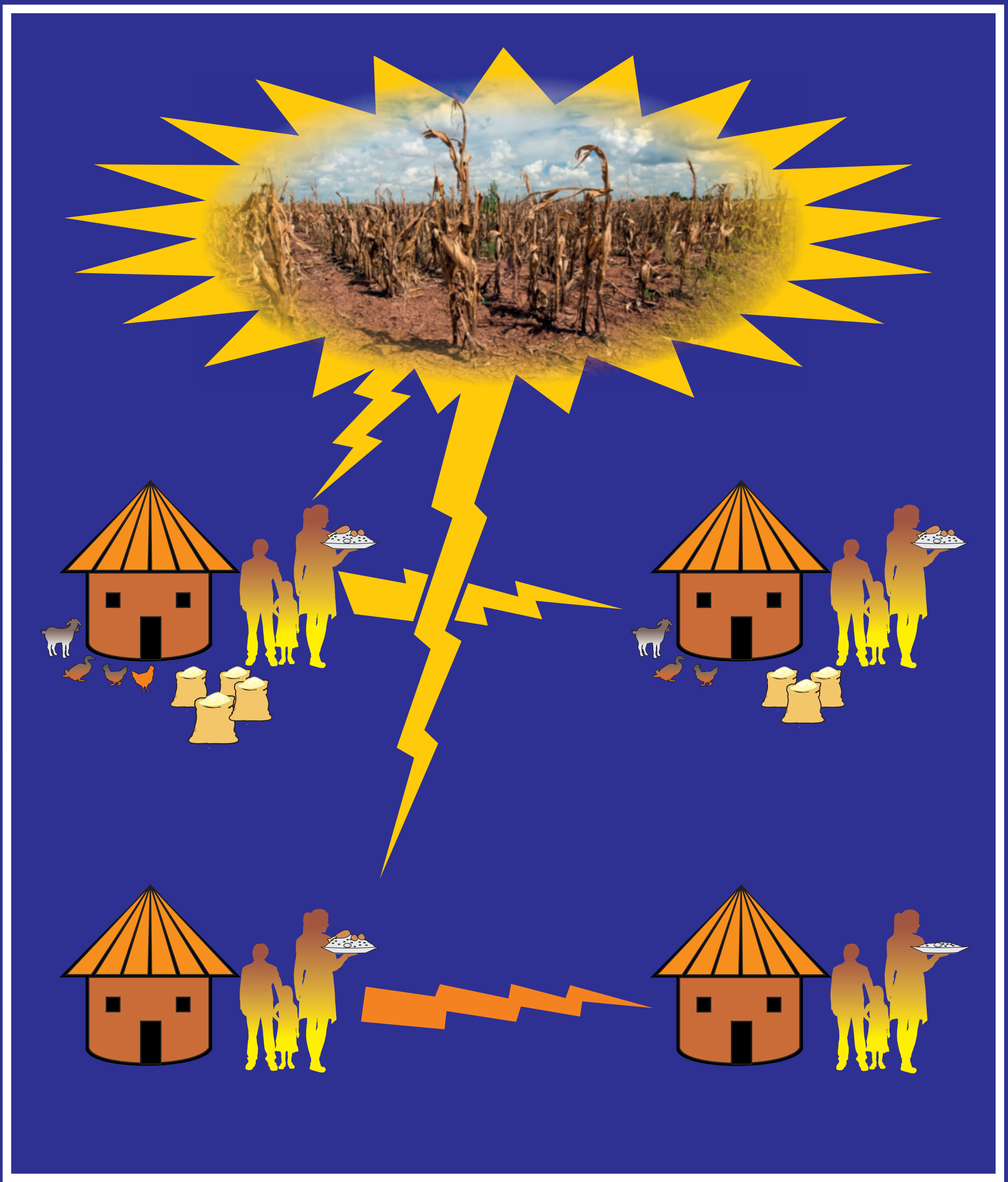
HOUSEHOLD RESILIENCE TO FOOD SECURITY SHOCKS



ISAAC GERSHON KODWO ANSAH

Propositions

1. Investment in resilience-building strategies is a key factor for improving the resilience of citizens in any developing country.
   (this thesis)

2. Food security cannot be achieved in any developing country where multiple shocks abound.
   (this thesis)

3. Integrated soil fertility management is the most efficient approach to enhance crop productivity.

4. All scientific problems already exist, we only pay attention when they cross their critical threshold.

5. In many developing countries, Covid-19 lockdowns did more damage than the pandemic itself.

6. A successful WUR PhD student is an efficient human resource manager.

Propositions belonging to the thesis, entitled

Household resilience to food security shocks

Isaac Gershon Kodwo Ansah

Wageningen, 14 June 2021

Household resilience to food security shocks

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Household resilience to food security shocks

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TABLE OF CONTENTS

CHAPTER 1

GENERAL INTRODUCTION

1. Introduction

1.1 Background

This section introduces three key issues that form the main theme of this thesis. Its first sub-section introduces the link between food security and household food demand. The next sub-section discusses shocks and their implications for food security, while the last sub-section introduces the concept of resilience in relation to food security and shocks.

1.1.1 Food security and household food demand

The primary goal of economic development is to generate sustainable improvements in the material wellbeing of people. For all indicators of material wellbeing, food security is often prioritised because according to Warr (2014) food *"is not a normal commodity"* but a necessity of life. FAO (2019) and the High Level Panel of Experts (HLPE, 2020) declare that everyone has the right to food. The United Nations' Sustainable Development Goals (SDG) 2030 agenda of ending poverty and hunger in all its forms is a result of the greater global attention that food security received in recent times. Food security has been a major policy objective of the international development community as well as of governments of developing and emerging economies over the last few decades (FAO/ECA/AUC, 2020; Guariso et al., 2014; MoFA, 2017). The best options to achieve and sustain household food security in developing countries, especially at the micro level of individual households, are still being discussed (Abdul Mumin and Abdulai, 2020). This debate is likely to continue for some time because sub-Saharan Africa's food security situation continues worsening. FAO/ECA/AUC (2020) reported a 2% rise in the number of people facing food insecurity and malnutrition in sub-Saharan Africa between 2014 and 2018.

Food security has the four key dimensions of availability, access, utilization and stability (EC-FAO, 2008). Until recently when HLPE (2020) added the two dimensions of agency and sustainability (see Table A1.1 in the appendix for definitions of all six dimensions), the availability dimension has been the major focus of food policies in developing countries. The challenges associated with household food demand, which relate to the access and stability dimensions of food security, have received less attention. Upton et al. (2016) consider economic access of households to a stable food supply as an important food security theme, especially in sub-Saharan Africa. Food demand at the household level can be constrained even if aggregate food supply in a country is sufficient (Smith and Haddad, 2001). For instance, households in rural areas that are often poorly integrated with urban and regional markets are challenged by locally high food prices (Cudjoe et al., 2010). Such inflationary pressures erode consumer purchasing power for food, leading to consumption of less calories and less nutritious food (Ecker and Qaim, 2011; Warr, 2014).

Constrained economic access to food acquisition, both in quality and quantity, contributes to 20% of the African population facing undernourishment (FAO/ECA/AUC, 2020). Poverty constrains economic access to food in developing countries (Smith et al., 2000; Van Wijk, 2002; WFP, 2012). The poor people lack economic resources and can hardly afford the quantity and variety of foods required for achieving food and nutrition security. Poverty compels households to select among food commodities that are all essential for balanced growth and development. World Bank (2020) reports that extreme poverty rates in Africa are rising, and about 40% of the sub-Saharan African population, which is equivalent to 433 million people in 2018, live below the extreme poverty line of US$ 1.90 a day. Shocks further compound these challenges associated with household food demand and stability.

1.1.2 Shocks as key drivers of household food security

Shocks threaten the achievement of all dimensions of food security. Consequently, economists pay substantial attention to shocks as critical causal factors of food insecurity (Akter and Basher, 2014; Alderman, 1996; Carter and Lybbert, 2012). A shock, defined in the context of this thesis, is an unexpected event which may disrupt the availability, access, stability, and utilization dimensions of household food security. Shocks affecting household food security vary in nature and scope. Shocks can either be idiosyncratic (affecting individual households) or covariate (affecting many households simultaneously). Échevin and Tejerina (2013) confirm that the scope of a shock determines the type of strategies that households use to cope with its effects.

Households in shock-prone areas often experience multiple incidences of shocks which often create more difficulties for coping than single shock events (Heltberg et al., 2015). Lazzaroni and Wagner (2016) find that the interplay of climate variability and international price volatilities increases the vulnerabilities of farm households in the Sahel region. Confronting these myriads of shocks to safeguard household food security requires resilience in household food acquisition and consumption.

A common covariate shock pertinent to household food security discussions in developing countries is weather variability, manifested in the form of poor rainfall, drought, floods, or storms (FAO/IFAD/UNICEF/WFP/WHO, 2018). Weather shocks often lead to harvest failures. In East Africa, the World Meteorological Organization (2020) report that below-average rains in both the long and short rainy seasons led to about 12 million people experiencing severe food insecurity in 2019. In Southern Africa, nearly 14 million people needed food assistance due to rainfall deficits, whereas in West Africa heavy floods in July and August 2019 caused crops and livestock losses (World Meteorological Organization, 2020).

Besides the weather, the sudden appearance of diseases and pest infestations can challenge food security in developing countries. Weather variability is often a precursor of insect pest infestations which destroy vast acreages of farms and cause significant yield losses (Salih et al., 2020; WMO-FAO, 2016). In 2020, desert locusts invaded farms in the Horn of Africa and destroyed vast areas of crops (Meynard et al., 2020; Peng et al., 2020). Since 2016 fall armyworm outbreaks have been challenging maize farming in Africa resulting in substantial yield losses, poor nutrition and illnesses (Baudron et al., 2019; Chimweta et al., 2020; Midega et al., 2018).

Price shocks count among the most frequent sources of food insecurity in developing countries (Barrett and Lentz, 2010; Regmi and Meade, 2013), affecting the access dimension. For poor people who spend the biggest chunk of their income on food purchases in line with Engel's law, food price shocks create serious problems for their food security. Price shocks may arise from low agricultural production and seasonal effects that cause supply disruptions in the marketplace (Ihle et al., 2020). In developing countries, fuel prices also drive other economic sectors. An increase in fuel prices therefore affects energy and transport sectors, culminating in high food prices. Moreover, many forms of political violence generate price shocks (Brück et al., 2019; FAO/ECA/AUC, 2020).

Health shocks, manifesting as human health problems such as epidemics, pandemics, and deaths, also affect household food security. Besides the possible trade-offs that households must make between health and food expenses, health shocks (e.g., temporary or chronic illness of household members) influence the human capital investment in food production (Genoni, 2012; Lim, 2017). Common diseases such as malaria, tuberculosis, and cholera often confront households in developing countries. Farmers, for instance, might not be able to access own-produced food when they fall sick, and the consequence on household food availability may be dire if hired labour cannot easily substitute family labour. Studies investigating the link between health shocks and food consumption such as Townsend (1994) and Yilma et al. (2014) find a very small or no effect. However, the recent health shock caused by the COVID-19 pandemic has been found to present severe implications for household food security (Deaton and Deaton, 2020; Devereux et al., 2020; Reardon et al., 2020).

1.1.3 Resilience as a panacea for safeguarding food security

Holling (1973) introduced the concept of resilience in ecology that later sparked renewed interest in other disciplines. According to Holling resilience is *"the persistence of relationships within a system, and is a measure of the ability of these systems to absorb changes of state variables, driving variables and parameters, and still persist"*. Since then, the wider scholarship has described resilience as a multi-attribute construct. However, the number of attributes of resilience is still being debated (Berkes et al., 2008; Folke, 2006; Walker et al., 2004). Béné et al. (2012) synthesize the extant literature and define three main attributes, namely, absorptive capacity, adaptive capacity, and transformative capacity.

Absorptive capacity defines the ability of households to minimize their exposure to shocks, but also having the mechanisms to recover quickly when shocks occur. This capacity ensures that households continue to perform their functions, and mostly constitutes coping strategies such as harvesting crops early to avoid floods, taking children out of school or even postponing debt repayments (OECD, 2014). Adaptive capacity aids households to respond to unexpected change by making informed choices of alternative mechanisms in advance, such as diversifying their livelihood activities and planting improved drought-resistant crop varieties (Heltberg et al., 2012). Transformative capacity refers to those conditions at the disposal of the household, that enable it to change from a configuration that is prone to specific shocks to another that is more robust to those shocks. For instance, a farm household that frequently faces low yield due to poor rainfall might decide to quit farming and engage in non-farm activities, such as processing or petty trading. According to Carpenter et al. (2005) and Folke et al. (2010), adaptive and transformative capacities are necessary to handle the primary sources of vulnerability. In other words, adaptive and transformative capacities involve medium to long-term mechanisms that help vulnerable systems to develop robustness against specific kinds of shocks.

In many fields, resilience has been applied to analyse whether and how systems can be made more robust to shocks (Barrett and Constas, 2014; Doran and Fingleton, 2016; Folke, 2006; Holling, 1973; Martin and Sunley, 2014). In the context of food security, analyses of resilience are limited even though few conceptual studies appeared in the last decade (Pingali et al., 2005b; Tendall et al., 2015a; Toth et al., 2016). Due to the impacts of recurrent shocks on food security, resilience is becoming increasingly important for local, regional, national, and global food security planning (Béné et al., 2017; Serfilippi and Ramnath, 2018). The motivation for this attention is that the degree of household resilience determines how well they can withstand or adapt to shocks (Alinovi et al., 2008; Babu and Blom, 2014; Fan et al., 2014; Thompson and Scoones, 2009). As a sequel, increasing number of programmes, policies and projects concentrate on helping to understand the nexus between resilience and household food security in order to improve societal wellbeing (EU, 2012; USAID, 2016).

A household is said to be resilient if it can consistently supply adequate, nutritious, and healthy food to its members despite the incidence of food security shocks. In this thesis, resilience to household food security shocks relates to strategies that help households to mitigate the effects of shocks on their food consumption. Smit and Wandel (2006) discuss that households develop strategies over time to respond and internalize these shocks albeit these strategies differ in their effectiveness. There are both *ex ante* and *ex post* shock coping strategies. For *ex ante* strategies, some farm households try to improve production or resource-use efficiency while others adjust by reallocating resources to new activities (Tambo, 2016) or diversify income through non-farm activities. Farmers may also shift to crops that are drought-tolerant or less dependent on purchased inputs (Azumah et al., 2017). *Ex post* shock coping strategies include depletion of assets, food stocks or cash savings (Kazianga and Udry, 2006; Zimmerman and Carter, 2003).

This thesis refers to the strategies used by households to safeguard their food security from shock effects as resilience-building strategies. When confronted with price and income shocks, many households resort to using their accrued or acquired resilience-building capacities such as cash savings, livestock and other assets or they consume from crop stocks which they have stored (Deaton, 1991; Doss et al., 2018).

1.2 Problem Statement

The growing interest in the concept of resilience as discussed in section 1.1.3 is the direct result of persistent food insecurity (FAO/IFAD/UNICEF/WFP/WHO, 2018), often driven by recurrent shocks affecting households as elaborated in sections 1.1.1 and 1.1.2. The challenge, however, is how to operationalize resilience in the context of household food security in order to assess it empirically. Economists have risen to this challenge by applying various conceptual and analytical models linking resilience and household food security, which often generate incomparable results (Constas et al., 2014a; Constas et al., 2014b). For instance, Alinovi et al. (2010) conceptualize resilience as multidimensional, developing a resilience index that includes food security as part of resilience factors. Other researchers argue that food security as a wellbeing outcome should not be measured as resilience (Béné et al., 2012). Upton et al. (2016) adopt the moment-based development resilience index proposed by Barrett and Constas (2014) as a measure of food security. These divergent measurements and conceptual approaches rather create confusion than enhancing our understanding of the resilience-food security nexus. This thesis contributes to this emerging literature by first outlining how food security resilience is conceptualized, operationalized, and analysed empirically, and then by investigating how resilience-building strategies affect households' resilience to shocks affecting their food demand.

Resilience is not directly observable, and hence not easily measurable. Also, the broader science literature has not yet agreed on a common definition and measurement of resilience (Southwick et al., 2014). Constas et al. (2014a) argue that the same risk of disharmony faces resilience conceptualization and measurement in socioeconomic studies. For instance, when economists talk about 'demand' they have specific definitions in mind. The same cannot be said about resilience because resilience means different things to many people at various times. Notwithstanding this conceptual and methodological difficulties, development actors and humanitarian agencies are urgently seeking solutions to the intricate food security problem through programmes and projects that help improve resilience to shocks affecting household food security. The danger is that social scientists tend to focus more on developing several new conceptual models and analytical techniques which generate divergent results (Serfilippi and Ramnath, 2018). A first plan to take stock of existing methods and assess to know whether these methods can be improved is surprisingly missing. Serfilippi and Ramnath (2018) review literature on resilience in general as applied by humanitarian organizations, but the question remains whether emerging food security studies diverge on the conceptualization and measurement of resilience.

Primarily, the frequent negative impacts of shocks on socioeconomic systems drive the interest in household resilience. While many studies document that common shocks affect households, others further explore coping mechanisms that households employ when they are confronted with shocks (Béné et al., 2017; Dercon, 2002). Alfani et al. (2015) state that *"the poorest households are confronted often with a multiplicity of shocks: droughts or floods reduce grain supplies, prices spike, and health shocks strike" (page 2)*. In fact, Komarek et al. (2020) question why households in developing countries face multiple shocks, but empirical analyses focus mostly on single or isolated shocks and ignore or give little attention to the effects of multiple shocks. The few papers assessing multiple shocks focus on the direct impacts on welfare outcomes but less attention on coping strategy choices (Akter and Basher, 2014; Lazzaroni and Wagner, 2016). Further, little is known about whether and how multiple shocks interrelate in their effects on household coping strategy choices and food security.

A central issue in food security studies concerns the ability of households to have economic access to a diverse diet in adequate quantities that satisfy the minimum acceptable dietary requirements. Poor households with low purchasing power tend to concentrate their food budget on less healthy energy-rich staple foods because they are generally cheaper than nutrient-rich foods (French et al., 2019). Shocks threaten food affordability, especially when they lead to significant income losses and household budget available for food purchases significantly reduces. Clements and Si (2017) reveal that cheaper, low quality, less diverse and more starchy foods are likely to dominate the food basket of households with reduced purchasing power. How resilient is household demand for various commodities to events that increase food prices and/or those that reduce household food budget? Guo (2011) shows that households with more assets and capitals have better food security, while others find that households with limited purchasing power tend to sacrifice expensive but nutrient-rich food items for cheap, energy-dense foods in the event of shocks (French et al., 2019; Gibson, 2013). These discussions are however not based on detailed analysis of specific food commodities.

The main rationale for resilience programming is to find workable programmes and policy interventions that would improve societal welfare by reducing or ending hunger caused by frequent shocks. Since resilience to food insecurity is an emerging research field, there is often a lack of adequate data on household food security that is based on already implemented resilience programmes and policy interventions. Nevertheless, research still needs to inform policies on programmes designed for improving resilience to food security shocks using existing cross-sectional survey data (Alfani et al., 2015). One approach that can help supply *a priori* policy advice given the existing resilience data challenges is to use simulation-based methods (Franses, 2005). Unfortunately, simulation-based assessment of resilience from household food security perspective is presently limited.

1.3 Objectives of the thesis

Based on the problem statement, the principal objective of this thesis is to study the relation between resilience-building strategies, shocks, and household food security. To meet this broad objective the following specific research objectives are defined:

i. Review the resilience literature from a food security perspective and identify and synthesize concepts, methodological approaches and relationships that exist between resilience and food security.

ii. Assess how *ex post* coping strategy choices differ in their responses to single shocks and to multiple coinciding shocks and quantify to what extent the *ex post* coping strategies relate to household food security.

iii. Measure the heterogeneous responses of households with different resilience-building strategies to price and income shocks affecting their food demand.

iv. Simulate how household food demand would respond to specific shocks as well as policy instruments intended to enhance household resilience capacities.

1.4 Methodological approach and data

To achieve these objectives, this thesis adopts different theoretical frameworks and methodological approaches. For addressing the first objective, existing conceptual and methodological frameworks would need analyses in a comprehensive way to avoid skipping important papers. This is done by following a systematic literature review technique discussed by Gough et al. (2012) and Jesson et al. (2011) to identify recent publications that analyse resilience from the perspective of household food security. The evidence provided by selected and included publications are synthesized and discussed in a conceptual way.

To address the second objective, theories of consumption and assets smoothing are used to conceptualize the links between shocks, *ex post* coping strategies and food security outcomes. The empirical strategy uses multiple micro-econometric techniques. Binary and multivariate probit models are used to analyse the effects of single shocks and their interactions with coping strategy choices. Multiple linear regression models are used to examine the association between shocks, coping strategy choices and household food security in a recursive framework using the conditional mixed process estimation technique developed by Roodman (2011), which is widely used in the literature. The data used to address research objective two is based on the Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) baseline survey data collected by the International Food Policy Research Institute (2015). The International Food Policy Research Institute designed this data specifically for farm households. The data has detailed information on shocks as well as on coping and adaptation strategies, thus making it suitable for investigating multiple shocks and coping strategy choices.

In addressing the third objective, this thesis uses microeconomic theory on household behaviour where the household maximizes utility from consuming a basket of food items conditional on a budget constraint. Adapting the quadratic almost ideal demand system (QUAIDS) suggested by Banks et al. (1997), selected resilience-building strategies are integrated into the QUAIDS model through the demographic translation approach of Pollak and Wales (1981). The empirical analysis of the second objective uses the three most recent rounds of household data from the Ghana Living Standards Surveys (GLSS), provided publicly available online by Ghana Statistical Service (GSS) (2018). The GLSS data has comprehensive information on economic (most importantly food expenditure data), socio-demographic and other indicators suitable for modelling food demand.

Finally, the methodology used to meet the fourth objective builds on the third. It also uses the theory of utility maximization and estimates the QUAIDS model. When households experience shocks affecting their food demand, they try to maximize utility under the constrained budget by substituting among the food items if the budget cannot be supplemented by income from other expenditure categories. The effects of shocks on food demand are analysed through simulations, making use of the estimated model presented in an earlier chapter. Price and income shocks derived from recent happenings in sub-Saharan Africa as reported by FAO/IFAD/UNICEF/WFP/WHO (2018) and Minot and Dewina (2013) are simulated based on the results of the adapted QUAIDS used for addressing the third objective. Lastly, the impacts of various meaningful policy scenarios derived from the Sustainable Development Goals on household food demand are assessed in a set of four complementary simulations. The baseline estimation of the QUAIDS model still uses the GLSS data.

1.5 Thesis Outline

The remainder of this thesis is organized as follows. Each of the chapters in 2 to 5 addresses one of the four research objectives stated in section 1.3. Each main chapter includes a short introductory section. After these four main chapters, chapter 6 provides the overall conclusions on the main findings and discusses policy and research implications that go beyond the findings discussed in the individual chapters. Chapter 6 also includes a critical reflection of the whole thesis trajectory leading to suggestions for further research.

Appendix A1.1

Table A1.1 The six dimensions of food security

Dimension	Definition
Availability	Having a quantity and quality of food sufficient to satisfy the dietary needs of individuals, free from adverse substances and acceptable within a given culture, supplied through domestic production or imports.
Access (economic, social and physical)	Having personal or household financial means to acquire food for an adequate diet at a level to ensure that satisfaction of other basic needs are not threatened or compromised; and that adequate food is accessible to everyone, including vulnerable individuals and groups.
Utilization	Having an adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.
Stability	Having the ability to ensure food security in the event of sudden shocks (e.g. an economic, health, conflict or climatic crisis) or cyclical events (e.g. seasonal food insecurity).
Agency	Individuals or groups having the capacity to act independently to make choices about what they eat, the foods they produce, how that food is produced, processed, and distributed, and to engage in policy processes that shape food systems.
Sustainability	The food needs of the present generations are met without compromising the food needs of future generations.

Source: HLPE (2020)

CHAPTER 2

RESILIENCE AND HOUSEHOLD FOOD SECURITY: A REVIEW OF CONCEPTS, METHODOLOGICAL APPROACHES AND EMPIRICAL EVIDENCE

2. Resilience and household food security: a review of concepts, methodological approaches and empirical evidence[1]

Abstract: The way economic studies conceptualize and measure resilience is very heterogeneous. This does not only challenge scientific progress, but also raises the question of whether they measure one identical concept with different methods or whether they measure different understandings of resilience. This chapter provides a review of concepts, methodological approaches and empirical evidence on resilience from a food security perspective, focusing on socio-economic research. We perform a systematic literature search to identify recent publications that analyze resilience from the perspective of household food security. We examine the historical evolution of concepts and methods used for measuring resilience and synthesize the evidence. We find that conceptual and analytical models have evolved over time, with important technical adjustments. Studies initially focused on measuring resilience as an end in itself, but more recently resilience is understood as a means to an ultimate end, hence resilience capacity is measured instead. Also, resilience was initially measured as an indicator of food security. Currently it is measured distinctly from food security. Multivariate techniques are found to be frequently used to quantify resilience. The empirical evidence suggests that households with higher resilience capacity tend to have less child malnutrition and better food security. We find that causal pathways through which resilience capacity affects food security in a microeconomic framework are barely explicitly considered in empirical analyses. Therefore, we suggest a model which explicitly addresses these pathways.

[1] This chapter is based on the article: Ansah, I. G. K., Gardebroek, C., & Ihle, R. (2019). Resilience and household food security: a review of concepts, methodological approaches and empirical evidence. *Food Security, 11*(6), 61187-61203. doi:10.1007/s12571-019-00968-1

2.1 Introduction

Farm households in developing countries often face a wide range of recurring and unanticipated environmental, ecological, or socio-economic shocks. The welfare costs of such shocks are often significant and draw policy and humanitarian attention. After Holling (1973)'s influential paper on resilience, this concept has been adopted by many development actors to better understand the robustness of food systems and their ability to adapt in the wake of shocks (Constas et al., 2016; Constas et al., 2014a; Pingali et al., 2005a). Besides, understanding resilience in household food systems may help in better programming interventions that affect food systems in shock-prone developing regions (Fan et al., 2014; OECD, 2013; Thompson and Scoones, 2009; UNDP, 2012). Furthermore, recent discourses in media and policy have been arguing that resilience in food systems could be a panacea for food security in developing countries (EU, 2012).

Resilience has been defined from a social-ecological perspective as the capacity of socioeconomic systems (e.g., households) to withstand shocks through absorption, adaptation and transformation (Folke, 2006; Gunderson, 2000; Walker et al., 2004). Resilience has been applied in various contexts to understand whether and how social and economic systems could become more robust to shocks (Barrett and Constas, 2014; Doran and Fingleton, 2016; Folke, 2006; Martin and Sunley, 2014). However, for the specific application of resilience to food systems only few conceptual studies have emerged and these tend to treat the topic from a general perspective (Pingali et al., 2005a; Tendall et al., 2015b; Toth et al., 2016). What remains a challenge is how to operationalize resilience in a household food systems context in order to assess it empirically. Further, due to the complex nature of the resilience concept, various studies tend to propose different theories and methods that often generate different results. Empirical studies published in recent years diverge on the operationalization and methodological measurement of resilience, thus yielding outcomes which are hardly comparable. Such heterogeneity challenges scientific progress and does little help to properly inform policy and investment decisions (Serfilippi and Ramnath, 2018). The heterogeneous results also raise the question of whether these studies measure the same concept with different methods or measure different things and refer to it as resilience. Therefore, a synthesis of studies that address resilience from a food security perspective is important and can help focus research by building on existing best practices.

The objective of this chapter is to review the resilience literature from a food security perspective and to identify and synthesize concepts, methodological approaches and relationships that exist between resilience and food security. First, we provide an overview of the developments of conceptual and analytical frameworks guiding the resilience-food security discourse. Second, we examine the empirical evidence of the relation between resilience and food security. Third, we assess whether the studies identified indeed operationalize and measure the relationship between resilience and food security. Serfilippi and Ramnath (2018) provide a literature review of the research on resilience in general as applied by humanitarian organizations. Our chapter extends their work in two main respects. First, we focus specifically on the links between resilience and food security. Second, we analyse also publications which assess this relation empirically. This helps to obtain an overview of existing models and, more importantly, how these models have been used in field applications, which provides useful insights in guiding policy and investment decisions (Béné et al., 2015a; Constas et al., 2016).

We pursue these objectives by focusing on the micro food system, where food is secured from three possible channels: direct entitlement (a household produces its own food entirely), indirect entitlement (a household purchases its food entirely), or mixed entitlement (a household partly produces and partly purchases food). We acknowledge, but do not focus on the macro food system, which assumes a much broader perspective beyond individual households and views the provision of food from an aggregated perspective at regional, national, transnational or global levels. At household level, shocks may affect food availability and eventually lead to food insecurity. Food security refers to the state where a household has access to sufficient, healthy and nutritious food that could sustainably nourish household members always (Pinstrup-Andersen, 2009). Food security can be measured by proxies such as food consumption scores, months of adequate food provision, household food expenditure, among others (Carletto et al., 2013). A shock is an event which may disrupt the normal functions of socioeconomic agents and/or their activities, impose challenges and threaten household food security. In the literature, two types of shocks often discussed are covariate shocks affecting many individuals at the same time (e.g., poor rainfall that leads to drought, or floods) and idiosyncratic shocks (e.g., diseases/illnesses or death that affect individuals or single households). Households may use various mechanisms such as crop diversification (Bullock et al., 2017; Lin, 2011), contract farming, vertical and horizontal integration and agricultural intensification (Azumah et al., 2017; Ellis, 1998) to cope with these shocks and adapt (Pingali et al., 2005a). The extent and success of households to employ such mechanisms for dealing with these shocks in their food systems is a measure of resilience. A resilient food system therefore retains its core functions of ensuring food security even when challenged by shocks.

The rest of the chapter is organized as follows. In section 2.2, a brief outline of the literature search process is given, while section 2.3 reports and discusses the literature search outcomes. We then present a synthesis of the literature review on resilience and food security in section 2.4 and section 2.5 concludes the chapter.

2.2 Literature search strategy and selection of included primary studies

To achieve the research objectives, we conducted a systematic literature search (Gough et al., 2012; Jesson et al., 2011) through CAB Abstracts, Web of Science, Scopus and Econlit, complemented with a 'snowball' in-document reference selection (i.e., identifying relevant articles referenced in other published papers). We used search terms developed from three main keywords, which are resilience (i.e., independent / intervention variable), food security (i.e., dependent variable) and household (i.e., scope variable or unit of analysis). These three keywords were identified with synonyms derived from the literature (see Table 2.1 below). We combined these three keywords into a complete search term string, connected with the Boolean operators "OR" for synonyms of the same keyword, and "AND" for the different keywords. This string was then entered into selected databases to retrieve the data.

We conducted the literature search on *title, abstract* and *key words,* and evaluated the completeness of the search strategy by checking the references from the relevant documents retrieved. We further restricted the retrieved articles by disciplinary focus, including economics, social science interdisciplinary (e.g. economics and sociology), agricultural economics and policy, and agriculture multidisciplinary. We preferred databases that provided links to export retrieved documents to the endnote reference software and excluded databases that do not relate to our subject area (e.g. psychology, ecology, etc.) and those that do not focus on primary studies (e.g. online blog, newspapers). Because most of the articles retrieved had global context, we further reduced the search results with the Boolean operator 'NOT' and the word 'global', excluding all studies with a global or macro focus.

After collecting papers from the databases, a first screening process involved reading through the titles, abstract and keywords to judge whether they related to the objective of this study. The objective was to investigate studies that addressed resilience and food security at the household level, either as the main or sub-objective of the study. Papers that did not meet the criteria were excluded outright while those that satisfied the criteria remained for further analysis. Table 2.1 presents the results from the initial search and further screening processes.

Table 2.1 Literature search results and screened articles

	Database				
Search scope	*Web of Science*	*Scopus*	*Cab Abstract*	*EconLit*	*Total*
Keyword 1: resilience Synonyms: absorptive capacity, adaptive capacity, adaptability, diversity, diversification, transformative capacity, transformability	605	3,516	4,699	1,878	
Keyword 2: food security Synonyms: food availability, food utilization, food access, food stability, food insecurity, food consumption scores, household dietary diversity, household food expenditure, undernourishment, malnourished, malnutrition, inadequate food intake, undernutrition	2,992	25,326	61,642	4,230	
Keyword 3: household Synonyms: micro-level, farmers, farm level, rural livelihood	48,239	176,912	567,028	94,201	
Combined search (#1 AND #2 AND #3)	28	41	322	38	430
Further screening by reading through titles, abstract, keywords	8	11	37	6	62
Retained after removing duplicates					52
Further screening with inclusion / exclusion criteria					25
Snowball “in-document” referrals					3
Retained and available for final review					28

After the initial screening and removing duplicates, 52 studies were retained, which were further subjected to a second level but stricter screening process according to specific inclusion criteria. An included study had (1) either conceptualized and/or measured resilience and (2) the unit of study being the household. Besides these two necessary conditions, the interest also centered on studies that had (3) derived a quantitative measure of resilience and/or (4) linked resilience to food security analytically or empirically. A paper must necessarily satisfy the first two conditions to be retained for further analysis. From the retrieved documents, we also identified three more studies that were relevant to the review, and so were included. In the end, 28 studies remained for the review on the conceptual, methodological and empirical analysis of resilience and food security. For the review of the empirical evidence, we focused specifically on studies that establish a (causal or correlational) relationship between food security (or any of its proxies) and resilience (or its attributes) at the household level. In Table 2.2 below, we report the included studies summarizing the nature of the paper (either conceptual, analytical or empirical), the main attributes of resilience assessed by each study, data requirements and methods used for quantifying the selected resilience attributes.

