Gendered Effects of Crop Diversification and Rainfall Shocks on Household Food Security Status in Nigeria

RESEARCH PROPOSAL

Presented to Partnership for Economic Policy (PEP)

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Cameroon

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Benin

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Cameroon

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Sunday Stephen AKOMOLAFE
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October 2020
SECTION I – PROJECT OVERVIEW & OBJECTIVES

1.1. Abstract (100 to 250 words)

The effects of climate variation on farming households in sub-Saharan Africa (SSA) continues to be an important policy question considering the low agricultural productivity, food security, and gender inequality problem in the region. Despite evidence that the food security status of women reflects the economic access to food of households, there is little evidence on the role of women in mitigating the effects of climate change on household food security status. We, therefore, seek to understand the effect of rainfall shocks on the household food security status and explore how the crop diversification behaviour of male and female household members help mitigate the effects of rainfall shocks. To do this, we will combine historical monthly rainfall dataset with the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) for Nigeria. We will employ the Margalef Index (MI) and income share as our measures of crop diversification and use the Household Dietary Diversity Score (HDDS) and reduced Coping Strategy Index (rCSI) to capture household food security status. We will then employ the household fixed effect to understand the nexus between rainfall shocks, household food security status and crop diversification behaviour of male and female household members. We will further test for robustness by employing instrumental variable, Poisson, and fractional probit regression models. Although we expect a positive relationship between diversification and household food security status, we expect that the diversification behaviour of females will have a greater positive effect than males’ in mitigating the effects of rainfall shocks on households.

1.2. Main research questions (max 500 words)

A large proportion of households in sub-Saharan Africa (SSA) are reliant on agriculture, producing food for home consumption and selling off surplus for income (Bjornlund et al., 2019). However, most of this agriculture is rainfed, covering around 97% of total cropland, and exposing agricultural production to high seasonal rainfall variability (Calzadilla et al., 2008). Irrigation systems are also few as less than 4% of the cropland in SSA is under irrigation, compared to 39% in South Asia and 29% in East Asia (Sheahan & Barrett, 2017). Hence, a sudden change in the rainfall pattern threatens the households’ food production capacity and food security status. However, households employ various mitigation and adaptation strategies to counter the effects of rainfall shocks. Such strategies vary across time and space and may include diversification (Porter, 2012; Reardon, 1997), insurance (McIntosh et al., 2013), and borrowing (Frankenberg et al., 2003).

Recent studies suggest that crop diversification is important in mitigating the effects of climate change on households by increasing agricultural production and diet diversity while conserving the soil (Asfaw et al., 2015; Asfaw et al., 2019; De Pinto et al., 2019). However, the crop diversification capability of households or individuals is limited by access to land, inputs and information, and because women in SSA are often characterised as having limited access to these three factors, it is important to assess the gender effects of crop diversification in mitigating rainfall shocks. More so, since the dietary diversity of women, reflects the household economic access to food (Doss et al., 2018; Kennedy et al., 2013), the role of women in mitigating the effects of climate change on households’ food security status is important and remains an empirical question.

The main purpose of this research proposal is to provide evidence on the nexus between rainfall shocks, crops diversification and household food security while exploring the inter- and intra-
household gender perspective of this relationship. In other words, the research proposal will answer
the following research questions:
(1) Do rainfall shocks affect the food security status of male and female-headed households
differently?
(2) And, to the degree that there is an effect of rainfall shocks on household food security status,
does the crop diversification behaviour of male and female household members help mitigate
this effect differently?

1.3. Main contributions (max 500 words)

This research proposal is particularly interesting for three main reasons:

First, we focus on the importance of crop diversification rather than non-farm diversification. Despite the importance of rural farmers as major food producers in the economy, many studies in economics literature focus on the welfare impacts of livelihood diversification of farming households to non-farm sectors (Reader, 1997; Barrett et al. 2000). In other words, these studies focus on non-farm diversification as a source of income to the farming households without exploring the risk of reduced agricultural labour and food supply in the overall economy. To the best of our knowledge, our research proposal is one of the few attempts to explore the effects of crop diversification on households.

Second, we focus on the role of women in improving household food security status by focusing on interhousehold and intrahousehold crop diversification behaviour of household members. We will use informative datasets (rainfall data and comprehensive household survey data) to fill the knowledge gap by assessing the extent to which household food security status varies with crop diversification and rainfalls simultaneously. We will explore fixed effects regression models to answer the research questions. We note the limitations of the fixed effect model and further note that the generalised method of moments Instrumental Variable (IV-GMM), Poisson and fractional probit regression models will be used to check for robustness of our estimates. We will also test for attrition across waves using Inverse Probability Weighting (IPW). To the best of our knowledge, our study is the only study that has proposed this empirical strategy to answer similar research questions.

Finally, this research proposal has many policy implications. On the one hand, by focusing on food security, this study is in line with the second Sustainable Development Goals (SDG 2: ‘Zero hunger’) of eradicating hunger and improving household food security status. It will help to understand how households can survive rainfall shocks while improving their agricultural production capacity and food security status through diversification within the farm sector rather than the non-farm sector. On the other hand, perceiving the impact of rainfall shocks on the food security of vulnerable groups, especially women, is useful to identify effective short and long-term empowerment policies in SSA countries. Nigeria is also relevant in this context, given the broader influence of Nigeria in SSA. Nigeria is characterised as having diverse socio-economic and climatic conditions, which are relevant in this context.
## SECTION II – CAPACITY BUILDING

