Kusunose, Mathenge & Alia, 2016). The inclusion of the residual in equation (3) mitigates the possibility that potential omitted variables in the food security equations are correlated with livelihood diversification strategies. Endogeneity of income diversification can be tested through the significance of the estimated coefficient of the residual. We run additional regressions by applying the Mundlak transformation to the random-effects regressions and the random-effects Poisson regressions.

## V. Results and discussion

### ***Determinant of income diversification***

Table 4 presents the random effects regressions results, with and without the Mundlak transformation that accounts for the correlation between the household random effects and the wealth variables. As hinted at previously, income diversification is more likely in male-headed households than in female-headed households. Endowments in labor and education, and in physical capital, such as wealth, are positively associated with more diverse income generation strategies. Our results are in line with previous studies which have found a higher wealth index and working resources to be associated with a higher participation in local off-farm activities (Démurger & al., 2010), and that variables related to the human capital are correlated with the involvement in off-farm employment activities and income (Demissie & Legesse, 2013). This is somewhat consistent with our descriptive statistics in which the two-based income source households report one of their sources to be self-employment. The availability of labor and some physical capital are pull factors for diversifying the income sources in this sample, as has been found in other studies (Ruben & Van Den Berg, 2001; Escobal, 2001; Oseni & Winters, 2009; Ali, Deininger & Duponchel, 2014).

Our results are also in line with the finding that better-off households are more diversified in rural Nigeria (Babatunde & Quaim, 2009), and that wealthier households tend to have more diversified income streams in Ethiopia (Block & Webb, 2001). Yet our study advances this literature by showing that income diversification decreases at the margins when wealth increases. In fact, the relationship between wealth and income diversification is better categorized as upward sloping with a diminishing effect rather than being an inverted U shape, contrary to what has been reported in other studies (Losch, Freguin-Gresh & White, 2012). Our results suggest that, in general, some findings about determinants of income diversification in cross sectional analysis also remain important in the panel data setting. This is an important contribution of our paper as the need for empirical evidence from panel data to capture changes over time in rural livelihood diversification has been stressed previously (Loison, 2015).

**Table 4: Regression results of determinant of income diversification**

	Random effects tobit	Random effects tobit with Mundlak transformation
Wealth index	0.034***	0.019***
Wealth index squared	-0.003***	-0.002***
Female-headed	-0.096***	-0.094***
Age of head	0	0
Labor force	0.026***	0.025***
Education (head)	0.007***	0.006***
Education (average HH)	-0.005*	-0.005**
Land size /100 (ha)	0.034	0.032
Livestock/100	-0.014	-0.013
Saving credit coop. presence	-0.015	-0.015
Agri. cooperative presence	-0.021	-0.022*
Women's group presence	0.013	0.012
Micro finance institution presence	-0.015	-0.014
Bank institution presence	-0.078***	-0.082***
Distance from administrative cap. /100	-0.046***	-0.044***
Distance from market town/100	0.007	0.01
Idiosyncratic shock	-0.006	-0.006
Natural shock	0.030**	0.029**
Price shock	0.028	0.027
Year (second survey wave)	0.026***	0.027***

Mean (wealth index over survey years)		0.025***
Mean (wealth index square over survey years)		-0.003**
Constant	0.039	0.054
Log likelihood	-3122.882	-3117.502
Wald chi2	431.04***	440.33***
Observations	5,858	5,858
Left-censored observations	2,393	2,393
Uncensored observations	3,465	3,465
Right-censored observations	0	0

Note: Region dummies are included in the regressions. Prob > chi2 for joint significance of the mean variables is 0.0046.

Significant levels are indicated with \*\*\* p<0.01, \*\* p<0.05, \* p<0.10.

There is no evidence that may reflect the potential credit alleviating constraint for rural households to increase their diversification strategy due to the presence of a saving and credit cooperative, or a microfinance institution in the community. However, our results do show that the existence of a formal bank in the community was negatively associated to income diversification (see Table 4). A similar result was found in rural Niger where the existence of a financial institution in the community seemed to negatively impact the probability of participating in businesses activities (Dedehouanou, Ousseini, Abdoulaziz & Jabir, 2016). Our result suggest that rural households may be able to finance income generating activities through directly available, and free financial resources so that they do not need to rely on formal banks. It may be also that there are some negative factors inherent to formal banks within the community that could possibly discourage rural households to additionally diversify their activities. The relative geographical location of the rural households with respect to the capital of the department - the second level administrative subdivision after the region - was related to income diversification, as it may be a favourable opening for livelihood diversification strategies opportunities. Indeed, rural households located far from the capital of the department were less likely to diversify, as has also been found in previous studies (Bhatta & Årethun, 2013; Ghimire, Huang & Shrestha, 2014).

