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The roles of nutrition-sensitive interventions and market access in enhancing household food security and resilience in Sierra Leone

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Abstract

Using Sierra Leone – a post-conflict country in West Africa – as a case study, this dissertation addresses pressing issues on how to make smallholder agriculture more nutrition-sensitive, mitigate the adverse effects of seasonality on food security, and strengthen rural households' resilience against shocks and stressors. The study utilizes self-collected panel data from 836 smallholder cocoa, coffee and cashew farming households in Eastern and Northern Sierra Leone between 2017 and 2019. The primary data is complemented with secondary data from the Sierra Leone Integrated Household Survey.

The first study exploits the quasi-experimental design to study the impacts and related pathways of an integrated agriculture-nutrition intervention. A focus is on the dietary outcomes of the interventions for cash cropping. Using a doubly robust estimator, the study finds that combining support for cash crop production and nutrition training led to a significant increase in household, maternal, and child dietary diversity and consumption of nutritious foodstuffs. The nutrition intervention alone is found to increase maternal intake of micronutrient-dense food groups significantly. However, the results indicate that solely supporting the production of the cash crops may significantly inhibit both household and individual dietary diversity. Improving caregiver's nutrition knowledge and confidence in influencing food-related decisions are found to be the key pathways linking the combined intervention to better dietary outcomes.

Utilizing data from two waves of the national household survey, the second study finds that agricultural seasonality imposes significant fluctuations on household dietary diversity and food security in Sierra Leone. The results show that rural households are most vulnerable to food insecurity during the lean season, during which they are compelled to frequently limit portion size at meal times and skip meals. Most importantly, the study finds that households residing closer to food markets consume more diverse diets and are more food secure in both lean and non-lean seasons than remoter households.

The final study employs the panel data on smallholder cash cropping households to examine the drivers of resilience capacity and its effects on food security in the face of shocks. Relative to non-participating households, the interventions are found to significantly increase the resilience capacity of the beneficiaries, by enhancing their adaptive capacity and ownership of productive assets. The empirical analysis also shows that more resilient households have superior future food security outcomes and are better positioned to effectively deal with shocks.

Based on these results, the thesis concludes that incorporating a nutrition component into cash crop interventions promises to deliver larger nutritional benefits than implementing them in isolation. Additionally, development strategies aimed at strengthening market access, adaptive capacity, and access to productive assets will not only alleviate seasonal hunger but also enhance the resilience of rural households against shocks and preserve their food security and overall wellbeing.

Zusammenfassug

Anhand einer Studie in Sierra Leone - einem Post-Konflikt-Land in Westafrika - befasst sich diese Dissertation mit drängenden Fragen, wie die kleinbäuerliche Landwirtschaft ernährungssensibler gestaltet, die negativen Auswirkungen der Saisonalität der landwirtschaftlichen Produktionsentwicklung auf die Ernährungssicherheit abgemildert und die Widerstandsfähigkeit ländlicher Haushalte gegen Schocks gestärkt werden können. Die Studie stützt sich auf Primärpaneldaten einer Befragung von 836 kleinbäuerlichen Kakao-, Kaffee- und Cashew-Haushalten im Osten und Norden Sierra Leones in den Jahren 2017 und 2019. Die Primärdaten wurden durch Sekundärdaten der Sierra Leone Integrated Household Survey ergänzt.

Die Studie nutzt ein quasi-experimentelle Design, um die Auswirkungen und die damit verbundenen Wege einer integrierten ernährungssensiblen Landwirtschaft-Intervention zu untersuchen. Ein Schwerpunkt liegt auf den Auswirkungen von Interventionen für den Anbau von Marktfrüchten auf die Ernährung der betroffenen Haushalte. Unter Verwendung des doubly robust Schätzers kommt die Studie zu dem Ergebnis, dass die Kombination einer Intervention zur Unterstützung für -des Anbaus von Marktfrüchten und einer Schulung zur gesunden Ernährung zu einer signifikanten Zunahme der Ernährungsvielfalt von Haushalten, Müttern und Kindern sowie einer Erhöhung des Verzehrs besonders nahrhafter Nahrungsmittel führte. Es wurde festgestellt, dass allein die Schulung zur gesunden Ernährung den Konsum von Nahrungsgruppen mit Mikronährstoffdichte von Müttern signifikant erhöhte. Die Ergebnisse deuten jedoch darauf hin, dass die alleinige Intervention zur Verbesserung des Anbaus von Marktfrüchten sowohl die Ernährungsvielfalt im Haushalt als auch die der jeweiligen Haushaltsmitglieder signifikant hemmen kann. Die Verbesserung des Ernährungswissens und der Einfluss der Betreuungsperson auf ernährungsbezogene Entscheidungen Einfluss zu nehmen sind wichtige Wege, auf denen kombinierte Interventionen zu besseren Ernährungsergebnissen führte.

Unter Verwendung der Daten zweier Befragungswellen der nationalen Haushaltserhebung kommt die Studie weiterhin zu dem Schluss, dass die Saisonalität der Landwirtschaft in Sierra Leone signifikante Schwankungen in der Ernährungssicherheit und Ernährungsqualität der Haushalte bewirkt. Die Ergebnisse zeigen, dass ländliche Haushalte während der mageren Jahreszeit, in der sie häufig gezwungen sind, die Portionsgröße der Mahlzeiten zu begrenzen und Mahlzeiten auszulassen, am stärksten von Ernährungsunsicherheit betroffen sind. Vor allem aber zeigt die Studie, dass Haushalte, die in geringerer Distanz von Märkten leben, vielfältigere Nahrungsmittel konsumieren und sowohl in der mageren als auch in der nicht-mageren Jahreszeit eine höhere Ernährungssicherheit aufweisen als Haushalte in abgelegenen Gegenden.

Eine weitere Studie verwendet Paneldaten kleinbäuerlicher Haushalte, die Markfrüchte anbauen, um die Triebkräfte der Widerstandsfähigkeit und ihre Auswirkungen auf die Ernährungssicherheit angesichts von Schocks zu untersuchen. Im Vergleich zu den nicht an der Intervention teilnehmenden Haushalten wird festgestellt, dass die Interventionen die Widerstandsfähigkeit der Begünstigten deutlich erhöhen, indem sie ihre Anpassungsfähigkeit und das Eigentum an Produktionsmitteln erhöhen. Die empirische Analyse zeigt auch, dass widerstandsfähigere Haushalte in Zukunft bessere Ergebnisse bei der Ernährungssicherheit erzielen und besser in der Lage sind, mit Schocks effektiv umzugehen.

Auf der Grundlage dieser Ergebnisse kommt die Dissertation zu dem Schluss, dass die Einbeziehung einer Ernährungskomponente bei Interventionen im Bereich von Marktfrüchten größere Vorteile für die Ernährung verspricht, als isolierte Umsetzung von Marktinterventionen. Darüber hinaus können Entwicklungsstrategien, die auf die Stärkung des Marktzugangs, der Anpassungsfähigkeit und des Zugangs zu Produktionsmitteln abzielen, nicht nur den saisonalen Hunger reduzieren, sondern auch die Resilienz ländlicher Haushalte gegen Schocks erhöhen und ihre Ernährungssicherheit und ihr allgemeines Wohlbefinden bessern.

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Isaac Bonuedi

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List of Abbreviation

ABS	Access to Basic Services
AC	Adaptive Capacity
AE	Adult Equivalent
AST	Assets
CBO	Community-Based Organization
CDDS	Child Dietary Diversity Score
COOPI	Cooperazione Internationale
COVID	Coronavirus Disease
CRE	Correlated Random Effects Model
CSI	Coping Strategy Index
FAO	Food and Agriculture Organization
FBO	Farmer-Based Organization
FCS	Food Consumption Score
GLOPAN	Global Panel on Agriculture and Food Systems for Nutrition
HDDS	Household Dietary Diversity Score
IFAD	International Fund for Agricultural Development
IPWRA	Inverse Probability Weighted Regression Adjustment
LANN	Linking Agriculture and Natural Resource Management towards Nutrition Security
MsHDDS	Micronutrient-sensitive Household Dietary Diversity Score
MsWDDS	Micronutrient-sensitive Women Dietary Diversity Score
OLS	Ordinary Least Squares
PROACT	Pro-Resilience Action 2015: Fostering Smallholder Agriculture in Sierra Leone
PSM	Propensity Score Matching
RCI	Resilience Capacity Index
SDG	Sustainable Development Goals
SLL	Sierra Leonean Leones
SPRING	Strengthening Partnerships, Results, and Innovations in Nutrition
SSN	Social Safety Nets
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WDDS	Women Dietary Diversity Score
WFP	World Food Programme
WHH	German Welthungerhilfe eV
WHO	World Health Organization
ZEF	Zentrum für Entwicklungsforschung / Center for Development Research

CHAPTER 1
Introduction

1.1 Background of the study

Global hunger has risen consecutively since 2014, reverting to the heights recorded a decade ago. Entering 2020, estimates suggest that, despite ample global food production, close to 690 million people worldwide still suffer from severe food insecurity and do not have sufficient access to food to meet their dietary needs (FAO et al., 2020). At the same time, over 2 billion people are adversely affected by hidden hunger and its associated non-communicable diseases (FAO et al., 2020). The COVID-19 pandemic is expected to cause additional 83 to 132 million people join to the ranks of the undernourished by the end of 2020 (FAO et al., 2020). Conflicts, climate change and its ensuing extreme weather events, as well as economic slowdowns and downturns were among the principal drivers of the rising global hunger rates between 2017 and 2019 (FAO et al. 2017; 2018; 2019). Hidden hunger remains primarily driven by high intakes of unhealthy and undiversified diets that are deficient in essential vitamins and minerals such as vitamin A, zinc, and iron. With the recent reversals eroding the decade-long progress in combating hunger, achieving a world without any form of hunger, food insecurity, and malnutrition remains one of the immense, and obstinate development challenges (FAO et al., 2019; United Nations, 2015).

Ironically, majority of the world's food insecure and malnourished population are smallholder farmers[1] in Africa, Asia, and other developing regions (IFAD, 2014; World Bank, 2007). Moreover, these smallholder households also live in extreme poverty and are highly prone to different shocks and stressors, which further exacerbate their already alarming food insecurity and nutrition situation. Households in rural areas, where agriculture is the mainstay, are disproportionately affected, albeit concerns about increasing food insecurity in urban areas continue to mount. The agriculture sector holds enormous potential to contribute to improved food security and nutrition by ensuring that nutritious foods, sufficient to meet everyone's dietary needs, are available and accessible at all times, either from own production or the

[1] According to the International Finance Corporation (2013) a smallholder farm in the developing world is usually a family-owned enterprise that grows crops or livestock on 2 or less hectares. However, smallholdings can exceed 10 hectares in some countries.

market. As Herforth et al. (2012) noted, exploiting this potential has been the rationale behind agricultural interventions, which have customarily focused on boosting food production and increasing incomes.

Over the years, these interventions, along with investments in agricultural modernization, have been instrumental in fostering agricultural productivity, increasing incomes, and alleviating hunger and poverty (World Bank, 2007). However, the persistence of food insecurity and poor nutrition outcomes, in a world of plentiful food supply, evinces that growth in agricultural production and incomes alone has a limited impact on nutrition (Fan & Pandya-Lorch, 2012; World Bank, 2015a). In particular, several empirical studies have shown that growth in food production is essential but does not always translate into improved nutritional outcomes (Berti et al., 2004; Ecker et al., 2012; Herforth et al., 2012; Pandey et al., 2016; Webb & Kennedy, 2014; World Bank, 2007). Similarly, other studies, notably Carletto et al. (2017), von Braun and Kennedy (1995), and World Bank (2007), have also documented that increased incomes from agricultural commercialization or cash cropping schemes may have little or no long-term impacts on maternal and child nutritional status. One main reason is that the conversion of higher food production or incomes into improved nutrition depends on several underlying, intra-household and community factors. These mediating factors include women's nutrition knowledge, control over income, decision-making power, health, and nutrition-related practices, and access to and utilization of health and sanitation facilities (Hawkes & Ruel, 2008; von Braun & Kennedy, 1995). Furthermore, there is a general consensus that, though effective in tackling the immediate causes of undernutrition, sole and full-scale delivery of food fortification, nutrient supplementation, and other nutrition-specific interventions are insufficient to reach global targets of eliminating all dimensions of malnutrition (Bhutta et al., 2013; Ruel et al., 2018).

This baffling disconnect between agriculture and nutrition has left policymakers, researchers, and the worldwide development community grappling with how to intervene in food systems at large, and smallholder agriculture in particular, to make them become more nutrition-sensitive (Fan & Pandya-Lorch, 2012; GLOPAN, 2014; IFAD, 2015). Realizing agriculture's potential for improved nutrition calls for an integration of agriculture with health and nutrition sectors, which have hitherto functioned in separate silos. This awareness has stimulated a growing push and support by national governments, donors, and development agencies for nutrition-sensitive agricultural interventions and investments – that incorporate explicit nutritional goals and actions (Herforth et al., 2012; Ruel et al., 2018; Ruel & Alderman, 2013). According to the FAO (2014) nutrition-sensitive agriculture is a "food-based approach to agricultural development that puts nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition and micronutrient deficiencies." It aims to enhance the nutrition-sensitivity of production-focused or market-oriented agricultural interventions through nutrition-related education and behavioural change communication strategies. In general, these complementary programmes stress on dietary modification and diversification by educating and informing target groups about the nutritional qualities of different foods and their significance in combating nutritional problems; provide training on home-gardening and animal husbandry, food preparation and safety, optimal child care and feeding practices, as well as proper hygiene and other health-related practices; and promote gender equality and women's empowerment.

Besides the need for integrated approaches, resilience building has also gained traction around development and food policy circles in recent years (Fan et al., 2014; FAO et al., 2015, 2017). This intensified interest in resilience building is, in part, due to the severe and frequent occurrences of health, economic, political, and climate-related shocks and stressors around the world (Zseleczky & Yosef, 2014). Adverse events, such as conflicts and prolonged crises, external market volatilities, climate change, and its consequent seasonal extremes, outbreaks of transboundary human epidemics as well as animal and plant pests and diseases, have a considerable impact on people's livelihoods (especially agriculture), food security and nutrition. Interestingly, the world is currently contending with the COVID-19 pandemic, which poses significant threat to lives and livelihoods. Poor and food-insecure households in agrarian settings are the most vulnerable and hardest hit by shocks and stressors, because they often lack the capacity to deal with or recover from shocks and stressors in a timely, efficient and sustainable fashion. Consequently, they adopt adverse coping strategies, which further deplete their long-term resilience and lead to higher levels of vulnerability, food insecurity and malnutrition.

This dissertation adds to the literature by analysing how nutrition-sensitive interventions, better market access, and enhanced resilience capacity can contribute to better food security and nutrition outcomes. The study is situated in Sierra Leone, a post-conflict country in West Africa. Despite returning to a peaceful state almost two decades ago, the devastating effects of the protracted civil war that engulfed the country between 1991 and 2002 continue to linger.

Sierra Leone is one of the least developed countries in the world and bottommost performers on the United Nation's Human Development Index (HDI) – scoring 0.438 in 2018 and ranking 181 out of 189 countries and territories (United Nations Development Programme, 2019). Over half (52.9 percent) of its 7 million residents were estimated to be poor in 2014 (World Bank & Statistics Sierra Leone, 2014), and 7 in every 10 inhabitants were disadvantaged in terms of their education, health, and living standard in 2017 (Statistics Sierra Leone, 2017). Despite making appreciable progress in curbing food insecurity and malnutrition since the ceasefire, serious levels of hunger persist (von Grebmer et al., 2019), with 44 percent of the population estimated to be food insecure in 2018 (World Food Programme, 2018). Poor dietary patterns (mainly monotonous, rice-based diets) remain a major underlying driver of malnutrition in the country (Ministry of Health and Sanitation & Action Against Hunger, 2017).

Agriculture, mainly rain-fed, smallholder subsistence farming, is the backbone of the economy and accounts for two-thirds of gross domestic product (GDP) and employment. The structure of the economy remains undiversified and overly dependent on the mining of diamonds and iron ore for export earnings. Cocoa is the top agricultural export commodity, constituting about 8 percent of Sierra Leone's exports value (World Bank, 2013). Acute infrastructural challenges persist, as households had to travel 10.4 miles (16.8 kilometres or 2 hours) to reach the nearest motorable road, and had to travel 7.7 miles (12.4 kilometres or 83 minutes) to reach the nearest functional market (World Food Programme, 2015). These structural weaknesses, coupled with high rates of environmental degradation (Binns & Bateman, 2017; World Bank, 2017), leave the nation and its households extremely vulnerable to adverse covariate and idiosyncratic shocks, including external market volatilities, ill-health, plant and livestock pests, and diseases and climate-related extreme events. The outbreak of the Ebola epidemic in 2014 (which took 3,955 lives) and incidence of floods and mudslides in 2017 (which killed 1,141 others) (WHO, 2015; World Bank, 2017), for instance, have severely interrupted Sierra Leone's post-war economic recovery and deteriorated its food insecurity situation.

Against this backdrop, this dissertation examines how agricultural interventions and policies targeted at making smallholder agriculture more nutrition-sensitive, strengthening market linkages and building households' resilience can improve the food security and nutritional outcomes in the country.

1.2 Research problem and contribution

This dissertation aims to address some gaps in different strands of literature on food and nutrition security. The first class of literature relates to the nutritional impacts of agriculture commercialization interventions or cash crop schemes. Agricultural commercialization (or value chain development) has long been upheld as key for achieving agricultural transformation, rural development, higher yields and incomes for farm households, and, in recent times, better food security and nutrition. Of particular interest is the role of cash crops such as cocoa, coffee, cashew, and other non-food export crops. Not only are these industrial crops important for processors and consumers in high- and middle-income countries, but also for the wellbeing of smallholder farmers and economic development of major producing countries in Africa, Asia, and Latin America.

In general, opinions are sharply divided over the food security impacts of increased cash crop production. For commercialization optimists, cash crop or market-oriented production may have beneficial food security and nutritional effects through several pathways, including changes in income (i.e. higher cash income allows for purchasing of food and non-food items), and availability of food from own production (i.e. as eased liquidity constraints facilitate the acquisition of better productive inputs) (DeWalt, 1993; Govereh & Jayne, 2003; Poulton et al., 2001; von Braun & Kennedy, 1995). However, opponents argue that commercialization-caused diversion of resources to non-food crops production, increased time and work burden on caregivers, shifts in control over income, bargaining power and other intra-household dynamics in favour of men as well as increased exposure to market-related risks may imperil food security and nutritional wellbeing (Carletto et al., 2017; Govereh & Jayne, 2003; von Braun & Kennedy, 1995). Empirical evidence on the impact of commercialization on food security and nutrition outcomes remains inconclusive: some positive (Kuma et al., 2018; Ogutu et al., 2019; Ogutu & Qaim, 2019; von Braun & Kennedy, 1995); some negative (Anderman et al., 2014; Immink & Alarcon, 1993; Ntakyo & van den Berg, 2019); or neutral (Carletto et al., 2017).

Besides the inconclusiveness of evidence, there is no study on the impact of integrated agriculture and nutrition interventions in export-based, tree crop value chains, mainly because nutritional considerations are rarely prioritized in previous interventions in these sectors. This dissertation bridges this gap in the literature by exploiting the novel design of the *Pro-Resilience Action* (PRO-ACT 2015*)* project, which provided support for tree crop production and nutrition-related information to smallholder cocoa, coffee and cashew, farmers in Eastern and Northern Sierra Leone. To the best of our knowledge, this is the first nutrition-sensitive agricultural intervention to be implemented in export-oriented sectors in the developing world. Hence, this dissertation presents the first evidence on how cash crop promotion programmes can work for better nutrition among smallholder households at the base of these value chains.

The second research gap addressed in the dissertation relates to the literature on the roles of seasonality and market access for food security. Largely influenced by climate variability, seasonal patterns in agriculture production consistently shape intra-annual food security in developing countries. Seasonality-induced instabilities in food availability, access and utilization render several households in these agrarian economies vulnerable to predictable, seasonal hunger every year. This recurrent phenomenon, coupled with its consequent damaging modifications in dietary quality and quantity, constitutes a major setback on governmental and global efforts to end all dimensions of hunger as well as achieve food security and improved nutrition. The adverse effects of seasonality on household welfare have been widely documented (Abay & Hirvonen, 2017; Devereux et al., 2012; Gill, 1991; Hillbruner & Egan, 2008; Hirvonen et al., 2016).

Moreover, an offshoot of the commercialization literature has shown the importance of market access for better food security and nutrition for smallholder farmers (Headey et al., 2019; Hirvonen et al., 2017; Koppmair et al., 2017; Sibhatu et al., 2015). One shortcoming of these studies is that they did not account for the differential effects of market access over the agricultural season. This research adds to existing knowledge by unifying these two strands of literature and analysing how market access interacts with seasonality to mitigate seasonal hunger in Sierra Leone. Apart from a handful of studies (Abay & Hirvonen, 2017; Handa & Mlay, 2006; Sibhatu & Qaim, 2017; Zanello et al., 2019), we are not aware of any previous study that examined the protective effects of markets against seasonal food insecurity, especially in the West African context.

The final research strand, to which this dissertation contributes, has to do with building household resilience against shocks and stressors. Despite the increasing adoption of resilience building, among international development organizations, as a key long-term goal for their interventions, research efforts have mainly focused on defining resilience in the context of food security and developing tools for measuring and monitoring it (Alinovi, D'Errico, et al., 2010; Barrett & Constas, 2014; Béné et al., 2012; Constas et al., 2014; FAO, 2016; Jones et al., 2018). Relatively little is understood about the 'predictive power' of the proposed measures

(Hoddinott, 2014). This research gap is addressed by exploiting the novel opportunity presented by the PROACT project in rural Sierra Leone. In particular, this dissertation goes beyond measuring household resilience capacity to (1) analyse the contribution of the intervention to changes in household resilience to food insecurity; and (2) examine whether those changes in resilience capacity play significant roles in mitigating the negative impact of shocks and improving household food security.

1.3 Main research questions

The following research questions undergird the studies contained in this dissertation:

1. Does integration of a nutrition component in cash crop promotion interventions, contribute to improved dietary outcomes among smallholder households?

2. How does market access interact with seasonality to mitigate the intra-annual fluctuations in household food security?

3. Can nutrition-sensitive interventions enhance the resilience of smallholder households to food insecurity? If so, does household resilience capacity mitigate the negative impact of shocks on their food security?

1.4 Conceptual Framework

This research contributes to policy efforts to end all forms of hunger and to achieve food security and improved nutrition by 2030 (United Nations, 2015). It is rooted in the prevailing concept of food and nutrition security. According to the 2009 Declaration of the World Summit on Food Security, “food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, [economic and physical] access, utilization, and stability [(vulnerability and shocks) over time]. The nutritional dimension is integral to the concept of food security” (FAO, 2009, p. 1)

Household food security is the application of this concept to the family level, with individuals within households as the focus of concern. Figure 1.1 presents a schematic representation of how the policy variables analysed in this study can affect household food security and nutrition through its four pillars. On top of the framework is the environment within which households live and operate. It highlights the social, economic, institutional, political, cultural, and natural factors that impact on food availability, food access, food utilization and stability – the conditions required to achieve food security. Among others, these factors include population, education, macro-economy (including foreign trade), policies and laws, natural resources endowments, technology, climate, household characteristics, livelihood systems, political, economic and social institutions, cultural norms, and gender (Thompson et al., 2009).

This study focuses on analysing how policies or interventions (by governmental and non-governmental institutions) in agricultural and food systems can improve the food security and nutrition situation of poor and vulnerable households in Sierra Leone. In particular, it analyses the impact of a nutrition-sensitive intervention by non-governmental organizations on the food security and resilience of smallholder households, who depend predominantly on cocoa, coffee, and cashew production for their livelihoods. It also examines how policies targeted at strengthening market access can help households to overcome seasonal hunger and maintain the consumption of nutritious foods at all times.

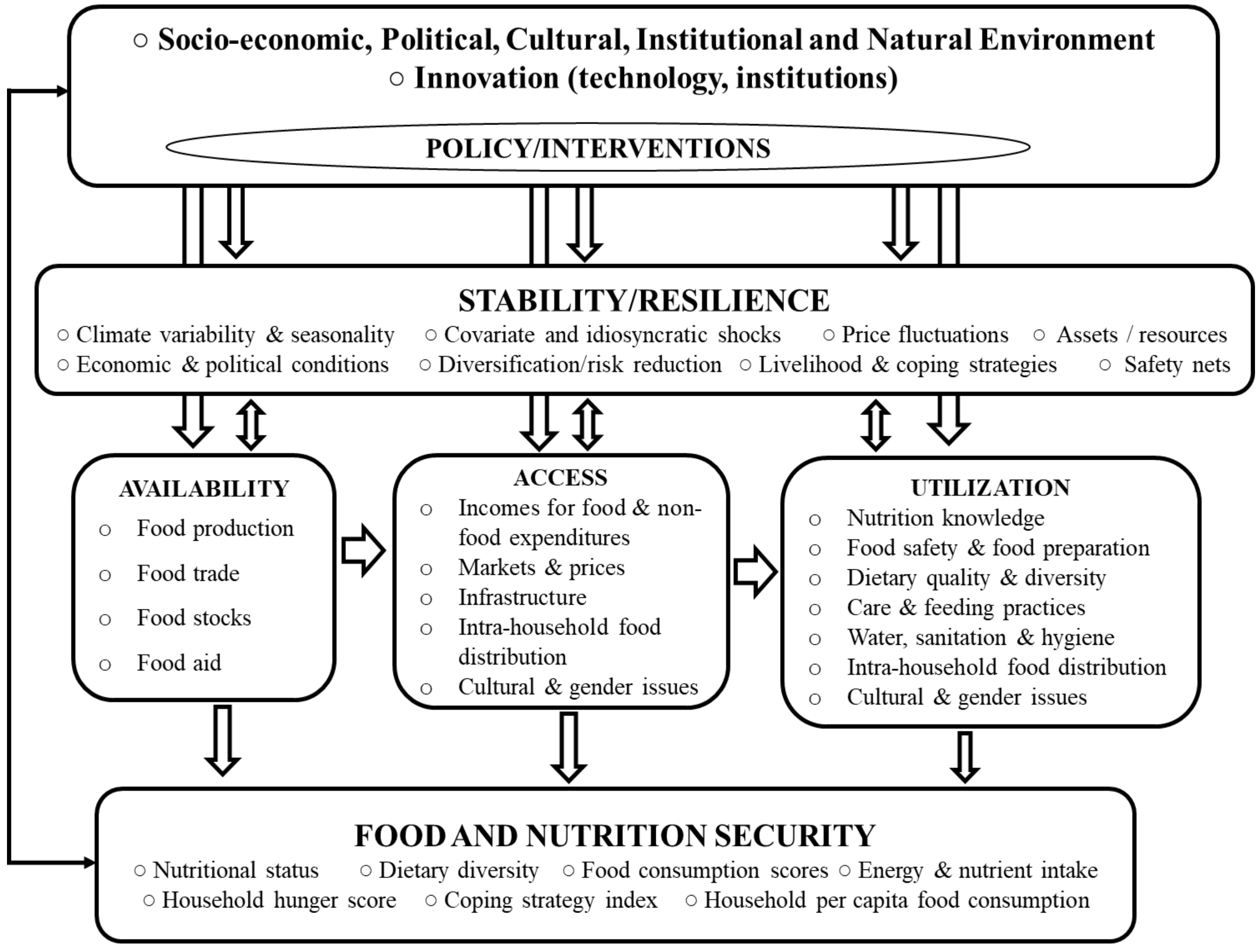


Figure 1. 1: Linking agricultural interventions and food and nutrition security.

Source: Own illustration based on Thompson et al. (2009).

Figure 1.1 shows that achieving food and nutrition security requires improving the availability of good-quality foods, enabling access to these foods, fostering the utilization of nutrients in the food a healthy and active life, and ensuring that these three dimensions remain stable over time. Food availability is affected by food production, distribution, and trade, among others. Economic and physical access to the available food depends on household incomes (or purchasing power), access to markets and other resources to acquire or produce food, social, religious and cultural norms that determine preferences and demand for certain types of food, as well as food allocation across gender and age within the household. The food utilization pillar concerns the intake of sufficient quantity and diversity of foods to meet their nutritional needs. It is affected by knowledge of the nutritional value of the foods that are consumed, health status (or ability to absorb and digest the nutrients in foods consumed), food safety (i.e., free from spoilage and toxic contamination), and food preparation and consumption (i.e., resources, knowledge, and ability to prepare and consume food under healthy and hygienic conditions). Lastly, for food security to prevail, availability, access, and effective utilization of food must not be subjected to fluctuations as a result of climate variability, seasonality, shocks and stressors, and market volatilities. Achieving stability calls for interventions or investments to reduce risk exposure, facilitate consistent access to food and input markets, and build resilience against shocks and stressors.

Chapter two examines the impact of a nutrition-sensitive intervention on food security and nutrition through the access and utilization dimensions. By fostering the production of cocoa, coffee, and cashew (non-food, cash crops), the programme is expected to boost productivity, increase smallholder incomes, and ultimately enhance access to nutritious foods. Increased income to cash crop farmers potentially improves household ability to acquire diverse, nutrient-rich foods from markets and facilitate expenditure on health care, education and other welfare-enhancing non-food items (Govereh & Jayne, 2003; Kuma et al., 2018; Poulton et al., 2001; von Braun & Kennedy, 1995). Higher cash crop incomes may also increase food availability from own-production by easing liquidity constraints on acquiring improved inputs for food production (Govereh & Jayne, 2003). Recent evidence from smallholder cash crop farmers in Ethiopia suggests coffee income is significantly associated with increased dietary diversity (Kuma et al., 2015) and improved food security (Kuma et al., 2018). However, higher incomes and increased food availability may not translate into significantly improved diets, and nutritional status (Herforth & Ahmed, 2015; World Bank, 2007). The reason is that additional incomes may not be spent on nutritious foods, and available nutritious foods may not be equally distributed across gender and age within the household, as well as according to the nutritional needs of household members. Also, other non-income constraints, such as poor knowledge of the nutritional value of foods and appropriate care practices, adverse cultural norms, low women's status and inability to control the use of incomes and influence purchasing decisions, may hinder the utilization of nutritious foods (even though they may be available and accessible). The project incorporates a nutrition component to address these intervening factors, to stimulate the intake of diverse diets (utilization), and sharpen the nutrition sensitivity of the cash crop component.

The third chapter addresses the issue of seasonal food insecurity. Seasonal fluctuations in agricultural production may induce instabilities in food availability, access, and utilization.

Hence, the chapter analyses the seasonal patterns of food production and consumption in Sierra Leone. It also examines the role of market access in curbing seasonal hunger in the country.

The fourth chapter also relates to the stability dimension of food and nutrition security. Exposure to shocks and stressors can aggravate the food insecurity situation of poor households and low-income countries. The onset of floods, droughts, conflicts, and the outbreak of crops, livestock and human diseases may directly destabilize food production, impede physical access to markets, and economic access to food, and diminish the intake and absorption of nutrients. In the absence of risk reduction policies or well-functioning social protection programmes, the use of negative coping strategies in response to adverse events may also indirectly impair food security in all its dimensions. Building the resilience of poor households against these hazards is critical to achieving food security by preserving the availability, accessibility, and utilization of nutritious foods.

Therefore, the last empirical chapter examines the contribution of nutrition-sensitive interventions, like the PROACT programme, to the resilience capacity of smallholder households. It also analyses the relationship between household resilience and future food security outcomes while accounting for shocks. The framework highlights the feedback effects of the state of food and nutrition security on the overall environment within which households dwell and operate. It views the dimensions of food security in a dynamic context, where food and nutrition insecurity can lead to political instability, deteriorate economic insecurity and undermine societal cohesion.

1.5 Organization of the thesis

As previously outlined, this dissertation comprises three empirical essays and is organised as follows. Chapter Two evaluates the differential impacts of the PROACT programme on the household, maternal and child dietary diversity. It also explores the access and utilization pathways linking the intervention to household food security and nutrition. Chapter Three examines the linkages between seasonality, access to markets and household food security. Chapter Four analyses the resilience capacity of smallholder farmers and its role in mitigating the damaging effects of shocks on food security. Chapter Five concludes the dissertation. It provides an overall summary of key findings and discusses policy implications and limitations of the research.

CHAPTER 2

Making cash crop value chains nutrition-sensitive: Evidence from a quasi-experiment in rural Sierra Leone

2.1 Introduction

The production of export-oriented cash crops like cocoa, coffee, and cashew is central to the livelihoods of many smallholder farmers and the prosperity of developing countries. While producing mainly for the nourishment of consumers in high-and-middle income countries, most smallholder cash cropping farmers in Sub-Saharan Africa do not earn enough income or produce sufficient food to feed themselves and their families all year round. Malnutrition is highly prevalent in growing localities, mainly due to the intake of monotonous, unhealthy diets that are deficient in vital micronutrients (De Vries et al., 2012; Freeman et al., 2014). The direct costs of widespread undernourishment in these sectors are enormous, including substantial losses in physical productivity and household incomes due to compromised work capacity from fatigue, ill-health, and substandard human capital formation (Bhutta et al., 2013; De Vries et al., 2012). Indirectly, these sectors also suffer from malnutrition-induced diversion of household resources away from farm and non-farm investments towards health care (De Vries et al., 2012, 2013b, 2013a). If this situation persists, farmers in these cash crop sectors will also miss out on the opportunity to improve their incomes and well-being on the back of increasing global demand for high-value cash crops.

Agricultural interventions in export crop supply chains have typically focused on addressing such concerns as low productivity/income, poor labor conditions, child labor, and other issues related to the social and environmental sustainability of production methods. Nutrition is rarely prioritized or clearly incorporated in the design, conduct, and appraisal of such agricultural development programmes. Although non-food, export crops inherently offer relatively low nutritional benefits to smallholder households, it is generally assumed that, by boosting productivity and incomes, these interventions will inevitably lead to improved nutritional outcomes. Several studies and systematic reviews of the impacts of commercialization and other agricultural interventions have, however, shown that household food production and income may rise without substantial improvements in neither food security nor nutritional status (Carletto et al., 2017; Herforth et al., 2012; Masset et al., 2012; von Braun & Kennedy, 1995; Webb & Kennedy, 2014; World Bank, 2007). The high rates of hunger and undernutrition in major cocoa, coffee, and tea producing areas, amidst increasing cash crop incomes, attest to this fact (De Vries et al., 2012, 2013a, 2013b). To some extent, this is because the pathway from income to nutrition is enhanced or attenuated by several individual, household, and community-level factors, including, intra-household control over income and other resources; women's status, education, nutrition knowledge, and decision-making power; caregiving, feeding and hygiene practices; and availability and utilization of health and sanitation services (Herforth & Ahmed, 2015; World Bank, 2007). For instance, merely facilitating economic access to nutritious foods through higher incomes may not necessarily translate into improved nutrition in settings where caregivers have insufficient knowledge of best feeding and caring practices or are less empowered to influence household spending on nutrition-enhancing goods and services.

Fostering the production of cocoa, coffee, and other non-food cash crops has long been an integral part of rural development strategies to boost incomes, alleviate poverty and ultimately improve food security in developing countries (Aberman et al., 2018; Masanjala, 2006). However, given unremittingly high rates of hunger and malnutrition in producing countries and inconclusive evidence on the food security and nutritional impacts of commercialization interventions[2], policymakers are increasingly grappling with how to intervene in agricultural and food systems to make them deliver not only increased economic returns but also act as channels for improved nutrition and well-being for smallholder families. In the light of increasing recognition that hunger and malnutrition need to be fought in multiple fronts (Nisbett et al., 2016; World Bank, 2007), there has been a growing call and support for integrated, nutrition-sensitive interventions by governments, donors, and development practitioners (Bhutta et al., 2013; Ruel et al., 2018; Ruel & Alderman, 2013). One of such approaches, with significant promise to address these problems in smallholder communities, is the nutrition-sensitive value chain (NSVC) model, which combines agricultural and nutrition-related interventions to promote both good agricultural practices and good nutritional practices along value chains (Allen & de Brauw, 2018; De la Pena & Garrett, 2018; Gelli et al., 2015; Hawkes & Ruel, 2012; Ruel & Alderman, 2013)

[2] See DeWalt (1993), von Braun and Kennedy (1995) and World Bank (2007) for survey of early literature. Recently, while some recent studies reported positive effects of cash cropping and commercialization on food security and nutritional outcomes (Kuma et al., 2015, 2018; Ogutu et al., 2019), Anderman et al. (2014) and Ntakyo and van den Berg (2019) found that cash cropping hurts food security among cocoa producers in Ghana and calorie intake among commercialized rice producers in Uganda respectively.

A growing body of research has demonstrated that such nutrition-sensitive interventions, mainly in food crop and livestock value chains, have improved production of, access to, and intakes of nutrient-rich foods; enhanced women's status; reduced morbidity and improved some dimensions of nutritional status of household members (Kumar et al., 2018; Leroy et al., 2016; Nisbett et al., 2016; Ogutu et al., 2018; Olney et al., 2015; Rosenberg et al., 2018). Empirical evidence is, however, lacking on the impacts of these integrated approaches in non-food, cash crop sectors, which are riddled with food insecurity and malnutrition (De Vries et al., 2012, 2013b, 2013a; Freeman et al., 2014). One main reason for this lacuna is that previous interventions in these value chains rarely give explicit nutritional considerations in their design and implementation.

This study aims to fill this research gap by drawing on the experience from the *Pro-Resilience Action* (PROACT) programme implemented in Sierra Leone by Welthungerhilfe and its partners. The study exploits the peculiar design of the programme, which involved the integration of a nutrition component into a tree crop value chain intervention, aimed at improving the food security and nutrition situation of smallholder cocoa, coffee and cashew farmers in Sierra Leone. In addition to evaluating the nutritional impacts of the project, the study aims to identify complementarities or synergies between the individual interventions, the potentials of which have spurred the push for integrated agriculture-nutrition programmes around policy circles (Ruel et al., 2018; Ruel & Alderman, 2013). While tackling key barriers to improved nutrition from different sectoral purviews, there may be interactions between these agricultural and nutrition programmes, such that combining the two can deliver larger nutritional and health benefits than implementing them in isolation. Except for few recent studies (Ahmed et al., 2020; Kumar et al., 2018; Ogutu et al., 2018; Pace et al., 2018; Rosenberg et al., 2018), most existing assessments of integrated agriculture and nutrition programmes tend to focus largely on the stand-alone impacts and give little considerations to the potential synergies between them. The knowledge gap is even more severe for cash crop sectors, where integrated interventions are lacking. The design of PROACT allows us to undertake these analyses.

By addressing the underlying determinants of malnutrition – food, health, and child care – in a holistic fashion, we expect complementarities between the two types of intervention. While the cash crop component is an income-oriented intervention aimed at ultimately enhancing economic access to nutritious foods, the nutrition programme is directed at improving nutrition knowledge and stimulating nutrition-sensitive spending and allocation of other household resources. As mentioned above, improving income alone may not certainly lead to better nutrition outcomes if caregivers (and key decision-makers) lack knowledge of best child feeding and caring practices, or the significance of consuming diverse diets. Similarly, even when they have adequate nutrition knowledge (e.g., through the nutrition intervention alone), they may have insufficient access to resources to purchase or produce the recommended, diverse foods. Jointly targeting the two interventions may ensure that they complement each other in effectively improving food and nutrition security. At the programmatic level, examining the complementarity effects of the interventions is interesting because the presence of such synergistic effects implies that stand-alone programmes reinforce each other in achieving the desired results. This could lead to better allocation of scarce resources, and reduce significantly the costs of implementing separate programmes to realize the same objectives.

The rest of the chapter is structured as follows. Section 2.2 gives a succinct overview of the study context, intervention and evaluation design. Section 2.3 presents the conceptual framework, data, and methods employed in the study. The empirical results are presented and discussed in Section 2.4. Section 2.5 concludes with key findings and policy implications.

2.2 Study setting and the intervention

2.2.1 The Sierra Leonean Context

Sierra Leone's economic development has been severely hampered by major shocks (including a decade-long civil war, global financial and commodity crises, the Ebola epidemic, and mudslides). These mishaps have pushed the once-prosperous West African country into a protracted fragile situation, characterized by widespread poverty, food insecurity, and malnutrition. In terms of human development, Sierra Leone is one of the bottommost countries in the world, ranking 182nd out of 189 on the 2019 Human Development Index (HDI) (United Nations Development Programme, 2019). More than half (52.9 percent) of its 7 million citizens subsist on less than \$1.90 a day (World Bank & Statistics Sierra Leone, 2014). 49.8 percent of its households were food insecure in 2015, and undernourishment afflicted 22 percent of the population in 2017(Development Initiatives, 2017; World Food Programme, 2015). The nutritional status of children is unsettling as 29.5 percent of under-fives are stunted, 14 percent are underweight, and 5 percent are wasted (Statistics Sierra Leone and The DHS Program, 2019). The country continues to battle with deficiencies in micronutrients such as iron, iodine, zinc, and vitamin A (Ministry of Health and Sanitation et al., 2015). This is mainly due to habitually intake of monotonous diets that mostly consist of rice and other starchy staples, green leafy vegetables, and palm oil. Consumption of fruits, vegetables, and other nutrient-dense food groups is infrequent and largely depends on households' purchasing power (Ministry of Agriculture, Forestry & Ministry of Health and Sanitation, 2016).

Agriculture is the backbone of the economy, accounting for about two-thirds of its employment and gross domestic output. After diamond and other minerals, cocoa (and to a lesser extent coffee and cashew) is Sierra Leone's main export commodity and foreign exchange earner (World Bank, 2013). With surging global demand, particularly from emerging markets, cocoa, coffee, and cashew sectors hold vast potential for increasing smallholder incomes, improving food security, reducing poverty, and advancing national development. The immense contribution of these sectors to the economies of Cote d'Ivoire and Ghana, Sierra Leone's West African neighbors, attests to this growth potential. However, unlike these major players in the global market, Sierra Leone accounts for a tiny percentage of the global supply of cocoa, coffee, and cashew. Yields remain relatively low, with production stuck below pre-war levels[3]. The majority of the country's tree crop plantations are aged, damaged, and overgrown, due to long periods of desertion, mainly during the decade-long civil unrest. Not only are smallholder incomes susceptible to fluctuations, but they also remain persistently low, as farmers are locked in a vicious cycle of low investments, low yields, and low incomes. This cycle is further perpetuated by low input use, pest and diseases, poor access to markets, credit, and modern productivity-boosting technologies, low knowledge, and adoption of best agronomic practices and aging farmers, as the younger generation is less interested in farming as a viable, sustainable career (Amara et al., 2015; Spencer, 2009).

This study is situated in the rural areas of Eastern and Northern Sierra Leone, where farming households predominantly depend on tree crops production for their sustenance. Besides being prominent for diamond, gold, and other mineral mining activities, the Eastern districts of Kailahun, Kenema, and Kono are also home to the majority of Sierra Leone's cocoa, coffee, and oil palm plantations. For instance, in 2015, it was estimated that about 85% and 92% of

[3] For instance, prior to the war, average cocoa yield was estimated to be 430.8 kg/ha during 1961-1990. During the war (1991-2002), it declined to 350.9 kg/ha and has recovered marginally to 367.3kg/ha (2003-2017) since the ceasefire. (Own calculation based on FAO estimates obtained from http://www.fao.org/faostat/en/#data).

areas planted, respectively, with coffee (191,791 ha) and cocoa (235,749 ha) in Sierra Leone were located in the Eastern province (Statistics Sierra Leone, 2017). Kenema district is the provincial headquarter and trade centre, whereas Kailahun dominates the cocoa, coffee, and oil palm production at regional and national levels. Kono district, albeit least in tree crops production, is the country's richest in diamond reserves. Most of Sierra Leone's food crops (upland rice, cassava, sweet potato, groundnut, and maize) are grown in the Northern region. The most important tree crops cultivated in its Bombali, Kambia and Port Loko districts are oil palm and cashew. Occupying less than 3% of total land under tree crops plantation in Sierra Leone, cashew is a relatively new tree crop and has been recently introduced in the country for its significant income potential (Statistics Sierra Leone, 2017).

About 8 out of every 10 persons in rural Sierra Leone are multi-dimensionally poor, deprived of education, healthcare, and a minimum standard of living, compared to 5 out of 10 in urban areas. The incidence of multidimensional poverty is higher in the North (75.7%) and East (67.5%) relative to the rest of the country (Statistics Sierra Leone, 2017). However, hunger is more prevalent in the East, with the rates of food insecurity being 46.8% in Kono, 47% in Kenema, and 50.5% in Kailahun. The food insecurity situation in the Northern districts (Bombali (46.6%), Kambia (42.6%), and Port Loko (30.5)) is comparably better than in the East, possibly because of greater involvement of Northern farming households in food crops production (WFP, 2018). Despite improving over the years, the nutritional status of children in these regions remains a major concern, with 25.3% and 30.9% of under-fives in the Eastern and Northern provinces respectively estimated to be stunted (Statistics Sierra Leone and The DHS Program, 2019). The Ebola epidemic, which devastated the country during 2014-2015, also dealt heavy blows to smallholder households in both regions by exacerbating constraints on labour supply. With an 81.1% death rate, the epidemic infected 13,575 persons nationwide, most of whom were within the working-age (70%) and resident in rural areas (54%). The North was the hardest-hit region, with Port Loko district recording the highest number of cases (3,594) and deaths (3,045) in the country. Kailahun was the epicentre in the East, losing 1,391 out of its 1,727 Ebola patients (Statistics Sierra Leone, 2017).

2.2.2 The PROACT intervention

The PROACT project was a four-year tree crop value chain project, launched in January 2017 by Welthungerhilfe (WHH) in partnership with Cooperazione Internationale (COOPI) and Inter Aide. With funding from the European Union, the project aimed to foster smallholder agriculture and improve the food and nutrition security among vulnerable cocoa, coffee, and cashew farmers in Sierra Leone. WHH focused on the development and reinforcement of cocoa and coffee value chains in the Kailahun, Kenema, and Kono districts in the Eastern Province. Both COOPI and Inter Aide worked in the Northern Province. While COOPI supported smallholder cashew farmers in the Bombali, Kambia and Port Loko districts, Inter Aide focused on vegetable production and safe water provisioning in the Bombali district.

This study is the product of an international research partnership between the Centre of Development Research (ZEF) at the University of Bonn, Bonn, Germany, and the implementing organizations, Welthungerhilfe and COOPI. With a specific focus on tree crops, the productivity, profitability and nutritional impacts of which are most likely to materialize in several years (after the project has phased out), the goal of the cooperation is to enable researchers to examine the early impacts of the project interventions to provide information on whether the programme is likely to have its intended impacts. This study focuses on the smallholder tree crop farmers supported by WHH and COOPI under the project. Figure 2.1 shows the map of PROACT project districts in Sierra Leone.

