Crop diversification and Nutrition Security: Evidence from Sub-Saharan Africa

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Motivation

- After a hiatus, promoting sustainable agricultural growth is back on the development agenda.
- Climate change is emerging as a major threats to the development of the sector and might worsen food insecurity
- Climate change might affect smallholder farmers disproportionately: a moderate increase in temperatures will have a negative impact on the production of stable crops
- **There is an public policy demand for identifying sustainable agricultural practices that can improve welfare and help farm households withstand the deleterious effect of climate change.**

Motivation

- Crop diversification is identified as the most ecologically feasible and cost effective CSA to improve agricultural production and improve food and nutrition security

Two possible channels:

- Diversification towards nutrient dense crops has the potential to improve nutrition for farm households
- Enhancing farm household's income. Though the pathway is not always direct and linear (food market, knowledge and preferences)
- However, the direct causal link between crop diversification and nutrition is not simple and the existing empirical evidence is mixed.

Objective

- Evaluate the impact of crop diversification on household food and nutrition security using estimation strategies that address self-selection and endogeneity bias.

Specific objectives :

- Evaluate the effect of crop diversification on household food and nutrition insecurity
- Evaluate the effect of crop diversification on farm household's poverty dynamics

Data

Nigeria General Household Survey (NGHS)- 2010-2011, 2012-2013, and 2015-2016

- Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) program of the World Bank in collaboration with the Nigerian National Bureau of Statistics (NBS)
- Panel of 5000 hh and 14,000 individuals
- Geo-reference households

Temperature and precipitation data

- The Climatic Research Unit (CRU-TS-4.03), University of East Anglia

Data

Table: Definition of crop diversity indices

Index	Mathematical Construction	Explanation	Adaptation in this paper
Number of crops	D=S	Richness	A Household produced S number of crops
Shannon-Weaver	$D = -\Sigma p_i \ln p_I, D > 0$ $D > 0$	Proportional abundance and Richness	p_i is proportion, or relative abundance of a species
Composite Entropy	$D = -\sum_i^p p_i ln_s (p_i) (1 - 1/S)$, $0 \leqslant D \leqslant 1$	Proportional abundance and Richness	p_i is proportion, or relative abundance of a species

Data

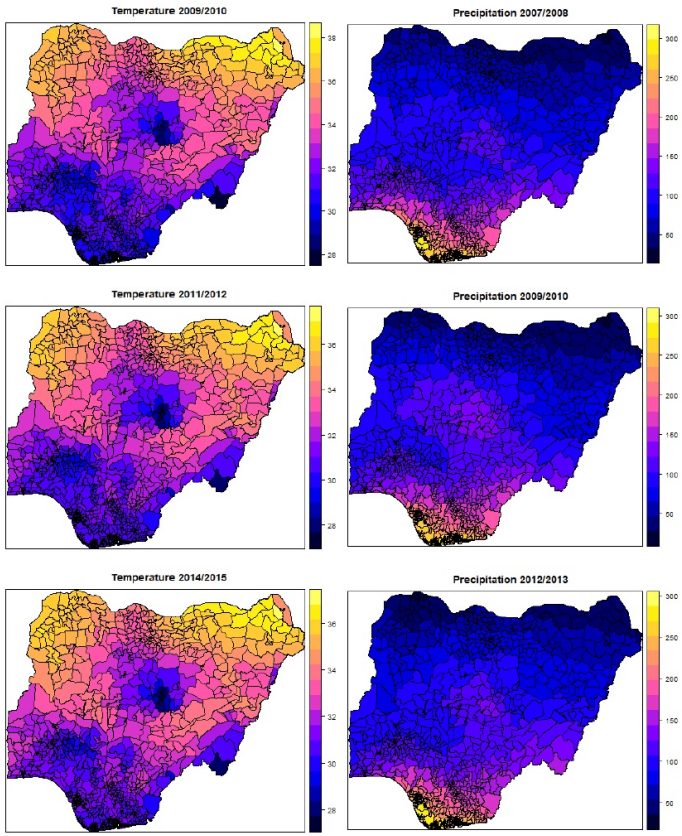
Guidelines for Measuring Household and Individual Dietary Diversity (FAO, 2010)