Household experience of natural shocks was positively related to livelihood diversification strategies. Households facing floods, droughts, or pests which affect agricultural and livestock production and non-farm business - natural shocks - were more likely to diversify. Our results suggest that rural households may view the possibility of diversifying as a livelihood strategy to cope with specific shocks. Demeke and Zeller (2012) found a similar result in the case of Ethiopia where the level and variability of rainfall had a significant effect on the decision by households to engage in any type of off-farm work.

### ***Relationship between income diversification and food security indicators***

Table 5 presents regression results for food security indicators. The estimated residuals from the random effects tobit regressions were included in the food security indicators equations to mitigate potential endogeneity from income diversification. Standard errors were bootstrapped to account for the fact that the residuals were estimated from another equation. The estimated coefficient of the residual was statistically significant indicating that unobserved factors in the error structure of the variables were correlated between the income diversification and food security indicators equations.

**Table 5: Income diversification and food security indicators: regression results**

	<b>Food accessibility</b>	<b>Food utilization</b>	<b>Food (un)availability</b>	
	<b>Food expenditures p.c.</b>	<b>Dietary diversity</b>	<b>Nutrient stock (quality)</b>	<b>Nutrient stock (quantity)</b>
Income diversification	60,883.480***	0.794***	-0.883*	-1.087
Idiosyncratic shock	-1,402.78	0.005	0.136	0.313**
Natural shock	687.82	0.014	0.563***	0.464**
Price shock	2,131.93	0.065**	0.480***	0.552**
Income diversification*Idiosyncratic shock	2,317.37	0.007	-0.365	0.237
Income diversification*Natural shock	4,090.71	-0.127*	0.151	0.307
Income diversification*Price shock	-9,855.45	-0.04	-0.625	-0.932
Residual from Table 4	-66,174.294***	-0.737***	1.148**	1.533**
Female-headed	9,650.768**	0.097***	0.094	0.033

Age of head	-80.117	0	-0.003	-0.001
Size of household	-9,853.893***	-0.005***	0.029**	0.032**
Education (head)	409.657*	0	-0.004	-0.008
Education (average HH)	2,177.429***	-0.001	-0.005	0.001
Land size /100 (ha)	-926.285	0.02	-0.169	0.175
Livestock/100	1,019.06	0.022	-0.455	-1.613***
Household borrowed money	1,696.73	0.031***	0.126**	0.065
Agricultural cooperative presence	2,249.15	0.022*	-0.339***	-0.203**
Women's group presence	-3,883.406**	-0.036***	0.064	-0.001
Micro finance institution presence	11,439.710**	-0.03	-0.378***	-0.576**
Bank institution presence	8,118.371**	0.060**	-0.484***	-0.639**
Distance market town /100	-13,414.872***	-0.044***	0.234***	0.119
Year (first survey wave)	12,872.883***	0.046***	-0.427***	-0.462***
Mean (Income diversification)	22,824.600***	0.034	-0.466*	-0.208
Mean (Income diversification*Idio. shock)	-25,057.657**	-0.094	0.136	-1.208
Mean (Income diversification*Natural shock)	-5,569.65	0.083	0.169	-0.166
Mean (Income diversification*Price shock)	51,364.224**	0.157	2.078***	2.816***
Constant	140,908.410***	1.917***	-0.002	-0.691***
Wald chi2	1103.11***	464.23***	2379.18***	1789.96***
Sigma u / a		0	1.313	1.553
LR test of sigma_u=0/ a =0: chibar2		0	1332.51***	968.23***
Observations	5,778	5,828	5,857	5,857
Number of hhid	2,921	2,929	2,929	2,929

*Note.* Region dummies are included in the regressions. Standard errors are bootstrapped with 100 replications. A random effects regression is used for the food expenditures equation and a random effects poisson regression is used for the other equations. The Mundlak transformation is additionally applied to all regressions. The likelihood-ratio (LR) test of  $\alpha = 0$  compares the panel estimator with the pooled (Poisson) estimator.