### 2.1. Team composition and experience

#### Team leader

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<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex (M/F)</th>
<th>Highest degree/diploma</th>
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<tbody>
<tr>
<td>Khadijat Busola AMOLEGBE</td>
<td>32</td>
<td>F</td>
<td>PhD. In Agricultural Economics</td>
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</table>

#### Training and experience

Lecturer at the University of Ilorin, Nigeria, and holds a Ph.D. in Agricultural Economics from the same institution. Has held various research fellowship positions at international institutions such as the International Institute of Tropical Agriculture (IITA) and Nordic Africa Institute, Sweden. Also, has been a research fellow at Dyson School of Applied Economics and Management, Cornell University, under the Structural Transformation of African Agriculture and Rural Spaces (STAARS) fellowship program. Research straddles agricultural development economics, food security, and poverty and inequality issues in sub-Saharan Africa, and she has published more than ten peer-reviewed journal articles. Has experience working with comprehensive household survey datasets such as the Living Standards Measurement Study (LSMS) data and has a strong working knowledge of analytical packages like Stata, SPSS, and R.

#### Expected capacity building

This study will improve her knowledge of climate shocks and food security literature. Moreover, this research proposal will strengthen her capacities in terms of the management of regional data, policy setting, and evaluation in Sub-Saharan Africa countries.

#### Contribution to the project

As the team leader, she will ensure the coordination of the research work. She will also co-lead the development of the research design and be in charge of the collection and treatment of all relevant data on rainfall shocks, crop diversification, and food security in Ethiopia, Malawi, and Nigeria.

#### Researcher #2

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<tr>
<th>Name</th>
<th>Age</th>
<th>Sex (M/F)</th>
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<tr>
<td>Eugenie Rose FONTEP</td>
<td>28</td>
<td>F</td>
<td>Master of Science in Economics</td>
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</table>

#### Training and experience

Ph.D. candidate of the African Economic Research Consortium (AERC) Collaborative Ph.D. Programme (CPP), hosted by the University of Yaoundé II. She is currently researching the evolving socio-economic impacts of the COVID-19 pandemic on forcibly displaced persons and
Before this, she served as Consultant for the European Commission and Agence Francaise de Développement, and Junior Consultant for the International Labour Organization Decent Work Team (ILO/DWT) for Central Africa. As a member of the United-Nations University World Institute for Development Economics Research (UNU-WIDER) network, her forthcoming papers are co-authored by Kunal Sen (UNU-WIDER Director).

**Expected capacity building**
This study will strengthen her capacities in addressing the causal relationship with several econometric issues.

**Contribution to project**
She will be responsible for the literature and policy context review. She will also contribute to methods, empirical analyses, and data management to draft the working paper and research article.

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### Researcher #3

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<tr>
<td>Bernadin Géraud Comlan AHODODE</td>
<td>34</td>
<td>M</td>
<td>Master of Science in Economics</td>
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</tbody>
</table>

**Training and experience**
Ph.D. Candidate in Knowledge/Innovation Economics, ERASMUS MUNDUS/IntraACP. Specialised in Economics of Innovation and Climate Change and have been engaged in the study aiming at assessing the incidence of climate change on agricultural production in Benin. He also worked with many International Non-Governmental Organisations.

**Expected capacity building**
Increase his capacity in food security and crop diversification and improve his skills in setting policy advice and research vulgarisation.

**Contribution to project**
Will be working with the team leader to gather the relevant data and treatment of all relevant data on rainfall shocks. Crops diversification and food security in Ethiopia, Malawi, and Nigeria. He will be also responsible for policy advice that can be drawn from the results of this research.

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### Researcher #4

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<th>Age</th>
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<tr>
<td>Emmanuelle Dorcas MBANGA PAGAL</td>
<td>30</td>
<td>F</td>
<td>Master of Science in Economics</td>
</tr>
</tbody>
</table>

**Training and experience**
Ph.D. candidate in Mathematics Applied to Social Science at the University of Yaoundé II, Cameroon. Team leader in a PEP research proposal aiming at assessing the impact of financial inclusion on women entrepreneurship. Mid-time associated lecturer at the Catholic University Institute of Saint Theresa of Yaounde (INUCASTY) field Mathematics, Statistics.
### Expected capacity building

This project will improve her skills in micro econometrics methods, proposal writing, and presentation as well as research management.

### Contribution to project

She will assist in data cleaning, descriptive statistics, results derivation, and interpretation.

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<tr>
<th>Government official/officer #1</th>
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<tr>
<td>Name</td>
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<tr>
<td>René NGOUCHEME</td>
</tr>
</tbody>
</table>

#### Training and experience

Expertise in agricultural performance and economics of knowledge, land certification, climate change, and sustainable development. Currently, a researcher associated at the institute of Agricole Research and Development (IRAD)

#### Expected capacity building

Increase skills and knowledge in climate change adaptations strategies in SSA countries

#### Contribution to project

He will serve as a bridge between the research team and relevant stakeholders in the Ministries, Departments, and Agencies.

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<tr>
<th>Government official/officer #2</th>
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<tbody>
<tr>
<td>Name</td>
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<tr>
<td>Sunday Stephen AKOMOLAFE</td>
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</table>

#### Training and experience

Sunday is a trained Agricultural Economist. He holds a Bachelor's and Master's degrees in Agricultural Economics and his last stage of Ph.D. in Agricultural Economics. His research interest has been in Agricultural policy especially in Irrigation and climate change. He is vast in policy issues in the Water Sector.

#### Expected capacity building

This research will help Stephen in surveying respect on the food security status of various smallholder farmers working under various irrigation schemes being overseen by his Office. This research will assist him in communicating the outcome of research to his colleagues who are involved in public policy formulation

#### Contribution to the project

Stephen is vast in data Management and analysis. He will bring the experience he has gained over the years in the analysis household survey data to this research. He will also contribute immensely in the area of data collection
2.2. List of past, current or pending (non-PEP) projects in related areas involving team members, including resulting publications (if any)

Indicate the funding institution, the title of the project and related publications, and list the team members involved.