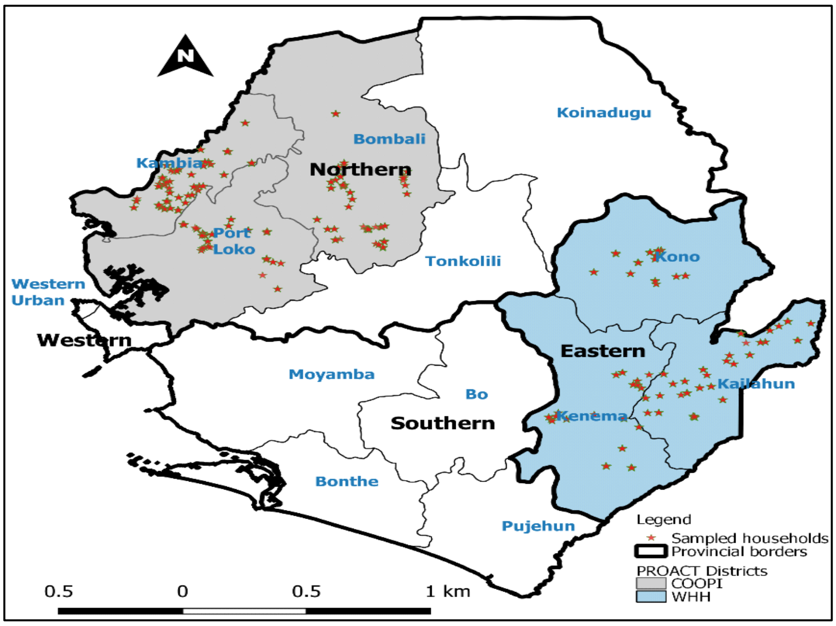


Figure 2. 1: Map of PROACT districts in Sierra Leone
Source: Own illustration.

The intervention was two-pronged, with cash crop and nutrition components. The main inputs of the cash crop intervention were capacity building through training in farmer field schools (FFS), provision of productive inputs, and support for market linkages (e.g., certification and traceability). During the FFS, trained extension workers from WHH, COOPI and implementing partners coach farmers on sustainable tree crop production and quality processing, with topics covering rehabilitation (rehabilitating old plantations, under-brushing, sanitation, pruning and shade management), nursery establishment, harvesting and primary processing (fermentation, and drying), as well as voluntary sustainability standard certification. In addition to acquiring knowledge on improved farming practices, beneficiaries were also equipped with some agricultural inputs, including improved cocoa, coffee, and cashew seedlings, watering cans, and polybags for nursery establishment and out-planting; pruning saws and shears, cutlasses, and head pans for husbandry of tree crops; and solar plastics for improved drying. By fostering the production of tree crops, the cash crop component is expected to boost yields and income for smallholders, and facilitate the purchase of diverse nutritious foods and other welfare-enhancing items.

The nutrition component is WHH's flagship nutrition intervention, Linking Agriculture, and Natural Resource Management towards Nutrition Security (LANN). This was incorporated to increase the nutrition-sensitivity of the tree crop intervention. The LANN component is a participatory community-based approach involving nutrition education, behavioural change communication and awareness creation on the benefits consuming diverse diets, proper child feeding and water, sanitation and hygiene (WASH) practices, and sustainable agriculture and natural resource management in rural areas. As gender-sensitive nutrition intervention, LANN activities also included gender sensitization training, aimed at educating households on the nutritional needs of different household members; advocating for greater participation of women in household financial and nutrition-related decision making; and encouraging men's engagement in domestic tasks, which are stereotyped as "women's works." By educating and engaging men in appropriate nutrition practices, the LANN approach is expected to transform norms around women's status, gender roles, and intra-household distribution of nutritious foods in targeted communities, as well as free up women's time to carry out better care and child feeding practices.

2.2.3 Evaluation design

The study design entails three treatment arms and a comparison group. The treatment groups are smallholder households who received only the cash crop intervention (hereafter, cash crop), those who benefited from only the LANN intervention (hereafter, nutrition), and those who were supported with both cash crop and LANN interventions (hereafter, combined). These treatment arms are mutually exclusive and represent the alternative modalities of the project design. The comparison group consists of non-participating households, who received none of these interventions (non-treated). Neither placement of the programme nor assignment to any of these treatment arms was randomized. By virtue of its focus on tree crops, the interventions were purposively targeted at smallholder households in the Eastern and Northern Provinces of Sierra Leone, where the agro-ecological conditions are most suitable for growing the targeted tree crops. This non-random programme placement constitutes one of two sources of endogeneity bias. The second source of bias emerges from voluntary participation. Households self-selected into the project by being members of farmer and women's groups registered with the implementing partners of WHH and COOPI. We apply quasi-experimental methods to address these endogeneity problems and credibly estimate the causal impacts of the cash crop and nutrition interventions on dietary outcomes.

2.3 Conceptual framework, Data, and Methods

2.3.1 Conceptual framework

The theoretical foundations for understanding how nutrition interventions, policies and other factors can affect changes in the demand for food and nutrients can be drawn from the theory of consumer behaviour (or utility maximization) (Babu et al., 2017; Blaylock et al., 1999; Singh et al., 1986). Agricultural households are considered to be producers as well as consumers, such that production and consumption decisions are interlinked and constrained by several factors. The household production decisions are constrained by available technologies, time, human capital, and other household resources used to produce a desired output. As consumers, households attempt to maximize satisfaction (in this case, good nutrition and health) by consuming own produced and purchased goods, given their budget constraint (imposed mainly by commodity prices, and income) (Blaylock et al., 1999; Gorton & Barjolle, 2013).

Changes in household income, food prices and other economic factors are considered to be important determinants of dietary choices, particularly, demand for healthy, high-quality diets. Environmental, sociodemographic, biological and other non-economic factors also play important roles in the household (and individual) decision process and dietary choices. Non-economic factors such as taste, preferences, information/nutrition knowledge, convenience, access, availability, diversity, safety and perceived quality, and societal norms also affect consumer behaviour and food choices, as do economic constraints. These complex set of factors, some of which are beyond the consumers' direct control, shape consumer behaviour, and may even result in dietary choices that are inconsistent with their own (good) nutrition, health and wellbeing (Blaylock et al., 1999; GLOPAN, 2017). For example, households (or individuals) with limited resources or low awareness of the nutrients in the food they have and consume may suffer from micronutrient-deficiencies due to high preference for and habitual consumption of (low-cost) calorie-dense diets.

This study focuses on how nutrition-sensitive interventions, among several policy actions, can be used to influence consumer awareness and behaviour in favour of healthy dietary choices. The literature is replete with several potential pathways through which agricultural interventions can affect nutritional outcomes (Gillespie & Kadiyala, 2012; Herforth & Harris, 2014; Ruel & Alderman, 2013; von Braun & Kennedy, 1995). While the specific channels vary among authors, four pathways resonate throughout the agriculture-nutrition literature. These are: 1) production for the household's own consumption; 2) incomes from market-oriented production can facilitate access to nutritious foods; 3) changes in food prices can affect the affordability of and access to nutrient-dense foods; and 4) women's engagement in agriculture can affect nutrition through gendered pathways including women empowerment, maternal health and nutritional status, and women's time use and caring capacity.

Based on the prevailing literature, we propose the conceptual framework in Figure 2. 2 to guide our empirical analysis. On top of the framework is the context or environment within which households live and operate. As Herforth and Harris (2014) noted, the environment is made up of several important elements, including the natural environment (weather and natural resource endowments); access to infrastructure (markets, roads, education and health services including WASH facilities); the health/disease environment; food market conditions; nutrition and health knowledge; socio-cultural norms, beliefs and practices; and policy and institutions.

In Figure 2.2, these social, economic, institutional, political, cultural, and natural factors determine households' resource endowments (e.g. land, labour, capital, etc.), who has control over their use, and how these resources are allocated to various livelihood activities. The smallholder farming households, in our framework, can allocate their productive resources to cash crop production and/or to other livelihood strategies (including food crops farming, hired labour on other farms, and off-farm employment). The PROACT programme enters the framework as an institutional intervention targeted at smallholder households involved in cocoa, coffee and cashew production. These non-food, tree crops have little or no intrinsic nutritional value, but are mainly grown for their economic value as a principal source of income.

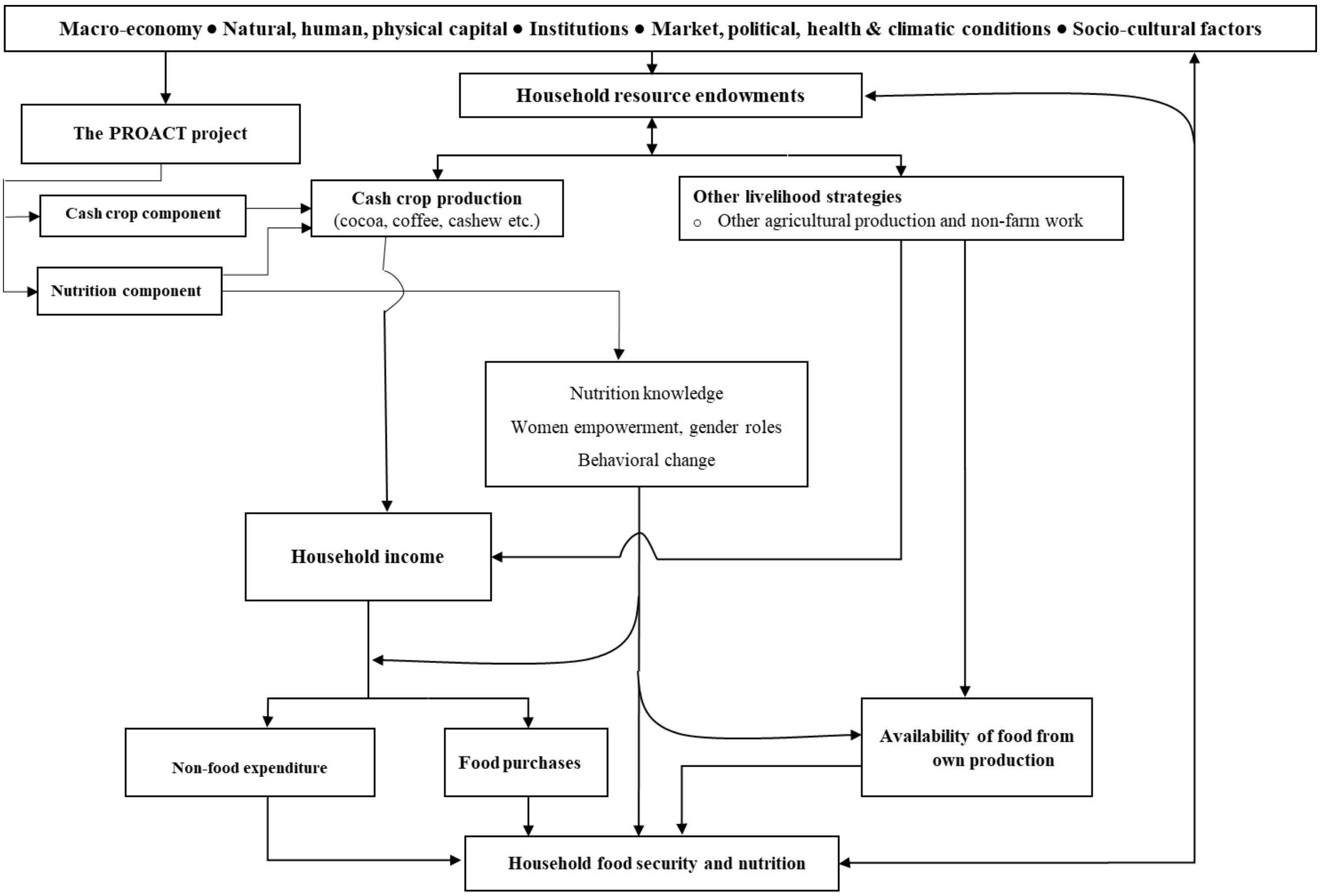


Figure 2. 2: Conceptual framework linking the PROACT interventions to household food security and nutrition.
Source: Adapted from von Braun and Kennedy (1994).

In this study, we hypothesize two broad pathways through which participation in the programme can affect food security and nutritional outcomes of these cash crop growers: the income-consumption pathway and women empowerment (i.e., women's nutrition awareness, control over the use of income and confidence). The income-consumption pathway is considered the most direct mechanism through which the cash crop component of the intervention could lead to improved nutrition. It is expected that increased cash crop income (potentially from project-led improvements in yields, quality, and prices) could enhance nutritional outcomes by facilitating expenditure on (or access to) diverse, nutrient-dense foods as well as non-food items/services, such as health care, education, and WASH facilities (von Braun and Kennedy, 1994; Poulton et al., 2001).

Indirectly, it can also have a spillover effect on food availability from own farms if the farming skills and tools obtained from the project are applied to food crop production (Govereh and Jayne, 2003). These project-induced changes may be seen in significantly increased food consumption expenditure and greater dietary diversity (in the short-to-medium term), and improved nutritional status (in the long-term). For instance, Ogutu et al. (2019) reported that commercial production contributes to higher incomes and increased nutrients from purchased foods among smallholder farm households.

However, evidence from other studies suggest that this may not always be the case, because income from cash crop production may be diverted to other uses; nutritious foods may not be purchased or fairly distributed within the household; caregivers may not have sufficient nutrition knowledge; and women may lack adequate decision-making power and control over the use of cash incomes and other resources (von Braun and Kennedy, 1994; Carletto et al., 2015). Additionally, household food security and nutrition may temporarily worsen prior to harvest, because the initial investment required to revamp overaged and unproductive cocoa, coffee and cashew plantations, coupled with their long maturation time, may create short-term shortfalls in household income and food provisioning, especially when subsistence production of food crops is inadequate.

Women empowerment, particularly nutrition knowledge, women's control over the use of income and social status, can affect how cash crop income translates into better dietary quality and overall nutrition. The nutrition intervention is expected to tackle these non-income barriers by increasing people's awareness of the nutritional value of different foods and stimulating household spending on and consumption of nutritious foods. Better nutrition knowledge as well as cooking skills acquired through the nutrition intervention can shift their preferences and lead them to prefer consumption bundles with more diverse nutritious foods (Babu et al., 2017; Rosenberg et al., 2018).

As noted previously, the nutrition intervention also aimed to improve women's status in targeted communities by engaging both men and women in discussions on gender-related topics (i.e., norms, equality, men's involvement in household chores and childcare, intra-household food allocation, and decision-making). These community-level gender-sensitization activities could also promote women's empowerment more broadly, with women having better control over the use of income and greater participation in decision-making regarding household purchases. Some studies have shown that greater women's control over income and participation in household food-related decisions are significantly associated with improved dietary diversity (Amugsi et al., 2016; Fischer & Qaim, 2012; Malapit et al., 2015).

2.3.2 Data, sampling design, and attrition

Our analysis is based on two waves of household survey data, which we collected in the project districts using highly-structured questionnaires. The first wave took place between November–December 2017 in the Eastern Province and February–March 2018 in the Northern Province. The second wave, tracking the same households, was conducted in the respective districts 12 months later, between November–December 2018 and February–March 2019. A two-stage cluster sampling method was used, with villages as the primary sampling units and smallholder tree crop farming households as the secondary sampling units. With probability proportional to the size (PPS) of each district, villages (clusters) were randomly sampled in the first stage of the sampling design. In the second stage, we used simple random sampling to select treated cocoa/coffee and cashew farming households from the sampled intervention villages.

We did not have prior information on non-treated households. As with any agricultural intervention that seeks to achieve a local economy-wide impact, the project intentionally encourages participants to share the new knowledge of better agricultural and nutritional practices with others. While this may increase the potential impact of the project, it complicates the evaluation design by increasing potential spillovers to non-project farm households and making it difficult to identify "uncontaminated" counterfactual. Circumventing this spillover effect – and being able select 'truly' control villages and households – would have meant selecting households from villages that are geographically further away from intervention villages. Doing so may also render the selected non-treated households less comparable to the treated ones, in terms of livelihoods and other socio-economic characteristics. Poor road networks in Sierra Leone, particularly in rural areas, imply that villages are isolated from one another. The resulting high travel costs (in terms of money and time) may limit social interactions as well as spillover across villages. We therefore selected the non-beneficiary households from non-project villages that are sufficiently close geographically to the programme villages, to limit the potential spillover effects while maximizing comparability between treated and non-treated groups. We used the lottery method to randomly sample non-beneficiary cocoa, coffee and cashew farming households from the identified non-project villages who volunteered to participate in the survey. To achieve consistency with the selection of treated households, the number of sampled non-treated households is also proportional to the number of volunteering households in the selected non-project villages.

The first wave covered 912 smallholder cash crop farming households and the follow-up 836 households from 6 districts and 129 villages in the Eastern and Northern Provinces of Sierra Leone. The average rate of attrition between the two surveys was 8.6 percent, with some variations across treatment and comparison groups. The probit models in Table A1 analyse how the attrition is associated with household and village characteristics in the baseline sample. The pseudo R-squared from the full sample results in column 5 shows that the control variables explain just 4.1% of the attrition between the two waves. That is, 96% of the attrition is random. With p-values greater than the conventional levels, the Wald tests show that all covariates are jointly not significant predictors of attrition. Hence, we conclude that the balanced panel of 836 households (1672 observations) is representative of the original sample, and attrition may not significantly bias the results. Of the 836 households, 251 were beneficiaries of only the cash crop intervention, 130 participated in only the nutrition intervention, and 193 households received the combined intervention. The remaining 262 households were non-participants.

2.3.3 Empirical strategy

This study sets out to examine the nutritional impacts of the nutrition-sensitive cash crop value chain intervention, with a particular focus on household and individual dietary diversity. It also explores the relative importance of the hypothesized pathways linking the income-focused and nutrition-centered interventions to improved nutritional outcomes, while disentangling their stand-alone and interaction impacts. To do so we adopt the analytical framework for multiple treatments discussed in Imbens (2000), Lechner (2001) and Wooldridge (2010). Here, we assume, for a given population, the treatment variable T can take G+1 different values, labelled {0, 1, 2,…, G}. While zero indicates the control group, 1, 2,…, G represents the different treatment options or levels, which are mutually exclusive. For each level of treatment, t, let the potential outcomes for randomly sampled household i, be $\{Y_{it} : t = 0, 1, 2, \ldots, G\}$. Thus, each household i has two potential outcomes: Y_{it} if it participates in treatment t and Y_{i0} if it does not participate in the programme at all. The causal effect of the intervention for household i is the difference between Y_{it} and Y_{i0}. Using the expectation operator $\mathbb{E}(.)$, we can define the treatment effects in terms of potential mean outcomes over the entire population as:

$$\mu_t = \mathbb{E}(Y_t), \quad t = 0, 1, 2, \ldots, G \qquad (2.1)$$

With t = 0 as the control, the average treatment effect (ATE) of treatment level $t \in \{1, 2, \ldots, G\}$ is given as

$$\tau_{t,ATE} = \mathbb{E}(Y_t - Y_0) = \mu_t - \mu_0 \qquad (2.2)$$

Restricting the expectation to only those who actually received treatment level t, the average treatment effect on the treated (ATET) is obtained as

$$\tau_{t,ATET} = \mathbb{E}(Y_t - Y_0|T = t) = \mathbb{E}(Y_t|T = t) - \mathbb{E}(Y_0|T = t) \qquad (2.3a)$$

The fundamental challenge to estimating the quantities in Equations 2.2 and 2.3a is the impossibility of observing a household participating in the intervention and not participating at the same time. That is, the expected outcome of the participating households in the absence of participation (μ_0 or $\mathbb{E}(Y_0|T = t)$) cannot be observed once they participated in the programme. However, randomization allows us to replace these expected unobserved counterfactual outcomes with the expected observed outcome of the non-participants, $\mathbb{E}(Y_0|T = 0)$. Hence, due to randomized assignment, the expected non-programme participation outcome is the same whether the household actually participates or does not participate in the intervention: $\mathbb{E}(Y_0|T = t) = \mathbb{E}(Y_0|T = 0)$. Equation 2.3$a$ can therefore be rewritten as

$$\tau_{t,ATET} = \mathbb{E}(Y_t - Y_0|T = t) = \mathbb{E}(Y_t|T = t) - \mathbb{E}(Y_0|T = 0) \qquad (2.3b)$$

Random assignment of treatment ensures that the difference-in-means estimators in Equations (2.2) and (2.3b), obtainable by an ordinary least squares (OLS) regression, are unbiased, consistent, and asymptomatically normal.

However, as often the case, assignment to the different treatment levels in the PROACT programme was not randomized. Participation was entirely voluntary, and households possibly choose a particular treatment that maximizes their utility (or wellbeing) relative to the utility obtainable from other alternatives. This self-selection into treatment may introduce systematic differences among participating and non-participating households, because the factors determining selection into different treatment groups will also most likely affect the outcome. For instance, the level of education may affect both dietary diversity and selection into nutrition-related treatments, as more educated household heads are more likely to know the benefits of good nutrition and would more likely value information on how to improve the nutritional wellbeing of their members. Consequently, in the absence of randomization, simply taking mean outcome value of non-participating households to be the counterfactual for participating households will be incorrect because $\mathbb{E}(Y_0|T = t) \neq \mathbb{E}(Y_0|T = 0)$.

Therefore, estimating the causal effects in our multiple treatments design, using observational data, calls for estimation methods that do not only accommodate multivalued treatment assignments but also account for the problem of self-selection. In this paper, we apply the inverse-probability-weighted regression adjustment (IPWRA) estimator (Cattaneo, 2010; Imbens & Wooldridge, 2009; Wooldridge, 2007). It is a propensity score method which addresses selection bias by estimating both outcome and treatment models, while controlling for all observable confounders associated with both treatment assignment mechanism and potential outcomes. Doing so replicates the randomization process (Linden et al., 2016). In particular, the IPWRA estimator uses weighted regression coefficients to compute the treatment effects, with the estimated inverse probabilities of treatment as weights (Linden, 2017; Linden et al., 2016; Uysal, 2015). The IPWRA estimator improves the balancing properties of samples across treatment levels by comparing each unit to all others, while attaching higher weights to observations that possess a similar probability of being in the treatment or comparison group and lower weights to those that are unalike (Wooldridge, 2007).

The IPWRA approach proceeds in three steps as follow. The first step involves estimating the treatment model, which relates the probabilities of programme participation to a set of covariates determining selection into a specific treatment. This can be expressed as:

$$p[T_i = t] = h(X_i; \gamma) + \omega_i \qquad (2.4)$$

where T is the treatment variable, taking different values t, which we label $\{0,1, 2, 3\}$. Drawn from a large population, each household i, $i = 1, \dots, N$, is only observed in one of four treatment groups: non-treated (t = 0); cash crop (t = 1), nutrition (t = 2) and combined (t = 3). X_i is a set of observable household, individual, village and district characteristics included as controls. ω_i is the error term. With multivalued treatment, a multinomial logit regression is used to estimate the parameters (γ) of Equation (2.4) and thus predict the probabilities or generalized propensity scores (Imbens, 2000; Słoczyński & Wooldridge, 2018; Wooldridge, 2007).

In the second step, using the inverse probabilities from Equation (4) as weights, a weighted regression models of the outcome (Y_i) for each treatment level are fitted to derive the treatment-specific predicted outcomes for each household. The conditional mean functions of the potential outcomes can be specified as:

$$\mathbb{E}(Y_{it}|X_i) = \mathbb{E}(Y_i|T_i = t, X_i) = \beta_{0t} + X_i'\beta_{1t} \qquad (2.5)$$

where β_t is the parameter vector. The full specification of the weighted regression for multivalued treatment is derived in Linden et al. (2016) and Uysal (2015). Thirdly, the means of the treatment-specific predicted outcomes are computed. The differences of these averages provide the estimates of the ATEs, while those based on a restricted subset of treated households give the ATETs. Identification of the treatment effect depends on achieving unconfoundedness or covariate balance (which requires the distribution of the covariates to be independent of treatment status). Covariate balance is achieved if the weighted standardized mean difference and variance ratio are close 0 and 1 respectively. Rubin (2001) and Stuart and Rubin (2007) suggest that the variables are out of balance if the weighted standardized variance ratio is greater than 2 or less than 0.5, and the weighted standardized mean difference is above 0.25. A second condition for identification of treatment effects is the overlap assumption. This requires that conditioned on observables, each household has a positive probability of receiving treatment. Strict overlap ensures that for each participating household in the sample, we observe some non-participating households with similar covariates. There is evidence that the overlap assumption is violated when an estimated density has too much mass around 0 or 1 (Busso et al., 2014).

A key feature that makes IPWRA estimator very attractive (relative to other matching methods) is its double-robustness to misspecifation of either the treatment or outcome model. In contrast, estimates of treatment effects from propensity score matching (PSM) methods will be inconsistent if the treatment model is incorrectly specified. Empirical applications and Monte Carlo simulations (Linden et al., 2016; Uysal, 2015) show that doubly robust estimations of multi-valued treatment effects yield consistent estimates even if either the treatment model or the outcome model (but not both) is misspecified. The parameters of interest are estimated using the '*teffects ipwra'* command (StataCorp, 2013)

Despite its virtues, a major weakness of the IPWRA estimators is that it does not entirely deal with the problem of endogeneity arising from unobserved heterogeneity. Admissibly, unobserved factors, which determine self-selection by households into the project, may also influence dietary diversity and other outcome variables of interest. To purge unobserved heterogeneity and exploit the panel structure of our data, we employed the correlated random effects (CRE) estimator due to Mundlak (1978)and Chamberlain (1984). As a pseudo fixed-effects estimator, the CRE approach includes the mean values of time-varying observable covariates as additional regressors in the estimable model (Wooldridge, 2010). The CRE model can be expressed as:

$$Y_{i\tau} = \beta_0 + \beta_1 Cashcrop_{i\tau} + \beta_2 Nutrition_{i\tau} + \beta_3 Combined_{i\tau} + \beta_4 X_{i\tau} + \beta_5 \bar{Z}_i + \beta_6 \eta_i + \varepsilon_{i\tau} \quad (2.6)$$

where $Y_{i\tau}$ is an indicator of dietary outcomes for household *i* at time τ, $Cashcrop$, $Nutrition$ and $Combined$ are indicators for households belonging to the cash crop only, nutrition only and both cash crop and nutrition treatment groups respectively. Their respective impacts are measured by the parameters β_1, β_2, and β_3. X is the vector of individual, household and community-level covariates, $\bar{Z}$ is the vector of the average values of all time-varying controls in *X*. η_i are unobserved time-invariant fixed effects and $\varepsilon_{i\tau}$ is the idiosyncratic error term. The use of the CRE estimator allows us to assess the robustness of the results from the IPWRA estimator.

2.3.4 Measurement of the outcome variables

The main outcome variables of interest are household dietary diversity score (HDDS) and individual dietary diversity score for reproductive-aged women (WDDS) and children aged 6-59 months (CDDS). We tied our analyses to these dietary diversity measures because they are the main food security and nutrition indicators targeted by the project in achieving its overall objective of improving the food and nutrition security situation of vulnerable groups. The HDDS is measured by summing the number of food groups consumed by a household out of 12 in the last 24 hours prior to the survey (Kennedy et al., 2010). The twelve food groups used to calculate HDDS are cereals; white tubers and roots; vegetables; fruits; meat; fish and other seafood; legumes, nuts, and seeds; milk and milk products; oil and fats; sugar and honey; and a miscellaneous group (consisting of spices, condiments, and beverages). The WDDS and CDDS are also measured by counting the number of food groups consumed by reproductive-aged women and under-fives respectively during the last 24 hours, based on the food groups proposed by the Food and Agriculture Organization of the United Nations (FAO) and USAID's Food and Nutrition Technical Assistance III Project (FANTA) (FAO & FHI 360, 2016). The WDDS is made up of ten food groups, while the CDDS is based on seven food groups; both excluding the last three food groups because of their minor contribution to micronutrient intake. The HDDS measures food consumption that reflects household access to diverse foods (hence, food security) at the household level, whereas WDDS and CDDS are proxy measures for nutrient adequacy of the diet of individuals (FAO & FHI 360, 2016; Kennedy et al., 2010). Several studies have validated these associations between dietary diversity, household food security, and nutrient adequacy of individual dietary intakes (Hatløy et al., 1998; Hoddinott & Yohannes, 2002; Nguyen et al., 2018).

Compared to a national average of 5.3 HDDS in 2017 (Ministry of Health and Sanitation & Action Against Hunger, 2017), our estimated mean of 6.8 suggests higher dietary diversity in rural Sierra Leone (see Table 2.1). However, this masks the prevalence of micronutrient deficiencies in the country as a result of low intake of micronutrient-rich foods. Typical Sierra Leonean diets are highly undiversified, consisting mainly of rice, cassava, palm oil, and inadequate portions of groundnuts, fish and other seafood, green leafy vegetables, and beans (Ministry of Agriculture, Forestry & Ministry of Health and Sanitation, 2016). As shown in Figure 2.3, the consumption of vitamin A and iron-rich foods is limited, partly due to inadequate knowledge of their nutritive values, poverty, and lack of access and availability. Since almost everyone consumes starchy staples, fats, and oil and condiments daily, their inclusion may inflate the dietary diversity scores and overstate access to and intake of micronutrient food groups. To quantify the impacts of the interventions on micronutrient intake among rural cash cropping households, as well as check the sensitivity of our estimates, we construct micronutrient-sensitive dietary diversity scores for household (MsHDDS) and women (MsWDDS). The modified scores are based on seven vitamin A and haem-iron rich food groups recommended by Kennedy et al. (2010). They include dark green leafy vegetables, vitamin A-rich vegetables or tubers; vitamin A-rich fruits; flesh and organ meat; fish and seafood; eggs; and dairy. Mazunda et al. (2018) have used similar country-specific micronutrient-sensitive dietary diversity indicators to analyse the effects of production diversity on food and nutrition security in Malawi.

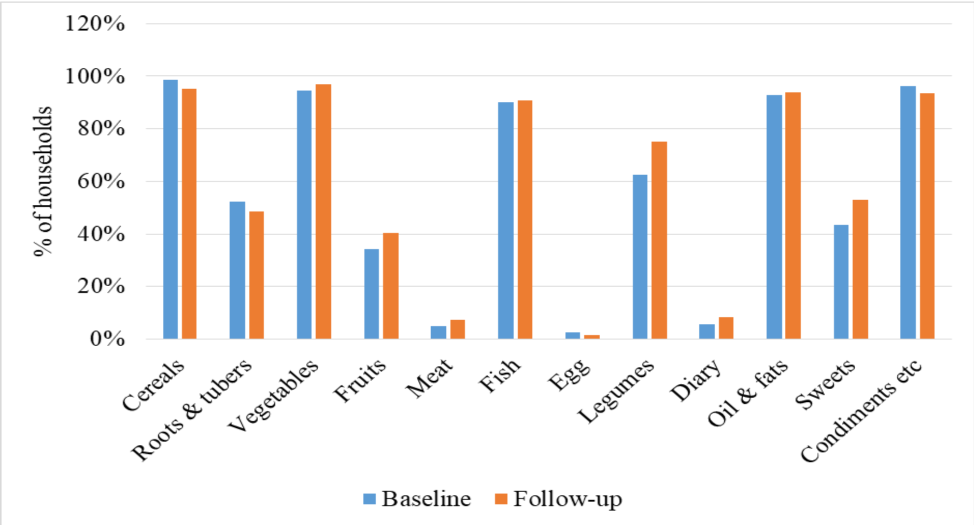


Figure 2. 3: Distribution of HDDS food groups by survey wave

2.3.5 Measurement of the impact-pathway variables

The targeted cash crops are non-food tree crops that have little or no intrinsic nutritional value to smallholder producers. They are mainly produced for cash, which is then used for food and other purchases. In this study, we examine two broad pathways through which the project can lead to better dietary outcomes for these cash crop growers: the income-consumption pathway and women empowerment (i.e., women's nutrition awareness, control over the use of income and confidence) (Malapit et al., 2015; Rosenberg et al., 2018; von Braun & Kennedy, 1995). The income-consumption pathway is considered the most direct mechanism through which the market-focused, cash crop component could lead to improved nutrition. It is expected that increased cash crop revenue (from better yields and prices) could lead to dietary improvements by easing budget constraints and enabling the household to afford consumption baskets with more diverse, nutrient-dense foods, and other welfare-enhancing goods in the marketplace (Kuma et al., 2018; Ogutu et al., 2019). Where households tend to consume more from own production, because of incomplete markets or high transaction costs, the cash crop intervention can also have a spillover effect on food availability from own farms if the acquired farming skills and tools are applied in food crop production (Govereh & Jayne, 2003). Overall, these project-induced changes may be seen in increased household food consumption expenditure. Household food consumption expenditure entails own food production and market purchases. In this study, own food consumption in the 12 months preceding the survey was valued at self-reported producer prices, while purchased food was measured by the total expenditure on foods bought from the market in the last 7 days. As indicators of household welfare all consumption expenditures were annualized and expressed in adult equivalent units[4].

In addition, we also analyse the impact of programme, particularly the nutrition intervention, on caregiver's nutrition knowledge, control over the use of incomes and confidence The level of nutrition knowledge is captured by the test score from three nutrition-related questions asking caregivers to state the roles of the three LANN-promoted food groups – energy, growth/body building and health foods – in the human body. It ranges from 0 to 3, with higher values indicating caregivers have better knowledge or awareness of the nutritional values of the foods available to them, which may stimulate consumption.

Women's control over income is captured by the degree of input into decisions on the use of income generated different economic activities they have undertaken. A woman is deemed to have adequate control if she participates in the activity and contributes at least some input in decisions about the use of income obtained from it (Alkire et al., 2013). Lastly, we considered women's confidence, a domain of women empowerment – leadership – which relates to public speaking (Alkire et al., 2013). A short description of the control variables employed in the study along with summary statistics from the first wave are reported in Table 2.1. The summary statistics by treatment groups are presented in appendix Table 2A.2.

[4] Due to data limitations on household incomes, we rely on house food consumption expenditure which is a better (and more direct) measure of household welfare than income (Deaton, 2018).

Table 2. 1: Description of variables and summary statistics at baseline

Variable	Description	Mean	Std. Dev
Household characteristics			
Household dietary diversity score (HDDS)	Sum of food groups (0–12) consumed by household in last 24 hours based on Kennedy et al (2010)	6.780	1.325
Micronutrient-sensitive HDDS (MsHDDS)	Sum of micronutrient-sensitive food groups (0–7) consumed by household in last 24 hours	2.039	0.859
Age of head	Age of household in years	47.46	14.44
Head is male	Dummy, = 1 if household head is a male and 0 otherwise	0.949	0.221
Head is married	Dummy, = 1 if household head is married and 0 otherwise	0.956	0.206
Head's years of schooling	Years of schooling based on highest level of formal education attained by household	3.611	5.338
Dependency ratio	Ratio of household members aged 0-14 & 65+ to those aged 15-64	1.431	1.283
Household size	Number of household members	6.911	2.657
Farm size	Total cash crops and food crops farm holding in acres	7.999	6.971
Livestock	Dummy, = 1 if household owns chicken and 0 otherwise	0.793	0.405
Off-farm income	Dummy, = 1 if household had at least one off-farm income source	0.459	0.499
Household wealth index	Asset-based wealth index (0 – 100) based on Smits et al. (2015)	50.89	13.17
Head is member of cooperative	Dummy, = 1 if household belongs to any cooperative/farmer group	0.407	0.492
Household experienced any shock	Dummy, = 1 if household experienced any major shock last year	0.695	0.461
Distance to market (miles)	Distance to nearest daily/periodic market by most frequent means of transportation in miles	7.564	9.033
Village has cooperative	Dummy, = 1 if any cooperative or farmer group exists in village	0.694	0.461
Number of households		836	
Caregiver's characteristics			
Women dietary diversity score	Sum of food groups (0–10) consumed by woman in last 24 hrs based on FAO and FHI 360 (2016)	5.459	1.443
Micronutrient-sensitive WDDS (MsWDDS)	Sum of micronutrient-sensitive food groups (0–7) consumed by woman in last 24 hours	2.083	0.937
Caregiver's age	Age of caregiver (woman) in years	37.14	11.94
Caregiver's education	Years of schooling based on highest level of formal education caregiver/woman attained	1.991	3.448
Number of women of reproductive age		636	
Child characteristics			
Child dietary diversity score	Sum of food groups (0–7) consumed by child in last 24 hours based on FAO and FHI 360 (2016)	3.534	1.305
Child's age (months)	Age of child in months	29.31	17.89
Child is a male	Dummy, = 1 if child is male and 0 otherwise	0.482	0.500
Number of children (6-59 months)		575	

2.4 Results and Discussion

2.4.1 Descriptive results and diagnostic checks

2.4.1.1 Descriptive statistics

From the pooled sample at baseline in Table 2.1, the majority of the sampled households (95%) are headed by males, with very low educational levels (less than 4 years of formal schooling). The average household has about 7 members, with 1.4 dependents per working-age person. In the light of the country's low life expectancy (52 years), it is unsettling that the mean age of household heads is about 47.5 years. This poses a significant threat to the productivity and sustainability of these cash crop sectors. The reason is that aged farmers are less productive, have lowered work capacity, and are unable to provide the physical strength required to carry out various labour intensive agronomic practices and post-harvest processing activities. That targeted households are smallholders is shown by the average farm size of about 8 acres (circa 3.6 hectares). The majority of households are shock-prone, with about 70% of them experiencing a major shock in the year preceding the survey. The average wealth index of 50.89 suggests that households possess some durable assets with moderate quality housing and services. Alternative sources of livelihood, aside from farming, are thin, as less than half of them reported to have at least one off-farm source of income. In terms of institutions, close to 70% of the households live in a village where a cooperative or any farmer group exists, and about 41% of them are group members. Households have to travel about 8 miles (about 13 km or one and half hours using the most common means of transportation) to reach the nearest food market, due to generally poor-quality roads and weak transport infrastructure in these rural communities. Out of 12, households consume from 6.78 food groups, suggesting somewhat high dietary diversity in Sierra Leone. At the individual level, while women of reproductive age consume 5.5 out of 10 food groups, and under-5 children receive less diversified diets (3.5), consuming from less than 4 food groups (out of 7).

2.4.1.2 Specification diagnostics

In observational studies, like ours, the covariates are typically never balanced across treatment groups (see Table 2A.2). Therefore, we utilized an inverse-probability-weighting method that uses a treatment-assignment model to balance the covariates. By this strategy, the covariates are balanced if the weighted distribution of each covariate is similar across treatment groups. We rely on standardized differences and variance ratios for conclusions about covariate balance over treatment groups, and thus correct specification of the treatment-assignment model. As shown in the diagnostic statistics in Table 2A.4, the standardized difference in the means of all treated and non-treated groups for each (weighted) covariate is less than 0.25, and the majority are close to 0. Moreover, the weighted variance ratios are mostly close to 1 or fall within the range (0.5 – 2) proposed by Rubin (2001). These results suggest that the treatment-assignment model is well specified, and the weights constructed from this model balance the covariates. In other words, the counterfactual outcomes are independent of the treatment indicator conditional on these covariates. In addition to conditional independence, non-violation of the overlap assumption is required for estimated treatment effects, using weighting and matching estimators, to be consistent. The overlap assumption asserts that each household has a positive probability of receiving each treatment level, given the covariates. Figure 2A.1 displays the overlap graphs of the estimated densities of the predicted probability of participating in each treatment level. None of the plots have too much probability mass around zero or one, suggesting that there is no evidence that the overlap assumption is violated. In sum, while the covariate balancing tests show successful bias reductions after weighting, the overlap distributions of the generalized propensity scores suggest a satisfaction of the common support conditions. Having verified that these assumptions hold, we now proceed to present and discuss the main results.

2.4.2 Empirical results

2.4.2.1 Determinants of programme participation

Table 2.2 shows the results of the multinomial logit model of programme participation. It reveals the factors associated with the predicted probabilities of participating in the different treatment arms of the intervention. The results show that the gender of the household head, farm size, group membership, the presence of a cooperative/farmer group in a village, wealth index, and off-farm income are significantly associated with the probability of participating in any two of the three treatment groups. Male household heads are less likely to participate in nutrition-related treatment groups than their female counterparts. This may be because the nutrition intervention is purposively designed to reach nutritionally most vulnerable and socially marginalized groups within target communities, particularly women and children below 5 years. Marital status does not significantly affect project participation, suggesting that both married and unmarried household heads are equally likely to participate in any of the interventions. While the age of the household head appears not to play a significant role in participating in the individual treatment groups, older farmers are more likely to decide on the combined intervention than younger farmers. The probability of receiving any intervention, either in isolation or jointly, increases with the farm size of the household, the head's membership of a farmer-based organization, and the presence of these groups in the village. The positive and significant association between farmer groups and the probabilities of program uptake reflects the importance of farmer groups both as social capital and a platform for delivery of development interventions. Households with off-farm sources of income are less likely to participate in the stand-alone cash crop and nutrition interventions, perhaps due to the related higher opportunity cost in terms of time and forgone alternative income. While asset-rich households are more likely to decide on only the nutrition intervention, they are less likely to adopt the cash crop intervention alone. This could be due to the higher valuation of nutrition information and its health-related benefits among asset-rich households, who may already possess the farming tools provided under the cash crop intervention. Finally, livestock ownership seems to lower the probability of project participation, particularly, the uptake of cash crop only intervention.

Table 2. 2: Multinomial logit – determinants of participation

	Cash crop	Nutrition	Combined
Age of head (years)	-0.007	0.002	0.009*
	(0.005)	(0.006)	(0.005)
Head is male (dummy)	-0.499	-1.673***	-1.385***
	(0.500)	(0.434)	(0.466)
Head is married (dummy)	-0.015	-0.169	0.750
	(0.518)	(0.442)	(0.538)
Head's years of schooling	-0.035**	-0.006	0.002
	(0.014)	(0.015)	(0.014)
Dependency ratio	-0.001	0.125*	-0.053
	(0.063)	(0.064)	(0.065)
Household size	-0.025	-0.156***	0.015
	(0.029)	(0.038)	(0.027)
Farm size (log, acres)	0.545***	0.739***	0.606***
	(0.112)	(0.133)	(0.123)
Livestock (dummy)	-0.475***	-0.269	-0.049
	(0.161)	(0.203)	(0.184)
Off-farm income (dummy)	-0.305*	-0.360*	0.077
	(0.163)	(0.196)	(0.165)
Household wealth index	-0.014**	0.018**	0.011
	(0.007)	(0.008)	(0.007)
Head is member of cooperative	1.463***	0.898***	1.616***
	(0.141)	(0.173)	(0.151)
Household experienced any shock	0.038	0.379**	-0.089
	(0.137)	(0.169)	(0.147)
Distance to market (log, miles)	0.115	-0.826***	-0.138
	(0.098)	(0.119)	(0.100)
Village has cooperative	0.106	0.647***	0.934***
	(0.148)	(0.194)	(0.181)
Constant	0.198	0.181	-2.980***
	(0.582)	(0.657)	(0.664)
District dummies	Yes	Yes	Yes
Observation	251	130	193

Notes: This table reports the treatment equation used for the household level analyses using the first wave sample.
The reference group is non-treated households with a sample size of 262.
Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.4.2.2 Impact on household diets

The stand-alone and joint impacts of the interventions on household diets are presented in Table 2.3. The results show that the cash crop intervention alone is associated with a statistically significant decline in the HDDS, with its recipients consuming 0.28 food groups less than non-intervention households. The nutrition only households are shown to consume 0.23 food groups more than non-intervention households, although it is not statistically significant. However, the treatment effects of the combined intervention indicate that, relative to the comparison group, HDDS significantly improved by 0.20 food groups (at 10 percent level). This represents almost a 3% increase in HDDS relative to the baseline value of 6.85 for non-participating households. As shown in panel B, these results remain consistent when we consider the ATE instead.

The average treatment effects on MsHDDS are shown in column 2 of Table 2.3. Though lower for cash crop households and higher for nutrition households, the results show that there is no significant difference in the consumption of micronutrient-dense foods between each stand-alone intervention group and the comparison group. However, the combined intervention households are found to consume 0.34 micronutrient-rich food groups more than non-participants. The estimated joint impact of both interventions on MsHDDS is statistically significant, suggesting that mainstreaming nutrition in tree crop value chain projects can be an effective strategy to combat micronutrient deficiencies among smallholder households. This may be the result of adjustment in household preferences and eating behaviour towards more healthy, high-quality diets in response to the nutrition information from the intervention (Rosenberg et al., 2018). Besides nutrition awareness, the preferences for improved diets can be associated with the replacement of starchy staples with high quality foods in caloric intake as household income improves (Bennett’s Law) (Bennett, 1941; Timmer et al., 1983)

Reported in columns 3–12 are the estimated treatment effects on the likelihood of consuming from different food groups. The goal is to identify the sources of change in household dietary diversity attributable to the programme. From the results, while cash crop only households are less likely to consume dark green leafy vegetables, they are more likely to increase the consumption of other vegetables and eggs compared to non-intervention households.

Table 2. 3: Impact on household dietary diversity and the likelihood of eating from nutrient-rich food groups

	Household dietary diversity		Food groups consumed by any household member									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	HDDS	Micronutrient-sensitive HDDS	Dark green leafy vegs	Vitamin A rich vegs & tubers	Other vegs	Vitamin A rich fruits	Other fruits	Meat	Fish	Eggs	Legumes nuts & seeds	Dairy
Panel A: Average treatment effects on treated (ATET)												
Cash crop	-0.276***	-0.052	-0.07**	0.03	0.06*	-0.00	0.03	0.01	-0.03	0.01*	-0.12***	-0.00
	(0.093)	(0.057)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)
Nutrition	0.226	0.092	0.00	0.01	0.08**	0.07*	0.16***	-0.02	-0.05	0.02**	-0.15***	-0.02
	(0.141)	(0.085)	(0.05)	(0.02)	(0.04)	(0.04)	(0.05)	(0.02)	(0.04)	(0.01)	(0.05)	(0.02)
Combined	0.203*	0.338***	0.04	0.10***	0.08**	0.11***	0.18***	0.01	-0.01	0.05***	-0.08**	0.06**
	(0.118)	(0.072)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.03)
POM of non-treated	6.932***	2.012***	0.77***	0.08***	0.76***	0.12***	0.24***	0.05***	0.92***	0.00	0.76***	0.06***
	(0.073)	(0.044)	(0.03)	(0.01)	(0.03)	(0.02)	(0.03)	(0.01)	(0.02)	(0.00)	(0.03)	(0.02)
Panel B: Average treatment effects (ATE)												
Cash crop	-0.288***	-0.062	-0.07**	0.01	0.05*	0.01	0.04	0.02	-0.04*	0.01*	-0.14***	0.01
	(0.088)	(0.056)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)
Nutrition	0.149	0.093	0.03	0.01	0.06*	0.07**	0.13***	-0.01	-0.04	0.02**	-0.17***	-0.01
	(0.115)	(0.071)	(0.04)	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.02)
Combined	0.218**	0.345***	0.03	0.11***	0.08***	0.11***	0.15***	0.01	-0.02	0.04***	-0.10***	0.06**
	(0.102)	(0.066)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.02)	(0.02)	(0.01)	(0.03)	(0.02)
POM of Non-treated	6.979***	2.041***	0.78***	0.09***	0.77***	0.12***	0.25***	0.06***	0.93***	0.00*	0.78***	0.06***
	(0.060)	(0.037)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.00)	(0.02)	(0.02)

Table 2.3 (*continued*)

Panel C: Complementarity and incremental effects (based on ATET)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	HDDS	Micronutrient-sensitive HDDS	Dark green leafy vegs	Vitamin A rich vegs & tubers	Other vegs	Vitamin A rich fruits	Other fruits	Meat	Fish	Eggs	Legumes nuts & seeds	Dairy
Complementarity	0.253	0.298***	0.107*	0.059	-0.056	0.035	-0.017	0.013	0.058	0.015	0.187***	0.079**
	(0.179)	(0.108)	(0.055)	(0.037)	(0.046)	(0.048)	(0.063)	(0.024)	(0.042)	(0.027)	(0.062)	(0.031)
Incremental impact of cash crop on nutrition	0.479***	0.390***	0.111***	0.074***	0.026	0.108***	0.146***	-0.001	0.012	0.039**	0.033	0.061***
	(0.109)	(0.067)	(0.029)	(0.026)	(0.026)	(0.029)	(0.037)	(0.017)	(0.022)	(0.017)	(0.035)	(0.023)
Incremental impact of nutrition on cash crop	-0.023	0.246***	0.038	0.09***	0.001	0.032	0.016	0.021	0.032	0.025	0.069	0.078***
	(0.154)	(0.093)	(0.045)	(0.03)	(0.033)	(0.042)	(0.054)	(0.019)	(0.036)	(0.019)	(0.053)	(0.024)

Note: All outcome variables are based on 24-hour dietary recall. POM stands for the potential-outcome mean. The outcome models in columns 1 and 2 were estimated using Poisson regression, and those in columns 3-12 were estimated using the probit model. All estimates were conditioned on the covariates in Table 2A.1 and shared similar treatment equations using the IPWRA method. Non-programme households are the comparison group for the ATET and ATE estimates.
Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

With respect to only nutrition households, the results show that their likelihood of consuming other vegetables, vitamin-A rich fruits, other fruits and eggs is significantly higher than non-programme households. The results also disclose that recipients of the combined intervention have significantly higher probability of consuming vitamin A-rich vegetables, other vegetables, vitamin A-rich fruits, other fruits, eggs, and dairy than their non-participating counterparts. The results do not show any significant differences in the likelihood of meat and fish intake among participating and non-participating households. However, all treatment groups display a significantly lower propensity to consume legumes, nuts, and seeds. This may be attributed to the seasonal shortfalls in the supply of this food group at the time of the survey. For instance, groundnut, which is commonly grown and consumed in Sierra Leone, is usually in short supply during the dry season (November to April). This results in higher prices over this period. Not only does this incentivize farmers to sell whatever is harvested to meet their cash needs but it also discourages consumption as they become less affordable.