Significant levels are indicated with \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

Table 5 shows that income diversification was significantly related to the different food security indicators. The estimated coefficients reflect resilience capacities of rural livelihood diversification without taking into account the impact of shocks. Food expenditures per capita and dietary diversity increased with income diversification level. Food unavailability - expressed in terms of days - was negatively associated with income diversification implying that the number of days households had to limit the variety of food eaten was reduced, as households

increased their livelihood diversification strategies. Our results are in line with previous studies which have found that income diversification was associated with food consumption in Burkina Faso (Reardon, Delgado & Matlon, 1992) and with calorie intake in Ethiopia (Block & Webb, 2001). Our results add to the literature by showing further that income diversification favours food accessibility as well as food availability and food utilisation in rural Nigeria. We also add to the literature by exploring the role of income diversification as capacity for mitigating or aggravating the impact of shocks experienced by rural households.

Shock experiences were differentially related to the food security indicators presented above. Idiosyncratic shock experiences, events such as illness, death of a family member, or loss of employment were positively associated with the number of days households had to limit portion sizes at meal times. Households experiencing natural shocks and price shocks increased the number of days they had to limit the variety of food eaten and the portion size at meal times. Yet they also increased the number of food groups consumed - dietary diversity - following price shocks suggesting that households reduce food availability for food utilization, following price shocks.

The effect of resilience capacities in mitigating or aggravating the impact of shocks were given by the estimated coefficients of the interactions of income diversification and the shock variables. Livelihood diversification did not succeed in mitigating or aggravating the impact of either idiosyncratic, natural, or price shocks on measures of food availability and food utilization. In general, income diversification per se improved food security through food accessibility, food availability, and food utilization. Where shocks experiences appeared to negatively affect food security, income diversification did not contribute to reducing the effect of shock experiences. Interestingly, while our income diversification findings indicate that female-headed households were less diversified, there appears to be another factor at work in Table 5. There was a direct effect of female-headed households being more food secure using the first two measures, and no more insecure as per the second two measures. Thus, there appears to be a gender dimension to food expenditure and dietary diversity determinants that merit more nuanced analysis by future research.

### ***Using alternative composite food security indicators***

In this section, we consider two alternative composite measures of food security indicators used in the literature (Maxwell, Vaitla, Tesfay & Abadi, 2013). The first measure is the Food Consumption Score (FCS) which is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. The advantage of the FCS over the sole dietary diversity measure is that it weights food groups. The FCS obtained from our pooled sample ranges from 0 to 112 (mean and standard deviation are respectively 52.131 and 19.510), with maximal values reflecting greater dietary diversity and food frequency and, thus, improved food security. The second measure which is the Reduced Coping Strategies Index (RCSI) examines the coping behaviors of households with respect to food deficit. Five food-based coping strategies questions — relying on less preferred and less expensive foods; reducing the number of meals eaten in a day; limiting portion size at meal times; borrowing food or relying on help from relatives or friends; restricting consumption by adults for small children to eat — and their frequency during the one-week period prior to survey, were asked to the households. The RCSI calculated from our pooled sample using the universal severity weight ranges from 0 to 52 (mean and standard deviation are 2.707 and 5.476, respectively). The higher the RCSI, the more severe the coping is applied by a household<sup>4</sup>.

Table 6 presents regression results for the two composite food security indicators. The same methodology as above is applied. The FCS is considered as continuous while the RCSI is considered as censored at zero because of the high number of zeros at the low level. In general, the results show the same trend observed in Table 5 concerning the relationship between income diversification and diet diversity, and nutrient stock and the role of income diversification in mitigating or aggravating the effect of shock experiences. Income diversification appears to be positively related to the Food Consumption Score while negatively related to the Reduced Coping Strategies Index. Increasing income diversification

---

<sup>4</sup> The coping strategy variables are highly correlated and imprecise when taken in isolation but more robust to measurement error and regional variation when taken together as a composite measure such as the RCSI.

thus leads to less severe coping behaviors by households with respect to food deficit. As previously found in Table 5, income diversification contributed neither to reduce nor to aggravate the effect of shock experiences.