<table>
<thead>
<tr>
<th>Name of funding institutions</th>
<th>Title of projects and related publications (link)</th>
<th>Team member(s) involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Enterprise Development in Low-Income Countries (PEDL)</td>
<td>Title: Motivating long-term participation of youth in agricultural activities</td>
<td>Khadijat Busola Amolegbe</td>
</tr>
<tr>
<td>International Fund for Agricultural Development (IFAD)/International Institute of Tropical Agriculture (IITA)</td>
<td>Title: Enhancing capacity to apply research evidence in policy for youth engagement in agribusiness and rural economic activities in Africa</td>
<td>Khadijat Busola Amolegbe</td>
</tr>
<tr>
<td>J-Pal Africa Digital Identification and Finance Initiative (DigiFi)</td>
<td>Title: Rural Household Enrolments' Enrolment in Digital Identification and Payment Systems</td>
<td>Khadijat Busola Amolegbe</td>
</tr>
</tbody>
</table>

2.3. List of past or current PEP-supported projects involving team members, including resulting publications

<table>
<thead>
<tr>
<th>Project code (e.g. PMMA-12345)</th>
<th>Title of project and related external (non-PEP) publications, if any</th>
<th>Team member(s) involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEP (first stage)</td>
<td>Title: Financial inclusion and women entrepreneurship in SSA</td>
<td>Team leader, Emmanuelle Dorcas MBANGA PAGAL</td>
</tr>
</tbody>
</table>

SECTION III – RESEARCH, METHOD AND DATA

This section should be completed by the team leader and/or research members

3.1. Literature review (1000 to 1500 words)

There is abundant literature on the effectiveness of diversification in coping with rainfall shocks and other agricultural shocks. Diversification helps households secure alternative sources of income, and literature suggests that households engaged in off-farm activities are often less affected by climate shocks (Reardon, 1997; Porter, 2012). Webb et al. (1992) find that the extent to which households in Burkina Faso were able to cope with drought shocks were strongly associated with their non-farm diversification patterns. Reardon (1997) also finds a strong positive relation between non-farm income share and total household income in SSA. Since agricultural production in most of SSA is rainfed, farming households often diversify to other non-farm sectors to survive seasonal variations in rainfall patterns and about 25 to 50% of household labour time is spent in non-farm activities (Eicher et al., 1982). Birthal et al. (2019) note that agriculture is vulnerable to climate shocks and that rainfall-deficit and heat-stress are linked to reduced agricultural productivity.
Porter (2012) also note that Ethiopian households are often unable to protect themselves from rainfall shocks that occur on average every five years in rural Ethiopia.

Demeke et al. (2019), using a panel dataset on Ethiopian households and fixed effects regression models, explore the relationship between rainfall shocks, food security. The authors use a time-varying household food security index constructed using principal components analysis as a measure of food security and find that there is a negative relationship between rainfall shock and household food security status. Thompson et al. (2010) also explore literature related to climate shock and household food security status and notes that climate variation is linked to land degradation, decreased crop productivity, price fluctuation, negative welfare effects on SSA households. Thompson et al. (2010) further note the gap in knowledge related to effects on climate shock on household food security and nutrition status.

Teklewold et al. (2013) assess the cropping system diversification and conservation system in Ethiopia. The authors use a multinomial endogenous switching regression model and note that sustainable agricultural practices (SAPs) adopted by households are linked to farm productivity and household food security. Using a survey dataset of Nigerian households and historical rainfall datasets, Mulubrhan et al. (2018) show that rainfall shocks are linked to decreased agricultural productivity and a 37% decrease in household consumption. Di Falco et al. (2005) find that higher crop diversity leads to better production outcomes during negative rainfall shocks in Ethiopia but fails to identify the association between crop diversity and the quality and quantity of food consumed by households. However, Tesfaye et al. (2020) note that crop diversification is linked to increased welfare and food security of Ugandan households. Still, Asfaw et al. (2019) note that household access to land, input, and information are crucial factors to understanding the welfare implications of different diversification strategies. In other words, diversification varies across various socio-economic segments, and policymakers need to understand the effects across specific segments of the population.

Quisumbing et al. (2018) and Asfaw et al. (2018) note that weather shocks have different effects on men and women assets depending on household characteristics. Quisumbing et al. (2018) note that drought has a minor impact on the wife’s assets compared to the husbands. Using the panel dataset, Mahajan (2014) shows that rainfall shocks effect on gender inequality are linked to the type of crop cultivated. The authors note that rainfall shocks are linked to the gender wage gap in rainfed rice-growing areas. Björkman-Nyqvist (2013), however, shows that exogenous variation in rainfall explains the is linked to gender inequality among Ugandan households. Beegle et al. (2008) also find that women and children are more affected by the adverse shocks affect of crop yields in Tanzania. Bandara et al. (2015) also find that agricultural shocks increase the probability of girls of quitting school by 70%. Mbidi (2006) also find that one standard deviation increases in rainfall decrease the rate of marriage among young adult females by 10 percent. However, Barrett et al. (2000) note the importance of gender roles as regards household diversification decisions. The authors note that men may take up non-farm jobs while women are left to on-farm work, and this household decision may also be linked to the gender wage gap.