Table 2.2 Main characteristics of reviewed studies

Author(s)	Type of study	Resilience attributes assessed	How resilience is operationalized	Main relationship examined	Shock(s) examined	Methodology	Data used
Alinovi et al. (2008)	Conceptual, analytical, empirical	Income and food access; Access to public services; Social safety nets; Assets; Adaptive capacity; Stability	Resilience index		None specified	Two-stage Factor Analysis	Cross-sectional
Keil et al. (2008)	Empirical	Share of expenditures between normal and drought years; differences in monthly consumption frequencies between normal and drought years	Drought resilience index		Drought	Principal Component Analysis	Cross-sectional
Alinovi et al. (2010)	Conceptual, analytical, empirical	Income and food access; Access to public services; Social safety nets; Agricultural assets; Non-agricultural assets; Agricultural practice and technology; Adaptive capacity; Stability	Resilience index	Resilience score and food consumption	None specified	Factor Analysis; Optimal scaling; linear regression	Repeated cross-sectional
Béné et al. (2012)	Conceptual	Absorptive capacity; adaptive capacity; transformative capacity			None specified		
Frankenberger et al. (2012)	Conceptual, analytical	Context, level of aggregation, disturbance, exposure, adaptive capacity, sensitivity, reaction to disturbance, livelihood outcomes	Livelihood change over time		None specified		
Vaitla et al. (2012)	Conceptual, analytical		Change over time of food security indicators		Food price inflation, illness, etc.		Panel
Wright et al. (2012)	Empirical	Adaptive capacity	Index created by adding up number of changes made to farming activities in the past 10 years	Adaptive capacity and food security	None specified	Correlation analysis	Cross-sectional

Ciani and Romano (2013)	Analytical, empirical	Household income; access to basic services; agricultural assets; non-agricultural assets; technological level; social safety nets; adaptive capacity; physical connectivity; economic connectivity; household characteristics	Composite resilience index	Resilience and food expenditure	Natural shocks, anthropic shocks, hurricane mitch	Factor Analysis; weighted least square	Panel
Nguyen and James (2013)	Empirical	Confidence to secure food, income, among others; confidence to secure flood-prone homes; interest in learning and implementing flood-based livelihoods, among others	Indexes of the three components		Floods (implied)	Factor Analysis	Cross-sectional
Constas et al. (2014a)	Conceptual		Resilience capacity		None specified		
Barrett and Constas (2014)	Conceptual		Development resilience index		None specified		
Browne et al. (2014a)	Empirical	Assets	Composite asset index		None specified	Principal Component Analysis	Cross-sectional
Browne et al. (2014b)	Empirical	Assets	Composite asset index		None specified	Principal Component Analysis	Cross-sectional
Lokosang et al. (2014)	Empirical	Assets	A composite index generated using various indicators for the attributes	Resilience index and real per capita food consumption	None specified	Principal Component Analysis; linear regression	Cross-sectional
Alfani et al. (2015)	Analytical, empirical		Changes in welfare outcomes	Resilience and consumption expenditure	Droughts/ rainfall	Blinder-Oaxaca counter-factual approach	Cross-sectional
Béné et al. (2015b)	Conceptual	Absorptive capacity; adaptive capacity; transformative capacity					

Daie Ferede and Wolde-Tsadik (2015)	Empirical	Income and food access; aspiration for change; asset possession; adaptive capacity; social safety net; cultural bond and reciprocity; stability; access to public services	Index of income and food access		None specified	Factor Analysis	Cross-sectional
Mutabazi et al. (2015)	Empirical	Intensification; Diversification; Alteration; Migration		Resilience and livelihood capitals	None specified	Principal Component Analysis; linear regression	Cross-sectional
Boukary et al. (2016)	Empirical	Assets; adaptive capacity; social safety nets; climate change	Composite Index		Climate change, proxied by long-term mean rainfall	Principal Component Analysis; structural equation modelling	Cross-sectional
Upton et al. (2016)	Empirical		Parametric constant		Drought	Moment-based regression	Panel
FAO (2016)	Conceptual, analytical	Access to basic services; Social safety nets; Assets; Adaptive capacity	Resilience capacity index		None specified		
d'Errico and Pietrelli (2017)	Empirical	Access to basic services; Assets; Sensitivity; Adaptive capacity	Resilience capacity index	Resilience capacity and child malnutrition	None specified	Structural Equation Modelling; instrumental variable regression	Cross-sectional and panel
Ambelu et al. (2017)	Empirical	Wealth; Household food insecurity access prevalence; Social capital; Psychosocial distress; Livestock; Infrastructure and social services; Peace and security; Human capital; Environment	Resilience scores	Relationships among resilience attributes or dimensions	Drought (implied)	Principal Component Analysis; Structural Equation Modelling	Cross-sectional
Knippenberg et al. (2017)	Analytical, Empirical		Livelihood change over time		Drought, flooding, crop disease and illness	Dynamic panel analysis and machine learning algorithms	Panel

Smith and Frankenberger (2018)	**Empirical**	**Absorptive capacity; Adaptive capacity; Transformative capacity**	**Resilience capacity index**	**Resilience capacity and hunger score**	**Floods**	**Factor Analysis; Fixed effects regression model**	**Cross-sectional panel**
d'Errico et al. (2018)	Empirical	Access to basic services; Social safety nets; Assets; Adaptive capacity;	Resilience capacity index	Resilience capacity and per capita consumption / dietary diversity	Reduction in per capita caloric intake and dietary diversity score	Factor analysis; structural equation modelling; Probit regression	Panel
d'Errico and Di Giuseppe (2018)	Empirical	Income and food access; access to basic services; assets; social safety nets; adaptive capacity	Resilience capacity index	Determinants of resilience including shocks	Weather shocks, wage shocks, etc.	Structural equation modelling; multinomial and binomial logit regressions	Panel
Béné et al. (2018)	Empirical	Absorptive capacity (rate of recovery), adaptive and transformative capacity (changes made by households in anticipation of shocks)	Resilience index	Changes in food security indicators	Covariate (drought, flood, high temperature, locust, army worm attacks, etc.), Idiosyncratic (sudden death of household member, accident, etc.)	Propensity score matching	Cross-sectional

2.3 Conceptualization, methodological approaches and empirical evidence of resilience in food security context

Of the selected 28 studies, 4 are purely conceptual, 16 are mainly empirical, 3 are both conceptual and analytical, 3 are both analytical and empirical, while 2 are conceptual, analytical and empirical in scope. Of the empirical papers, only few examine the effect of resilience on some aspect of household food security. Out of the 21 studies with an empirical focus, 13 use cross-sectional data, 6 use panel data while 2 use repeated cross-sectional data for analysis. Figure 2.1 shows that most of the studies published before 2014 were gray literature. From 2014 onwards, the number of articles published in peer-reviewed journals has increased.

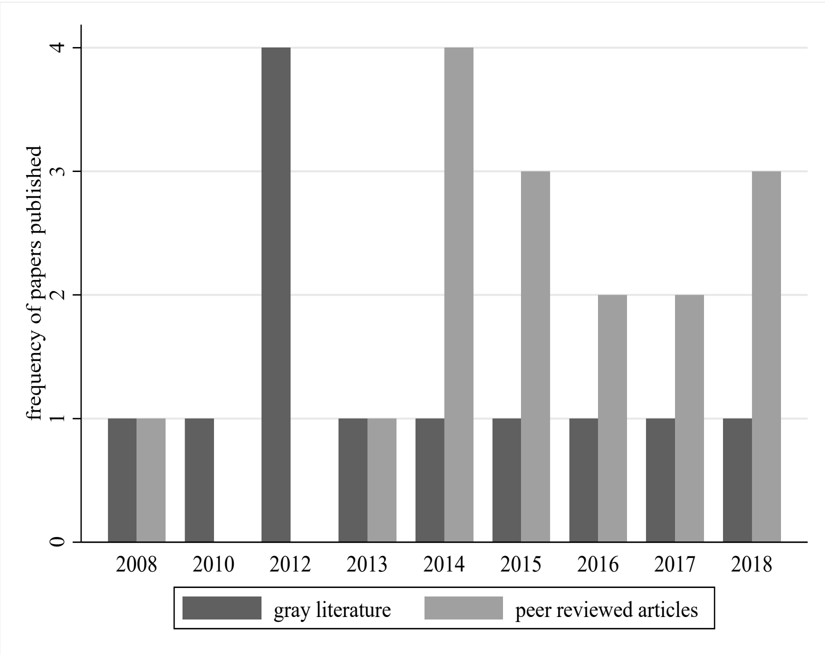

Figure 2.1 Overview of gray literature and peer reviewed articles on food security and resilience published between 2008 and 2018

From the reviewed papers, the largest number of gray literature published occurred in 2012, while that published in peer-reviewed journals peaked in 2014. For many of the studies reviewed, we observe a general lack of harmony or consistency in terminologies regarding resilience and its attributes. Most of the papers based their titles on the type of shock considered. For instance, studies that examine household resilience to droughts refer to drought resilience. Besides heterogeneity in terminology, definitions of resilience in the context of household food security also showed wide variation, even though the fundamental notions conveyed by these definitions converge to the general understanding of resilience in the literature.

2.3.1 Historical evolution of conceptualizing resilience from food security perspective

The nature of resilience is such that defining and conceptualizing it from a food security perspective has been quite evasive, discerning from the historical overview that follows. Alinovi et al. (2008; 2010) developed a conceptual framework that was meant to link resilience and food security at the household level, with ideas for this linkage comparable to the sustainable livelihood approach of Chambers and Conway (1992), and Bebbington (1999). The conceptual models of Alinovi et al. (2008; 2010) were later formalized as the FAO's RIMA-I framework (FAO, 2016). Conceptually, resilience of a household is assumed to be derived from assets, capitals and opportunities (Alinovi et al., 2010; Alinovi et al., 2008). Resilience is composed of four core pillars, which are Income and Food Access (IFA), Assets (AST), Social Safety Nets (SSN) and Access to Public Services (APS). Two other dimensions, Stability (S) and Adaptive Capacity (AC), were framed to cut across these four pillars. In the 2010 study, assets were separated into Agricultural (AA) and Non-agricultural assets (NAA), while a technology uptake component was included, called Agricultural practice and technology (APT). The fundamental hypothesis was that the assets, capitals and opportunities are resilience dimensions that reflect the degree of stability (i.e., the degree to which the assets and options available to households do not change over time) and adaptability (Alinovi et al., 2010; Alinovi et al., 2008; Ambelu et al., 2017; Lokosang et al., 2014). Based on these, households with larger amounts of assets or better resources and options are perceived to be more resilient, and capable of coping/adapting better with shocks. The challenge with this resilience-food security framework, as noted by Béné et al. (2012), is the limited attention given to the agency of households to learn and adapt their systems to changing contexts. Households are not unreceptive to shocks, implying that there are both *ex ante* and *ex post* shock coping mechanisms that were not captured in the basic conceptual framework. Two other limitations of the framework are that resilience cannot be disentangled from food security, since the two variables were lumped together, and that shocks could not be distinctly analyzed because they are part of the model.

Béné et al. (2012) argued that previous conceptual models ignored the agency and power of households as decision making units. To address this limitation, they propose a 3-D resilience framework, where resilience is understood as *capacity* with three key attributes which characterize the set of necessary actions that any system exposed to shocks need to undertake. The actions include: what needs to be done to help the system absorb a shock when it occurs; what needs to be done to help the system adapt in a way that makes it less exposed to the shock; and what needs to be done for the system to transform so that it is no longer prone to similar shocks. Accordingly, the three attributes derived correspond to absorptive capacity, adaptive capacity and transformative capacity.

- Absorptive capacity defines the ability of the system to minimize its exposure to shocks, but also having the mechanisms to recover quickly when shocks actualize. This capacity ensures the persistence of system functions, and mostly constitute coping strategies such as harvesting crops early to avoid floods, taking children out of school or even delaying debt repayments (OECD, 2014).
- Adaptive capacity measures "*the ability to make informed choices about alternative livelihood strategies based on changing conditions*" (Béné et al., 2012). Diversification of livelihood activities, use of drought resistant crop varieties, among others are some key adaptive strategies that help households to deal with shocks (Heltberg and Lund, 2009).
- Transformative capacity refers to the system level conditions that are necessary for changing the basic configuration of the system to create long-term resilience. Researchers argue that the adaptive and transformative capacities are necessary for dealing with the primary sources of vulnerability (Béné et al., 2012; Carpenter et al., 2005; Folke et al., 2010). In other words, adaptive and transformative capacities involve medium to long-term mechanisms that help vulnerable systems to develop robustness against specific kinds of shocks.

Frankenberger et al. (2012) proposed a conceptual framework for resilience analysis, which integrates attributes from the livelihood approach, the disaster risk reduction and the climate change adaptation literature. This framework conceptualizes resilience as consisting of the context, level of aggregation, disturbance, exposure, adaptive capacity, sensitivity, resilience and vulnerability pathways, and livelihood outcomes (e.g., food security). The framework links resilience pathways to food security in a given context via ex-ante preparedness and prevention as well as ex-post response and recovery mechanisms. Given that the ex-ante preparedness is strong, households stand less risk of experiencing food insecurity when shocks occur. While the framework recognizes food security as an outcome variable that should stay distinct from resilience, the integration of three different approaches in addition to various household-level livelihood indicators makes the information needs for operationalizing the conceptual model rather complex and difficult to implement in practice. Vaitla et al. (2012) also developed a conceptual model of resilience in the context of food security based on a livelihood change framework. This framework links household assets and various activities and strategies to income. It proposes that the households employ their assets and combine them with their activities to generate income. Given the income so generated, the model aims to understand its distribution over consumption, savings and investment. A household that invests and saves can generate more assets and income, which ensures that shocks do not have a detrimental effect on food security (adequate food consumption). Conversely, adequate food consumption ensures good health and ability to work, leading to higher income and accumulation of assets to deal with uncertainties. Indirectly, this framework links resilience to having sufficient levels of assets and income. A defining characteristic of this framework is the accommodation of feedback effects in the system. It postulates that the distribution of income feeds back into the household's asset portfolio in future periods. Such a formulation introduces dynamics which makes it quite distinct from the linear, static livelihood change models that is often used.

In 2014, the Resilience Measurement Technical Working Group (RM-TWG) of the Food Security Information Network, drawing on lessons from earlier studies proposed a resilience framework underpinned by food security objectives (Constas et al., 2014a; Constas et al., 2014b). Their proposition confirmed the conceptualization by Béné et al. (2012) that resilience is a capacity with well-defined *ex ante* attributes. This framework provides empirical guidance to some recent studies that assess resilience and household food security (d'Errico and Pietrelli, 2017; Smith and Frankenberger, 2018). The RM-TWG defines resilience as *"the capacity that ensures that adverse stressors and shocks do not have long-lasting adverse developmental consequences"* (page 6). While this definition has a development-oriented programming motivation, Barrett and Constas (2014) suggest a more precise definition for development resilience as the *"capacity over time of a person, household or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. If and only if that capacity is and remains high over time, then the unit is resilient"*. The conceptualization by Barrett and Constas (2014) aims to measure the dynamics of wellbeing or other livelihood outcomes in a shock-prone context, but appears less suitable for providing a quantitative measure of resilience per se (FAO, 2016). However, the paper recognizes that wellbeing dynamics is conditioned by the choices households make within the limits of constraints imposed by policies, institutions and natural conditions.

Learning from the limitations in RIMA-I, FAO (2016) updated this conceptual framework to RIMA-II, in which the agency of households is directly recognized by incorporating shock coping strategies, such as consumption smoothing, asset smoothing and new livelihood adoption. Food security is no longer treated as an indicator of resilience and shocks are separated from the pillars that contribute to resilience capacity. In the RIMA-II framework, resilience capacity consists of access to basic services (ABS), assets (AST), social safety nets (SSN), sensitivity (S) and adaptive capacity (AC), while food security is indicated by food expenditure and dietary diversity derived using the Simpson index.

The historical perspective provided above shows a consistent improvement in the way resilience is conceptualized in relation to food security. Initial studies did not pay much attention to agency and freedom of households, but current conceptualizations either accommodate agency or acknowledge that households are rational agents which decide and choose options for better livelihoods through *ex ante* risk management or *ex post* shock coping measures. Furthermore, the initial framework of Alinovi et al. (2008; 2010) tended to select the so-called resilience pillars (attributes) arbitrarily. With time however, there appears to be recognition that the attributes included should be distinct and focused. Consequently, many studies tend to agree with the conceptual model proposed by Béné et al. (2012) that absorptive capacity, adaptive capacity and transformative capacity are adequate representation of resilience attributes (FAO, 2016; Smith and Frankenberger, 2018). Moreover, we observe a paradigm shift in considering resilience as an outcome variable towards the realization that resilience is a capacity that influences livelihood outcomes such as food and nutrition security, health, among others. Consistently, studies addressing resilience from a food security perspective are building consensus on the fact that shocks need to be an integral part of the resilience framework but need to stand alone as a threat to both livelihood outcomes and resilience capacity.

2.3.2 Methodological approaches used to assess resilience and household food security

We discuss operationalization as a measurement strategy for resilience, consisting of the statistical, econometric or other approaches used to turn the latent resilience concept into a quantitative measure. Before one could adequately assess resilience and food security, it is necessary to distinguish between resilience and resilience capacity. In fact, this distinction is crucial because resilience as a concept has been very difficult to operationalize. To make a distinction between resilience and resilience capacity, we follow Béné et al. (2015a), who discuss that resilience should not be seen as an end in itself but as a short term outcome. Studies that perceive resilience not as an intermediate or short-term outcome but rather an end in itself may tend to measure resilience in terms of wellbeing indicators, such as food security. However, if resilience is seen as a means to an ultimate goal, we expect studies to evaluate resilience capacity as an intermediate outcome, which then serves as a variable that influences a final desired outcome, such as food security. Such a perspective would require that resilience is measured as a separate variable from food security. We therefore assess the analytical framework on the basis of whether resilience is measured as capacity (means to an end) or as resilience (ultimate outcome).

2.3.2.1 Operationalizing and measuring resilience from a household food security context

In operationalizing resilience from a food security perspective, few studies have emerged, and these use a variety of methods to quantify resilience and/or its attributes. One of the earliest studies that developed a methodology for measuring resilience in a food security context is Alinovi et al. (2008). Their analytical framework postulates resilience as a multidimensional latent variable, consisting of six key variables, which are the pillars outlined in section 2.3.1. Each of the pillars is also latent but can be quantified from observed socioeconomic and institutional variables. Such a setup naturally leads to a hierarchical model, where resilience is a composite of the latent pillars. To quantify these latent variables, the authors propose the application of multivariate techniques and test this using Palestinian public perception survey data. In a follow-up study, Alinovi et al. (2010) used a combination of multivariate techniques to derive a resilience index from eight variables (see section 2.3.1) based on the Kenya Integrated Household Budget Survey. The methodology developed in these two studies was formalized into the so-called Resilience Index Measurement Analysis (RIMA) model (FAO 2016) by incorporating two more variables, which are climate change (CC) and enabling institutional environment (EIE). To measure these latent pillars and resilience, factor analysis and structural equations modelling were suggested.

The RIMA methodology and its predecessors helped to understand heterogeneity in the resilience index across geographical areas and livelihood groups but suffered from a number of flaws. First, because resilience was not conceived as a capacity, the resilience index is generated as a composite of both the determinants and outcome of resilience. This is less helpful in understanding the coping mechanisms implemented by households when faced with shocks. Also, by capturing all potential shocks in the variable 'stability' the model fails to directly assess the nature and extent of household resilience to specific shocks (Frankenberger et al., 2012). Recognizing these drawbacks, Ciani and Romano (2013) made an important technical adjustment to the RIMA model. They relax the assumption of a composite resilience and food security variable and treat food access (a proxy for food security) as an outcome variable while resilience is an explanatory variable to food security. This way, food security was measured distinctly from resilience (which was indirectly seen as capacity). Additionally, stability (which denoted a composite of shocks) was modelled as an independent variable to food security. The Ciani and Romano model further made a step ahead in terms of the food security dynamics by using panel data and modelling food consumption expenditure growth rates. However, resilience dynamics per se was still not addressed by the model.

Few other studies propose different methodologies for assessing resilience in food security context. Vaitla et al. (2012) derive a measure of resilience from changes in food security outcomes or indicators over two consecutive (i.e., hunger and postharvest) seasons. This empirical strategy suffers from a similar problem of not actually quantifying resilience but instead food security, because resilience was not considered as a capacity. According to d'Errico et al. (2018), the best Vaitla and colleagues could achieve was the assessment of factors influencing wellbeing. The reason being that the approach adopted, and the nature of data used (i.e. cross-sectional) did not guarantee an adequate measure of resilience as capacity. A slightly different analytical framework for resilience and food security is proposed by Alfani et al. (2015). Motivating their framework on the grounds of consumption and income smoothing, the authors learn from the program evaluation literature and build their model on a counterfactual framework. A synthetic measure of resilience is obtained by comparing an estimated counterfactual food security indicator against a supposed permanent value. The approach permits the authors to categorize households in the available cross-sectional data set as resilient, chronically poor and non-resilient. While the approach proposed by Alfani et al. (2015) is interesting, it also fails to deal with the dynamic nature of resilience. Moreover, the model does not derive a quantitative measure of resilience as capacity.

The updated RIMA-II model treats resilience as capacity; food security and shocks are modelled as separate variables from resilience capacity (FAO, 2016). Food security is considered as the 'achievement of resilience', and is no longer used as an indicator of resilience as it used to be in

RIMA-I. The RIMA-II model consists of direct (descriptive) and indirect (inferential) analytical components. The direct analysis involves quantifying resilience capacity index (RCI) and a resilience structure matrix (RSM) from four variables (ABS, AST, SSN and AC) using factor analysis. The indirect analysis involves exploring the potential determinants of food security, with RCI as a key variable, through a multiple indicator multiple cause (MIMIC) framework. Despite the recognition of resilience as capacity in the RIMA-II model, limitations still exist. First the model is still not able to measure the actual dynamics of resilience and food security (d'Errico et al., 2018). Furthermore, it is not yet understood which resilience capacities are acquired or deployed in the short-, medium- and long-term horizons (FAO, 2016). Additionally, the agency of farm households exhibited through *ex ante* management and *ex post* shock coping mechanisms are not yet modelled. Since resilience is dynamic, and many of the common shocks faced by farm households recur, the literature on coping and adaptation strategies suggest that farm households are not passive agents, but rather take definite or specific actions before, during and after occurrence of shocks (Levine et al., 2011).

In a number of recent studies some of the aforementioned limitations of the RIMA-II model are addressed. d'Errico et al. (2018) adopt the RIMA-II model, using the structural equations modelling to quantify resilience, but a regression analysis to examine the link between resilience capacity and food security. Through the use of a panel data, the authors account for resilience dynamics, incorporating specific shocks in the food security-resilience model. In essence, the extension by d'Errico et al. (2018) also marks an improvement in the RIMA-II analytical model. A recent paper by Knippenberg et al. (2017) develops a different analytical framework for assessing resilience in relation to food security. The model is underpinned by the theory of poverty dynamics, where food security in period t depends on the value in period t-1, and is proxied by Coping Strategy Index (CSI). The distribution of the CSI is conditional on shocks, given a set of other characteristics that also conditions the shocks experienced by the household. Then, an autoregressive process for CSI is specified which accommodates square terms to account for non-linearities in the persistence of CSI. While the approach is interesting, exploring resilience through the CSI reduces resilience only to the first dimension (absorptive capacity) as discussed by Béné et al. (2012), and ignores the adaptive and transformative components of resilience. Finally, Béné et al. (2018), following the approach of Béné et al. (2016), derive a resilience index based on self-evaluated questions relating to the rate of recovery from shocks based on data from the Scaling-Up Resilience to Climate Extremes for over 1 Million People in the Niger River Basin (SUR1M) project.

From the studies reviewed so far, we can discern three quantitative or statistical techniques for operationalizing and measuring resilience in relation to food security. The most widely employed approaches are multivariate methods. The second approach is less prevalent, and is based on direct proxy variables while the third is based on econometric approaches. The data used for household level resilience measurement is predominantly cross-sectional obtained from national demographic and household surveys (Boukary et al., 2016; Browne et al., 2014b). However, individual researcher-designed and self-administered surveys have also been used (Daie Ferede and Wolde-Tsadik, 2015; Keil et al., 2008). The dominance of cross-sectional studies is attributed to the current lack of well-designed panel surveys that incorporate resilience concepts. Nonetheless, a few studies exist that use panel data (Knippenberg et al., 2017; Smith and Frankenberger, 2018) from livelihood-centered projects. In fact, Knippenberg et al. (2017) use a high frequency (monthly) panel data specifically designed to assess resilience under the Measuring Indicators for Resilience Analysis (MIRA) project in Malawi. In terms of measured variables, observed indicator variables chosen for quantifying resilience tend to be arbitrary since there is no generally agreed guideline or theory for the selection of variables. Therefore, variable selection tends to be driven by context-specific and data availability factors rather than theory (Constas et al., 2016).

The multivariate techniques are index-based methods where resilience is treated as a latent variable and measured from a set of observed variables supposed to relate to resilience (capacity). The observed indicator variables may be quantitatively scaled into a composite index, with variables weighted subjectively or statistically. For the subjective weighting, the criteria vary but are often based on the literature or a Delphi technique (Alshehri et al., 2015). The common multivariate techniques include factor analysis (FA), principal component analysis (PCA), and structural equation modelling (SEM). Nowadays, the use of multiple indicator multiple cause (MIMIC) models under the SEM framework has been advocated and applied (d'Errico et al., 2018; FAO, 2016). Unlike PCA which ignores measurement errors, FA takes errors into account since the set of observed variables may be an imperfect measure of the latent resilience capacity construct. SEM combines factor analysis and a regression component, where resilience or its attributes are first derived from a set of indicators, and then correlations among the measured attributes and/or other observed variables are examined using the regression component. A number of studies employ multivariate techniques in measuring resilience capacity in food security (Alinovi et al., 2008; d'Errico and Di Giuseppe, 2018; d'Errico et al., 2018; Smith and Frankenberger, 2018). Browne et al. (2014a) also use PCA to generate a resilience score from multiple asset indicators, arguing from the assets and risk management literature that, a measure of asset ownership could be an indicator of household resilience.

Regression-based approaches for quantifying household resilience in food security context are few. So far, only three econometric methods are encountered in the review. In the first approach, Knippenberg et al. (2017) measures resilience in two ways. First, they use an autoregressive linear probability estimator to calculate the probabilities of transitioning from one state of shock to another using a high frequency panel data from the MIRA project. With this approach, resilience is measured in terms of the perceived persistence of or recovery from a previous shock's effects by the households. Secondly, the authors employ the Blundell-Bond estimator to track how household food security (using CSI as proxy) changes over time. Here, resilient households are those that experience declining levels of the coping strategy index over time.

The second econometric approach is a moment-based estimation of development resilience by Cissé and Barrett (2016) based on a theory proposed by Barrett and Constas (2014). The moment-based method has also been applied by Upton et al. (2016) to derive a new quantitative measure of food security. The technique involves estimating both the mean (first moment) and variance (second moment) of a welfare function which accommodates lags to account for persistence in the impact of previous welfare level on its current values. The moment-based approach does not only require the availability of panel data, but also determining a threshold level of the outcome variable. Given that adequate panel data exists, this approach has the advantage that one could combine individual measures of resilience to provide a more aggregated measure. The third is a counterfactual model used by Alfani et al. (2015) and Béné et al. (2018) that is based on an intertemporal consumption or program evaluation framework. Save these few studies, the majority of the econometric approaches are used to examine the (causal) relationship between resilience and food security or some other livelihood outcomes, such as income and assets.

2.3.2.2 Methods to assess causality between resilience and household food security

To establish a (causal) relationship between resilience and household food security, various econometric methods have been employed. While many of the approaches achieve their intended aims, most do not offer causal explanation of the resulting parameters, since they do not control for endogeneity. There are two potential sources of endogeneity. The first arises from possible interdependence among the resilience attributes. Béné et al. (2012) indicate that each of the three capacities is required at specific intensity of a shock, arguing that absorptive capacity is needed or applied at low intensities (mild shocks), while adaptive capacity is important to deal with more intense (moderate) shocks. When the intensity of the shock is beyond the system's coping and adaptation, then transformative capacity is necessary to change the system configuration, making it no longer vulnerable to that specific type of shock. Nonetheless, these three capacities could reinforce each other, thereby creating interdependence. The second source of endogeneity arises from a possible reverse causal relationship among resilience capacity, shocks and food security, because the *"state of being food insecure is both a cause and consequence of cycles of vulnerability"* (Misselhorn and Hendriks, 2017). Households with higher resilience capacity to deal with food insecurity shocks are more likely to have better and more stable food security system than households with lower resilience capacity. But it also remains possible that the more food secure is a household, the better able they are in adopting strategies or instituting mechanisms that foster their resilience to food insecurity shocks. Further, there are actions that households engage in that may expose them to shocks. Therefore, not all shocks may be exogenous to the household.

Typically, the methods used include linear (ordinary least squares and instrumental variable) regression analysis (Alinovi et al., 2008; d'Errico and Pietrelli, 2017) or its variants, such as (variance) weighted least squares (Ciani and Romano, 2013), probit models (d'Errico et al., 2018), fixed effects regression models (Smith and Frankenberger, 2018) and propensity score matching (Béné et al., 2016) as well as correlation analysis (Wright et al., 2012). Analysts that use ordinary least squares and probit regression analysis presuppose that resilience is exogenous to food security. Whereas this could hold in some cases, endogeneity may exist. The chance is even greater when most of the indicator variables for quantifying resilience are endogenous to household food security. Recognizing potential endogeneity issues, some studies apply instrumental variable regression (d'Errico and Pietrelli, 2017) or propensity score matching (Béné et al., 2016). In the resilience and food security literature, the encountered causes of endogeneity include measurement error and selection bias. Simultaneity is not yet tested, even though Smith and Frankenberger (2018) acknowledge that there could be possible reverse causal relation between food security and shock exposure. The challenge with the propensity score matching as a way to control for endogeneity is the inability to control for unobserved heterogeneity.

Analysts that use panel data methods intend to account for resilience dynamics (d'Errico and Di Giuseppe, 2018). Of course, resilience is important only in the incidence of shocks. Therefore, some authors try to examine how resilience evolves over time (given that panel data is available), and usually evaluate resilience and household food security before and after a major shock event. To examine this dynamic relationship, the difference-in-difference regression method is used, especially to examine how development project interventions enhance the resilience of households to deal with specific shocks. The aim is to provide policy advice on whether resilience-building interventions are worth their investment or not.

2.3.3 Empirical evidence on the relationship between resilience and household food security

After having discussed the methods for assessing causality/correlation between resilience and food security in section 2.3.2.2, we now turn to discuss the empirical findings in the reviewed studies. Existing studies tend to use different food security measures as well as resilience attributes. This makes it difficult to employ a typical meta-analytic approach in analyzing the evidence. Due to this difficulty, we adopt a conventional approach where we try to document and discuss evidence for the various studies, with the aim to draw lessons that can guide future research and policy decisions. In order to judge whether these empirical studies adequately assess resilience and food security, we use a framework with three main criteria. The first criterion is based on the definition used for resilience. Constas et al. (2016) already observed that people deal with resilience in different ways and came up with a classification of various definitions used: (1) "*resilience is a capacity, hence can be predicted, explained or constructed by selecting other variables*"; *(2)*" *resilience, once constructed as a variable, can be defined as a capacity that predicts wellbeing*"; *(3)* "*resilience is a property, (i.e., observed change over time or return time) of a wellbeing outcome*" and (4) "*resilience is used as an approach strategy, to frame problems and/or structure policy interventions*". We adopt this typology of definitions in order to assess which of the definitions guided the empirical analysis. Our second criterion is whether studies model the dynamic elements of resilience capacity. With the third criterion, we expect empirical studies to model shocks.

We find three sets of empirical studies. In the first set, researchers usually adopt the first definition of Constas et al. typology, hence they do not measure resilience as capacity, but rather as an indicator food security. Resilience is therefore measured from a set of variables that relate to food security. Because they are not able to separate resilience and food security, they often neither account for resilience dynamics, nor shocks. These studies generally conclude that households with higher resilience scores have better food security, hence policies and program interventions could aim at improving food security directly, and this could lead to better resilience. We consider these studies as not adequately analyzing resilience and food security, leading to a risk of circular reasoning, particularly for the relatively recent studies in this category. Empirical studies in this category include Alinovi et al. (2008), Alinovi et al. (2010), Ambelu et al. (2017), Boukary et al. (2016), Browne et al. (2014a), Browne et al. (2014b) and Lokosang et al. (2014).

In the second set of studies, researchers adopt the first and second definitions of the Constas et al. typology, hence resilience is measured as capacity and used as an intermediate variable that can predict or explain food security (d'Errico and Pietrelli, 2017; d’Errico et al., 2018; Smith and Frankenberger, 2018). This set of studies do better at assessing resilience and food security because they provide a quantitative measure of resilience; some of them assess resilience dynamics (d'Errico and Di Giuseppe, 2018) and/or directly model shocks (Béné et al., 2016; d’Errico et al., 2018). The general conclusion from this set of studies informs resilience programming to focus on interventions that improve resilience. Once resilience is improved, food security would be assured.