**Table 6: Income diversification and composite measures of food security indicators**

	<b>Food Consumption Score (FCS)</b>	<b>Reduced Coping Strategy Index (RCSI)</b>
Income diversification	47.205***	-7.978***
Idiosyncratic shock	0.775	1.563**
Natural shock	0.278	3.589***
Price shock	2.487	2.180**
Income diversification*Idiosyncratic shock	-3.899	-0.784
Income diversification*Natural shock	-3.279	1.217
Income diversification*Price shock	-0.819	-0.03

Note. Full regression results are presented in Table A2 in the Appendix. Significant levels are indicated with \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

### ***Income diversification transition and food security***

In a final consideration, we exploited the panel nature of our data set to examine the average effects of income diversification transitions on changes in food security, and we estimated the average effects of moving into a higher or a lower level of income diversification in the subsequent year. We used the nearest-neighbor matching (NNM) estimator from the literature on impact evaluation (Abadie & Imbens, 2006, 2011; StataCorp, 2015), a technique which has been used in a similar panel context of estimating the effect of participation in non-agricultural labor markets on inputs expenditures in Vietnam (Stampini & Davis, 2009). Specifically, the NNM technique constructs two different counterfactual groups of households by separately matching households that moved into a higher level of income diversification and households which moved into a lower level of income diversification, in the subsequent year, to those that stayed in the same level of income diversification between years, on the basis of similarities observed in the initial characteristics.

The average effect of moving into a higher (lower) level of income diversification on change in food security is computed by taking the difference of the average of the change in food security indicators between the group of the “movers” households and the group of the corresponding counterfactual households. Although the NNM estimator relies on the conditional independence assumption (CIA)<sup>5</sup>, it has the advantage of being non-parametric and so does not rely on any explicit functional form for the change in food security indicators, or the change in income diversification. In addition, household fixed effects were net out by considering the change in food security indicators and the change in income diversification level, thereby reducing potential bias that might result from time invariant unobserved heterogeneities.

Table 7 shows that the transition into a higher or a lower level of income diversification did not bring about a significant increase or decrease of food accessibility (expenditure measure) and food availability (nutrient stock measures). With respect to these measures of food security, the nearest-neighbor matching results show that there is no evidence that transiting into either a higher or a lower level of income diversification subsequently provided a welfare improvement. Rather, moving into a higher or a lower level of income diversification led to an increase in food utilization as measured by dietary diversity. When considering the composite measures of food security, the results show that moving into a higher level of income diversification led to an increase in the food consumption score while moving into a lower level of income diversification brought about less severe coping behaviors by households with respect to food deficit.

---

<sup>5</sup> The observed and the counterfactual groups are identified only on the basis of observable characteristics.

**Table 7: Income diversification transitions and food security - nearest-neighbor matching**

<b>Change in:</b>	<b>Food expenditures p.c.</b>	<b>Dietary diversity</b>	<b>Nutrient stock (quality)</b>	<b>Nutrient stock (quantity)</b>	<b>Food Consumption Score</b>	<b>Reduced Coping Strategy Index</b>	<b>Number of observations</b>
Average effect of moving into a lower level of income diversification	-148.476 (2,009.20)	0.216* (0.126)	-0.105 (0.076)	-0.048 (0.064)	1.779 (1.176)	-0.655** (0.299)	1,763
Average effect of moving into a higher level of income diversification	-5,129.97 (3,188.90)	0.342*** (0.114)	0.065 (0.079)	0.02 (0.066)	2.414** (1.051)	-0.44 (0.296)	1,953

Note. Robust standard errors in parentheses. Significant differences are indicated with \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

## VI. Conclusion

We have taken advantage of one of the large household panel surveys carried out under the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project in Sub-Saharan Africa. We have used broad empirical approaches to studying income diversification in and of itself, and income diversification in relation to food security in rural Nigeria. We have used the panel nature of the data to investigate changes over time in these key measures. The panel nature of the data has also allowed us to account for household level responses to shock experiences by rural households over time.

We have found that endowments in labor and education and in physical capital, such as wealth were positively associated with more diverse income generation strategies. The availability of labor and some physical capital are pull factors for diversifying income sources. In particular, we have provided evidence that the relationship between wealth and income diversification in rural Nigeria is better categorized as upward sloping with a diminishing marginal effect rather than an inverted U-shape or a U-shape. We have also found that households facing price shocks and those facing shocks affecting agricultural and livestock production and non-farm business were more likely to diversify. Finally, we have identified an important gender dimension to income diversification strategies, both in terms of the level of diversification adopted by male compared to female-headed households, and the flexibility of adapting income diversification strategies over time.