Doss et al. (2018) note the importance of women in improving the food security status of households. The authors note that women’s homestead plots and gardens help improve household dietary diversity. The authors further note that women often grow high nutrient and energy-rich food crops like cereals, roots and tubers to ensure an adequate supply of essential nutrients for their household. Mvula et al. (2018) note that in addition to being the primary supplier of labour for domestic activities, women supply farm labour for various production activities. FAO (2011), however, note that women are constrained by access to resources and the decisions on the use and management of farm plots is controlled by men. Hence, the capability of women to
use crop diversification strategies to mitigate the effects of rainfall shocks on the food security status of households remain an empirical question.

Our study seeks to provide new evidence on the nexus between rainfall shocks, crop diversification, and household food security status, focusing on the inter- and intra-household gender analysis. We will combine historical monthly rainfall data with the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) for Nigeria. We will focus on both crop enterprises and construct a diversity index using the Margalef index (MI) (Barrett and Reardon, 2000). We will also measure diversity using a vector of income shares associated with different income sources based on crop enterprises (Davis et al., 2010). We will focus on two measures of food security status, which are the Household Dietary Diversity Score (HDDS) and the reduced Coping Strategy Index (rCSI). We will then employ household fixed effects models to answer the research questions carrying out robustness checks using IV, Poisson regression and fractional probit regression methods. It is also worth noting that there is abundant evidence in other literature on the importance of biodiversity in enabling climate resilience and reducing climate variability and managing biotic and abiotic stresses, this aspect is out of the scope of our study.

3.2. Methodology (1200 to 1600 words)

Theoretical Framework
In light of Strauss (1986) and Strauss and Thomas (1995, 1998) works, the functional form of food security production is formulated as follows:

\[ F = F(N, A, D, \mu) \]

With: \( N \) input of food security, \( A \) household socio-demographic characteristics, \( D \): health environment factors, and \( \mu \): household unobserved characteristics. Following the agricultural household models of consumer demand and production (Singh et al., 1986), we consider that the crop production \( q \) is a function of soil characteristics \( s \), rainfall level \( \rho \), and the technology \( \tau \) (Breman et De Ridder, 1992). Thus, the reduced form of the food security demand function is:

\[ \gamma = \gamma(P, A, D, W, s, \rho, \tau, \varepsilon) \]

Each demand function varies with a vector of commodities prices \( P \), household socio-demographic characteristic \( A \) including gender, health environment factors \( D \), total income \( W \), crop production factors, and household unobserved characteristics including measurement errors and innate food security \( \varepsilon \).

Empirical strategy
The main interest of this study is to examine whether households can improve their food security status by diversifying within the agricultural sector, that is examining the household food security status response to exogenous changes in household diversification decision. We will test two main hypotheses:

1. Rainfall shocks have negative effects on household food security status. That is after controlling for household characteristics and other characteristics that may confound our results.
   - Female headed households are more negatively affected by the effects of rainfall shocks than male headed households.
However, crop diversification helps mitigate the effects of rainfall shock on household food security status. That is, the magnitude of the effects of rainfall shocks on households is muted by the degree to which households diversify.

- The crop diversification behaviour of female household members has more positive effects in mitigating the effects of rainfall shocks than the crop diversification behaviour of male household members.

To measure the degree of diversification, we will employ two basic methods - the most common method is by using the income share related to the various enterprises and crop cultivated, and the second method is the use of a diversification index, the Margalef Index (MI).

The income share is calculated as the share of total income derived from each crop cultivated by the household. The use of income share as a measure of diversification is common in economics literature because it is easy to construct and understood. Barrett et al. (2000) and Reardon (1997) note that ease of communication and computational simplicity are some of the advantages of using income share as a measure of diversification, however, this measure works best with aggregate levels of analysis. Barrett et al. (2000) suggested the use of indices for a disaggregated level of analysis, noting that it is often convenient to use scalar measures to represent observed diversification patterns. Barrett et al. (2000) and Reardon (1997) further note that, unlike income shares, indices capture the multidimensional aspects of household diversification behaviour.

Therefore, we will also employ a multidimensional measure of diversity by constructing a Margalef Index (MI) following Asfaw et al. (2016) and Margalef (1958). Although there are also no perfect indices for capturing diversification behaviours of households, unlike other indices used in the economics literature, MI is a measure of species richness (Morris et al., 2014; Gamito, 2010). Sibhatu et al. (2015) note that MI has a superior discriminant ability and is mostly used in agrobiodiversity literature. Sibhatu et al. (2015) also note that MI captures the area of land cultivated and covered by different crop varieties. Therefore, MI has the strength to capture crop diversification which is the major focus of our study. The formula is given as:

\[
MI = \frac{(A - 1)}{\ln(C)}
\]

Where: C is the total population count overall farmer-managed units of diversity options, and A is the number of farmer-managed units of diversity. The index has a lower limit of zero if only one unit of diversity is observed. These indices are calculated for crop ventures, and we will construct indices at the household level and for male and female household members.