In the third set of empirical studies, researchers adopt the third definition of the Constas et al. typology, such that resilience is measured as an observed change in food security over time or return time of food security to its previous level after a shock. However, studies that measure return time do not actually question whether the previous level of food security was desirable or not, which could be a major limitation. The nature of this approach is such that dynamics are often well modelled, and some incorporate shocks. Nevertheless, this empirical approach does not provide a quantitative measure for resilience capacity per se. Inferring from these studies, the function of policy is to provide targeted interventions that enable vulnerable households to cope with shocks so that changes in food security do not fall below catastrophic levels. Studies falling into this category include Knippenberg et al. (2017), Alfani et al. (2015), Béné et al. (2016) and Upton et al. (2016). To organize the discussion of the limited empirical evidence organized, the next subsections discuss findings based on the indicators of food security used.

2.3.3.1 Resilience and child malnutrition, hunger score and self-reported months of adequate food

Findings from the empirical studies indicate that resilience capacity enhances the ability of households to cope with various shocks so that household food security is not adversely affected. d'Errico and Pietrelli (2017) find that households with higher resilience capacity had lower probability of having malnourished children as well as lower number of malnourished children. Smith and Frankenberger (2018) find that Bangladeshi households with higher resilience capacity reported more months of adequate food provision or less self-reported days of hunger. Likewise, using weight-for-age as a measure of child malnutrition, Alfani et al. (2015) report that resilient households tend to have lower incidences of child malnutrition, compared to the non-resilient and chronically poor. In addition, the authors identify resilient households as those that have smaller families, better education, low dependency ratios and higher levels of quality items. Wright et al. (2012) used a proxy for adaptive capacity developed from the number of changes made in farming practices over the past ten years by Bangladeshi households. The authors confirm a statistically strong, negative association between adaptive capacity and number of self-reported months of hunger. This result suggests that as households make more changes to their farming practices, they become more adaptable and the number of months they experienced hunger declined. Even though the authors caution against a causal interpretation of this finding, the result establishes a link between resilience (measured in terms of adaptive capacity) and food security.

2.3.3.2 Food consumption, food expenditure and dietary diversity

Available evidence indicates a positive and statistically significant relationship between food consumption, food expenditure or dietary diversity and household resilience. Alinovi et al. (2010) find that a unit increase in the level of resilience is associated with a statistically significant increase of 0.38% in the level of food consumption, controlling for location, gender and household size. Ciani and Romano (2013) establish a positive relationship between expenditure growth rate and resilience. They interpret this to mean that households with higher initial levels of resilience experience better levels of food security in future when challenged by eventualities. Lokosang et al. (2014) examine how resilience affects per capita food consumption and find statistically significant positive correlation between household resilience and real per capita food consumption in South Sudan after establishing resilience profiles across locations and population groups. Alfani et al. (2015) find that resilient households often have higher and stable consumption than the non-resilient and chronically poor. d'Errico et al. (2018) find that households with higher resilience capacities in an initial period are less likely to suffer a reduction in per capita calorie intake in a future period even when shocks hit them. On the other hand, high resilience capacity increases the probability of recovery from food loss due to shocks in previous periods. Additionally, the authors interact resilience and shocks, reporting an inverse relationship which suggests that resilience weakens the impacts of shocks on food security.

2.3.3.3 Resilience as a measure of food security

In this category of studies, resilience is measured as an indicator of food security, such that higher resilience scores are assumed to be indicative of better food security status. Since these studies do not really disentangle resilience and food security, care should be taken in interpreting their conclusions. Alinovi et al. (2008) use factor analysis to construct resilience indices for five sub-regions of Palestine. Using several observed indicators, the authors quantify household resilience to food insecurity based on Palestinian Public Perception Survey dataset. Browne et al. (2014b) create a resilience index based on asset ownership and propose this as a tool for measuring and monitoring household food security, whereas Daie Ferede and Wolde-Tsadik (2015) use income and a food access indicator derived from factor analysis as a proxy for resilience. Upton et al. (2016) first discuss the insufficiency of existing food security measures to accommodate all the components of food security proposed by 1996 FAO definition. Therefore, to bridge this measurement gap the authors propose four main axioms, which relate to scale, time, access and outcomes, and then apply a moment-based approach to reconstruct a new measure for food security. They find that development resilience measured from the moment-based model gives an adequate measure of food security that satisfies all the four axioms.

2.4 Synthesis of reviewed literature and a conceptual framework for food system resilience analysis

The Béné et al. (2012) framework provides a simplified and good starting point for operationalizing resilience from the food system or food security perspective. We extend this framework to focus specifically on household food security and examine the various causal pathways through which resilience capacity affects food security. Essentially, our conceptual framework considers the household unit as the agent of the food system, interacting in complex ways with the activities, and food security is an indicator of the ultimate outcome of these interactions (Ericksen, 2008). We argue that households are the major decision-making units of the household food system, and the choices they make govern the overall food security of the household (Constas et al., 2016; FAO, 2016).

Figure 2.2 recognizes absorptive capacity, adaptive capacity and transformative capacity as the three key attributes of resilience (Béné et al., 2012). These capacities relate to the decisions, choices and actions that the households embark on, either *ex ante* or *ex post* a shock. These capacities indicate how the household moderates or deals with the impact of shocks on livelihood outcomes.

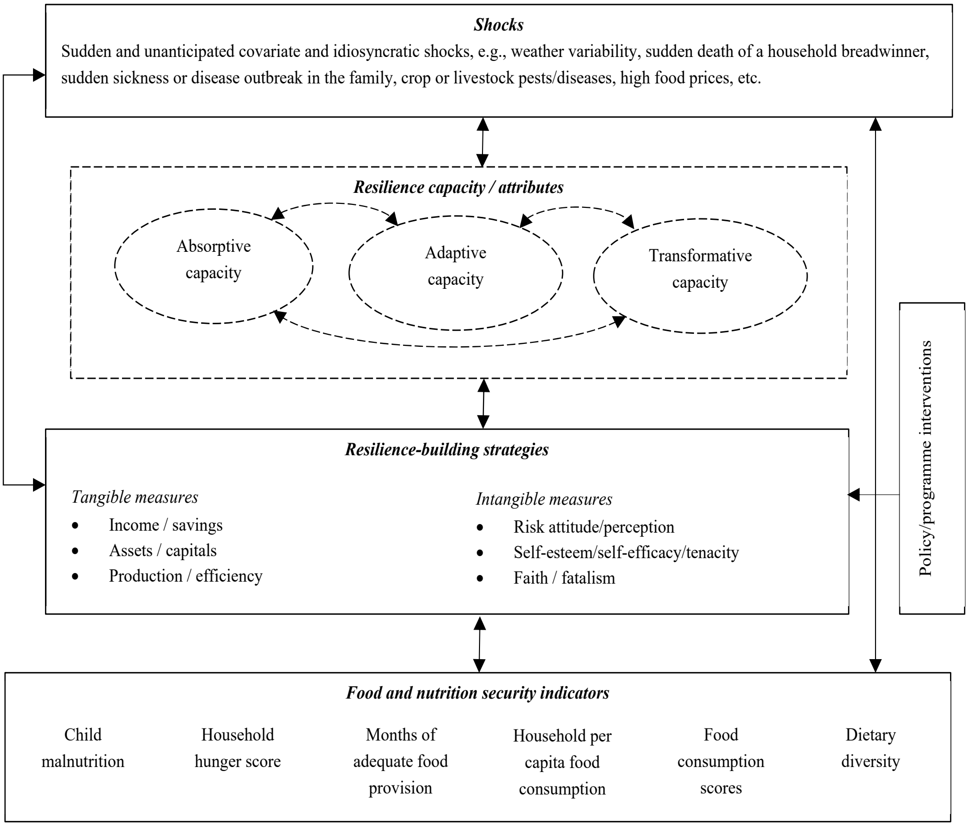

Figure 2.2 Conceptual framework for the links between resilience and household food security

Source: Modified based on Béné et al. (2012).

Our primary interest lies in how these attributes, jointly or autonomously affect household food security in the wake of shocks, through primary causal pathways. We consider these primary causal pathways as the strategies available to the households for building resilience capacity. These causal pathways therefore define the set of capabilities households have for building resilience in their food systems.

In figure 2.2, resilience capacity is developed or achieved through the primary causal pathways. Policy interventions and programmes that target livelihood or welfare outcomes could influence the resilience building strategies, hence resilience capacity (Béné et al., 2017; Vaitla et al., 2012). The economic, legal and political settings within which a household operates could influence the resilience-building strategies. The quantitative and qualitative amounts of these causal pathway variables in turn determine the extent to which shocks affect household food security. Therefore, the effect of resilience capacity on food security is accomplished through the causal pathways, which has received limited attention in the literature. The primary tangible causal pathways or resilience-building strategies that we focus on are income/savings, assets/capitals (human, financial, natural, social and physical) and production/efficiency. Intangible components of resilience-building mechanisms include risk attitudes/perceptions, self-esteem and self-efficacy or tenacity that may increase or undermine (e.g., faith or fatalism) resilience capacity. Shocks have direct influence on these intermediate variables as well as on food security. On the other hand, a drop in food security could also generate specific idiosyncratic shocks (e.g., illness can arise from poor nutrition). This makes it necessary to explore possible two-way causality among shocks, resilience capacities and food security measures, which is also a major weakness in the literature. In fact, research shows that lack of income and poverty are the fundamental causes of food insecurity (Misselhorn and Hendriks, 2017). Hence, for two households with similar income levels, the one with a stable source of income could be more resilient than the other whose income source is unstable.

In the farm household setting, an important pathway for building resilience capacity to food insecurity drives through productivity and efficiency (Keil et al., 2008). A household with an efficient production system, for instance through the adoption of better agronomic practices, diversification, agro-ecological management or sustainable intensification, is likely to be more resilient and able to withstand shocks that threaten food security. World Bank (2008) reports that climate change affects virtually all dimensions of food security, especially availability through low productivity. For example, droughts often negatively affect crop productivity through inadequate supply of water to the plants. However, a household with an efficient production system would better manage the drought, enhance production efficiency (Keil et al., 2008) and make adequate food readily available to the household. With stable food production there could also be improved farm income if the household participates in markets. This mechanism, whereby efficiency and productivity gains generate higher resilience capacity, could lead to reduced poverty and improved food security. Efficiency gains could also come from reduced cost of managing risks and asset decapitalization (World Bank, 2008), such that households do not sell out productive assets just to cope with sudden shocks.

Additionally, resilience capacity could be developed through asset accumulation and capital formation. These channels of building resilience capacity have received relatively good attention (Browne et al., 2014a; Lokosang et al., 2014; Smith and Frankenberger, 2018). From the reviewed literature, many of the studies use assets and capitals as the observed indicators for indexing resilience capacity. A household with more assets is likely to be more resilient to shocks that threaten food security through consumption smoothing (i.e., selling assets to maintain current level of consumption). On the other hand, households with more capital can always leverage on these to mitigate or minimize the effects of shocks that threaten their food security. For example, a household with abundant family labor (human capital) could deploy some to engage in off-farm or non-farm work to generate extra income (Kochar, 1999), whereas those with high social capital can fall on networks for assistance during stressful periods (d'Errico et al., 2018). We therefore consider these pathways as the basic blocks to building resilience capacity.

Furthermore, all these tangible components of building resilience are influenced by intangible components. People's ability to take risks, their self-efficacy and tenacity as well as their faith condition their entrepreneurial mindset or agency. Many poor farmers in traditional and rural societies remain poor and food insecure due to their risk-averse behavior, and their entrenched faith in their "gods". For instance, Keister (2011) examines how religion conditions attitude towards work, which then affects wealth (asset) accumulation. Faith and fear of the unknown (i.e., fatalism) can affect people's choices of enterprises, such that those with entrenched faith reject higher return options that they perceive as infringing upon their faith. Also, research has established that risk-averse smallholder farmers are usually reluctant to adopt improved agricultural innovations that offer higher returns, thereby remaining stuck to their known lower-return traditional methods of farming (Brick and Visser, 2015). Therefore, these intangible components of resilience-building mechanisms influence the tangible components and food security outcomes.

The framework could help appreciate how policy interventions affect resilience or its attributes (Béné et al., 2017; Unmesh and Das, 2017) through the primary causal pathways. The setup of the framework also permits us to examine whether the resilience attributes are endogenous by testing for simultaneity or reverse causality and self-selectivity bias. As noted by Constas et al. (2016), analyzing resilience as capacity makes it imperative to test for endogeneity. For example, a system with high absorptive capacity would have the basic capability to engage in better adaptation; but it is also possible that households with higher adaptive capacity could easily absorb the effect of mild shocks when they occur. Thus, conceptually and empirically it may not be sufficient to focus on one capacity and ignore others due to potential interdependence among the capacities. We suggest that the intervening causal variables (which represent the mechanisms for building resilience) are key, and policy interventions meant to enhance resilience could be more effective when they target these variables. Therefore, more research is needed that focuses on the causal variables and how these eventually affect food security.

2.5 Conclusions

Analyses of resilience in many disciplines show a very heterogeneous understanding of what they intend to measure which challenges scientific progress. Many studies claim to measure resilience although their analyses barely explicitly operationalize resilience. We review how these studies conceptualize and measure resilience in the context of food security. We systematically collect and review studies of that focus, by assessing their evolution in conceptualization and measurement. We furthermore critically check whether these studies indeed assess resilience and food security.

We find that both conceptual frameworks and methodologies for measuring resilience in the context of food security have witnessed a clear evolution. Studies initially focused on measuring resilience as a final outcome, but more recently resilience (capacity) is understood as an intermediate or short-term outcome that influences or conditions ultimate welfare outcomes such as food security. Correspondingly, the methods of analysis have experienced a similar evolution.

Initially, resilience was measured as an indicator of food security. Currently it is measured distinctly from food security. Multivariate techniques (e.g., factor analysis, principal component analysis, structural equations modelling and multiple indicator multiple cause models) dominate as tools for quantifying resilience capacity while few regression-based approaches have also been developed. Despite these substantial progress in conceptualization and measurement, we still have a blurred understanding of which of the tangible (e.g., income, assets, savings, etc.) and intangible (e.g., self-efficacy, tenacity, risk perception, etc.) elements are the basis of resilience capacities that are actually important and under which conditions they become important.

Second, from the review of empirical evidence we conclude that resilience (capacity) has been found to improve food security (measured by various indicators) in general. The implication is that policies and program interventions that aim to enhance resilience capacity of households can contribute towards reducing child malnutrition and ensuring long-term food security among the poor in developing countries. For instance, consider a typical rural community which hitherto had no access to the regional market. An intervention building road to connect such a village to the market offers the opportunity for farm households to participate in markets by selling marketable surpluses to earn income. Moreover, market access can provide off-farm labor opportunities to members of the household, which would improve their income. Given higher incomes from market participation and off-farm engagement, households could save towards future uncertainties. During times of shocks, these savings could provide a hedge to smoothen consumption, such that the food security of the household becomes resilient to these shocks.

Third, in relation to whether the reviewed studies indeed assess resilience and food security, we conclude that most studies fall short of expectation. Those studies often measured resilience as an indicator of food security, which makes it difficult to distinguish between the two. They also did not examine resilience dynamics and the effects of shocks. This implies that the comparability of findings of such studies can be improved by basing future research on common grounds in terms of operationalization of the concept this research aims to assess, as well as the methodological toolkit for doing so empirically. For advancing this thought, we propose a framework in this chapter which is meant to help address the weaknesses of the current literature. This framework identifies the primary causal pathways to food security as resilience-building strategies. It also allows to examine possible synergies, tensions and trade-offs among absorptive capacity, adaptive capacity and transformative capacity on food security.

CHAPTER 3

SHOCK INTERACTIONS, COPING STRATEGY CHOICES AND HOUSEHOLD FOOD SECURITY

3. Shock interactions, coping strategy choices and household food security[2]

Abstract: Agriculture-based livelihoods in developing countries are often challenged by a multitude of unforeseeable shocks, but economic research mostly focuses on single shocks. This chapter investigates how climate, health, pest and price shocks individually and in combination relate to farm households' coping strategy choices. First, we use binary probit models to examine how interactions from coinciding shocks relate to coping strategy choices. Next, we assess how coping strategies relate to household food security in a recursive framework. We find that when shocks are considered individually, the nature of shocks and their duration affect the likelihood of using savings. However, when climate shocks interact with health, pest or price shocks, there are incremental effects that increase the probability of depleting household assets to cope. Our findings suggest that governmental and non-governmental organizations should support rural farm households in managing the effects of multiple shocks through the provision and enhancement of markets for labour, insurance and outputs as well as formal safety nets. This support will help them to protect their assets and foster long-term wealth creation for escaping chronic poverty and food insecurity.

[2] This chapter is based on the article: Ansah, I. G. K., Gardebroek, C., & Ihle, R. (2020). Shock interactions, coping strategy choices and household food security. *Climate and Development*, 1-13. doi:10.1080/17565529.2020.1785832.

3.1 Introduction

The 2017 Sustainable Development Goals (SDGs) report highlights that economic shocks, natural disasters, conflict and wars, among other shocks, create economic losses of more than USD 250 billion annually. These various shocks usually affect both farm and off-farm activities of the rural poor and the vulnerable in developing countries, thus creating significant threats to their food security. Yet the current literature has mainly assessed shocks in isolation, although many rural farm households manage multiple risks concurrently (Béné et al., 2017; Dercon, 2002; Heltberg et al., 2015; Kalaba et al., 2013; Tongruksawattana and Wainaina, 2019). This pattern was addressed in a review article authored by Komarek et al. (2020), in which they examine multiple risks in agriculture that are present during 1974-2019 and raise concerns about the limited attention this topic receives, especially in the context of developing countries. Given that farm households have to manage multiple shocks, their *ex ante* risk management and *ex post* coping strategy choices may differ from those under the condition of individual isolated shocks due to possible incremental effects of shock interactions on welfare outcomes, e.g. food security. Detailed empirical evidence on how incremental effects of shock interactions relate to coping strategies is, however, rare. This chapter investigates whether experiencing coinciding shocks leads to the choice of different coping strategies compared with those chosen in response to individual shocks. In doing so, we define a shock as *"any event which may disrupt the normal functions of socioeconomic agents and/or their activities, impose challenges and threaten household food security"* (Ansah et al., 2019).

Our motivations for assessing multiple shocks are as follows: First, it generates more complete insights by exposing combined effects beyond individual isolated shock effects (Komarek et al., 2020). Second, studies show that multiple shocks and their combined reinforcing effects on welfare are the main causes of vulnerabilities (Leichenko et al., 2010; O'Brien et al., 2009). Third, projections indicate that future shocks from climate change, urbanization and socioeconomic changes are likely to increase and occur simultaneously (FAO, 2016, 2017; Rosenzweig et al., 2014; Wheeler and von Braun, 2013). This shift will affect the nature and the effectiveness of coping and adaptation strategies to shocks (Intergovernmental Panel on Climate Change, 2019).

Two empirical studies so far provide the need for further consideration of multiple shocks. Mazumdar et al. (2014) analyse how health shock acts as an 'intensifier' after a climate shock in India. They found that food consumption, school enrolment and medical treatment are worsened for households that suffer from health shocks after a climate shock. Lazzaroni and Wagner (2016) use two-period panel data to examine how the interaction of price and drought shocks affects child health in rural Senegal, concluding that multiple shocks worsen health problems. These studies account for interactions among a limited number of shocks, but they do not look specifically at how shock interactions influence coping strategy choices.

We build on these studies by using household data to address two main objectives. First, we assess how *ex post* coping strategy choices differ between those in response to single shocks and to coinciding shocks. Second, we investigate to what extent the *ex post* coping strategies relate to household food security. We include combinations of all possible shocks farm households face and multiple coping strategy choices.

This study contributes to the literature in two ways. First, we systematically assess multiple shocks, relating specific shocks and their combinations to specific *ex post* coping strategy choices and food security. This is relevant as not all strategies may be effective against individual shocks in contrast to coinciding shocks, and vice versa. Second, we provide knowledge on how specific strategies respond to coinciding shocks, which is key for informing implementation strategies, especially given the attention that strategies for building resilience against multiple vulnerabilities currently receive from humanitarian agencies and international development organizations (EU, 2012; USAID, 2012; USAID, 2016).

Section 3.2 outlines the conceptual framework from which we derive the study hypotheses. Section 3.3 explains the empirical strategy. Section 3.4 discusses the results, and section 3.5 details the conclusions and implications of our study.

3.2 Conceptual Framework

3.2.1 Literature on Coping Strategies

Economic literature discusses coping mechanisms mostly in the context of income shocks, which may emerge from, among others, droughts, floods, illnesses, pests or diseases. Mechanisms for dealing with income shocks are broadly discussed under asset smoothing and consumption smoothing. However, the distinction between coping strategies for asset smoothing and consumption smoothing is not always clear-cut.

With regard to asset smoothing, households aim at preserving productive assets for income generation even in bad times. Studies discussing asset smoothing identify portfolio diversification, including production, employment and economic activity choices (Dercon, 2002; Morduch, 1995). Strategies for asset smoothing are often *ex ante* measures with low transaction and opportunity costs that enable households to absorb short-run impacts of shocks (DeLoach and Smith-Lin, 2018). Other studies discuss *ex post* asset smoothing strategies, such as decreasing consumption, skipping meals or relying on social networks (Échevin and Tejerina, 2013; Kazianga and Udry, 2006; Zimmerman and Carter, 2003). Ashraf and Routray (2013) find that households reduce both their number of meals per day and number of purchases of expensive items to cope with income loss due to droughts.

For consumption smoothing, households accrue assets in good times and deplete them in bad times to maintain consumption (Deaton, 1991; Rosenzweig and Wolpin, 1993). Zimmerman and Carter (2003) distinguish between productive assets, such as livestock and land, and non-productive assets, such as cash savings and stored grains. Households facing health shocks such as illness of household members may sell livestock or use their savings to smooth consumption (DeLoach and Smith-Lin, 2018; Islam and Maitra, 2012; Isoto et al., 2017). When facing droughts, some households smooth consumption by depleting their livestock or grain stocks (Fafchamps et al., 1998; Kazianga and Udry, 2006). If labour markets exist, households also smooth consumption by participating more in off-farm work (Heltberg et al., 2015; Kochar, 1995, 1999).

In general, households with more assets tend to be more resilient and able to cope better with shocks. However, the specific assets used for coping depend on the severity of the shock(s). For instance, Paul (1998) observed that (productive) assets are not generally depleted under normal drought conditions, but it is the intensification effect that forces households to deplete assets.

3.2.2 Individual and Coinciding Shocks, Coping Strategies and Food Security: A Conceptual Model and Hypotheses

The literature discussed suggests that coping strategy decisions depend on the shock characteristics (see Figure 3.1). These characteristics relate to the nature of shocks (Lokonon, 2019). A shock may be caused by the climate or weather, e.g. drought or floods; human health problems, e.g. illness or the death of a household member; pests, e.g. crop pest infestation or animal diseases, or price shocks, e.g. high food/input prices. Their nature also determines whether the shock is idiosyncratic (affecting individual households) or covariate (affecting many households in a given location). Moreover, their frequency, intensity (severity of shock) and duration (how long the shock remains) are crucial characteristics. Households may be hit by an isolated individual shock, a sequence of two or more shocks that may be independent of the other or related in a cascade-like way or two or more coinciding shocks.

Food security is challenged by these shocks in a number of ways. For example, drought or crop diseases reduce crop yields. Low yields cause high prices (Harvey et al., 2014) in local markets, making food more expensive, reducing purchasing power and lowering calorie intake (Ecker and Qaim, 2011). High food prices often hurt the poorest quintile of the population which includes many farm households (Magrini et al., 2017). Furthermore, illness or the death of household members reduces household labour allocation and increases health or funeral expenditures (Lim, 2017), all of which reduces household income and calorie intake.

Whether occurring in isolation or coincidentally, shocks lead to either real income loss (Møller et al., 2019) by reducing profits or increasing the costs of consumption or the destruction of assets, the death of livestock by fire. In the case of individual shocks, the coping strategies a household would choose in order to minimize the effects on its welfare largely depends on the costs, i.e. real income loss or direct asset loss, caused by these shock characteristics. More intense shocks may cause higher costs such that households would be forced to adopt different coping strategies than when dealing with mild shocks. For instance, if a household head is hit by a health shock, e.g. became infected with malaria for few days, it may barely destabilize household food consumption even though this person may not be able to generate income for a few days. Household savings may be sufficient to help maintain household food security in the case that the household head is unable to maintain previous income levels during that period. However, a more intense shock, such as extended drought for weeks at the start of a cropping season, may lead households to deplete assets in order to maintain pre-shock food consumption levels, especially when their savings are not sufficient for coping.

When shocks coincide, the separate effects of the individual shocks on household food security, via real income and/or asset loss, may interact and reinforce each other, producing a composite effect that differs from the sum of the isolated shocks. We call this additional effect an *incremental effect*. For example, when a bad crop harvest coincides with or is closely followed by high food prices, the resulting effect on household food security is likely to be more pronounced than it would be if both individual shocks had occurred at different times.

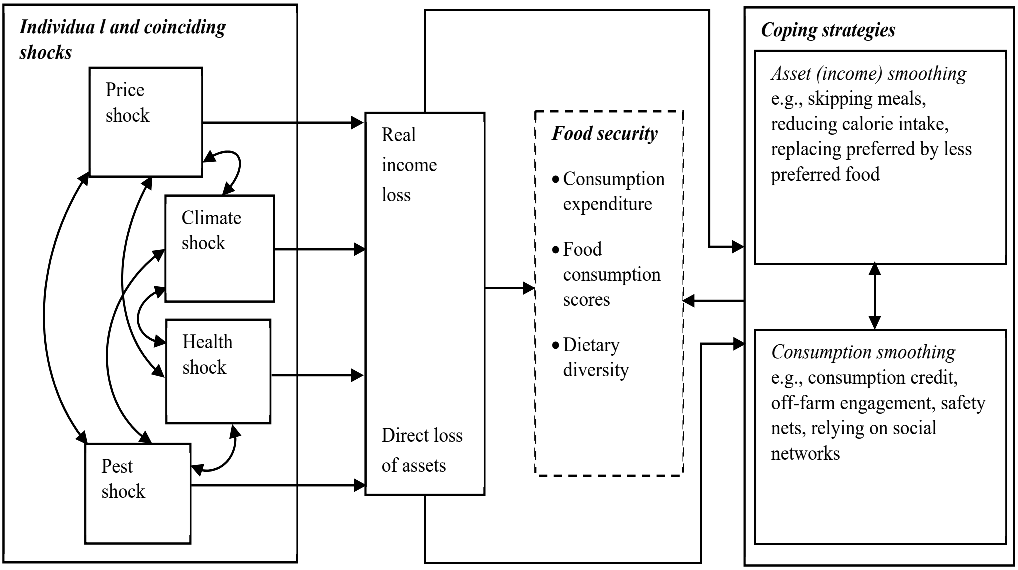

Figure 3.1 A conceptual framework linking shocks, coping strategies and food security

Source: Authors.

When they coincide, the bad harvest may lead to a lower income at the same time the household needs to purchase food at higher prices. Thus, this household suddenly faces a situation that will severely challenge its food security since it needs to supplement the reduced subsistence production with purchased food that is more expensive than usual. Assume that another household is hit by a crop failure, e.g. due to a fire that destroyed large parts of its harvest, but harvests of other farmers are at average levels. Maintaining household food security will be less challenging in this latter case as consumption expenditures at average prices will be much lower in the latter than in the former case. If this household is only hit by high food prices while it has an average harvest, the effect on its food security may be negligible since it produces all of its own food and the average harvest prevents the household from needing to purchase food at those elevated prices. Hence, an incremental effect caused by the concurrence of two or more shocks may force the household to choose different coping strategies.

Alternatively, coinciding shocks may neutralize each other's effects on real income or assets, thus requiring no coping. For instance, consider a semi-commercial farm household facing a drought. Even though the drought is likely to cause low yields, effects of this shock can be offset by the increased prices in the local market, which are caused by limited general supply.[3] Consequently, the income of the household may not be affected in any way even though it was exposed to two coinciding shocks.

We assess to what extent such incremental effects affect the choice of coping strategies, that is to say to what extent differences exist between the coping strategy choices of farm households exposed to isolated individual shocks and those exposed to coinciding shocks that may interact by neutralizing or reinforcing each other. To mitigate or moderate the effects of shocks on income and asset losses, households will choose from a portfolio of coping strategies at their disposal. Hence, we hypothesize that the type(s) of coping strategies chosen also depends on the characteristics of the shocks, including their idiosyncratic or covariate nature.

All else equal, we suppose that if coinciding shocks have a reinforcing interaction effect, a strategy that helps households to cope with an isolated individual shock may no longer be effective due to the incremental effect of shock interactions. Given an incremental effect of the concurrence or closely temporal sequence of two or more shocks, households may need to use their savings to counterbalance the resulting real income loss to maintain or re-achieve food consumption at the pre-shock level. However, if savings are insufficient, the household may be forced to use additional strategies until all available options are exhausted and before productive assets need to be depleted. The choice of coping strategies depends on the objectives of the household, whether they are to smooth consumption or smooth assets. Households with asset smoothing motives may resort to temporarily changing consumption behaviour, such as skipping meals or reducing calorie intake. Consumption smoothing households may borrow money from friends or credit institutions.

Zimmerman and Carter (2003) hypothesize that households respond differently to shocks depending on their level of assets. Hoddinott (2006) confirms this hypothesis empirically using panel data from rural Zimbabwe. Barrett et al. (2016) and Hoddinott (2006) argue that asset accumulation is crucial for escaping chronic poverty and reducing food insecurity. Ellis (2000) points out that asset depletion seems often to be the last option when households experience shocks with high impacts. These findings give rise to a first set of hypotheses on the effect of multiple shocks and their interactions on coping strategy choices.

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[3] If the percentage increase in output prices equals the reciprocal value of the percentage decrease in output quantity, the revenue generated from the household's marketed surplus remains unaffected. If the price increase exceeds the quantity decrease, the household revenue will increase.

H1a: The number of experienced shocks matters in choosing coping strategies.

H1b: Coinciding shocks have incremental effects on coping strategy choices.

H1c: Incremental effects of coinciding shocks make households more likely to deplete assets than single shocks.

For farm households, the principal goal of coping with shocks is to maintain food security. Akter and Basher (2014) conclude that household food security in Bangladesh worsened because of the combined effects of the 2007-2009 food price shock and income shocks in the same period. According to Béné et al. (2015), the outcome of household food security is the resultant effect of a shock, a household's coping capacity, i.e. resilience, and the coping strategies that were applied.

Coping strategy choices affect food security through a number of pathways. If a household has adequate savings or assets or receives help from families and relatives, the effects of the real income loss on food security may be reduced or neutralized. But if adequate mechanisms are not feasible for the household, they may resort to negative coping behaviours such as reducing consumption, skipping meals or eating less preferred food. Eventually, households may deplete productive assets as a last option.

Corbett (1988) argues that when faced with recurrent shocks affecting consumption, farm households sequentially adopt coping strategies, starting with strategies that require minimum commitment of household productive assets. Ellis (2000) outlines five main coping mechanisms that are sequentially adopted when households face shocks that threaten food security. The first is anticipatory in nature, involving income diversification. The second draws on social networks. If these two mechanisms are insufficient for coping, the next is for some household members to migrate temporarily. Besides migration, households may deplete agricultural assets such as implements and livestock. If all these mechanisms fail, the last option is to deplete fixed assets such as land or buildings. In consideration of these findings, our second hypothesis is:

H2: Asset depletion plays a moderation role under shock interactions to maintain food security.

3.3 Empirical Strategy

We use data on shocks and coping strategies taken from the Ghana baseline survey of the Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) project. This data is available publicly online and contains a report showing a map of the surveyed communities

(International Food Policy Research Institute, 2015). We also include a customized map of the study area showing the districts, the number of communities and the number households surveyed in each district (see Figure 3.2). The data was collected in the 2013/2014 agricultural season through a quasi-randomized control trial designed to estimate the causal impacts of Africa RISING interventions on the target population. It includes qualitative measures of shocks and coping strategies used by farm households in northern Ghana. Farmers were asked to identify the various shocks they had experienced that severely and negatively affected their household's assets and/or income. Note that the magnitude of the various shocks was not measured. Moreover, due to the cross-sectional nature of the data, it does not assess successive shocks, which requires panel data, but it does assess combinations of shocks.

Our empirical strategy is as follows: Farm households identified 21 different shocks, including an 'other' category (see section A3.1 and Tables A3.1 and A3.2 in the appendix for details on all reported shocks and coping strategies), but only a few were frequent. Due to relatively low frequencies and similarities among most of these shocks, we categorize them into the four main groups of shocks discussed in the previous section of this chapter in Figure 3.1, namely climate, pest, health and price shocks. Climate shocks include droughts, floods and storms. Pest shocks include crop pests, diseases and livestock pests or diseases. Health shocks include illness and the death of a household or family member. Price shocks include large increases in input or food prices and large dips in crop sale prices.