With regards to the implications for income diversification on food security, we have found that income diversification favours food accessibility as well as food availability and food utilisation in rural Nigeria, reflecting the role of resilience capacities of rural livelihood diversification. However, income diversification has a different role for mitigating or aggravating the impact of shocks experienced by rural households in this context. Where shock experiences appear to negatively affect food security, income diversification does not contribute to reducing the effect of shock experienced. Our results on income diversification overall suggest that income diversification is a desirable option in alleviating food insecurity. Yet we find that transiting into a higher level of income diversification may be an option for

welfare improvement in terms of food consumption score. Also, transiting into a lower level of income diversification may be an option for less severe coping behaviors with respect to food deficits.

To return to our opening theme, income diversification and flexibility in income diversification strategies are important contributors to dealing with climate variability and will play a growing role in confronting climate change. Our findings suggest education plays an important role in this process and supports the importance of rural education efforts. We also find that agriculture remains important to the rural economy, and efforts to improve agricultural productivity will impact a large percentage of the rural population. The importance of self-employment merits further detailed attention in order to understand what factors allow or hinder movement into self-employment. This appears to be an important next step to understanding the interaction between income diversification and food security in rural Nigeria. Finally, the gender results that we find in both the income diversification patterns and food security findings merit further detailed analysis to understand what mechanisms constrain female-headed households' diversification strategies, and what compensating approaches they have adopted that are captured by the direct effect of female-headed households on food accessibility and utilization.

## References

- Abadie, A., & Imbens, G. W. (2006). Large Sample Properties of Matching Estimators for Average Treatment Effects. *Econometrica*, 74(1), 235–267.
- Abadie, A., & Imbens, G. W. (2008). On the Failure of the Bootstrap for Matching Estimators. *Econometrica*, 76(6), 1537–1557.
- Abdulai, A., & CroleRees, A. (2001). Determinants of income diversification amongst rural households in Southern Mali. *Food Policy*, 26(4), 437–452.
- Ali, D.A., Deininger, K. & Duponchel, M. (2014). Credit constraints, agricultural productivity, and rural nonfarm participation: evidence from Rwanda. Policy Research working paper; no. WPS 6769. Washington, DC: World Bank Group.
- Awotide, B. A., Awoyemi, T. T., Diagne, A., Kinkingnihoun, F.-M., & Ojehomone, V. (2012). Effect of Income Diversification on Poverty Reduction and Income Inequality in Rural Nigeria: Evidence from Rice Farming Households (SSRN Scholarly Paper No. ID 2214159).
- Babatunde, R.O. & Qaim, R. (2009). Patterns of Income Diversification in Rural Nigeria: Determinants and Impacts. *Quarterly Journal of International Agriculture* 48:4. pp. 305–320.
- Barrett, C. B, Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy*, 26(4), 315–331.
- Barrett, C. B., & Reardon, T. (2000). Asset, activity, and income diversification among African agriculturalists: Some practical issues (SSRN Scholarly Paper No. ID 257344). University of Wisconsin-Madison Land Tenure Center: USAID BASIS CRSP.
- Bezu, S., & Barrett, C. (2012). Employment Dynamics in the Rural Nonfarm Sector in Ethiopia: Do the Poor Have Time on Their Side? *The Journal of Development Studies*, 48(9), 1223–1240.
- Bezu, S., Barrett, C. B., & Holden, S. T. (2012). Does the Nonfarm Economy Offer Pathways for Upward Mobility? Evidence from a Panel Data Study in Ethiopia. *World Development*, 40(8), 1634–1646.
- Bhatta, B. P., & Årethun, T. (2013). Barriers to rural households' participation in low-skilled off-farm labor markets: theory and empirical results from northern Ethiopia. *SpringerPlus*, 2(1), 97.
- Block, S., & Webb, P. (2001). The dynamics of livelihood diversification in post-famine Ethiopia. *Food Policy*, 26(4), 333–350.
- Dedehouanou, S., Ousseini, A., Abdoulaziz, L. H., & Jabir, M. (2016). *Spillovers from off-farm self-employment opportunities in rural Niger* (Working Papers PMMA No. 2016-08). PEP-PMMA.
- Demeke, A.B. & Zeller, M. (2012). Weather risk and household participation in off-farm activities in Rural Ethiopia. *Quarterly Journal of International Agriculture* 51 (1): 1-20.
- Demissie, A. & Legesse, B. (2013). Determinants of income diversification among rural households: The case of smallholder farmers in Fedis district, Eastern Hararghe zone, Ethiopia. *J Dev Agric Econ*, 5(3):120- 128.