Also, the study will focus on two different measures of food security status: Household Dietary Diversity Index (HDDS) and reduced Coping Strategy Index (rCSI). These two measures are commonly used as indicators of household food security. The HDDS is a measure of food access and we will follow the steps listed in the International Dietary Data Expansion (INDDEX) project to construct the HDDS (Swindale et al., 2006). The HDDS is the number of food groups consumed by the households over a period; for this study we will use seven days. That is, the HDDS is the number of food groups consumed by the household within the last seven days. We will also focus on 12 main food groups that are pulses, legumes and nuts; roots and tubers; cereals; fruits; vegetables; eggs; meat, poultry and offal; sugar and honey; fish and seafood; oil and fat; milk and milk products; and miscellaneous. Therefore, households that consume all the food groups within the seven days reference period will be assigned a score of 12. Higher scores are linked to greater diversity and associated with improved food security, better food access, and higher quality, while low scores are linked to food insecurity (Amolegbe et al., 2019).
The rCSI is an easy assessment of the coping strategies employed by households to cope with shocks. Vaitla et al. (2018) note that the rCSI is best used with other food security measures to give a clear picture of household food security status. We will follow the methods by Maxwell et al. (2008) to construct the rCSI. Maxwell et al. (2008) note that rCSI is determined by multiplying each of five common household coping strategies in response to food shortages by universal severity weights and the number of days in the past seven. The five coping strategies employed by households include: (1) relying on less preferred and less expensive foods; (2) borrowing food, or relying on help from a friend/relative; (3) limiting the portion sizes at mealtimes; (4) restricting consumption by adults for small children to eat; and (5) reducing the number of meals eaten in a day. Each of these strategies is assigned weights to construct the rCSI, and higher scores are associated with lower food security and greater hardship. The dietary diversity score represents the number of different foods or groups consumed over a given reference period by individual or households.

After constructing the relevant variables, different specifications will be used to verify our hypotheses. Indeed, for the evaluation of the impact of rainfall on household food security, we adopt the following fixed-effect panel specification:

\[ P_{ht} = c + \lambda CD_{ht} + \delta H_{ht} + \Omega V_h + LT_t + g(T_t \times V_h) + \mu_{ht} \]  
\[ P_{ht} = \alpha + \beta R_{ht} + \delta H_{ht} + \varphi V_h + \gamma T_t + \omega(T_t \times V_h) + \epsilon_{ht} \]

\( P_{ht} \) is household food security measure – HDSS and rCSI. \( CD_{ht} \) is crop diversification measure (income share and MI), \( R_{ht} \) is average historical/seasonal rainfall, \( H_{ht} \) is a vector of time-variant household characteristics such as age, sex, and education level of household head, household size, adult equivalence, and \( V_h \) is a vector of time-invariant characteristics. \( T \) is the time effect for period \( t \). \( \epsilon_{ht} \) and \( \mu_{ht} \) are the error term. The coefficients of interest are \( \beta \) and \( \lambda \), which show the relationship between diversification, rainfall, and household food security status, respectively. The coefficients should be negative for rainfall, and positive for crops diversification. Equation 4 and 5 will be operationalised for male and female-headed households.

We will assess the crop diversification mitigating effects of rainfall shocks on household food security status through the equation below:

\[ P_{ht} = \zeta + \xi(CD_{ht} \times R_{ht}) + R_{ht} + \theta V_h + \vartheta T_t + \eta(T_t \times V_h) + \epsilon_{ht} \]

Compared to the previous equation, the interaction between \( CD_{ht} \): crops diversity measure and \( R_{ht} \): average rainfall is included in this equation to show the mitigating effects \( \xi \) listed above. Thus, we expect a positive sign from this interaction coefficient. Equation 6 will also be operationalized based on the crop diversification measure of male and female household members.

**Robustness checks**

Although the household survey dataset contains rich data that may be used to control for observed characteristics, there remains the problem of endogeneity (reverse causality) which may confound the estimates. Therefore, the identification strategy for the equation 4 is to reduce the bias by instrumenting changes in farm diversity over time with changes in rainfall patterns. The change in rainfall over time should be a valid instrument, as it is likely to have an important effect on household food security status in SSA where most households are food producers. Drawing strength from Yang and Choi (2005), the IV equations are given as:
\[
\Delta CD_{h(t+1)} = \pi_0 + \pi_1 \Delta RD_{h(t+1)} + \pi_2 \Delta RW_{h(t+1)} + \pi_3 V_h + \epsilon_{h(t+1)} \\
\Delta P_{h(t+1)} = \rho + \beta \Delta CD_{h(t+1)} + \pi_4 V_h + \mu_{h(t+1)}
\]  

\[7\]

\[8\]

\(\Delta RD_{h(t+1)}\) and \(\Delta RW_{h(t+1)}\) are the changes in rainfall relevant for \(\Delta CD_{h(t+1)}\) the change in crops diversity measure between \(t\) and \(t+1\), in the dry and wet seasons, respectively. The inclusion of \(V_h\) allows for heterogeneity in the time trend from \(t\) to \(t+1\) across households depending on time-invariant characteristics. \(\epsilon_{h(t+1)}\) is the error term. The predicted change in crops diversity, \(\Delta CD_{h(t+1)}\) is shown in equation 8 and \(\rho\) is a constant term, substitutes for the change in year effects, \(\pi_4\) for the change in the vector \((X_t - X_{t+1})\), and the new error term \(\mu_{h(t+1)}\). Equation 8 will be the estimating equation for the regression analysis. To correct the endogeneity problem in equation 6, we will use the generalized methods of moment (GMM) instrumental variable approach based on order 1 and 2, or order 2 and 3 lags of the endogenous variable \((CD_t \times R_t)\) as an instrument. Once the estimates are made, we will carry out the various robustness tests before interpretation.

Also, as HDDS is a count variable, equations 4, 5 and 6 will be estimated using a Poisson regression model. For rCSI, a fractional variable between 0 and 1, we will use a fractional probit regression model.