Panel C of Table 2.3 explores the synergistic – complementarity and incremental – effects of the cash crop and nutrition interventions[5] (derived from the ATET results in Panel A). The results show that the joint impacts (of the combined intervention) on HDDS and MsHDDS are greater than the sum of the stand-alone impacts of cash crop and nutrition interventions. This points to the presence of positive interaction effects between the cash crop and nutrition interventions on the diversity of household diets. Interestingly, such complementarity effects are found to be strong (statistically) for the micronutrient-sensitive measure of household dietary diversity. The results (in column 2) also show positive and significant incremental effects of combining the nutrition and cash crop interventions on MsHDDS. Furthermore, the disaggregated results (in columns 3 –12) show that these effects on the likelihoods of consuming from individual food groups are generally positive (though not significant). Overall, the estimates for household dietary diversity show positive synergies when households partake in both interventions.

[5] From Eq. (2.6), β_1 and β_2 capture respectively the stand-alone impacts of the cash crop and nutrition interventions. β_3 measures the joint impact of the combined intervention. Complementarity exists between the cash crop and nutrition interventions if β_3 is significantly greater than $(\beta_1 + \beta_2)$, the sum of their stand-alone impacts. The difference between β_3 and β_1 measures the incremental impact of the nutrition intervention on cash crop households, while the difference between β_3 and β_2 measures the incremental impact of the cash crop intervention on nutrition households.

2.4.2.3 Impact on maternal diets

Women of reproductive age (15-49 years) and children below age five (6-59 months) are most vulnerable to nutritional deficiencies, especially in rural areas where entrenched socio-cultural norms strongly tilt intra-household distribution of nutritious foods in favour of men (KIT et al., 2018; Madjdian, 2018). Because of the considerable intergenerational and irreversible consequences of poor maternal and child nutrition, it is vital to go beyond the household to analyse how nutrition-sensitive interventions, might impact on individual dietary diversity (as a proxy indicator of nutrient adequacy). Table 2.4 reports the stand-alone and joint impacts of the interventions on women's diets. As shown by the ATET estimates in Panel A (column 1), the exclusive receipt the cash crop and nutrition interventions are associated with 0.08 (1.5%) decline and 0.22 (4.2%) increase in WDDS from their respective baseline values. These effects are, however, not sufficiently large to result in significant differences in the diets of women in these households and those in non-beneficiary households.

The joint impact of the combined interventions on WDDS is estimated to be 0.35 (6.1%) more food groups relative to women in non-treated households. This positive impact of the combined treatment on WDDS is statistically significant at 1 percent error level. The estimated impacts on the modified WDDS (MsWDDS in column 2) suggest improvement across all treatment groups compared to non-participants, but only shows significant impact for recipients of the nutrition intervention (either exclusively or in combination with the cash crop component).

The remaining results in columns 3–12 of Table 2.4 shed more light on the impacts on the likelihood of consuming from individual nutrient-dense food groups. The probabilities of women consuming non-vitamin A-rich vegetables, fruits, and eggs are significantly higher for exclusive cash crop households than non-intervention households. Women who exclusively received the nutrition intervention are estimated to have a significantly higher likelihood of consuming dark green leafy vegetables, fish and seafood, and eggs (which are dense in vitamin A and iron) and other fruits (non-vitamin A-rich) than their counterparts in non-participating households. Similarly, the combined treatment is found to significantly increase the likelihood of women consuming dark green leafy vegetables, vitamin A-rich vegetables and fruits, other vegetables and fruits, eggs, and dairy than non-treated women. Women in all treatment groups are less likely to consume from the legumes, nuts, and seeds food group compared to those in the comparison group. While this result contradicts prior expectations, it may be explained by the limited availability and associated higher prices at the time of the survey (which coincides with the dry season).

Table 2. 4: Impact on women dietary diversity and the likelihood of eating from nutrient-rich food groups

	Maternal dietary diversity		Food groups consumed by a woman aged 15-49 years									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	WDDS	Micronutrient-sensitive WDDS	Dark green leafy vegs	Vitamin A rich vegs & tubers	Other vegetables	Vitamin A-rich fruits	Other fruits	Meat	Fish	Eggs	Legumes nuts & seeds	Dairy
Panel A: Average treatment effects on treated (ATET)												
Cash crop	-0.08	0.04	0.00	0.02	0.09**	-0.02	0.06**	-0.01	-0.01	0.02***	-0.10***	0.02
	(0.10)	(0.06)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)
Nutrition	0.22	0.22***	0.09**	-0.01	0.03	0.06	0.21***	-0.03	0.08***	0.03**	-0.15***	-0.01
	(0.16)	(0.08)	(0.04)	(0.03)	(0.05)	(0.04)	(0.05)	(0.02)	(0.03)	(0.01)	(0.05)	(0.02)
Combined	0.35***	0.36***	0.07**	0.14***	0.11***	0.08***	0.19***	-0.01	-0.04	0.04***	-0.07*	0.07***
	(0.13)	(0.08)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.03)
POM of non-treated	5.48***	1.97***	0.73***	0.11***	0.75***	0.13***	0.21***	0.07***	0.86***	0.00*	0.77***	0.05***
	(0.07)	(0.05)	(0.03)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.00)	(0.03)	(0.02)
Panel B: Average treatment effects (ATE)												
Cash crop	-0.16*	0.03	-0.02	0.02	0.06*	0.00	0.06**	0.01	-0.04	0.02**	-0.12***	0.03*
	(0.10)	(0.06)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)
Nutrition	0.11	0.17**	0.08**	-0.03	-0.00	0.05	0.18***	-0.01	0.06**	0.03***	-0.17***	-0.00
	(0.13)	(0.07)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.02)
Combined	0.28**	0.36***	0.05	0.14***	0.09***	0.10***	0.16***	0.00	-0.04*	0.04***	-0.09***	0.07***
	(0.11)	(0.07)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)
POM of non-treated	5.56***	2.01***	0.75***	0.13***	0.77***	0.13***	0.22***	0.07***	0.87***	0.01**	0.78***	0.05***
	(0.06)	(0.04)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.00)	(0.02)	(0.01)

Table 2.4 (*continued*)

Panel C: Complementarity and incremental effects (based on ATET)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	WDDS	Micronutrient-sensitive WDDS	Dark green leafy vegs	Vitamin A rich vegs & tubers	Other vegetables	Vitamin A-rich fruits	Other fruits	Meat	Fish	Eggs	Legumes nuts & seeds	Dairy
Complementarity	0.221	0.108	-0.018	0.125***	-0.004	0.037	-0.074	0.020	-0.109***	-0.008	0.169***	0.073**
	(0.202)	(0.110)	(0.051)	(0.041)	(0.053)	(0.051)	(0.064)	(0.024)	(0.038)	(0.019)	(0.062)	(0.031)
Incremental impact of cash crop on nutrition	0.437***	0.324***	0.069**	0.112***	0.027	0.101***	0.134***	-0.005	-0.031	0.019	0.021	0.059***
	(0.126)	(0.077)	(0.029)	(0.028)	(0.025)	(0.027)	(0.037)	(0.015)	(0.025)	(0.015)	(0.035)	(0.022)
Incremental impact of nutrition on cash crop	0.137	0.144	-0.013	0.149***	0.082*	0.019	-0.014	0.013	-0.119***	0.014	0.074	0.089***
	(0.176)	(0.093)	(0.037)	(0.034)	(0.042)	(0.044)	(0.056)	(0.017)	(0.027)	(0.018)	(0.052)	(0.024)

Note: All outcome variables are based on 24-hour dietary recall. POM stands for the potential-outcome mean. The outcome models in columns 1 and 2 were estimated using Poisson regression, and those in columns 3-12 were estimated using the probit model. All estimates were conditioned on the covariates in Table 2A.1 and shared similar treatment equations using the IPWRA method. Non-treated households are the comparison group for the ATET and ATE estimates. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results in Panel C (columns 1–2) show that, relative to non-beneficiaries, the joint impacts of the combined intervention on WDDS and MsWDDS are larger than (the sum of) their isolated impacts, albeit statistically non-significant. Receiving the cash crop intervention on top of the nutrition programme is estimated to have significant incremental impact on the dietary diversity of women (in nutrition only households). The remaining complementarity and incremental impacts are generally positive, signifying the presence of potential synergies between the two types of intervention in improving the quality of women's diets and tackling maternal micronutrient deficiencies.

2.4.2.4 Impact on child diets

Table 2.5 shows the differential impacts of the programme on the diets of under-five children, the most nutritionally at-risk individuals. Column 1 presents the estimated average treatment effects on children's dietary diversity, while columns 2–8 unbundle the child dietary diversity score and track the effects on the likelihood of consuming from its constituent food groups. Compared the non-treated households, exclusive receipt of the cash crop treatment appears to significantly reduce the diversity of children's dietary diversity by 6% or 0.2 food groups. A similar positive (but insignificant) impact is found for children in households that received only the nutrition intervention. However, combining both interventions is shown to significantly increase the dietary intake of under-five children by 0.24 food groups (6.43%) more than their peers in non-intervention households.

Table 2. 5: Impact on child dietary diversity and the likelihood of eating from individual food groups

	Child dietary diversity	Food groups consumed by a child under age 5						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CDDS	Grains & Tubers	Vitamin A fruits & vegs	Other fruits & vegs	Meat & fish	Eggs	Dairy	Pulses
Panel A: Average treatment effects on treated (ATET)								
Cash crop	-0.20**	0.02	-0.05	-0.04	-0.02	0.03**	-0.04	-0.10**
	(0.10)	(0.02)	(0.04)	(0.03)	(0.03)	(0.01)	(0.03)	(0.04)
Nutrition	-0.05	0.04	-0.03	-0.02	-0.07	0.17**	0.03	-0.12*
	(0.13)	(0.03)	(0.05)	(0.05)	(0.05)	(0.07)	(0.04)	(0.07)
Combined	0.24**	0.01	0.12***	0.01	0.03	0.09***	0.06*	-0.06
	(0.11)	(0.02)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.05)
POM of Non-treated	3.67***	0.91***	0.24***	0.89***	0.85***	0.02**	0.10***	0.63***
	(0.08)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.03)
Panel B: Average treatment effects (ATE)								
Cash crop	-0.19*	0.02	-0.04	-0.03	-0.02	0.04**	-0.05*	-0.10**
	(0.10)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)
Nutrition	-0.05	0.05**	-0.04	-0.02	-0.07	0.17**	0.01	-0.10
	(0.12)	(0.02)	(0.04)	(0.05)	(0.05)	(0.07)	(0.04)	(0.07)
Combined	0.24**	0.01	0.15***	0.01	0.03	0.08***	0.04	-0.08*
	(0.11)	(0.02)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)
POM of Non-treated	3.65***	0.92***	0.23***	0.89***	0.86***	0.02***	0.11***	0.63***
	(0.07)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)

Table 2.5 *(continued)*

Panel C: Complementarity and incremental effects (based on ATET)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CDDS	Grains & Tubers	Vitamin A fruits & vegs	Other fruits & vegs	Meat & fish	Eggs	Dairy	Pulses
Complementarity	0.494***	-0.058	0.191***	0.065	0.116*	-0.110	0.071	0.161**
	(0.131)	(0.036)	(0.06)	(0.056)	(0.06)	(0.073)	(0.047)	(0.078)
Incremental impact of cash crop on nutrition	0.446***	-0.014	0.164***	0.048*	0.046	0.059**	0.098***	0.037
	(0.166)	(0.021)	(0.038)	(0.026)	(0.029)	(0.024)	(0.029)	(0.042)
Incremental impact of nutrition on cash crop	0.446***	-0.036	0.145***	0.028	0.101*	-0.075	0.032	0.065
	(0.103)	(0.266)	(0.049)	(0.047)	(0.051)	(0.072)	(0.037)	(0.065)

Note: All outcome variables are based on 24-hour dietary recall. POM stands for the potential-outcome mean. The outcome models in column 1 were estimated using Poisson regression, and those in columns 2-8 were estimated using the probit model. All estimates were conditioned on the covariates in Table 2A.1 and shared similar treatment equations using the IPWRA method. Non-treated households are the comparison group for the ATET and ATE estimates.
Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The disaggregated results in models 2–8 reveal that the positive dietary change for children in combined intervention households is significantly due to improvements in the intake of vitamin A-rich fruits and vegetables, eggs, and dairy products. There are no significant differences in the probabilities of consuming starchy staples, non-vitamin A-rich fruits and vegetables, meat, and fish. The absence of statistical significance in most of these results (in models 2-8) is in contrast with the (modest) evidence of improvement in consumption from similar food groups at household and maternal levels. This could be a reflection of adverse intra-household food distribution practices which restrict the quantity and quality of dietary intake of (women and) children. Generally, food allocation in Sierra Leone is based on household status and not on the nutritional requirements of individuals (Pasqualino et al., 2016; SPRING, 2017). This results in children being least favoured in the distribution of dietary protein and other nutritious foods. This may also be compounded by the existence of food taboos and social norms which forbid children from consuming certain healthy foods (SPRING, 2017).

Similar to the results at the household and maternal levels, all treatment groups witnessed significant decline in the likelihood of pulses (including legumes and nuts). As mentioned above, the reduced consumption may be owed to their limited availability and the associated higher prices at the time of the survey.

On a whole, the results in panel C show positive and significant complementarity between the cash crop and nutrition interventions in bettering the diversity of child diets. These child-level results corroborate our findings at household and women's levels: that integrating direct (nutrition-focused) and indirect (livelihood support) interventions promise to be the most instrumental approach to accelerate progress toward improved nutrition among poor smallholder households.

2.4.2.5 Possible mechanisms

Investigating which mechanisms are at work behind these results is of high relevance to policy. Understanding these impact pathways is essential in identifying promising entry points within the agriculture–nutrition nexus through which nutrition-sensitive value chain interventions, like the PROACT, can achieve maximum nutritional and health benefits. As aforementioned, the cash crop component, by enhancing production and processing of targeted export-oriented cash crops, is envisaged to increase smallholder household incomes – economic access – and indirectly contribute to overall household food and nutrition security. The nutrition-focused component is a demand-side intervention aimed at "nudging" or stimulating positive behaviour change at household and community levels, particularly, in the areas of dietary diversity, child feeding and hygiene practices, women's status and nutrition-sensitive use of household resources (including cash crop income). We, therefore, consider food consumption expenditure, nutrition knowledge, and women empowerment to be the primary pathways linking the programme to household food and nutrition security.

2.4.2.5.1 The food consumption pathway

Table 2.6 reports the estimated impacts on annual household food consumption expenditure per adult equivalent units. The stand-alone impact of the cash crop intervention on total food expenditure per adult equivalent is positive, while that of nutrition alone is negative. However, both stand-alone impacts are not statistically significant, indicating there is no marked difference in the food consumption expenditure of these households and non-intervention households. The joint impact of the combined intervention is positive and significant.

Table 2. 6: Impact on household food consumption expenditure

	Total food expenditure per AE (log)	Purchased food per AE (log)	Produced food per AE (log)
	(1)	(2)	(3)
Panel A: Average treatment effects on treated (ATET)			
Cash crop	0.256	0.222	-0.366
	(0.160)	(0.164)	(0.353)
Nutrition	-0.018	-0.007	-0.261
	(0.209)	(0.215)	(0.572)
Combined	0.342^{*}	0.321^{*}	-0.279
	(0.175)	(0.177)	(0.426)
POM of non-treated	13.622^{***}	13.569^{***}	8.093^{***}
	(0.151)	(0.153)	(0.303)
Panel B: Average treatment effects (ATE)			
Cash crop	0.226	0.183	-0.472
	(0.146)	(0.150)	(0.295)
Nutrition	-0.070	-0.031	-0.502
	(0.171)	(0.175)	(0.436)
Combined	0.308^{**}	0.303^{**}	-0.602^{*}
	(0.145)	(0.146)	(0.342)
POM of non-treated	13.640^{***}	13.558^{***}	8.031^{***}
	(0.127)	(0.129)	(0.235)

Notes: All food expenditure measures were annualized to facilitate comparison. AE stands for adult equivalent units, with the scale adopted from Haughton and Khandker (2009). POM stands for the potential-outcome mean. All specifications are semi-log models. All estimates were conditioned on the covariates in Table 2A.1 and shared similar treatment equations using the IPWRA method. Non-treated households are the comparison group for the ATET and ATE estimates. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results in columns 2 and 3 reveal that this is primarily due to a significant increase in market purchases, which protectively have compensated for the decline in consumption from own production. In terms of magnitudes, the joint impacts of the combined intervention represent a 40.8 percent and 37.9 percent increase in total food consumption expenditure and purchased food per adult equivalent unit, respectively, relative to the non-programme households. These correspond to SLL336,661.18 (US$45.59) and SLL236,841.73 (US$32.07) higher annual food consumption and annual food purchases above the respective baseline values of non-treated households[6].

As the WFP (2018) observed, the fall in own food consumption expenditure across all treated households could be due to erratic rainfall patterns (i.e., delayed onset of the rainy season, unevenly distributed and lower than average precipitation levels, and flooding) in 2018. These rainfall irregularities led to significant reductions in the already extremely low agricultural production and household food stocks (World Food Programme, 2019). More importantly, these adverse weather conditions also resulted in lower than average yields of cocoa and other primary cash crops (reducing household incomes to purchase food) and increased food insecurity (World Food Programme, 2019). Another possible reason for the non-significant consumption effects among cash crop only households is that the targeted tree crops have long maturation periods, requiring several years to yield harvests at economically profitable levels. At the time of this study, most tree crop plantations in Sierra Leone were overaged, overgrown, and were being rehabilitated and replaced with new seedlings as part of the programme. It may, therefore, be too early to witness any significant effects of the cash crop component on yield, cash crop income (which constitutes the lion's share of their incomes), food consumption, and ultimately food and nutrition security. Lastly, the absence of a positive impact of the nutrition intervention on the food consumption expenditure of the nutrition only households could be explained by the fact that spending and other aspects of dietary behaviour modifications occur slowly over time and may be hindered by other factors, including the poor weather conditions mentioned above (Kelly & Barker, 2016; World Food Programme, 2018).

[6]Given that we estimated semi-logarithmic regressions with dummy regressors (treatment indicator), we calculated the percentage change of each treatment (relative the non-programme group) as: $(e^{\beta} - 1) \times 100$, where β is the estimated coefficient of each treatment. See Table A2 for the baseline means of consumption variables by treatment group. The annual average exchange rate in 2017 was US$1: SLL7,384.4.

2.4.2.5.2 The nutrition knowledge and women empowerment pathways

Next, we consider the nutrition knowledge and women empowerment pathways. The average effects on caregiver's nutrition knowledge and empowerment (in terms of control over income and confidence) are reported in Table 2.7. The results show that, compared to the control group, there is a significant improvement in nutrition knowledge across all treatment groups, with the largest increase occurring among nutrition only households, followed by combined intervention households. The results in columns 2–5 indicate that except for nutrition only women who involved in food crops farming and livestock rearing, there is no significant change in women's control over the use of income.

Concerning the programme's impact on advancing the agency of women, the results show that recipients of the nutrition intervention (either exclusively or jointly with the cash crop element) are significantly more likely to be confident in discussing issues around food and management of household resources with their spouses than non-intervention women. Though insignificant, women in cash crop only households appear to have relatively lower confidence compared to non-project women for being expressive to their husbands on matters related to the allocation of food and other household resources. This could also explain why the reported improvement in nutrition knowledge among women from exclusive cash crop households did not translate into positive changes in household and individual dietary diversity. When it comes to public speaking, the stand-alone nutrition women are the only treatment group that demonstrates a significant increase in the probability of being confident in expressing their opinion in the assembly of women or both men and women. Taken together, these results suggest that improving nutrition knowledge as well as bolstering women's confidence can empower them to influence household decisions in ways that prioritize the nutrition and general well-being of their families.

Table 2. 7: Impact pathways: nutrition knowledge and women empowerment

		Caregiver has adequate control over income from…				Caregiver is confident in voicing her opinion …		
	Caregiver's nutrition knowledge	Food crop farming	Cash crop farming	Livestock rearing	Off-farm business	Husband/ Partner	Meeting with males & females	Meeting with only women
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Average treatment effects on treated (ATET)								
Cash crop	0.18**	-0.02	0.01	0.02	0.03	-0.03	-0.04	-0.02
	(0.08)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.04)
Nutrition	0.71***	0.09***	0.05	0.10**	-0.01	0.13***	0.18***	0.15***
	(0.11)	(0.03)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
Combined	0.55***	0.03	0.03	0.03	0.04	0.08**	0.06	0.02
	(0.10)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
POM of non-treated	1.36***	0.79***	0.68***	0.65***	0.44***	0.72***	0.46***	0.63***
	(0.07)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Panel B: Average treatment effects (ATE)								
Cash crop	0.27***	-0.02	0.04	0.01	0.03	-0.03	-0.02	-0.03
	(0.08)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Nutrition	0.74***	0.07**	0.03	0.06	-0.01	0.10***	0.16***	0.12***
	(0.09)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Combined	0.55***	0.03	0.05	0.02	0.06	0.06**	0.05	0.02
	(0.08)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
POM of non-treated	1.33***	0.79***	0.66***	0.66***	0.46***	0.72***	0.46***	0.62***
	(0.06)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

Note: POM stands for the potential-outcome mean. The outcome model in column 1 were estimated using Poisson regression and those in columns 2-8 were estimated using the probit model. All estimates were conditioned on the covariates in Table 2A.1 and shared similar treatment equations using the IPWRA method. Non-treated households are the comparison group for the ATET and ATE estimates. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2.4.2.6 Robustness checks

To check the robustness of the main results (in Tables 2.3–2.5), we employed the Mundlak CRE estimator, which addresses the problem of endogeneity resulting from the selection on unobservables. The CRE method does so by including the means of the time-varying regressors as additional covariates in the regression model to allow for the time-invariant unobserved household effects to be correlated with the explanatory variables. The CRE results are reported in Tables 2A.4–2A.6 (in appendix).

The estimated impacts of the interventions on household, maternal, and child dietary outcomes are generally consistent with the respective IPWRA results. The CRE results confirm that both household, maternal, and child dietary diversity scores are significantly higher for combined intervention households relative to non-participating households. We do not find any significant impact of the nutrition intervention alone on both household and individual dietary diversity measures. The CRE results also support the previous finding that all recipients of the nutrition intervention are more likely to consume vitamin A-rich vegetables, fruits, and tubers. Lastly, they also confirm that solely promoting cash crop production may have adverse impacts on the dietary diversity of households and individuals.

2.4.2.7 Discussion

This study evaluates a unique integrated export-oriented value chain intervention to explore how to make agricultural and rural development investments nutrition-sensitive, and thus exploit their maximum contributions to improving nutrition. With interesting findings, our analyses demonstrate the differential impacts of the intervention on dietary outcomes across different treatment groups. Our results show that, in relation to non-participating households, merely providing households with support for cash crop production had negative impacts on household and individual dietary diversity. Similarly, exclusively implementing the nutrition-focused intervention had positive but no significant impact on household and maternal dietary diversity. However, delivering both interventions in conjunction significantly improved household, maternal and child dietary diversity. Most importantly, the combined intervention had positive and significant impact on micronutrient intake, relative to non-treated households. The results show that improvement in increased food consumption through market purchases (albeit, weak), nutrition knowledge (viz. increased awareness of the nutritional value of foods), and women empowerment (confidence) are potential pathways linking the combined intervention to better dietary outcomes. Overall, the results point to positive synergies when households participate in both cash crop and nutrition programmes jointly instead of uniquely.

These results suggest that, notwithstanding its attraction of higher economic returns to land and labour, singly promoting the production of non-food, export-oriented crops can considerably detract from the food security and nutritional status of smallholder households and their families. Similar findings have been previously reported in the literature. For instance, Alderman et al. (2014) found that cash cropping hurts food security among cocoa producers in Ghana, the world's second-largest producer of cocoa. Caswell et al. (2012) and de Vries et al. (2012, 2013b, 2013a) have also documented a high prevalence of food insecurity and malnutrition (partly owed to poor quality diets) in major cocoa, coffee, and tea growing areas in Africa, Asia, and Latin America, despite huge investments in these sectors. In the same vein, commercialized production of food crops as cash crops, such as rice in Uganda (Ntakyo & van den Berg, 2019), sugarcane in Mexico (Dewey, 1981), and vegetables in Guatemala (Immink & Alarcon, 1993), has been found to be undesirably associated with dietary deterioration and lower food caloric intake.

Several factors could explain this finding in the case of Sierra Leone. Intensified cash crop production may result in an increased work burden on women and take away from the time available for acquiring and preparing nutritious foods for the family. In the rural Sierra Leonean setting, women – the primary caregivers – are also involved in early crop care and post-harvest processing activities related to cocoa and cashew production (including collection, transportation, breaking, fermentation, and drying). With our data collection coinciding with harvesting months in Sierra Leone, it is plausible that women's involvement in these farming activities would likely increase their time-constraints and adversely affect nutrition-related caring practices. Indeed, SPRING's nutrition assessment for Sierra Leone reported that competing demands on women's time might also contribute to poor self and infant and young child feeding in the country (SPRING, 2015). Besides, encouraging the expansion of tree crop production may lead to the diversion of land, labour, and other productive resources away from food production, and culminate in a reduced availability of diverse nutritious foods. We found no significant change in the land area(s) under cash crops (and food crops) cultivation after one year of project implementation (because most of the project-supported activities involved gap filling and rehabilitation of old plantations). However, the data showed a dip in food consumption, largely from own production between the two waves because of poor weather conditions, which adversely affected agricultural production (WFP, 2018; WFP, 2019).

The analyses demonstrate that compared to non-intervention households, the project has significantly increased nutrition knowledge across all treatment groups, particularly among the nutrition intervention households. This result is comparable to findings from several studies that nutrition education programmes that inform households about the nutritional value of foods, as well as the importance of consuming diverse, well-balanced diets, have the potential to increase dietary diversity and avert several micronutrient deficiencies (Berti et al., 2004; Faber & Benadé, 2003; Leroy & Frongillo, 2007; World Bank, 2007). This may be due to modifications in food choices and other nutrition-related behaviours, particularly increased preferences for consumption bundles with more diverse, nutritious foods, as households become more aware of the importance of healthy eating (Rosenberg et al., 2018)

However, merely arming caregivers with information and knowledge about the nutritional importance of the foods they have and consume may not be enough to improve dietary outcomes markedly. As shown by our results, relative to non-intervention households, nutrition knowledge significantly improved among the individual intervention households with no corresponding enhancement in dietary diversity scores. The pathway analyses reveal that women's confidence – a proxy indicator of women's status or empowerment – is one of many key factors reinforcing the link between nutrition knowledge and positive nutrition outcomes. The stand-alone cash crop households, we do not find the improved nutrition knowledge translating into better household and individual dietary outcomes, possibly because they experienced no significant change in women's confidence relative to non-intervention households. However, in all nutrition intervention households, where women feel more confident, particularly about making nutritionally vital decisions with their partners, improved nutrition knowledge increased the likelihood of better dietary outcomes.

In highly patriarchal societies like Sierra Leone, where deeply entrenched socio-cultural and religious beliefs marginalize women, women tend to have low status, low self-confidence, and low self-esteem relative to men. Cultural norms preclude women from participation in decision-making processes, as well as accessing and exercising control over resources (Abdullah et al., 2016; UNICEF Sierra Leone, 2011). Intra-household distribution of meat, fish, and other nutritious foods favour men at the expense of women and children. Alaofè et al. (2017) and Smith et al. (2003) have shown that the caregiver's level of confidence is a critical factor affecting maternal and child nutritional status. For instance, women with low self-esteem and low status may have good knowledge of appropriate child feeding practices and the significance of consuming healthy diets. However, they may lack the confidence and power to influence the intra-household allocation of food and other nutrition-sensitive decisions. In a recent study, Amugsi et al. (2016) found that women's participation in decision-making concerning household purchases was significantly associated with higher dietary diversity in Ghana. These findings indicate that developmental efforts aimed at improving nutrition in Sierra Leone stand to immensely benefit from empowering women to put nutrition-related knowledge to practice.

The study has some limitations which are worth highlighting. The first one relates to the lack of randomization and the absence of pre-intervention (baseline) data. While the estimation methods employed in the study account for potential selection bias (due to non-random programme placement and self-selection of participants), the absence of baseline data weakens the evaluation design. With our first wave data collection occurring several months after the project start-up, possible initial impacts of some project interventions at the time of the first wave may have resulted in an underestimation of the average treatment effects. The second source of limitation arises from the short time horizon of the study. Agreeably, it takes time for programmes to reach full implementation at the level planned (Leroy et al., 2016). The existence of time lags imply that substantial, detectable impacts cannot be achieved within the first year of project implementation. Although this study investigated the early impacts of the project interventions, the time frame is too short to fully capture the impacts of the interventions, particularly considering the long-maturing period of the targeted tree crops. The long-term impacts, as well as their sustainability, will need to be examined in follow-up studies after sufficient time has elapsed between implementation and evaluation.

2.5 Conclusion

Fostering smallholder agriculture through cash cropping schemes has long been an integral part of agricultural interventions to boost productivity and alleviate poverty in many developing countries, with seldom explicit nutritional considerations. To accelerate progress towards ending all forms of hunger and malnutrition by 2030, there is a growing recognition and push for nutrition-enhancing agricultural investments targeted toward smallholder farmers. However, there is limited empirical evidence on whether integrating nutrition-related interventions in agricultural development project offers additional nutritional benefits, particularly in export-oriented cash crop sectors. This study bridges this knowledge gap by evaluating the nutritional impacts of an innovative nutrition-sensitive value chain intervention, uniquely designed to address food and nutrition insecurity among smallholder export cropping farmers in Sierra Leone, a country plagued with high rates of food insecurity and malnutrition. In particular, we analysed the programme impacts on household and individual dietary outcomes. Based on a quasi-experimental design involving multiple treatments and two waves of household surveys, we estimated the programme effects using inverse-probability weighted regression adjustment, a doubly robust estimator.

We find that, compared to non-intervention households, isolated promotion of cash crop production is associated with dietary deterioration at household, maternal, and child levels, whereas singly providing nutrition-related information has no significant effect on these dietary outcomes. However, combining both interventions is found to significantly improve the consumption of diverse, nutritious diets at household and individual levels, relative to no intervention. In particular, coupling a cash cropping intervention with a nutrition-related intervention is found to significantly increase the likelihoods of consuming vitamin A and iron-rich foods. We found improvements in food access (food expenditure), nutrition knowledge and women empowerment to be the potential pathways linking the combined intervention to better dietary outcomes. The results suggest that nutrition-sensitive investments in cash crop sectors promise to be an effective way to increase dietary diversity and sustainably reduce micronutrient deficiencies among nutritionally vulnerable smallholder families.

CHAPTER 3

Seasonality, market access and food security in Sierra Leone

3.1 Introduction

Achieving food security requires that people have access at all times to adequate nutritious foods to meet their dietary needs for a healthy and active life. However, not everyone in the world has stable, all-year-round access to enough safe and nutrient-rich food. Millions of people, mostly smallholder farmers in agrarian economies, are afflicted by predictable and preventable seasonal food insecurity every year, primarily because of cyclical fluctuations in food availability and access (Devereux & Longhurst, 2009; Devereux, Vaitla, & Swan, 2008). Current estimates, without accounting for the potential impacts of the COVID-19 pandemic[7], indicate that nearly 690 million people worldwide suffer some form of hunger, be it chronic or transitory (FAO et al., 2020). The burden is most substantial in Asia (381.1 million) and Africa (250.3 million) (FAO et al., 2020),, where the levels of hunger remain severe or alarming, and even deteriorating in almost all sub-regions of the latter (von Grebmer et al., 2018).

Unlike conflict, climate variability and extremes and natural catastrophes, seasonality is often neglected as a significant contributor to food insecurity and malnutrition, even though it is a common cause and its impacts are not insignificant (Devereux, et al.,, 2012; Vaitla, et al., 2009). Seasonality is characteristic of rural livelihood in developing countries, where majority of the world’s poor, food insecure and malnourished people live and depend primarily on rain-fed agriculture[8] (Devereux, et al. 2012; Khandker & Mahmud, 2012). Household income, food security and nutrition, and other welfare outcomes in these agrarian settings exhibit noticeable seasonal disparities, driven by regular patterns of the agricultural cycle. They improve markedly in immediate postharvest months when food supply and purchasing power abound, and deteriorate

[7] The COVID-19 pandemic may increase the global number of undernourished people by 83 to 132 million in 2020, depending on the extent of contraction in economic growth (with expected losses in global GDP ranging between 4.9 and 10 percentage points) (FAO et al., 2020).

[8] While rural areas remain the epicentre for poverty, food insecurity and malnutrition, the concentration of these problems is increasingly shifting to urban areas, as more and more people migrate and live under poor conditions in rapidly expanding megacities in Africa, Asia and Latin America (Fan, 2017; Ravallion, 2002).

sharply in pre-harvest months, particularly during the so-called “lean” or “hunger” season. During this lean season period, which often coincides with the rainy season in many low-income countries, food stocks from the previous harvest are depleted, markets become inaccessible, food prices rise steeply, wages plummet, and income-generating avenues become limited (Khandker & Mahmud, 2012; Vaitla et al., 2009). The hardest hit are vulnerable and poor households, who are unable to insure their consumption against fluctuations in production and income (Alderman & Paxson, 1994; Dercon, 2002; Dercon & Krishnan, 2000). In particular, these households often do not have adequate buffer food reserves, or past savings, or access to credit, remittances or social protection schemes to smooth consumption all year round (Alderman & Paxson, 1994; Gilbert et al., 2017; Khandker & Mahmud, 2012).

In the face of financial constraints, they are often coerced to sell their produce at low prices in postharvest months and purchase them back, a few months later, at higher prices during the lean season (Burke et al., 2019; Stephens & Barrett, 2011). These seasonality effects may also spread to urban areas as limited food supply (from remote, rural areas) leads to food price inflation and negative dietary and nutritional adjustments (Anderson et al., 2018; Gilbert et al., 2017). Furthermore, by compelling households to adopt negative coping strategies (such as depleting their assets or going into debt), seasonality may exacerbate their vulnerability to poverty and undermine their resilience against adverse shocks (Alderman & Paxson, 1994; Dercon, 2002). What is more debilitating is the adoption of deleterious consumption-related coping strategies to mitigate seasonal food insecurity. These may include the rationing of available food and changing the quality (diversity), quantity, and frequency of their diets (Maxwell & Caldwell, 2008). Several studies have reported significant negative effects of agricultural seasonality on poverty, food security, household and individual diets, and children’ and adults’ health and nutritional status (Abay & Hirvonen, 2017; Devereux et al., 2012; Handa & Mlay, 2006; Hillbruner & Egan, 2008; Raihan et al., 2018; Ravaoarisoa et al., 2019; Hirvonen, Taffesse, & Hassen, 2016).

Dietary changes involving the consumption of less nutritious and highly monotonous diets (e.g., largely cereal- or tuber-based) may quickly fill the stomach and dispel hunger pangs, but compromise dietary quality and increase the risk of micronutrient deficiencies (Thompson & Amoroso, 2011). Such short-term food deprivations (nutritional shocks) may have long-term consequences for individuals, especially pre-schooling children (Alderman et al., 2006). In particular, children that repeatedly experience seasonal hunger are at high risk of undernutrition, including insufficient micronutrient intake (or hidden hunger). Undernutrition, in turn, weakens their immune systems and irreversibly stunts their cognitive and physical development – with undesirable consequences of reduced productivity, educational attainment and earning potential as adults (Bhutta et al., 2013; Khandker & Mahmud, 2012).

Among several potential policy approaches to tackle seasonality and its attendant food insecurity (Khandker et al., 2012; Vaitla et al., 2009), emerging literature underscores the primacy of market access in improving dietary and nutritional outcomes, especially of poor, vulnerable and food insecure households (Headey et al., 2019; Hirvonen et al., 2017; Sibhatu & Qaim, 2017). Both rural and urban households trade in local markets either as sellers of own produce or buyers of food produced by others (or both). Conceptually, well-functioning and easily accessible markets can contribute to overall food and nutrition security by ensuring consistent availability of and economic access, through on-farm and off-farm income, to diverse nutritious foods at affordable prices. Furthermore, nearness to markets increases the time available for proper feeding and care practices; reduces food prices and transportation costs, thus increasing household's effective purchasing power and demand for diverse diets; and boosts productivity and farm diversification through improved access to productive inputs. Evidence from previous studies accentuates the importance of access to markets and commercialization for dietary quality, food security and livelihoods of rural households (Abay & Hirvonen, 2017; Handa & Mlay, 2006; Headey et al., 2019; Hirvonen et al., 2017; Koppmair et al., 2017; Ogutu et al., 2019; Sibhatu et al., 2015; Sibhatu & Qaim, 2017; Stifel & Minten, 2017; WFP, 2017; Zanello et al., 2019). In particular, these studies have largely shown that proximity to markets or increased commercialization has significant positive effects on food security and dietary diversity at household and individual levels as well as children's nutritional status.

However, there is limited evidence on the role of market access in mitigating seasonal fluctuations in food consumption and overall wellbeing. The empirical research on seasonality and market access have so far been carried out in separate silos. Only a handful of studies have attempted to unify these two strands of literature (Abay & Hirvonen, 2017; Handa & Mlay, 2006; Sibhatu & Qaim, 2017; Zanello et al., 2019). Abay and Hirvonen (2017) reported that market access improves dietary diversity but does not reduce seasonal fluctuations in Ethiopian children's anthropometrics.

For rural Ethiopian households, Sibhatu and Qaim (2017) showed that purchased foods constitutes over half of household calorie intake during the lean season. Zanello et al. (2019) found that, in Afghanistan, while cropping diversity matters for dietary diversity during the regular season, market food availability improves dietary diversity in the lean season. Lastly, Handa and Mlay (2006) demonstrated that proximity to road enables Mozambican households to smooth their consumption over the agricultural cycle. Apart from these few studies that looked at the interaction between seasonality and market access and their impact on food and nutrition security, we are not aware of any other study that has examined these interactions in the post-war context with prevailing limitations in rural infrastructure. In particular, to what extent the effect of markets on dietary diversity and food security varies at different times of the year is not well understood. A possible reason is that most of the studies that exists are based on data collected at one point time during the year. Obtaining a better understanding of the seasonal implications of markets for nutrition will help improve knowledge and policy.

This chapter addresses this research gap with data from Sierra Leone, a post-conflict West African country, characterized by pervasive agricultural seasonality, malnutrition, and food insecurity and major constraints on market access. The study combines nationally representative data from the 2011 and 2018 Sierra Leone Integrated Household Survey (SLIHS) to study the protective effects of closeness to food markets against seasonal food deprivation.

The remainder of this chapter is organised as follows. Section 3.2 presents a conceptual framework that links seasonality, markets and food security. Section 3.3 provides a contextual overview of seasonality and food security in Sierra Leone. Section 3.4 discusses the data and methods, and the results are presented and discussed in Section 3.5. Section 3.6 concludes the chapter with key findings and policy implications.

3.2 Conceptual framework

In agricultural household models, the separability assumption of interlinked household decisions on production, consumption, labor allocation, and leisure is relaxed. Therefore, households are assumed to maximize their expected utility of consumption of on-farm food produce and other consumption goods that must be bought in the marketplace, given these interlinkages and the associated constraints. In a dynamic setting with seasonal agricultural production, the household must decide how to meet its consumption needs both in each year's harvest as well as lean seasons (Saha, 1994; Stephens & Barrett, 2011). For risk-averse households, maximizing inter-temporal utility leads to precautionary savings equating expected marginal utilities across seasons. Thus, all things being equal, households will prefer smoothing consumption over time, (Stephens & Barret, 2011; Dercon & Krishnan, 2000). When households have access to well-functioning markets, these preferences will lead to a stable optimal consumption path. However, if markets are incomplete or non-existent, and credit constraints are binding, consumption will be subjected to fluctuations in income or purchasing power, due to, for instance, seasonality- or shock-induced variabilities in prices and wages.

In the absence of complete formal insurance and financial markets and effective social protection, poor households and individuals undertake a wide range of risk management and coping actions to limit the variability of income and consumption (Alderman & Paxson, 1994). The risk management strategies are directed at income smoothing, for instance, through diversification (livelihoods, crops, or fields) or attempting to earn extra income (by temporarily migrating, or taking additional jobs). The goal of risk coping strategies is to smooth consumption over time. These include self-insurance (through the accumulation or depletion of savings, assets, or buffer stocks), borrowing, and informal risk-sharing arrangements that involve mutual support between family networks, groups, or communities (Dercon & Krishnan, 2000; Dercon, 2002; Alderman & Paxson, 1994).

When these mechanisms fail, consumption smoothing does not happen, as households are unable to fully insure consumption against fluctuations in income or purchasing power. Seasonal food insecurity is a manifestation of the failure to achieve year-round smoothing of food consumption. This may be due to agricultural seasonality and the associated delay between the planting and harvesting of staple food crops, which have different seasonal production cycles (Khandker et al., 2012). Consequently, the months leading up to harvest are often characterized by depletion of food stocks (from own-production), high food prices, limited employment avenues for agricultural workers, and loss of livelihoods, income and other entitlements to foods (Devereux et al., 2012; Khandker & Samad, 2016). With production patterns being strongly determined by agroclimatic conditions and the level of agricultural technology applied, seasonality and its resultant seasonal food stress will be more intense in areas with rain-fed, monocrop agriculture, than in more favorable locations that permit multiple cropping, and farm diversification, and are less reliant on erratic rainfall for irrigation (Abay & Hirvonen, 2017).

Beyond agricultural seasonality, and the absence of self-insurance, seasonal food deprivation is also related to market inefficiencies arising from poor market and infrastructural conditions which prevent certain households from accessing food even in times of abundant food availability (Devereux et al., 2012; Khandker et al., 2012; Khandker & Mahmud, 2012). Most agricultural households in the developing world are located in geographically isolated areas with weak connectivity to formal market institutions, poor-quality transport, and other market-related infrastructure (Fafchamps & Hill, 2005; Stifel & Minten, 2017). These poor market conditions, coupled with isolation, increase transaction costs (e.g., transport, time, and search costs), and hurt households in a number of ways. For instance, the associated high transaction costs can increase output and input prices; lower agricultural production due to limited access to modern productivity-enhancing inputs and technologies and lower the accessibility, availability and diversity of foods on local markets, particularly in remote locations (Dorosh et al., 2003; Renkow et al., 2004; Stifel & Minten, 2017)

Figure 3.1 depicts the conceptual interlinkages among seasonality, markets and household food security and nutrition. It delineates the pathways through which markets can improve household consumption smoothing or household food security and nutrition across seasons. The framework illustrates that households live within and are influenced by socio-economic, political, institutional, natural and ecological contexts. Given the environment within which people live and operate, households allocate their resources to diverse livelihood options to obtain the highest expected returns and meet their welfare needs (considered here to be food security and nutrition).

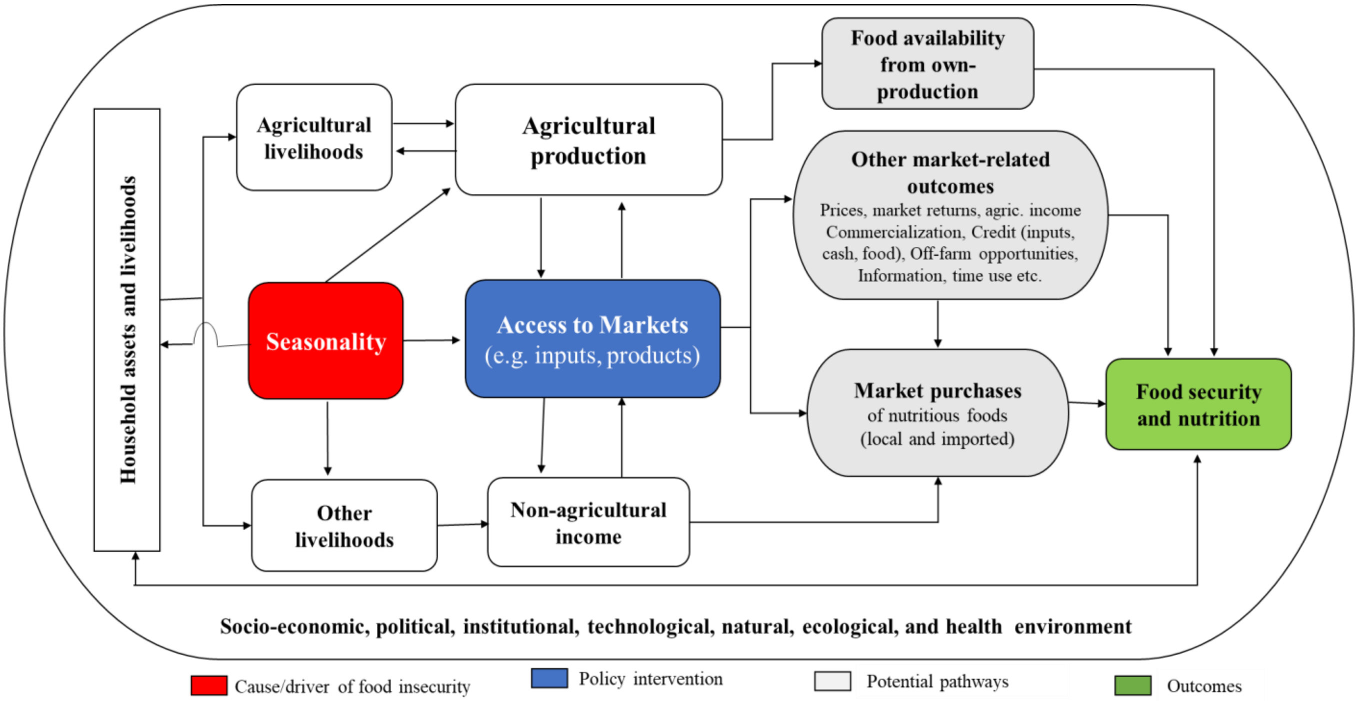


Figure 3. 1: Conceptual framework linking seasonality, market access and food security

In general, as illustrated in the figure, households tend to engage in agriculture-based livelihoods (as farmers or agricultural wage earners), and/or other livelihoods (non-agricultural economic activities). Households involved in agricultural production (usually rural dwellers) can access diverse, nutritious foods directly from own production and/or, indirectly, through market purchases (with income from the sale of farm produce in the market). Subsistence production is less important as a source of nutritious foods for non-agricultural households, who reside typically in urban areas. They essentially depend on markets to access (local and imported) foods with income from their off-farm ventures. The relative importance of own production and market purchases for household food security and nutrition depends on several factors, including the seasonal pattern of production, access to markets, and households' net trading position.