Faced with these shocks, farm households reported the different *ex post* strategies they used to cope[4]. We group the reported coping strategies into six main categories based on frequency use, nature and similarities among the strategies. The categories are: use of own cash savings, asset depletion, i.e. sale of assets, crop stocks, livestock, land or building; social networks, i.e. unconditional help from families and friends or other relations; consumption change, i.e. changed eating patterns or reduced consumption expenditures; safety nets, i.e. unconditional help from the government, NGOs or religious groups, and labour deployment, i.e. non-working adults take on employment, employed members take on more jobs or migration in search of jobs.

[4] In the data there is no information on ex ante coping strategies. However, these are partly reflected in some of the control variables, e.g. accumulated assets or savings.

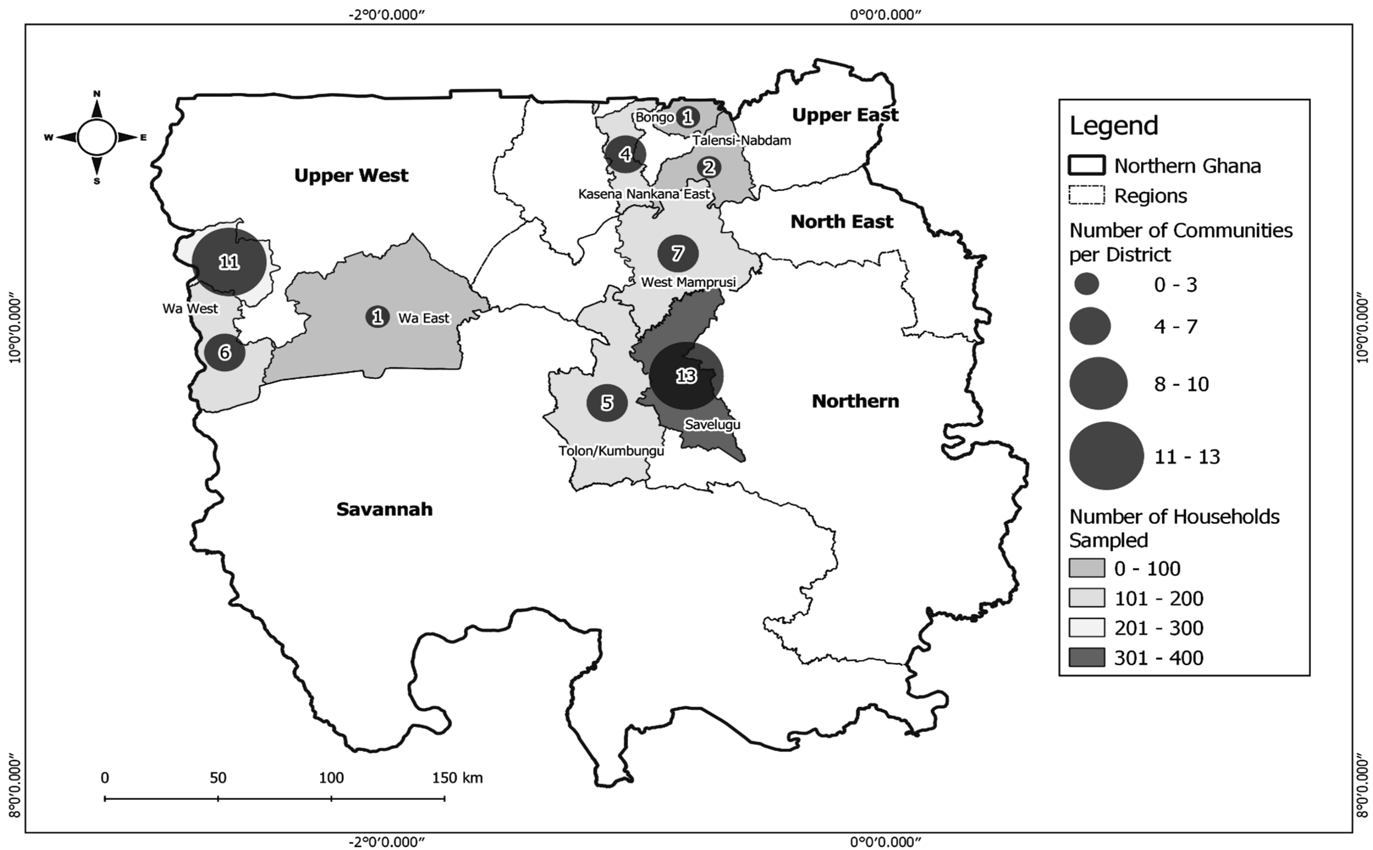

Figure 3.2 A map of Northern Ghana showing the surveyed districts, communities and number of households

Source: Authors, based on survey data 2014 (International Food Policy Research Institute, 2015)

3.3.1 Investigating the Effect of Isolated and Multiple Shocks on Coping Strategy Choices

To test *H1a*, we use binary probit models formulated in equations (3.1) and (3.2) to examine how multiple shocks affect the likelihood of choosing each of the 6 coping strategy categories. In Model 1 represented by equation (3.1), we investigate the relation between the number of shocks and each coping strategy choice[5]:

$$P(C_j)=1|n,X)=G(b_0+b_1n+b_2W+b_3X) \tag{3.1}$$

where a household's choice for adopting coping strategy category j is C_j, (j= 1, …, 6), the number of shock categories is n (= 0, 1,…4), shock characteristics are W, control variables are vector X and G is the cumulative density function (CDF) of the standard normal distribution. In model (3.1), rejecting b_1=0 indicates that the number of shocks matters for choosing coping strategy C_j (*H1a*).

Next we test whether facing multiple shocks has incremental effects using probit model (3.2). This model has four dummy variables to indicate whether the household reported a certain number of shocks (d_n=1) or not (d_n=0). The no shock category (n = 0) is set as the benchmark. Here we assume that the intensity of each shock is fixed and that households do not experience the same category of shock multiple times.

$$P(C_j=1|n,X)=G(b_0+b_{11}d_1+b_{12}d_2+b_{13}d_3+b_{14}d_4+b_2W+b_3X) \tag{3.2}$$

We test sequentially whether the differences between the parameters, i.e. b_{12} - b_{11}; b_{13} - b_{12}; b_{14} - b_{13}, equal zero. Significant differences from zero indicate that being exposed to a higher number of shocks affects coping strategy choices. From model (3.2) we can then determine the incremental effect of additional shocks on coping strategy choices.

3.3.2 Analyzing Specific Shock Interactions and Coping Strategy Choices

To test *H1b* and *H1c*, we use the probit model specified in equation (3.3) to examine whether and to what extent specific shock categories and interaction effects influence coping strategy choices.

$$P(C_j=1\left|s,X)=G(b_0+\sum_{i=1}^{I}b_is_i+\sum_{i=1}^{I}\sum_{j=1}^{J}b_{ij}s_is_j+b_2W+b_3X);\quad i\neq j\right. \tag{3.3}$$

---

[5] We also estimate model (3.1) using the actual number of shocks reported by households in the original data. We find that the parameters have the same signs and statistical significance as the shock categories, except for asset depletion and labour deployment.

where each shock category, i.e. climate, health, pest and price shocks, is denoted by s_i. Equation (3.3) is estimated two times: once excluding the double summation term for shock categories and once for the complete model. In the complete model, the coefficient b_{ij} measures two-shock interaction effects. Rejecting b_i=0 and b_{ij}=0 indicates that two-shock interaction effects affect coping strategy choices.

3.3.3 Assessing the Effect of Coping Strategy Choices on Food Security

For testing *H2*, a key econometric concern is endogeneity. Endogeneity may arise from two sources. First, given that households may self-select (Heckman, 1979) and choose particular coping strategies and not others, food security and coping strategy choices may be interdependent. Unobserved factors influencing coping strategy choices may also influence food security. For instance, food-secure households might adopt more *ex ante* risk management strategies that make them more capable of coping with shocks than food-insecure households. Although food security may also influence coping strategy choices, we do not expect this to happen since households reported shocks that occurred in the past whereas the food security data is more recent (measured during the survey period). Second, endogeneity may arise from unobserved factors that may influence the choice of one coping strategy as opposed to the others.

To test *H2* given possible endogeneity, we use a recursive model by augmenting equation (3.4) with equation (3.5):

$$\Pr(C_{ij}=1|s,X)=G(s'\alpha+X'b), \quad j=1,2,.....,J \tag{3.4}$$

$$FS=\gamma_0+\gamma_1 s+\gamma_2 C_{ij}+\gamma_3 s*C_{ij}+\gamma_4 X+u \tag{3.5}$$

where *FS* denotes a food security indicator (*HDDS*, *FCS*, *CSI*), *s* is a vector of shocks and their interactions, *u* is a normal error and the other symbols are as they were already defined. Given that coping strategy choices may be endogenous to food security, standard estimation methods may produce biased and inconsistent results. The recursive model helps to solve the endogeneity issue by jointly[6] estimating the coping strategy model (3.4) and the food security model (3.5) through maximum likelihood (Roodman, 2011). The multivariate probit model (3.4) is estimated, and then the predictions are incorporated in the linear food security model (3.5) in order to estimate its

[6] Joint estimation is done using Roodman's (2011) conditional mixed process (cmp) program in Stata.

parameters. This model structure allows correlation among the variables, while controlling for the possible endogeneity of coping strategy choices in the food security model.

3.4 Results and Discussion

This section presents the core estimation results. Complementary results as well as summary statistics of the data are provided in section A3.1 and Tables A3.1 - A3.6 of the appendix.

3.4.1 Effects of Single and Multiple Shocks on Coping Strategy Choices

The results of the probit models (3.1) and (3.2) for testing hypothesis *H1a* are presented in Table 3.1 and Table 3.2 respectively. The number of different shock categories experienced is significantly related to asset depletion, safety nets and labour deployment coping strategies. For shock characteristics, the results show that households reporting a severe idiosyncratic shock are more likely to choose savings but less likely to change consumption. If the average duration of shocks increases, the likelihood of choosing savings decreases, but the likelihood of choosing asset depletion, labour deployment, consumption change and social networks increases.

To confirm and estimate incremental effects of multiple shocks, we turn to the results of model (3.2). Even though facing any number of shocks increases the likelihood of choosing savings, the parameter differences between combined shocks are not significant. This result means that the incremental effects of shock interactions do not affect the likelihood of choosing savings as a coping strategy. In other words, whether a household faces a single shock or multiple shocks, savings can be used to cushion the effects. Moreover, this result implies that facing more than one shock does not have any significant increasing effect on choosing savings as a coping strategy. Rational households would first choose their available savings for coping with shocks. With regard to safety nets and labour deployment, multiple shocks, compared with single shocks, have no incremental effect on the likelihood of choosing such strategies.

Regarding asset depletion, both the number of shocks in model (3.1) as well as the parameter differences corresponding to an increasing number of shocks in model (3.2) (from 2-4 shocks) are significant. Holding the nature and duration of shocks constant, we can infer from this result that experiencing two or more shocks affects the likelihood of choosing asset depletion as a coping strategy. As discussed by Corbett (1988) and Ellis (2000), households tend to explore other low-cost options of coping, e.g. the use of cash savings when facing only one shock rather than depleting their productive assets.

Table 3.1 Marginal effects of the number of shocks on coping strategy choices

VARIABLES	(1) Savings	(2) Asset depletion	(3) Safety nets	(4) Labour deployment	(5) Consumption change	(6) Social networks
Number of shocks (n)	0.0021	0.1171***	-0.0123**	0.0146***	0.0004	-0.0058
	(0.0162)	(0.0132)	(0.0063)	(0.0053)	(0.0059)	(0.0141)
Idiosyncratic	0.1905***	0.0371	0.0122	0.0060	-0.0292***	0.0147
	(0.0269)	(0.0247)	(0.0106)	(0.0085)	(0.0113)	(0.0247)
Duration of shocks	-0.0681*	0.0557*	-0.0018	0.0245***	0.0225**	0.0769***
	(0.0349)	(0.0291)	(0.0132)	(0.0086)	(0.0100)	(0.0280)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,100	1,100	1,100	1,100	1,100	1,100

Note: *Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

Table 3.2 Marginal effects of shock frequencies and statistical tests of equality of shock parameters

VARIABLES	(1) Savings	(2) Asset depletion	(3) Safety nets	(4) Labour deployment	(5) Consumption change	(6) Social networks
One shock (d1)	0.2903**	0.1134	-0.0374		0.1348	0.2310
	(0.1215)	(0.1558)	(0.0339)		(8.7210)	(0.1510)
Two shocks (d2)	0.3234***	0.2623*	-0.0352	0.2213	0.1776	0.2693*
	(0.1217)	(0.1551)	(0.0339)	(14.5051)	(8.7210)	(0.1514)
Three shocks (d3)	0.3145**	0.3950**	-0.0522	0.2253	0.1711	0.2483
	(0.1228)	(0.1549)	(0.0353)	(14.5051)	(8.7210)	(0.1521)
Four shocks (d4)	0.2280*	0.4292***		0.2457	0.1182	0.1520
	(0.1308)	(0.1588)		(14.5051)	(8.7210)	(0.1580)
Idiosyncratic	0.1918***	0.0384	0.0127	0.0069	-0.0296***	0.0161
	(0.0268)	(0.0247)	(0.0116)	(0.0125)	(0.0111)	(0.0246)
Duration of shocks	-0.0667*	0.0515*	-0.0036	0.0354***	0.0209**	0.0775***
	(0.0350)	(0.0293)	(0.0143)	(0.0124)	(0.0098)	(0.0280)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,100	1,100	1,009	762	1,100	1,100
Chi-square test of differences between the number of shocks						
d2 vs. d1 shock	0.76	17.48***	0.03	0.00	5.51**	1.44
d3 vs. d2 shock	0.06	21.16***	1.42	0.09	0.34	0.46
d4 vs. d3 shock	2.52	0.64	2.19	1.18	3.73*	3.52*

Note: *Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Empty spaces indicate insufficient observations to estimate parameters.*

Furthermore, for households with savings, a single shock increases the likelihood to use their savings first instead of depleting their assets (Doss et al., 2018). The outcomes of the Chi-square tests on parameter differences for the reported number of shocks confirm this finding. Our significant test result means that for a household that is already experiencing a single shock, any additional shock increases the probability of depleting assets.

3.4.2 Specific Shock Interactions and Incremental Effects on Coping Strategy Choices

Before discussing the results on shock interactions, we will briefly discuss the effects of individual shocks on coping strategy choices resulting from the probit regressions of equation (3.3) for the six coping strategies. We include dummies for the climate, health, pest and price shock categories as the main covariates, while controlling for shock characteristics, socioeconomic and demographic characteristics of the households as well as institutional factors such as access to health facilities, among others. Marginal effects are presented in Table 3.3; each column from the second to the last represents a specific coping strategy model.

Controlling for shock duration and the idiosyncratic nature of shocks, we infer from these results that individual climate, pest and price shocks correlate positively with asset depletion; pest and price shocks have a negative correlation with social networks; pest shock has an inverse correlation with savings; and price shocks correlate inversely with safety nets. A climate shock increases both the probability of a household using their savings as a coping strategy by 0.11 and the probability of them using asset depletion by 0.11, all else held constant. It does not lead to choosing social networks as a coping strategy, probably due to its covariate nature where many households in a given location may be affected. A pest shock increases the likelihood of choosing asset depletion and labour deployment but reduces the likelihood of using savings and social networks. A health shock has a positive effect only on choosing social networks (0.192). A price shock directly affects asset depletion but reduces the likelihood of using safety nets and social networks.

The coefficients of the shock characteristics indicate that a severe idiosyncratic shock increases the likelihood of using savings and asset depletion but reduces the likelihood of altering consumption. On the other hand, as the average duration of shocks increases, the likelihood of choosing savings reduces while the likelihood of choosing labour deployment, choosing consumption alteration and using social networks increases. These results are plausible, particularly with regard to shock duration. Given the limited amount of savings rural farm households included in this study have, an extended shock episode means that their savings are likely to quickly become exhausted. Hence, alternative coping strategies like off-farm labour participation, relying on social networks and altering consumption must be engaged.

Table 3.3 Marginal effects from binary probit coping strategy models that only include single shocks

VARIABLES	(1) Savings	(2) Asset depletion	(3) Safety nets	(4) Labour deployment	(5) Consumption change	(6) Social networks
Climate shock	0.1100***	0.1100***	-0.0118		0.0077	0.0286
	(0.0357)	(0.0324)	(0.0120)		(0.0144)	(0.0294)
Pest shock	-0.0895***	0.1174***	0.0024	0.0252**	0.0060	-0.0610**
	(0.0312)	(0.0259)	(0.0114)	(0.0128)	(0.0108)	(0.0269)
Health shock	0.0501	0.0415	0.0043	0.0033	0.0173	0.1919***
	(0.0341)	(0.0295)	(0.0131)	(0.0133)	(0.0130)	(0.0326)
Price shock	-0.0049	0.1553***	-0.0571***	0.0105	-0.0190	-0.0604**
	(0.0347)	(0.0274)	(0.0221)	(0.0130)	(0.0122)	(0.0303)
Idiosyncratic	0.1851***	0.0577**	0.0056	0.0123	-0.0333***	-0.0194
	(0.0277)	(0.0255)	(0.0108)	(0.0131)	(0.0115)	(0.0246)
Duration of shocks	-0.0671*	0.0442	0.0011	0.0342***	0.0259***	0.0917***
	(0.0353)	(0.0293)	(0.0129)	(0.0127)	(0.0100)	(0.0280)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,050	1,050	1,050	651	1,050	1,050

Note: *Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

The results for the estimated b_i and b_{ij} in model (3.3) for testing *H1b* and *H1c* shown in Table 3.4 paint a clearer picture of how the incremental effects of shock interactions influence coping strategy choices. Based on the marginal effects, we quantify the incremental effects of specific shock interactions.

Two-shock interactions do not influence the choice of a household using their savings as a coping strategy. This finding strengthens the conclusions derived from the previous results that show that only one shock is sufficient for choosing savings. For asset depletion, it is a different story. While a single shock does not significantly relate to asset depletion, the incremental effect of two-shock interactions increases its likelihood. Comparing the estimates in Tables 3.3 and 3.4, we see clear differences in how coping strategy choices respond to individual and multiple shocks. Under shock interactions, there is an incremental effect that affects the likelihood of choosing a given coping strategy. For instance, both climate and health shocks have a significant positive effect, while their interaction term is significant and negative. The combined effect (0.3363+0.2842-0.1980 = 0.423) is larger than the sum of the individual shock effects as reported in Table 3 (0.11+0.0415=0.152). The value of 0.423 implies that when climate and health shocks coincide, the probability of depleting assets to cope is about 27% (0.423-0.152) higher than if any of the shocks separately affected the household at different times. We draw similar conclusions for the interaction of pest and health shocks. The combined effect (0.265+0.2842-0.1073=0.442) is larger than the sum of the individual effects (0.1174+0.0415=0.159). So, the interaction between pest and health shocks makes a household more likely to deplete assets than the summed effect of the individual shocks by about 28% (0.442-0.159). For the remaining coping strategies, shock interactions do not seem to have any significant incremental effect.

Table 3.4 Marginal effects from binary probit coping strategy models that include shock interactions

VARIABLES	(1) Savings	(2) Asset depletion	(3) Safety nets	(4) Labour deployment	(5) Consumption change	(6) Social networks
Climate shock	0.1382	0.3363***	-0.0374		0.2203	0.2540**
	(0.0970)	(0.1221)	(0.0387)		(9.4014)	(0.1290)
Pest shock	-0.0945	0.2650***	0.0121	0.0421	0.0908**	0.0358
	(0.0950)	(0.0880)	(0.0392)	(0.0260)	(0.0410)	(0.0914)
Health shock	0.1392	0.2842**	-0.0103	0.0033	0.2549	0.3564***
	(0.0922)	(0.1205)	(0.0350)	(0.0258)	(9.4014)	(0.1259)
Price shock	0.2124*	0.2890***	-0.5274	0.0316	-0.1384	0.0105
	(0.1162)	(0.0996)	(38.4437)	(0.0272)	(10.4379)	(0.1067)
Climate x pest	0.0628	-0.0656	-0.0143		-0.0434	-0.1177*
	(0.0833)	(0.0736)	(0.0317)		(0.0299)	(0.0694)
Climate x health	-0.0219	-0.1980*	0.0305		-0.2075	-0.2076
	(0.0975)	(0.1187)	(0.0393)		(9.4014)	(0.1286)
Climate x price	-0.1255	-0.1236	0.2631		0.2025	-0.0661
	(0.1028)	(0.0849)	(34.4722)		(10.4379)	(0.0844)
Pest x health	-0.0497	-0.1073*	-0.0017	-0.0013	-0.0257	0.0253
	(0.0687)	(0.0605)	(0.0333)	(0.0264)	(0.0305)	(0.0689)
Pest x price	-0.0431	-0.0393	0.2476	-0.0334	-0.0968***	-0.0674
	(0.0667)	(0.0544)	(17.0171)	(0.0258)	(0.0307)	(0.0580)
Health x price	-0.1284*	-0.0033		0.0005	-0.0497	0.0248
	(0.0709)	(0.0597)		(0.0255)	(0.0306)	(0.0718)
Idiosyncratic	0.1864***	0.0584**	0.0053	0.0140	-0.0333***	-0.0175
	(0.0279)	(0.0257)	(0.0131)	(0.0133)	(0.0112)	(0.0246)
Shock duration	-0.0754**	0.0393	-0.0001	0.0353***	0.0226**	0.0947***
	(0.0355)	(0.0298)	(0.0153)	(0.0131)	(0.0100)	(0.0282)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,100	1,100	919	775	1,100	1,100

Note: *Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

When analysing coping strategies independently, the results indicate that shock interactions mainly affect the likelihood of depleting assets. On the other hand, when coping strategies are analysed simultaneously, the multivariate probit results in Table 3.5 further strengthen the findings that climate-health, climate-price and pest-health shock interactions increase the likelihood of depleting assets to cope with incremental effects. Based on these findings, hypothesis *H1c,* which states that the incremental effect of multiple shocks makes households more likely to deplete assets than single shocks, cannot be rejected. When controlling for shock characteristics, other coping strategies, particularly the use of savings, may be sufficient to cope with single shocks, in which case assets can be accumulated or invested to generate wealth. However, when shocks coincide the incremental effects force households to deplete stored assets to satisfy consumption goals.

3.4.3 Do Coping Strategies Moderate the Effect of Shocks on Household Food Security?

The results for testing *H2* using model (3.5) are reported in the second part of Table 3.5 for FCS, CSI and HDDS. Model performance across all three food security models shows statistically significant likelihood ratio (LR) chi-square statistics, indicating a good fit. The parameters ρ_{14}, ρ_{24} and ρ_{34} test for the correlation of unobserved factors affecting food security and the coping strategies. The results appear mixed, depending on the food security model used. In the CSI model, there is a significant positive correlation between savings and food security, asset depletion and food security as well as social networks and food security, which means that savings, assets and social networks are likely endogenous in the CSI function. However, in the HDDS and FCS models, only asset depletion has a significant negative correlation with food security, again confirming possible endogeneity of asset depletion in the food security model.

Table 3.5 Recursive model results for food security and coping strategies

Variable	Multivariate probit with CSI model			Multivariate probit with HDDS model			Multivariate probit with FCS model		
	Savings	**Asset depletion**	**Social networks**	**Savings**	**Asset depletion**	**Social networks**	**Savings**	**Asset depletion**	**Social networks**
Climate shock	0.446*	1.018***	0.963**	0.430	1.114***	0.841*	0.384	1.252***	0.834*
	(1.94)	(3.16)	(2.07)	(1.56)	(2.58)	(1.89)	(1.38)	(3.06)	(1.77)
Pest shock	-0.136	0.920***	0.149	-0.265	0.936***	0.224	-0.261	0.975***	0.169
	(-0.60)	(3.80)	(0.43)	(-0.99)	(3.12)	(0.68)	(-0.97)	(3.39)	(0.49)
Health shock	0.355	0.845***	1.287***	0.391	0.988**	1.196***	0.370	1.047***	1.233***
	(1.63)	(2.67)	(2.83)	(1.49)	(2.34)	(2.75)	(1.39)	(2.62)	(2.67)
Price shock	0.376	1.168***	0.0173	0.692**	0.638*	0.253	0.635*	0.674**	0.147
	(1.33)	(4.39)	(0.04)	(2.05)	(1.81)	(0.65)	(1.89)	(1.99)	(0.37)
Climate x pest	0.0744	-0.341*	-0.484*	0.129	-0.171	-0.561**	0.168	-0.342	-0.457*
	(0.38)	(-1.74)	(-1.84)	(0.54)	(-0.69)	(-2.27)	(0.71)	(-1.44)	(-1.76)
Climate x health	-0.149	-0.446	-0.762	-0.0402	-0.701*	-0.582	-0.00360	-0.895**	-0.596
	(-0.66)	(-1.48)	(-1.64)	(-0.15)	(-1.69)	(-1.31)	(-0.01)	(-2.26)	(-1.27)
Climate x price	-0.172	-0.682***	-0.276	-0.427	-0.150	-0.419	-0.367	-0.219	-0.325
	(-0.70)	(-3.15)	(-0.86)	(-1.44)	(-0.50)	(-1.36)	(-1.24)	(-0.77)	(-1.03)
Pest x health	-0.0875	-0.417***	0.156	-0.128	-0.411**	0.0838	-0.151	-0.321	0.0722
	(-0.54)	(-2.59)	(0.60)	(-0.66)	(-2.02)	(0.34)	(-0.77)	(-1.64)	(0.28)
Pest x price	-0.0904	-0.130	-0.260	-0.132	-0.0442	-0.333	-0.111	-0.125	-0.260
	(-0.57)	(-0.91)	(-1.19)	(-0.69)	(-0.24)	(-1.56)	(-0.58)	(-0.71)	(-1.19)
Health x price	-0.267	-0.0620	0.142	-0.401**	0.0859	0.0475	-0.400**	0.151	0.0346
	(-1.57)	(-0.40)	(0.52)	(-1.99)	(0.43)	(0.18)	(-1.97)	(0.78)	(0.13)
Idiosyncratic	0.438***	0.230***	-0.0621	0.511***	0.271***	-0.132	0.514***	0.316***	-0.127
	(5.76)	(3.16)	(-0.67)	(5.74)	(3.04)	(-1.41)	(5.70)	(3.59)	(-1.29)
Duration of most shock	-0.220**	0.169*	0.344***	-0.223**	0.186*	0.329***	-0.199*	0.122	0.408***
	(-2.48)	(1.95)	(3.21)	(-2.17)	(1.87)	(3.09)	(-1.89)	(1.29)	(3.82)
Constant	-1.040**	-2.131***	-2.090***	-0.872	-2.607***	-1.687**	-0.909*	-2.521***	-1.873***
	(-2.10)	(-3.77)	(-2.92)	(-1.61)	(-3.90)	(-2.44)	(-1.67)	(-3.90)	(-2.63)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Food security models	***CSI***	***HDDS***	***FCS***
Savings	-16.42^{***} (-4.69)	-0.557 (-1.34)	-0.447^{**} (-2.02)
Climate shock	-0.487 (-0.19)	-0.559^{**} (-2.12)	0.0249 (0.18)
Savings x climate shock	0.873 (0.34)	0.571^{**} (2.13)	0.0976 (0.68)
Asset depletion	25.55^{***} (6.14)	1.228^{***} (2.59)	0.534^{**} (2.20)
Asset depletion x climate shock	-6.023^{*} (-1.90)	0.871^{**} (2.54)	0.260 (1.44)
Social networks	-6.959 (-1.39)	-1.803^{***} (-2.92)	-0.544^{*} (-1.72)
Social networks x climate shock	2.744 (0.98)	0.402 (1.41)	0.135 (0.87)
Pest shock	-3.065 (-1.38)	-0.145 (-0.62)	-0.205^{*} (-1.67)
Savings x pest shock	0.645 (0.30)	-0.0957 (-0.41)	0.206^{*} (1.66)
Asset depletion x pest shock	-0.660 (-0.28)	-0.791^{***} (-2.99)	-0.138 (-0.99)
Social networks x pest shock	9.612^{***} (3.75)	0.239 (0.89)	0.141 (0.97)
Health shock	-0.0593 (-0.03)	0.689^{***} (2.71)	-0.130 (-0.99)
Savings x health shock	0.611 (0.26)	-0.435^{*} (-1.69)	0.194 (1.43)
Asset depletion x health shock	3.421 (1.28)	-0.361 (-1.21)	0.314^{**} (2.01)

Social networks x health shock	-5.474 (-1.46)	0.0417 (0.11)	-0.0424 (-0.20)
Price shock	-5.150** (-2.10)	-0.267 (-1.06)	-0.165 (-1.24)
Savings x price shock	5.267** (2.24)	0.125 (0.49)	0.347** (2.56)
Asset depletion x price shock	1.096 (0.44)	0.256 (0.93)	0.102 (0.71)
Social networks x price shock	6.161** (2.17)	-0.233 (-0.78)	-0.0793 (-0.49)
Constant	23.73***	6.861***	2.556***
	(3.13)	(10.07)	(7.05)
Control variables	Yes	Yes	Yes
Model diagnostics			
ln σ_4	22.436*** (92.96)	1.918*** (23.94)	1.0202 (1.04)
ρ_{12}	-0.6043*** (-9.50)	-0.5720*** (-9.70)	-0.5625*** (-9.84)
ρ_{13}	-0.1712*** (-3.34)	-0.1891*** (-3.46)	-0.1947*** (-3.36)
ρ_{14}	0.6574*** (2.37)	0.1999* (0.35)	0.1596 (0.30)
ρ_{23}	-0.2505*** (-3.14)	-0.2619*** (-3.34)	-0.2403*** (-3.10)
ρ_{24}	0.8140*** (0.92)	-0.5221*** (-4.90)	-0.5896*** (-7.77)
ρ_{34}	0.2276*** (1.78)	0.4241*** (1.54)	0.2934** (2.38)
$LR\ \chi^2$	573.96***	565.02***	590.49***
N	1284	1284	1282

Note: *t-values in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

Consistent with *H2*, households that deplete assets have significantly higher scores on FCS and HDDS. Under climate shocks, farm households that deplete assets are able to maintain or improve the diversity of foods consumed. Also, the negative correlation of climate shocks with CSI (note that larger negative values reflect better food security) implies that households that choose to deplete their assets when facing climate shock show less adverse consumption responses such as reducing or skipping meals. Households that deplete assets when faced with health shocks are able to maintain or improve the diversity and frequency of the food consumed. Households that use savings when they experience price shocks also exhibit lower adverse food consumption habits. Overall, these results show that depleting assets under shock interactions helps households to moderate the incremental effects. This is a key point for households that aim at consumption smoothing and in difficult periods would rather deplete their assets to maintain consumption rather than disrupting their consumption patterns. On the other hand, using savings in case of a pest shock increases households' dietary diversity and food consumption frequency. The reason for savings use increasing food security under price and pest shocks is not immediately apparent from the cross-sectional data we use, but for semi-commercial farm households, higher prices for home produced goods often lead to positive income effects that benefit those with marketable surpluses.

The results indicate that the moderating effect of social networks on food security is generally missing. This finding contrasts one finding from Islam and Walkerden (2014), who reported that social networks enabled Bangladeshi households to cope with natural disaster shocks in the initial stages. Our results also support a second finding of the authors that a social network strategy is no longer effective as the effect of the shock intensifies. Similarly, Béné et al. (2016) found that social networks played virtually no role in fisher households' resilience in Ghana, Fiji, Sri Lanka and Vietnam.

3.5 Conclusion and Implications

While smallholder farmers in developing countries face multiple shocks, researchers mostly consider these shocks in isolation. We analyse the relationship between coinciding shocks and coping strategy choices of farm households in northern Ghana using binary probit models and a recursive model that incorporates multivariate probit and linear regression models.

We find that multiple shocks interact and generate incremental effects that influence coping strategy choices. First, controlling for the nature and duration of shocks, we determine that the effects of single shocks can be cushioned using measures that do not place demand on assets, e.g. cash savings and social networks. With shock interactions, however, households choose asset depletion to cope and maintain or increase food consumption. This choice implies that in rural settings where multiple shocks may occur, external interventions are required to help manage the interactive effects of coinciding shocks in order for households to cope without depleting their productive assets. To achieve this, non-governmental organizations that operate in the region can modify their intervention packages and prioritize access to functioning markets, especially for labour, savings or insurance, and outputs as a part of their key objectives. The provision of micro insurance especially, can help protect assets by transferring risks and acting as a safety net, which encourages households to venture into higher returning activities (Janzen and Carter, 2013).

Second, the coping strategy chosen depends on which of the four specific shocks (climate, pest, health and price) interact. In our study, climate-health, climate-pest, climate-price and pest-health shock interactions were shown to be the main reasons for choosing asset depletion. Given the prevalence of climate and health challenges in the study area, for example the high mosquito prevalence that increases the likelihood of people contracting malaria, it is not surprising that Northern Ghana continues to report high food insecurity and poverty levels. Multiple shock interactions partly explain why chronic food insecurity and poverty exist in shock-prone rural economies since they often place hefty demands on asset depletion due to their incremental effects. While asset accumulation is crucial for the poor to rise out of chronic poverty (Barrett et al., 2016), multiple shocks make it difficult to accumulate sufficient assets to escape poverty (Adato et al., 2006; Carter and Barrett, 2006).

Third, asset depletion is found to moderate the effect of climate shocks on households' dietary diversity and to reduce the likelihood that households exhibit adverse consumption habits. Asset depletion is also found to cushion the effect of health shocks on the diversity and frequency of household food consumption. Similarly, savings help to moderate the effect of climate shocks on household dietary diversity and of price shocks on the diversity and frequency of food consumption. Social networks play no significant role in cushioning the effects of shocks on household food security in the study context.