### 3.3. Data requirements and sources (1000 to 1300 words)

**Rainfall data**

Rainfall data that will be used for this study will be obtained from the Nigeria Meteorological Centre. Monthly average rainfall data for all the towns across the 36 states and the Federal Capital Territories 2009 to 2019 will be used for this study. We will calculate the historical and seasonal rainfall averages for each town, herewith otherwise referred to as average historical and seasonal. The historical rainfall average is given as

\[R = \frac{(F_{m,y} - F_{m})}{F_{m}}\]

Where \(F_{m}\) is the the rainfall for a particular month \(m\) over the year 2009 to 2019 and \(F_{m,y}\) is the rainfall for month \(m\) at time \(y\). In this case, \(R\) is the historical rainfall average. We will also construct a seasonal average and pay particular attention to the rainfall average in the dry season and the wet months (season). The seasonal average is calculated by comparing the rainfall in two adjacent months and it is given as

\[R = \frac{(F_{m,y} - F_{m-1,y})}{F_{m-1,y}}\]

The dataset will then be georeferenced, and households will be assigned the historical and seasonal rainfall averages close to them based on their household location and date of survey interview.

Figure 1 shows the month-to-month rainfall trend in Nigeria for the period 2009 and 2016. The wet season runs from April to October, with a short dry spell in August and reduced rainfall in 2013.
Generally, it is important to note that Nigeria has diverse rainfall pattern with a longer dry spell in the northern parts of the country than the south. Hence, the differences in rainfall pattern across time and space suggest present an opportunity for us to explore the effects on households.

**Household survey data**

This study will use the four waves of the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) project for Nigeria. The LSMS-ISA project is a nationally representative and comprehensive panel survey conducted by the World Bank and the National Bureau of Statistics of various countries. In sub-Saharan Africa, the survey covers eight countries – Ethiopia, Nigeria, Malawi, Niger, Mali, Burkina Faso, Tanzania, and Uganda. The survey collects data on the household, agricultural, and community characteristics and captures the seasonal variations in SSA. That is, each of the waves was collected twice – during the post-planting and post-harvest visits, and information was collected at household, agricultural, and community levels. The household questionnaire captures data on the individual members of the household. It includes details about food and non-food consumption, labour outcomes, non-farm enterprises, dwelling conditions, assets, education, and health conditions. Each household and individual in the household have a unique identification. The agricultural questionnaire captures information at the plot level and includes details on on-farm activities, crop production, sales and storage, input use, landholding, livestock holdings, and technology use. The community questionnaire includes details about the facilities present in the communities, social networks, retail prices, and governance. The dataset is georeferenced; therefore, we will be able to merge the rainfall datasets to the households. The survey covers both urban and rural areas and cuts across all the regions in the countries. The frequency of the survey for each country varies depending on the data demand by the country and the availability of funds. The LSMS-ISA project is funded by the Bill and Melinda Gates foundation.

The Nigeria LSMS-ISA survey is a redesign of the General Household Survey (GHS) and an implementation (introduction) of a panel component called the GHS-Panel. The GHS cross-sectional survey of 22,000 households is usually carried out annually between February and March, while the panel component is conducted every two years. The GHS-Panel survey is conducted by
the National Bureau of Statistics (NBS) and the World Bank and the first wave was also collected in 2010/2011, the second wave was collected in 2012/2013, the third wave in 2015/2016, and the fourth wave 2018/2019. The Nigeria GHS Panel data sets were carried out in two visits, that is the post-planting and post-harvest visits. The post-planting falls between August and October, and the post-harvest is usually from February to April. The GHS-Panel consists of 5,000 households, which is a sub-sample of the GHS. The sample is nationally representative covering the rural and urban areas of the six geopolitical zones, and the information includes household, agricultural, and community-level characteristics. Our observational units for this study are farming households that are present during both survey waves, and we will focus on data such as include self-reported data on household income, expenditure, consumption, agricultural activities, and other non-farm activities. We will also consider the seasonal variation by considering the post-planting and post-harvest surveys across each survey wave.

Such a comprehensive panel dataset offers some advantages for our study. We will be able to account for time variations, thereby increasing the precision of our estimates. Also, the individual dimension of the panel data models offers the possibility to learn more about the dynamic of individual behaviours which are particularly important in this context, especially when exploring the crop diversification behaviour of households. We will also use a fixed-effect model which offers the possibility of consistent estimators, resolving, therefore, potential unobserved heterogeneity problems due to the omitted variable bias (Cameron & Trivedi, 2005; Leszczensky & Wolbring, 2018). However, despite the advantages, the panel dataset may also present some limitations. The absence of autocorrelation is needed to guarantee the validity of the moment conditions. However, error terms for different periods may be correlated, especially when data used are particularly vulnerable to exogenous shocks, the standard errors, therefore, tend to be severely downward biased. Hence, we will employ an instrumental variable technique to check for the robustness of our estimates. Panel data estimator also have small sample properties, and the traditional misspecification test tends to be misleading. Although the LSMS-ISA surveys track individuals over time and across waves, we will test for attrition across waves using the Inverse Probability Weighting (IPW) methods recommended by Foster and Bickman (1996) and Verbeek and Nijman (1992).

Table 1: Food security status at baseline

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Male headed</th>
<th>Female headed</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>HDDS</td>
<td>8.08</td>
<td>8.04</td>
<td>8.28</td>
</tr>
<tr>
<td></td>
<td>rCSI</td>
<td>3.07</td>
<td>2.84</td>
<td>4.37</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>9715</td>
<td>8248</td>
<td>1467</td>
</tr>
<tr>
<td>Post planting</td>
<td>HDDS</td>
<td>8.03</td>
<td>8.00</td>
<td>8.15</td>
</tr>
<tr>
<td></td>
<td>rCSI</td>
<td>3.86</td>
<td>3.69</td>
<td>4.78</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>4893</td>
<td>4144</td>
<td>749</td>
</tr>
<tr>
<td>Post harvest</td>
<td>HDDS</td>
<td>8.13</td>
<td>8.08</td>
<td>8.42</td>
</tr>
<tr>
<td></td>
<td>rCSI</td>
<td>2.27</td>
<td>1.97</td>
<td>3.95</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>4822</td>
<td>4104</td>
<td>718</td>
</tr>
</tbody>
</table>

*** p<0.01, ** p<0.05, * p<0.1
Source: authors’ calculation

Table 1 shows the descriptive statistics of household food security status at baseline (Wave 1). We present the differences based on the sex of the head of households and based on seasonality. We
also present the t-test difference in mean between the male-headed and female-headed households. Households are more food secure during the post harvest season than the post planting season. We also note that on average, female headed households have higher HDDS than male headed households, hence consume more diverse diet. However, the rCSI shows that female headed households are less food secure.