Seasonality affects food consumption and food security through its influence on both agricultural and non-agricultural livelihoods. Seasonality in agricultural production predominantly arises from the usual cycles of agricultural activities (e.g. planting, growing, and harvesting seasons), which are strongly influenced by local agronomic and weather conditions. Low adoption of improved irrigation technologies means that agricultural production in most developing countries is mainly rain-fed, and hence, markedly affected by climate change and its related variations in rainfall patterns. Some livelihoods in the non-farm sector may also be affected by agricultural seasonality, due to their strong backward/forward linkages with the agricultural sector. These includes employments in the retail food sector, agro-processing industries, and agro-input businesses. Some non-agricultural livelihoods, such as those in the construction, manufacturing, tourism and fashion industries, may also be seasonal due to weather vagaries, or season-related changes in tastes and preferences.

Markets – physical or virtual arrangements established to facilitate the exchange of goods and services among buyers and sellers – play important roles in ensuring household food security. Access to well-functioning (inputs, output, and financial) markets enables agricultural households to acquire the inputs they need to boost productivity; and to sell more produce at higher prices (relative to selling at the farm gate). This in turn incentivizes farmers to invest in their own enterprises and increase the quantity, quality and diversity of the goods they produce; thereby increasing the supply or availability of nutritious foods in the marketplace. Greater market access – enabled by effective policies that lower transaction costs through improved connectivity, better transport infrastructure, and access to efficient logistics services – also facilitates the movement of locally produced or imported foods from surplus areas to consumers in food deficit areas to bridge short-term food shortages. This could enhance food supply in the market throughout the year and mitigate seasonality-induced fluctuations in food availability. Besides the quality of (physical) transport and market infrastructure, the availability of markets in close proximity to households is another important aspect of market access that contributes to the level of transaction costs. Closeness to markets encourages market participation for both producers and consumers by lowering search/information, transportation, time and other transactions costs. This in turn fosters food security by improving food availability and facilitating physical and economic access to healthy foods across seasons.

In highly competitive settings, low transaction costs foster market efficiency by ensuring that price signals convey accurate and reliable market information, prices are less volatile, gains from trade are realized, and trade flows are unhindered. However, high transaction costs incurred in accessing markets sharply impede market integration, particularly by reducing the degree to which markets are linked by arbitrage or price information are transmitted from one market to another. Such prohibitive transaction costs, for instance due to isolation, and lack of transport and communication infrastructure, result in incomplete markets, as is the case of Sierra Leone where over 80 percent of households live in communities with no functional market (WFP, 2015). In this regard, market integration breaks because the costs (disutility) of transaction through market exchange may be too high relative to price differentials (utility gains) such that it may not be economically feasible for some households to participate in markets (Abdulai, 2000; Moser et al., 2009). For instance, de Janvry et al. (1991) have shown that remoteness and its resultant high transport costs may drive potential sellers out of the market, thereby confining them to subsistence farming.

Furthermore, transaction costs between markets/regions as well as their degree of integration may vary across the agricultural season. This may affect the speed with which price information (or demand and supply shocks) are transmitted between markets/regions across seasons, resulting in different seasonal price transmission regimes (Cramon-Taubadel, 2017; Moser et al., 2009). For instance, transport costs are lower in the dry season (when roads are passable) than in the rainy season (when they are not). This may cause the speed of price transmission to vary accordingly, with the level of integration being higher in the dry season than in the rainy season (Cramon-Taubadel, 2017).

All in all, high transaction costs inhibit market integration, resulting in incomplete price transmission and reduction of information available to economic actors, which in turn lead to decisions that contribute to inefficient outcomes. These may include the adoption of low-yielding food crops instead of high-value cash crops, limited access to and use of productivity-enhancing technologies, huge postharvest losses at the farmgate due to poor market access, and low dietary diversity and poor nutrition (due to low diversity in own production). Food prices fluctuate sharply, in response to variations in food supply and demand, from one season to another. In general, diverse, nutritious foods often abound, at low prices, during postharvest periods[9]. Food prices start to rise gradually as the supply glut dwindles and demand for food grows, especially during the

[9] Beyond excess supply, the low sales price of staple food during harvest and immediate postharvest periods can be explained by temporary liquidity constraints, high storage and other transaction costs, impatience, and high aversion about future price risks (Burke et al., 2019; Stephens & Barret, 2011).

growing season when dietary energy requirements for pre-planting activities are high. Food prices peak at the height of the lean season – in the months leading up to the next harvest, with grain prices in major markets increasing by 25-40% between the harvest and lean seasons, and typically more than 50% in more remote markets (Burke et al., 2019; Gilbert et al., 2017).

However, as food prices affect the (real) incomes of households, the direction of the change in real incomes, and related effects on food security, depends on a household's trade position: net sellers of food benefit from price increases, while net buyers would experience declining real incomes in the short run. Low food prices do not only make nutritious foods relatively cheaper on the market, but also improve the real income or purchasing power of buyers. Hence, given better access to markets (with low transaction costs), both the substitution and income effects of lower food prices ensure that net food buyers have improved access to diverse foods during the postharvest season (Aksoy & Isik-Dikmelik, 2008; Kalkuhl et al., 2016; Matz et al., 2015). Farm households, especially the net sellers need access to markets to sell their produce. Improved market access lowers the inputs costs, transport costs and overall transaction costs, and raises the price of output and incomes from agricultural production. With farm incomes being largely seasonal – rising during the harvest and postharvest seasons along with increased food availability from own production – net-selling households will also experience similar improvements in food security and nutrition. Thus, all things being equal, household food security and nutrition outcomes can be expected to improve during the harvest/postharvest season.

Household consumption (and food security) in the lean season is limited by the household capacity to keep sufficient stocks to satisfy consumption requirements, as well as its physical and economic access to food in the marketplace (Burke et al., 2019; Khandker & Mahmud, 2012; Pitt & Khandker, 2002). For most poor households, the lean season is characterized by high food prices, depletion of food stocks, savings, and assets, limited off-farm income-generating opportunities, and heavy rainfalls, among others (Devereux et al., 2012; Gilbert et al., 2017; Vaitla et al., 2009). These seasonality-induced adversities do not augur well for the food security and overall well-being of the poor and net food buyers, who mostly rely on purchased foods to meet their dietary needs. Not only is access to food physically inhibited by heavy downpours and the resultant poor transport conditions, but also economically through diminished purchasing power. Net food sellers may benefit from inter-temporal price arbitrage if they stored output from the previous harvest and sell them at relatively higher prices in the lean season (Burke et al., 2019; Stephens & Barrett, 2011). However, with a significant number of households in low-income countries being net food buyers (Aksoy & Isik-Dikmelik, 2008), household food security may deteriorate during the lean season, all other things being equal.

Improving access to markets can contribute to food consumption smoothing by enhancing physical and economic access to food, as well as the availability of foods in the market across seasons. This may occur through several mechanisms. First, better access to markets lowers transaction costs, and facilitate market participation (or commercialization), as well as the movement of fresh, healthy foods from local and international markets to food deficit areas. Fafchamps and Hill (2005) have shown that the likelihood of selling to the market increases with proximity to the market, where net sellers can receive a higher price relative to selling at the farmgate. Higher market price for net food sellers, in turn, can boost the net returns to agricultural production (farmers' income). On the other hand, for net food buying households, the lower transaction costs associated with better market access increase both the variety of foods available in local markets and their ability to afford (access) them to bridge transitory shortfalls in food supply from own production (Zannello et al., 2017; Stifel & Minten, 2017; Sibhatu & Qaim, 2017).

Second, off-farm avenues are scarcer in more remote areas. However, improved market access increases opportunities for seasonal migration and (temporary) off-farm income-generating activities, which may enhance the ability of households to access healthy foods at all times (Handa & Mlay, 2006; Jacoby & Minten, 2009).

Last but not least, access to (product) markets may also improve access to credit (in the form of cash, inputs, or food), thereby enabling households to smooth consumption across seasons (Schrieder & Heidhues, 1995; Zeller et al., 1997).

3.3 Seasonality and food security in Sierra Leone

Located in Western Africa, Sierra Leone is inhabited by approximately 7 million people. Guinea borders it to the north-east, Liberia to the south-east, and the Atlantic Ocean to the south-west (Taqi et al., 2017). The country has a tropical – hot and humid – climate with two distinct seasons: a rainy season from May to October and a dry season from November to April (Amadu et al., 2017). The average annual rainfall is around 3000 mm, with July and August being the dampest months (450-540 mm). Monthly temperature ranges from 25 to 34 ℃ and averages around 26 ℃. In December and January, when the cold, dry, and dusty Harmattan wind blows from the Sahara, the temperature could drop to about 16 ℃ at night (Dossou-Yovo et al., 2017; World Bank Climate Change Knowledge Portal, 2019). Figure A1 in the appendix shows the long-term average rainfall and temperature patterns that characterize the different seasons in Sierra Leone.

The country is rich in natural resources, with significant reserves of diamond, iron ore, gold, and bauxite, among others. 53% of its land is agricultural. However, a cursory look at the country's economic, social, and nutritional indicators discloses that this natural resource wealth has not bettered the lots of most Sierra Leoneans. The last four decades have seen an interaction of several factors hampering the country's economic development, thereby leaving it among the poorest economies in the world. Notable among these factors are the vicious civil war, exogenous shocks (e.g., the Ebola epidemic, mudslides, and the collapse of commodity prices), and entrenched structural and institutional constraints.

As a low-income country, it has an income per capita of $474 and ranks 184th out of 189 countries in terms of human development (UNDP, 2016). In 2017, almost two-thirds of its populace were identified to be poor in multiple dimensions, with the incidence of poverty more pronounced in rural areas (86.3%) than urban areas (37.6%) (Statistics Sierra Leone, 2019). Despite making progress over the years, the food insecurity situation in the country remains dire and alarming. Almost half (49.8%) of its households consume insufficient nutritious food to maintain a healthy and active life (World Food Programme, 2015). The precarious state of food security in the country is manifested in high rates of chronic malnutrition or stunting (affecting over 30% of under-five children (Ministry of Health and Sanitation & Action Against Hunger, 2017) and under-five mortality (94 deaths per 1,000 per live births (Statistics Sierra Leone & UNICEF Sierra Leone, 2017). This is also seen in the poor performance on the Global Hunger Index, with the country ranking 114th out of 119 countries (von Grebmer et al., 2018).

3.3.1 Seasonality of agriculture

Agriculture is the mainstay of Sierra Leone's economy, accounting for two-thirds of employment and gross domestic output (GDP) (Gboku et al., 2017). The country's leading food crops are rice, cassava, maize, millet, sweet potato, and groundnut. These are mainly cultivated by smallholder farmers manning 0.5-2 hectares of farmland (Amadu et al., 2017). Approximately 85% of farmers cultivate rice, the most important staple food crop, consumed daily throughout the country (Ministry of Agriculture, Forestry & Ministry of Health and Sanitation, 2016). The next most significant food crop, cultivated by 77.2% of rural households, is cassava. Cassava and the other minor staples are widely and frequently consumed, particularly to meet household energy needs when rice is scarce (World Food Programme, 2011). Dark green leafy vegetables like cassava leaves and potato leaves are key ingredients in household diets. Mapped out in Figure 3.2 is the seasonal calendar in a typical year.

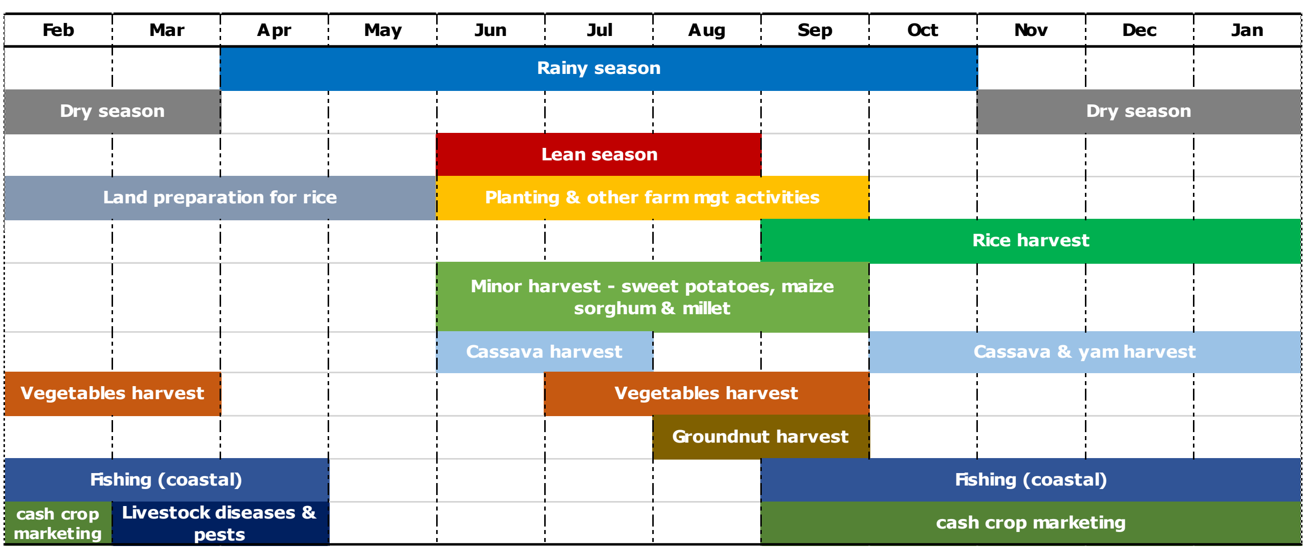


Figure 3. 2: Seasonal calendar in a typical year in Sierra Leone
Source: Based on Pasqualino et al. (2016) & *FEWS NET* (2016).

Given that Sierra Leone's farming system is mainly rain-fed, land preparation and weeding activities commence before the onset of the rains. Planting activities occur predominantly in the rainy season between April and October. Rice is traditionally grown in inland valley swamps (IVS) or on upland farms. In the uplands, rice is either mono-cropped or inter-cropped with cassava, maize, groundnuts, sweet potatoes, okra, tomatoes, beans, and other food crops, using slash-and-burn shifting cultivation. Vegetables are often cultivated in backyard gardens, on the upland farm, or the perimeters of swamp farms (Binns & Bateman, 2017). As shown in Figure 3.3, harvesting of rice usually takes place toward the end of the lean season from September to February, with a minor harvest of sweet potatoes, maize, and sorghum/millet occurring between June and August. Cassava is mostly harvested between March and August (Figure 3.3). The timing of its harvest ensures 'food security' in terms of food availability during periods when the most preferred staple food crop – rice – is in short supply or too expensive to afford. Non-food cash crops (e.g., cocoa, coffee and cashew) are typically harvested and marketed at the end of the rains from November to March.

In many developing countries, it is typical that a significant share of food available for household consumption comes from subsistence production[10]. Most of the world's poor, food insecure and malnourished are smallholder farmers. They grow staple food crops for own-consumption and local markets while sourcing more nutrient-dense foods from the market. In Sierra Leone, over 60% of households consume from their production (Statistics Sierra Leone, 2014). This suggests that subsistence farming constitutes an essential source of food for many households in the country. As a result, seasonal variations can have significant effects on household food availability, consumption, and, ultimately, nutritional status.

[10] For instance, Sibhatu and Qaim (2017) found that own production provides 58 percent of caloric intake of rural households in Ethiopia, while purchased foods accounted the remaining 42 percent.

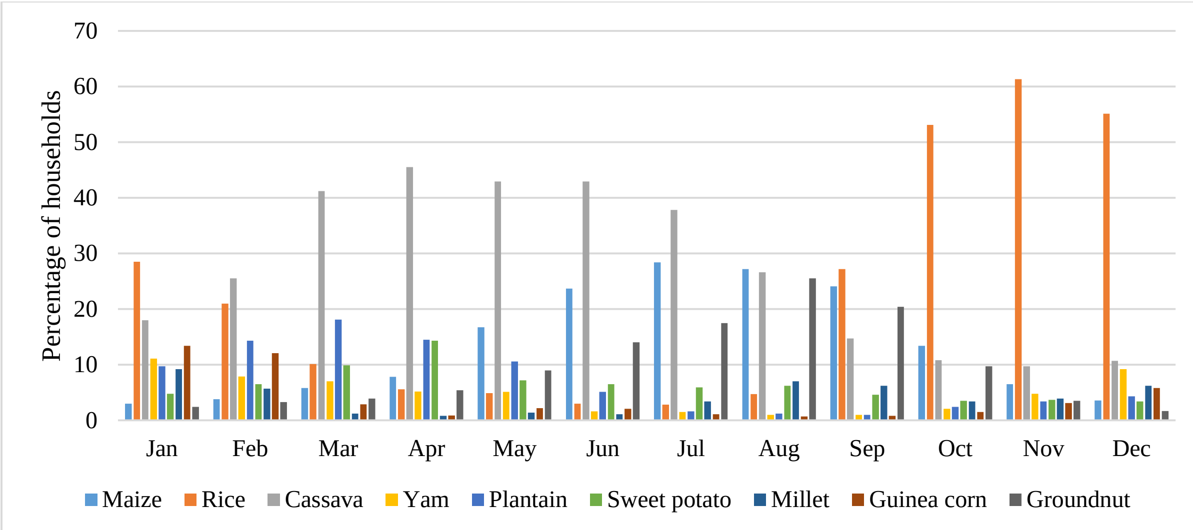


Figure 3. 3: Months crops were mainly harvested by households.
Source: Own construct based on SLIHS 2011/2012

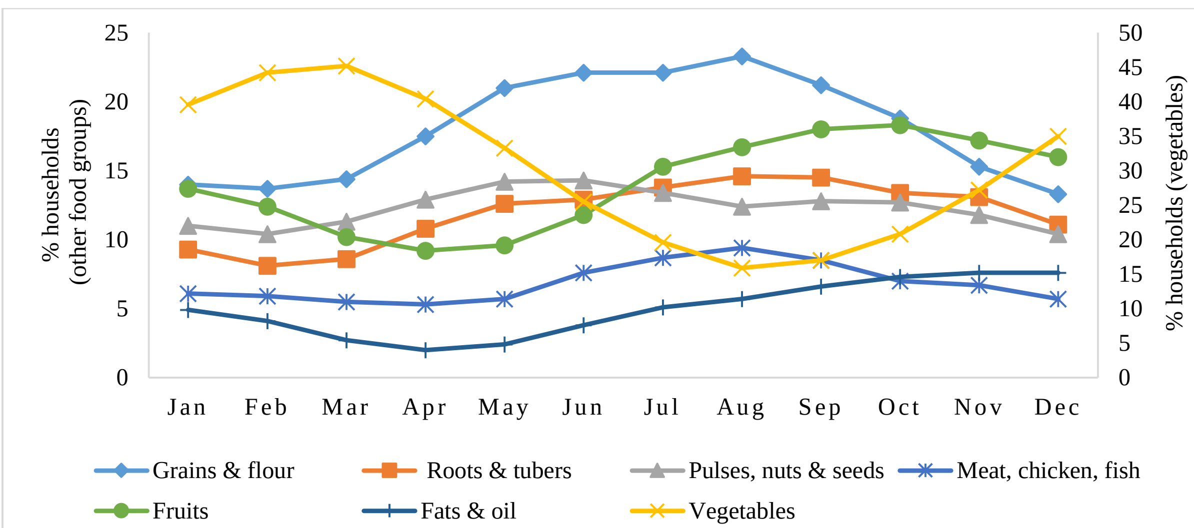


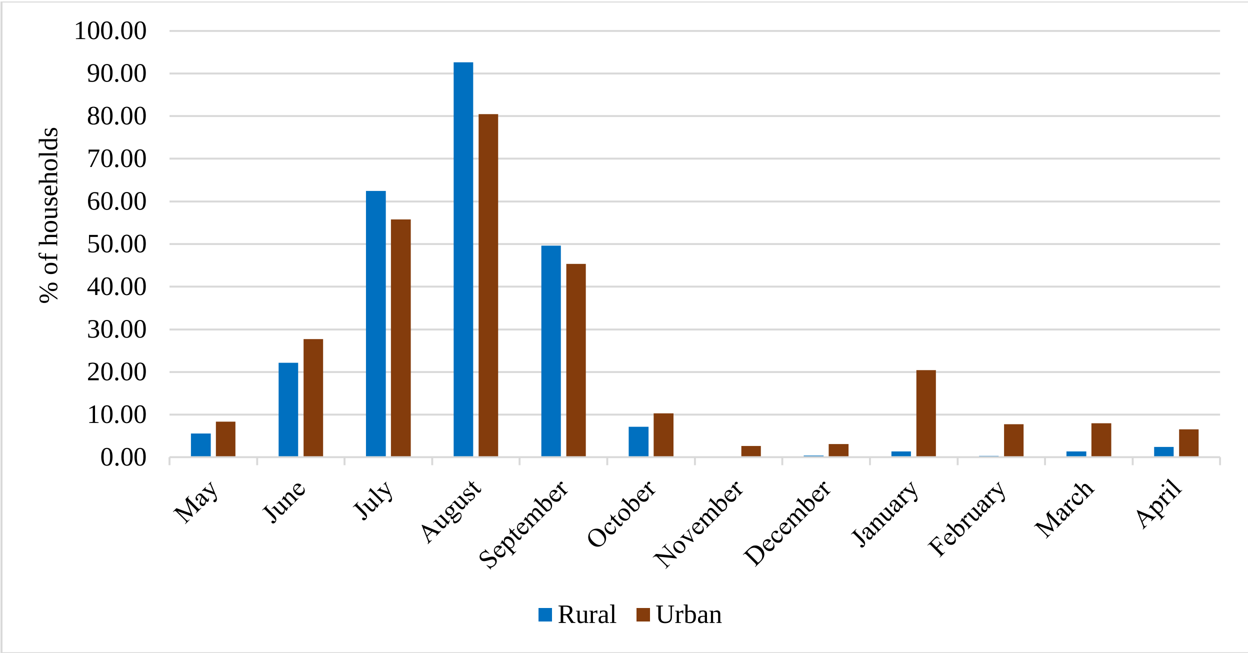
Figure 3. 4: Percentage of households not having enough of its own produced food to eat in the last 12 months
Source: Own construct based on SLIHS 2011/2012

Figure 3.4 illustrates seasonal trends in the share of Sierra Leonean households reporting the inadequacy of different food groups from own production. What is most apparent is that, except for vegetables, a shortage of all food groups is more acute in the lean season (June–August). The share of household reporting self-insufficiency is lowest for fats and oil, followed by meat, poultry, and fish. There is seasonal variation in the availability of grains and flour (cereals), vegetables, and fruits from own production. The share of households lacking sufficient grains and flour (mainly rice) from subsistence production rises in pre-harvest months (February–August) and peaks at the climax of the lean season. It then declines steadily during September–January, as the harvest brings in more rice at lower prices.

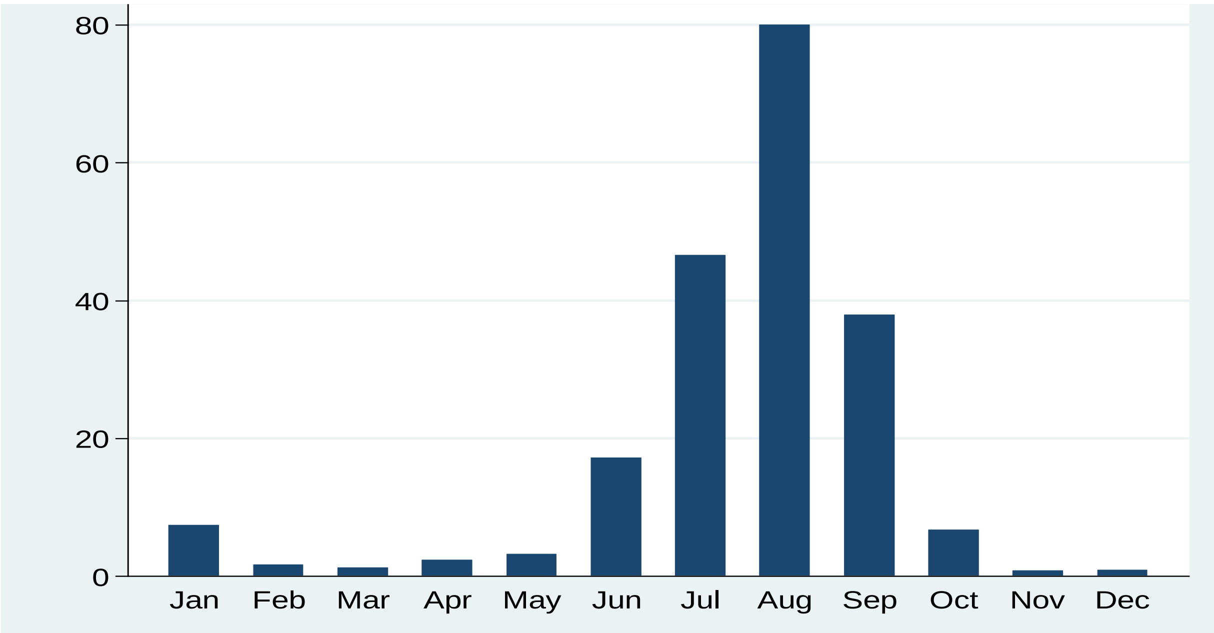
The availability of vegetables and fruits from own farms exhibits counter-cyclical patterns, even though the share of households not having enough vegetables is always larger than that of fruits. While the latter declines during March-August (implying increasing availability), the former rises during April–October (reflecting dwindling availability from own farms). The reverse is also true: in the seasons when fruits are more available, vegetables are in limited supply. These counter-cyclical patterns are driven by the seasonality of production and availability. Given that these food groups are dense in micronutrients, and their intake is most likely to be reduced in the face of hunger, resource constraints, and adversities, such seasonal fluctuations may lead to an increased burden of micronutrient deficiencies, particularly among nutritionally vulnerable groups like children and women.

3.3.2 Seasonality of food security

The seasonality of food security is quite evident in Sierra Leone. The food security situation varies in parallel with the agricultural production cycle, as most people derive their livelihoods from agriculture. As Binns and Bateman (2017) observed, there is a long-standing, regular pattern of cyclical food insecurity among many households. The seasonality and persistence of food insecurity in Sierra Leone are illustrated in the graphs in Figure 3.5, which depicts the months of inadequate household food provisioning (MIHFP) between 2005/2006 and 2017/2018. MIHFP captures months (during the past 12 months), identified by households, during which they did not have access to sufficient food to meet their household needs (Bilinsky & Swindale, 2010). As a food insecurity indicator, the MIHFP enables stakeholders to identify months in which there is limited access to food irrespective of the source of the food (i.e., subsistence, markets, barter, or food assistance).



Panel A: May 2005 – April 2006. *Source*: World Food Programme (2011)



Panel B: January – December 2017 (rural households in the Eastern & Northern Provinces).
Source: Own construct based on ZEF/WHH survey (2017/2018)

Figure 3. 5: Months of inadequate household food provisioning in Sierra Leone

As shown in panel A of Figure 3.5, households, in both rural and urban areas, are most vulnerable to hunger during the lean season (June – September), when there is increased demand for labour for agricultural activities, food stocks are lowest, commerce slumps and rainfall is torrential. It is also the time of the year when there is a high prevalence of sickness (mainly malaria and diarrheal diseases), malnutrition, indebtedness, distress, destitution, and exploitation (Devereux & Longhurst, 2009). Panel B of Figure 3.5 illustrates that this pattern persists in rural areas over time.

The month of August is the peak of the often-called 'hunger gap,' during which the percentage of households reporting inadequate household food provisioning is highest. However, this proportion plummets sharply in the subsequent months, mainly due to increased food availability from the harvest of food crops. The percentage of households facing hunger as a result of inadequate food access increases temporarily in January. Plausibly, this may be the lag effect of excess spending during the end of year celebrations, and diminished purchasing power.

In the absence of adequate safety nets and well-functioning financial markets, resource-poor households and countries lack the capacity to prepare, cope with, or recover from shocks, including recurrent seasonal shortfalls in food supply and access (Alderman & Paxson, 1994; Dercon, 2002). To cope with hunger and alleviate the impacts of shocks, they are left with no option but to adopt negative (short-term) coping strategies, which may undermine their resilience in the long-term. In Sierra Leone, WFP (2011) found reliance on less preferred, less expensive food, and limiting meal size portions as well as the number of meals per day as the most common coping strategies used by households in response to shocks (including seasonal hunger). When local rice is in short supply, especially in the lean season, most households switch to other available crops such as cassava, maize, wild foods, and sometimes imported rice to mitigate hunger (Binns & Bateman, 2017). The most common non-food coping mechanisms, some of which may be irreversible, include decumulation of savings, sale of household assets (including productive assets), borrowing (money and food), and cutting back expenditure on health and education (WFP, 2015).

3.3.3 Seasonality of food consumption

Food is a basic need and, therefore, a high priority of every household (especially the poor) is to achieve food security. That is, to secure enough food to ensure adequate dietary intake of all members at all times. This makes stability – of food availability, accessibility, and utilization – both an important pillar and a necessary condition for food security. However, the food consumption and expenditure patterns of most households fluctuate throughout the year, with some households being chronically or transitorily food insecure within the year. In Sierra Leone and other agrarian settings, such vagaries in household food security, to a large extent, mirror intra-annual fluctuations in food availability, prices, and entitlements to food. Figure 3.5 illustrates the seasonal pattern of consumption of major staple crops in Sierra Leone. Most households consume rice throughout the year. That a high percentage of households consume rice all year round, even in the months of acute shortage (from own production), implies high dependence on markets for its procurement (See also Figure 3A.2 in appendix II). The other starchy staples consumed throughout the year are cassava and maize. As substitutes to rice, they are more frequently consumed when there is limited availability of or access to rice. Consumption of other cereals, roots, and tubers (e.g., yam, plantain, sweet potato, millet, and guinea corn) is less frequent and variable within the year. Groundnut is the most important oilseed legume in Sierra Leone. It is frequently included in household diets, and its consumption does not vary significantly throughout the year.

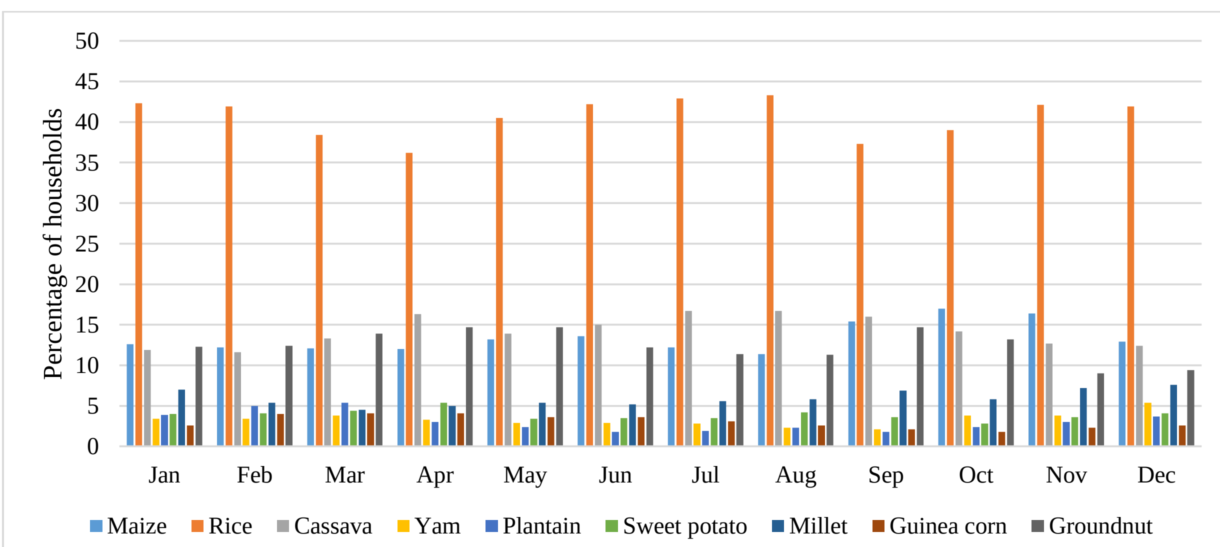


Figure 3. 6: Months crops were mainly consumed by households.
Source: Own construct based on SLIHS 2011/2012

Table 3. 1: Share of food groups in the total food budget, by area, season and expenditure quartile

	Locality (%)				Season/quarter of the year (%)					Expenditure Quartile (%)				
	Rural	Urban	Total	*t*-test	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	*F*-test	1	2	3	4	*F*-test
Panel A: SLISH 2011														
Food share	68.2	52.7	62.7	15.5***	58.5	65	64.4	62.8	49.97***	68.1	66.8	63.1	52.6	340.73***
Cereals	41.1	31.9	37.8	9.3***	33.7	41	39.8	36.3	82.02***	41.9	41.3	37.9	30.1	248.15***
Rice	38.8	27.4	34.7	11.4***	30.8	38.4	36.1	33.4	67.47***	40	39.2	34.8	24.9	355.46***
Roots, tubers	4.8	3.4	4.3	1.3***	4.7	4.1	4.8	3.4	15.59***	3.6	3.9	4.6	5.1	24.25***
Meats	1.3	2.3	1.6	-0.9***	2.1	1.4	1.4	1.4	12.12***	1.0	1.0	1.5	3	119.38***
Fish	14.2	14.4	14.3	-0.2	13.7	13.6	13.9	16.2	31.77***	14.5	14	14.2	14.3	0.66
Dairy	0.3	1.7	0.8	-1.4***	1.1	0.7	0.7	0.6	15.86***	0.2	0.4	0.7	1.9	204.49***
Oil & fats	13.7	13.5	13.6	0.2	14.2	12.9	13.2	14.3	15.87***	14.5	13.9	13.7	12.4	25.57***
Fruits	1.2	1.2	1.2	0.0	1.4	1.6	0.8	1	23.22***	0.8	1.1	1.1	1.9	39.25***
Vegetables	9.8	11.7	10.5	-1.9***	11.3	9.6	9.8	11.3	40.67***	9.8	10.1	10.8	11.2	17.03***
Pulses (beans)	5.6	6.3	5.9	-0.6***	6.3	5.7	5.8	5.6	6.34***	5	5.8	6.3	6.3	15.52***
Condiments	0.8	1.9	1.2	-1.1***	1.5	1.0	1.3	1.0	17.69***	0.8	0.9	1.3	2	117.11***
Beverages	1.1	4.5	2.3	-2.3***	3	1.9	2.2	2.2	11.72***	1.1	1.3	2.1	4.8	206.83***
Panel B: SLISH 2018														
Food share	47.1	44.1	45.6	3.1***	44.6	49.1	47.4	45.6	75.11***	50.4	48.4	47.4	42.7	61.33***
Cereals	27.1	22.2	24.7	4.9***	24.7	25.6	25.1	24.7	18.74***	31.2	29.5	26.6	20.7	380.31***
Rice	24	16.7	20.4	7.3***	20.6	20.9	20.9	20.4	10.40***	29.2	26.6	22.8	15.4	620.07***
Roots, tubers	7.5	3.3	5.4	4.2***	4.6	4.5	5.3	5.4	52.82***	7	6.5	6.3	4.2	58.054***
Meats	1.3	1.9	1.6	-0.7***	1.3	1.8	1.6	1.6	4.71***	0.7	1	1.3	2.2	49.20***
Fish	13.5	14.9	14.2	-1.5***	14.5	13.9	14.2	14.2	2.02	12.6	13	14.2	14.8	22.36***
Dairy	0.4	2.4	1.4	-2.0***	1.5	1.3	1.2	1.4	14.10***	0.1	0.3	0.7	2.5	344.30***
Oil & fats	11.4	10.9	11.2	0.6***	10.7	11.7	11.4	11.2	13.14***	12.2	12	11.9	10.2	71.78***
Fruits	3.4	2.1	2.8	1.3***	4.8	1.4	2.4	2.8	232.57***	2	2.8	3	2.7	5.76***

Vegetables	9	9	9	-0.1	8.7	9.2	9.4	9	14.88***	9.5	9.2	9.3	8.7	10.35***
Pulses (beans)	4.3	4	4.2	0.3**	3.8	4.5	3.9	4.2	21.34***	3.7	4.4	4.4	4	9.74***
Condiments	1	1.9	1.4	-0.9***	1.6	1.3	1.2	1.4	28.75***	0.4	0.8	1.2	1.9	167.32***
Beverages	0.6	3.6	2.1	-3.0***	2.3	1.9	2	2.1	2.54*	0.1	0.4	1	3.9	326.13***

Notes: The locational and quartile proportions are based on annualized expenditure values. The asterisks ***, ** and * respectively denote 1%, 5% and 10% levels of statistical significance of *t* and *F* tests for differences in means.

Source: Own construct based on 2011 & 2018 Sierra Leone Integrated Household Survey (SLIHS).

Table 3.1 also reports the food shares by locality, seasons (quarter), and expenditure quartile in 2011 and 2018. It is also demonstrates the presence of statistically significant differences in food budget shares across area of residence, season and consumption quartile. In 2011, food expenditure accounted for about 63% of total household consumption expenditure (income). This indicates that household budgets are food-intensive. Albeit high, the food share declined substantially to 45.6% in 2018, possibly due to increased affluence over time. In line with Engels Law, rural households – who are relatively more impoverished – allocated a larger proportion of their total consumption expenditure on food than urban households in both survey periods. That is, the relative importance of food consumption declines as income rises. This is further depicted by the inverse association between food share and income level, captured by the expenditure quartiles in both periods.

Within the food budget, cereals accounted for the largest share, although it declined significantly from 37.8 in 2011 to 24.7% in 2018. Poorer households (lower expenditure quartiles) allotted more income to their consumption than more affluent households. As typical of the Sierra Leonean diet, rice is the most important item on the food budget, especially for relatively poor households. With food shares over one-third of household income, cereals (starchy staples) predominate household budgets, which may lead to the consumption of less nutritious and less diversified diets. Households also tend to spend more on fish, oil and fats, vegetables, and pulses (beans). Fish is the most important source of protein, consumed by the poor and rich alike. However, its relative importance in food consumption declines with income as households shift toward meats. Root and tubers, dairy, beverages, condiments, and meat accounted for minor shares of the food budget in both periods. However, their importance appears to increase over time. Consumption of micronutrient-dense food groups, notably, fruits, vegetables, meats, and pulses, seems to increase with affluence. This suggests that these food groups are income-sensitive.

With respect to seasonality, food shares were higher in the second and third quarters (pre-harvest months) than in the first and fourth quarters of the year. In comparison with postharvest months (October–December and January–March), the average household tends to spend more on cereals and cut back expenditure on oil and fats, fruits, and vegetables during the thin months (July–September). The behaviour of these food shares across seasons suggests that households trade-off dietary quality for dietary quantity as they shift away from micronutrient-rich foods such as fruits and vegetables toward calorie-dense staple foods, in response to hunger, rising food prices and resource-constraints (D'Souza & Jolliffe, 2012).

3.3.4 Infrastructure and access to markets

Infrastructure in Sierra Leone suffered severely from the protracted armed conflict. Despite investing $134 million annually, since the war ended, to rebuild and modernize infrastructure (Pushak & Foster, 2011), the nation's stock of infrastructure remains inadequate and poorly maintained. In particular, Sierra Leone's progress towards recovery and sustained economic development is severely hindered by poor-quality roads, weak transport infrastructure, and poor road connectivity (see Figure 3A.3 in appendix) (FEWS NET, 2017; Pushak & Foster, 2011).

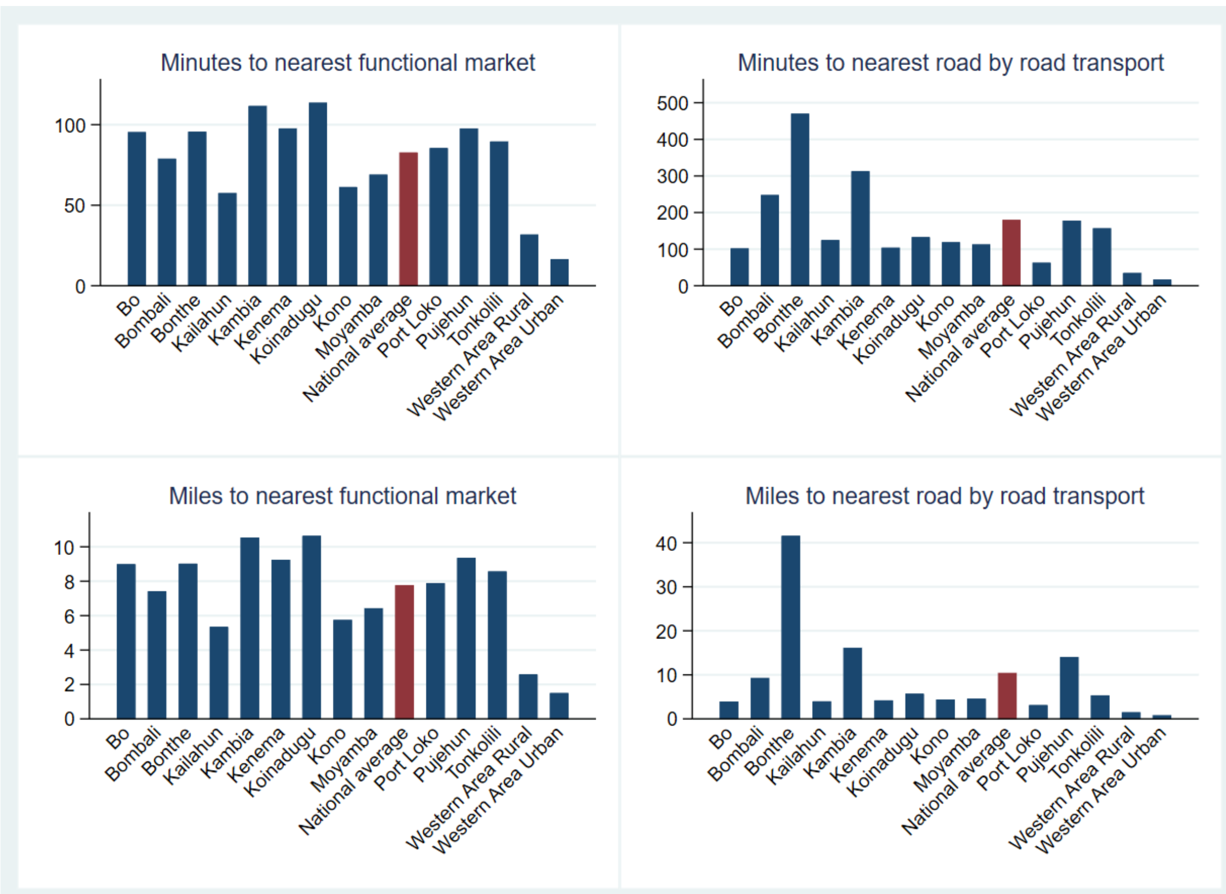


Figure 3. 7: Travel time and distance to functional market and road by district in Sierra Leone, 2015
Notes: 1 mile = 1.61 km. *Source*: Own construct based on World Food Programme (2015)

These poor infrastructural conditions, coupled with the consequent high transaction costs, obstruct people's access to markets (for inputs, produce, and credit), the transportation of goods, inputs and people, as well as, access to new income-earning opportunities and social services. Of particular interest in this study is the access to product markets, which is a critical determinant of food security. Market access is generally considered in the literature in terms of distance, time, and costs of traveling to the nearest market, town/urban centre or all-season road (Abay & Hirvonen, 2017; Headey et al., 2019; Hirvonen et al., 2017; WFP, 2017). According to the 2015 Sierra Leone Comprehensive Food Security and Vulnerability Analysis (CFSVA) survey, 83% of Sierra Leone households live in communities with no functional market (WFP, 2015). Figure 3.7 depicts the distribution of market access indicators across districts. On average, households had to travel (usually by foot) about 83 minutes (≈ 7.8 miles or 12.6 kilometres) to reach the nearest market. In terms of road access, Figure 3.7 also reveals they had to travel by road transport for about 180 minutes (≈ 10.43 miles or 16.7 kilometres) reach the nearest road by a road transport). While this may be driven by the Bonthe district, which is located on an island, Figure 3.7 reflects the precarious state of market linkages and overall infrastructure in the country. This low market penetration (or high isolation) means that households have to incur high transaction costs to participate in distant markets, where people converge from different locations to either sell or buy foods, inputs, and other products. As discussed previously, this constraints on market access may have negative impacts on food security through several pathways, including agricultural production, prices, incomes, food availability, and food access.

3.4 Data and Methods

3.4.1 Data

The data used for the empirical analysis is obtained from the second and third rounds of the Sierra Leone Integrated Household Survey (SLIHS) conducted by Statistics Sierra Leone in 2011 and 2018. The SLIHS is a cross-sectional, nationally representative income and expenditure survey, specifically designed to provide relevant statistics on the living standards of Sierra Leoneans and to guide the formulation of interventions towards poverty reduction in Sierra Leone. While the first round was conducted in 2003/2004, only the second and third rounds of SLISH are comparable in terms of sampling techniques and questionnaires. The two-stage cluster random sampling design was used in both rounds, with the enumeration area the primary sampling unit and households the secondary sampling unit. A salient feature of the 2011 and 2018 SLIHS is that they were administered over 12 months (January-December). The study exploits this aspect of the dataset to analyse the associations between seasonality, nearness to food markets, and food security in Sierra Leone. In addition to household income and consumption expenditure, the SLIHS collected information on agricultural production, health, education, and other social, economic, and demographic characteristics of individuals, households, and communities. Also included in the 2018 SLISH (but not in earlier rounds) is a food security module, which we utilized in our analysis. The SLISH covered 6,727 and 6840 households in 2011 and 2018, respectively. However, the final sample for the analyses consists of 13,256 households after combining the various modules from both rounds.