Appendix A3.1 Study Context and Data Summary

A3.1.1 Study Area

Northern Ghana, consisting of Northern, Upper East and Upper West regions, is an interesting region to analyse the interaction of shocks and household food security. The region typifies vulnerable regions in sub-Saharan Africa with many livestock and crop production challenges. Notwithstanding several interventions from the government and donor agencies in these areas, poverty and food security statistics are worse than in other parts of Ghana. For instance, the United Nations World Food Programme (WFP (2012) reported that more than 680,000 people in northern Ghana were severely food insecure and 140,000 of these people had poor diet and lived mostly on staples. The Ghana Statistical Service (Ghana Statistical Service (GSS, 2018) reported that poverty rates in the Upper West, Northern and Upper East regions stand at 71%, 61% and 55% respectively. These rates were the three highest among all regions in Ghana, and together contributed to 67% of all people living in extreme poverty in Ghana (GSS, 2018).

The prevalence of multiple shocks further increases the vulnerability of households to falling into poverty or becoming food insecure (Antwi-Agyei et al., 2012). Households are often exposed to multiple shocks that challenge their food security.

Climate shocks exist as droughts, storms and floods. Northern Ghana experiences erratic one-season rainfall, with precipitation varying from 900mm to 1400mm of rain (MacCarthy et al., 2017). A simulation study by Wossen et al. (2014) showed that the irregular onset of rain is as important as the cessation of rain for optimal crop production, food security and poverty reduction. Their results show that an unanticipated rainfall shortage during the growing season causes 91% of farmers to fall below the poverty line. In this study, the poverty line was the threshold defining food insecurity. Abbam et al. (2018) estimated a 10-year mean precipitation ratio of 0.88 between 1960-1969 and 2005-2014, which indicates deficits in recent rainfall and drier conditions. These worsening rainfall parameters affect crop and livestock production, since farmers depend mainly on rain-fed agriculture (Asante and Amuakwa-Mensah, 2015). With such variability in rainfall, farmers tend to use limited amounts of fertilizer in their crop production (Alem et al., 2010), leading to yield losses.

Pests and diseases are a second category of shocks. Households engaged in crop and livestock production in this region face high pest and disease infestations. Since 2016, fall armyworm outbreaks have been a major problem. They have been associated with yield losses, poor nutrition and illnesses. Health shocks in the form of illnesses are very common. For instance, Aikins (2007) identifies malaria, anaemia and pneumonia as the top three illnesses that affect households in northern Ghana. In drier periods, the Navrongo Rotavirus Research Group (2003) reports 1,717 episodes of diarrhoea in northern Ghana within one year. The concomitance of malarial and diarrheal diseases during cropping seasons leads to the loss of vital agricultural labour due to the household members being ill, thus affecting production and yields.

The fourth category of shocks are input and commodity price volatilities. Cudjoe et al. (2010) show that northern Ghanaian households that have the highest poverty levels are more vulnerable to rising food prices due to the large proportion of their income that is spent on food. Meanwhile, during harvest seasons farmers receive extremely low prices due to gluts, thus negatively affecting their income (Abokyi et al., 2018).

A3.1.2 Summary Statistics

A summary of shocks (and interactions) as well as coping strategies reported in the dataset are given in Table A3.1. About 2% of the households reported that they did not experience any shock category, while 7% reported having been affected by all four shock categories. Also, 70% and 74% reported to have been affected by climate shocks and health shocks respectively. In Kenya, Tongruksawattana and Wainaina (2019) found that droughts were the dominant shocks reported over a 10-year period between 2000-2010. Pests and price shocks were reported less frequently than health and climate shocks. When households experienced more than one shock, it was most frequently a combination of climate and health shocks or climate and pest shocks. We also summarize the characteristics and costs (in terms of real income or direct loss of assets) of the most severe shocks reported in the dataset. For instance, 53% of households reported that the most severe shock led to income loss, while 27% reported the outcome of asset loss. Besides, 55% of farmers indicated that the most severe shock experienced was idiosyncratic. Lastly, the average duration of all shocks that the households experienced was about 10 weeks.

About 63% of households use cash savings to cope with shocks, followed by asset depletion (24%) and social networks (21%). Labour deployment, safety nets and consumption changes are less used as coping mechanisms in the study area. This is not surprising, especially in relation to safety nets and labour deployment. Non-farm labour markets and formal insurance schemes mostly do not exist, and formal safety nets are largely not available in most Ghanaian rural communities. Consequently, the three most frequent strategies households choose to cope with shocks are using cash savings, depleting assets and relying on social networks.

In addition to shocks and coping strategies, we present the food security outcomes of the study area in terms of the household dietary diversity score (HDDS),[7] the food consumption score (FCS) and the coping strategy index (CSI).[8] The HDDS measures the number of different kinds of food consumed and the frequency of consumption (Maxwell et al., 2014). Table A3.1 shows that the average household had a HDDS of about 8, implying that households had modestly diversified foods since a HDDS has a maximum of 12. The FCS is similar to the HDDS since it also measures dietary diversity and nutritional quality, but its measurement is over a 7-day or, in some instances, 24-hour recall of the various food items consumed by the household. In this study, we use the natural log of the FCS in the model estimation, as reported in Table A3.1, in order to reduce outliers and to facilitate interpretation of results. The data shows that the average household has a weekly FCS value of 89.93. The CSI is an indirect measure of food insecurity and counts how frequent a household adopts certain adverse consumption behaviours when it has inadequate income to purchase food (Maxwell et al., 2014). For example, household members may skip meals or reduce the amount of food eaten, or some adult members may sacrifice their meals for their children. Higher values of CSI indicate greater food insecurity. Table A3.1 shows that on average a

[7] HDDS is a count of 12 predefined food groups: cereals; white roots and tubers; meat and poultry; fish; eggs; milk and dairy; fruits; vegetables; pulses, legumes and nuts; sweets; spices and condiments and beverages. FCS counts and weighs the number of days within the past seven days that 8 food groups are consumed. The food groups and assigned weights are: cereals, tubers and roots = 2; meat and fish = 4; milk = 4; oil and fats = 0.5; fruits = 1; vegetables = 1; pulses = 3 and sugar = 3 (Kennedy, G., Berardo, A., Papavero, C., Horjus, P., Ballard, T., Dop, M., Delbaere, J., and Brouwer, I. D. (2010). Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores. *Public Health Nutrition* **13**, 2010-2018. For the FCS used in this study, the measurement is based on the amount (in kilos) consumed over the past seven days.

[8] CSI measures the frequency and severity of behaviours in which people engage when faced with inadequate food or lacking sufficient money to purchase food (Maxwell, 2014). CSI was measured over a 7-day period for this data.

household's CSI is 10.24. The high coefficient of variation (CV) of the CSI shows a greater dispersion in the CSI compared to the FCS and HDDS. Thus, some households exhibit adverse consumption behaviours such as skipping meals or reducing calorie intake in difficult times.

Table A3.1 also summarizes various socioeconomic, demographic and institutional variables in the data. The average household head is about 48 years old, and only 15% of them are female. Educational attainment of respondents is generally low, with the average person having received only 2.4 years of formal education.

Table A3.1 Summary statistics of model variables

Variable	**Mean**	**CV**	**Min**	**Max**
Number of shocks	2.08	0.47	0	4
No shock	0.02	7.76	0	1
One shock	0.31	1.50	0	1
Two shocks	0.33	1.43	0	1
Three shocks	0.27	1.64	0	1
All four shocks	0.07	3.52	0	1
Specific shocks, interactions and costs of shocks				
Climate shock	0.70	1.43	0	1
Pest shock	0.38	1.06	0	1
Health shock	0.74	1.83	0	1
Price shock	0.28	1.73	0	1
Climate x pest	0.34	2.29	0	1
Climate x health	0.47	2.37	0	1
Climate x price	0.25	1.94	0	1
Pest x health	0.25	2.59	0	1
Pest x price	0.17	2.43	0	1
Health x price	0.16	3.27	0	1
Income loss due to shock (1=yes, 0=no)	0.53	0.50	0	1
Asset loss due to shock (1 = yes, 0 = no)	0.27	0.44	0	1
Income and asset loss due to shock (1= yes, 0 = no)	0.61	0.49	0	1
Average duration of shocks (weeks)	9.59	1.37	0	104.29
Coping strategies				
Savings	0.63	0.77	0	1
Asset depletion	0.24	1.87	0	1
Safety nets	0.03	5.65	0	1
Labour deployment	0.02	6.58	0	1
Consumption change	0.03	5.58	0	1
Social networks	0.21	1.95	0	1
Food security indicators				
Food Consumption Scores (log)	3.98	0.25	0.17	7.34
Household Dietary Diversity Score	7.83	0.24	2	12
Coping Strategy Index	10.24	1.84	0	137.5
Control variables				

Upper East region (1 if Upper East, 0 Northern)	0.16	2.19	0	1
Upper West region (1 if Upper West, 0 Northern)	0.32	1.37	0	1
Age of household head	47.85	0.30	19	91
Sex (1 if male, 0 female)	0.85	0.43	0	1
Education (years)	2.39	1.98	0	20
Social group membership (1 if yes, 0 no)	0.62	0.78	0	1
Household size	8.78	0.59	1	40
Health facility (distance in minutes by walking)	28.57	0.81	1	180
District capital (distance in minutes by walking)	56.22	0.71	0	365
Asset diversity (count of assets owned)	7.66	0.40	1	20
Family labour (count of persons)	2.11	0.51	1	5

In relation to the data used in the analysis presented in this paper, a few caveats need to be highlighted. First, while about 21 different shocks and coping strategies were reported in the survey (see Table A3.2 below), the very low frequencies and overlap required aggregating them into categories. Although this aggregation made the data more suitable for analysis, this organization of the data also means that individual shocks and strategies were treated as having an equal effect, which may not always be the case. If all strategies and shocks had sufficient observations, aggregation could have been avoided. Therefore, future research may aim at gathering more observations and checking for the robustness of the results on shock interactions, coping strategies and food security while using more comprehensive datasets.

The second caveat relates to gauging the effectiveness of coping strategy choices in alleviating the effects of shocks on household food security. Households reported shocks and coping strategies that occurred earlier in time, whereas the food security indicators were based on measurements taken on the interview date. The time lags between the occurrence of the shock(s) or the point in time of the choosing of coping strategies and the recording of the food security measurement differ by household, such that the households had different available time horizons to implement a certain coping strategy. The length of the available time horizon could affect whether the effects on its food security have been more or less prevented or neutralized by time the recording of the food security measurement is taken. Therefore, one needs to be careful in attributing differences in household food security entirely to the coping strategies adopted.

Third, we do not address how the magnitude of successive shocks condition household decisions on choosing coping strategies due to a lack of information in the data. Future research could therefore shed more light on this aspect.

Table A3.2: Shocks and coping/adaptation responses arranged in order of frequencies, showing significance of pairwise or bivariate correlations

Shocks	Response strategies																							
	R1	R21	R2	R18	R15	R14	R22	R5	R11	R7	R3	R10	R4	R12	R8	R20	R9	R17	R19	R6	R16	R13	#sig	N(yes)	%
S1		***		***	***	***	***		***	***	***				*	**							9	797	62.24
S13		**	***				***		*				***		*	**							5	422	32.99
S14				***			***			*													2	396	30.96
S4		***	***	***	***					**					**								6	384	29.95
S12	***	***			*	***	***		**	**	**												7	377	29.48
S2		***			***	**				***	**												5	366	28.62
S3	***	***	**	***	***	***						*		***						**	**		9	239	18.69
S9	***	***	***	***	**	***	**		*	***			*										8	201	15.72
S8	***	***		***	***	***	***		***											***			8	165	12.90
S20	***	***		***	***	***	**							**									7	122	9.54
S10		***		**	***	*					***			*		**	**		***				7	73	5.71
S22	***	**		**	**		***																5	58	4.53
S19		**	**	*			**			**					*								4	48	3.75
S17				*												***		***					2	47	3.67
S5		*	**	***	**	**				**		***	*					***					7	46	3.60
S15				**									**					***	***				4	38	2.97
S7		*		*	*	**																	1	27	2.11
S11	**	***	**	***		**										***							6	24	1.88
S18	***																						1	24	1.24
S21		***																					1	12	0.94
S16																							0	8	0.63
S6	**							***															2	5	0.39
#sig	9	14	7	11	10	10	9	1	3	7	4	1	2	2	1	5	1	3	2	2	1	0			
N(yes)	803	426	267	209	140	119	104	38	33	22	21	21	18	11	6	3	3	2	2	1	1	1		**1281**	
%	62.69	33.26	20.84	16.32	10.93	9.29	8.12	2.97	2.58	1.72	1.64	1.64	1.41	0.86	0.47	0.23	0.23	0.16	0.16	0.08	0.08	0.08			

Legend: S1=droughts/floods; S2=storms; S3=crop pest/disease; S4=livestock death/theft; S5=non-agricultural household business failure; S6=salary employment loss; S7=large fall in crop sale prices; S8=large rise in food prices; S9=large rise in agricultural input prices; S10=severe water shortage; S11=loss of land; S12=illness or accident of household member; S13=death of household member; S14=death of family member; S15=household separation/divorce; S16=jailed; S17=fire outbreak; S18=hijacking/robbery/burglary; S19=dwelling damaged/destroyed; S20=emergency cash needs and sale of crops at very low prices; S21=political/tribal/livestock conflict; S22=other shocks; R1=use of own savings; R2=help from relatives/friends; R3=help from government; R4=help from NGOs/religious organizations; R5=changed eating patterns; R6=intensifying employment; R7=non-working adult members find work; R8=household members migrate; R9=reduce expenditure on health/education; R10=source credit; R11=sale of agricultural assets; R12=sale of durable assets; R13=sale of land/building; R14=sale of crop stocks; R15= livestock sales; R16=intensifying fishing; R17=sent children to live elsewhere; R18=engaged in spiritual efforts/interventions; R19=smoking/drinking; R20=begging; R21=do nothing; R22=other responses.

Tetrachoric Correlations: *** $p<0.01$; ** $p<0.05$; * $p<0.10$. Empty cells are indicative of non-significant tetrachoric correlation

Table A3.3 Marginal effects of control variables from probit model (3) which only includes single shocks

Variables	(1) **Savings**	(2) **Asset depletion**	(3) **Safety nets**	(4) **Labour deployment**	(5) **Consumption change**	(6) **Social networks**
Upper East region	0.2830***	-0.0526	0.0131	0.0564***	-0.0374*	-0.0681
	(0.0462)	(0.0395)	(0.0139)	(0.0173)	(0.0195)	(0.0417)
Upper West region	0.1162***	-0.0133	-0.0171	0.0056	-0.0470**	-0.0380
	(0.0417)	(0.0372)	(0.0151)	(0.0221)	(0.0197)	(0.0355)
Age	-0.0005	-0.0001	-0.0001	-0.0002	-0.0007	0.0003
	(0.0011)	(0.0010)	(0.0004)	(0.0004)	(0.0005)	(0.0009)
Sex	-0.0614	0.0258	-0.0097	0.0000	0.0107	0.0211
	(0.0427)	(0.0375)	(0.0129)	(0.0161)	(0.0187)	(0.0351)
Education	0.0007	-0.0032	0.0006	0.0011	0.0013	0.0039
	(0.0032)	(0.0029)	(0.0010)	(0.0013)	(0.0011)	(0.0027)
Social group membership	-0.0359	0.0252	0.0088	0.0342**	-0.0078	0.0448*
	(0.0304)	(0.0263)	(0.0112)	(0.0160)	(0.0107)	(0.0257)
Household size	0.0034	0.0014	-0.0003	-0.0025	-0.0002	0.0031
	(0.0031)	(0.0026)	(0.0012)	(0.0019)	(0.0011)	(0.0025)
Health facility	0.0009	-0.0009	0.0001	0.0005*	0.0002	-0.0003
	(0.0008)	(0.0006)	(0.0003)	(0.0003)	(0.0002)	(0.0007)
District capital	0.0004	0.0005	-0.0002	0.0000	-0.0000	-0.0009**
	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0003)
Asset diversity	0.0090*	0.0156***	-0.0018	-0.0009	-0.0036	-0.0233***
	(0.0052)	(0.0043)	(0.0019)	(0.0022)	(0.0022)	(0.0045)
Family labour	-0.0007	-0.0060	0.0118**	-0.0149**	0.0099**	-0.0288**
	(0.0137)	(0.0120)	(0.0048)	(0.0067)	(0.0048)	(0.0118)

*Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

Table A3.4 Marginal effects of control variables based on probit model (3) which includes shock interactions

Variables	**Models with two-level shock interactions**					
	(1) Savings	(2) Asset depletion	(3) Safety nets	(1) Labour deployment	(2) Consumption change	(3) Social networks
Upper East region	0.2749***	-0.0589	0.0171	0.0569***	-0.0390**	-0.0673
	(0.0463)	(0.0399)	(0.0168)	(0.0174)	(0.0187)	(0.0418)
Upper West region	0.1118***	-0.0052	-0.0205	0.0076	-0.0418**	-0.0260
	(0.0423)	(0.0376)	(0.0181)	(0.0225)	(0.0186)	(0.0356)
Age	-0.0005	-0.0002	-0.0002	-0.0001	-0.0007	0.0002
	(0.0011)	(0.0010)	(0.0005)	(0.0004)	(0.0005)	(0.0009)
Sex	-0.0658	0.0301	-0.0132	0.0014	0.0098	0.0233
	(0.0427)	(0.0378)	(0.0156)	(0.0164)	(0.0184)	(0.0350)
Education	0.0008	-0.0032	0.0007	0.0010	0.0009	0.0038
	(0.0032)	(0.0029)	(0.0012)	(0.0013)	(0.0011)	(0.0027)
Social group membership	-0.0400	0.0245	0.0100	0.0359**	-0.0095	0.0435*
	(0.0304)	(0.0264)	(0.0134)	(0.0163)	(0.0104)	(0.0257)
Household size	0.0035	0.0014	-0.0002	-0.0026	-0.0005	0.0033
	(0.0031)	(0.0026)	(0.0014)	(0.0020)	(0.0011)	(0.0025)
Health facility	0.0008	-0.0009	0.0001	0.0005*	0.0003	-0.0003
	(0.0008)	(0.0006)	(0.0004)	(0.0003)	(0.0002)	(0.0007)
District capital	0.0004	0.0006*	-0.0002	0.0000	-0.0001	-0.0009**
	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0003)
Asset diversity	0.0095*	0.0158***	-0.0024	-0.0008	-0.0032	-0.0234***
	(0.0052)	(0.0043)	(0.0022)	(0.0022)	(0.0022)	(0.0045)
Family labour	-0.0007	-0.0042	0.0148**	-0.0147**	0.0114**	-0.0275**
	(0.0137)	(0.0120)	(0.0058)	(0.0067)	(0.0048)	(0.0118)
Model diagnostics						
Observations	1,100	1,100	919	775	1,100	1,100
Pseudo R-square	0.0899	0.1168	0.0997	0.2688	0.2808	0.1092
Wald Chi-square	132.31	141.06	27.03	59.38	87.11	124.96
P-value	0.000	0.000	0.2548	0.000	0.000	0.000

*Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

Table A3.5 Effects of control variables on coping strategy choices based on the multivariate probit model (4)

Variable	**Multivariate probit with FCS function**			**Multivariate probit with HDDS function**			**Multivariate probit with CSI function**		
	Savings	Asset depletion	Social networks	Savings	Asset depletion	Social networks	Savings	Asset depletion	Social networks
Upper East	0.856***	-0.387***	-0.123	0.853***	-0.337**	-0.158	0.574***	0.0847	-0.327**
	(6.13)	(-2.96)	(-0.74)	(6.21)	(-2.49)	(-1.02)	(4.76)	(0.78)	(-2.04)
Upper West	0.408***	-0.287**	0.00606	0.364***	-0.0954	-0.0712	0.433***	-0.105	-0.0364
	(3.15)	(-2.27)	(0.04)	(2.97)	(-0.75)	(-0.55)	(4.22)	(-1.03)	(-0.27)
Age	0.007	-0.024	0.034*	0.006	-0.023	0.031	0.006	-0.019	0.035*
	(0.42)	(-1.30)	(1.71)	(0.36)	(-1.21)	(1.60)	(0.38)	(-1.14)	(1.74)
Age square	-0.000	0.000	-0.000*	-0.000	0.000	-0.000*	-0.000	0.000	-0.000*
	(-0.52)	(1.23)	(-1.79)	(-0.46)	(1.19)	(-1.68)	(-0.49)	(1.16)	(-1.83)
Sex	-0.178	0.006	0.132	-0.175	0.0192	0.132	-0.267**	0.172	0.0523
	(-1.42)	(0.04)	(0.98)	(-1.39)	(0.14)	(1.00)	(-2.29)	(1.41)	(0.39)
Education	0.004	-0.018*	0.015	0.004	-0.014	0.015	-0.004	-0.007	0.014
	(0.43)	(-1.84)	(1.49)	(0.41)	(-1.41)	(1.47)	(-0.43)	(-0.70)	(1.39)
Social group	-0.136	0.165*	0.147	-0.152*	0.168*	0.125	-0.052	-0.0338	0.193**
	(-1.56)	(1.90)	(1.52)	(-1.73)	(1.89)	(1.31)	(-0.70)	(-0.47)	(1.98)
Household size	0.005	0.0183**	0.002	0.009	0.002	0.009	0.010	0.003	0.0120
	(0.52)	(2.18)	(0.16)	(1.07)	(0.24)	(0.98)	(1.37)	(0.48)	(1.29)
Health facility	0.003	-0.007***	-0.000	0.003	-0.005**	-0.001	0.001	-0.002	-0.001
	(1.40)	(-3.01)	(-0.07)	(1.28)	(-2.05)	(-0.50)	(0.42)	(-0.88)	(-0.55)
District capital	0.001	0.002	-0.003**	0.001	0.002	-0.003**	0.001	0.002*	-0.003**
	(1.17)	(1.56)	(-2.14)	(1.20)	(1.44)	(-2.02)	(1.03)	(1.88)	(-2.48)
Asset diversity	0.025	0.078***	-0.096***	0.018	0.094***	-0.110***	0.066***	0.015	-0.074***
	(1.64)	(5.39)	(-5.50)	(1.07)	(6.11)	(-6.47)	(5.15)	(1.17)	(-4.02)
Family labour	-0.014	0.006	-0.126***	-0.002	-0.029	-0.108**	0.007	-0.016	-0.111**
	(-0.36)	(0.16)	(-2.82)	(-0.05)	(-0.70)	(-2.50)	(0.21)	(-0.48)	(-2.48)

*Note: t-values in parentheses; *** p<0.01, ** p<0.05, * p<0.1.*

Table A3.6 Effects of control variables on food security based on model (5)

Variables	(1) **FCS**	(2) **HDDS**	(3) **CSI**
Age	0.0540^{***}	0.0431^{*}	0.0139
	(4.36)	(1.86)	(0.05)
Age square	-0.000528^{***}	-0.000560^{**}	-0.0000691
	(-4.46)	(-2.52)	(-0.03)
Sex	0.122	0.0255	-5.783^{***}
	(1.49)	(0.17)	(-3.28)
Education	-0.0292	0.00131	0.142
	(-1.52)	(0.04)	(0.40)
Education square	0.00240^{*}	0.00152	-0.0224
	(1.85)	(0.63)	(-0.94)
Income loss	0.296^{***}	0.909^{***}	-1.858
	(4.63)	(7.62)	(-1.59)
Asset loss	0.282^{***}	0.621^{***}	1.480
	(2.85)	(3.34)	(0.84)
Both income and asset loss	-0.213^{*}	-0.570^{**}	-3.190
	(-1.74)	(-2.48)	(-1.47)

*Note: Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.*

CHAPTER 4

RESILIENCE TO HOUSEHOLD FOOD DEMAND SHOCKS

4. Resilience to household food demand shocks

Abstract: Food acquisition and consumption are often threatened by price and income shocks. This chapter analyses how household food demand responses to price and income shocks are affected by resilience capacity. Using assets, livestock and crop stocks as proxies for resilience capacities, we integrate them in a quadratic almost ideal demand system. Results show that food demand responses depend on the type of shock, food group affected, amount of resilience capacities and household type. With an increase in assets, demand sensitivity of protein foods to income shocks decreases for all households but sensitivity to price shocks decreases only for poor and urban households. Both livestock and crop buffer stocks decrease demand sensitivity of pulses to income shocks for all household types. These results imply that household food demand can be made more robust to price and income shocks if resilience capacities are increased via asset recapitalization, livestock restocking and crop buffer stock improvement.

4.1 Introduction

The second Sustainable Development Goal (SDG 2) aims to end all forms of hunger and malnutrition by 2030. Achieving this goal might be difficult if (adequate) mechanisms do not exist to manage the effects of sudden events affecting household food acquisition and consumption in developing and emerging economies. In these economies, the demand for various food commodities by poor and vulnerable households are recurrently challenged by price and income shocks. The sources of these shocks vary, but typically exchange rate volatilities affect food prices because many of these countries rely heavily on imports to meet domestic demand for specific staple foods (Seck et al., 2010). Within 2009-2019, Soullier et al. (2020) report that sub-Saharan and West African countries both have rice import dependency ratios of about 46%. For Ghana, this value even stands at 66%. Even for economies with substantial domestic food production, seasonality of production implies that frequent price surges are common in lean seasons whereas income dips commonly occur during bumper harvests. Connected to seasonal price volatilities are unfavorable weather (e.g., drought and floods), and pests and diseases (e.g., fall armyworm) that lead to poor crop yields. Further, human health problems (illnesses) affect the incomes derived by farm households from their agricultural and non-agricultural enterprises through sick days and lost labor.

Regardless of the source, price and income shocks affect food demand directly by reducing purchasing power for food. Such shocks also produce heterogeneous welfare effects on households. For instance, Cudjoe et al. (2010) recount how the 2007/2008 global food crises generated diverse welfare impacts on various population subgroups in Ghana. First, they find that overall consumption of staple foods declined by 7.1% for rural consumers and 9.3% for the urban folks, the effect being larger for the poor and those in urban areas. The authors further note that food demand by rural households was less responsive to price changes than demand by urban households, and that staple food consumption of the urban poor suffered the most from food price surges. What drives these heterogeneous welfare impacts for the rural and urban households or for the poor and non-poor? Why do certain households respond stronger to shocks than others? A plausible explanation is that different households have diverse stocks of capital, resources or capacities that enable them to respond differently to price and income shocks.

By reducing real income and consequently purchasing power, food price and income shocks cause households to immediately reconstitute their food budget allocations or modify their consumption plans (Ross et al., 2020). This therefore creates a direct link between food demand and resilience to price and income shocks. While the primary focus of food demand studies is to address the question of *"what is the welfare effect of a price change?"* (Araar and Verme, 2019), there are other equally important questions that food demand studies can and should address. For example, why does the specific food demand of individuals, households or population subgroups respond differently to price and income shocks? Are the differences in shock responses related to different resilience capacities? The major goal of this chapter is to address these questions because prior food demand studies have paid them little attention.

Existing studies addressing resilience from a food security perspective treat food consumption and/or food security in a composite form. Such measures include food consumption scores, household dietary diversity scores and coping strategy indices. In the composite form it is difficult to understand how specific food commodities that provide food security respond to shocks differently. We take a more devolved approach and analyse how individual food commodities or groups respond to price and income shocks. With reduced purchasing power, households might respond to price and income shocks by trading-off relatively expensive, protein-rich foods for cheaper, energy dense ones when they do not have enough capacities to counter the effects of the shocks on their food demand (Skoufias et al., 2011; Wood et al., 2012). Such forced food demand shifts have consequences for household food security (Gibson, 2013). Magrini et al. (2017) note that the relative shares of various food commodity groups, particularly of cereals, in the total food budget matter, and that stronger substitution effects permit easy switches among food groups under price shocks.

We focus on how diverse resilience capacities affect household resilience to price and income shocks affecting their food demand. When confronted with price and income shocks, many households resort to using their accrued or acquired resources and capacities such as cash savings, livestock and other assets or they consume from crop stocks which they have stored out of pure prudence (Deaton, 1991; Doss et al., 2018). We investigate how these resources, referred to in the literature as resilience-building strategies or resilience capacities (Ansah et al., 2019) enable households to respond differently to price and income shocks affecting their food demand.

This study is certainly not the first on food demand in Ghana, but one of very few studies to link household food demand to the notion of resilience to food demand shocks. In the Ghanaian context, studies such as Osei-Asare and Eghan (2014) analysed meat consumption using a single wave (round) of the Ghana Living Standards Surveys (GLSS). Ansah et al. (2020c) also studied demand for fourteen food groups using the sixth round of the GLSS data from six out of ten regions. While acknowledging the contribution of these prior efforts to our understanding on food demand in Ghana, their findings have both spatial and temporal restrictions. We build on these studies by employing a more comprehensive and updated dataset that spans more than a decade, and make a novel contribution to this literature by applying an analytical technique that provides a means to directly link household food demand to the notion of resilience to price and income shocks. The approach we take helps us to understand whether specific resilience-building strategies play any role towards a resilient food demand by reducing household food demand sensitivity to the negative effects of price and income shocks.

The next section of the chapter highlights the theory and underlying assumptions guiding this study, after which section 4.3 lays out the empirical strategy. Section 4.4 explains the data used in more detail while section 4.5 presents and discusses the estimation results. Section 4.6 concludes.

4.2 Resilience in household food demand

According to standard microeconomic theory, households maximize utility U^f from consuming a food bundle containing n food commodity groups ($g_1, g_2, \ldots, g_n$) given that total expenses on them do not exceed the available household food budget, E (see equation 4.1). Each g_i is purchased or valued at price p_i[9]. The household allocates the constrained budget to the preferred food groups according to the relative prices to be paid as efficiently as possible to obtain maximum utility from the consumption bundle.

$$\underset{g_1,\ldots,g_n}{Max}\left\{U^f(g_1, g_2, \ldots, g_n)\,\middle|\,\sum_{i=1}^{n} p_i\, g_i \leq E\right\} \tag{4.1}$$

A crucial component of this maximum utility from food consumption consists in reaching the best possible food and nutrition security status achievable for the household. That is, large parts of a

[9] In case the household is producing some home-grown vegetables in the courtyard, owns fruit trees etc., which is a widespread phenomenon throughout Africa, we value these self-produced quantities at market prices.

household's utility from food consumption will be created by having sufficient quantities of food available which are of the quality, diversity and the sensory characteristics (Varela and Ares, 2012; Watson, 1992) that meet household's preferences.

Maximizing U^f subject to E results in Marshallian demand functions for each food group. Banks et al. (1997) specify the system of demand functions as food shares with a Quadratic Almost Ideal Demand System (QUAIDS) as in equation (4.2).

$$w_g = \alpha_g + \sum_{i=1}^{n} \gamma'_{gi} \ln(p_i) + \beta_{1g} \ln\left[\frac{\mathrm{E}}{a(\mathrm{p})}\right] + \frac{\beta_{2g}}{b(\mathrm{p})}\left[\ln\left\{\frac{\mathrm{E}}{b(\mathrm{p})}\right\}\right]^2 \qquad (4.2)$$

In equation (4.2), a household allocates a share w_g of its total food budget E to food group g_i $(g, i = 1, 2, \dots., n;\ g \neq i)$, p is the observed vector of prices for the g food groups. The parameters $\alpha, \gamma, \beta_1, \beta_2$ denote the regression constant as well as partial effects of prices, food expenditure and quadratic food expenditure on w_g, respectively. The symbol a is a Translog price index, calculated as in equation (4.3), that is homogenous of degree one in prices and used to deflate nominal food expenditure, while b, specified in equation (4.4), is a Cobb-Douglas price index that is also homogeneous of degree zero in prices.

$$a(p) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{g=1}^{n} \sum_{i=1}^{n} \gamma_{gi} \ln p_g \ln p_i \qquad (4.3)$$

$$b(p^h, \theta) = \beta_0 \mathop{\Pi}_{i=1}^{n} p_i^{\beta_i} \qquad (4.4)$$

Each food share w_g can change instantaneously by shocks such as sudden substantial price and income changes. In this chapter, we are concerned with the ability of households to maintain the stability of its utility gained from food consumption by preserving food budget allocation which copes as well as possible with shocks to food prices p_i and household income E; that is, we are concerned with the household's resilience to food demand shocks.

If the food budget contracts due to shocks, households might respond in diverse ways. They may be able to maintain pre-shock consumption patterns and quantities of all food commodities by allocating budget for non-food expenditures to food purchases or by liquidating assets.

Alternatively, households may be forced to adapt their consumption and purchase patterns by reallocating within the food budget if they have no means to (temporarily) adapt the budget to guarantee acquisition of sufficient food commodities or nutritional components so that their food intake can remain as close as possible to pre-shock levels. The degree of a household's capability to maintain pre-shock food purchases and consumption patterns after being affected by one or more significant food-demand relevant shocks reflects resilience of the household food demand.