- Démurger, S., Fournier, M. & Yang, W. (2010). Rural households' decisions towards income diversification: evidence from a township in northern China. *China Economic Review* 21, 532–544.
- Dimova, R. & Sen, K. (2010). Is household income diversification a means for survival or a means of accumulation? Panel data evidence from Tanzania. BWPI Working Paper Number 122. London: Brooks World Poverty Institute.
- Ellis, F. (2000). The Determinants of Rural Livelihood Diversification in Developing Countries. *Journal of Agricultural Economics*, 51(2), 289–302.
- Escobal, J. (2001). The Determinants of Nonfarm Income Diversification in Rural Peru. *World Development*, 29(3), 497–508.
- Filmer, D., & Pritchett, L. H. (2001). Estimating Wealth Effects without Expenditure Data-or Tears: An Application to Educational Enrollments in States of India. *Demography*, 38(1), 115–132.
- Ghimire, R., Huang, W.-C., & Shrestha, R. B. (2014). Factors Affecting Nonfarm Income Diversification among Rural Farm Households in Central Nepal. *International Journal of Agricultural Management and Development (IJAMAD)*, 04(2).
- Loison, S. A. (2015). Rural Livelihood Diversification in Sub-Saharan Africa: A Literature Review. *The Journal of Development Studies*, 51(9), 1125–1138.
- Losch, B., Freguin-Gresh, S., & White, E. T. (2012). Structural transformation and rural change revisited: Challenges for late developing countries in a globalizing world. Agence Française de Développement and the World Bank: Washington, DC.
- Maxwell, D., Vaitla, B., Tesfay, G. & Abadi, N. (2013). Resilience, Food Security Dynamics and Poverty Food Traps in Northern Ethiopia: Analysis of Biannual Panel Dataset, 2011-2013, Feinstein International Centre, Tufts University
- Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. *Econometrica*, 46(1), 69–85.
- Murata, A., & Miyazaki, S. (2014). *Ex-post Risk Management Among Rural Filipino Farm Households* (Working Paper No. 67). JICA Research Institute.
- Oluwatusin, F. M., & Sekumade, A. B. (2016). Farm Households Income Sources Diversification Behaviour in Nigeria. *Journal of Natural Sciences Research*, 6(4), 102–111.
- Oseni, G., & Winters, P. (2009). Rural nonfarm activities and agricultural crop production in Nigeria. *Agricultural Economics*, 40(2), 189–201.
- Pieters, H., Guariso, A. & Vandeplass, A. (2013). Conceptual framework for the analysis of the determinants of food and nutrition security. FOODSECURE Working paper no. 13.
- Reardon, T., Delgado, C., & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *The Journal of Development Studies*, 28(2), 264–296.
- Ruben, R., & Van den berg, M. (2001). Nonfarm Employment and Poverty Alleviation of Rural Farm Households in Honduras. *World Development*, 29(3), 549–560.
- Sahn, D. E., & Stifel, D. (2003). Exploring Alternative Measures of Welfare in the Absence of Expenditure Data. *Review of Income and Wealth*, 49(4), 463–489.
- Schwarze, S. & Zeller, M. (2005). Income diversification of rural households in Central Sulawesi, Indonesia. *Quarterly Journal of International Agriculture* 44, 61–74.

- Smale, M., Kusunose, Y., Mathenge, M. K., & Alia, D. (2016). Destination or Distraction? Querying the Linkage Between Off-Farm Work and Food Crop Investments in Kenya. *Journal of African Economies*, 25(3), 388–417.
- Smith, R. J., & Blundell, R. W. (1986). An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply. *Econometrica*, 54(3), 679–685.
- StataCorp. 2015. Stata: Release 14. Statistical Software. College Station, TX: StataCorp LP
- Upton, J. B., Cissé, J. D., & Barrett, C. B. (2016). Food security as resilience: reconciling definition and measurement. *Agricultural Economics*, 47(S1), 135–147.