3.4.2 Measurement of variables

3.4.2.1 Dietary diversity and food security indicators

The key to a healthy, high-quality diet for better nutrition is consuming a variety of foods from different groups (Arimond et al., 2011; Thiele & Weiss, 2003). Dietary diversity is usually measured as the count of food groups or individual food items consumed by a household or an individual over a 24-hour or 7-day recall period (Kennedy et al., 2010). However, the household food consumption data from SLISH 2011 and 2018 were based on daily food diaries, completed over a 5-day interval for one month. Food consumption expenditures were thus aggregated over a 30-day recall period, involving 4–5 visits to each household. Most households are likely to consume from diverse food groups at least once a month. Hence, a dietary diversity indicator based on food groups consumed over extended recall periods, say 30 days, may not only be an overestimate but also a poor predictor of dietary quality or nutritional adequacy (Ecker, 2018). Another limitation is that we do not have household-level information on the quantities and prices of food items consumed.

Therefore, we resort to the Simpson diversity index or Berry index to measure dietary diversity based on the shares of food groups in total (purchased and own produced) food expenditure. The household dietary diversity index (*HDDI*) for household *i* is constructed as

$$HDDI_i = 1 - \sum_{\mathrm{j=1}}^{\mathrm{k}} \omega_{\mathrm{ij}}^{2} \qquad (3.1)$$

where ω_{ij} is the share of food group *j* in total food consumption expenditure of household *i* and *k* is the number of food groups[11]. The *HDDI* is bounded between 0 and 1, with 0 representing a situation where household *i* spends on or consumes from only one food group and 1 where the household devotes equal shares of its food budget to all food groups considered. Thus, while higher values are suggestive of a higher diversity of household food expenditure, lower values are indicative of less diversity in food expenditure, and thus, consumption of more concentrated or highly monotonous diets (Drescher et al., 2007; Liu et al., 2014; Thiele & Weiss, 2003). An *HDDI* based on logit transformation was also constructed to ensure predicted values are within the (0, 1) interval. The transformed *HDDI* is expressed as ln[*HDDI*/(1-*HDDI*)]. In analysing the role of markets, *HDDI* based on purchased foods and own-produced foods are also computed to identify the relative importance of different food sources for household dietary diversity across seasons.

Household food insecurity is measured by the coping strategy index (*CSI*) (Maxwell & Caldwell, 2008) and household hunger scale (*HHS*) (Ballard et al., 2011). These household hunger indicators capture the severity and frequency of strategies households adopt in the face of inadequate household food access.

[11] In this paper, we used 12 food groups (i.e. k = 12) based on Anim and Frimpong (2018) and Kennedy et al. (2010). These include 1) cereals; 2) roots and tubers; 3) chicken; 4) meat; 5) fish; 6) diary (eggs, milk and milk products); 7) fruits; 8) vegetables; 9) pulses; 10) oils and fats; 11) condiments; and 12) beverages and confectionary.

From a nutritional perspective, one limitation of *HDDI* is that it does not take into account the relative nutritional value of the consumed food groups. WFP's food consumption score addresses this concern. However, the relevant information on the frequency of food groups consumed is not available in the dataset. For robustness checks, we also employed the shares of food, staple foods, and non-staple foods in total food consumption expenditure as proxy indicators of food consumption patterns. As an indicator of household food security, household food expenditure share captures both the quality and quantity of household food consumption. The share of household food expenditure on staple foods approximates the share of dietary energy supply (availability) derived from cereals, roots and tubers, and other starchy staples. The share of the food budget spent on non-staples captures the quality of food consumed at the household level. As total household income (which can be proxied by of total consumption expenditure) increases, households will reduce the proportion of budget spent on food (Engel's Law). They will also shift their diets away from starchy staples and spend more on nutrient-dense, non-staple foods such as meat, fish, fruits, vegetables, dairy, legumes, and oils (Bennett's Law) (Timmer et al., 1983). To ensure that changes in HDDI are reflective of changes in the nutritional quality of the foods that households consumed, all consumption expenditures (and budget shares) are based on real values, which adjust for price movements

3.4.2.2 Seasonality and market access indicators

The study measures seasonality in two ways, in the spirit of Chirwa et al. (2012), and Handa and Mlay (2006). First, based on the month of interview, seasonality is captured by eleven monthly dummy variables for each round of SLISH, with December as the reference category. Second, the study aggregates the months of interview into three farming seasons or trimesters (four-month periods) based on Famine Early Warning Systems Network's (FEWS NET) seasonal calendar of a typical year in Sierra Leone (Pasqualino et al., 2016). Trimester 1 spans from February–May and captures the dry, post-harvest, and pre-planting period when there is neither serious food shortage nor food glut. The major agricultural activities occurring within this period are land preparation for rice and marketing of cash crops (mainly cashew, coffee, and palm oil). Trimester 2, which covers the period June–September, is the growing season as well as the lean period when food insecurity is most acute. It concurs with the wettest season of the year when rainfall conditions are most suitable for land preparations (upland rice), planting (rice, cassava, vegetables, yams, sweet potato, and pepper), weeding (groundnut, maize, and millet) and minor harvest (of maize, millet, cassava, and cashew). Trimester 3 (October–January) is the harvesting and marketing period, traversing the rainy and dry seasons. Most households have increased food supply and purchasing power during this period, as it coincides with the harvest and marketing of several food crops and cash crops.

Market access has been measured in different ways, of which distance or time to a nearest market centre or nearest all-weather or paved road are most often used (Headey et al., 2019; WFP, 2017). In this study, based on the available data, we measured proximity to food markets by the time (minutes) it takes a household to reach the nearest food market by the most frequent means. This market access indicator was reported as categorical (i.e. six 15-minute categories), rather than continuous. Hence, a household is considered to be close to a food market (or have good access) if it reaches food markets within one hour. With foot/walking being the most frequent mode of reaching markets in Sierra Leone, the 60-minute cut-off point is equivalent to a walking distance of 5 km. Similar proximity thresholds have been used in the literature (Abay & Hirvonen, 2017). While proximity to markets does not necessarily capture nutritional dimensions of market quality (e.g. diversity, availability and affordability of foods sold in the market) (Headey et al., 2019), it is the most suitable market access indicator in the dataset employed in this study.

3.4.2.3 Control variables

Several control variables are also included in the analysis to account for the influence of other drivers of dietary diversity and food security. Household socio-economic characteristics are captured by the head's age, gender, marital status and education status, livelihoods (sector of head's occupation), an asset-based wealth index, and household ownership of livestock and agricultural land. Household head's religion is used to control for the influence of beliefs and practices on food consumption. Household demographic structure is captured by the number of members aged 0-15, 15-64, and over 64. The nearness of drinking water supply and health clinic is also included to control for community characteristics. Lastly, district and survey fixed effects are also included to deal with omitted variable bias due to unobserved heterogeneity.

3.4.3 Model specification and estimation strategy

The analysis is carried out in two sections. In the first section, we estimate a food consumption model that relates different indicators of household dietary diversity and food security to a set of seasonal variables and control variables. The basic specification for food security–seasonality model, is given as:

$$Y_{it} = \alpha + \beta S_{it} + \delta X_{it} + \gamma D_i + \psi T + \varepsilon_{it} \qquad (3.2)$$

where Y_i is the dietary diversity or food security indicator of household *i* surveyed at time *t*. *S* is a vector of seasonal dummies, capturing the month or farming season within which the interview occurred. *X* is a vector of household socio-economic and demographic characteristics. *D* is a set of district fixed effects; *T* is the linear time trend, capturing general, unobserved non-seasonal differences in household food and nutrition security between the survey years 2011 and 2018, and ε is the error term. The scalar β contains the parameters of interest, capturing the individual effects of different seasons. We used the Wald *F* test to test for the joint significance of all seasonality coefficients.

In the second part, we examined the role of market access as a potential policy instrument in addressing seasonal food insecurity in Sierra Leone. The formal approach to quantify the relative seasonal effects of market access on food security is to estimate a food security model with seasonality and market access measures and their interaction term (along with other covariates) as explanatory variables. However, given the data at hand, including the entire 11 monthly (seasonal) dummies along with five separate categories of time to food markets and their interaction terms will result in over-parameterization. This will churn out a bunch of regression coefficients that have low statistical power and are difficult to interpret. To overcome these problems, while accounting for the non-linear relationship between market access and household diets and food security across seasons, we take a more straightforward approach, following Abay and Hirvonen (2017), by dividing seasonality and market access into two groups each. We categorize the month of the interview into the lean season (*LS*) and non-lean (sufficient) season (*NL*) and market access as close to markets (*CM*) and far from markets (*FM*). We then estimate the following model:

$$Y_{it} = \alpha + \beta_1 LSCM_{it} + \beta_2 NLCM_{it} + \beta_3 NLFM_{it} + \delta X_{it} + \gamma D_i + \psi T + \varepsilon_{it} \qquad (3.3)$$

where *LSCM*, *NLCM*, and *NLFM* are seasonality and market access interaction terms. *LSCM* equals 1 if the season of interview is lean (that is, June – September, the period of most acute food deprivation), and the household is located close (or within 60 minutes distance) to a food market and zero otherwise. *NLCM* takes the value of 1 if the season is non-lean (that is, harvest and post-harvest months when relative food sufficiency exists, October – May), and the household is located close to a food market and zero otherwise. *NLFM* equals 1 if the season is non-lean, and the household is not close (more than 60 minutes distance) to a food market and zero otherwise. Hence, the reference category covers households interviewed in the non-lean season and are located far from a food market. All other variables remain as previously defined. The β coefficients capture the seasonal effects of market access on household diets and food security relative to the reference category, which we expect to be positive and statistically significant.

Considering seasonal variabilities and location of markets to be mostly exogenous to household consumption decisions, the ordinary least squares (OLS) technique is utilized to estimate the parameters in the models specified above. Concerns for heteroscedasticity, which typically affects the analysis of cross-section data, are addressed by the use of robust standard errors. The possibility that households that are concerned about their food security and nutritional wellbeing may relocate to areas with better market access raises concern about the endogeneity of the market access variable. However, this concern is allayed by the fact that widespread poor transport infrastructure imposes high transportation costs and creates relocation difficulties for households seeking better dietary and food security outcomes. Also, private land markets are absent in Sierra Leone, as lands are mostly acquired based informed consent either through family inheritance or by community allocation (Ochiai, 2017). This makes private land acquisition highly difficult. As Hirvonen et al. (2017) argued, the absence of private land markets suggests that households seeking better dietary diversity would have considerable difficulties doing so by relocating their families or farms nearer to the markets.

3.4.4 Descriptive statistics

Reported in Table 3.2 are the description and summary statistics of the variables employed in the analysis. The results of the test of difference-between-means are shown in the last column of Table 2. The descriptive results show that, on average, the HDDI increased from 0.75 in 2011 to 0.86 in 2018. This suggests that the diets of Sierra Leonean households have significantly improved, in terms of diversity, over the years. As a reflection of increased affluence, the share of food expenditure has significantly declined from 0.63 to 0.46 over the seven years. In particular, the share of staple foods in household food expenditure declined, whereas that of non-staple foods significantly increased between 2011 and 2018, showing the growing importance of nutritious, non-staple foods in household diets in Sierra Leone. The distribution of households across seasons is quite uniform in both waves of SLIHS. Market access has also remarkably improved, with 79% of households reaching the nearest food market within an hour in 2018, relative to 68% in 2011.

Table 3. 2: Summary statistics

	2011		2018		Pooled		
	Mean	SD	Mean	SD	Mean	SD	Diff.
Dietary diversity & food security indicators							
HH dietary diversity index, HDDI (0–1)	0.75	0.10	0.86	0.06	0.81	0.10	0.11***
Transformed HDDI	1.17	0.57	1.93	0.65	1.55	0.72	0.76***
Purchased HDDI	0.73	0.11	0.85	0.07	0.79	0.11	0.12***
Transformed purchased HDDI	1.08	0.62	1.87	0.58	1.48	0.72	0.79***
Own food HDDI	0.72	0.34	0.76	0.31	0.74	0.32	0.03***
Transformed own food HDDI	0.39	1.04	1.1	1.79	0.79	1.55	0.72***
Share of food in HH consumption exp.	0.63	0.18	0.46	0.16	0.54	0.19	-0.17***
Share of staple foods exp. in the food budget	0.42	0.15	0.30	0.11	0.36	0.15	-0.12***
Share of non-staple foods exp. in food budget	0.45	0.12	0.48	0.14	0.46	0.13	0.03***
Coping strategy index			7.98	8.33	7.98	8.33	
Household hunger scale (0–6)			1.17	1.13	1.17	1.13	
Seasonality & market access							
Post-harvest season (February–May) (1/0)	0.35	0.48	0.33	0.47	0.34	0.48	-0.02**
Lean & growing season (June–September) (1/0)	0.35	0.48	0.33	0.47	0.34	0.47	-0.02*
Harvest season (October–January) (1/0)	0.30	0.46	0.33	0.47	0.32	0.46	0.04***
Close to food market (=1 if time is < 60 mins)	0.68	0.47	0.79	0.41	0.73	0.44	0.11***
Lean & close to food market (1/0)	0.29	0.45	0.34	0.47	0.31	0.46	0.06***
Lean season & far from food market (1/0)	0.16	0.36	0.08	0.27	0.12	0.32	-0.08***
Non-lean season & close to food market (1/0)	0.39	0.49	0.45	0.50	0.42	0.49	0.06***
Non-lean season & far from food market (1/0)	0.17	0.38	0.13	0.34	0.15	0.36	-0.04***
Control variables							
HHD is male (1/0)	0.74	0.44	0.75	0.43	0.75	0.44	0.001
Age of HHD (years)	45.59	14.19	45.91	14.26	45.75	14.22	0.33
HHD is monogamous marriage (1/0)	0.63	0.48	0.61	0.49	0.62	0.49	-0.02
HHD is polygamous marriage (1/0)	0.16	0.37	0.16	0.37	0.16	0.37	0.00
HHD is divorced, separated or widowed (1/0)	0.15	0.36	0.17	0.37	0.16	0.37	0.02**

HHD is never married (1/0)	0.05	0.22			0.05	0.22	
No. of HHM aged 0-14 years	2.20	1.71	2.31	1.76	2.26	1.74	0.11***
No. of HHM aged 15-64 years	3.17	1.69	3.25	1.92	3.21	1.82	0.08*
No. of HHM aged over 64 years	0.23	0.50	0.25	0.50	0.24	0.50	0.02
HHD is waged/salaried employee (1/0)	0.15	0.36	0.25	0.44	0.20	0.40	0.11***
HHD is employed in agriculture (1/0)	0.58	0.49	0.42	0.49	0.50	0.50	-0.16***
Head is employed in non-agriculture (1/0)	0.24	0.43	0.18	0.39	0.21	0.41	-0.06***
HH owns any livestock (1/0)	0.39	0.49	0.50	0.50	0.44	0.50	0.11***
HH owns any agricultural land (1/0)	0.55	0.50	0.49	0.50	0.52	0.50	-0.06***
HH wealth index (0–100)	52.13	11.40	56.97	13.70	54.55	12.83	4.84***
HHD is Christian (1/0)	0.23	0.42	0.23	0.42	0.23	0.42	-0.01
HHD is Muslim (1/0)	0.76	0.43	0.77	0.42	0.76	0.43	0.01
HHD has other or no religion (1/0)	0.01	0.09	0.00	0.06	0.01	0.08	-0.00***
HHD has no education (1/0)	0.67	0.47	0.52	0.50	0.60	0.49	-0.14***
HHD has primary education (1/0)	0.08	0.27	0.11	0.32	0.10	0.30	0.04***
HHD has secondary education (1/0)	0.18	0.38	0.24	0.43	0.21	0.41	0.06***
HHD has post-secondary education (1/0)	0.06	0.23	0.09	0.28	0.07	0.26	0.03***
HHD has college degree (1/0)	0.02	0.14	0.04	0.19	0.03	0.17	0.02***
Time to drinking water source <30 mins	0.88	0.32	0.86	0.35	0.87	0.33	-0.02***
Time to drinking water source 31–60 mins	0.09	0.29	0.11	0.31	0.10	0.30	0.01*
Time to drinking water source >60 mins	0.02	0.15	0.03	0.18	0.03	0.17	0.01**
Time to health clinic < 30 mins	0.42	0.49	0.57	0.50	0.50	0.50	0.16***
Time to health clinic 31–60 mins	0.34	0.47	0.23	0.42	0.28	0.45	-0.11***
Time to health clinic >60 mins	0.25	0.43	0.20	0.40	0.22	0.42	-0.05***
Pathway variables							
Share of gross value of farm output sold (0-1)	0.15	0.26	0.61	0.28	0.33	0.35	0.46***
Sold crops at farm gate buyer (1/0)	0.27	0.44	0.18	0.39	0.22	0.42	-0.08***
HH operates a non-farm enterprise (1/0)	0.18	0.38	0.51	0.50	0.34	0.48	0.33***
HH accessed credit for consumer goods (1/0)	0.25	0.43	0.34	0.47	0.31	0.46	0.09***
Observations, *N*	6628		6628		13256		

Notes: HH stands for household; HHD denotes household head and HHM refers to household member. 1/0 is a binary indicator and equals 1 if yes, and 0 otherwise. SD denotes standard deviation. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Source: Own computation based on SLISH 2011 & 2018.

Most households are male-headed, with a mean age of about 46 years. Most household heads are monogamously married. We do not observe any significant change in these characteristics during 2011-2018, except for a 2% increase in the proportion of divorced, separated, or widowed household heads. Islam remains the dominant religion of household heads. Although it remains unacceptably low, literary rates have improved over the years, with about 15% decline in the percentage of household heads who had no formal education from 67% in 2011. This is seen in the significant upticks in the proportions of households attaining primary and secondary education. Attainment of post-secondary and college education remains undesirably low.

In terms of livelihoods, agriculture is the primary source of employment for household heads, although its importance had declined from 58% in 2011 to 42% in 2018. On the contrary, the percentage of household heads engaged in waged or salaried employment in public or private sectors has significantly increased from 15% to 25% over the same period, signifying nascent transformations in the overall structure of the Sierra Leonean economy. While the ownership of agricultural land has declined, ownership of livestock and possession of some durable assets (generally, of medium quality) have also improved during the study period. With regards to access to basic social services, the majority of households can reach a drinking water source within half an hour, although the proportion has fallen by 2% from 88% in 2011. Although improving, access to health care leaves much to be desired, as less than two-thirds of the surveyed households reported reaching the nearest health clinic within 30 minutes by the most frequent means of transportation. Finally, the descriptive results show significant increase in commercialization or market participation, measured in terms of the share of the value of farm output sold [12] (Carletto et al., 2017; von Braun & Kennedy, 1995) and whether the farm output was sold at the farmgate or not. The proportion of households operating a non-farm enterprise as well as those who accessed consumer credit also improved significantly over the period. These intermediary variables are examined in the analyses to understand the potential pathways through which market access can contributes to overcoming seasonal fluctuations in household dietary diversity and food security.

[12] Following von Braun and Kennedy (1994) and Carletto et al. (2017) we computed the commercialization index as the share of the total value of farm output sold. Due to data limitations, only the value of food crops and cash crops produced by the household during the last 12-months preceding the survey are considered in measuring the index. Similarly, due to inconsistencies as well as missing information on prices for identical crops and units for some households, the average sales prices reported by the sampled households are used to value farm output.

3.5 Results and discussion

3.5.1 The effects of seasonality on dietary diversity and food security

Reported in Tables 3.3 and 3.4 are the regression results from an OLS estimation of Equation (3.1) with seasonality measured by monthly dummies and farming seasons respectively. These results describe the extent of seasonality in household dietary diversity and food security in Sierra Leone. The results of Wald tests for the joint significance of seasonal indicators are presented below both tables. As evidenced by the test results in Table 3.3, the null hypothesis that all seasonal dummies are simultaneously equal to zero is rejected at 1 percent level in all models. This suggests that seasonality exerts substantial fluctuations in household diets and food security in Sierra Leone.

The estimated parameters of models 1–2 in Table 3.3 show that household diets were significantly better or more diverse in January and February compared to December. This may be most probably due to food availability from harvest and New Year festivities. Both models are similar in terms of economic and statistical significance. In terms of magnitude, the results show that dietary diversity was 0.019 units (model 1) or 12.75% (model 2) [13] significantly higher in January than in December, all other things being equal. Similarly, it was 0.014 units (model 1) or 10.85% (model 2) higher in February than in December, albeit it declined from its level in January. From thence, food diversity declined throughout the rest of year (relative to December) as the lean season approaches. June appears to be the worst, with 0.017 units (model 1) or 8.97% (model 2) decline dietary diversity. As shown in model 3, the general decline in dietary quality is reflected in households cutting back the share of food expenditure on micronutrient-rich, non-staple foods (such as fish, meat, dairy, fruits, and vegetables) in months other than December. Although it remains relatively low compared to December, the negative effects of October and November on household dietary diversity become smaller and weaker as diverse foods become more available and accessible during the harvest season.

[13] Since model 2 has a log-transformed outcome variable, a more accurate estimate of the percentage effect is calculated as (100 x [exp(β)-1]) where β represents the coefficient of the seasonality variables or other binary indicator (say, β) (see Wooldrige, 2010, p. 71)

Table 3. 3: Effects of monthly seasonality on household dietary diversity and food security

	Dietary diversity			Food security		
	(1)	(2)	(3)	(4)	(5)	(6)
	HDDI	lnHDDI	NSTASH	FDSH	lnCSI	HHS
January	0.019***	0.120***	-0.005	-0.064***	0.446***	0.357***
	(0.003)	(0.025)	(0.006)	(0.008)	(0.084)	(0.066)
February	0.014***	0.103***	-0.020***	-0.032***	0.388***	0.260***
	(0.003)	(0.025)	(0.006)	(0.007)	(0.078)	(0.064)
March	0.004	0.037	-0.015**	-0.009	0.310***	0.133**
	(0.003)	(0.024)	(0.006)	(0.007)	(0.076)	(0.061)
April	-0.006*	-0.011	-0.026***	0.002	0.143*	0.090
	(0.003)	(0.026)	(0.006)	(0.007)	(0.078)	(0.058)
May	-0.011***	-0.046*	-0.029***	0.005	0.125	0.134**
	(0.003)	(0.025)	(0.006)	(0.007)	(0.079)	(0.061)
June	-0.017***	-0.094***	-0.036***	0.019***	0.203***	0.142**
	(0.003)	(0.026)	(0.006)	(0.007)	(0.077)	(0.060)
July	-0.003	-0.011	-0.046***	0.016**	0.159**	0.146**
	(0.003)	(0.025)	(0.006)	(0.007)	(0.078)	(0.059)
August	-0.009***	-0.059**	-0.028***	0.033***	0.291***	0.227***
	(0.003)	(0.025)	(0.006)	(0.007)	(0.075)	(0.058)
September	-0.013***	-0.051*	-0.041***	0.044***	0.098	-0.047
	(0.003)	(0.027)	(0.006)	(0.007)	(0.079)	(0.058)
October	-0.012***	-0.076***	-0.033***	0.029***	0.271***	0.181***
	(0.003)	(0.024)	(0.006)	(0.007)	(0.074)	(0.057)
November	-0.005	-0.011	-0.011*	0.005	-0.159**	-0.020
	(0.003)	(0.028)	(0.006)	(0.008)	(0.077)	(0.059)
Constant	0.767***	1.521***	0.394***	0.799***	2.118***	1.582***
	(0.011)	(0.074)	(0.018)	(0.021)	(0.397)	(0.316)
Controls	yes	yes	Yes	yes	yes	yes
District fixed effects	yes	yes	Yes	yes	yes	yes
Year fixed effects	yes	yes	Yes	yes	n/a	n/a
N	13122	13122	13122	13122	6624	6624
R^2_{adj}	0.46	0.43	0.136	0.37	0.300	0.194
F-test for months	26.30	17.77	12.69	38.85	9.30	6.86
F(*p*-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: OLS estimation. HHDI is the Berry index of household dietary diversity. lnHDDI is logit transformed HDDI. FDSH is the share of food expenditure in total consumption expenditure. NSTASH is the share of expenditure on non-staple foods in the household food budget. lnCSI is the log of coping strategy index, and HHS is the household hunger scale. The omitted category is December. The control variables are provided in Table 3.2. Robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Turning to household food security, the results in model 4 show that the months of January and February are associated with significantly lower food share of total consumption expenditure (a proxy of income): -0.064 and -0.032 respectively. This signifies that the households spent significantly less on food as they become richer and more food secure, potentially from lower food prices and increased food availability as well as cash incomes during these harvest months. However, the effects of seasonality on the food share of household consumption expenditure tends to be positive as households approach the lean months. The positive and statistically significant effects of the seasonal variables – June through October – on the food share of total household expenditure suggests heightened food insecurity over this period, during which food supply becomes limited, food prices hit the roof, and effective purchasing power and other means of accessing food diminish considerably. The resultant negative dietary changes are previously seen in significantly lower dietary diversity and share of food expenditure on non-staple foods (models 1–3).

Although they remain significantly higher compared to December, the models 5 and 6 in Table 3.3 show a general decline in the effects of seasonal variables on CSI and HHS throughout the year. In particular, the effect size of seasonality on both food insecurity indicators declines consistently from January to May, fluctuated from June to October, before resuming the downward trend as the lean (food-deficit) season gives way to the harvest (food sufficient) period. Out of eleven, the coefficients of eight monthly dummies are positive and statistically significant in models 5 and 6, demonstrating that Sierra Leonean households remain vulnerable to food insecurity throughout the year, even in the harvest months. This may compel households to adopt severe coping strategies – including limiting dietary frequency frequently, quality and quantity – to deal with short-term food inadequacy.

These results are generally consistent with those reported in Table 3.4, with seasonality captured by agricultural season dummies. At the national level, we find that both dietary diversity and food insecurity deteriorate during the post-harvest and growing (lean) seasons, relative to the harvest season. The negative effects of post-harvest and lean seasons on household diets and food security are jointly significant in all models of panel *A*. This is shown by the *F* statistics and its *p*-values, which suggest a rejection of the null hypothesis that both seasons jointly have no significant effect on food consumption in Sierra Leone.

Table 3. 4: Effects of farming seasons on household dietary diversity and food security

	Dietary diversity			Food security		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: National	HDDI	lnHDDI	NSTASH	FDSH	lnCSI	HHS
Post-harvest season	-0.003*	-0.006	-0.010***	-0.000	0.106***	0.043
	(0.002)	(0.012)	(0.003)	(0.003)	(0.040)	(0.032)
Growing/lean season	-0.012***	-0.067***	-0.026***	0.039***	0.023	-0.026
	(0.002)	(0.012)	(0.003)	(0.003)	(0.040)	(0.031)
Constant	0.741***	1.095***	0.549***	0.621***	1.680***	1.273***
	(0.003)	(0.016)	(0.005)	(0.006)	(0.095)	(0.084)
Controls	yes	yes	Yes	yes	yes	Yes
District fixed effects	yes	yes	Yes	yes	yes	Yes
Year fixed effects	yes	yes	Yes	yes	n/a	n/a
N	13256	13246	13256	13256	6628	6628
R^2_{adj}	0.415	0.380	0.073	0.300	0.209	0.137
F-test for seasons	32.22	18.98	42.65	95.61	4.03	2.33
F(*p*-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.018)	(0.097)
Panel B: Rural						
Post-harvest season	0.001	0.003	-0.008**	0.014***	0.026	0.032
	(0.002)	(0.015)	(0.004)	(0.005)	(0.049)	(0.046)
Growing/lean season	-0.009***	-0.059***	-0.036***	0.056***	0.149***	0.044
	(0.002)	(0.016)	(0.004)	(0.005)	(0.049)	(0.045)
Constant	0.732***	1.075***	0.549***	0.622***	1.617***	1.129***
	(0.003)	(0.020)	(0.006)	(0.008)	(0.118)	(0.102)
Controls	yes	yes	Yes	yes	yes	Yes
District fixed effects	yes	yes	Yes	yes	yes	Yes
Year fixed effects	yes	yes	Yes	yes	n/a	n/a
N	7591	7583	7591	7591	3337	3337
R^2_{adj}	0.397	0.370	0.105	0.347	0.188	0.116
F-test for seasons	9.86	11.10	63.19	82.84	5.12	0.53
F(*p*-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.001)	(0.589)
Panel C: Urban						
Post-harvest season	-0.001	0.010	-0.012**	-0.034***	0.200***	0.038
	(0.002)	(0.019)	(0.005)	(0.005)	(0.065)	(0.046)
Growing/lean season	-0.004**	-0.023	-0.006	-0.003	0.020	-0.047
	(0.002)	(0.019)	(0.005)	(0.005)	(0.061)	(0.043)
Constant	0.761***	1.140***	0.558***	0.588***	1.754***	1.481***
	(0.004)	(0.025)	(0.009)	(0.011)	(0.156)	(0.143)
Controls	yes	yes	Yes	yes	yes	Yes
District fixed effects	yes	yes	Yes	yes	yes	Yes
Year fixed effects	yes	yes	Yes	yes	n/a	n/a
N	5665	5663	5665	5665	3291	3291
R^2_{adj}	0.352	0.281	0.044	0.153	0.157	0.132
F-test for seasons	2.62	1.50	3.25	28.63	6.08	1.94
F(*p*-value)	(0.073)	(0.223)	(0.039)	(0.000)	(0.002)	(0.144)

Notes: OLS estimation. See notes beneath Table 3.3. Robust standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The reference category is the harvest season (October–January).

As evidenced by the magnitude of the coefficients in panel *A* of Table 3.4, the largest decline in dietary quality (models 1–3) occurs during the lean season, the period of most acute food shortage. In particular, the lean season is associated with 0.012 units (model 1) or 34.4% (model 2) decline in dietary diversity and 0.026 units (model 3) reduction in non-staple share of the food budget, compared to the harvest season. Dietary quality also declines during the post-harvest season, but by smaller margins compared to the hunger season. While the growing/lean season is also significantly associated with higher shares of food expenditure (model 4), we do not find its effects on other food insecurity indicators statistically significant (models 5–6). Nonetheless, as shown by the Wald test results, both seasonal dummies are jointly significant in explaining the variations in the food security variable over the year.

In terms of locality, the results in panels *B* and *C* of Table 3.4 generally reveal that seasonality is more of a rural phenomenon than an urban one. In absolute terms the coefficients of the seasonal variables are larger and more statistically significant for rural households than urban households. This portrays that agricultural seasonality may induce considerable fluctuations in the dietary diversity and food security of rural households than urban households. This is not surprising because rural livelihoods are largely agricultural-based and strongly intertwined with the seasonal dynamics of agricultural production. Compared to the harvest season (base category), the results in panel *B* suggest that rural households surveyed during the lean season experienced significant reductions in dietary diversity (models 1–2), and the share of non-staple foods (model 3), as well as significant increments in food insecurity (models 4–5). The estimated coefficients are statistically significant, indicating that the hunger season is an important contributor to low dietary diversity and high food insecurity in rural areas. This finding is consistent with Sibhatu and Qaim (2017) who reported that the dietary diversity of rural households in Ethiopia decreases significantly during the growing season, mainly due to lower availability from subsistence production.

With respect to urban areas, the results in panel *C* provide mixed and non-robust evidence of the effects of farming seasons on dietary diversity and food security. What is worth noting, however, is the general lack of statistical significance of the effects of the lean (growing) season on these welfare outcomes. This indicates that increased food insecurity in Sierra Leone during this time of the year may be more of a rural occurrence than an urban one. A possible reason is that urban households, which are less dependent on subsistence farming for foods, may have stable access to food from local and international markets because of their better connectivity.

These analyses highlight the importance of seasonality in shaping the dietary quality and food security, particularly in agrarian settings. The results reveal that food expenditure patterns and, for that matter, household dietary diversity and food security in Sierra Leone primarily follow the regular patterns of agricultural production. This finding is consistent with fluctuations in food consumption patterns over the agricultural cycle in Mozambique (Handa & Mlay, 2006). In a related study, Chirwa et al. (2012) examined household consumption expenditure in Malawi. They showed that the incidence of poverty in Malawi is significantly affected by seasonality, with estimated poverty rates likely to be higher during the hunger season than in the post-harvest season.

3.5.2 The role of market access in mitigating seasonal food insecurity

The results presented in the previous section demonstrate that household diets and food security are subject to significant seasonality – with no consideration for market access. The extent to which households have access to or are engaged in markets is vital for food security in all of its dimensions – availability, accessibility, utilization, and stability. In this section, we analyse the interaction effects of market access and seasonality on household dietary diversity and food security. Given that insufficient food access constitutes one of the most important underlying causes of malnutrition, this analysis is pertinent for policies aimed at smoothing food consumption within the year and reducing vulnerability to seasonal food insecurity.

Tables 3.5–3.7 provide the results based on Equation (3.3), which relates several indicators of household dietary diversity and food security to seasonally-defined market access variables and all the controls included in previous models. Table 3.5 reports the results at the country level, whereas Tables 3.6 and 3.7 present sub-sample results by residence and poverty status. The reference category consists of households surveyed in the lean season and located far from the food market. The magnitude of seasonal changes in dietary diversity and food security with respect to the degree of market access are captured by the coefficients of *LSCM*, *NLCM*, and *NLFM*.

Table 3. 5: Impact of market access and seasonality on household dietary diversity and food security

	Dietary diversity			Dietary diversity by source				Food security		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	HDDI	lnHDDI	NSTASH	Purchased HDDI	Purchased lnHDDI	Own food HDDI	Own food lnHDDI	FDSH	lnCSI	HHS
LSCM	0.010^{***}	0.031^{*}	0.024^{***}	0.022^{***}	0.109^{***}	-0.007	-0.043	-0.007	-0.378^{***}	-0.163^{***}
	(0.003)	(0.018)	(0.004)	(0.003)	(0.017)	(0.011)	(0.058)	(0.005)	(0.056)	(0.058)
NLCM	0.023^{***}	0.107^{***}	0.040^{***}	0.045^{***}	0.252^{***}	-0.016	-0.309^{***}	-0.036^{***}	-0.264^{***}	-0.112^{**}
	(0.003)	(0.017)	(0.004)	(0.003)	(0.017)	(0.010)	(0.053)	(0.005)	(0.053)	(0.056)
NLFM	0.013^{***}	0.073^{***}	0.028^{***}	0.040^{***}	0.229^{***}	-0.034^{***}	-0.293^{***}	-0.045^{***}	-0.330^{***}	-0.094
	(0.003)	(0.019)	(0.004)	(0.004)	(0.019)	(0.011)	(0.049)	(0.006)	(0.057)	(0.060)
Constant	0.750^{***}	1.457^{***}	0.341^{***}	0.695^{***}	1.097^{***}	0.712^{***}	1.411^{***}	0.822^{***}	2.739^{***}	1.906^{***}
	(0.011)	(0.074)	(0.018)	(0.013)	(0.075)	(0.049)	(0.373)	(0.021)	(0.387)	(0.319)
Controls	yes	yes	yes	Yes	yes	Yes	yes	yes	yes	yes
District FE	yes	yes	yes	Yes	yes	Yes	yes	yes	yes	yes
Year FE	yes	yes	yes	Yes	yes	Yes	yes	yes	n/a	n/a
N	13122	13112	13122	13122	13122	6508	6508	13122	6624	6624
R^2_{adj}	0.452	0.430	0.134	0.469	0.480	0.217	0.166	0.356	0.294	0.187

Notes: OLS estimation. See notes to Table 3. *LSCM* equals 1 if lean season and close to food market and zero otherwise; *NLCM* (*NLFM*) equals 1 if non-lean season and household is close to (far from) from the food market and zero otherwise. The reference category is lean season and far from the market. FE denotes fixed effects. The controls are listed in Table 3.2. Robust standard errors in parentheses. Statistical significance represented as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

By and large, we observe that closeness to market improves both dietary diversity and food security in the lean season as well as non-lean season. Table 3.5 shows that, in the lean season, the HDDI is 0.01 units (model 1) or 3.1% (model 2) higher for households with better market access than distant households. This suggests that households dwelling near food markets consume more varied diets during the lean season than households residing farther away from food markets. Albeit small, the coefficients are significant at the conventional error levels, providing evidence that enhancing access to (food) markets can contribute significantly to reducing seasonal hunger and its associated adverse dietary adjustments.[14] Unsurprisingly, compared to the base category, the non-lean season indicators are associated with significantly higher dietary diversity (models 1–3), irrespective of proximity to markets. This result may be explained by the increased availability of diverse nutrient-dense foods (at affordable prices) during the non-lean season. However, it is interesting to note that, the effect sizes of *NLCM* are generally larger than those of *NLFM* across the different specifications. This suggests that even in the non-lean season households that have better access to markets enjoy more diverse diets than those with poorer access. These results highlight the importance of better market access in preventing drastic reductions in dietary quality at certain times of the year, resulting particularly from the seasonal dynamics of agricultural production.

Jumping to the food security outcome variables, *LSCM* is associated with a 0.007 units (model 8) 31.48% (model 9) or 0.163 units (model 10) reduction in the *FDSH*, *CSI* and *HHS* respectively. These estimates are strongly significant (except for model 8). The coefficients are rightly signed, indicating the being closer to markets is associated with better food security outcomes during the lean season than being farther away (in same season). This result offers some evidence that, during the lean season, households that have better access to markets experience significantly less (severe) hunger and adopt less harmful coping strategies in the face of short-term food deprivation.

[14] Abay and Hirvonen (2016) reported that children located in Ethiopian villages with better market access enjoy more diverse, consuming 0.73 food groups more during the lean season, and 0.71 additional food groups during the sufficient/non-lean season (compared children residing farther away from food markets during the lean season). In the case of Malawi, Koppmair et al (2016) reported that one additional hour of walking time to district markets lowers household, maternal and children’s dietary diversity by 0.207 – 0.265 food groups. In their cross-country study (covering Indonesia, Ethiopia, Kenya and Malawi), Sibhatu et al. (2015) also found that household dietary diversity improves by 0.001 food groups for every 1 kilometre reduction in market distance. While these effect sizes may seem small, the role of markets in improving nutrition remains robust across various studies and “improving market access for subsistence farms seems to be a more promising developing strategy” (Sibhatu & Qaim, 2018).

As one would expect, food security also improves during the non-lean (harvest and post-harvest) season with proximity to food markets. These results are statistically significant at 1 percent level. These results point out that nearness to food markets is instrumental in alleviating transitory insufficient food access and its consequential use of severe coping strategies when faced with seasonal food stress. In particular, nearness to food markets significantly reduces the number of days households had to rely on less preferred and/or less expensive food, borrow food or rely on help from others, limit the portion size at mealtimes, restrict consumption by adults, the number of meals eaten in a day and go to bed feeling hungry compared to isolated households in the lean season (see Table 3.8).

In Table 3.5, models 4–7 demonstrate that market-purchased foods contribute significantly to higher dietary diversity than from own-produced food in both lean and non-lean seasons. For instance, the results from models 4–5 show that in the hungry season, the dietary diversity index of purchased foods is 0.022 units (model 4) or 11.5% (model 5) higher for households near food markets than households isolated from markets. This result also holds in the non-lean season, considering the positive difference between the coefficients of *NLCM* and *NLFM* in models 4–5: nearness to food markets increases the diversity of purchased foods. On the other hand, the interaction effects of seasonality and market access on dietary diversity from subsistence production (models 6–7) are negative, indicating that market access has a limited impact on household dietary diversity and food security through the subsistence pathway. This may be due to limited productivity and availability of diverse foods from own production. Because of this, subsistence production cannot make available the needed diverse foods in sufficient quantities for improved food and nutrition security throughout the year.

Table 3. 6: Impact of market access and seasonality on household dietary diversity and food security in rural and urban Sierra Leone

	Dietary diversity			Dietary diversity by source				Food security		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	HDDI	lnHDDI	NSTASH	Purchased HDDI	Purchased lnHDDI	Own food HDDI	Own food lnHDDI	FDSH	lnCSI	HHS
Panel A: Rural households										
LSCM	0.005^{*}	0.015	0.012^{***}	0.011^{***}	0.052^{***}	-0.025^{**}	-0.119^{**}	0.004	-0.448^{***}	-0.153^{**}
	(0.003)	(0.019)	(0.004)	(0.004)	(0.019)	(0.012)	(0.055)	(0.006)	(0.065)	(0.065)
NLCM	0.017^{***}	0.089^{***}	0.046^{***}	0.043^{***}	0.248^{***}	-0.023^{**}	-0.267^{***}	-0.035^{***}	-0.265^{***}	-0.098
	(0.003)	(0.018)	(0.004)	(0.003)	(0.019)	(0.011)	(0.052)	(0.006)	(0.057)	(0.060)
NLFM	0.012^{***}	0.077^{***}	0.028^{***}	0.040^{***}	0.230^{***}	-0.035^{***}	-0.235^{***}	-0.042^{***}	-0.320^{***}	-0.088
	(0.003)	(0.019)	(0.004)	(0.004)	(0.020)	(0.011)	(0.048)	(0.006)	(0.059)	(0.061)
Constant	0.725^{***}	1.246^{***}	0.401^{***}	0.669^{***}	0.864^{***}	0.633^{***}	1.326^{***}	0.789^{***}	1.563^{***}	1.169^{***}
	(0.017)	(0.115)	(0.024)	(0.019)	(0.112)	(0.066)	(0.358)	(0.030)	(0.492)	(0.443)
Controls	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
District FE	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	Yes	yes	yes	yes	n/a	n/a
N	7513	7505	7513	7513	7498	7513	5279	7513	3337	3337
R^2_{adj}	0.422	0.395	0.129	0.419	0.438	0.089	0.151	0.364	0.252	0.157
Panel B: Urban households										
LSCM	0.015^{**}	0.010	0.027^{*}	0.034^{***}	0.167^{***}	0.056^{*}	0.225	-0.027^{*}	-0.134	-0.336
	(0.008)	(0.089)	(0.016)	(0.009)	(0.053)	(0.032)	(0.308)	(0.015)	(0.242)	(0.229)
NLCM	0.022^{***}	0.069	0.026	0.041^{***}	0.233^{***}	0.022	-0.297	-0.034^{**}	-0.056	-0.285
	(0.008)	(0.087)	(0.016)	(0.009)	(0.052)	(0.032)	(0.281)	(0.015)	(0.242)	(0.228)
NLFM	0.004	-0.048	0.014	0.029^{***}	0.161^{***}	0.026	-1.065^{***}	-0.039^{**}	-0.320	-0.068
	(0.009)	(0.092)	(0.018)	(0.010)	(0.061)	(0.037)	(0.330)	(0.019)	(0.309)	(0.277)
Constant	0.784^{***}	1.627^{***}	0.368^{***}	0.739^{***}	1.311^{***}	0.830^{***}	1.890	0.792^{***}	4.331^{***}	3.664^{***}
	(0.016)	(0.143)	(0.038)	(0.017)	(0.122)	(0.078)	(1.488)	(0.033)	(0.605)	(0.462)
Controls	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
District FE	yes	yes	yes	yes	Yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	Yes	yes	yes	yes	n/a	n/a
N	5609	5607	5609	5609	5607	5609	1229	5609	3287	3287
R^2_{adj}	0.404	0.374	0.150	0.435	0.405	0.176	0.195	0.278	0.241	0.188

Notes: OLS estimation. The reference category is lean season and far from the market. See notes to Table 3.5. Robust standard errors in parentheses. Statistical significance indicated as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. 7: Impact of market access and seasonality on household dietary diversity and food security by poverty status in Sierra Leone

	Dietary diversity			Dietary diversity by source				Food security		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	HDDI	lnHDDI	NSTASH	Purchased HDDI	Purchased lnHDDI	Own food HDDI	Own food lnHDDI	FDSH	lnCSI	HHS
Panel A: Income poor households										
LSCM	0.008**	0.024	0.019***	0.012***	0.062***	-0.010	-0.115	0.001	-0.256***	-0.078
	(0.004)	(0.024)	(0.005)	(0.004)	(0.022)	(0.014)	(0.072)	(0.006)	(0.067)	(0.068)
NLCM	0.021***	0.088***	0.049***	0.041***	0.229***	-0.010	-0.274***	-0.036***	-0.259***	-0.071
	(0.003)	(0.022)	(0.005)	(0.004)	(0.022)	(0.014)	(0.066)	(0.006)	(0.063)	(0.067)
NLFM	0.012***	0.068***	0.035***	0.034***	0.196***	-0.040***	-0.335***	-0.048***	-0.348***	-0.076
	(0.004)	(0.026)	(0.005)	(0.005)	(0.024)	(0.014)	(0.064)	(0.007)	(0.067)	(0.069)
Constant	0.757***	1.506***	0.344***	0.690***	1.045***	0.729***	1.246***	0.759***	2.451***	1.324**
	(0.017)	(0.123)	(0.030)	(0.021)	(0.130)	(0.082)	(0.400)	(0.033)	(0.634)	(0.592)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
District FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	n/a	n/a
N	6092	6088	6092	6092	6081	6092	3629	6092	3022	3022
R^2_{adj}	0.457	0.413	0.133	0.442	0.449	0.150	0.175	0.378	0.207	0.172
Panel B: Non-income poor households										
LSCM	0.009**	0.024	0.023***	0.031***	0.144***	-0.004	0.056	-0.013	-0.489***	-0.316***
	(0.004)	(0.027)	(0.006)	(0.005)	(0.028)	(0.015)	(0.095)	(0.009)	(0.101)	(0.104)
NLCM	0.019***	0.104***	0.028***	0.048***	0.259***	-0.020	-0.359***	-0.032***	-0.305***	-0.231**
	(0.004)	(0.026)	(0.006)	(0.005)	(0.027)	(0.015)	(0.090)	(0.009)	(0.096)	(0.100)
NLFM	0.014***	0.074***	0.017***	0.049***	0.273***	-0.026*	-0.271***	-0.042***	-0.276***	-0.141
	(0.004)	(0.027)	(0.006)	(0.005)	(0.032)	(0.015)	(0.074)	(0.010)	(0.105)	(0.107)
Constant	0.745***	1.384***	0.361***	0.702***	1.125***	0.685***	1.250**	0.837***	2.792***	2.294***
	(0.015)	(0.098)	(0.023)	(0.016)	(0.101)	(0.060)	(0.557)	(0.028)	(0.483)	(0.371)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
District FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	n/a	n/a
N	7030	7024	7030	7030	7024	7030	2879	7030	3602	3602
R^2_{adj}	0.423	0.409	0.137	0.475	0.464	0.251	0.174	0.337	0.265	0.179

Notes: OLS estimation. The reference category is lean season and far from the market. See notes to Table 3.5. Robust standard errors in parentheses. Statistical significance indicated as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The results in Tables 3.6–3.7 consistently point to the importance of market purchases in smoothing consumption and, thus, enhancing food and nutrition security among rural and urban households as well as poor and non-poor households alike. With most households sourcing majority of their foods from markets, the results suggest that, by increasing availability and access to a variety of foods throughout the year, improved market access has the potential of mitigating seasonal fluctuations in household diets and food security.