How is this stable food consumption achieved? The literature on consumption smoothing as well as on coping and adaptation to shocks suggests that a household would exhibit a stable consumption pattern if they have assets and buffer stocks or livestock to depend on (DeLoach and Smith-Lin, 2018; Doss et al., 2018; Zimmerman and Carter, 2003). The literature also shows that increasing purchasing power leads to a shift of the food budget share spent on starchy staples towards more high-value products such as meat, dairy and fish (Bairagi et al., 2020; Cockx et al., 2018; Mottaleb et al., 2018). Gibson (2013) shows that the converse also holds: declining purchasing power leads to a preference shift towards less expensive, less nutritious, and energy-dense starchy staples. The literature reports that poor and vulnerable households adopt actions for coping with the effects of shocks that deteriorate their food security. For example, such households switch to purchasing and eating less preferred foods (Béné et al., 2017; Chagomoka et al., 2016). Kumar and Quisumbing (2014) find that food allocation patterns between household members are adapted: adult members choose to stay hungry so that children have adequate food available. From these findings, we derive hypotheses for analyzing resilience of food demand.

The main hypothesis is that the effects of price and income shocks on food demand are influenced by resilience capacities such as assets, livestock and crop stocks (Ansah et al., 2019). Thus, we consider assets, livestock, and crops stocks as proxies for resilience capacities. The function of these resilience capacities is to stabilize food purchasing power such that households are still able to afford and maintain their preferred food bundle even when hit by price and income shocks. In other words, we hypothesize that resilience capacities make households' demand for specific food products less sensitive (indicated by γ_{gi} and β_1 in equation 2) to the adverse effects of price and income shocks. The response of households to such shocks would depend on the size of the shock though. Since the literature shows that amid such shocks households are more likely to substitute pricy foods with cheaper ones (e.g., Bairagi *et al.* 2020), we further hypothesize that households endowed with more resilience capacities are less sensitive in their demand for protein-rich foods to price and income shocks than those with less capacities.

4.3 Empirical strategy

We estimate the Banks et al. (1997) QUAIDS model specified in equation (4.5) using the Lecocq and Robin (2015) approach in Stata[10].

$$w_g = \alpha_g + \sum_{i=1}^{n} \gamma'_{gi} \ln(p_i) + \beta_{1i} \ln e + \beta_{2i} [\ln e]^2 + \mathrm{u} \qquad (4.5)$$

where $e = E/a(p)$ is total food expenditure deflated with the price index, β_1 and β_2 are percentage changes in food shares associated with marginal changes in food expenditure and quadratic food expenditure, respectively, and u is a random error term.

Following the demographic translation approach of Pollak and Wales (1981), and Barnes and Gillingham (1984), as well as recent applications (Bairagi et al., 2020; Caro et al., 2017) we replace α_i of equation (4.5) by a prediction involving the resilience capacity variables. In equation (4.6) below, the α_i is based on both the levels of the households' resilience capacity variables (r_i) as well as their interactions with prices and food expenditures.

$$\alpha_g = \alpha'_{g0} + \sum_{i=1}^{n} \mu_{gi} z_i + \sum_{r=1}^{R} \theta_i \ln r_i + \sum_{r=1}^{R} \psi_{gi} \ln p_i \ln r_i + \sum_{r=1}^{R} \xi_{gi} \ln e \ln r_i + \lambda_i IMR \qquad (4.6)$$

where z_k are demographic variables. The parameter θ_i measures the direct effects, while ψ_{gi} and ξ_{gi} measure the interaction effects of resilience capacities with food prices and food expenditure, respectively. The parameter λ_i in the model is to correct for bias due to zero consumption of some food commodities by some households through the use of Heckman's Inverse Mills Ratio (IMR) approach (Heckman, 1979).

The interaction effects ψ_{gi} and ξ_{gi} measure the effects of the resilience capacities on price and income shocks, which help to test our hypotheses. A statistically significant ψ_{gi} indicates that the

[10] In estimating equation (5) using the 'aidsills' Stata command the adding-up ($\sum \alpha_g = 1$; $\sum \beta_g = 0$; $\sum \gamma_{kg} = 0$), homogeneity ($\sum \gamma_{gk} = 0$) and symmetry ($\gamma_{gk} = \gamma_{kg}$) restrictions are imposed to satisfy economic theory.

response of household food shares to price shock p_i differs depending on the level of resilience capacity r_i. Theory suggests that the own-price effects γ'_{gi} in equation (4.5) on food demand are negative. Hence, a statistically significant and positive (negative) coefficient means the negative own-price effect is dampened (raised) by an increased resilience capacity r_i. A positive estimate of ψ_{gi} means that the budget shares w_g of households with higher resilience capacity r_i are less sensitive to the negative effect of price shocks on food demand.

The bias correction for zero food consumption due to preference heterogeneity in equation (4.6) follows Mittal (2010), Ulubasoglu et al. (2016) and Bronnmann et al. (2019). We compute the IMR both for selection (i.e., households that consumes the commodity group g_i) and non-selection (i.e., households not consuming food from group g_i). The IMR values enter each food share equation in the QUAIDS model due to likely cross-price effects among the food groups.

Also, we deal with potential endogeneity of total food expenditure in the food budget share equations. Testing for endogeneity uses the Durbin-Wu-Hausman (Hausman, 1978) approach where the residuals ($\hat{v}$) from a reduced form food expenditure model[11] are included in each food share equation w_g through the orthogonal decomposition of u (Lecocq and Robin, 2015) as specified in equation (4.7).

$$u = \rho_i \hat{v} + \varepsilon \tag{4.7}$$

where ρ_i is the parameter measuring food expenditure endogeneity in each food share equation, and ε is a mean-zero and constant variance error term. A statistically significant ρ_i means that food expenditure is endogenous in that food share equation.

4.4 Data

The data used are obtained from the three most recent rounds of the Ghana Living Standards Surveys (GLSS, Ghana Statistical Service, 2018). The GLSS is a nationally representative repeated cross-sectional dataset collected through a joint effort by the Government of Ghana and the World Bank. The GLSS collects detailed information on livelihoods and living standards among various segments of the population to facilitate policy-making and governmental planning. We use the fifth

[11] $E_i = b_0 + \sum b_k x_k + v_i$, where x is a vector of variables explaining food expenditure (including all variables in the QUAIDS model. Ownership of motorbike, phone and fridge are used as instruments); b_0 and b_k are the vectors of parameters to be estimated and v is the predicted residual that is included in each share equation (5).

(GLSS 5), sixth (GLSS 6) and seventh (GLSS 7) rounds of data which were collected in 2005/2006, 2012/2013 and 2016/2017, respectively. Detailed information on demographics, health, education, employment, income, consumption expenditures on individual food and non-food items, assets and other relevant variables are common features of all the three rounds. For this analysis, we focus on food consumption and expenditure, demographic profiles, and resilience capacity variables.

The consumption and expenditure data used for our analysis comprise the amounts spent for all quantities of food commodities by a household[12]. Prices were recorded at the community (village) level and matched at the community levels with the household consumption data. We created six groups of food commodities (staples, pulses, greens, protein foods, oils, and miscellaneous foods)[13] by slightly adapting the groupings suggested by Kennedy et al. (2010) for estimating food consumption scores. We limit the data concerning demographic characteristics such as age and sex to those of the household heads because they usually make the decisions regarding household food purchases (Posel, 2001).

4.5 Results and discussion

This section presents the core results from the QUAIDS model estimation. In the appendix, a data summary (A4.1.1) as well as complementary results (A4.1.2) are presented.

4.5.1 Summary of elasticities and predicted food budget shares from the QUAIDS estimation

Table 4.1 summarizes the estimates of the own-price, cross-price and expenditure elasticities as well as the predicted budget shares. These results suggest that all six food groups are normal goods having positive expenditure elasticities. The estimates having a positive sign mean that consumption of all food groups increases with total food expenditure. Staples, protein foods and miscellaneous foods have expenditure elasticities smaller than one and are therefore considered necessities for the average household in Ghana as their demand will increase less than a proportionate income increase. Pulses, greens and oils have expenditure elasticities larger than one and are considered luxury foods, hence demand for these goods will increase more than a proportionate household income increase.

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[12] Quantity data exists only for the GLSS 7. For GLSS 5 and 6, only total expenditure was recorded for each food commodity.

[13] Staples include cereals and tubers; greens include vegetables and fruits, and proteins include dairy, meat and fish.

Table 4.1 Average price elasticities, expenditure elasticities and food budget shares from the QUAIDS model

Source of price change		**Food demand response to price change**					
		Staples	*Pulses*	*Greens*	*Proteins*	*Oils*	*Miscellaneous*
Staples	*Marshallian*	**-0.986*****	0.336	0.538**	0.153	-0.193	-0.660
		(0.094)	(0.291)	(0.179)	(0.111)	(0.185)	(0.241)
	Hicksian	**-0.650*****	0.428	0.921***	0.498***	0.399*	-0.310
		(0.107)	(0.297)	(0.194)	(0.121)	(0.200)	(0.265)
Pulses	*Marshallian*	0.000	**-1.415*****	-0.138*	0.138**	0.023	0.081
		(0.030)	(0.077)	(0.057)	(0.036)	(0.058)	(0.075)
	Hicksian	0.066**	**-1.324*****	-0.063	0.205***	0.139*	0.150*
		(0.029)	(0.074)	(0.054)	(0.034)	(0.055)	(0.071)
Greens	*Marshallian*	0.155*	-0.207	**-1.038*****	0.025	-0.204	-0.249
		(0.068)	(0.196)	(0.134)	(0.082)	(0.135)	(0.173)
	Hicksian	0.243***	-0.085	**-0.937*****	0.116	-0.048	-0.157
		(0.070)	(0.200)	(0.138)	(0.084)	(0.138)	(0.177)
Protein foods	*Marshallian*	0.106**	0.381***	0.038	**-1.068*****	-0.665***	0.078
		(0.038)	(0.115)	(0.075)	(0.045)	(0.066)	(0.095)
	Hicksian	0.326***	0.683***	0.288***	**-0.843*****	-0.277***	0.307***
		(0.032)	(0.096)	(0.063)	(0.037)	(0.061)	(0.080)
Oils	*Marshallian*	0.016	0.062	-0.142**	-0.194***	**-0.819*****	0.327***
		(0.025)	(0.070)	(0.048)	(0.029)	(0.049)	(0.063)
	Hicksian	0.101***	0.178*	-0.046	-0.107***	**-0.669*****	0.415***
		(0.025)	(0.069)	(0.049)	(0.030)	(0.048)	(0.062)
Miscellaneous	*Marshallian*	-0.179	0.084	-0.271	0.035	0.292	**-0.503**
		(0.153)	(0.434)	(0.279)	(0.183)	(0.302)	(0.403)
	Hicksian	-0.086	0.212	-0.164	0.130	0.457	**-0.406**
		(0.151)	(0.428)	(0.293)	(0.180)	(0.299)	(0.379)
Expenditure elasticity		0.888***	1.221***	1.013***	0.913***	1.566***	0.926***
		(0.051)	(0.131)	(0.096)	(0.060)	(0.081)	(0.123)
Budget share		0.378***	0.074***	0.100***	0.247***	0.095***	0.105***
		(0.005)	(0.000)	(0.003)	(0.004)	(0.002)	(0.003)

*Legend: *** $p<0.001$, ** $p<0.01$, * $p<0.05$; standard errors in parentheses; own-price elasticities in boldface font.*

The results further show that spending on pulses has the highest own-price elasticity (Marshallian = -1.415; Hicksian= -1.324), while miscellaneous foods reports the lowest own-price elasticity (Marshallian = -0.503; Hicksian = -0.406). These values are similar to those reported in the Ghanaian food demand literature (Ansah et al., 2020c). The estimates of all own-price elasticities of demand are negative, implying that demand for each food group decreases *ceteris paribus* as its price increases. Only pulses are very responsive to own-price changes based on both Marshallian and Hicksian price elasticities (Banks et al., 1997), while demand for greens and protein foods is almost proportionately responsive to own-price changes from the Marshallian perspective. The own-price elasticities of staples, oils and miscellaneous foods are relatively inelastic, since the values are larger than zero but smaller than one.

The cross-price elasticity estimates from Table 4.1 reveal notable links among the six food groups. For instance, staples are Hicksian substitutes to pulses, greens, protein foods and oils. This implies that demand for staples will rise for price increases of these commodities. These substitution patterns indicate that households replace more nutritious protein foods by energy-rich staples when affected by price or income shocks. Also, we find protein foods to be substitutes for staples and pulses. This indicates that households switch from expensive protein foods to the starchy staples during misfortunes to be able to maintain as much as possible the level of food intake derived from the pre-shock food bundle consumed. Only a few complementary relations exist among the food groups studied. Greens and protein foods are both complements to oils. This is a plausible finding as fish, meat, dairy products and vegetables are often cooked with oils in a typical Ghanaian household served in a mixture or sauce called 'stew'.

4.5.2 Interaction effects of resilience capacities with price and income on household food demand

Table 4.2 summarizes the interaction effects between resilience-building strategies and price and income shocks on household food demand based on the estimated QUAIDS model. These parameters measure the sensitivity of food demand to own-price and income changes conditional on the resilience capacities of households. Food demand is said to be less (more) sensitive to shocks if the share household allocates to that food group is reduced less (more) when price or income increases. We report average effects for the entire sample, for sub-samples rural and urban households as well as for poor and non-poor households separately. Table 2 highlights that the resilience capacity variables show very heterogeneous interaction effects with prices and income shocks on household food demand.

Table 4.2 Interaction effects of resilience capacities with prices and income on food demand

Sample	Resilience Capacity	Sensitivity of food demand to own-price or income shocks					
		Staples	*Pulses*	*Greens*	*Protein foods*	*Oils*	*Miscellaneous*
Whole sample	*Own-price changes*						
	Assets	Increases	No effect	Decreases	Decreases	Decreases	Increases
	Livestock	Decreases	No effect	Increases	Increases	No effect	Increases
	Crop stocks	No effect	Decreases	No effect	No effect	Decreases	No effect
	Expenditure (income) changes						
	Assets	Decreases	Increases	Increases	Decreases	Increases	No effect
	Livestock	No effect	Decreases	Decreases	No effect	Increases	Increases
	Crops stocks	Decreases	No effect	No effect	No effect	Increases	Increases
Rural households	*Own-price changes*						
	Assets	Increases	No effect	No effect	No effect	No effect	Increases
	Livestock	Increases	No effect	Increases	Increases	No effect	No effect
	Crop stocks	Decreases	Decreases	No effect	No effect	Decreases	No effect
	Expenditure (income) changes						
	Assets	Decreases	Decreases	No effect	Decreases	No effect	Increases
	Livestock	No effect	Decreases	No effect	No effect	Increases	Increases
	Crops stocks	Decreases	Decreases	No effect	No effect	Increases	Increases
Urban households	*Own-price changes*						
	Assets	No effect	No effect	No effect	Decreases	Decreases	No effect
	Livestock	Decreases	No effect	Increases	No effect	No effect	No effect
	Crop stocks	No effect	No effect	No effect	Increases	No effect	No effect
	Expenditure (income) changes						
	Assets	No effect	No effect	No effect	Decreases	No effect	No effect
	Livestock	Decreases	Decreases	Decreases	No effect	No effect	Increases
	Crops stocks	No effect	Decreases	No effect	No effect	No effect	No effect
Poor households	*Own-price changes*						
	Assets	No effect	Decreases	No effect	Decreases	No effect	No effect
	Livestock	No effect	No effect	Increases	Increases	No effect	Increases
	Crop stocks	No effect	No effect	No effect	No effect	Decreases	No effect
	Expenditure (income) changes						
	Assets	Increases	No effect	Decreases	Decreases	Decreases	Increases
	Livestock	Increases	Decreases	Decreases	Decreases	No effect	Increases
	Crops stocks	Increases	Decreases	Decreases	No effect	No effect	Increases
Nonpoor households	*Own-price changes*						
	Assets	Increases	No effect	No effect	No effect	Decreases	Increases
	Livestock	Decreases	No effect	Increases	Increases	No effect	No effect
	Crop stocks	No effect	Decreases	Decreases	Increases	Decreases	No effect
	Expenditure (income) changes						
	Assets	No effect	No effect	Increases	Decreases	No effect	No effect
	Livestock	No effect	Decreases	No effect	No effect	Increases	Increases
	Crops stocks	Decreases	Decreases	No effect	Decreases	Increases	Increases

4.5.2.1 Assets, shocks and food demand

Assets generally reduce food demand sensitivity to income shocks, but this effect depends on the household type. For instance, an increasing level of assets reduces demand sensitivity of protein foods for all households, while demand sensitivity of staples and pulses reduces only for rural households. Poor households tend to benefit from having more assets because their demand for protein foods, greens and oils are less sensitive to income shocks as assets increase, thus ensuring diversity of food consumption even in difficult times. These results show that when the poor have good assets their consumption of protein foods (dairy, meat and fish) as well as greens (vegetables and fruits) are more stable. For a balanced, healthy diet, nutrition scientists advocate for adequate intake of fruits and vegetables (Gehlich et al., 2020; Van Duyn and Pivonka, 2000). In Ghana, there is evidence of very low intake of fruits and vegetables (Amfo et al., 2019; Frank et al., 2019). Therefore, assisting the poor to improve their assets would ensure adequate and frequent consumption of fruits and vegetables which can prevent non-communicable diseases such as cancer and obesity (Yahia et al., 2019), and safeguard food and nutrition security (Murillo-Castillo et al., 2020).

The interaction effect of assets with prices on food demand look quite different from that of income. Generally, an increasing level of assets is found to increase sensitivity of demand for staples and miscellaneous foods but reduces sensitivity of demand for greens, protein foods and oils to price shocks. Again, the degree of sensitivity depends on household types. Poor households' sensitivity of demand for pulses and protein foods to price shocks decreases as assets increase. In contrast, rural and non-poor households demand for staples are more sensitive to price shocks as assets increase. Overall, the key role of assets as a resilience capacity lies in reducing protein food demand sensitivity to income shocks for all households.

4.5.2.2 Livestock, shocks and food demand

The effects of livestock on food demand sensitivity to price and income shocks are also diverse. Generally, increasing levels of livestock reduces demand sensitivity of staples and protein foods to income shocks. Like assets, the effect depends on the household type. Mostly, poor households' food demand is less sensitive as quantity of livestock owned increases. With price shocks, urban and non-poor households' demand sensitivity of staple foods reduces while sensitivity of staples, greens and protein foods to price shocks increases for rural and poor households as livestock increases. The result further shows that price shocks tend to be difficult for poor and rural households to deal with because the sensitivity of their demand for basic staples and protein foods increase as livestock increases. This is especially plausible if the amount of livestock owned is below a boundary called the Micawber threshold[14] (Zimmerman and Carter, 2003).

The data summary shows that rural and poor households are those owning more livestock. For these households, livestock is an important productive asset which contributes to their income. In many rural areas, the main assets of the poor are livestock kept as a store of wealth and prestige, or as draught animals for agricultural purposes (Hänke and Barkmann, 2017; Mazzeo, 2011). For these primary reasons, rural and poor households might not sell their livestock to cushion price shocks but may use other coping strategies. Therefore, as long as the quantity of livestock owned falls below the Micawber threshold, such households would somewhat reduce the budget shares allocated to protein foods and greens when faced with purchasing power reducing price shocks. Instead, they would increase demand for staples (cereals and tubers) which provide rather cheap carbohydrates as one way of asset smoothing. On the other hand, urban and non-poor households that keep small ruminants (sheep, goat) and poultry have the primary motivation of selling them and using the proceeds to purchase foods necessary for household survival at critical times (Hänke and Barkmann, 2017).

4.5.2.3 Crop buffer stocks, shocks and food demand

Similar to assets and livestock, the interaction effects of crop buffer stocks with prices and income on household food demand is mixed. Generally, increasing levels of crop buffer stocks reduce demand sensitivity of staples, pulses, greens and protein foods to price and income shocks depending on household types. Non-poor households' demand for staples, pulses and protein foods are less sensitive to income shocks as crop stocks increases. Poor households demand for greens tend to be more stable due to dampened sensitivity to income shocks, while their demand for staples are more sensitive to income shocks as crop buffer stocks increase.

[14] This is an initial minimum level of livestock assets below which a household will adopt a strategy that defends the level of livestock owned. Below the Micawber threshold, households live in a virtuous circle of poverty, not being able to lift themselves up to a higher standard of living. Above the Micawber threshold, households engage in a virtuous circle of savings and accumulation that makes them experience a higher standard of living.

For many rural households, crop buffer stocks are basically meant for consumption smoothing. However, poor households might also derive part of their income from the sale of these stocks through temporal arbitrage (Tesfaye and Gebremariam, 2020), even though Saha and Stroud (1994) argue that the food security motive for holding crop buffer stocks is stronger. If temporal arbitraging is a dominant reason for some poor households holding crop buffer stocks, then it is not surprising to observe their high sensitivity of staple food demand to price shocks, as they would respond to high prices by selling more of their stocks.

Overall, crop buffer stocks help households to maintain stable consumption of staples, pulses, greens and protein foods, thus ensuring food and nutrition diversity amid adversity.

4.5.3 Robustness Checks

To examine the robustness of these findings, we carry out sensitivity tests by estimating the baseline model using various subsamples in addition to the core population subgroups already discussed in section 5.2. In these sensitivity tests, we restrict the dataset to female-headed households only (29% of observations) as well as to households without any livestock (64%) and without any crop stocks (62%). Table 4.3 summarizes the outcomes of these estimations regarding the interaction effects in comparison with the results of the baseline model. The results on the robustness are condensed by the robustness score shown in the last column of Table 4.3. It measures the proportion of the alternative model estimates that agree with the baseline model estimates in terms of direction and statistical significance. This robustness score ranges from 0 to 1, with higher (lower) scores indicating more (less) accordance between baseline and the alternative model specifications. A score of zero implies that the estimates of an interaction effect between a given resilience capacity and a food group are very sensitive to subset used in the estimation of the alternative models. A score of one indicates that the estimates of an interaction effect are completely robust across all subsamples used and coincide with the baseline results in terms of direction and statistical significance.

Table 4.3 shows that the baseline model is quite robust to alternative sample composition as well as model specifications. Consider the resilience capacity-price interaction effect estimates reported from the share equations for the staples, pulses, protein foods and miscellaneous foods. The robustness score for crop stocks is one, which means that the interaction effects estimates of crop stocks and own prices of the food commodities are the same in the alternative and baseline models. Similar findings hold for the interaction effect of livestock with prices for household demand for oils.

Table 4.3 Model sensitivity check on interaction effects and food demand

Food group	Resilience Capacity	Baseline model	Female-headed	Zero livestock	Zero crops stocks	Robustness score
Own-price changes						
Staples	Assets	Increases	No effect	Increases	Increases	0.67 (2/3)
	Livestock	Decreases	No effect		Decreases	0. 50 (1/2)
	Crops stocks	No effect	No effect	No effect		1.00 (2/2)
Pulses	Assets	No effect	Increases	Increases	Increases	0.00 (0/3)
	Livestock	No effect	No effect		Decreases	0.50 (1/2)
	Crops stocks	Decreases	Decreases	Decreases		1.00 (2/2)
Greens	Assets	Decreases	Decreases	No effect	No effect	0.33 (1/3)
	Livestock	Increases	No effect		Decreases	0.00 (0/2)
	Crops stocks	No effect	Decreases	Decreases		0.00 (0/2)
Protein foods	Assets	Decreases	No effect	Decreases	Decreases	0.67 (2/3)
	Livestock	Increases	Increases		No effect	0.50 (1/2)
	Crops stocks	No effect	No effect	No effect		1.00 (2/2)
Oils	Assets	Decreases	No effect	Decreases	Decreases	0.67 (2/3)
	Livestock	No effect	No effect		No effect	1.00 (2/2)
	Crops stocks	Decreases	No effect	Decreases		0.50 (1/2)
Miscellaneous foods	Assets	Increases	Increases	Increases	Increases	1.00 (3/3)
	Livestock	Increases	No effect		No effect	0.00 (0/2)
	Crops stocks	No effect	No effect	No effect		1.00 (2/2)
Expenditure (Income) changes						
Staples	Assets	Decreases	Decreases	Decreases	Decreases	1.00 (3/3)
	Livestock	No effect	Decreases		Decreases	0.00 (0/2)
	Crops stocks	Decreases	No effect	Decreases		0.50 (1/2)
Pulses	Assets	Increases	Decreases	No effect	No effect	0.00 (0/3)
	Livestock	Decreases	Decreases		No effect	0.50 (1/2)
	Crops stocks	No effect	Decreases	Decreases		0.00 (0/2)
Greens	Assets	Increases	Increases	Increases	No effect	0.67 (2/3)
	Livestock	Decreases	Increases		No effect	0.00 (0/2)
	Crops stocks	No effect	No effect	Increases		0.50 (1/2)
Protein foods	Assets	Decreases	Decreases	Decreases	Decreases	1.00 (3/3)
	Livestock	No effect	No effect		Decreases	0.50 (1/2)
	Crops stocks	No effect	No effect	Decreases		0.50 (1/2)
Oils	Assets	Increases	Increases	Increases	Increases	1.00 (3/3)
	Livestock	Increases	Increases		Increases	1.00 (2/2)
	Crops stocks	Increases	Increases	Increases		1.00 (2/2)
Miscellaneous foods	Assets	No effect	Increases	Increases	Increases	0.00 (0/3)
	Livestock	Increases	Increases		Increases	1.00 (2/2)
	Crops stocks	Increases	No effect	Increases		0.50 (1/2)

Demand for protein foods reports consistent results between the baseline and alternative model specifications. The least robustness score is 0.50 for the interaction effects of livestock with protein foods prices as well as livestock with income, which means that 50% of the results in the alternative models agree with the results found in the baseline model.

The robustness score improves even further when the interaction effects of income and resilience capacities in the demand for oils are considered. The score is one for all three resilience capacities, implying that 100% of the results from the alternative models are consistent with the baseline model outcomes. Similarly, the score for miscellaneous foods demand equals one for livestock. There are a few exceptions where the robustness score is zero. For instance, the interaction effects of income with assets (pulses and miscellaneous foods), livestock (staples and greens) and crops stocks (pulses and greens) are zero, implying that the baseline and alternative model results are entirely different.

Overall, about 56%[15] of the alternative model estimates are consistent in terms of significance and sign with the baseline model estimates despite reduced sample sizes and different model specifications[16] suggesting that the results of the model using the entire dataset are satisfactorily robust and reliable.

4.6 Conclusions and Implications

This chapter analyses demand for specific food groups, their sensitivity to price and income shocks and the role that resilience capacities play in households' coping with food demand shocks. We sketch a theoretical framework from which we derive hypotheses that are tested using a quadratic almost ideal demand system. In doing that, we take into account all critical econometric issues that might confound our results such as zero food preferences and food expenditure endogeneity and also assess the robustness of our results.

We find from the expenditure elasticity estimates that staples, protein foods and miscellaneous foods are necessities for the average household in Ghana while pulses, greens and oils can be

[15] This is obtained by averaging the robustness scores. There are 84 interaction effects parameter estimates from the alternative specifications, of which 47 are consistent in terms of significance and sign with the baseline model.
[16] By restricting the data to subsets of the sample, the model slightly changes because such variable is dropped from the model.

considered as luxury foods. Own-price elasiticity estimates indicate that pulses respond most to price shocks followed by greens and protein foods. In addition, starchy staples are substitutes for protein foods, pulses and oils based on cross-price elasticity estimates. This implies that one or more of these latter food groups would be substituted for staples in the event of shocks that drastically reduce household food purchasing power.

Resilience capacities, proxied by assets, livestock and crop buffer stocks, play significant shock-impact control roles in household food demand. Demand for protein-rich foods (dairy, meat and fish) are less sensitive to price and income shocks as assets increase. This means that when two households with similar characteristics face the same price or income shocks, the one with more assets will reduce the share of the food budget allocated to protein foods less than the other household with less assets. Livestock generally increases the sensitivity of demand for protein-rich foods and greens (vegetables and fruits), but decreases the sensitivity of demand for staples to price shocks. Crop buffer stocks are important in reducing the sensitivity of demand for staples (cereals and tubers) to price and income shocks.

The role of resilience capacities in reducing food demand sensitivity to price and income shocks depends on household types. For poor households, assets and livestock reduce the sensitivity of their demand for protein foods as well as vegetables and fruits to the negative effects of income shocks. For rural and non-poor households, the role of crop stocks is to reduce the sensivity of demand for staples and pulses to income shocks.

Before concluding, we emphasize a few caveats. First, the methods employed as well as the specific aims of this chapter warranted that we aggregate the data across a number of food groups. Certainly, data aggregation is usually less desirable than a less aggregated data which permits finer analysis. Nevertheless, this is a common approach in food demand analysis due to the large array of food commodities. Second, we considered food expenses assuming that these are good proxies for actual food intakes at the household level. Within-household allocation patterns are therefore assumed constant, which might not necessarily be true. Therefore, future research should consider using actual calorie intakes[17], and compare the outcomes with the findings of this chapter.

[17] The data did not contain actual quantities purchased and consumed to enable us compute actual calorie consumption.

We conclude by highlighting the implications of our findings. Assets, livestock and crop stocks mostly reduce the sensitivity of demand for protein foods and greens to income shocks for poor households. This is an important finding as interventions to enhance food security resilience usually focus on poor and vulnerable households. Interventions aimed at helping poor and vulnerable households to acquire more assets, or restock their livestock or build adequate crop buffer stocks capable of feeding them throughout the year are needed to reduce food demand sensitivity to price and income shocks. In fact, nutrition scientists confirm that protein foods, vegetables and fruits are essential components of a nutritious and healthy diet. Therefore, improving the resilience capacities of poor households would guarantee that they do not sacrifice these essential foods that provide high quality nutrition for the less pricy starchy staples during hard times.

Appendix A4.1

A4.1.1 Data summary

Table A4.1 summarizes the key variables. The average annual food expenditure in Ghana over the study period approximates GhȻ4,135[18]. Out of this total food expenditure, an average of 37.7%, 6.5%, 10.4%, 25.0%, 7.9% and 12.5% respectively, is allocated to the staples, pulses, greens, protein foods, and miscellaneous foods. Food prices vary within and across food groups. Food groups like pulses and miscellaneous foods exhibit volatile prices with high coefficients of variation, indicating that they tend to vary widely. Also, the average household size (in adult equivalence units) is about five adults. The average household head is about 46 years old. In the sample, 70.6% of household heads is male, while about 76% is nonpoor. For the resilience capacity variables, we summarize how these vary across population subgroups, particularly for poor vs. non-poor households and rural vs. urban households. Key observations are as follows.

The extremely poor have more assets than the poor, but the non-poor have the highest value of assets as would be expected. For livestock, the very poor have more (measured in tropical livestock units, TLU) than the poor and the non-poor. In other words, the (very) poor have the most livestock units, while the nonpoor have the least. The finding that poor people in rural areas own the most livestock is similar to what is reported in the literature (Do et al., 2019). For crops stocks, a similar pattern of dominant ownership by the very poor, poor and non-poor is observed. Most poor people in rural areas have limited access to markets and face poor infrastructure. For this reason, they usually stock part of their produce in anticipation of any eventualities. Because of the high stocks kept by the very poor and poor, they tend to consume their own produced food commodities for more periods (months) within the year than the non-poor households.

[18] 1 Euro =GhȻ6.77 or 1 US$ = GhȻ5.77

Table A4.1 Summary statistics

Variable	Mean	Std. Dev.	CV	Min	Max
Food expenditure (Gh₵'000)	4.135	30.964	7.488	.028	5151.567
Budget shares					
Cereals & tubers (staples)	0.377	0.159	0.421	0	0.999
Pulses	0.065	0.096	1.468	0	0.977
Vegetables & fruits (greens)	0.104	0.076	0.735	0	0.992
Dairy, meat and fish (proteins)	0.25	0.126	0.505	0	0.999
Oils	0.079	0.076	0.966	0	0.994
Miscellaneous foods	0.125	0.127	1.017	0	0.999
Prices (GH₵/kg)					
Cereals & tubers	5.313	3.961	0.745	0.387	21.588
Pulses	3.294	1.549	0.470	0.580	5.686
Vegetables & fruits	4.405	2.941	0.668	0.595	21.269
Dairy, meat and fish	9.835	3.628	0.369	3.417	14.726
Oils	4.052	1.732	0.427	0.680	6.500
Miscellaneous foods	5.782	4.210	0.728	0.529	20.141
Socio-demographics					
Household size (adult equivalence)	4.300	2.833	0.659	0.933	30.127
Sex of household head (1 if male)	0.706	0.455	0.645	0	1
Age of household head	45.826	15.839	0.346	15	99
Non-poor (1 if non-poor)	0.759	0.428	0.563	0	1
Phone	0.883	0.321	0.363	0	1
Fridge	0.262	0.439	1.681	0	1
Motorbike	0.082	0.275	3.34	0	1
Months of consuming own produced food	3.334	4.187	1.256	0	12
Resilience-building strategies					
Assets (Gh₵'0000) – sample	1.578	51.854	32.862	0	7502.062
Rural households	1.09	54.543	50.051	0	7502.062
Urban households	2.216	48.106	21.706	0	5000.142
Very poor	0.437	15.653	35.799	0	1000.25
Poor	0.354	1.418	4	0	47.077
Non-poor	1.953	59.192	30.302	0	7502.062
Livestock (TLU) – sample	0.773	4.13	5.342	0	312.6
Rural household	1.208	4.954	4.103	0	312.6
Urban households	0.205	2.587	12.615	0	250
Very poor	1.888	7.105	3.763	0	312.6
Poor	1.350	4.297	3.184	0	82.7
Non-poor	0.510	3.393	6.655	0	255.1
Crops stocks (tons) – sample	0.923	4.064	4.402	0	132.921
Rural household	1.461	5.061	3.465	0	132.921
Urban households	0.220	1.934	8.79	0	114.36
Very poor	1.670	5.569	3.335	0	129.61
Poor	1.733	5.369	3.098	0	78.06
Non-poor	0.676	3.469	5.133	0	132.921
Survey rounds					
GLSS 5 (% of total observations)	0.232	0.422	1.821	0	1
GLSS 6 (% of total observations)	0.383	0.486	1.269	0	1
GLSS 7 (% of total observations)	0.385	0.487	1.263	0	1
Number of observations = 35,768					

A4.1.2 Estimates from the baseline QUAIDS model

We report the results from the QUAIDS model in Table A4.2 and briefly discuss these results in this section. As suspected, total food expenditure is endogenous in three out of the six food demand equations. A joint test of overall food expenditure exogeneity indicates rejection of the null hypothesis, and that controlling for endogeneity is required in order to obtain unbiased estimates. Also, the bias correction parameter for zero food consumption is statistically significant in most of the food share equations, indicating that controlling for endogeneity due to zero consumption is important for the results we obtained.