Questions	Food groups from dietary diversity questionnaire to create HDDS	Yes=1 No=1
1	Cereals	
2	White tubers and roots	
3	Vegetables (a combination of vitamin A rich vegetables and tubers, dark green leafy vegetables and other vegetables)	
4	Fruits(a combination of vitamin A rich fruits and other fruits)	
5	Meat (combination of organ meat and flesh meat)	
6	Eggs	
7	Fish and other seafood	
8	Legumes, nuts and seeds	
9	Milk and milk products	
10	Oils and fats	
11	Sweets	
12	Spices, condiments and beverages	

*HDDS (0-12), total number of food groups consumed by members of the household. Values for 1 through 12 will be either "0" or "1". Sum (1+2+3+4+5+6+7+8+9+10+11+12)

Data

Maps of Temperature and Precipitation[7]



Study-1

Objective: Evaluate the effect of crop diversification on household food and nutrition insecurity

- **Outcome variable:** Yearly HH consumption per adult equivalent; Number of Months a household was food insecure; Household dietary diversity index
- **Estimation Strategy:** Generalized panel data switching regression model with correlated unobserved effects.

Results

Table A1: Determinants of adult equivalent consumption and crop diversification

Variable	Adopters: adult-equivalent consumption		Non-adopters: adult-equivalent consumption		Selection equation	
	Coffe.	Std. Err.	Coffe.	Std. Err.	Coffe.	Std. Err.
Household characteristics						
flhh	0.0891*	0.0366	0.1031**	0.0348	0.0249	0.0625
age	-0.0002	0.0007	-0.0007	0.0008	0.0022	0.0014
hh_members	-0.0580***	0.0032	-0.0722***	0.0042	0.0146*	0.0064
illiterate_hh	-0.0974***	0.0218	-0.1255***	0.0261	-0.0235	0.0443
lnvalue_assets	0.1120***	0.0083	0.1290***	0.009	-0.023	0.0156
Production input						
lvstck_holding_tlu	-0.0003**	0.0001	0.0038**	0.0013	0.0014	0.0010
farm_size_agland	-0.0067**	0.0024	-0.0048	0.0043	0.0438**	0.0166
labor_hired	0.000	0.000	0.0006***	0.0001	0.0005*	0.0002
Biophysical factors						
workab_mea	-0.0121	0.0139	-0.0039	0.0177	0.1594***	0.0318
avg_dist_hh	-0.0001	0.0003	0.0000	0.0003	-0.0003	0.0005
dist_market	-0.0008**	0.0003	0.0000	0.0003	-0.0012*	0.0006
Institutional factors						
ext_reach_public	0.1043*	0.0453	0.1185*	0.0472	-0.139	0.0897
use_fin_serv_credit	0.2253*	0.0974	0.1995*	0.1004	0.0709	0.1805
Climate change						
three_year_avg_tmp	-0.0289**	0.0089	-0.0108	0.0087	0.8572***	0.1467
three_year_avg_pre	-0.0017**	0.0005	-0.0002	0.0005	0.0038***	0.0010
Regions						
zone1	-0.2376***	0.0548	-0.0947	0.0541	0.079	0.1019
zone2	-0.2913***	0.0591	-0.1381*	0.0609	0.0361	0.1119
zone3	-0.3562***	0.0600	-0.1620*	0.0634	0.2401*	0.1154
zone4	-0.1651**	0.0619	-0.0158	0.0580	-0.0029	0.1103
zone5	0.1341	0.0711	0.2023***	0.0609	0.0347	0.126
Instrumental variables						
lagged_tmp					-0.7478***	0.1440
sdipos_mean					1.6567***	0.1094
Constant	12.2722***	0.3519	10.8803***	0.3245	-5.3974***	0.6996
Regression Diagnosis						
corr(e.trt,e.lperaeq_c)			-0.2220**			
Log-likelihood			-9323.9163 ***			

Results

Treatment effects estimates of crop diversification on welfare

Outcome	ATE		ATT	
	Margin	Std. Err.	Margin	Std.Err.
Adult-equivalent consumption	0.2858***	0.0699	0.2486***	0.0995
Number of food insecure months	-0.1833***	0.074	-0.1727**	0.0758
Nutrition secure, (mean food groups cut-off)	0.0724	0 .0456	0.0777*	0.0459

* p<0.05, ** p<0.01, *** p<0.001

Study-2

Objective: Evaluate the effect of crop diversification on farm household's poverty dynamics

- **Outcome variable:** Poverty status of households Yearly using HH consumption per adult equivalent
- **Estimation Strategy:** Endogenous switching model that accounts for both initial condition bias and sample attrition bias.