Figure 2 shows the descriptive statistics of households based on crop yields of female and male-headed households and plot ownership of male and female household members. Results in figure 2 are presented for eight commonly cultivated crops in Nigeria – cassava, yam, maize, sorghum, millet, rice, and groundnut cowpea, and data were obtained from the fourth wave of the LSMS-ISA survey for Nigeria. The result shows that almost cassava, yam and maize are some of the commonly cultivated crops by households, with female-headed households growing mostly cassava. Cowpeas and groundnut are relative less cultivated compared to other crops, and the share of cowpeas cultivated by women (households head and plot managers) for instance represent about half of those cultivated by men. Likewise, sorghum is twice cultivated by male-headed households and plot managers compared to women household heads and plot managers. This suggests differences in the type of crops cultivated across and within households and provides insight as to how the crop diversification behaviours of households and individuals may be linked to household food security.

**Figure 2: Gender difference in crop yields per kg/ha**

![Graph showing gender difference in crop yields per kg/ha](image)

Source: Authors, own calculations using the wave 4 Nigeria LSMS Integrated Surveys on Agriculture

**SECTION IV – INFORMING POLICY**

### 4.1. Government affiliation

a) Name the government institution at which you are employed, and describe its general mandate

The Institute of Agricultural Research for Development is operating under the joint technical supervision of the Ministry of Scientific Research and Innovation and the Ministry of Finance. The institute research crops, livestock, forestry, fisheries, and natural resources.
The Lower Niger River Basin Development Authority, Nigeria is a government parastatal managing water resources for agricultural activities and rural development.

b) What is/are your specific role(s) (as employees) in the institution

<table>
<thead>
<tr>
<th>Government official/officer #1</th>
<th>René NGOUCHEME</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>René NGOUCHEME</td>
</tr>
<tr>
<td><strong>Title/position</strong></td>
<td>Head of General Affairs Services</td>
</tr>
<tr>
<td><strong>Role/responsibilities</strong></td>
<td>Coordinate research and general services on scientific evaluation at the Headquarter</td>
</tr>
<tr>
<td><strong>Who do you directly report to?</strong></td>
<td>Executive Director</td>
</tr>
<tr>
<td><strong>Please describe the extent/nature of your influence on policy decisions</strong></td>
<td>Participate at the first line in decision advises for the institute and taking for my division</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Government official/officer #2</th>
<th>Sunday Stephen AKOMOLAFE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Sunday Stephen AKOMOLAFE</td>
</tr>
<tr>
<td><strong>Title/position</strong></td>
<td>Senior Planning Officer I</td>
</tr>
<tr>
<td><strong>Role/responsibilities</strong></td>
<td>In charge of data management and analysis. Engage in project monitoring and evaluation. Design an annual project work plan for the Authority. Responsible for managing the Authority’s Databank and Database. Work as a web administrator of the Authority. Assist in the conduct of promotion exercise as a Data Analysis.</td>
</tr>
<tr>
<td><strong>Who do you directly report to?</strong></td>
<td>Executive Director</td>
</tr>
<tr>
<td><strong>Please describe the extent/nature of your influence on policy decisions</strong></td>
<td>Responsible for preparing Annual Budgets of the Authority, and advise senior managers on budget allocation decisions.</td>
</tr>
</tbody>
</table>

4.2. Describe the policy context and needs

a) Describe the specific policy issue(s), questions, or needs faced by your institution and that the research project aims to inform - both in terms of socio-economic outcomes (identify the target/beneficiary population), and the related policy processes (whether it is at the stage of the debate, decision, design, implementation, review, reform, etc.).

Explain why the evidence to be produced with this research is important/useful to inform decision-making, especially with regard to your institution’s specific mandate and strategies.

This study is of interest to our institutes for at least two reasons. First, it is concentrated on crop diversification and food security which are of great interest in our activities on crops (cereals, root and tuber crops, legumes, and fruit trees) carried out in the Biotechnology laboratory. Second, it assesses the impact of rainfall shocks on crop diversification and food security. For these reasons, the results of this study will strengthen and extend the ministry of Tutela programs devoted to agricultural research. It will help them especially identify priority areas and a group of
individuals that need capacity-building interventions. The target beneficiaries of the study are farmers, the rural population, and women who are carrying out about 80% of activities in the agricultural sector.

b) What are the current policy options/scenarios, faced by (or available to) decision-makers - in terms of potential interventions, approaches, etc. - in relation to this particular issue?

If possible, also provide a brief history of policy initiatives (and related reforms, if any) implemented in the past to address the issue, indicating generally what worked and what didn’t (i.e., why is this still an issue?).

Mobilization, optimal allocation of resources, and prioritization of development objectives are the missions of the ministry of Tutela and our institute. By identifying the heterogeneous effects of rainfall shocks on crop diversification and food security, this research will result in well-targeted and efficient policy advice, in line with the objectives of this ministry.

c) How do you expect this evidence will be used/assimilated effectively into the relevant policy decision/advisory processes? Be as precise as possible, indicating the specific decisions or recommendations that have to be made by your institution.