Table 3.9 shows that proximity to food markets, in the lean season, is significantly associated with increased budget shares of non-staple food groups (namely, meats, fish and seafood, dairy, vegetables, and fats and oil) relative to remoteness to food markets. Households with better market access tend to devote less of their food budget to cereals (mainly rice) and switch to alternative starchy staples (namely roots and tubers) during the lean season. This signifies the counter-cyclical consumption patterns of these calorie-dense foods. Furthermore, the results also disclose that, compared to lean-season-and-isolated households, the shares of meats, fish and seafood, dairy, fruits, vegetables, legumes and fats and oils in household food budget are significantly higher during the non-lean season, regardless of food markets proximity. In other words, market access is more important for accessing and consuming nutritious diverse foods in the lean season than during the non-lean season (when they are more available from own production).

Table 3. 8: Effects of market access and seasonality on food insecurity coping strategies in Sierra Leone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Number of days (out of 7) household (any member) had to ...							
	rely on less preferred/expensive food	borrow food, rely on help	limit portion size at meal times	restrict consumption by adults	restrict consumption by children	reduce number of meals	go to bed feeling hungry	go an entire day without a meal
LSCM	-0.085**	-0.264***	-0.267***	-0.203***	-0.147	-0.197***	-0.197**	-0.053
	(0.040)	(0.059)	(0.045)	(0.076)	(0.145)	(0.051)	(0.091)	(0.138)
NLCM	-0.014	-0.163***	-0.187***	-0.037	-0.049	-0.117**	-0.037	0.100
	(0.037)	(0.053)	(0.041)	(0.071)	(0.135)	(0.047)	(0.084)	(0.129)
NLFM	-0.014	-0.212***	-0.164***	-0.076	0.044	-0.122**	0.087	0.117
	(0.042)	(0.058)	(0.045)	(0.077)	(0.146)	(0.052)	(0.087)	(0.136)
Constant	-0.363	0.325	0.131	-0.865***	0.698	-0.262	0.172	-1.456**
	(0.273)	(0.337)	(0.283)	(0.321)	(0.495)	(0.313)	(0.403)	(0.569)
Wald χ^2	1351.62***	804.75***	1051.56***	894.52***	734.26***	879.26***	795.02***	2323.70***

Notes: Poisson estimations based on SLISH 2018.The number observations is 6624. All models included all controls in Table 3.5 and district fixed effects. Robust standard errors in parentheses. Statistical significance denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3. 9: Impact of market access and seasonality on budget shares of food groups in Sierra Leone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Cereals	Rice	Roots & tubers	Meats	Fish & seafood	Diary	Fruits	Vegetables	Legumes	Fats & oil
LSCM	-0.021***	-0.024***	0.002*	0.002***	0.009***	0.001***	-0.000	0.005***	0.004***	0.011***
	(0.005)	(0.005)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)
NLCM	-0.062***	-0.062***	-0.001	0.002***	0.010***	0.001***	0.001**	0.011***	0.002**	0.010***
	(0.005)	(0.005)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)
NLFM	-0.054***	-0.054***	-0.000	0.002***	0.009***	0.002***	0.002***	0.013***	0.007***	0.015***
	(0.005)	(0.005)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)
Constant	0.403***	0.373***	0.029***	-0.005	0.112***	0.005	0.010***	0.075***	0.031***	0.126***
	(0.018)	(0.019)	(0.005)	(0.005)	(0.010)	(0.004)	(0.002)	(0.006)	(0.005)	(0.007)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes
District FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	Yes
N	13120	13120	13120	13120	13120	13120	13120	13120	13120	13120
R^2_{adj}	0.627	0.586	0.178	0.120	0.559	0.152	0.101	0.543	0.428	0.593

Notes: OLS estimation. The reference category is lean season and far from the market. See notes to Table 3.5. Robust standard errors in parentheses. Statistical significance indicated as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.5.3 Exploring potential pathways

The results presented in the previous section suggest that closeness to markets holds significant potential to mitigate seasonal fluctuations in dietary diversity and food security. The results in Table 3.10 explore the potential pathways that could underlie this finding. Market participation is measured by the crops commercialization index and an indicator of whether or not the household sold at the farmgate (in models 1–2). Access to off-farm incomes is captured by whether or not any household member operates a non-farm business enterprise (in column 3). Lastly, the credit pathway is examined in column 4.

Table 3. 10: Potential pathways linking market access to improved food security

	(1)	(2)	(3)	(4)
	Commercialization index	Sold produce at farmgate	Operates a non-farm enterprise	Obtained credit for consumer goods
Panel A: Market access				
Close to market	0.022^{***}	-0.186^{*}	0.364^{***}	0.298^{***}
	(0.008)	(0.098)	(0.077)	(0.094)
Constant	0.769^{***}	-1.772^{*}	-5.209^{***}	0.278
	(0.064)	(0.926)	(0.391)	(0.633)
Controls	Yes	Yes	yes	yes
District FE	Yes	Yes	yes	yes
Year FE	Yes	Yes	yes	yes
N	4980	4016	13187	4418
Panel B: Interacting seasonality & market access				
LSCM	0.017	-0.156^{**}	0.316^{***}	0.267^{***}
	(0.012)	(0.077)	(0.061)	(0.078)
NLCM	0.019^{*}	0.101	0.187^{***}	0.155^{**}
	(0.010)	(0.072)	(0.063)	(0.078)
NLFM	0.046^{***}	0.037	0.319^{***}	0.282^{***}
	(0.011)	(0.077)	(0.060)	(0.076)
Constant	0.754^{***}	-1.110^{**}	-3.109^{***}	-0.003
	(0.065)	(0.520)	(0.228)	(0.383)
Controls	Yes	Yes	Yes	yes
District FE	Yes	Yes	Yes	yes
Year FE	Yes	Yes	Yes	yes
N	4980	4016	13187	4418

Notes: Results in column 1 are based on OLS estimation, and those in columns in 2-4 are probit estimations. A household is considered to be close to the market if the time to the nearest market is 60 mins or less. See notes to Table 3.5 for a list of control variables. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results show that rural households with better market access are associated with a significantly higher level of commercialization and lower propensity to sell at the farmgate. As discussed above, the literature has shown that transaction costs decline, and relative market prices improve, with reductions in travel time or distance between production and exchange locations (Fafchamps & Hill, 2005; Renkow et al., 2004). This improves the profitability of transporting and selling their output at the nearest market, instead of selling them at lower prices at the farmgate (Fafchamps & Hill, 2005). The results in Panel B reveal that the effect of proximity to markets on commercialization is strongest in the non-lean seasons when rural farm households need to reach markets to sell their produce.

The results also disclosed that households located in areas with better market access also have a higher propensity of engaging in off-farm economic ventures than isolated households. This may be because households in remote areas have limited access to thicker markets – with many buyers and sellers – which render the operation of non-farm enterprises less economically viable. From a food security perspective, operating off-farm enterprises provides households with an alternative source of income, with which they can bridge deficits in household food supplies, especially in the lean season. The presence of an off-farm source of income in the household is associated with more diverse diets and less seasonal variation in consumption over the year in Mozambique (Handa & Mlay, 2007).

Lastly, closeness to markets is found to be strongly associated with the likelihood of getting credit for consumption purposes. Most Sierra Leonean households obtain credit from families, friends, and neighbours. However, market traders, being the second most important source of credit (Statistics Sierra Leone, 2018), are also instrumental in easing financing constraints on households and improving food security. In the face of limited or non-existent credit from formal financial institutions, access to (output) markets can contribute to improved food security by connecting financially-constrained households to market traders, who offer credits in the form of cash, foods, or inputs. As shown by the results in Panel B (column 4), this can enable households to bridge short term or seasonal food shortages. These results are also consistent with findings in other studies. For instance, Schrieder and Heidhues (1995) have shown that access to production and consumption credits has a positive and significant impact on rural households' food security in Cameroon. In a related study, Annim and Frempong (2018) have also shown that access to credit contributes to the consumption of a diversified diet in Ghana.

3.6 Conclusions

This chapter examines the role of seasonality in shaping household dietary diversity and food security over the agricultural production cycle in Sierra Leone. The analyses of household consumption patterns over the year and agricultural seasons, using the 2011 and 2018 SLISH datasets, reveal that seasonality exerts considerable fluctuations in the dietary diversity and food security of Sierra Leonean households. We find that household diets and food security primarily follow the regular patterns of agricultural production: improving during the harvesting season and worsening in the post-harvest period. We find that rural households are most vulnerable to food insecurity during the lean season when coping strategies such as limiting portion size at mealtimes and skipping meals are most frequently deployed. Although it remains low, the results show that household dietary diversity improves during the lean season compared to its level in the harvesting period, as households modify their diets in response to limited supply and access to rice – the main staple food. Furthermore, this study demonstrates that proximity to food markets holds beneficial effects of mitigating seasonal variabilities in household diets and food security. In particular, we find that households with better market access consume more diverse diets and are more food secure throughout the year than remoter households. The results also show that nearness to food markets facilitates all-year-round access to and intake of nutritious non-staple food groups such as meats, fish and seafood, dairy, legumes, and vegetables. Lastly, the results reveal that closeness to markets can smoothen seasonal fluctuations in household dietary diversity and food security by enhancing commercialization, access to off-farm income-generating opportunities, and access to credit – all of which are important in bridging short-term household food deficits.

A key policy implication of these findings is that fostering access to markets and integration for remoter households can significantly reduce vulnerability to seasonal food insecurity and avert the use of deleterious strategies to cope with persistent seasonal food deprivation. The reason is that, in a country where households predominantly source their foods from markets, poor market access significantly reduces food access and availability by impeding the cost-effective movement of foodstuffs from surplus areas to deficit areas. More distant markets are associated with higher production costs and lower profitability (and income) for sellers and higher transportation costs and food prices (lower effective purchasing power) for buyers, all of which exacerbate seasonal fluctuations in food availability and access at both local and national levels.

A major limitation of this study is that, while it attempts to quantify the effects seasonality using a seasonally-disaggregated data, the data is in essence cross-sectional. The lack of high-frequency panel data prevents us from analysing the dynamics of market access as well as the patterns of food consumption, food security and dietary diversity of specific households and individuals across seasons and over time. Another shortcoming is that in characterizing market access the study focuses on geographical proximity to food markets, which may be a very poor indicator of other dimensions of market quality. These important conditions of food markets include the quality of road and other market infrastructure, the varying transport costs, availability and affordability of different foods in the market across seasons, and frequency of openings. Last but not least, the extent of financial markets integration and its implications for food security and nutritional outcomes across seasons are not overtly examined in this study, even though the pathway analysis suggests access to credits could be instrumental improving these outcomes. Future studies may benefit from availability of data that capture these dimensions of markets.

Despite these limitations, the findings from this study are relevant for policy in Sierra Leone and other developing countries with similar contextual features. As previously highlighted, markets are not well-integrated in Sierra Leone, with majority of households living in communities with no functional market (World Food Programme, 2015). Poor road conditions severely inhibit physical access to markets. Most Sierra Leonean communities are served by dirt or feeder roads, which become impassable during the rainy (and lean) season when household food shortage is rife, and households gravely need to reach markets to purchase and sell food items. Lengthy distances to roads and markets do worsen not only the energy and time burden on households but also their already precarious food and nutrition security situation. Hence based on the results, we conclude that development strategies aimed at strengthening market access through improved market infrastructure and roads can significantly contribute to year-long food consumption smoothing, improved dietary diversity, and overall food and nutrition security in Sierra Leone and Africa at large.

CHAPTER 4

Enhancing household resilience to food insecurity: the case of smallholder cash crop farmers in rural Sierra Leone

4.1 Introduction

The world is not on track to eliminate all forms of malnutrition and poverty by 2030 (FAO et al., 2019). Global hunger has steadily increased since 2014, wiping out the decade-long progress made in reducing malnutrition and leaving 690 million people worldwide undernourished (FAO et al., 2020). Climate-related extreme events (such as cyclones, heatwaves, floods, and droughts), conflict, and economic downturns have been identified as the principal contributors to the reversal (FAO et al., 2019; FAO et al., 2017, 2018). Poor and vulnerable individuals and communities, whose livelihoods are highly dependent on agricultural activities, are the worst affected because they often lack the capacity to adequately prepare, adapt, and recover from these climatic, economic, social and environmental shocks when they occur.

Households in Sierra Leone live in one of the most fragile and shock-prone countries in the world. Based on its level of exposure and vulnerability to extreme events, the West African country was placed eighth on the Global Climatic Risk Index for 2017 (Kreft et al., 2017). As a post-war state, Sierra Leone continues to suffer from the lingering deleterious effects of a decade-long civil war, which ravaged the country between 1991 and 2002. The rates of poverty (60%), adult illiteracy (51.6%), undernourishment (30.9%), stunting (38%) and food insecurity (49.8%) remain alarming, leaving the country consistently among the bottommost performers as regards human development (Statistics Sierra Leone and ICF International, 2014; World Bank & Statistics Sierra Leone, 2014; World Food Programme, 2015). Although appreciable progress in economic development has been achieved since peace returned, Sierra Leone's road to recovery, stability, and reconstruction has not been any smoother. It has been battered by major exogenous shocks and natural disasters that caused significant disruption to economic activities; loss of livelihoods; damage to infrastructures; and human casualties. Notable among them were the 2007/2008 worldwide financial, food, and fuel crises; the 2014-2016 West

African Ebola outbreak, which claimed 1,463 lives (WHO, 2015); and floods and landslide disasters in 2017, which led to the demise of 1,141 others (World Bank, 2017).

At the micro-level, most households are also exposed to multiple, interconnected, and, sometimes, recurrent shocks. In 2011, as high as 83 percent of Sierra Leonean households reported to have recently experienced at least one shock that had adversely affected their welfare in terms of production and consumption (World Food Programme, 2011). Although this proportion declined to 53.3 percent in 2015 (World Food Programme, 2015), majority of households remain susceptible to a variety of covariate and idiosyncratic shocks. These often range from human epidemics, floods, pre-and post-harvest losses due to pests and diseases, death and illness of household members, lack or loss of a job, food price instabilities, and high costs of agricultural inputs (World Food Programme, 2011, 2015). These extreme events do not only exacerbate their already precarious food security situation but also tend to hamper efforts to eliminate hunger, malnutrition, and poverty in the country.

Poor and vulnerable households across the world grapple with diverse, shocks and stressors on almost a regular basis. By devoting millions of dollars in humanitarian assistance every year, international development and aid communities have enormously contributed to saving many lives cornered in climate-related and conflict-induced crises in different parts of the world. However, they have not adequately strengthened the long-term capacity of the affected populations to withstand future shocks and stresses (Frankenberger et al., 2012). Poverty, high dependency on rain-fed agriculture and natural resources, conflict and poor governance, inadequate physical infrastructure and other structural vulnerabilities remain largely unaddressed, leaving these populations in persistent fragility and consistently in need of humanitarian assistance (Béné et al., 2020; Frankenberger et al., 2012).

In poor and shock-prone countries, like Sierra Leone, robust and adequate social protection systems are woefully inadequate (World Bank, 2015b). As a result, households are often constrained to adopt negative coping strategies like selling productive assets, depleting savings, incurring debts, cutting health and educational expenses, or undesirably changing the frequency, quantity, and nutritional mix of their meals (World Food Programme, 2011, 2015). Some of these survival mechanisms, however, can aggravate vulnerability to food insecurity and poverty (Carter & Barrett, 2006). For instance, resorting to the intake of less diverse and nutrient-dense foods or de-enrolling children from school can irreversibly retard their cognitive and physical development (Hoddinott et al., 2013). These short-term negative responses may detract from their human capital accumulation and prospects of escaping hunger and poverty in the long-run (Carter & Barrett, 2006).

Recent decades have seen increasing frequency and severity of adverse events (Zseleczky & Yosef, 2014). As a result, there has been heightened interest and growing discussion around policy circles on the need to prioritize resilience in development programmes to strengthen the capacity of poor, vulnerable households, communities and nations to alleviate the impact of shocks and stressors on food security and nutrition (Fan et al., 2014; FAO et al., 2018; The Montpellier Panel, 2012). Building resilience, as Fan et al. (2014) described, entails strengthening household, societal, national, and institutional capacities to be better able to avert, anticipate, prepare for, adapt, and recover from shocks, and even become better-off after a disaster has struck. Resilience has a long-standing history in different fields such as engineering, ecology, epidemiology, and psychology (Fletcher & Sarkar, 2013; Holling, 1996; Park et al., 2013). However, its thinking and practice have recently been adopted in the field of development to ‘ensure that adverse stressors and shocks do not have long-lasting adverse development consequences’ (Constas et al., 2014; Fan et al., 2014; FAO et al., 2015). In particular, resilient food and agricultural systems are considered not only to have capacities to withstand various shocks themselves but also to reinforce household resilience to food security shocks by preserving the availability of, access to and utilisation of diverse, nutritious foods (Frankenberger et al., 2012; Smith & Frankenberger, 2018). Therefore, understanding the drivers and impacts of household resilience may contribute to better investment decisions and the design of interventions and policies that affect food and agricultural systems in vulnerable, developing areas.

Despite garnering much attention around policy circles and in the literature, there is little evidence on the effects of resilience on food and nutrition security. The main reason is that resilience has been conceptualised as a ‘capacity,’ which can be constructed or explained by focusing on assets, coping strategy index, food consumption, and other indicators of food security or household wellbeing (D’Errico et al., 2016). According to Cissé and Barret (2018), for instance, resilience is the capacity of a household or other unit to avoid poverty in the face of different shocks and stressors. Hence, a household is deemed resilient if it maintains its food security level above a critical threshold over time. Using this approach, Phadera et al. (2019) constructed resilience as the probability that a household will sustain at least the threshold asset level required to support consumption above the poverty line. Their results showed that an asset transfer program in rural Zambia increased household resilience by raising the beneficiaries’ probability of being non-poor in future periods. Knippenberg et al. (2019) also explored household resilience in relation to food security by tracking changes in the coping strategy index (CSI) over time in response to shocks.

By conceptualising and measuring resilience in terms of wellbeing indicators, these studies view resilience as an end in itself or the final goal of a development programme. Consequently, they fail to adequately delink resilience from food security because they constructed resilience from other variables related to food security (Ansah et al., 2019; Béné et al., 2020). Also, since resilience is primarily about the ability or capacity of a household to deal with shocks, resilience should rather be seen as an intermediate outcome necessary to achieve a long-term developmental goal, such as improved wellbeing (Béné et al., 2020; d'Errico et al., 2018; d'Errico & Pietrelli, 2017; Hoddinott, 2014; Smith & Frankenberger, 2018). As the United Nations' Rome-based organizations emphasized 'resilience-building programming needs to be evaluated for its medium-and long-term impacts on food and nutrition security in the face of recurrent shocks and chronic stressors' (FAO et al., 2015).

Therefore, the purpose of this study is to exploit the development intervention discussed in Chapter 2 to examine what kind of interventions are needed to build the resilience capacity of households. The other key questions investigated in this chapter include: why are some households more resilient than others? Does resilience capacity mitigate the negative effects of shocks on food security? In answering these questions, to the best of our knowledge, this is the first study to examine the impact of an integrated agricultural value chain and nutrition programme on household resilience capacity. The study also goes beyond measuring household resilience capacity to examine how it relates to changes in household food security in the face of shocks in Sierra Leone. By so doing, it sheds light on the predictive power of resilience capacity. This kind of analysis remains a grey area in the empirical literature on resilience analysis (Hoddinott, 2014).

The remainder of this study is structured as follows. Section 4.2 presents the conceptual framework that undergirds our analysis of the links among resilience, shocks, and food security. It is also describes the programme understudy. Section 4.3 explains the methodology used to measure household resilience capacity. The data and methods are presented in Section 4.4. Section 4.5 analyses and discusses the results of the estimations. Section 4.6 concludes the study with key findings and policy implications.

4.2 Conceptual framework, and the PROACT programme

4.2.1 Conceptualizing resilience capacity

In the wake of increasing occurrence and severity of unanticipated shocks and stressors, building resilience for food and nutrition security has been the subject of discourses and research in development in recent years (Fan et al., 2014; FAO et al., 2017, 2018). The concept of resilience is elusive and has been variously defined and used in different fields, including ecology, engineering, epidemiology, and psychology. In the ecological literature, resilience is described as 'the amount of disturbance a system can absorb before shifting into an alternative state' (Holling, 1973). Further, the Intergovernmental Panel on Climate Change (IPCC) defined resilience as 'the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner'(Field et al., 2012). While a plethora of definitions exists in different fields, they share some common elements. In general, they stressed that resilience is the ability or capacity to react to temporal (shocks) or persistent (stressors) adverse events, such that they do not have long-term damaging development consequences (Constas et al., 2014). Additionally, resilience can be viewed or analysed at different levels: from individuals to aggregate units such as households, communities, organisations, and systems, or nations (Fan et al., 2014).

In this study, we focus on the resilience capacity of smallholder farm households to food security shocks. To conceptualise resilience and its link with food security, a household's resilience is assumed to be derived from several household attributes, also known as resilience pillars. These pillars are either measured subjectively through self-evaluation of households' perceived abilities to prepare, withstand, adapt, or recover from future adverse events or objectively through a factor analysis of observed household and community characteristics. In their pioneering work on measuring household resilience in the context of food security, Alinovi et al. (2008; 2010) considered these pillars to be income and food access, assets, social safety nets and public services, adaptive capacity and stability – all of which are latent (unobserved) variables and are obtained through a factor analysis of their respective observed variables. Smith and Frankenberger (2018) and Béné et al. (2020; 2016) conceptualised these pillars in terms of absorptive, adaptive, and transformative capacities. Here, the absorptive capacity has to do with the ability to lessen exposure to shocks and to recover quickly from shocks when affected. The adaptive capacity entails the ability to make informed and proactive decisions on different livelihood activities in response (or to adapt) to changing environments within which they live and operate. The transformative capacity refers to household and communal access to basic services, infrastructures, institutions, and other enabling conditions that enhance resilience. Ansah et al. (2019) provided a succinct survey of literature on different methods of conceptualising, measuring, and operationalising household resilience in the context of food and nutrition security). In this study, we adopt the most widely used approach to measuring resilience capacity, developed by the United Nations Food and Agriculture Organization (FAO, 2016). In the FAO's Resilience Index Measurement Analysis (RIMA) approach, overall resilience capacity can be derived from four underlying pillars, namely access to basic services, ownership of assets, access to social safety nets, and adaptive capacity (FAO, 2016). The RIMA approach has been applied in resilience analyses in several countries in Africa (d'Errico et al., 2018; d'Errico & Pietrelli, 2017) as well as Palestine (Alinovi, Mane, et al., 2010; Brück et al., 2019). The technical details of the RIMA approach are covered below.

4.2.2 Linking resilience capacity and food security

With these initial ideas in mind and drawing from existing literature (Ansah et al., 2019; FAO, 2016; Frankenberger et al., 2012), we postulate the conceptual framework in Figure 4.1 to guide our analysis. The framework highlights the broader environment within which a household (or other units of focus) dwells and acts. This context encompasses, among others, social, environmental, political, and institutional settings. These settings govern the availability and allocation of resources to households, livelihood options from the use of those resources, and how the economic returns from the use of those resources culminate in food and nutrition security and other such welfare outcomes. Not only does the context determine the degree – severity, frequency, and duration – of households' exposure to idiosyncratic and covariates shocks and stressors, but it is also, in turn, affected by these shocks and stressors. While idiosyncratic shocks affect particular households (e.g., death or illness of household members), covariate shocks affect several households located within a community, sub-region or similar geographical area (e.g., droughts, floods, the outbreak of human, livestock, or crop diseases/pests, and high and volatile food prices).

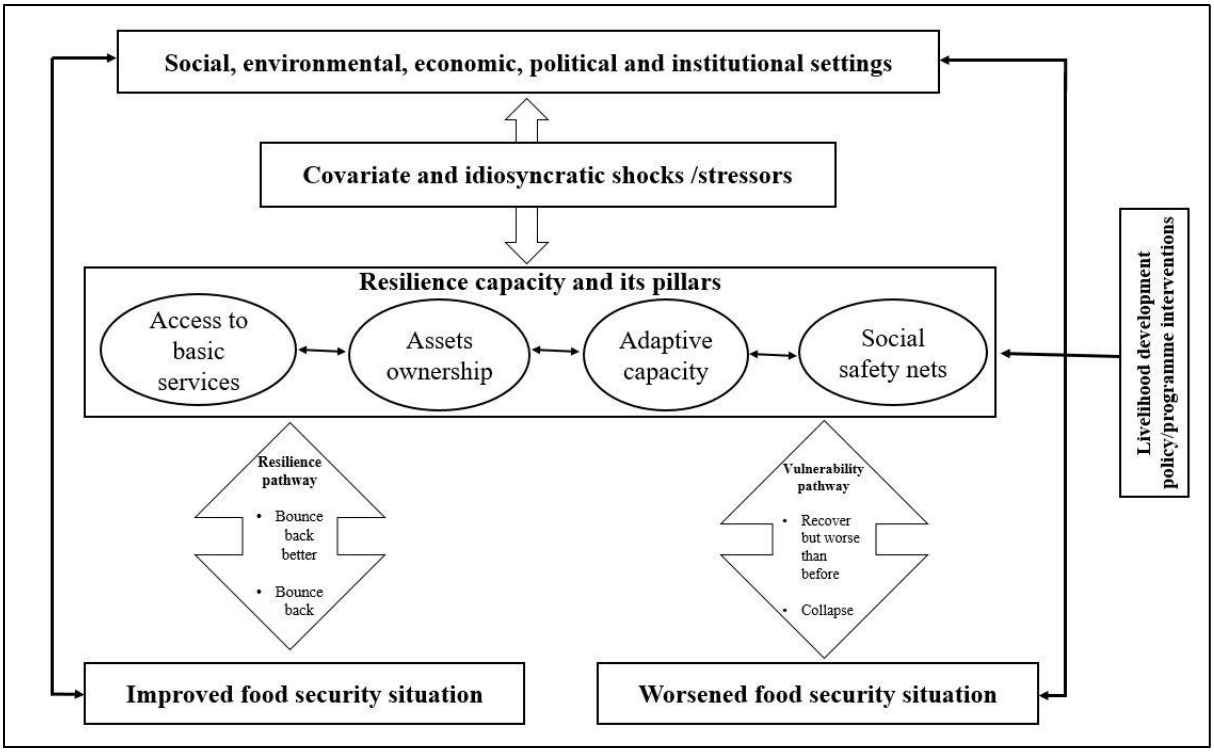


Figure 4. 1: Conceptual framework linking household resilience and food security.

Source: Own illustration based on Ansah et al. (2019), FAO (2016), and Frankenberger et al. (2012).

One of the primary goals of households is to maximise their welfare, in this case, food and nutrition security. That is, to have at all times, physical and economic access to sufficient nutritious food required to lead a healthy and active life. Adverse shocks and stressors significantly inhibit the attainment of this fundamental goal, mainly by eroding the household's abilities to prepare *ex-ante* and withstand, adapt, or recover *ex-post* a shock. In the face of impending or actual shocks, households take different decisions and actions based on their attributes or capacities to prevent or attenuate their detrimental effects on food security (and other aspects of wellbeing). In line with the FAO approach, Figure 4.1 identifies the nature and extent of a household's access to basic services (ABS), assets owned (AST), adaptive capacity (AC) and access to social safety nets (SSN) as the four key building elements of its resilience to adversities. Their availability, accessibility, and utilisation in the wake of shocks could also be influenced by the local settings within which households live. As described in FAO (2016), ABS captures the household's ability to meet basic needs as well as to access and effectively utilise basic institutional and public services, such as schools, health centres, markets, and water, sanitation, and hygiene infrastructures. AST includes productive and non-productive assets, with the former contributing to income-generating activities and the latter reflecting the household's living standards and wealth. AC captures the household's ability to devise new livelihood strategies to adapt to new circumstances effectively. SSN covers the household's ability to receive timely and steady assistance from families and friends, government, international agencies, and civil society organisations when disaster strikes.

By contributing to household resilience capacity, these pillars represent the resilience mechanisms that are deployed to deal with anticipated or actual threats to food security. In general, they are activated in an attempt to absorb or withstand shocks or bounce back to the original state of wellbeing after a shock. They also serve as entry points for policy interventions and programmes directed at building resilience capacity of households (Ansah et al., 2019). As described in Box 1, this study examines to what extent nutrition-sensitive agricultural interventions can contribute to building these capacities of smallholder households in rural Sierra Leone. Detailed information on the interventions are provided in Chapter 2.

Over the long-term, the mechanisms activated by a household in response to a shock can improve or worsen the household's food security situation (or overall welfare) after the shock is past. Without loss of generality, Figure 4.1 posits two potential trajectories to wellbeing *ex-post* a shock. More resilient households are able to bounce back to or even better than their initial level, hence follow the resilience pathway to improved food security status (Hoddinott, 2014). Those on the vulnerability pathway are less resilient households. They either recover partially or collapse after a shock and end up with a worsened food security situation than their pre-shock level (Hoddinott, 2014). Any change in food security status has feedback effects on the overall context as well as future capacity to deal with shocks. While improved food security and nutrition could enhance household resilience against looming shocks, compromised food security and nutrition could undermine the household's ability to withstand future shocks, and result in a downhill spiral of resilience and wellbeing.

Box 1 The case of the PROACT project in rural Sierra Leone

Context

In Sierra Leone, cocoa, coffee and cashew hold tremendous potential for improving smallholder households' incomes, wellbeing, and overall national development. However, this potential remains largely unexploited because several challenges have militated against their production. The protracted internal conflict and the recent Ebola epidemic were injurious to these high-value cash crop sectors in the country. Other obstacles facing tree crop growers include unfavorable weather conditions, lack of sufficient knowledge, and adoption of best farming and post-harvest practices, inputs and credit constraints, poor physical infrastructure, and pervasive poverty. These difficulties have persistently kept productivity and smallholder incomes very low and rendered growers highly vulnerable to food insecurity, and several shocks and stressors.

The programme interventions

In a quest to help smallholder farmers overcome these constraints and revamp cocoa, coffee and cashew production in the country, the Pro-Resilience Action 2015 (PROACT) project (hereafter, intervention or programme) provided growers with comprehensive training on agronomic, harvesting, and post-harvest practices in farmer field schools. The intervention also supplied farmers with inputs, such as seedlings, polybags, cutlasses, pruning saws, shears, and solar plastics. These soft and hard inputs were provided to build their capacities to rehabilitate old and unproductive plantations, establish new nurseries, and undertake high-quality post-harvest processing of cocoa, coffee, and cashew.

Incorporated within this cash crop intervention was a nutrition-based programme, which provided locals with a multi-sectoral training on nutrition, gender, nutritious food crops production, water, sanitation and hygiene (WASH), and resource management. Through role-playing, drama, cooking sessions, and other participatory approaches, trained experts and extension officers work with participants to identify local health and nutrition problems and devise practical solutions to them. This supplementary intervention, also named Linking Agriculture and Natural Resource Management towards Nutrition Security (LANN), aimed to spread nutrition awareness and stimulate positive behavioral change for good health and improved nutrition, particularly for nutritionally vulnerable members of households and communities. The training in both project components was delivered in the targeted communities on the platform of existing or newly formed cooperatives, women's groups, and other farmer-based or community-based organizations.

By applying the nutrition lens to support for cash crop production, the services provided to smallholder households through the programme has the potential to strengthen their resilience capacity against food insecurity and shocks. Precisely, this integrated agriculture and nutrition intervention could enhance resilience by building their adaptive capacity and assets. The agricultural and nutrition education components could reinforce adaptive capacity by improving farmers' knowledge of good agricultural and nutritional practices. The transfer of agricultural tools, in addition to the skills development, could also boost their resilience capacity by alleviating input constraints and expanding their productive assets base. It could also contribute to restoring depleted productive assets in the wake of shocks and enhancing post-shock recovery by facilitating agricultural production and income generation.

4.3 Measuring resilience: the RIMA-II approach

Resilience is a complex and latent concept that is not readily observable or measurable. Different researchers, practitioners, and organisations have defined and measured it in different ways (Alinovi et al., 2008; Ansah et al., 2019; Constas et al., 2014; d'Errico et al., 2018; d'Errico & Pietrelli, 2017; Smith & Frankenberger, 2018). From a food security perspective, resilience is commonly considered as the capacity to preserve people's access to and intake of sufficient nutritious food despite being affected shocks and stressors. Here, capacity consists of a range of *ex-ante* attributes that can reinforce a household's 'ability to anticipate, absorb, accommodate, or recover from the effects a hazardous event in a timely and efficient manner' (Field et al., 2012) – without compromising their food security and overall wellbeing.

In this study, given the data at hand, we quantify household resilience capacity based on the Resilience Index Measurement Analysis II (RIMA-II) framework developed by the United Nations Food and Agriculture Organization (FAO) (FAO, 2016). Within this framework, the attributes that contribute to resilience are categorised into four fundamental pillars, namely Access to Basic Services (ABS), Assets (AST), Adaptive Capacity (AC), and Social Safety Nets (SSN). Each pillar is viewed as a latent variable, comprising of several socio-economic indicators that can be collected by a household survey. Complete details of the indicators utilised in measuring each pillar are provided in the appendix.

Estimating resilience through FAO's RIMA-II methodology involves two steps. The first stage entails a factor analysis to predict each pillar from a set of observed characteristics that are used as proxy indicators of the latent variable. As a data reduction technique, factor analysis predicts a common latent variable as a linear combination of the underlying (unobserved) factors that reflect the extent of inter-correlations between the observed variables. In this study, the factors retained are those that explain at least 90% of the variation and inter-correlations among the observed variables. When multiple factors are retained, the pillar is constructed as the weighted sum of the selected factors, with the proportion of variance explained as weights (d'Errico & Pietrelli, 2017).

In the second stage, the resilience capacity index (RCI) – a latent outcome which identifies the relationship among the four pillars while taking into account food security indicators – is estimated through the Multiple Indicators Multiple Causes (MIMIC) model. The MIMIC model consists of structural and measurement components. While the structural component correlates the estimated pillars to resilience capacity through a structural equation modelling (SEM), the measurement component specifies the relationship between predicted latent variable (RCI) and a set of observed outcome variables (food security indicators). The structural and measurement components of the SEM-MIMIC framework can be respectively modelled in Equations (4.1) and (4.2):

$$[RCI]_{it} = [\delta_1, \delta_2, \delta_3, \delta_4] \times \begin{bmatrix} ABS \\ AST \\ SSN \\ AC \end{bmatrix}_{it} + [\varepsilon_1] \tag{4.1}$$

$$[W_1, W_2, \cdots, W_n] = [\alpha_1, \alpha_2, \cdots, \alpha_n] \times [RCI] + [\varepsilon_2, \varepsilon_3, \cdots, \varepsilon_n] \tag{4.2}$$

where *RCI* is the resilience capacity index of household *i* at time *t*. *ABS*, *AST*, *SSN*, and *AC* are the four-factor indexes of resilience pillars. W_n are the different welfare (food security) outcomes. δ_i and α_i are coefficients (loadings) to be estimated and ε_i are error terms. In this study, we used the household dietary diversity score (HDDS) and per capita food consumption expenditure as food security indicators (W_n) in the measurement model (Equation 4.2). In analysing the predictive power of resilience capacity, we also utilised the food consumption score (FCS) as an alternative measure of household wellbeing.

RCI has no unit of measurement as it is innately latent or unobserved. A reference unit is defined by constraining the coefficient of food consumption expenditure to unity, implying that a one standard deviation rise in RCI leads to one unit rise in the standard deviations of food expenditure. The coefficients of other food security indicators are interpreted similarly. The estimated RCI is transformed into a standardised index, with values ranging from 0 to 100, using the min-max scaling. Higher values of RCI denote higher resilience to food insecurity (FAO, 2016).

Compared to RIMA-I, which initially treated resilience as an indicator of food security, RIMA-II models food security, and shock indicators as separate variables from resilience capacity. Within this updated framework, food security is considered as a resilience outcome. At the same time, shocks are deemed exogenous and are used as regressors to analyse their impacts on household resilience and food security. Beyond measuring resilience capacity, policymakers are also interested in understanding their predictive power, especially in the context of future food security status and shocks (FAO, 2016; Hoddinott, 2014). Thus, it is interesting to explore the dynamic nature of resilience to determine whether a household's ability to maintain their food security in the face of a shock is shored up by their resilience capacities before the occurrence of the shock.

In so doing, we require a food security measure that was not included in the RIMA II model to alleviate potential endogeneity in our resilience indicator. Hence, we adopt the food consumption score (FCS), a widely applied measure of household food security developed by WFP. The FCS simultaneously captures household dietary diversity, food frequency, and nutritional importance of the different food groups consumed. Higher values of FCS are indicative of better food security outcomes. As expressed in Equation (4.3), the FCS is constructed by aggregating the frequency of food groups consumed in the past seven days weighted by the relative nutritional value of the food groups.

$$FCS = \sum_{g}^{G} \omega_g \times days_g \tag{4.3}$$

where $days_g$ is the number of days a household had consumed from a given food group g during the one week preceding the survey, and ω_g is the assigned nutritional value (weight). G is the set of eight food groups used in measuring the food consumption score. The food groups (and respective weights) are main staples (2); pulses (3); vegetables (1); fruits (1); meat/fish (4); milk (4); sugar (0.5) and oil (0.5) (World Food Programme, 2008).

4.4 Data and methods

4.4.1 Data

The primary data used for this study come from two household surveys of smallholder tree crop farmers in the Eastern and Northern Provinces of Sierra Leone. We conducted the surveys as part of a research collaboration between the Center for Development Research (ZEF) at the University of Bonn, Germany, and Welthungerhilfe (WHH), Sierra Leone. The dataset is a panel in nature, comprising of 836 randomly sampled smallholder households from six project districts tracked over one year. The two-stage cluster sampling design was used, with villages as the primary sampling units and smallholder tree crop farming households as the secondary sampling units. With probability proportional to the size (PPS) of each district, villages (clusters) were randomly sampled in the first stage of the sampling design. In the second-stage, simple random sampling was used to select cocoa/coffee and cashew farming households from the sampled villages. The 836 sampled households comprised 251 households who benefited from the cash crop intervention alone, 130 households from the nutrition alone, and 193 households from both interventions. The remaining 262 were households from non-intervention villages, and they participated in neither the cash crop nor nutrition intervention.

Face-to-face interviews were conducted with sampled households during November 2017–March 2018 and November 2018–March 2019 using comprehensive household and community questionnaires. At the household level, surveys collected information on agricultural production, consumption expenditures, income sources, ownership of productive and non-productive assets, food security, types of shocks, and household socio-economic and demographic characteristics, among others. Information on access to market, educational and health infrastructure, and other basic social services were obtained at the community level.

Using the geocodes of the villages surveyed, a gridded data was extracted on monthly precipitation over the period 1981–2016 from Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). This village-level precipitation data was used to construct a measure of long-term rainfall variability during the growing season (April-September) in Sierra Leone

4.4.2 Model specification and Estimation strategy

4.4.2.1 Model specification

The empirical approach used in this study involves three steps, which are consistent with the conceptual framework presented above. First, we construct the resilience capacity index through the RIMA-II approach. Second, we analyse the effect of the program interventions on household resilience. Third, we assess the effects of past resilience capacity on future food security outcomes, while accounting for some shocks that affected households over the study period. Given that resilience is a dynamic concept, we focus on changes in household ability to withstand shocks and bounce back, at least, to the previous level of wellbeing. To investigate the impacts of the programmes on resilience and food security outcomes, we specify the following growth model (Brück et al., 2019):

$$\Delta Y_i = \alpha + \delta T_i + \beta X_i + \varepsilon_i \quad (4.4)$$

where ΔY is the change in resilience or food security indicators for household i between time t and t+1. T is the indicator of a household's participation in the intervention. X is a vector of control variables, including a set of idiosyncratic and covariate shocks, district dummies, as well as household and village level characteristics. ε is the error term. δ is the parameter of interest, capturing the impact of the programme on resilience and food security outcomes.

The shock variables included in the model are frequently reported household and market shocks, namely, illness and death of household members, food price fluctuations, and abnormal increase in major food prices. We complement these self-reported shocks with an index of climatic risk, namely long-term variability of monthly precipitation. This is defined as the coefficient of variation and measured as the standard deviation of rainfall in the growing season divided by the mean rainfall in the same period (expressed as a percentage). The long-term growing season precipitation is measured at the village level over the period 1981-2016. The higher the coefficient of variation, the more variable the rainfall of a village is over the long-term. The household characteristics include the household head's age, gender, and marital status, and household size. The squares of age and household size are included to account for non-linearities. Other household controls include the number of sleeping rooms in the dwelling and indicator variables for head ever attended school and membership of a cooperative and other farmer groups. Village level controls include distance to the nearest town, elevation, and the presence of a cooperative and electricity in the village. Further details on the definition, measurement as well as summary statistics of all the variables used in the study are provided in the appendix (Table 4A.1).

Our next task is to explore to what extent resilience is a good predictor of household food security attainments. In a dynamic context, we are interested in the effect of resilience capacity at time t on food security outcomes at time t+1. Theoretically, we expect past resilience capacity of the household to boost food security or food consumption growth over the two periods. In this analysis, the FCS is employed as the measure of food security. The hypothesised link between resilience and food security dynamics can be formalised as:

$$\Delta FCS_i = \alpha + \varphi FCS_i + \gamma_1 RCI_i + \gamma_2 \Delta RCI_i + \beta X_i + \varepsilon_i \qquad (4.5)$$

where ΔFCS_i represents a change in the food consumption score of household i between the first wave (t-1) and second wave (t). FCS_i is lagged food consumption score, capturing the initial level of food security. RCI_i is lagged resilience capacity index, and its coefficient measures the impact of household resilience at time t-1 on the growth of FCS. All things being equal, a positive sign of γ_1 suggests that having higher resilience capacity index in the past, on average, fosters household consumption growth. Following d'Errico et al. (2019) we also include the between-wave change in the resilience capacity index (ΔRCI_i). The main reason for its inclusion is that, by construction, the RCI is an all-inclusive index for several important household characteristics that reflect households' latent ability to cope with shocks and maintain food security. As a result, ΔRCI_i captures changes in household resilience to food insecurity as these underlying variables change over time. As d'Errico et al. (2019) noted, the sign of its coefficient (γ_2) can shed light on the role of such resilience factors in attenuating the impacts of shocks on FCS growth. A positive and significant estimate of γ_2 suggests that increases in resilience capacity over time enable households to absorb shocks and remain on the long-term growth trend of food consumption (or food security). All other variables remain as previously defined. Except for ΔRCI_i, all explanatory variables are measured at the baseline (time t-1).

Resilience and food security are self-reinforcing drivers, such that being more resilient enhances food security, and being food secure increases households' resilience or ability to manage diverse shocks better and sustain their food consumption. Therefore, employing the growth specification does not only permit us to exploit the panel structure of our dataset, but also to overcome potential endogeneity bias arising from the two-way relationship between household resilience capacity and food security (d'Errico et al., 2019; Smith & Frankenberger, 2018).

4.4.2.2 Estimation strategy

In our case of multiple treatments, we assume that $T = \{0, 1, 2, 3\}$. This suggests that T has four mutually exclusive treatment groups and takes the value 0 if household i participated in neither the cash crop nor the nutrition intervention, 1 if it participated in only the cash crop intervention, 2 if it benefited from nutrition only and 3 if combined interventions. Assuming that the treatment assignment is random, we can define the average treatment effect (ATE) for a pair of treatments as:

$$\delta_{ml}^{ATE} = E[Y_{im} - Y_{il}] \qquad (4.6)$$

which is the difference between the expected outcome after participation in intervention *m* and the expected outcome after participation in intervention l for a household randomly selected from the population. The impact on the outcome of randomly drawn participants of programme *m*, also known as the average treatment effect on the treated (ATET), can be estimated as:

$$\delta_{ml}^{ATET} = E[Y_{im} - Y_{il} | T_i = m] \qquad (4.7)$$

With our panel data and under the assumption of no correlation between the explanatory variables and the error term, we can obtain unbiased estimates of the parameters in Equation (4.4) using pooled OLS, and random effects (RE). However, this rather strong assumption may be violated in our case, the reason being that the assignment into the different treatment groups was not random, due to purposive programme placement and voluntary participation. Depending on which intervention was implemented in the village, farming households choose whether to participate or not. This participation decision may also be influenced by several observed and unobservable factors, which may result in a systematic difference between treated and non-treated households. Thus, voluntary participation renders our treatment variable T_i potentially endogenous, since it may be correlated with unobserved characteristics that are absorbed in the error term ε_i. This gives rise to the issue of self-selection, which, if left unaddressed, may lead to biased estimates of δ.

Several quasi-experimental techniques have been used in the literature to address the problem of selection bias. A widely applied panel data method is difference-in-differences (DiD) estimator. However, it is not applicable in our case because it requires a pre-treatment (baseline) data, which is not available. The first wave of the data used here took place six months after the project began to roll out in Sierra Leone. While the instrumental variables (IV) method could also address the problem of selection bias, it requires valid instruments for the endogenous treatment variables. However, it is not considered because finding an IV that is both exogenous (i.e., uncorrelated with household characteristics) and relevant (i.e., influence participation in treatment and control groups differently) is quite challenging, especially in our case of multiple endogenous treatments. The regression discontinuity design approach is also discarded because there was no well-defined, quantifiable selection, or eligibility criterion. Consequently, matching estimators seem to be the most appropriate approach to adopt.

Given data and design constraints, we employ a two-step approach to analyse the impact of the programme on household resilience and food security. In the first step, we address the potential bias from selection on observables by following Lechner (2002) and Tambo and Mockshell (2018) and applying the propensity score matching (PSM) with multiple treatments approach. Here, we estimate the individual conditional probabilities between participating and non-participation households for each intervention through probit regressions. For each treatment arm, only the first wave data is used in estimating the conditional probabilities or propensity scores. Equipped with these scores, we construct a counterfactual for each treatment level by using the nearest neighbour algorithm to match participating households with non-participating households based on a set of covariates, X. By so doing, we ensure that all covariates are balanced across treatment and control groups, within the region of common support. The matched sample is employed in the second step, where the panel growth regression models in Equations 4.4 and 4.5 are estimated using the Ordinary Least Squares estimator with Fixed Effects (OLS-FE), following Smith and Frankenberger (2017).

4.4.2.3 Assessing the matching quality

Table 4.1 presents the descriptive statistics of the covariates used in the study after implementing the propensity scores matching with the nearest-neighbour algorithm. The results are based on the sample from the first round of the survey. We examine the statistical comparability of each treatment arm and control group using the *t*-test for differences-in-means. The reported *p*-values from these tests are well above the conventional levels of statistical significance, except for a few cases in each treatment category. This suggests that, on average, the covariates are quite balanced across the treated and non-treated groups. Thus, the matched non-treated households can be used as a valid counterfactual for each treatment group. The pseudo-R^2s after matching are fairly low, indicating that there are generally no systematic differences in the distribution of covariates between the matched treated and comparison groups. As shown at the bottom of Table 4.1, only observations that are on common support have been used to create the matched sample for the remaining analyses in this study.