Results

Table 2 – Poverty transition rates (in %), with and without missing, 2011-2016

Poverty status, wave $t-1$	Poverty status, wave t		
	Non-poor	Poor	Missing
(a)Balanced Panel			
Non-poor	65.07	34.93	
Poor	16.43	83.87	
All	23.98	76.02	
(b)All households (Unbalanced Panel)			
Non-poor	66.94	33.06	33.33
Poor	17.11	82.89	66.67
All	25.37	74.63	72.07

Results

Table 6 – Multivariate Probit model: Poverty Entry

	Count		Shannon Weaver Index		Composite entropy Index	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Household Head characteristics						
Sex: Female	-0.037	0.135	-0.0358	0.135	-0.0359	0.135
Age	0.001	0.004	0.001	0.003	0.001	0.003
Illiterate	0.113	0.102	0.112	0.102	0.112	0.102
Household characteristics						
Household size	-0.123***	0.016	-0.122***	0.016	-0.122***	0.016
Value of assets (ln log)	0.030	0.026	0.0303	0.026	0.0304	0.026
Livestock holding(TLU)	-0.001	0.004	-0.001	0.003	-0.0001	0.001
Land Size (acres)	-0.001	0.003	-0.001	0.003	-0.001	0.003
Access to formal credit (1 = Yes)	0.237**	0.103	0.238**	0.103	0.238**	0.103
Access to agri. extension service (1=yes)	0.151	0.141	0.159	0.14	0.159	0.14
Climate change						
Three Year Lagged Temperature	0.052	0.035	0.052	0.035	0.052	0.035
Three Year Lagged Precipitation	-0.003*	0.002	-0.003*	0.002	-0.004*	0.001
Crop Diversification						
Crop Diversification	-0.552**	0.248	-0.172**	0.086	-0.202**	0.101
Regions						
North central	-0.053	0.177	-0.0635	0.177	-0.0641	0.177
North east	-0.272	0.215	-0.3	0.213	-0.301	0.213
North west	-0.554**	0.218	-0.573***	0.217	-0.574***	0.217
South east	0.367**	0.185	0.345*	0.184	0.343*	0.184
South south	0.325	0.211	0.317	0.211	0.315	0.211
Intercept	-1.549	1.265	-2.122*	1.226	-2.120*	1.226
Log likelihood	686.81		686.81		686.81	
χ_2(d.o.f)	686.81(70)		685.96(70)		685.99(70)	
P-value	0.000		0.000		0.000	
# Observations	2088		2088		2088	

The standard errors are robust.

Household is defined in the period when it is first observed (in 2010/11) and remains the same.

Significance levels: * : 10% ** : 5% *** : 1%

Results

Table 7 – Multivariate Probit model: Poverty Persistence

	Count		Shannon Weaver Index		Composite entropy Index	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Household Head characteristics						
Sex: Female	-0.252**	0.123	-0.255**	0.123	-0.255**	0.123
Age	-0.00842**	0.004	-0.00834**	0.004	-0.00834**	0.004
Illiterate	0.189**	0.094	0.187**	0.094	0.187**	0.094
Household characteristics						
Household size	0.181***	0.015	0.180***	0.015	0.180***	0.015
Value of assets (In log)	-0.104***	0.025	-0.104***	0.025	-0.104***	0.025
Livestock holding(TLU)	0.00054	-0.002	0.001	-0.002	0.001	-0.002
Land Size (acres)	-0.002	0.002	-0.002	0.002	-0.002	0.002
Access to formal credit (1 = Yes)	-0.608***	0.094	-0.606***	0.094	-0.606***	0.094
Access to agri. extension service (1=yes)	0.0161	0.134	0.0155	0.134	0.0153	0.134
Climate change						
Three Year Lagged Temperature	0.0397	0.032	0.0392	0.032	0.0391	0.032
Three Year Lagged Precipitation	-0.001	0.002	-0.001	0.002	-0.001	0.002
Crop Diversification						
Crop Diversification	0.185	0.228	0.085	0.078	0.099	0.091
Regions						
North central	0.597***	0.154	0.589***	0.154	0.589***	0.154
North east	0.438**	0.185	0.439**	0.185	0.439**	0.185
North west	0.884***	0.187	0.873***	0.187	0.874***	0.187
South east	0.341**	0.163	0.345**	0.162	0.345**	0.162
South south	0.0465	0.187	0.0523	0.187	0.0528	0.187
Intercept	1.963*	1.148	2.138*	1.109	2.137*	1.109
Log likelihood	686.81		686.81		686.81	
χ_2(d.o.f)	686.81(70)		685.96(70)		685.99(70)	
P-value	0.000		0.000		0.000	
# Observations	2088		2088		2088	

The standard errors are robust.