The expenditure share of each food group responds to both own-price and cross-price changes. As expected, when own-price increases the expenditure share drops for all food groups except miscellaneous foods. Also, total food expenditure affects the shares allocated to pulses, greens, oils and miscellaneous foods in a nonlinear manner.

In terms of the demographic variables, the results show statistically significant differences in the demand for the various food groups across age, sex, regions and expenditure profiles. Age increases the share of the food budget allocated to staples, proteins and miscellaneous foods but decreases the share allocated to pulses and oils. Generally, women household heads allocate larger share of their food budget to staples, pulses and miscellaneous foods while men household heads allocate larger share to pulses, greens and protein foods. For regional heterogeneities, the budget share allocation for all food groups is larger in all regions than in the base region, Upper West. This is not surprising, considering that Upper West is the poorest region in Ghana (Ghana Statistical Service (GSS), 2018). Finally, compared to the very poor the very rich, rich and poor all allocate higher proportion of their food budget to protein foods.

Table A4.2 Estimates from the QUAIDS model for food groups

Variables		(1) w1	(2) w2	(3) w3	(4) w4	(5) w5	(6) w6
CT price (p1)	γ_{i1}	-0.019	-0.006	0.057***	0.027	0.002	-0.061**
		(0.040)	(0.023)	(0.020)	(0.030)	(0.021)	(0.026)
PU price (p2)	γ_{i2}	-0.006	-0.038***	-0.010	0.034***	-0.007	0.027***
		(0.013)	(0.008)	(0.007)	(0.010)	(0.007)	(0.010)
VF price (p3)	γ_{i3}	0.057**	-0.010	-0.006	0.004	-0.008	-0.037*
		(0.027)	(0.015)	(0.014)	(0.021)	(0.014)	(0.019)
DMF price (p4)	γ_{i4}	0.027**	0.034***	0.004	-0.024***	-0.046***	0.005
		(0.012)	(0.007)	(0.006)	(0.009)	(0.008)	(0.011)
OIL price (p5)	γ_{i5}	0.002	-0.007	-0.008	-0.046***	-0.002	0.062***
		(0.011)	(0.007)	(0.006)	(0.009)	(0.008)	(0.010)
MISC price (p6)	γ_{i6}	-0.061	0.027	-0.037	0.005	0.062**	0.004
		(0.055)	(0.030)	(0.028)	(0.042)	(0.027)	(0.037)
Food expenditure	β_{i1}	0.033	0.049***	-0.027**	-0.002	0.071***	-0.124***
		(0.021)	(0.012)	(0.011)	(0.017)	(0.011)	(0.015)
Quadratic food expenditure	β_{i2}	-0.006***	-0.003***	0.002***	-0.002**	-0.001***	0.009***
		(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)
Residual food expenditure	ρ_{iv}	0.075***	0.002	-0.007	0.020	-0.038***	-0.052***
		(0.019)	(0.010)	(0.010)	(0.014)	(0.009)	(0.013)
Assets	θ_1	-0.098**	0.019	0.014	-0.083**	0.006	0.142***
		(0.044)	(0.024)	(0.023)	(0.033)	(0.021)	(0.030)
TLU	θ_2	-0.198***	0.081***	-0.099***	-0.038	0.117***	0.138***
		(0.057)	(0.031)	(0.029)	(0.043)	(0.028)	(0.039)
Crops stocks	θ_3	2.065***	-0.408***	-0.175	0.260	-0.993***	-0.750***
		(0.291)	(0.155)	(0.145)	(0.220)	(0.137)	(0.215)
p1*assets	ψ_{11}	-0.175***	-0.032	0.041	0.071	-0.021	0.117***
		(0.061)	(0.033)	(0.031)	(0.046)	(0.029)	(0.042)
p2*assets	ψ_{21}	0.036**	-0.001	-0.016*	-0.011	-0.016**	0.008
		(0.016)	(0.009)	(0.008)	(0.012)	(0.008)	(0.011)
p3*assets	ψ_{31}	-0.165***	-0.018	0.036*	0.111***	-0.008	0.044
		(0.040)	(0.022)	(0.021)	(0.031)	(0.019)	(0.028)
p4*assets	ψ_{41}	-0.010	-0.019	0.009	0.046**	0.020	-0.046***
		(0.025)	(0.013)	(0.013)	(0.019)	(0.012)	(0.017)
p5*assets	ψ_{51}	-0.052**	0.039***	0.012	-0.018	0.029***	-0.010
		(0.020)	(0.011)	(0.010)	(0.015)	(0.010)	(0.014)
p6*assets	ψ_{61}	0.330***	0.046	-0.067	-0.181***	0.018	-0.146**
		(0.092)	(0.050)	(0.047)	(0.070)	(0.044)	(0.063)
p1*TLU	ψ_{13}	0.225***	0.078**	-0.166***	-0.124***	-0.095***	0.081**
		(0.061)	(0.033)	(0.031)	(0.045)	(0.030)	(0.041)
p2*TLU	ψ_{23}	-0.087***	0.005	0.003	0.063***	-0.006	0.023**
		(0.016)	(0.008)	(0.008)	(0.012)	(0.008)	(0.011)
p3*TLU	ψ_{33}	0.223***	0.018	-0.120***	-0.115***	-0.044**	0.039
		(0.044)	(0.024)	(0.022)	(0.033)	(0.022)	(0.030)
p4*TLU	ψ_{43}	-0.003	0.026	0.053***	-0.090***	0.064***	-0.050*
		(0.040)	(0.022)	(0.021)	(0.031)	(0.020)	(0.028)
p5*TLU	ψ_{53}	0.102***	-0.091***	-0.007	0.017	-0.004	-0.018
		(0.028)	(0.015)	(0.014)	(0.021)	(0.014)	(0.019)
p6*TLU	ψ_{63}	-0.414***	-0.080*	0.247***	0.221***	0.130***	-0.104*
		(0.091)	(0.049)	(0.046)	(0.067)	(0.044)	(0.061)
p1*crops stocks	ψ_{14}	0.073	-0.014	0.010	-0.109**	0.005	0.034
		(0.068)	(0.037)	(0.034)	(0.051)	(0.033)	(0.046)
p2*crops stocks	ψ_{24}	-0.039**	0.042***	-0.040***	-0.007	0.014*	0.029***
		(0.015)	(0.008)	(0.008)	(0.012)	(0.007)	(0.010)
p3*crops stocks	ψ_{34}	0.065	-0.019	0.025	-0.079**	0.005	0.003
		(0.050)	(0.027)	(0.025)	(0.038)	(0.025)	(0.034)
p4*crops stocks	ψ_{44}	0.112***	-0.057***	0.064***	-0.014	-0.048***	-0.057**
		(0.036)	(0.019)	(0.018)	(0.027)	(0.017)	(0.025)

p5*crops stocks	ψ_{54}	-0.066**	-0.024	0.013	0.078***	0.043***	-0.045**
		(0.028)	(0.015)	(0.014)	(0.021)	(0.014)	(0.019)
p6*crops stocks	ψ_{64}	-0.130	0.040	-0.043	0.157**	-0.011	-0.013
		(0.104)	(0.056)	(0.053)	(0.077)	(0.051)	(0.071)
Expenditure*assets	ξ_{i1}	0.012***	-0.004*	-0.005**	0.007**	-0.007***	-0.003
		(0.004)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Expenditure*TLU	ξ_{i3}	0.003	0.012***	0.003*	0.002	-0.011***	-0.009***
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Expenditure*crops stocks	ξ_{i4}	0.013***	0.002	-0.000	-0.002	-0.011***	-0.003*
		(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Rurality (rural = 1, 0 urban)	μ_{i1}	0.051***	0.007***	-0.003***	-0.035***	-0.018***	-0.002
		(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Household size	μ_{i2}	0.034***	0.017***	-0.057***	-0.121***	-0.001	0.130***
		(0.012)	(0.006)	(0.006)	(0.009)	(0.006)	(0.008)
Age	μ_{i3}	0.009***	-0.008***	-0.001	0.004*	-0.008***	0.004**
		(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Sex	μ_{i4}	-0.014***	-0.005***	0.027***	0.042***	0.006***	-0.056***
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Greater Accra	μ_{i5}	-0.115***	-0.082***	0.018***	0.050***	-0.000	0.129***
		(0.004)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Eastern	μ_{i6}	-0.065***	-0.088***	0.012***	0.052***	-0.012***	0.102***
		(0.005)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
Central	μ_{i7}	-0.078***	-0.082***	0.018***	0.019***	-0.010***	0.134***
		(0.006)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Volta	μ_{i8}	-0.035***	-0.068***	-0.006**	0.054***	-0.011***	0.066***
		(0.005)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Ashanti	μ_{i9}	-0.084***	-0.084***	0.026***	0.061***	0.004*	0.078***
		(0.005)	(0.003)	(0.002)	(0.004)	(0.002)	(0.003)
Western	μ_{i10}	-0.100***	-0.100***	0.015***	0.088***	-0.007***	0.103***
		(0.005)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
Brong Ahafo	μ_{i11}	-0.047***	-0.084***	0.013***	0.050***	-0.008***	0.076***
		(0.005)	(0.003)	(0.002)	(0.004)	(0.002)	(0.003)
Northern	μ_{i12}	-0.044***	-0.024***	0.039***	0.013***	0.000	0.016***
		(0.005)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
Upper East	μ_{i13}	-0.025***	-0.011***	0.016***	0.019***	0.014***	-0.012***
		(0.004)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)
Poor vs. very poor	μ_{i14}	0.014	0.001	-0.015***	-0.014*	-0.035***	0.050***
		(0.011)	(0.006)	(0.006)	(0.008)	(0.005)	(0.007)
Rich vs. very poor	μ_{i15}	0.044**	-0.002	-0.030***	-0.042***	-0.054***	0.084***
		(0.017)	(0.009)	(0.009)	(0.013)	(0.008)	(0.011)
Very rich vs. very poor	μ_{i16}	0.074***	-0.014	-0.046***	-0.068***	-0.079***	0.133***
		(0.027)	(0.014)	(0.013)	(0.020)	(0.013)	(0.018)
Mills ratio for CT	λ_{i1}	0.068***	0.007***	-0.013***	-0.032***	-0.015***	-0.015***
		(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Mills ratio for PU	λ_{i2}	-0.053***	0.070***	-0.001	-0.024***	-0.029***	0.037***
		(0.003)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
Mills ratio for VF	λ_{i3}	-0.007**	0.007***	0.051***	0.004*	0.005***	-0.061***
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Mills ratio for DMF	λ_{i4}	-0.030***	-0.009***	-0.010***	0.112***	0.011***	-0.074***
		(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Mills ratio for OIL	λ_{i5}	-0.015***	-0.008***	-0.005***	-0.022***	0.060***	-0.011***
		(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Mills ratio for MISC	λ_{i6}	-0.020***	-0.017***	-0.000	-0.013***	-0.020***	0.070***
		(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Constant	α_{i0}	0.319***	-0.120**	0.185***	0.355***	-0.157***	0.417***
		(0.100)	(0.055)	(0.051)	(0.077)	(0.050)	(0.069)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 5

DO RESILIENCE-BUILDING STRATEGIES ENHANCE HOUSEHOLD FOOD DEMAND? EVIDENCE FROM POLICY SIMULATIONS

5. Do resilience-building strategies enhance household food demand? Evidence from policy simulations

Abstract: To improve poor households' food security, policy interest focuses on specific instruments that effectively enhance household resilience to food demand shocks. In this chapter, we simulate the impacts of income and price shocks on household food demand. We then assess how a policy instrument that increases household capacity, proxied by the value of physical assets owned, livestock ownership, and household crop buffer stocks, would affect the shock's impact on food demand. The simulation results show that a general increase in food prices induces a demand switch from all other foods to basic staples and protein foods while negative income shocks negatively affect demand for protein foods. A policy instrument that raises resilience capacities of all households by 20% offsets the negative effects of simultaneous price and income shocks and increases the demand for protein foods by a significant effect for the non-poor. On the other hand, a policy instrument that increases only the assets, livestock, and crop stocks of poor households is more beneficial to the vulnerable and increases their demand for basic staples, protein foods, and miscellaneous foods. These findings illustrate that improving household resilience capacity through incentivizing them to raise their buffer stocks, boosting assets or livestock ownership helps especially vulnerable households to maintain their consumption of nutrient-rich foods if faced with price or income shocks.

5.1 Introduction

Since the mid-1940s the Food and Agriculture Organization (FAO) is committed to the search for sustainable ways of eradicating the substantial food security challenges that poor people face. One way of achieving this is to protect the limited food resources that poor people have access to by creating and sustaining their resilience to shocks that frequently affect livelihoods in developing countries (Dercon, 2002; Doss et al., 2018). Accordingly, governments worldwide, including the Government of Ghana (GoG), have adopted the Sustainable Development Goals (FAO/IFAD/UNICEF/WFP/WHO, 2018) in order to foster this resilience.

In 2018, the GoG launched a new agriculture investment strategy dubbed “Investment for Food and Jobs” (IFJ) through the Ministry of Food and Agriculture (MoFA), which aims to improve the production, marketing and export of crops and livestock (MoFA, 2018). The IFJ strategy seeks to improve food and nutrition security of poor households and make them resilient to shocks through increased subsistence food production and better income. Two components of the IFJ that are directly associated with food security are the programmes “Planting for Food and Jobs” (PFJ) (Ansah et al., 2020b; MoFA, 2017) and “Rearing for Food and Jobs” (RFJ).
The PFJ programme aims at improving farm income and food security through raising the productivity of selected staple cereals (maize, rice, soybean) as well as roots and tubers (cassava, yam and cocoyam). Complementary to that, the RFJ programme aims to stimulate speedy growth in the livestock sector to enhance the production and the consumption of animal-based foods by supplying farmers with improved breeds and supporting feed, nutrition, health and other services that foster high livestock productivity and total animal production.

The IFJ strategy hence links to household food security via several mechanisms. First, providing households with livestock in the form of small ruminants (sheep and goats), cattle or poultry offers opportunities for increased income if some of the animals are marketed. Through production and reproduction, livestock production can augment household’s capacity to absorb socioeconomic shocks besides generating a continuous flow of income. Such improved income from livestock production enhances household food purchasing power, thereby enabling their members to enjoy a larger diversity of foods and the ability to afford a nutrient-rich diet consisting of dairy products, meat, fish, fruits or vegetables. Through the PFJ programme, increased output of staple crops can improve the capacity of households to maintain buffer stocks which also enhances their ability to cope with shocks threatening their food provision. Since many households in Ghana derive their livelihoods from marketing crop produce, a successful implementation of this policy would also ensure increased income. Hence, purchasing power for food would also improve and households would be in a better position to afford more nutritious diets.

Effectively implementing these IFJ programmes can be challenging due to limited information on how various intervention options would affect household food demand. Hence, the purpose of this chapter is to analyse how the policy instruments of the IFJ strategy would affect the resilience of household food demand. In particular, we address the following two questions: (1) what are the impacts of temporary price increases and income shocks on household food demand? (2) to what extent would a policy that increases resilience capacities of households offset the effects of shocks on their food demand? We address these questions using the marginal approach to food demand analysis, which examines the direct effects of price and income shocks as well as targeted policies that increase household resilience capacities by holding the nominal household food budget fixed. This chapter makes two contributions to the literature on food demand analysis and food security resilience. First, we adopt an approach that helps to decompose the complex effects of specific policy scenarios aimed at enhancing the resilience of households to shocks affecting their food demand. Policy makers have alternative instruments at their disposal for achieving a certain policy target. As food insecurity is often associated with unbalanced consumption of specific commodities (Murillo-Castillo et al., 2020), such policies need to target specific diet items. For instance, obesity is a nutritional disorder caused by excess consumption of foods that are high in fats or sugars. Anemia is associated with lack of iron, vitamin B12 or folic acid in the diet. Food and nutrition experts advocate for regular and adequate intake of fruits and vegetables as well as pulses and nuts to limit the risk of obesity (Frank et al., 2019; Gehlich et al., 2020). Hence, a policy to correct obesity, for example, requires instruments that discourage excess consumption of fatty foods while encouraging regular and adequate eating of fruits and vegetables. However, households with low purchasing power normally limit the consumption of pricy nutrient-rich foods such as meats or dairy as well as vegetables and fruits.

Second, we analyze the response of household food demand to price and income shocks in a manner that permits policies to be targeted at specific socioeconomic groups, since strategies aimed at enhancing resilience to food demand shocks might not be relevant for nor benefit all population subgroups equally (Williams et al., 2020). For instance, price shocks might alter the food bundle consumed by forcing some households to switch from protein-based foods to carbohydrate-rich staples (Gibson, 2013; Laborde et al., 2020). Policies which are effective and use scarce public funds in the most efficient way need to be tailored to specific food groups as well as to specific segments of the population which are intended to be the main beneficiary of the policy.

The rest of the chapter is organized as follows. Section 5.2 provides a brief overview of the data, after which section 5.3 lays out the empirical strategy. Section 5.4 presents and discusses the simulation results and section 5.5 concludes.

5.2 Overview of the Data

We use data from the three most recent rounds of the Ghana Living Standards Surveys (GLSS, Ghana Statistical Service (GSS, 2018) which are representative for the Ghanaian population. Table 5.1 summarizes the data. Due to the wide array of food items consumed by Ghanaian households, we follow Bairagi et al. (2020) and aggregate them into six categories. These include staples (cereals and tubers), pulses, greens (vegetables and fruits), proteins (dairy products, meat and fish), oils and miscellaneous foods. The data shows that the average household spends about Gh₵4,100 per year on food purchases. The staples take the largest share of the food budget while pulses take the least. This implies that the average Ghanaian diet contains a lot of staples. Also, the data shows that protein foods cost the most among the food groups. Table 5.1 also summarizes demographic characteristics such as age, sex, household size and other variables.

As resilience capacities are not directly observable, they need to be proxied by suitable variables in order to measure them empirically. We focus on households' ownership of physical assets, livestock as well as crop buffer stocks as the literature shows that they are key resources determining resilience when households face economic shocks threatening food demand. For example, food security impacts of the COVID-19 pandemic in industrialized countries have been minimal (Deaton and Deaton, 2020) due to an easy and affordable economic access to food despite pandemic-induced food price shocks (Ihle et al., 2020). The recent rush of many consumers across the globe to hoard food after lockdown declarations to contain the COVID-19 pandemic provides evidence that food buffer stocks enhance the resilience of households in times of crisis and uncertainty (Barrett, 2020; Wang et al., 2020).

Resilience capacity in this chapter is proxied by value of physical assets, livestock ownership and crop stocks. Table 1 also reports detailed summaries of the resilience-building strategies for the total sample as well as from socioeconomic and location perspectives. The distribution of each of these resilience-building strategies depends on the household's socioeconomic status (i.e., being poor[19] or not) as indicated in Table 5.1. Poor households own more livestock and crop stocks than non-poor households, while the non-poor households possess more assets.

Table 5.1 Summary statistics

Variable	Mean	Std. Dev.	CV	Min	Max
Food expenditure (GhȻ'000)	4.135	30.964	7.488	.028	5151.567
Budget shares					
Cereals & tubers (staples)	0.377	0.159	0.421	0	0.999
Pulses	0.065	0.096	1.468	0	0.977
Vegetables & fruits (greens)	0.104	0.076	0.735	0	0.992
Dairy, meat and fish (proteins)	0.25	0.126	0.505	0	0.999
Oils	0.079	0.076	0.966	0	0.994
Miscellaneous foods	0.125	0.127	1.017	0	0.999
Prices (GHȻ/kg)					
Staples (cereals & tubers)	5.313	3.961	0.745	0.387	21.588
Pulses	3.294	1.549	0.470	0.580	5.686
Greens (vegetables & fruits)	4.405	2.941	0.668	0.595	21.269
Proteins (dairy, meat and fish)	9.835	3.628	0.369	3.417	14.726
Oils	4.052	1.732	0.427	0.680	6.500
Miscellaneous foods	5.782	4.210	0.728	0.529	20.141
Socio-demographics					
Household size (adult equivalence)	4.300	2.833	0.659	0.933	30.127
Sex of household head (1 if male)	0.706	0.455	0.645	0	1
Age of household head	45.826	15.839	0.346	15	99
Non-poor (1 if non-poor)	0.759	0.428	0.563	0	1
Phone ownership	0.883	0.321	0.363	0	1
Fridge ownership	0.262	0.439	1.681	0	1
Motorbike ownership	0.082	0.275	3.34	0	1
Months of consuming own produced food	3.334	4.187	1.256	0	12
Resilience-building strategies					
Assets (GhȻ'0000) – total sample	1.578	51.854	32.862	0	7502.062
Rural households	1.09	54.543	50.051	0	7502.062
Urban households	2.216	48.106	21.706	0	5000.142
Very poor	0.437	15.653	35.799	0	1000.250
Poor	0.354	1.418	4.000	0	47.077
Non-poor	1.953	59.192	30.302	0	7502.062
Livestock (TLU) – total sample	0.773	4.13	5.342	0	312.600
Rural household	1.208	4.954	4.103	0	312.600
Urban households	0.205	2.587	12.615	0	250.000
Very poor	1.888	7.105	3.763	0	312.600
Poor	1.350	4.297	3.184	0	82.700

[19] In the GLSS data, households are categorized into very poor, poor and non-poor based on a well-defined poverty line for each survey round. In our analysis, we consider both the very poor and poor as poor.

Non-poor	0.510	3.393	6.655	0	255.100
Crops stocks (tons) – total sample	0.923	4.064	4.402	0	132.921
Rural household	1.461	5.061	3.465	0	132.921
Urban households	0.220	1.934	8.79	0	114.36
Very poor	1.670	5.569	3.335	0	129.610
Poor	1.733	5.369	3.098	0	78.060
Non-poor	0.676	3.469	5.133	0	132.921
Survey rounds					
GLSS 5 (% of total observations)	0.232	0.422	1.821	0	1
GLSS 6 (% of total observations)	0.383	0.486	1.269	0	1
GLSS 7 (% of total observations)	0.385	0.487	1.263	0	1
Number of observations = 35,768					

Source: Authors.

Figure 5.1 further shows that most households in the sample have low levels of assets, livestock and crop stocks. The shape of the distribution of assets markedly differs from the other two which are highly skewed towards zero. More than 60% of the respondents reported not to possess any livestock as well as crops stocks. The distribution of assets, however, is bimodal with its probability mass not located in the zero.

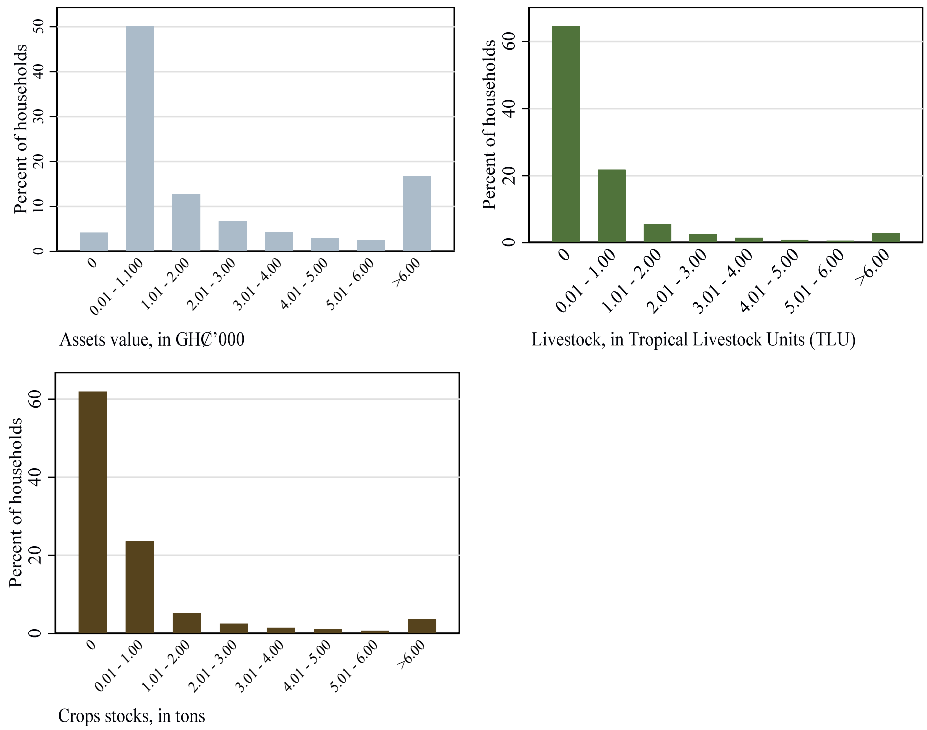

Figure 4 *Distribution of resilience capacities*
Source: Authors.

5.3 Empirical strategy

5.3.1 Model for policy simulation

The simulations are based on the following adapted version of the Quadratic Almost Ideal Demand System (QUAIDS) suggested by Banks et al. (1997):

$$w_g = \alpha_g + \sum_{k=1}^{K} \gamma'_{gk} \ln(p_k) + \beta_{1g} \ln e + \beta_{2g} [\ln e]^2 + \mathrm{u} \tag{5.1a}$$

$$\alpha_g = \alpha'_{g0} + \sum_{k=1}^{n} \mu_{gk} z_k + \sum_{r=1}^{R} \theta_k \ln r_k + \sum_{\mathrm{r}=1}^{R} \psi_{gr} \ln p_g \ln r_k + \sum_{\mathrm{r}=1}^{R} \xi_{gr} \ln e \ln r_k + \lambda_g IMR \tag{5.1b}$$

The variable w_g denotes the budget share allocated to food group g, e is deflated total food expenditure; β_1 and β_2 are predicted percentage point changes in budget shares associated with one-unit changes in food expenditure and quadratic food expenditure, respectively, and u is a random error term. The intercept α_g models the effects of households' resilience capacities (r_k) as well as their interactions with prices and food expenditures; z_k are demographic variables as shown in Table 5.1. The parameters θ_k measure the direct effects, and ψ_{gr} and ξ_{gr} measure the interaction effects of resilience capacities with food prices, and food expenditures, respectively. The parameter λ_g corrects for zero consumption of food commodities by households through the use of Heckman's Inverse Mills Ratio (IMR) approach (Heckman, 1979).

5.3.2 Simulation of price and income shocks and resilience capacities

The simulations measure to what extent resilience capacities cushion or magnify the impact of shocks on household food demand through the ψ_{gr} and ξ_{gr} parameters. A positive value of any of these parameters indicates that resilience capacity r_k reduces the (negative) effect of a price or an income shock on the demand for a specific food commodity, while a negative value implies that this effect is magnified. If any of them carries a positive sign, the demand for food group g is less sensitive to the negative impact of the respective shock, while a negative sign indicates higher sensitivity, that is, less stability. A household which has sufficient resilience capacities will show food demand which is less sensitive to price and income shocks.

By considering shocks for the simulations which have been empirically observed or which would result from hypothetical or actual policy choices, the post-shock food demand shares for each household can be predicted. Minot and Dewina (2013) document that during the global food crisis, the consumer food price index in Ghana rose by 18% between June 2007 and June 2008. Therefore, we simulate a 20% increase in the prices of all food groups (scenario S1).

FAO/IFAD/UNICEF/WFP/WHO (2018) indicates that climate shocks reduce household income across Africa significantly. The report finds that average per capita consumption expenditure reduces by 20% if temperatures rise by 1ºC. Hence, we simulate an income shock in the form of a 20% reduction of disposable expenditures on food, as scenario S2. The directions and magnitudes of the simulated changes in food group expenditure shares of each household provide evidence on the (de-)stabilizing effects of resilience capacities on aggregated food demand and, hence, food security.

One core aim of this chapter is to provide specific policy advice regarding how assets, livestock and crop stocks can be used for improving resilience. Therefore, we consider the following scenarios which quantify specific policy interventions targeting assets, livestock, and crop stocks. We regard the following scenarios:

S1: a uniform and simultaneous 20% increase in prices of all food groups. This is the general price shock scenario which resembles events of the magnitude as reported by Minot and Dewina (2013) which tend to happen often in developing countries. Sources of such price shocks can be currency depreciation or fuel price surges (Dalheimer et al., 2021).

S2: a uniform and simultaneous 20% drop in total food expenditure of all households. Such shocks affecting household income can be caused by climate change, inflation or covariate public health challenges such as infectious diseases (e.g., cholera and typhoid) that reduce household income.

S3: a simultaneous 20% general food price increase and a 20% general drop in food expenditure. Such a scenario refers to a situation during which food expenditure substantially drops while food prices are increased. Such a scenario is more severe than S1 or S2, but it might arise in contexts such as the massive explosion in the harbour of Beirut in 2020 (Rigby et al., 2020). Scenario S3 therefore assesses how coincidences of price and income shocks affect the composition of food demand.

S4: various targeted increases in the resilience capacities of all households. We simulate four policy interventions which are linked to the current IFJ strategy (MoFA, 2018). Scenarios S4a to

S4d are hence intended to examine the food demand effects of specific policy interventions. Sub-scenario 4a considers a general 20% increase in all resilience capacities. Under this policy, households with zero resilience capacities do not benefit as much as those with positive resilience capacities. Thus, more than 60% of households in the data who have zero livestock, or zero crop stocks might not benefit much from this policy. In three more scenarios, each of the resilience capacities is raised separately. In scenario 4b the assets of each poor household are increased by Gh₵1,000; in S4c each poor household is provided with one extra unit of tropical livestock units, equivalent to one cow or 10 sheep or goat; and in S4d each poor household is offered one ton of crop stock as a safety net.

To quantify the effects of price and income shocks in scenarios S1 to S3, the predicted shares from model (1a) and (1b) are used as baseline as they most closely correspond to the observed situation. To quantify the effects of the resilience capacities scenarios S4a to S4d, the predictions of scenario S3 are used as baseline as this scenario represents a very severe threat to food security and the SDGs aim at increasing resilience in such emergency contexts.

5.3.3 Assessing household food demand responses

The simulations quantitatively examine to what extent the responses in food expenditure shares vary with the observed as well as the assumed levels of resilience capacities in the presence of major shocks subject to the baseline resilience endowment and the baseline price and expenditure structure. This allows to assess to what extent and in which direction assets, livestock ownership and crop stocks affect changes in food demand shares.

We first assess demand trade-offs among food groups caused by a loss in purchasing power. We pay particular attention to the substitution of basic starchy staples by protein foods as Gibson (2013) argues that poor people tend to consume more starchy staples, especially during hard times, while the rich have more protein foods in their diets. Households possessing high resilience capacities are expected to barely replace protein foods by starchy staples (Clements and Si, 2017). Second, we assess the effect of households' resilience capacities on changes in post-shock food expenditure shares. For instance, a price shock might cause the share of the budget spent on protein foods to drop for all households which might be larger for households with lower resilience capacities compared to those with higher resilience. This would signal that resilience capacities reduce the negative effect of shocks on demand for protein foods.

The policy scenarios S4a to S4d examine to what extent a policy that enhances a selected resilience capacity for the most vulnerable group of households offsets shock impacts. We compare the expenditure share changes caused by a simultaneous food price increase and expenditure decrease to those resulting from an equally sized shock while resilience capacities are hypothesized to be improved. A positive net effect[20] implies that the policy reduces sensitivity, i.e., increases resilience to food demand shocks while a negative net effect indicates lower resilience. This assessment helps to understand how households and food groups respond on average to specific policy instruments. We conduct t-tests on statistical differences between the baseline and the comparative scenarios and summarize the results using confidence interval bar graphs.

5.4 Results and discussion

5.4.1 Changes in food expenditure shares due to price, income and policy shocks

The first block of Table 5.2 summarizes the predicted average changes in expenditure shares for each of the food groups resulting from scenarios S1, S2 and S3 in relation to the baseline. These averaged predictions show that price and income shocks lead to significant substitutions between the six food groups. The price shock of S1 increases the share allocated to staples by 3.8 percentage points and that of miscellaneous foods by 17.4 percentage points. Demand for pulses, greens, protein foods and oils significantly drop by 13.4, 9.9, 0.2 and 13.1 percentage points, respectively. Thus, a strong price increase leads to the substitution of pulses, greens, protein foods and oils for staples and miscellaneous foods. Except for protein foods, the effects of such a shock on consumption patterns are much larger across all food groups than those of the income shock in S2.