## Appendix

**Table A1: Description of the variables used in the regression**

Variables	Definition	Mean	Std. Dev.
Female-headed	Gender of household head (1=female, 0=male)	0.124	0.32992
Age of head	Age of household head	50.83	14.8571
Labor	Number of laborers in household	3.268	1.86244
Education (head)	Years of schooling of household head	4.363	5.51932
Education (average HH)	Average years of schooling of household members	3.135	3.27828
Wealth index	First principal component of indicators of household asset variables (vehicles, home characteristics, furniture, and household appliances)	-0.643	2.06884
Land size /100 (ha)	Total landholdings (ha)	0.013	0.1252
Livestock/100	Tropical Livestock Units TLU (1 TLU equals 1 cow/horse, 0.8 donkeys and 0.2 sheep/goat)	0.043	0.1847
Saving credit coop. presence	A saving credit cooperative institution exists in the community=1; 0 otherwise	0.166	0.371893
Household borrowed money	HH borrowed any money from friends, relatives or money lenders =1 ; 0 otherwise	0.282	0.44987
Agri. cooperative presence	An agricultural cooperative exists in the community=1; 0 otherwise	0.298	0.45722
Women's group presence	A women's group exists in the community=1; 0 otherwise	0.624	0.48439
Micro finance institution presence	A microfinance institution exists in the community=1; 0 otherwise	0.077	0.26605
Bank institution presence	A formal bank institution exists in the community=1; 0 otherwise	0.088	0.28319
Distance from administrative cap. /100	Household distance in kilometers to Capital of Department of Residence	0.763	0.536303
Distance market town/100	Distance to the nearest market	0.705	0.38685
Idiosyncratic shock	Household negatively affected by idiosyncratic shocks: illness, death of a family member, or loss of employment =1; 0 otherwise	0.086	0.280441
Natural shock	Household negatively affected by geographical shocks: natural disasters such as floods, droughts, or pests =1; 0 otherwise	0.137	0.343778
Price shock	Household negatively affected by price shocks: unexpected prices changes of food prices, input and output prices =1; 0 otherwise	0.053	0.223208

**Table A2: Income diversification and composite measures of food security indicators: full regression results**

	Food Consumption		Reduced Coping	
	Score	Score	Strategy Index	Strategy Index
Income diversification	47.205***	51.884***	-7.978***	-8.873***
Idiosyncratic shock	0.775	0.747	1.563**	1.571**
Natural shock	0.278	0.389	3.589***	3.598***
Price shock	2.487	2.348	2.180**	2.179**
Income diversification*Idiosyncratic shock	-3.899	-4.652	-0.784	1.003
Income diversification*Natural shock	-3.279	-1.61	1.217	1.485
Income diversification*Price shock	-0.819	2.302	-0.03	0.343
Residual from Table 4	-46.152***	-47.175***	9.004***	8.920***
Female-headed	6.318***	6.324***	0.754	0.793
Age of head	0.047***	0.045**	-0.030**	-0.030**
Size of household	-0.321***	-0.301***	0.247***	0.242***
Education (head)	0.079	0.083	-0.023	-0.025
Education (average HH)	-0.097	-0.097	-0.048	-0.051
Land size /100 (ha)	2.507	2.562	-0.977	-0.966
Livestock/100	3.261	3.217	-2.265	-2.280*
Household borrowed money	2.444***	2.492***	1.864***	1.866***
Agricultural cooperative presence	1.357**	1.393**	-1.598***	-1.598***
Women's group presence	-3.272***	-3.258***	1.458***	1.454***
Micro finance institution presence	-3.591**	-3.754***	-4.325***	-4.318***
Bank institution presence	3.831**	3.973***	-4.342***	-4.362***
Distance market town /100	0.773	0.78	1.149**	1.165***
Year first survey wave	3.611***	3.795***	-3.247***	-3.243***
Mean (Income diversification)	6.413***		-1.809	
Mean (Income diversification*Idio. shock)	-2.391		4.322	
Mean (Income diversification*Natural shock)	3.971		0.849	
Mean (Income diversification*Price shock)	8.627		0.539	
Constant	40.413***	40.802***	-0.689	-0.873
Wald chi2	776.14***	520.61***	1181.71***	1634.59***
Observations	5,836	5,837	5,730	5,730
Number of hhid	2,929	2,930	2,927	2,927
Left-censored observations			3,583	3,583
Uncensored observations			2,147	2,147

Note. Region dummies are included in the regressions. Standard errors are bootstrapped with 100 replications. Random effects regression is used for the Food Consumption Score equation and random effects tobit regression is used for the Reduced Coping Strategy Index equation.