Household is defined in the period when it is first observed (in 2010/11) and remains the same.

Significance levels: * : 10% ** : 5% *** : 1%

Capacity building

- A one week training of 15 PhD and Masters students on impact evaluation in collaboration with University Clermont Auvergne
- Mentor 2 Msc students

Study 3- Climate Change and Child Health

- Food insecurity has been responsible for malnutrition in agricultural households especially in developing countries
- Stunting and wasting among children contributes significantly to human capital development trap in Africa
- Childhood nutrition affected negatively with rising temperature and droughts affecting welfare and nutrition of young children

Objective

- Investigates the impact of changing temperatures and precipitation on child health indicators - stunting and underweight.
  - Specifically, monthly maximum average near-surface temperature ($^{\circ}C$) and total monthly precipitation (mm)
- Investigate the different effects on children living in rural and urban areas.
- Test the combined effects of changes in temperature and precipitation.

Key Findings

	Stunting			Underweight		
	Urban	Rural	All	Urban	Rural	All
Year preceding temperature	12.5% - 18.4%	16.5% - 25.5%	16.1 % - 23.2 %	9.6 % -12.2%	12.4% -15.9%	12.3 % -14.6 %
Three year lag precipitation	-0.4% - 0.5%	-0.6% - 0.8%	-0.6 % -0.7%	0.1% -0.2%	0.2%	0.2%

Study 4 - Climate Smart Agriculture and Welfare

- Crop diversification is one of Climate smart agriculture (CSA) to reduce the vulnerability of agriculture households to food insecurity challenges
- Although a growing body of literature tries to understand the impact on CSA on yield and welfare improvement,not enough is known about the joint effects of CSA practices, and this warrants further research.

Objective

Objective: Evaluate the effects of adoption of two potentially CSA practices(namely, intercropping,improved seed and their combination

- **Outcome variable:**Yearly HH consumption per adult equivalent
- **Estimation Strategy:**Multinomial endogenous switching regression approach for multiple treatments

Results

ATE of multiple treatments–All

Outcome variable- Yearly household consumption per adult equivalent ATE - MESR			
Intercropping vs. Untreated	0.015***	Intercropping vs. Improved Seed	-0.112***
Improved Seed vs Untreated	0.128***	Intercropping vs. Both	-0.032**
Both vs Untreated	0.048***	Improved Seed vs. Both	0.079 ***

$*p < 0.1, **p < 0.05, ***p < 0.01$

Policy implication

- There is a need for climate-friendly policies to mitigate the long-term effect of climate change on malnourishment e.g. Promote human capital accumulation and nutritional programs at schools on a particular focus on rural area
- Otherwise, climate change could reverse years of progress in lowering children's malnutrition.
- Crop diversification plays significant role in increasing consumption and reducing the food insecure months, while it has a lesser effect on diet diversity.
- Adopting crop diversity is negatively associated with poverty entry but does not affect poverty persistence.
- Mitigating the effect of climate change on welfare might require adoption of more than on CSA than one-size fits all interventions.

Dissemination + way forward

Conferences

- Climate, Disease Outbreaks and WaSH Response on 14th -15th April 2021
- ARUA 2021 Biennial International Conference 18-20 November 2021
- Biennial Conference of the Economic Society of SA

Publication plan

- Crop diversity and welfare dynamics: Empirical Evidence from Nigeria (with Hiywot Girma – World Development)
- Climate Change and Child Health: A Nigerian Perspective (with Eduard van der Merwe and Matthew Clance) – Journal of Development Economics)
- Climate Smart Agriculture and Welfare (with Hiywot Girma and Noluthando Mngwengwe, – Journal of Development Perspective)
- Impact of Crop Diversification on Food and Nutrition Security of Rural Households in Nigeria- (with Hiywot Girma - Journal of Development Studies)

Thank you!

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