Table 4. 1: Difference-in-means test for covariate balance after nearest-neighbour matching

	Cash crop			Nutrition			Combined			Any intervention		
Variable	**Treated**	**Control**	***p*-value**	**Treated**	**Control**	***p*-value**	**Treated**	**Control**	***p*-value**	**Treated**	**Control**	***p*-value**
Head is male	1.00	0.95	0.08	0.95	0.87	0.34	0.98	0.97	0.75	0.96	0.99	0.04
Head is married	0.86	0.81	0.41	0.95	0.87	0.34	0.76	0.76	0.98	0.76	0.77	0.78
Head ever attended school	0.47	0.52	0.58	0.48	0.42	0.73	0.46	0.40	0.59	0.50	0.51	0.76
Household size	6.55	6.72	0.71	6.19	7.08	0.20	6.67	6.65	0.97	6.84	7.29	0.10
Household size squared	51.30	51.84	0.95	42.86	54.92	0.25	50.41	47.43	0.68	53.59	62.10	0.09
Head's age (years)	43.03	43.73	0.76	41.95	47.75	0.20	46.87	48.43	0.60	46.87	44.98	0.15
Head's age squared	2004.90	2081.30	0.72	1929.90	2507.00	0.21	2399.70	2539.50	0.66	2401.00	2186.00	0.11
Head is a cooperative member	0.35	0.36	0.93	0.19	0.10	0.39	0.28	0.27	0.91	0.47	0.43	0.43
Number of sleeping rooms	2.67	2.87	0.05	2.43	2.50	0.77	2.78	2.82	0.73	2.74	2.74	0.97
Elevation (log)	5.10	5.12	0.92	5.46	5.45	0.99	5.07	5.02	0.70	5.05	5.11	0.40
Illness of a household member	0.41	0.43	0.82	0.67	0.53	0.39	0.41	0.33	0.41	0.41	0.41	0.96
Death of a household member	0.36	0.38	0.87	0.43	0.24	0.20	0.46	0.43	0.82	0.37	0.39	0.60
Volatile food prices	0.20	0.32	0.10	0.14	0.00	0.08	0.28	0.21	0.43	0.22	0.28	0.12
Abnormal food price increases	0.09	0.06	0.56	0.14	0.19	0.69	0.11	0.09	0.73	0.08	0.11	0.43
Intensity of Ebola cases	0.00	0.00	0.23	0.00	0.00	0.10	0.00	0.00	0.47	0.00	0.00	0.40
Rainfall variability	-0.23	-0.23	0.80	-0.33	-0.34	0.80	-0.23	-0.17	0.13	-0.21	-0.23	0.14
Cooperative in village	0.61	0.71	0.20	0.57	0.58	0.96	0.72	0.71	0.97	0.73	0.65	0.06
Distance to nearest town (km)	1.97	2.02	0.78	1.48	1.24	0.56	1.84	1.87	0.91	1.78	1.67	0.38
Common support observations	248	253		120	112		177	203		567	230	
Off common support	3	9		10	150		16	59		7	32	
Matched pseudo-R^2		0.035			0.064			0.085			0.042	

Notes: Control are non-treated households. The *p*-values indicate the statistical significance of t-test on differences-in-means between non-treated and treated (cash crop, nutrition and combined) households.

4.5 Results and discussion

4.5.1 Estimating household resilience capacity

The results of the FAO-RIMA II model for estimating resilience capacity are presented in Table 4.2. It reports the second-stage estimates of the association between the different attributes and the latent variable, resilience capacity index. The first step results, involving factor analysis of observed variables to obtain the latent resilience pillars, are reported in Table 4A.2 (in appendix III).

The structural component (Panel A) links the individual attributes (pillars) to resilience capacity. The results show that all the pillars' coefficients are positive, with adaptive capacity being most influential in explaining the resilience capacity of smallholder farmers. Access to basic services is the least driver of resilience capacity. The influence of these pillars in the formation of household resilience capacity is statistically significant at conventional error levels. With the RCI expressed in standard deviation units, the magnitude of the coefficients suggests, for instance, that a one standard deviation increase in adaptive capacity results in an increase in the RCI value by 0.235 standard deviations.

The measurement component (in Panel B) reports the relationship between the estimated resilience (from the structural model) to observed food security indicators. The coefficient of food consumption expenditure is constrained to unity to make the coefficient of household dietary diversity easy to interpret (FAO, 2016). Hence, the results indicate that a one standard deviation increase in RCI leads to a 1.38 increase in the magnitude of household dietary diversity. This suggests that more resilient households are significantly associated with the intake of more diverse diets. Also reported in Panel B are the indirect effects of the pillars of resilience capacity on household dietary diversity. The coefficients reveal that adaptive capacity, ownership of assets, and social safety are the pillars of resilience capacity that contribute most significantly to improved household dietary diversity. The diagnostics tests, reported beneath Table 4.2, imply the MIMIC results are a good fit for the data.

Table 4. 2: MIMIC model of estimating resilience capacity index

Panel A: Structural component	
	Resilience capacity index (*RCI*)
Access to Basic Services (*ABS*)	0.091^{*}
	(0.051)
Assets (*AST*)	0.160^{***}
	(0.060)
Adaptive Capacity (*AC*)	0.235^{***}
	(0.062)
Social Safety Nets (*SSN*)	0.108^{**}
	(0.050)
Panel B: Measurement component	
	Food consumption expenditure per capita
Resilience capacity index (*RCI*)	1
	(0.000)
	Household dietary diversity score (*HDDS*)
Resilience capacity index (*RCI*)	1.380^{***}
	(0.367)
Indirect effects of resilience pillars	
Access to Basic Services (*ABS*)	0.126
	(0.081)
Assets (*AST*)	0.221^{***}
	(0.069)
Adaptive Capacity (*AC*)	0.324^{***}
	(0.070)
Social Safety Nets (*SSN*)	0.149^{**}
	(0.066)
Panel C: Good-of-fit statistics	
χ^2	80.564^{**}
Root Mean Square Error of Approximation *(RMSEA)*	0.030
Prob RMSEA	0.869
Standardised root mean squared residual *(SRMR)*	0.014
Comparative fit index (*CFI*)	0.936
Tucker-Lewis index (*TLI*)	0.809
Observations	1642

Standard errors in parentheses: * $p < 0.10$, $^{**}p<0.05$ $^{***}p<0.01$

4.5.2 Descriptive analyses of household resilience capacity

Table 4.3 reports the descriptive statistics of the estimated resilience capacity index and its pillars by survey wave and treatment group. It also shows whether or not the observed differences in the means of the non-intervention group and each treatment group are statistically significant. At baseline, the least resilient households were recipients of the cash crop only intervention, and the most resilient households are the nutrition only group. The results show that, compared to the non-intervention group, cash crop only households had significantly lower resilience capacity. In contrast, the nutrition alone, as well as the combined cash crop and nutrition households had a significantly higher resilience capacity index. The summary statistics of the individual pillars (from the first-stage, factor analysis) also show significant heterogeneity across treatment groups at baseline.

Table 4. 3: Descriptive statistics of resilience and its pillars

	Panel A: Baseline				
	Non-treated	Cash crop	Nutrition	Combined	Total
Resilience capacity index	56.59	51.46***	59.79**	59.09**	56.12
	(12.25)	(13.21)	(14.13)	(13.96)	(13.62)
Access to basic services	-0.277	-0.0912***	0.268***	0.0578***	-0.0592
	(0.907)	(0.545)	(0.348)	(0.509)	(0.678)
Assets	0.123	-0.122***	0.210	0.256*	0.0936
	(0.705)	(0.752)	(0.767)	(0.855)	(0.779)
Adaptive capacity	-0.122	-0.269***	-0.136	-0.189	-0.184
	(0.575)	(0.560)	(0.538)	(0.572)	(0.567)
Social safety nets	-0.0108	0.0357	0.0945**	-0.0269	0.0158
	(0.377)	(2.027)	(0.624)	(0.764)	(1.213)
Observations	262	251	130	193	836
	Panel B: Follow-up				
Resilience capacity index	62.73	61.91	62.79	65.59***	63.15
	(10.86)	(9.997)	(11.08)	(10.94)	(10.73)
Access to basic services	0.0735	-0.0123**	0.158**	0.0666	0.0592
	(0.366)	(0.430)	(0.420)	(0.414)	(0.409)
Assets	-0.0573	-0.152*	-0.202**	0.00638	-0.0936
	(0.536)	(0.635)	(0.617)	(0.628)	(0.605)
Adaptive capacity	0.164	0.161	0.227	0.210	0.184
	(0.375)	(0.363)	(0.380)	(0.347)	(0.366)
Social safety nets	0.00701	-0.0195	-0.0392	-0.0263	-0.0158
	(0.450)	(0.362)	(0.329)	(0.330)	(0.380)
Observations	262	251	130	193	836

The reported values are sample means, and those in parenthesis are standard deviations. ***, ***, and * denote statistical significance at 1%, 5% and 10% levels for t-test on differences-in-means between non-treated and each treatment group.

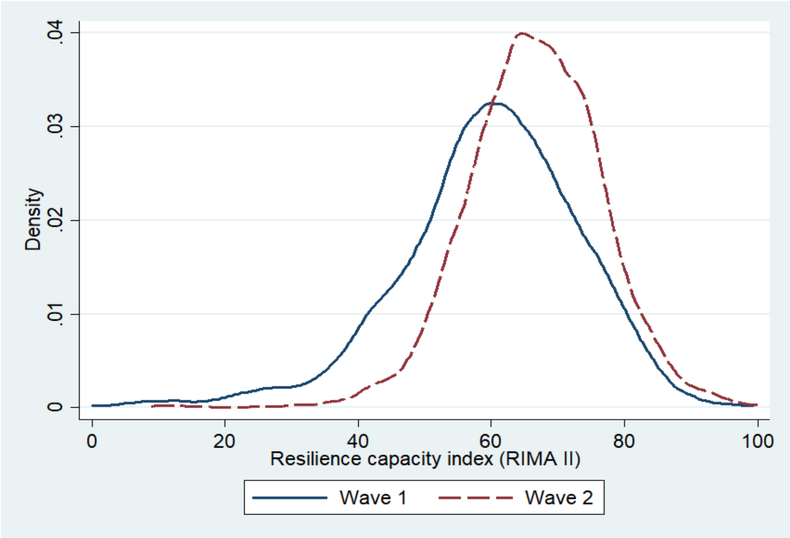


Figure 4. 2: Density distribution of resilience capacity index over survey wave

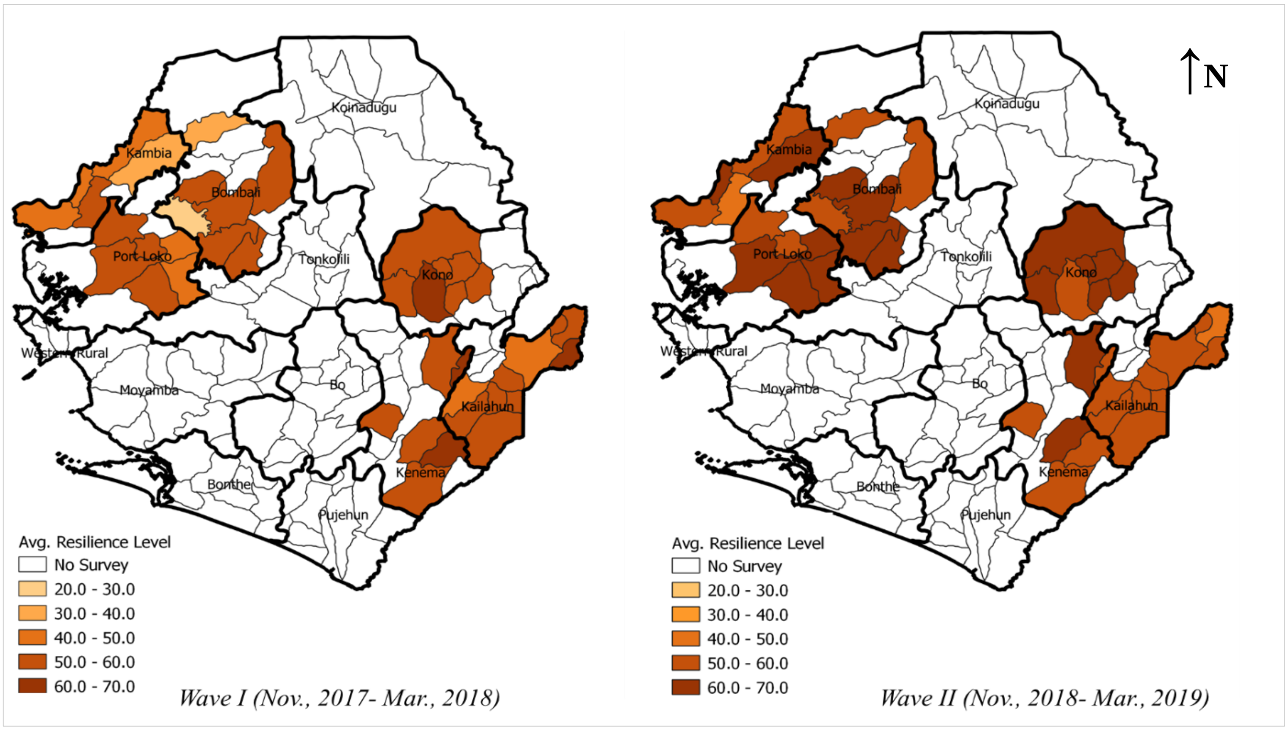


Figure 4. 3: Map of resilience capacity index across chiefdoms and survey wave

At follow-up, the resilience index increased across all treatment groups, with cash crop only households being the least resilient and the beneficiaries of the combined intervention the most resilient. However, the average resilience index for the isolated cash crop and nutrition households is not significantly different from that of non-intervention households. Similar improvements are also shown in the resilience components. Except for access to basic services and assets for individual cash crop and nutrition households, there are no significant differences in the resilience pillars between treated and non-treated groups at follow-up. Figures 4.2 and 4.3 depict variations in the estimated resilience capacity index over time and across study areas. Evidently, resilience capacity has increased (on average) over the study period (Figure 4.2) and across all districts (Figure 4.3). However, these changes cannot be directly attributed to the participation in the nutrition-sensitive agricultural intervention understudy. Such causal inferences can be drawn from the following results.

4.5.3 Impact of nutrition-sensitive programmes on household resilience

The impacts of the project on household resilience to food insecurity are reported in Table 4.4 These results are based on the panel growth model specified in Equation (4.4). The coefficients of interest are those of the treatment variable. Column 1 reports the overall impact of participation in the programme. Participation in any component of the intervention has a positive and significant impact on the change in household resilience capacity over the one-year period. All other things being equal, the results show that being a beneficiary contributes, on average, 2.15 points to the growth in household resilience capacity. Quantitatively, this amounts to a 3.8 percent increase from the baseline value of 56.6 for non-treated participants (see Table 4.4). This finding suggests that, relative to the non-treated group, the programme has significantly enhanced the ability of households to maintain their wellbeing in the face of shocks. That is, interventions households are better able to absorb and react to shocks, without compromising their food security. The results in columns 2–4 show the heterogeneous impacts of the integrated programme relative to the comparison group. The change in resilience capacity is positive across all treatment groups. The largest and most statistically significant increase in resilience capacity occurred among cash crop only households. Albeit positive, the impact of the nutrition only and combined intervention households on change in household resilience capacity are statistically insignificant. This could be due to a number of reasons.

Table 4. 4: The impact of the programme on household resilience capacity

	(1)	(2)	(3)	(4)
Treatment	Any intervention	Cash crop	Nutrition	Combined
Dependent variable	ΔResilience	ΔResilience	ΔResilience	ΔResilience
Treatment	2.151*	3.964***	1.199	1.833
	(1.148)	(1.257)	(2.167)	(1.691)
Illness of any household member	1.293	1.678	2.019	3.839*
	(1.269)	(1.554)	(2.196)	(1.985)
Death of any household member	-0.392	-2.062	3.795	1.038
	(1.592)	(1.820)	(3.057)	(2.318)
Perceived food price fluctuations	6.420**	5.771	1.296	6.757
	(2.981)	(3.832)	(4.482)	(5.067)
Perceived food price inflation	-2.094	5.475*	-8.820	-0.119
	(3.483)	(3.177)	(5.870)	(5.382)
Rainfall variability	-35.284*	-76.410***	-27.419	5.246
	(21.396)	(28.743)	(38.409)	(34.650)
Age of household head	0.259	0.285	0.735*	-0.005
	(0.249)	(0.371)	(0.409)	(0.323)
Age of household head squared	1.004	0.374	-5.728	-3.647
	(3.116)	(3.976)	(5.352)	(4.814)
Head is male	-1.668	-1.003	6.460	-4.858**
	(1.549)	(1.884)	(5.488)	(2.092)
Head is married	-0.401	-1.257	-1.913	1.029
	(0.888)	(1.283)	(2.723)	(1.407)
Household size	0.008	0.075	0.123	-0.074
	(0.054)	(0.082)	(0.207)	(0.088)
Household size squared	-0.002	-0.003	-0.005	0.001
	(0.002)	(0.004)	(0.004)	(0.003)
Head is a cooperative/group member	1.205	-0.028	-0.069	0.446
	(1.081)	(1.263)	(2.225)	(1.651)
Distance to nearest town	0.497	-0.307	0.239	1.121
	(0.557)	(0.759)	(1.373)	(0.813)
Electricity in village	-3.488	1.417	9.194*	-5.454
	(3.594)	(3.655)	(5.254)	(4.851)
Cooperative in village	0.193	1.897	1.971	0.836
	(1.671)	(1.843)	(3.248)	(2.301)
Elevation	1.114	0.974	3.391	1.238
	(1.315)	(1.578)	(2.909)	(1.348)
Constant	-21.270*	-30.833*	-45.297*	-2.150
	(11.946)	(16.427)	(23.653)	(16.946)
District fixed effects	Yes	Yes	Yes	Yes
Observations	797	501	232	380
R^2	0.199	0.224	0.170	0.247

Notes: The results are based on OLS-FE estimates of Equation (4.4) using the matched sample. The reference category for treatment status is non-treated households. All explanatory variables are measured at time *t-1* (baseline). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The disaggregation by treatment groups, along with loss of observations after employing the matching technique, considerably lowered the number of observations analysed for each sub-sample. As Leroy et al (2016) noted, this reduction in the sample sizes could have resulted in lower statistical power in detecting meaningful effects of the nutrition only and combined interventions (models 3–4). Another reason could be because the resilience pillars are composed of variables (e.g. land, education, livestock, assets, etc.) that are slow-changing. Hence, they are unlikely to vary significantly in a short timespan of one year in response to the interventions. The implication is that we may have to adopt an indirect approach of examining other short-run determinants of household resilience (such as per capita food consumption expenditure, dietary diversity, and food consumption score) to assess how much they have changed over time, and eventually, to draw evidence on the impact of the interventions (d'Errico et al., 2020; FAO, 2016).

In the next section, we unpack the resilience capacity index to gain some insights on the drivers of these differential impacts of the intervention. Prior to that, we momentarily analyse the coefficients of the control variables. Among the self-reported shocks included in the models, only fluctuation in food prices appears to exert a significant impact on the change in household resilience capacity. As shown in columns 1–2, households that experienced unstable food prices at baseline tend to have a significantly higher improvement in resilience capacity. This may be due to increased (on-farm and off-farm) diversification as households adapt their livelihoods in response to perceived food price risks. Long-term rainfall variability is included as an objective measure of covariate shocks. The results show that increased rainfall variability during the growing season significantly undermines household resilience capacity over time, possibly due to reduced farm productivity and income. The age, gender, and marital status of the household head are shown to have no statistically significant impact on household resilience capacity across all treatment groups. However, household size exerts a negative and significant impact on households' capacity to withstand and deal with food security shocks. This inverse relationship can be explained by the fact that the larger the household size, the fewer the resources available per person to absorb and cope with shocks. The positive coefficients of its squared term suggest that the adverse effect of house size on resilience capacity rises with growth in the number of household members. Lastly, households dwelling in villages that are farther from towns (economic hubs) are less resilient. This may be due to reduced access to markets, employment avenues, and basic services that are critical for strengthening household resilience capacity.

4.5.4 Impact on resilience pillars

To understand the mechanisms behind the resilience-boosting impact of the nutrition-sensitive intervention, we employ the resilience pillars (ABS, AST, AC, and SSN) as outcome variables in the same specification in Equation (4.4). The estimated composite and differential programme impacts on these pillars are presented in Tables 4.5 and 4.6. First of all, the results in Table 4.5 show that, relative to non-programme households, household ability to access basic services significantly declined over the study period. Given that the ABS pillar is made up of variables (e.g. quality of dwelling infrastructure, access to roads, schools, markets, health, and financial facilities) that are unlikely to change remarkably within a short period of one year, it is surprising that ABS deteriorated significantly across all treatment groups

Table 4. 5: Table 5: The impact of the interventions on resilience pillars: ABS and AST

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔABS	ΔABS	ΔABS	ΔABS	ΔAST	ΔAST	ΔAST	ΔAST
Any intervention	-0.253***				0.092			
	(0.054)				(0.078)			
Cash crop		-0.317***				0.203**		
		(0.078)				(0.087)		
Nutrition			-0.134***				-0.034	
			(0.049)				(0.156)	
Combined				-0.197***				0.020
				(0.066)				(0.123)
Constant	0.187	-0.097	-0.283	0.932	-1.409**	-1.935**	-1.529	-0.739
	(0.645)	(1.112)	(0.584)	(0.785)	(0.693)	(0.937)	(1.517)	(1.161)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	797	501	232	380	797	501	232	380
R^2	0.259	0.279	0.455	0.429	0.152	0.214	0.193	0.187

Notes: See notes beneath Table 4.4. ABS stands for access to basic services and AST represents ownership of assets. The reference category for treatment status is non-treated households. Robust standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

There is no obvious reason to believe this may be due to the programme. However, it may be explained by the erratic rainfall patterns during the 2018 rainy season in Sierra Leone, which led to seasonal floods, washed-out roads and bridges, and limited access to essential services (World Food Programme, 2019). As WFP (2019) puts it, "…these shocks have not only increased short-term hunger but also compromised the resilience of poor households."

Consistent with prior expectations, the project has a positive impact on the assets dimension of household resilience capacity (see Table 4.5, columns 5–8). However, this asset-building effect is only significant for cash crop alone households. Further disaggregation of the AST pillar (in appendix Table 4A.3) by its constituents reveals a significant increase in the agricultural asset index across the cash crop households. This indicates that the transfer of productive inputs to smallholder farmers can significantly contribute to building their resilience capacity. This result is consistent with Phadera et al. (2019), who showed that an asset transfer program significantly boosted household resilience in rural Zambia. The absence of a strong impact on other AST components (e.g. the ownership on non-productive assets, land, and livestock) may be because they are not less likely to vary significantly within a year (d'Errico et al., 2020).

Table 4. 6: The impact of the interventions on resilience pillars: AC and SSN

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔAC	ΔAC	ΔAC	ΔAC	ΔSSN	ΔSSN	ΔSSN	ΔSSN
Any intervention	0.180***				-0.100			
	(0.047)				(0.101)			
Cash crop		0.170***				-0.038		
		(0.057)				(0.111)		
Nutrition			0.216**				-0.057	
			(0.093)				(0.113)	
Combined				0.137**				-0.029
				(0.069)				(0.057)
Constant	-0.232	0.361	-1.203	-0.831	0.807	2.421	-1.922	-0.960
	(0.400)	(0.579)	(0.989)	(0.551)	(1.803)	(3.093)	(1.618)	(0.673)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	797	501	232	380	797	501	232	380
R^2	0.316	0.421	0.262	0.422	0.046	0.047	0.139	0.224

Notes: See notes beneath Table 4.4. AC denotes adaptive capacity and SSN represents social safety nets. The reference category for treatment status is non-treated households. Robust standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The results in columns 1–4 of Table 4.6 show a positive and significant impact of the programme on the AC pillar across all treatment groups. This suggests that the integrated intervention played a significant role in enhancing the adaptive capacity of the beneficiaries compared to non-beneficiaries. The disaggregated results (in appendix Table 4A.4) disclose a significant increase in the number of income sources (a proxy of income diversification) as the main driver of the programme's impact on the adaptive capacity of the treated households. Being a beneficiary exerts no significant impact on the average education of household head and dependency ratio. However, the diversity of food crops produced (a proxy of on-farm diversification) significantly decline across all treatment groups because of poor weather conditions during the 2018 cropping season, which adversely affected agricultural production in the country. The remaining results in Table 4.6 (columns 5–8) demonstrate that the programme had a negative and insignificant impact on access to social safety nets. The negative (or substitution) effect on the SSN pillar hints that being a beneficiary of the present programme may limit the households' eligibility and participation in other social protection programmes. However, the absence of a significant impact is mainly because the programme understudy is not a social protection programme, entailing neither cash nor in-kind transfers to households.

4.5.5 Effects of resilience capacity on food security

In the preceding analysis, we measured household resilience capacity and analysed its dynamics over time in relation to the programme. The ultimate goal of such resilience building interventions is to improve food security and other welfare outcomes. Therefore, it is paramount, for policy decisions, to examine whether the observed changes in household resilience translate into improved food security among smallholder households in rural Sierra Leone. Table 4.7 presents the effects of household resilience on changes in household food security while controlling for shocks and other covariates iteratively.

As envisaged, the coefficients of the initial food consumption score are negative and statistically significant across all specifications. This points to the prospect of convergence among households, with food insecure households catching up with food-secure households over time. D'Errico et al. (2019) reported similar results in their threshold analysis of the effects of resilience and temperature shocks on the food security of rural households in Tanzania. Smith and Frankenberger (2018) also found convergence among households affected by floods in Bangladesh.

Table 4. 7: The effects of resilience capacity on food security

	(1)	(2)	(3)	(4)
	ΔlnFCS	ΔlnFCS	ΔlnFCS	ΔlnFCS
Initial FCS	-0.028***	-0.028***	-0.028***	-0.028***
	(0.001)	(0.001)	(0.001)	(0.001)
ln(Resilience)	0.629***	0.674***	0.672***	1.234***
	(0.139)	(0.146)	(0.147)	(0.307)
Δln(Resilience)	0.513***	0.553***	0.549***	1.118***
	(0.141)	(0.147)	(0.148)	(0.308)
Illness of any household member			-0.034	-0.027
			(0.029)	(0.030)
Death of any household member			0.006	0.016
			(0.034)	(0.034)
Perceived food price fluctuation			-0.078	-0.078
			(0.066)	(0.062)
Perceived food price inflation			0.021	0.039
			(0.045)	(0.047)
lnRainfall variability			-1.217**	-10.656***
			(0.609)	(4.032)
lnRainfall variability x ln(Resilience)				2.311**
				(0.946)
lnRainfall variability x Δln(Resilience)				2.263**
				(0.940)
Constant	-0.482	-0.769	-0.979	-3.286**
	(0.562)	(0.633)	(0.643)	(1.314)
District fixed effects	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes
Shocks	No	No	Yes	Yes
Observation	836	836	836	836
R^2	0.718	0.731	0.733	0.742

Notes: The results are based on OLS-FE estimates of Equation (4.5). Except for differenced variables, all explanatory variables are measured at time *t-1* (baseline). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The lagged resilience index exerts a robust significant, and positive effect on the change in FCS over the study period. All other things being equal, and on average, a 1 percent increase in the previous level of resilience index is estimated to result in 0.63–1.23 percentage increase in FCS between the two survey periods. This implies that being more resilient (in the past) strongly boosts household wellbeing, in terms of growth in the diversity and frequency of consuming nutritious diets. Furthermore, the food security effects of between-wave change in resilience index are also statistically significant. The estimates indicate that a 1 percentage change in the resilience index is positively associated with 0.51–1.18 percentage change in FCS over the two waves, holding all other factors constant. These results suggest that it is not only the previous (pre-shock) *level* of resilience capacity that matters for household wellbeing but its *change* – increment – over time as well. Thus, strengthening resilience capacity over time can help rural households to deal with adversities effectively, and boost their food security. These results are also consistent with the incipient literature on the predictive power of resilience capacity to food insecurity. For instance, recent studies have shown that higher resilience capacity is significantly and positively related to future food security status of households in Tanzania and Uganda (d'Errico et al., 2018, 2019) and Bangladesh (Smith & Frankenberger, 2018). In the case of Mali, d'Errico and Pietrelli (2017) showed that children in more resilient households have a lower probability of stunting. Similar results were obtained by d'Errico et al. (2019), who showed that both the level and growth of resilience strongly drive food consumption growth in rural Tanzania.

Resilience capacity connotes the ability of households to withstand and bounce back from shocks. This ensures that shocks and stressors do not have long-lasting adverse effects on their food security and overall wellbeing (Constas et al., 2014; Fan et al., 2014; FAO et al., 2015). The estimated results in columns 3–5 account for some idiosyncratic and covariate shocks. The self-reported idiosyncratic shocks that hit households between the two waves do not have any significant effects on changes in FCS[15]. However, increase in long-term rainfall variability – a proxy of covariate shocks – is shown to hinder desirable changes in household food consumption significantly. The results suggest that a 1 percent rise in rainfall variability can significantly diminish the FCS by 1.2 –10.7 percentage points over the study period. This can be explained by the fact that agricultural production in Sierra Leone and other low-income agrarian economies is predominantly rain-fed. Thus, in the absence of effective irrigation systems, higher rainfall variability in the growing season can considerably hurt farm yield, household income, and, in the end, household food security.

So a policy-relevant question is, does resilience capacity mitigate the adverse effects of shocks on household food security? This vital question is addressed in column 5 of Table 4.7, where rainfall variability is interacted with the resilience variables. The coefficients of these interaction terms are positive and statistically significant. The implication is that the previous level of resilience capacity and its change over time play significant roles in attenuating the adverse effects of rainfall variability on food security. Thus, building the resilience of rural households is essential in protecting their food security and enabling them to bounce back

[15] The non-statistical significance of shocks may be attributed to low accuracy of self-reported events, which are prone to recall and reporting bias (d'Errico et al., 2018; FAO, 2016). For instance, households may consider events to which they are constantly exposed as usual, and may not report them as shocks during the survey period.

(better) when disaster strikes. This evidence is consistent with the findings of Smith and Frankenberger (2018), who reported that resilience capacity reduced the negative impact of flooding on household food security in northern Bangladesh. In a related study, d'Errico et al. (2018) found that rural households in Tanzania and Uganda, with a higher resilience index, had better future food security outcomes and were better positioned to absorb and adapt to conflict-related shocks. However, our results stand in contrast to Dedehouanou and McPeak (2019). They showed that although income diversification (an indicator of adaptive capacity) improves food security among rural households in Nigeria, it neither mitigates nor exacerbates the (negative) effects of shocks on food security.

4.6 Conclusions

With some shocks and stressors becoming more severe and frequent in recent times, building household resilience is increasingly identified as being critical in ridding the world of hunger and malnutrition. This awareness has led to increased prioritisation of resilience in the design and implementation of agricultural interventions in poor and vulnerable environments. One of such interventions is the PROACT programme, an integrated cash crop, and nutrition promotion intervention implemented among smallholder farmers in rural Sierra Leone. While there is extensive evidence on the impacts of such nutrition-sensitive interventions on nutrition and other welfare outcomes, little is known about their role in enhancing household resilience to food insecurity. Moreover, few studies have gone beyond measuring household resilience capacity to analyse its role in predicting future food security outcomes in the face of shocks.

This study fills these important gaps in the nascent literature on resilience and food security and nutrition. To the best of our knowledge, this is the first study to assess the impact of a nutrition-sensitive programme on resilience among smallholder cash crop households. The analyses presented in this study are three-fold. First, it constructs an aggregate index of household resilience capacity to food insecurity and identifies which elements are most important for resilience building. Second, it evaluates the impact of the intervention on household resilience and its underlying drivers. Third, it examines the linkages between resilience and future food security outcomes in the face of shocks. These analyses are based on a two-period panel survey of cocoa, coffee and cashew farming households in Eastern and Northern Sierra Leone. Faced with non-randomized programme targeting and lack of pre-intervention data, the study employs the propensity score matching procedure to deal with selection bias. Based on the matched sample, the regression models are estimated using the OLS-FE estimator.

The results suggest that adaptive capacity and ownership of assets are the most important drivers of household resilience to food insecurity in rural Sierra Leone. The study finds a positive and significant resilience-enhancing impact of the integrated intervention, especially for households who were supported with agricultural training and farm tools. Increased diversity of income sources (an element of adaptive capacity) and higher productive assets index (a component of assets) are the main contributors to the resilience-building impact of the overall intervention. The cash crop and nutrition interventions are found to significantly improve the adaptive capacity of smallholder households, both individually and jointly. However, only that stand-alone impact of the cash crop intervention is significant in improving the assets pillar as well as overall household resilience capacity.

These results stand in contrast to the findings in Chapter 2, which disclosed that the cash crop intervention alone negatively impacted the diversity of household and individual diets, whereas the combined interventions improved these outcomes significantly. Though positive, the impact of the nutrition intervention alone was generally insignificant, except for the micronutrient-sensitive dietary diversity of women. A possible explanation for the discrepancies in the impacts of interventions is that Chapter 2 focuses on dietary diversity, an indicator which is sensitive to short-term changes in dietary quality and food security. However, most of the variables used to construct the resilience pillars in this Chapter are not likely to change remarkably in the short-term (in this case, over one year). This suggests that the cash crop intervention, in particular, may be effective in the long run, although it appears to cause deterioration in dietary quality in the short-run. The reason being that the expected changes in resilience and overall well-being due to the cash crop intervention are to be driven by changes in incomes from improved production of cocoa, coffee and cashew – all of which have long gestation periods (i.e. 2-5 years). Hence, the desired impacts may be achieved after sufficient time has elapsed following (full) implementation for optimal use of programme inputs and services at the farm level (at least for the newly planted tree crops to reach reproductive age).

Importantly, the results in this Chapter show that household resilience capacity does not only exert a positive and significant effect on food security but also plays a protective role in dampening the negative impact of rainfall variability on food consumption growth. The short period of the data precludes the analysis of the long-term effects of the programme. However, the results show that it is not only the previous level of household resilience that matters for improving food security but also increases in households' ability over time to absorb shocks and sustain the consumption of healthy diets.

Put together, these findings affirm that more resilient households are better positioned to maintain their wellbeing (food security) in the face of shocks. Resilience building begins with investing in the capacity of people, communities, and countries to overcome their vulnerabilities, and withstand and quickly bounce back, even better, after a shock. For rural households in Sierra Leone, the results suggest that policies and interventions targeted at strengthening their capacity to adapt their livelihoods to changing climatic and socio-economic conditions can contribute to reinforcing their resilience against food security shocks. The results show the number of income sources is the most important component of adaptive capacity. This implies that enhanced adaptive capacity can be attained through fostering the diversification of income-generating activities or livelihood strategies in these communities. Ownership of assets, particularly agricultural assets, also appear to be a significant contributor to the resilience capacity and food security for rural households in Sierra Leone. In this light, interventions aimed at retooling smallholder farmers with productive assets or enabling them to accumulate assets are also vital in building their resilience capacity.

CHAPTER 5

General Conclusions and Policy Implications

It is alarming that, although farmers across the world already produce sufficient food to feed everyone on earth, a growing number of people worldwide still do not consume or have regular access to nutritious and sufficient food. The recent upturn in global hunger rates, after a decade-long decline, indicate that we are progressing neither towards ensuring access to safe, nutritious and sufficient food for all people all year round (SDG target 2.1), nor towards eradicating all forms of malnutrition (SDG target 2.2) by 2030. Conflict, climate-related shocks, and economic slowdowns and downturns have undercut efforts to attain a world without hunger, food insecurity and malnutrition (FAO et al., 2017; 2018; 2019; 2020). The ongoing COVID-19 pandemic, by imposing increased difficulties to access healthy diets on many poor and vulnerable populations worldwide, is threatening to add to extra 83–132 million people to the ranks of the undernourished at the end of 2020 (FAO et al. 2020).

Given the importance of agriculture for the livelihoods of the rural poor, which form the majority of the world's food insecure and malnourished population, agricultural development holds enormous potential to contribute significantly to the global fight against poverty, hunger and malnutrition. However, studies have extensively shown that agricultural growth (as well as income growth) is good but not adequate to effectively address the problems of food insecurity and malnutrition (Ecker et al., 2012; World Bank, 2007). In a perfect world, households (consumers) would have full information about the benefits of high-quality, nutritious foods, and producers (and other actors along food value chains) would also be fully aware of how to produce and supply these nutrient-rich foods to consumers. Through commodity prices, which reflect the nutritional value of foods, market forces would offer incentives to everyone engaged in producing or consuming nutrient-dense foods. Households' preferences and dietary choices will be consistent with what is nutritionally optimal (i.e., consumption bundles with more diverse, and healthy foods). The presence of well-functioning and efficient (agri-food) markets will also guarantee the availability of nutritious foods at all times, by ensuring that food shortages in some areas are consistently matched with surpluses from other localities in a timely and cost-effective manner. They will also ensure that household consumption follows a stable path, rather than being susceptible to fluctuations in purchasing power (income and prices), seasonality, and other shock-induced variabilities in physical and economic access to high-quality, healthy foods .

However, our world is far from being ideal. As a result, market prices do not necessarily reflect the nutritional value of foods, and even if they do, healthy diets could be too costly and unaffordable for the poor and vulnerable – leading to food insecurity and all forms of malnutrition. Furthermore, although nutritious foods may be available and accessible (by means of increased productivity and incomes), inadequate nutrition awareness, preferences (food habits), societal norms, and other non-income factors could lead many households to make poor dietary choices (or food-related decisions) that are incompatible with optimal nutrition outcomes. Last but not least, households may also fail to smooth consumption over time, partly, because of poor market conditions, inadequate self-insurance, or general inability to deal with shocks.

With agriculture being the primary source of calories and essential nutrients and a major source of income for the world's poor and undernourished populations, the crucial question is how can agriculture be made more nutrition-sensitive? That is, how can we intervene in agricultural and food systems so as to not only increased productivity and incomes but also healthy diets and nutrition to everyone at all times, while strengthening households' resilience against shocks and stressors?

Providing evidence-based answers to these vital questions is the overall goal of the studies contained in this dissertation. In particular, the dissertation addresses three policy-relevant issues, namely, (i) the role of nutrition-sensitive interventions in improving the dietary quality of smallholder farmers in export-oriented, cash crop sectors; (ii) the effects of agricultural seasonality and the importance of market access in alleviating intra-annual fluctuations in household dietary diversity and food security; and (iii) the impact of integrated agriculture and nutrition interventions in building household resilience. As a contribution to knowledge and policy efforts to end hunger, achieve food security, and improved nutrition, this dissertation tackles interconnected issues that relate to the utilization, access and stability dimensions of food security at the house level. The studies are situated in Sierra Leone, a post-conflict and least developed country in West Africa, characterised by high levels of food insecurity, malnutrition, and vulnerability to shocks. In this concluding chapter, we summarise the main findings of the studies, draw policy implications, and offer suggestions for further research.

5.1 Summary of key findings

The first study (Chapter 2) exploits the unique design of a multi-faceted project to analyse how complementing an agricultural intervention with a nutrition-based component can improve the dietary outcomes of cash cropping households and their families. To the best of our knowledge, this is the first study to examine how interventions in non-food, export crop value chains can be more nutrition-sensitive. As an observational study, we employed a quasi-experimental design (involving three treatments and one comparison group) to evaluate the stand-alone and combined impacts of a cash crop production intervention and a nutrition-focused intervention on household, maternal and child dietary diversity. The analysis was based on a two-wave panel data covering 836 smallholder cocoa, coffee, and cashew farming households in Eastern and Northern Sierra Leone. The inverse-probability-weighting regression adjustment, a doubly robust estimation method which alleviates selection bias and accommodates multivalued treatments, was used to estimate the treatment effects after one year of project implementation.

The results showed that promoting cash crop production alone was associated with significantly lower household and individual dietary diversity compared to non-intervention households. While the nutrition intervention alone was found to exert no significant impact on household diets, it significantly increased maternal intake of micronutrient-dense food groups. However, we found that supplementing support for cash crop production with nutrition training led to significant improvement in dietary diversity and consumption of nutritious foodstuffs at household and individual level, relative to no intervention. The results showed improvements in caregivers' nutrition knowledge and confidence in influencing food-related decisions to be the potential pathways through which the combined intervention led to better dietary outcomes. These findings demonstrate that integrating a nutrition component into agricultural commercialization or broader livelihood support programmes in export crop sectors can deliver larger nutritional and health benefits than implementing them in isolation.

Achieving food security requires that people's access to and utilization of sufficient, healthy foods remain stable over time. However, increasing occurrence, severity, and unpredictability of extreme weather events (Zseleczky & Yosef, 2014) continue to undermine national and global efforts to eradicate hunger and achieve food security, because they prevent stable access to and intake of diverse, nutritious foods. Chapters 3 and 4 investigated the roles of improved market access and resilience capacity in preserving household diets in the face of seasonal variability and shocks.

The second study (Chapter 3) tackled the issue of seasonality, which persistently determines the intra-annual availability of and access to food in developing countries. Although the primacy of markets for better dietary and nutrition outcomes has been underscored in the literature, there is limited evidence on the relative importance of markets for dietary diversity and food security across seasons. Isolation from markets, exacerbated by poor infrastructural conditions and the associated high transaction costs, hinder agricultural production, market participation, the movement of goods and people, and ultimately people's access to food all year around. Using data from national household surveys in 2011 and 2018, we analysed how market access interacts with seasonality to mitigate seasonal hunger in Sierra Leone. We found that agricultural seasonality imposes significant fluctuations in household dietary diversity and food security: improving during the harvesting season and worsening in the post-harvest period. The results showed that rural households are most vulnerable to food insecurity during the lean season, compelling them to limit portion size at mealtimes and skip meals frequently. Most importantly, we found that households residing closer to food markets consume more diverse diets and are more food secure in both lean and non-lean seasons than remoter households.

As an extension to the previous study, the last empirical research (Chapter 4) addressed the fact that aside seasonality, most poor and rural households are continuously exposed to several shocks and stressors which weaken their resilience and exacerbate their already alarming food and nutrition security situation. The study examined whether participation in the integrated agriculture and nutrition intervention (introduced earlier) increased rural households' resilience to food insecurity. It also investigated whether higher resilience capacity mitigates the negative impact of shocks on their food security. The two-wave panel data employed (in the first study) enabled us also to trace the dynamics of resilience capacity across time and space.

The results suggest that adaptive capacity and ownership of assets are the most important contributors to household resilience to food insecurity in rural Sierra Leone. Relative to non-beneficiaries, the results showed that the intervention significantly increased the resilience capacity of the participating households, especially those who were supported with agricultural training and farm tools. A disaggregated analysis of the components of resilience capacity revealed that the number of income sources (an indicator of diversification and element of adaptive capacity) and productive assets index (a component of assets) were the main drivers of the resilience-building impact of the programme. Importantly, the results showed that household resilience capacity does not only exert a positive and significant effect on food security but also plays a protective role in dampening the negative impact of rainfall variability on growth in the food consumption score. Finally, the results disclosed that it is not only the previous level of household resilience that matters for improving food security but also growth in households' ability over time to absorb shocks and sustain the consumption of healthy diets.

5.2 Policy implications

The findings from the empirical studies in this dissertation have important implications for development strategies aimed at bettering the dietary quality and food security of smallholder households in Sierra Leone and Africa at large. The results from Chapter 2 imply that solely promoting the production of export-oriented cash crops may be detrimental to the food and nutrition security of smallholder households, especially during the early years when intervention-related activities (e.g., farm rehabilitation) foist productivity and income losses on tree crop farmers. However, such unintended negative consequences can be minimized if nutrition is explicitly prioritized in the design and conduct of market-oriented agricultural interventions. In particular, the findings suggest that agricultural commercialization interventions in the cocoa, coffee, cashew, and other non-food export crop sectors can be more nutrition-sensitive if they incorporate a nutrition component that raises households' awareness of the nutritional value of different foods as well as empowers women to influence household decisions and the use of resources in nutrition-enhancing ways for all household members.

Additionally, the evidence presented in Chapter 3 points to the potential role of interventions aimed at strengthening market access through improved market infrastructure and roads in reducing seasonal hunger, particularly in poor rural areas. Thus, in addition to focusing on the development of individual agricultural value chains for improved nutrition, broader investments in market linkages through market-related infrastructural development – to reduce transportation costs and facilitate market access for both producers and buyers – can be instrumental in curbing intra-annual fluctuations in dietary quality and food security as well as increasing the nutrition sensitivity of smallholder agriculture in rural Africa.

Another aspect of markets that is essential for price stabilization and ensuring year-round food security is storage infrastructure. Post-harvest losses of staple crops pose significant threat to food security in Africa partly because of poor storage and deficiencies in other post-harvest management systems. In Sierra Leone, most warehouses were destroyed during the civil and traditional storage methods are less effective in limiting post-harvest losses during storage.

Hence, investments in improved on-farm storage and other related infrastructure has the potential to smooth yearly food consumption and improve food security. A recent study in Tanzania has demonstrated that the provision of low-cost hermetic storage bags can reduce storage loss and contribute significantly to reducing seasonal food insecurity by improving farming households' access to food throughout the year (Brander et al., 2020). Relatedly, policies directed at eliminating demand and supply-side constraints in local financial markets can significantly boost access to and use of financial services (e.g., credit, savings, mobile money services, and insurance and other risk-management products), with the potential of reducing seasonality in food consumption. Finally, we find that in shock-prone environments like Sierra Leone, rural households with higher resilience capacity are more food secure. Thus, preserving or improving food security, in the face of shocks and stressors, calls for investments in building the capacities of vulnerable households to anticipate effectively, prepare, withstand, or cope with shocks and bounce back even better. For smallholder tree crop farmers in rural Sierra Leone, we identified adaptive capacity, ownership of assets, and access to social safety nets to be the most important capacities than need to be strengthened. Specifically, the results suggest that interventions that promote the accumulation of assets, livelihood (or income) diversification, education, and cash or in-kind transfers are key in building the resilience of smallholder farmers against food security shocks. In sum, the studies highlight that for the beneficial impacts of the interventions on nutrition and food security to be sustained over time, it is critical that policies are focused on improving market linkages, eliminating structural constraints, and improving the long-term resilience capacity of households.

5.3 Limitations and suggestions for further research

This dissertation is based on data from Sierra Leone, a post-war country in West Africa characterized by the predominance of smallholder farming, severe infrastructural constraints which inhibit market access, and widespread food insecurity and poor nutrition. The fact that these developmental traits are characteristic of most rural areas in Africa and other developing regions implies that some of the general findings and policy implications discussed above may also be relevant beyond the Sierra Leonean context. However, the study is not without limitations, and caution must be exercised in extrapolating the results. The first study on the impact assessment of the project was based on observational data, with no pre-intervention baseline information. The use of a doubly robust estimator enabled us to account for selection on observable characteristics, while the correlated random effects model helped to address time-invariant unobserved heterogeneity. However, we have not successfully dealt with biases from time-varying unobserved factors. The two-stage control function approach may be applied to resolve this issue. Nonetheless, it was not considered because of difficulty of finding valid instruments for the multiple treatments. Also, given a short time frame of one year, this study attempts to capture the early impacts of the interventions. However, the targeted tree crops (e.g., cocoa, coffee, and cashew) take three to five years to become productive and profitable. It is envisaged that there will be a reversal when the trees reach maturity, and food consumption increases along with growth in cash crop income. This calls for follow-up studies to assess the long-term impacts of the project after ample time passes between implementations and evaluation. Furthermore, some key challenges (including the absence of baseline data) which threaten the identification of programme impact(s) can be successfully surmounted through strong partnership and coordination between project implementers and evaluators – before, during, and after the project is rolled out.