Are you aware of any cost- or budget-related considerations that should be taken into account in the context of these policy decision/advisory processes?

Also, justify the timing of the proposed research project - how does it fit with the calendar of the related policy decision/advisory processes?

Stakeholders retained for this study oversee the development and implementation of research and innovation policies in our countries. From this perspective, the identification of factors that influence agricultural performance is critical for the success of his programs. Therefore, this study is crucial because it will provide the first empirical evidence on the effects of rainfall shocks on crop diversification and food security. As a result, recommendations drawn from this study will strengthen post-shock agricultural policies in Sub-Saharan Africa.

4.3. Stakeholder mapping and dissemination

List all other potential stakeholder institutions, i.e., institutions that you consider as potential users of the same research evidence (other than your own). These can include other ministries and government agencies, as well as civil society organisations, NGOs, private sector, etc.

<table>
<thead>
<tr>
<th>Name of institution/organization #1</th>
<th>Ministry of Scientific Research and Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>List the key representatives or target research users (policy makers or influencers)</td>
<td>- Eugene Ejolle EHABE/ Executive Director IRAD</td>
</tr>
<tr>
<td>Describe briefly why and how you believe this institution could use the evidence</td>
<td></td>
</tr>
<tr>
<td>This resource person suggested that we question the effect of crop diversification on food security, as policies could be rapidly strengthened in this area.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of institution/organization #2</th>
<th>River Basin Development Authorities (RBDA) in Nigeria</th>
</tr>
</thead>
<tbody>
<tr>
<td>List the key representatives or target research users (policy makers or influencers)</td>
<td></td>
</tr>
</tbody>
</table>
Describe briefly why and how you believe this institution could use the evidence

These Organisations are in rainfall limited areas of the state. They have the responsibility for providing water for irrigation to complement rainfall shortage which characterises the area. Result of this research will help them in modeling water requirement for farmers under their areas of coverage.

Name of institution/organization #3
- House Committee of Water Resources and Senate Committee on Water Resources in Nigeria

List the key representatives or target research users (policy makers or influencers)
- Aliyu Pategi Ahman, Chairman House Committee of Water Resources
- Sada Soli, Chairman Senate Committee on Water Resources

Describe briefly why and how you believe this institution could use the evidence

These committees are the subcommittees of the House of Representatives and Senate. They are saddled with the responsibilities of making law relating to water resources in the country as well as oversight functions on various agencies in the water sector. The result of this research will be an eye-opener by providing scientific evidence of what is obtainable on the field and will, in turn, help them in legislation that will ameliorate shocks resulting from erratic rainfall in the country.

4.4. Outline your engagement/dissemination strategy

Describe how you intend to engage with these other stakeholder institutions (listed in 4.3) to ensure that they:

1) Contribute to informing the research work (i.e. consultations)
2) Are kept informed of the research progress and findings

At the beginning of the project, we intend to have consultations with the stakeholders and the researcher team. A national policy conference where the research project will be presented to the public stakeholders as well researcher will be organized. A periodical consultation with stakeholders will take place from these consultations, we will get inputs and incorporate them into the research in accordance with Stakeholder expectation (the one mention in section 4.3). This will be followed up with periodic meetings and updates to intimate about the progress of the research.
Following the interim results, we will also plan to organize working sessions (workshop), meetings to disseminate the results and obtain comments. After the final results have been approved by PEP, we will work with the stakeholders to organize a national policy conference where the research project will be presented to the public. Other forms of dissemination will also include policy briefs, newspaper articles, blog posts, etc. Policy briefs will be widely distributed during this seminar. The research team also aims to present the results of the project at international conferences. The researchers also aim to publish the results of their project in a refereed journal.

The preliminary dissemination strategy is as follows:

<table>
<thead>
<tr>
<th>Event</th>
<th>Audience</th>
<th>Media coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial stage</td>
<td>Kick-off workshop. Presentation and discussion of, (i) national policy context, (ii) research questions, (iii) methodology, (iv) data, and (v) policy relevance of the project.</td>
<td>Researchers, graduate students, policy markers</td>
</tr>
<tr>
<td>2. Middle stage</td>
<td>Monthly seminar: presentation and discussion on preliminary results.</td>
<td>Researchers, graduate students, policy markers</td>
</tr>
<tr>
<td>3. Final stage</td>
<td>Final workshop. Presentation and discussion of, (i) results, and (ii) policy recommendations.</td>
<td>Policymakers, researchers, graduate students.</td>
</tr>
</tbody>
</table>

**SECTION V – OTHER CONSIDERATIONS**

5.1. Describe any ethical, social, gender or environmental issues or risks that should be noted in relation to your proposed research project.

There is no major risk in this study. Nevertheless, throughout this project, the integrity and security of researchers and authorities associated will be ensured through responsible and transparent communication. Finally, as regards the production of research outcomes, the background of the researchers involved in this project is the first guarantee of the success of this research.

5.2. References and plagiarism:


McIntosh, Sarris, A. and Papadopoulos, F., 2013. Productivity, credit, risk, and the demand for weather index insurance in smallholder agriculture in Ethiopia. Agricultural Economics 44:399–417


Mvula, P., & Mulwafu, W. 2018. Intensification, Crop Diversification, and Gender Relations in Malawi. In Andersson Djurfeldt, A., Mawunya Dzanku, F., & Isinika, A. (Eds.), Agriculture,
Diversification, and Gender in Rural Africa: Longitudinal Perspectives from Six Countries: Oxford University Press.