In chapter three, we employed a repeated cross-sectional data to assess the interplay between seasonality and market access in affecting household food security. The main shortcoming of using the pooled cross-sectional data is that it precludes the analysis of the long-term effects of seasonality and market access on food security because the data does not capture their variations over time. Future studies that use high-frequency panel data to capture the dynamic changes in market access and seasonality, as well as account for individual heterogeneity, may be useful in corroborating the evidence provided here. In addition, the analyses are confined to the household-level due to the absence of individual-level data. Consequently, the study does not show how seasonality affects the intra-household distribution of foods, especially nutrient-dense foodstuffs. A more comprehensive analysis based on seasonally disaggregated panel and individual-level nutrition data may also be useful in shedding light on the effects of seasonality on the dietary quality of nutritionally vulnerable household members.

In chapter four, we departed from previous cross-section studies by using panel data to measure household resilience, assess its dynamics over time as well as infer its effects on food security. To this end, we employed an indicator-based index to measure resilience capacity and its pillars objectively. Despite providing a standardized metric for comparison of different categories of people, households, or communities, the objective approach to resilience measurement is not free from limitations. First, the choice of the observed primary indicators – though dictated by data availability – is arguably subjective as there is, hitherto, no consensus on a standard set of resilience indicators. Further, the objective approach heavily relies on the observation of (predetermined) external characteristics of the people or communities whose resilience is being evaluated. It does not account for their knowledge of resilience and self-judgment of their abilities to deal with shocks and stressors. Follow-up studies that combine both objective and subjective tools can significantly contribute to the robust measurement of resilience capacity and its further use in mapping hotspots and understanding drivers and impacts.

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Appendix I

Table 2A. 1: Attrition Probit Regressions

	Non-treated Attrition	Cash crop Attrition	Nutrition Attrition	Combined Attrition	Full sample Attrition
	(1)	(2)	(3)	(4)	(5)
Cash crop					-0.27
					(0.17)
Nutrition					0.01
					(0.20)
Combined					-0.23
					(0.18)
Age of head (years)	-0.01	0.01	-0.01	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Head is male (dummy)	0.00	-0.47	0.00	-1.07*	-0.09
	(0.00)	(0.70)	(0.00)	(0.64)	(0.36)
Head is married (dummy)	0.00	-0.27	0.00	-0.15	-0.50
	(0.00)	(0.72)	(0.00)	(0.75)	(0.37)
Head's years of schooling	-0.03	-0.02	-0.02	-0.00	-0.01
	(0.03)	(0.03)	(0.05)	(0.03)	(0.01)
Dependency ratio	-0.10	0.04	-0.22	0.18*	-0.01
	(0.13)	(0.09)	(0.24)	(0.11)	(0.05)
Household size	0.06	-0.00	-0.02	0.00	-0.00
	(0.05)	(0.05)	(0.09)	(0.05)	(0.03)
Farm size (acres)	0.20	0.01	0.07	-0.04	-0.02
	(0.21)	(0.25)	(0.37)	(0.26)	(0.11)
Livestock (dummy)	0.14	0.20	0.45	0.14	0.19
	(0.41)	(0.31)	(0.52)	(0.39)	(0.17)
Off-farm income (dummy)	0.06	0.13	0.13	0.08	0.11
	(0.25)	(0.30)	(0.39)	(0.31)	(0.13)
Household wealth index	-0.01	0.00	0.01	-0.00	-0.00
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Head is member of cooperative	0.34	0.36	-0.25	0.27	0.17
	(0.28)	(0.32)	(0.43)	(0.32)	(0.14)
Household experienced any shock	-0.58**	0.39	-0.15	-0.01	-0.05
	(0.25)	(0.32)	(0.49)	(0.31)	(0.13)
Distance to market (miles)	0.45***	-0.44**	0.62*	0.16	0.18**
	(0.15)	(0.19)	(0.32)	(0.23)	(0.08)
Village has cooperative	0.78**	-0.19	-0.02	-0.20	0.10
	(0.30)	(0.31)	(0.40)	(0.40)	(0.14)
Constant	-2.10**	-0.99	-1.86	-0.59	-1.01**
	(0.99)	(1.04)	(1.40)	(1.02)	(0.49)
Pseudo R-squared	0.168	0.121	0.138	0.142	0.041
Wald test (*p-value*)	0.215	0.459	0.807	0.357	0.208
Observations	281	268	124	209	912
Attrition rate (%)	10.274	6.343	9.091	7.656	8.333

Notes: The dependent variable is an attrition indicator, assuming the value one for households which drop out of the sample after the first wave and zero otherwise. Coefficient estimates are reported with robust standard errors clustered at village level in parentheses. District dummies were included but not reported to conserve on space. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2A. 2: Baseline summary statistics by treatment group

	Non-treated	Cash crop	Nutrition	Combined	*F*-test
Household characteristics					
Household dietary diversity score (HDDS)	6.847	6.359	6.977	7.104	14.12***
	(1.039)	(1.332)	(1.486)	(1.414)	
Micronutrient-sensitive HDDS	2.031	1.829	2.146	2.254	10.05***
	(0.683)	(0.804)	(0.881)	(1.047)	
Age of head (years)	47.38	46.30	46.92	49.41	1.78
	(12.58)	(14.72)	(16.58)	(14.78)	
Head is male (dummy)	0.973	0.964	0.862	0.953	8.48***
	(0.162)	(0.186)	(0.347)	(0.211)	
Head is married (dummy)	0.969	0.968	0.885	0.969	5.25***
	(0.172)	(0.176)	(0.321)	(0.174)	
Head's years of schooling	3.844	2.952	3.515	4.218	2.30*
	(5.316)	(4.902)	(4.909)	(6.086)	
Dependency ratio	1.394	1.391	1.725	1.334	2.81**
	(1.223)	(1.331)	(1.492)	(1.121)	
Household size	6.809	6.884	6.208	7.560	7.16***
	(2.351)	(2.827)	(2.112)	(3.003)	
Farm size (acres)	6.904	7.822	8.396	9.451	6.19***
	(5.315)	(5.984)	(7.065)	(9.428)	
Livestock (dummy)	0.859	0.713	0.785	0.813	5.83***
	(0.349)	(0.453)	(0.413)	(0.391)	
Off-farm income (dummy)	0.496	0.363	0.454	0.539	5.35***
	(0.501)	(0.482)	(0.500)	(0.500)	
Household wealth index	50.33	47.29	54.49	53.93	13.67***
	(11.65)	(11.82)	(13.73)	(15.03)	
Head is member of cooperative	0.183	0.550	0.300	0.596	42.15***
	(0.388)	(0.499)	(0.460)	(0.492)	
Household experienced any shock	0.718	0.645	0.792	0.663	3.45**
	(0.451)	(0.479)	(0.407)	(0.474)	
Distance to market (miles)	10.013	7.282	3.577	7.293	26.38***
	(13.493)	(4.539)	(3.306)	(7.355)	
Village has cooperative	0.584	0.689	0.692	0.850	12.84***
	(0.494)	(0.464)	(0.463)	(0.358)	
Number of households	262	251	130	193	
Maternal characteristics					
Women dietary diversity score (WDDS)	5.568	5.158	5.295	5.822	6.89***
	(1.195)	(1.447)	(1.662)	(1.507)	
Micronutrient-sensitive WDDS	2.017	1.951	2.189	2.273	5.12***
	(0.739)	(0.979)	(0.978)	(1.059)	
Caregiver's age (years)	37.51	35.79	38.46	37.49	1.73
	(11.06)	(12.14)	(14.78)	(10.57)	
Caregiver's education (years)	1.695	2.010	2.947	1.737	48.29***
	(3.313)	(3.371)	(3.621)	(3.535)	
Number of women of reproductive age	199	196	95	146	
Child characteristics					
Child dietary diversity score	3.600	3.330	3.476	3.734	2.89**
	(1.172)	(1.258)	(1.363)	(1.428)	
Child's age (months)	30.06	27.85	32.76	28.38	1.65
	(17.36)	(17.45)	(17.04)	(19.22)	
Child is a male	0.463	0.480	0.537	0.474	0.42
	(0.500)	(0.501)	(0.502)	(0.501)	
Number of children (6-59 months)	160	179	82	154	

(Table A2 continued)

	Non-treated	Cash crop	Nutrition	Combined	*F*-test
Pathway variables					
Purchased food per adult equiv. (annual in real Leones)	625728.5	593847.9	638705.4	675251.5	0.63
	(645224.3)	(586541.6)	(500790.4)	(716148.2)	
Total food consumption per adult equiv. (annual in real Leones)	825635.0	775931.0	812235.2	953118.8	2.24*
	(684320.9)	(658656.0)	(725971.6)	(892938.8)	
Nutrition knowledge (0–3)	1.134	1.430	2.054	1.829	27.39**
	(1.051)	(1.105)	(0.983)	(1.162)	
Caregiver has adequate control over use of income from …..					
Food crops farming	0.714	0.693	0.754	0.705	0.53
	(0.453)	(0.462)	(0.432)	(0.457)	
Cash crops farming	0.653	0.645	0.569	0.585	1.42
	(0.477)	(0.479)	(0.497)	(0.494)	
Livestock rearing	0.603	0.618	0.585	0.596	0.15
	(0.490)	(0.487)	(0.495)	(0.492)	
Off-farm economic activities	0.443	0.422	0.415	0.492	0.91
	(0.498)	(0.495)	(0.495)	(0.501)	
Caregiver has adequate confidence in participating/voicing her opinion …					
Issues around food and resources with husband	0.737	0.653	0.792	0.777	4.13***
	(0.441)	(0.477)	(0.407)	(0.417)	
At community meetings with men & women	0.427	0.363	0.600	0.430	6.74***
	(0.496)	(0.482)	(0.492)	(0.496)	
At Women's group meetings	0.588	0.566	0.638	0.637	1.10
	(0.493)	(0.497)	(0.482)	(0.482)	

Notes: The sample means are reported with standard deviations are in parentheses. The asterisks *, **, *** indicate the means are jointly different from zero at 10%, 5% and 1% significant levels.

Table 2A. 3: Covariate balance summary

	Cash crop				Nutrition				Combined			
	Standardized difference		Variance Ratio		Standardized difference		Variance ratio		Standardized difference		Variance ratio	
	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted
Age of head (years)	-0.08	0.02	1.37	1.57	0.02	0.07	1.82	2.19	0.11	0.00	1.33	1.39
Head is male	-0.07	-0.07	1.48	1.47	-0.37	-0.01	4.19	1.05	-0.12	-0.07	1.81	1.46
Head is married	-0.03	-0.03	1.17	1.15	-0.31	0.06	3.29	0.71	0.01	-0.06	0.94	1.34
Head’s years of schooling	-0.18	-0.05	0.85	0.97	-0.05	0.07	0.88	0.94	0.06	-0.14	1.29	0.86
Dependency ratio	0.01	-0.01	1.17	1.22	0.18	-0.02	1.41	0.96	-0.05	0.03	0.96	1.10
Household size	-0.03	0.02	1.40	1.73	-0.21	0.09	1.03	1.84	0.19	-0.06	1.62	1.24
Farm size (log, acres)	0.27	-0.09	0.71	0.69	0.37	0.06	0.81	0.68	0.35	-0.05	0.77	0.72
Livestock (dummy)	-0.19	0.00	1.27	1.00	-0.06	-0.03	1.09	1.03	0.02	0.02	0.97	0.98
Off-farm income (dummy)	-0.16	0.06	0.80	1.10	-0.06	-0.09	0.93	0.84	0.05	0.05	1.06	1.09
Household wealth index	-0.19	0.03	1.13	1.42	0.13	0.11	1.53	1.26	0.18	-0.02	1.66	1.18
Head is member of cooperative	0.75	-0.01	1.27	1.01	0.38	-0.03	1.30	1.01	0.89	-0.06	1.20	1.02
Household experienced any shock	-0.03	-0.06	1.01	1.02	0.14	0.09	0.94	0.96	-0.06	-0.02	1.02	1.01
Distance to market (log, miles)	0.13	0.12	0.64	0.66	-0.52	0.07	0.71	0.54	-0.01	-0.07	0.57	0.54
Village has cooperative	0.13	0.10	0.91	0.93	0.26	-0.10	0.81	1.05	0.50	0.02	0.57	0.99

Notes: The control group is non-treated households.

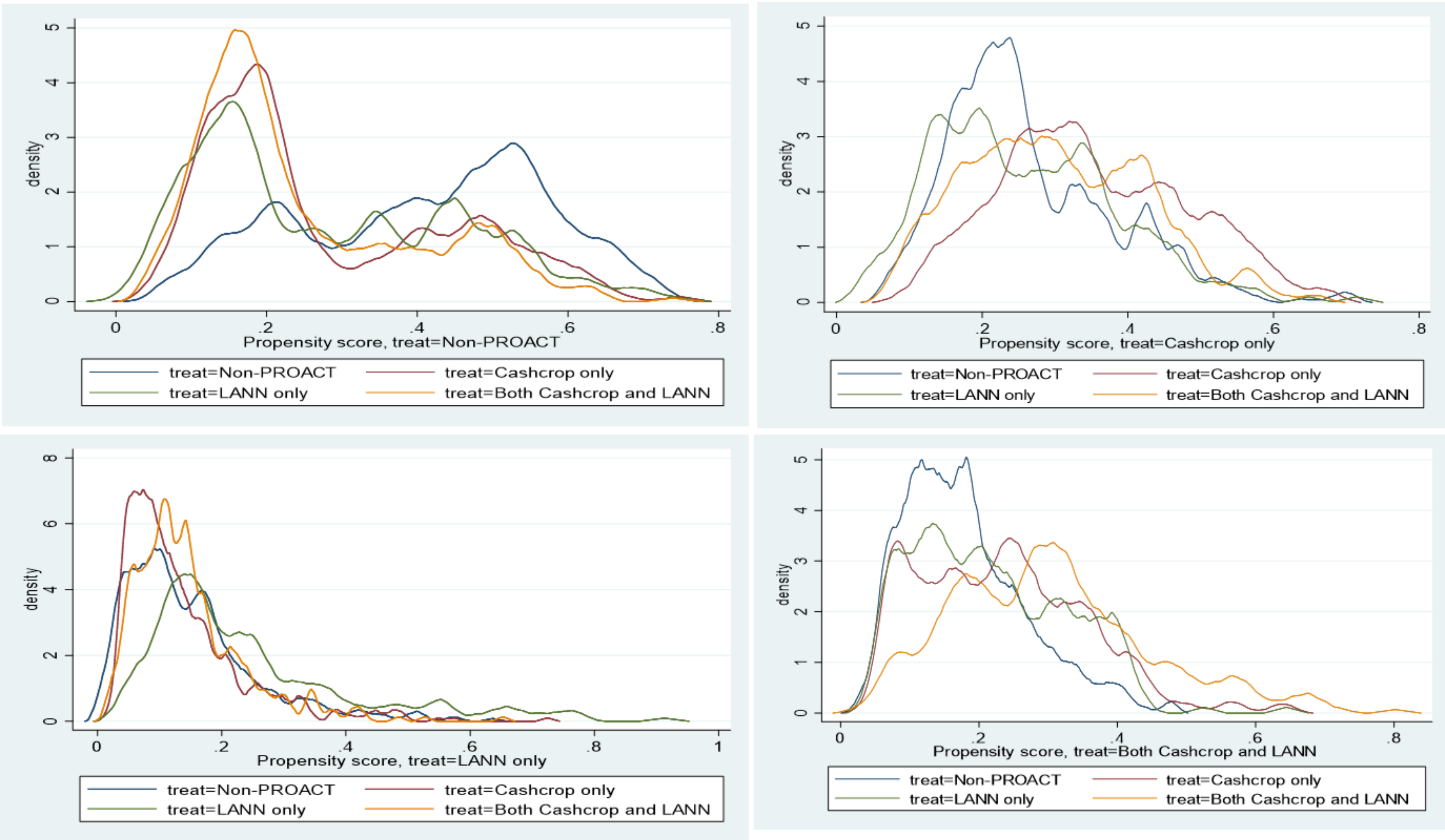

Figure 2A. 1: Overlap plots

Table 2A. 4: CRE estimates of impacts on household dietary diversity and likelihood of consuming nutrient-rich food groups

	Household dietary diversity scores		Food groups consumed by any household member									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	HDDS	MsHDDS	Dark green leafy veg	Vitamin A-rich veg & tuber	Other vegs	Vitamin A-rich fruits	Other fruits	Fish	Meat	Eggs	Legumes	Dairy
Cash crop	-0.027**	-0.004	-0.199*	0.146	-0.076	0.208*	0.195*	-0.244*	0.004	0.436	-0.411***	0.104
	(0.013)	(0.027)	(0.113)	(0.130)	(0.115)	(0.114)	(0.104)	(0.130)	(0.170)	(0.402)	(0.096)	(0.173)
Nutrition	-0.008	0.022	-0.223	0.270*	-0.182	0.537***	0.127	-0.268*	-0.226	0.681	-0.292**	-0.132
	(0.017)	(0.032)	(0.143)	(0.157)	(0.138)	(0.136)	(0.120)	(0.158)	(0.192)	(0.555)	(0.118)	(0.198)
Combined	0.025*	0.150***	0.064	0.539***	-0.008	0.602***	0.494***	-0.169	-0.105	0.917	-0.439***	0.429**
	(0.014)	(0.028)	(0.120)	(0.131)	(0.116)	(0.125)	(0.110)	(0.135)	(0.167)	(0.702)	(0.105)	(0.175)
Constant	1.779***	0.286***	6.524*	-4.554	8.834**	17.970***	15.635***	-3.368	16.640***	26.270	-28.099***	13.082**
	(0.480)	(0.099)	(3.685)	(4.482)	(3.960)	(4.222)	(3.871)	(4.695)	(5.627)	(22.919)	(3.821)	(5.508)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mundlak CRE variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672	1672

Notes: Results in Columns 1–2 are based on Poisson CRE specification and Columns 3–12 from probit CRE specification. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2A. 5: CRE estimates of impacts on maternal dietary diversity and likelihood of consuming nutrient-rich food groups

	Maternal dietary diversity		Food groups consumed by woman aged 15-49 years									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	WDDS	Micronutrient-sensitive WDDS	Dark green leafy vegs	Vitamin A rich vegs & tubers	Other vegeta bles	Vitamin A rich fruits	Other fruits	Meat	Fish	Eggs	Legumes nuts & seeds	Dairy
Cash crop	-0.030	-0.095	-0.037	0.173	-0.017	0.175	0.169*	-0.302**	-0.062	0.356	-0.312***	0.291
	(0.470)	(0.253)	(0.106)	(0.107)	(0.111)	(0.124)	(0.101)	(0.124)	(0.152)	(0.317)	(0.105)	(0.185)
Nutrition	-0.102	0.010	-0.159	0.303**	-0.193	0.473***	0.190	-0.204	-0.125	0.372	-0.240*	-0.399*
	(0.140)	(0.081)	(0.139)	(0.128)	(0.132)	(0.142)	(0.117)	(0.164)	(0.194)	(0.332)	(0.123)	(0.237)
Combined	0.724**	0.522***	0.103	0.630***	0.128	0.572***	0.448***	-0.400***	0.002	0.616**	-0.355***	0.572***
	(0.322)	(0.180)	(0.117)	(0.110)	(0.122)	(0.124)	(0.107)	(0.130)	(0.156)	(0.313)	(0.114)	(0.187)
Constant	2.379	11.128***	0.899	-1.939	1.286	21.392***	16.777***	-7.073*	15.361***	21.045**	-13.869***	19.626***
	(3.729)	(2.180)	(3.628)	(3.566)	(3.810)	(4.175)	(3.654)	(4.225)	(5.393)	(9.283)	(3.856)	(6.158)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mundlak CRE variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272	1272

Notes: Results in Columns 1–2 are based on Poisson CRE specification and Columns 3–12 from probit CRE specification. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2A. 6: CRE estimates of impacts on child dietary diversity and likelihood of consuming from individual food groups

	Child dietary diversity	Food groups consumed by child under age 5						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CDDS	Grains & Tubers	Vitamin A fruits & vegs	Other fruits & vegs	Meat & fish	Eggs	Dairy	Pulses
Cash crop	-0.15	0.05*	-0.02	-0.03	-0.03	0.02	-0.05*	-0.08*
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)
Nutrition	-0.03	-0.01	0.04	-0.05	-0.01	0.06**	-0.01	-0.07
	(0.13)	(0.03)	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)
Combined	0.19*	0.01	0.16***	0.02	0.04	0.05**	0.02	-0.11**
	(0.11)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)	(0.05)
Constant	3.64***	1.01***	0.00	0.79***	0.85***	-0.15**	0.26***	0.88***
	(0.35)	(0.08)	(0.12)	(0.10)	(0.10)	(0.07)	(0.09)	(0.14)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wave dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mundlak CRE variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1027	1027	1027	1027	1027	1027	1027	1027

Notes: Results in Columns 1 are based on Poisson CRE specification and Columns 2–8 from probit CRE specification.
Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix II

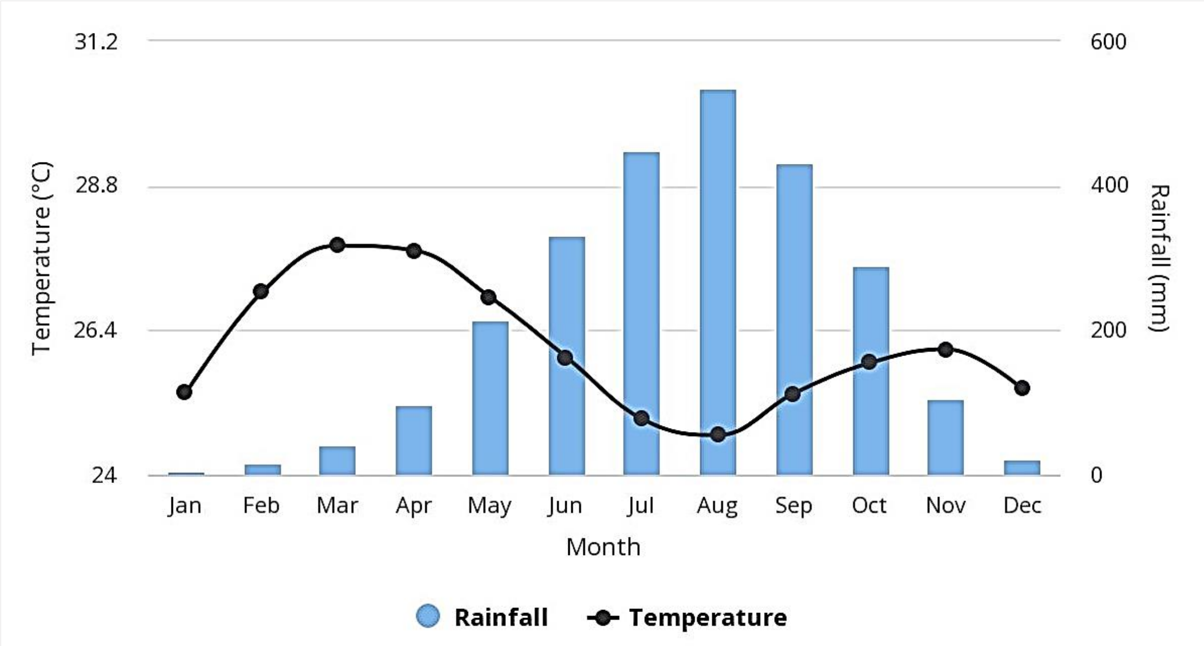

Figure 3A. 1: Long term average monthly temperature and rainfall in Sierra Leone, 1901–2016

Source: World Bank Climate Change Knowledge (2019).

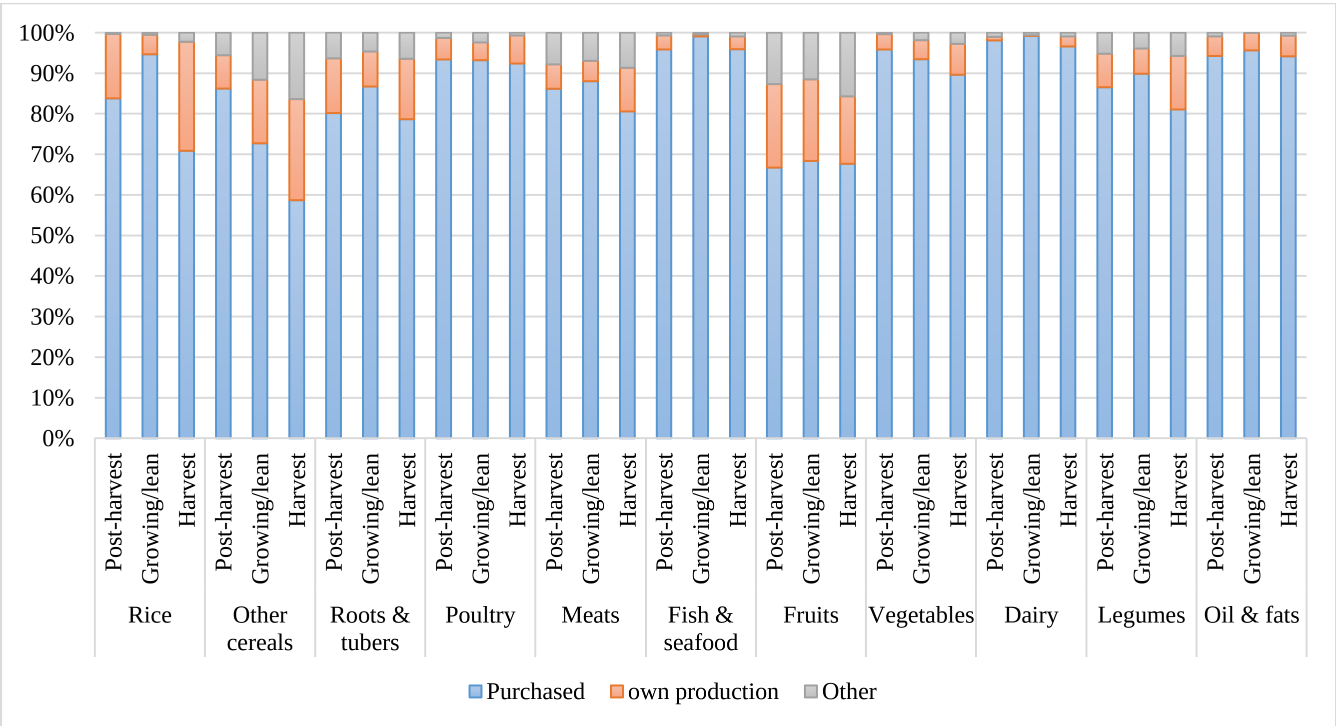

Figure 3A. 2: Primary sources of food by group and season.

Note: The "Other" category consists of food obtained as in-kind, gifts, and food aid. The post-harvest season covers February – May, growing/lean season spans June –September and harvesting season covers October – January.

Source: Own construct based on SLISH 2018

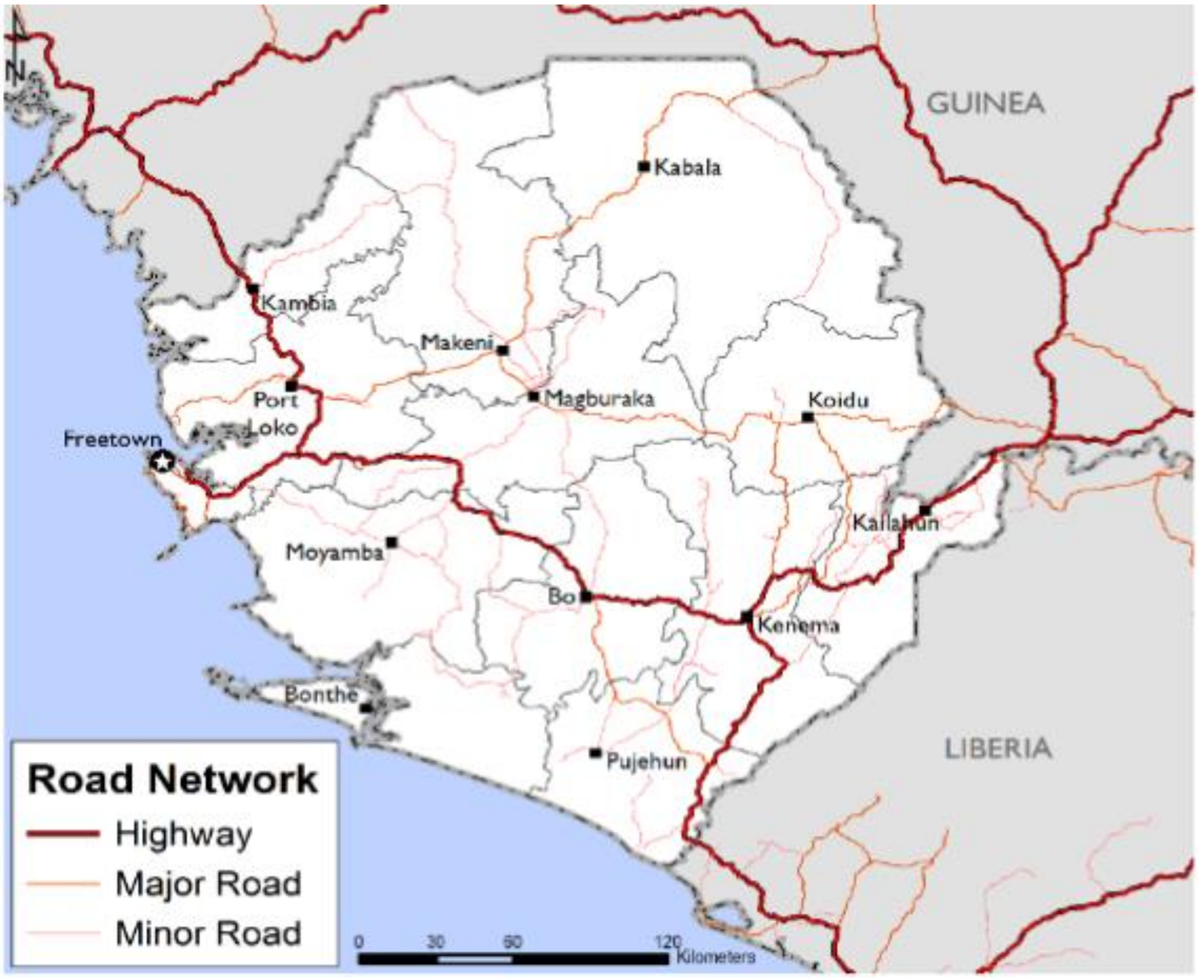

Figure 3A. 3: Road network in Sierra Leone, October 2015.

Source: FEWS NET (2017)

Table 3A. 1: Effects of monthly seasonality on household dietary diversity and food security in rural Sierra Leone

	Dietary diversity				Food security		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HHDI	lnHDDI	STAPSH	NSTASH	FDSH	lnCSI	HHS
January	0.020***	0.116***	0.015*	-0.004	-0.011	0.234**	0.363***
	(0.005)	(0.032)	(0.008)	(0.008)	(0.012)	(0.112)	(0.098)
February	0.014***	0.080**	0.009	-0.011	0.025**	0.178*	0.172**
	(0.005)	(0.032)	(0.008)	(0.008)	(0.010)	(0.101)	(0.086)
March	0.009**	0.048	0.008	-0.014*	0.034***	0.177*	0.113
	(0.004)	(0.030)	(0.008)	(0.008)	(0.010)	(0.096)	(0.082)
April	-0.001	0.016	0.025***	-0.030***	0.040***	0.122	0.216***
	(0.005)	(0.034)	(0.008)	(0.008)	(0.010)	(0.100)	(0.083)
May	-0.010**	-0.044	0.043***	-0.034***	0.041***	-0.186*	0.021
	(0.005)	(0.030)	(0.008)	(0.008)	(0.010)	(0.106)	(0.090)
June	-0.019***	-0.090***	0.067***	-0.061***	0.068***	0.197*	0.167*
	(0.005)	(0.033)	(0.008)	(0.008)	(0.010)	(0.104)	(0.086)
July	-0.000	-0.024	0.058***	-0.051***	0.072***	0.294***	0.297***
	(0.005)	(0.031)	(0.008)	(0.008)	(0.010)	(0.100)	(0.084)
August	-0.002	-0.027	0.056***	-0.051***	0.084***	0.346***	0.308***
	(0.005)	(0.031)	(0.008)	(0.008)	(0.010)	(0.091)	(0.085)
September	-0.012**	-0.052	0.058***	-0.049***	0.075***	0.072	-0.025
	(0.005)	(0.034)	(0.008)	(0.008)	(0.010)	(0.107)	(0.083)
October	-0.011**	-0.074**	0.055***	-0.046***	0.052***	0.436***	0.345***
	(0.005)	(0.029)	(0.008)	(0.008)	(0.010)	(0.091)	(0.080)
November	-0.003	0.023	0.001	-0.005	0.023**	-0.303***	-0.152*
	(0.005)	(0.038)	(0.008)	(0.008)	(0.010)	(0.099)	(0.080)
Year of survey=2018	0.123***	0.791***	-0.111***	-0.030***	-0.198***	0.000	0.000
	(0.002)	(0.015)	(0.003)	(0.003)	(0.004)		
Constant	0.736***	1.296***	0.355***	0.457***	0.719***	1.229**	1.036**
	(0.017)	(0.118)	(0.026)	(0.025)	(0.031)	(0.507)	(0.444)
Controls	yes	yes	yes	yes	yes	yes	yes
District fixed effects	yes	yes	yes	yes	yes	yes	yes
N	7513	7513	7513	7513	7513	3337	3337
R^2_{adj}	0.427	0.398	0.264	0.136	0.371	0.265	0.172
F-test for months	12.65	9.41	24.60	18.93	18.49	11.64	7.05
F(*p*-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: OLS estimation. HHDI is the Berry index of household dietary diversity. lnHDDI is logit transformed HDDI. FDSH is the share of food expenditure in total consumption expenditure. STAPSH is the share of expenditure on staple foods in household food budget. NSTASH is the share of expenditure on non-staple foods in household food budget. lnCSI is the log of coping strategy index and HHS is the household hunger scale. The omitted category is December. The control variables are provided in Table 3.2. Robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3A. 2: Effects of monthly seasonality on household dietary diversity and food security in urban Sierra Leone

	Dietary diversity				Food security		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	HHDI	lnHDDI	STAPSH	NSTASH	FDSH	lnCSI	HHS
January	0.015***	0.107***	-0.004	-0.003	-0.104***	0.783***	0.447***
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.13)	(0.09)
February	0.010***	0.095**	0.003	-0.029***	-0.082***	0.781***	0.461***
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.13)	(0.10)
March	0.004	0.050	0.003	-0.019*	-0.067***	0.549***	0.206**
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
April	0.001	-0.002	0.018**	-0.011	-0.063***	0.357***	0.108
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
May	-0.001	-0.005	0.017**	-0.018*	-0.058***	0.464***	0.252***
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
June	-0.004	-0.082**	0.022***	0.002	-0.050***	0.307***	0.188**
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
July	0.003	0.030	0.013*	-0.030***	-0.051***	0.225*	0.113
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
August	-0.007*	-0.069*	0.023***	0.009	-0.037***	0.374***	0.233***
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
September	-0.000	-0.005	0.020***	-0.019*	-0.010	0.325***	0.081
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
October	-0.003	-0.038	0.020***	-0.006	0.002	0.206*	0.114
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
November	-0.001	-0.051	0.017**	-0.013	-0.012	0.128	0.226***
	(0.00)	(0.04)	(0.01)	(0.01)	(0.01)	(0.12)	(0.09)
Year of survey=2018	0.077***	0.625***	-0.096***	-0.055***	-0.069***		
	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)		
Constant	0.796***	1.625***	0.392***	0.399***	0.821***	3.483***	2.934***
	(0.01)	(0.11)	(0.03)	(0.04)	(0.03)	(0.56)	(0.39)
Controls	yes	yes	yes	yes	yes	yes	Yes
District fixed effects	yes	yes	yes	yes	yes	yes	Yes
N	5609	5607	5609	5609	5609	3287	3287
R^2_{adj}	0.407	0.378	0.410	0.155	0.316	0.258	0.198
F-test for months	5.38	5.83	4.58	3.86	29.14	7.47	4.42
F(*p*-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: OLS estimation. See notes to Table 3A.1. Robust standard errors in parentheses. Statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix III

Table 4A. 1: Description of variables and summary statistics (pooled sample from two waves)

Variables	Description/measurement	Mean	Std. Dev
Household / village characteristics			
Age of household head	Age of household head in years	47.96	14.44
Household head is male	Dummy = 1 if yes	0.95	0.221
Household size	Number of household members	6.69	2.478
Head ever attended school	Dummy = 1 if yes	0.48	0.49
Head is a cooperative member	Dummy = 1 if yes	0.48	0.499
Number of sleeping rooms	Number of rooms use for sleeping	4.03	1.80
Elevation	The altitude of household dwelling above the ground	198.43	127.49
Electricity in village	Dummy = 1 if yes	0.039	0.193
Cooperative in village	Dummy = 1 if yes	0.71	0.45
Distance to nearest town	Distance to nearest town from the village in kilometers	12.42	8.66
Access to basic services (ABS)			
Housing infrastructure index	Composite index of the quality of housing infrastructure: drinking water source, toilet, and materials used for wall, roof and floor. Each dwelling characteristic is classified into three general quality categories namely high, middle and low quality. The index is created through factor analysis and normalized to the scale 0-100, with higher values indicating better housing conditions.	46.78	18.51
Distance to primary school	Distance in kilometers	0.94	1.77
Distance to health center	Distance in kilometers	3.94	5.56
Distance to food market	Distance in kilometers	12.00	11.65
Distance to bank	Distance in kilometers	14.18	14.12
Distance to safe water supply	Distance in kilometers	3.982	9.573
Distance to tarred road	Distance in kilometers	9.69	17.79
Assets (AST)			
Agriculture asset index	Composite index of dummy variables indicating ownership of agricultural tools such as shovel, hand fork, hoe, axe, cutlass, and	46.78	30.11

	pruning saw and rice mill. The index is created through factor analysis and normalised to the scale as 0-100, with higher values indicating higher productive asset position.		
Wealth index	Composite index of dummy variables indicating ownership of non-productive assets such as bicycle, generator, motorbike, radio, lantern, stove, torchlight and television. The index is created through factor analysis and normalized to the scale as 0-100, with higher values indicating higher wealth position.	77.42	24.16
Land per capita	Acres of land owned by household divided by household size	1.31	1.247
Tropical Livestock Units	Numbers of livestock owned converted to a common unit. Conversion factors are: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01.	0.35	0.883
Adaptive Capacity (AC)			
Number of non-farm income sources	Count of off-income sources reported by the household.	0.41	0.782
Active population per capita	Number of household members aged 15-64 years old divided by household size.	0.49	0.210
Average education	Average years of schooling of household head and spouse.	2.65	3.462
Food crop production diversity	Number of food groups produced in the last 12 months.	2.04	1.342
Social Safety Nets (SSN)			
Public transfers per capita	Annual cash and in-kind transfers from governmental and non-governmental agencies per capita (in Leones)	6049.3	66754.8
Private transfers per capita	Annual cash and in-kind transfers from private sources per capita (in Leones)	6335.5	39118.5
Access to credit	Dummy = 1 if any household had access to credit in the last 12 months	0.60	0.490
Food security indicators			
Household Dietary Diversity Score	Number of food groups consumed (out 12) in the last 24 hours. The 12 food groups are cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other seafood,	6.92	1.346

	legumes, nuts and seeds, milk and milk products, oils and fats, sweets, spices, condiments and beverages.		
Food consumption per capita (log)	Log of annual total food consumption expenditure divided by household size.	13.90	1.217
Food consumption score	Composite measure of the diversity and frequency of food groups consumed over the previous seven days, weighted according to the relative nutritional value of the consumed food groups.	69.91	19.91
Shock variables			
Perceived food price fluctuations	Dummy = 1 if yes	0.13	0.332
Perceived abnormal increase in major food prices	Dummy = 1 if yes	0.06	0.229
Death of a working household member	Dummy = 1 if yes	0.10	0.305
Death of other household member	Dummy = 1 if yes	0.16	0.364
Loss of harvest/property to fire/flood	Dummy = 1 if yes	0.01	0.114
Drought, poor or irregular rains	Dummy = 1 if yes	0.03	0.180
High costs of agricultural inputs	Dummy = 1 if yes	0.06	0.233
Household member chronically ill	Dummy = 1 if yes	0.23	0.418
Household member temporarily ill	Dummy = 1 if yes	0.16	0.364
Political problems	Dummy = 1 if yes	0.02	0.131
Theft of money/valuables	Dummy = 1 if yes	0.05	0.227
Theft of crops or livestock	Dummy = 1 if yes	0.03	0.158
Unusually high level of human disease	Dummy = 1 if yes	0.04	0.200
Lack or loss of employment	Dummy = 1 if yes	0.00	0.0489
Pest invasion	Dummy = 1 if yes	0.02	0.151
Severely high level of livestock disease	Dummy = 1 if yes	0.00	0.0690
Lack of agriculture inputs	Dummy = 1 if yes	0.07	0.262
Other shocks	Dummy = 1 if yes	0.03	0.183
Rainfall variability	Coefficient of variation of rainfall during the growing season (April-September) between 1981-2016	44.73	11.15
Ebola intensity	Confirmed Ebola cases in chiefdom divided by chiefdom population	14.744	20.14
Observations		1672	

Table 4A. 2: Factor analysis of resilience pillars

Pillar	Primary variables/proportion	Factors retained: Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Uniqueness	Bartlett test of sphericity	KMO	Total proportion
Access to Basic Services (*ABS*)	Housing infrastructure index	0.30	-0.01	0.36	-0.05	-0.08	0.76			
	Proximity to primary school	0.40	-0.39	-0.11	0.05	-0.07	0.67			
	Proximity to health centre	0.55	-0.07	-0.01	-0.07	0.09	0.67		0.547	
	Proximity to food market	0.31	0.20	-0.23	0.22	0.00	0.76	305.946***		
	Proximity to bank	0.15	0.05	0.04	-0.15	0.13	0.93			
	Proximity to safe water supply	0.07	0.09	0.28	0.27	0.06	0.83			
	Proximity to tarred road	0.28	0.43	-0.05	-0.11	-0.08	0.72			
	Proportion of variance explained	0.45	0.23	0.17	0.10	0.03				0.9863
Ownership of Assets (*AST*)	Agricultural asset index	0.42	-0.35	-0.01			0.70			
	Non-productive asset index	0.55	0.15	-0.16			0.64		0.561	
	Land per capita	-0.08	0.34	0.11			0.85	228.17***		
	Tropical Livestock Unit	0.23	-0.09	0.31			0.85			
	Proportion of variance explained	0.61	0.25	0.11						0.9665
Adaptive Capacity (*AC*)	Number of income sources	0.18	0.11	0.12	0.18		0.84			
	Active population per capita	0.01	0.05	0.35	-0.24		0.81		0.469	
	Average education of head & spouse	-0.11	0.47	0.13	-0.04		0.73	71.535***		
	Number of food crops produced	0.60	0.14	0.07	0.15		0.58			
	Proportion of variance explained	0.42	0.22	0.17	0.11					0.9205
Social Safety Nets (*SSN*)	Cash or in-kind transfers from government & NGOs	0.82					0.32			
	Remittances & other private transfers	0.82					0.32		0.501	
	Head had credit access	-0.04					0.98	934.292***		
	Proportion of variance explained	0.98								0.979

Notes: *** indicates statistical significance at 1 percent level and rejection of the null hypothesis that the variables are not inter-correlated. KMO is the Kaiser-Meyer-Olkin measure of sampling adequacy.

Table 4A. 3: Impact of PROACT programme on the components of the asset pillar

	Δ Agriculture asset index				Δ Wealth index				Δ household landholding per capita			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Any intervention	17.30***				-0.42				0.00			
	(7.63)				(6.10)				(0.38)			
Cash crop		17.76***				-1.77				0.02		
		(5.00)				(3.70)				(0.12)		
Nutrition			7.00				1.33				-0.35	
			(7.12)				(5.85)				(0.45)	
Combined				12.07*				0.26				-0.31
				(6.45)				(4.74)				(0.28)
Constant	9.21	36.95	-71.92	18.94	-28.85	-52.21	9.62	-34.71	0.21	0.95	0.63	2.01
	(33.67)	(48.75)	(73.68)	(49.74)	(26.77)	(37.02)	(59.89)	(43.55)	(1.10)	(1.82)	(2.96)	(2.59)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shocks	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	797	501	232	380	797	501	232	380	797	501	232	380
R^2	0.423	0.439	0.477	0.48	0.123	0.107	0.236	0.173	0.138	0.170	0.163	0.190

Table 4A.3 (*continued*)

	Δ Tropical livestock units			
	(13)	(14)	(15)	(16)
Any intervention	0.03			
	(0.13)			
Cash crop		0.02		
		(0.08)		
Nutrition			0.02	
			(0.08)	
Combined				0.10
				(0.11)
Constant	1.38*	2.18*	1.20	1.23
	(0.79)	(1.23)	(1.13)	(0.99)
Controls	Yes	Yes	Yes	Yes
Shocks	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes
Observations	797	501	232	380
R^2	0.089	0.118	0.074	0.196

Notes: Notes: The results are based on OLS-FE estimates of Equation (4.4) using the matched sample. The reference category for treatment status is non-treated households. All explanatory variables are measured at time *t-1* (baseline). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4A. 4: Table 4A.4: Impact of PROACT programme on the components of the adaptive capacity

	Δ Number of income sources				Δ Active members per capita				Δ Food crop production diversity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Any intervention	0.162**				-0.016				-0.768***			
	(0.075)				(0.024)				(0.178)			
Cash crop		0.258***				-0.044				-0.540**		
		(0.091)				(0.028)				(0.220)		
Nutrition			-0.006				-0.011				-1.147***	
			(0.138)				(0.043)				(0.370)	
Combined				0.076				0.034				-0.808***
				(0.102)				(0.033)				(0.254)
Constant	-1.207*	-1.818*	0.237	-1.321	-0.282	-0.205	-0.594	-0.449	2.069*	0.753	2.973	4.739***
	(0.718)	(0.943)	(1.853)	(1.060)	(0.210)	(0.294)	(0.500)	(0.334)	(1.190)	(1.538)	(3.416)	(1.748)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Shocks	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	797	501	232	380	797	501	232	380	797	501	232	380
R^2	0.414	0.506	0.316	0.518	0.092	0.118	0.156	0.164	0.097	0.169	0.238	0.153

Notes: The results are based on OLS-FE estimates of Equation (4.4) using the matched sample. The reference category for treatment status is non-treated households. All explanatory variables are measured at time *t-1* (baseline). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$