Similar to S1, S2 leads to a statistically significant increase in the shares of staples (0.2%) and miscellaneous foods (2.7%), substituting for the pulses (-1.8%), greens (-0.4%), proteins (-0.2%) and oils (-1.4%). Demand for protein foods is thus slightly more sensitive to an income shock than to a price shock. In other words, households first reduce other food items and proteins just slightly and rather increase staples and miscellaneous foods. This result draws attention to the need to manage weather or climate shocks that affect crop yields and cause income losses. Persistent and

[20] This net effect is the difference between the effect of a selected policy assumed in one of the scenarios S4a to S4d on expenditure shares and the effect of the baseline scenario S3 on these shares. The baseline scenario S3 results from the resilience capacities which have been observed for all households given a simultaneous price and income shock. The four policy effects result from the identical shock but given hypothesized increases in the resilience capacities for the most vulnerable households.

strong income shocks would mean that poor households with limited food purchasing power avoid consuming protein foods, which adversely affects their health (FAO/IFAD/UNICEF/WFP/WHO, 2018).

Table 5.2 Predicted average percentage point changes in expenditure shares

Shock or policy scenario	Staples	Pulses	Greens	Protein foods	Oils	Miscellaneous foods
Block 1: Shock scenarios (baseline: predicted demand shares)						
S1 (20% price increase)	3.757	-13.405	-9.894	-0.197	-13.074	17.352
	(0.006)	(0.063)	(0.023)	(0.003)	(0.058)	(0.155)
S2 (20% income decrease)	0.157	-1.769	-0.389	-0.210	-1.447	2.705
	(0.001)	(0.021)	(0.004)	(0.002)	(0.021)	(0.074)
S3 (S1 and S2 combined)	3.853	-15.010	-10.318	-0.359	-14.355	19.744
	(0.006)	(0.067)	(0.023)	(0.004)	(0.059)	(0.165)
Block 2: Policy scenarios (baseline: demand shares predicted by scenario S3)						
S4a (20% increase in all	2.130	-12.821	-4.657	1.423	-5.510	6.445
resilience capacities)	(0.005)	(0.064)	(0.024)	(0.014)	(0.042)	(0.108)
S4b (GhȻ1,000 increase in	6.422	-20.613	-7.844	4.346	-15.259	11.831
poor households' assets)	(0.045)	(0.116)	(0.047)	(0.040)	(0.119)	(0.148)
S4c (1TLU increase in poor	8.805	-18.595	-11.327	7.241	-12.992	10.548
households' livestock)	(0.071)	(0.112)	(0.106)	(0.097)	(0.123)	(0.141)
S4d (1 extra ton increase in	12.743	-18.642	-9.380	8.152	-12.649	11.255
poor households' crop stocks)	(0.116)	(0.111)	(0.102)	(0.114)	(0.122)	(0.145)
Block 3: Net policy effects between policy scenarios and scenario S3						
S4a – S3	-1.724	2.262	10.369	16.444	9.510	21.000
	(0.007)	(0.047)	(0.076)	(0.066)	(0.080)	(0.126)
S4b – S3	2.570	-6.534	7.156	19.387	-0.585	26.164
	(0.048)	(0.131)	(0.091)	(0.069)	(0.152)	(0.158)
S4c – S3	4.954	-3.554	1.238	22.130	0.812	24.879
	(0.073)	(0.121)	(0.160)	(0.103)	(0.168)	(0.154)
S4d – S3	9.061	-3.699	5.543	21.221	1.489	25.500
	(0.120)	(0.121)	(0.147)	(0.104)	(0.157)	(0.156)

Note: All effects are statistically significant at 1% level; standard errors of prediction in parentheses.

Further, the two simultaneous shocks considered in S3 produce effect sizes which are larger than those from S1 and S2 separately but slightly less than their sum. These results agree with empirical evidence that multiple shocks have nonlinear effects on food demand (Ansah et al., 2020a). Like income shocks only, simultaneous price and income shocks produce adverse effects on the expenditure shares allocated to pulses, greens, proteins and oils, again raising nutritional quality concerns as the consumption of these food items would decrease.

The results of the simulated policy scenarios S4a to S4d are reported in block 2 of Table 5.2. The results show that simultaneously increasing all resilience capacities of households that got exposed to the same shocks as in S3 helps to limit demand reductions for protein foods especially. All four policy scenarios increase demand for protein foods. For instance, a 20% general increase in resilience capacities increases demand for protein foods by 1.4 percentage points, while a Gh₵1,000 increase in the assets of poor households increases demand for protein foods by 4.4 percentage points, thus more than neutralizing the negative effect that would be imposed by the two shocks in scenario S3 if households' resilience capacities were not improved.

The third block of Table 5.2 reports the net policy effects as the difference between policy scenarios S4a to S4d and the baseline scenario S3. The net policy effects provide the net effect of the resilience capacities in dampening the impacts of simultaneous price and income shocks on food demand. The results of the policy scenarios S4a to S4d suggest that enhanced resilience capacities stimulate demand for protein foods and miscellaneous foods most strongly. For each food group, effects of the policy scenarios on stimulating demand are very heterogenous. For instance, if the aim would be to increase protein foods consumption, then S4c increasing livestock units of poor households would be the best choice since it generates the largest increase in the food budget share allocated to protein foods. On the other hand, if the objective is to increase the consumption of pulses, greens or oils, then scenario S4a increasing resilience capacities of all households by 20% would be most effective. These net policy effects can thus be used to inform the choice of the most effective intervention for stabilizing or even stimulating the demand for a specific category of food commodities.

5.4.2 Effects of resilience capacities on household food demand responses

This section graphically summarizes to what extent the predicted sensitivity of food demand is in response to a simultaneous price and income shock as simulated in S3.[21] This set of predictions is split according to poverty status of the household as well as to its observed resilience capacity level. For that, the empirical distribution of each capacity, i.e., of the amount of assets, livestock and crop stocks ownership, is discretized into having zero, moderate or good endowment[22].

Figure 5.2 analyzes how food demand responses to the severe shocks in S3 differ by asset ownership. The demand for staples and miscellaneous foods increases for all households. However, the magnitude of the response differs for poor and non-poor households as well as by asset levels. Poor households increase their demand for staples by about 3 percentage points when suffering the major shock assumed in S3, while this effect is about one percentage point larger for the non-poor. The effect of asset ownership on the demand for staples is slightly lower for poor households with moderate and good assets than for those with no assets. This relation reverses for non-poor households as those with more assets allocate larger shares of the food budget to staples when exposed to simultaneous price and income shocks.

The poor sacrifice a higher share of the food budget allocated to protein foods than the non-poor irrespective of asset levels. Contrary to that, non-poor households with no assets reduce their food budget share allocations to pulses most. Asset ownership leads to smaller reduction of the share spent on greens following this combined shock. Households with no assets reduce the budget spent on oils more than those with moderate and good assets.

These results demonstrate that food demand of poor vs. non-poor household respond differently to simultaneous price and income shocks. Frequently, the poor sacrifice a larger part of their food shares allocated to nutrient-rich foods like proteins and greens which is consistent with the finding of Cudjoe et al. (2010) who note that very poor households are not able to cope with shocks to their food demand. Consequently and as observed by FAO/IFAD/UNICEF/WFP/WHO (2018), they tend to use coping strategies like skipping meals or eating less nutritious food, compromising

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[21] Because the effects of scenarios S1 and S2 are similar to those of scenario S3, we only discuss the results of scenario S3 here in detail.

[22] After determining which households belong to the first category having a zero value of a given resilience capacity, we categorize the remaining ones into possessing good (second category) and moderate levels of this capacity (third category) using a statistical approach for determining the threshold based on the Stata command ‘astile’.

nutrient diversity and diet quality.

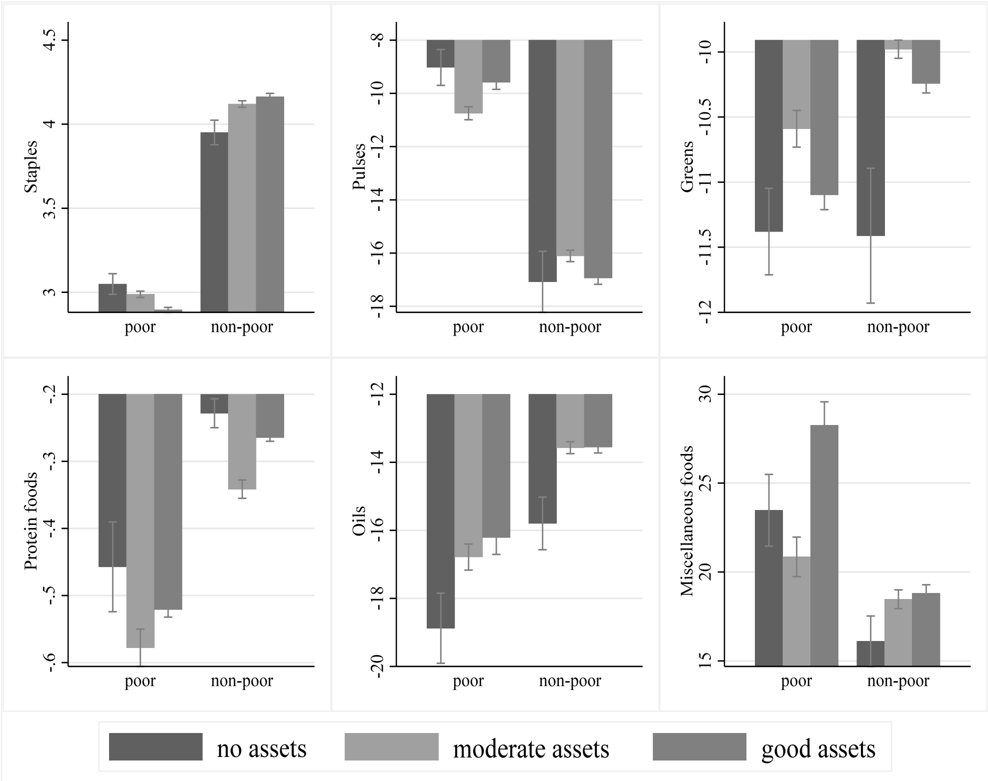

Figure 5.2 Household food demand responses from scenario S3 by assets and poverty status

Figure 5.3 summarizes the variation of budget shares obtained from S3 by level of livestock ownership. As in Figure 5.2, a simultaneous price and income shock increases demand for staples and miscellaneous foods for all households and reduces demand for the remaining food groups. For staples, the effect is larger for households with no livestock. Poor households without livestock reduce their budget shares allocated to greens and oils the most. Thus, having some livestock tends to stabilize demand.

One of the key reasons households keep livestock is to provide a hedge during hard times (Amankwah et al., 2012). As the results of S4c shows, one of the ways to help poor households to cope with shocks is to stock or restock their livestock assets. Livestock ownership tends to increase the sensitivity of demand for protein foods. A shock reducing income and raising protein foods prices at the same time plausibly cause those households to substitute their protein food purchases by slaughtering own livestock.

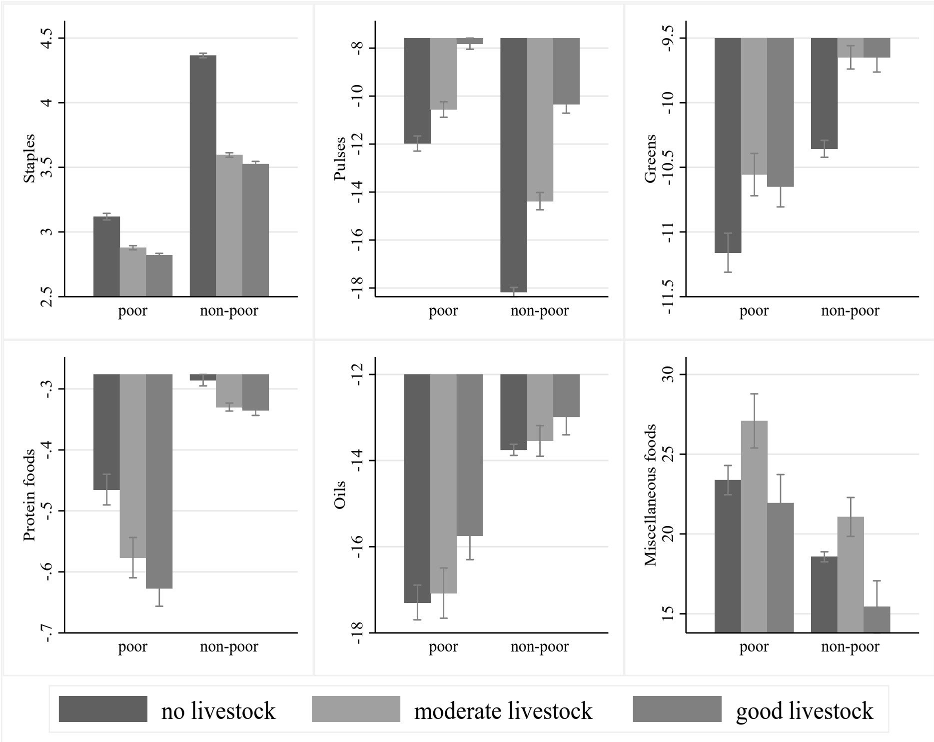

Figure 5.3 Household food demand responses from S3 by livestock ownership and poverty status

Figure 4 assesses how the budget share changes predicted by S3 differ by crop stock level owned by a household. Again, households with moderate and good crop stocks tend to have more stable budget shares for pulses, greens, proteins and oils than households without assets. Poor households, however, often show less stable demand for all groups except staples and pulses than the non-poor. These results show that simultaneous price and income shocks cause a shift from consuming expensive nutrient-rich foods to cheap energy-dense starchy staples and miscellaneous foods as also found by Laborde et al. (2020).

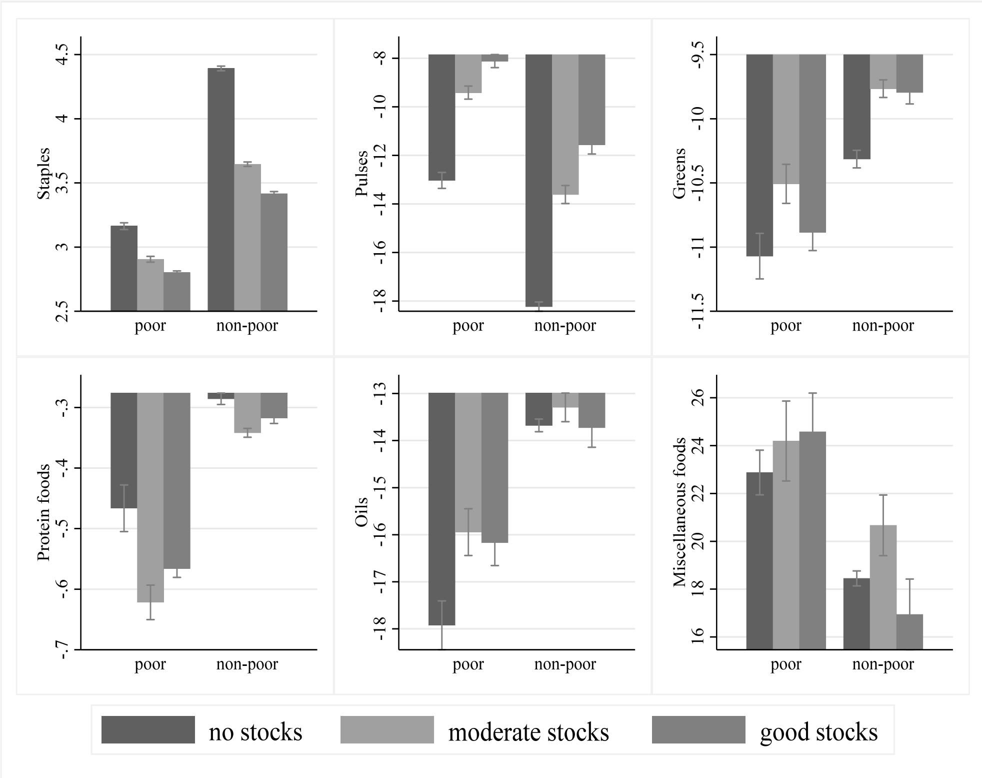

Figure 5.4 Household food demand responses from S3 by crop stocks and poverty status

5.4.3 Net policy effects of increased resilience capacities on food demand

Figure 5.5 summarizes the average net policy effects of scenarios S4a to S4d by poverty status. Consider scenario S4a which offers a 20% general increase in assets, livestock and crop buffer stocks of all households after being exposed to a simultaneous price and income shocks in scenario S3. The first quadrant of Figure 5.5 shows that only for the demand for staples this intervention is not able to offset the budget share reduction resulting from S3. If all households are better endowed with all three resilience capacities, the budget shares of all other food groups increase. Demand for protein foods increases by more than 17 percentage points for the non-poor but only 12.5 percentage points for poor households. Non-poor households tend to benefit more from this policy because the percentage point changes in expenditure shares of protein foods, oils and miscellaneous foods are higher for them than the poor.

Scenario S4b which simulates the effects of a Gh₵1,000 increase in the value of physical assets of only poor households generates quite different outcomes in terms of food demand compared to S4a. Because this policy specifically targets poor households, their demand for basic staples and protein foods increases more than without the policy. Unlike policy S4a, poor households' demand for pulses, greens and oils declines even more than in the baseline S3 while the non-poor increase their demand shares for these foods relative to the baseline. Compared to S4a, policy S4b is discriminately and tends to favor poor households' food demand more than the non-poor, especially in terms of basic staples and protein foods. Nonetheless, the fact that poor households' demand for greens drops even more than in S3 raises nutritional concerns regarding the consumption of vegetables and fruits which are important sources of minerals and vitamins.

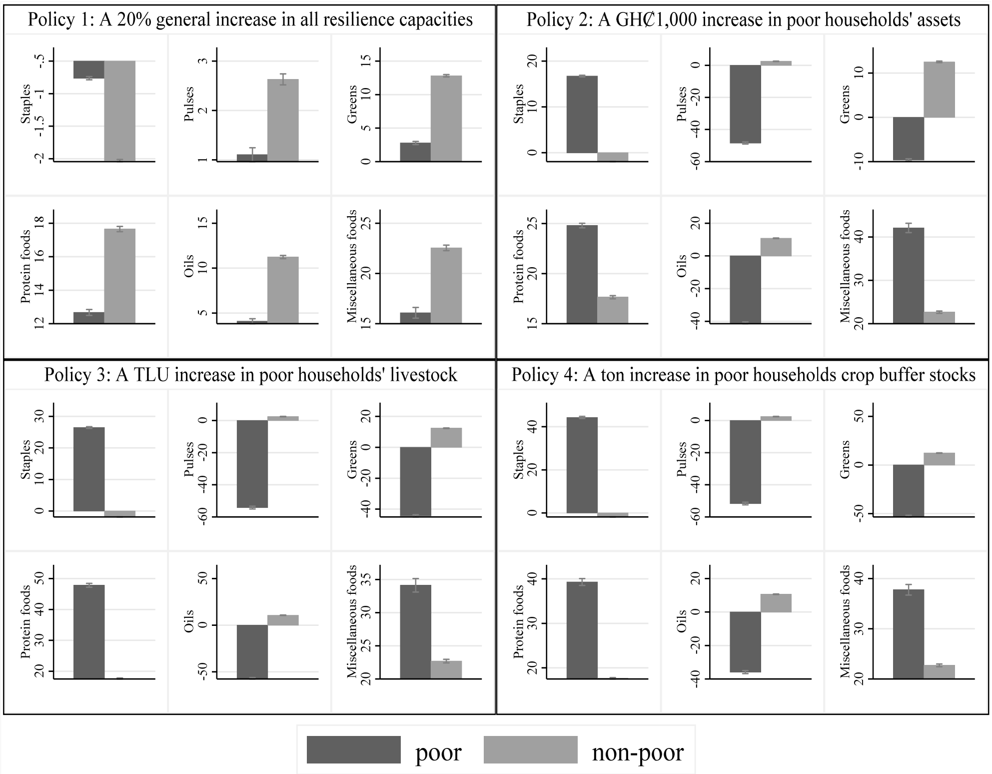

Figure 5.5 Net effects of policy intervention options on household food demand

The net policy effects of scenario S4c assessing the effects of an increase in livestock of poor households by 1 TLU resemble those of S4b as demand for basic staples, protein foods and miscellaneous foods increases. Again, the augmented demand of poor households for staples, proteins and miscellaneous foods is reasonable since the policy targets only poor households. Just like the net effects of S4b, the drop in consumption of pulses and greens as well as oils raises concerns of food diversity and nutrition security.

Finally, the net effects of scenario S4d which increases poor households' crop stocks by one ton also resembles those of S4b and S4c, since they all target poor households. Demand for staples, protein foods and miscellaneous foods increase more for poor households than for non-poor households as observed for policies S4a and S4b. Comparing all four policies, each policy affects food groups and households differently. In other words, different policies have heterogeneous effects on household food demand. For instance, policy S4c generates the largest positive effect on poor households' demand for protein foods, while policy S4a tends to increase non-poor households demand for all food groups except staples. Thus, depending on the interest of policy makers, specific policy options can be chosen for different households and for different food groups.

5.5 Conclusions

Food security and nutrition policies in developing countries are often general, which makes the poor and vulnerable households continue to bear the brunt of frequent shocks affecting their food demand. This chapter analyses demand for specific food groups, their responses to price and income shocks and how policy interventions targeted at increasing resilience capacities enable household food demand to cope with the effects of shocks. We use simulation analysis to examine potential effects of policies aimed at increasing resilience capacities. The key findings emerging from this study are summarized next.

First, price and income shocks have significant impacts on demand for various food commodities. A general price shock exerts a much larger effect than an equally-sized income shock, but a simultaneous price and income shocks has the highest impact on food demand. This implies that policies aimed at reducing or mitigating multiple shocks are important as such shocks create more problems for household food demand. Specifically, the effects of simultaneous price and income shocks tend to reinforce each other in reducing the demand for pulses, protein foods and greens.

Second, a policy that increases household resilience capacities through the provision of assets, livestock and crop stocks has positive impacts on demand for various food commodities. Given simultaneous price and income shocks, a policy that simulatneously increases household assets, livestock and crop stock by 20% stimulates demand for all food groups except for staples, which falls. Such a policy tends to be more beneficial to the non-poor than the poor in terms of household food demand. However, a policy that targets only the poor through an increase in assets, livestock or crop stocks of the poor benefits them more than non-poor households in terms of food demand. In fact, policies that target poor households enable them to increase their demand for staples, proteins and miscellaneous foods while reducing demand for pulses, greens and oils.

Multiple shocks are real events that households face. By far, assets, livestock and crop buffer stocks are the main resources that poor and vulnerable households have to cope with shocks. With the evidence this study provides that ownership of assets, livestock and crop stocks enhance household resilience to food demand shocks, policies that focus on improving these household resilience capacities must be pursued. The benefits of such policies like those specified in Ghana's IFJ strategy are significant because our results show that these policies have large positive effects on household food security by stabilizing or even stimulating demand for diverse foods. Two policy options are therefore suggested based on our findings. The first is that poor and vulnerable households should be targeted and supported to improve their resilience capacities, through the supply of breeding livestock. The second is that price stabilization and equalization mechanisms such as food commodity buffer systems should be pursued to help stabilize food prices throughout the year.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

6. General Discussion and Conclusions

6.1 Introduction

Progressively, resilience of food systems is considered in addressing food security in developing and emerging economies, where multiple shocks from the weather, human health problems, pests, diseases as well as price inflation threaten household food security. However, because resilience is not directly observable, it remains a challenge how to operationalize or empirically assess it to facilitate decision-making.

This thesis investigates the relation between resilience-building strategies, shocks, and household food security. This broad goal is achieved using a four-step research approach. The first step involves a systematic literature review to analyse concepts, methods, and empirical evidence of the relation between resilience and household food security. The second step involves analysing multiple shocks and examining how they influence household coping strategy decisions and choices. The third step learns from the outcomes of the first and second steps to inform the choice of methods for analysing resilience to household food demand shocks. The fourth step uses the methods in step three to simulate shocks and policy options that can enhance household resilience to food demand shocks. Key conclusions from the four core chapters, corresponding to each specific research objective stated in section 1.3 of the general introductory chapter, align with findings from the general resilience and food demand literature. Next, section 6.2 synthesizes the central results from chapters 2 to 5 and reflecting on their implications for our understanding of shocks, resilience, and household food security in developing economies.

6.2 Synthesis of the results and conclusions

6.2.1 Summary of main findings

In addressing the first research goal, this thesis analyses resilience concepts, methods, and empirical evidence in the context of household food security using a systematic literature review. Chapter 2 points out that existing studies commit limited attention to multiple shocks in resilience and household food security analysis. This informs the decision to pursue in chapter 3 the second research goal of examining the effects of multiple shocks on household resilience to food security shocks via their effects on coping strategy choices. Chapter 2 also demonstrates how the difficulty in conceptualizing and empirically assessing resilience from the perspective of household food security could be tackled by proposing a framework that connects resilience-building strategies to household food security. Analysing concepts and methods in chapter 2 as well as investigating multiple shocks in chapter 3 both prove to be valuable in guiding methods to use in subsequent chapters. Both highlight the key strategies that households use to cope with food security threatening shocks. Chapter 3 distinguishes coping strategies households use when they face single shocks as opposed to when they face multiple coinciding shocks. These findings inform the need to further examine the effects of simultaneous price and income shocks on household food demand in chapters 4 and 5.

Findings from chapters 2 and 3 show that households use certain coping strategies more frequently than others when they face shocks threatening their food security. Non-productive assets such as crop stocks and cash savings are frequently used, while productive assets such as livestock and land are less frequently used. The results of chapter 3 show that strategies such as safety nets and changing consumption patterns (e.g., skipping meals or reducing the amount of food consumed) are less frequently used. The finding that multiple shocks affect certain coping strategy choices in chapter 3 also guides the types of resilience-building strategies to consider in analysing household food demand and policy options in chapters 4 and 5, respectively.

The findings from chapters 4 and 5 provide two stylized facts that help explain why households in Ghana appear to skip meals or reduce the amount of food eaten less when coping with shocks. First, when confronted with reduced purchasing power, households have a tendency to substitute expensive nutrient-rich food items such as dairy, meat and fish for less expensive energy-dense staple foods. Second, households resort to resilience-building strategies in the form of assets, livestock and crop stocks to augment their purchasing power and help them stabilize food demand despite the effects imposed by price and income shocks. These *ex ante* (i.e., developing resilience capacities to help stabilize purchasing power) and *ex post* (i.e., substituting among food products) actions taken by households confirm the finding in chapter 2 that they are not passive agents that look on helpless when confronted with shocks. Instead, they choose available options that can help better their livelihoods during times of existential stress.

Chapter 2 further points out that multivariate techniques such as factor analysis, principal component analysis and structural equation modelling are dominantly used for investigating resilience in the context of food security. These methods not only require huge data inputs (Ciani and Romano, 2013; FAO, 2021) but also often lack adequate theoretical underpinning. Therefore, our choice of methods in chapters 3, 4 and 5 reflects data availability, theoretical considerations, and model parsimony. This helps to achieve the second objective of analysing the effects of (multiple) shocks on coping strategy choices in chapter 3, the third research objective of assessing how resilience-building strategies affect household food demand in chapter 4, as well as the fourth research objective of examining policy options for improving resilience to household food demand shocks in chapter 5.

In sum, the main conclusions of chapter 2 are that no single measurement approach is accepted as the 'gold standard' for analysing resilience and household food security, and that the causal pathways linking resilience and household food security is missing. Despite the divergent measurement approaches, a consistent conclusion from chapter 2 is that resilience improves household food security. Chapter 3 concludes that household coping strategy choices differ between coping with multiple shocks and single shocks, and that these coping strategy choices variously affect household food security. The main conclusion of chapter 4 is that specific resilience-building strategies such as assets, livestock and crop stocks have heterogeneous effects on household demand for various food items and for different socioeconomic groups. Chapter 5 concludes that simultaneous price and income shocks produce larger effects on household food demand than each separate shock. The conclusions of chapter 4 reinforces that of chapter 2, that coping strategy choices affect food security to different extents. Also, conclusion from chapter 5 links very well with that of chapter 3 that multiple shocks create more severe impacts on household food security than single shocks. Conclusions from the last three chapters reinforce the synthesis in chapter 2 that households develop specific resilience-building strategies to cope with a myriad of shocks. All chapters arrive at a unanimous conclusion that resilience-building strategies enhance household food demand and overall food security. Next, I discuss the larger implications of these overall results under three main themes which correspond to the specific research goals of this thesis stated in section 1.3 of the general introductory chapter.

6.2.2 Resilience measurement and analysis in food security context

The overall results of this thesis help to differentiate between resilience concepts and methods for analysing food security. While building on, and adding to, a prior review of resilience by Serfilippi and Ramnath (2018), chapter 2 of this thesis contributes to clarifying the conceptual evolution and technical adjustments to methods for resilience analysis. It highlights their comparative strengths and weaknesses, as well as provides a framework for linking resilience to its causal pathways, referred to in this thesis as resilience-building strategies or resilience capacities. Chapter 3 brings a distinct perspective into food security resilience analysis by showing that multiple shocks produce different effects on coping strategy choices than single shocks. The lack of consistency in resilience concepts and methods reviewed in chapter 2, which lead to divergent results, encourage academics and practitioners to continue refining resilience measurements, since no single method is generally accepted.

A major source of measurement inconsistency is the set of indicators chosen to represent resilience capacities. Different indicator-based measures have been proposed and used such as the FAO (2016)'s resilience index and measurement analysis (RIMA) and the resilience capacity index from TANGO International (Murendo et al., 2020; Smith and Frankenberger, 2018). Chapter 2 discusses a vast array of resilience capacity indicators while chapters 3, 4 and 5 elaborate on the relative contributions of specific indicators to food security resilience. For instance, the relations between household food demand and ownership of assets, livestock and crops stocks are heterogeneous. Chapters 3, 4 and 5 reveal how different resilience capacity indicators (e.g., cash savings, social networks, assets, livestock, and crop stocks) respond to diverse types of shocks and their combinations. These findings have implications on how to conceptualize and enhance food security resilience. Knowing how different resilience-building strategies respond to distinct types of shocks and their compound effects can aid international development actors to tailor their resilience programmes. This specific area of multiple shocks in resilience measurement and analysis requires further research.

An overarching aim of this thesis is to understand how we can consistently empirically assess resilience and household food security. This thesis does not provide a quantitative measure of resilience. On the contrary, chapters 4 and 5 provide a theoretically motivated and logically consistent approach for empirically analysing resilience to household food demand shocks. These results show that carefully selected resilience-building strategies are accurate indicators of resilience capacities that can be developed and help to stabilize or even stimulate household demand for diverse food items, and hence improve food security overall.

6.2.3 Enhancing food security resilience in multi-shock environments

This thesis points out that food security resilience is achievable by enhancing specific household resources and capacities. Notably, ownership of assets, cash savings, livestock and crop stocks accumulated out of precaution and prudence prove to be valuable household resilience-building strategies against food security shocks, as demonstrated throughout the four core chapters of this thesis. Empirical insights from chapters 3, 4 and 5 show a positive correlation of ownership of assets, livestock and crop stocks with food security or food demand. Chapter 3 particularly evaluates different measures, but still finds positive correlations of these resilience-building strategies with household food security. Recent evidence from the ongoing pandemic indicates that on-farm crop storage improves household food security in Kenya (Huss et al., 2021).

It is worth mentioning that there are practical limits to the use of resilience-building strategies for enhancing resilience at the household level. Shocks can destroy household-level resilience capacities if they are severe and last long. For instance, very intense conflicts, fire outbreaks, and natural disasters often destroy accumulated wealth and productive assets like livestock and crop buffer stocks, which this thesis reveals are important strategies for enhancing food security resilience. Under such circumstances, one option to help households recover and improve their resilience is national and regional publicly funded safety nets such as food aid, social protection and emergency relief programmes (d'Errico et al., 2020; Devereux, 2016). Another feasible option that is receiving increasing attention in developing countries is weather-based index insurance (Habtemariam et al., 2021; Hazell and Hess, 2010). Since weather variability counts among the major threats to household food security, insuring farmers' livelihood activities through risk sharing with insurance companies can shift the burden from government and NGOs to households and firms.

An example based on the current coronavirus (COVID-19) pandemic would clarify matters. In developing countries, the initial phases of the coronavirus pandemic lockdowns did not have significant negative impacts on household food security (Laborde et al., 2020). Most households depended on their buffer stocks and cash savings to finance their consumption during those initial lockdown periods. As the pandemic lingers on and households run out of stocks and savings, however, limited market supply would cause surging food prices (Chiwona-Karltun et al., 2021; Reardon et al., 2020). Mishra et al. (2021) reveal that in regions where there is coincidence of droughts with the coronavirus pandemic, their compound negative effects on food security could be dire. Currently, reported food security challenges are rising, and international organizations such as the United Nations World Food Programme (UN-WFP) would need to intervene in the form of food aid or emergency relief plans.

6.2.4 Policy options for enhancing resilience in multi-shock environments

Shocks to food security often trigger the need for change in food system processes, and policy must play an active and leading role in this transformation. If policymakers fail to make satisfactory initial investment in strategies that can help manage food security risks, it can later lead to costly coping and adaptation, welfare losses and sometimes loss of lives if interventions further delay (Mishra et al., 2021). Do policy options exist to facilitate this transformation and enhance household food security resilience?

General conclusions of this thesis show that there are feasible policy options for enhancing household resilience to food security shocks. One area where policy can and should play an active role is food system transformation (den Boer et al., 2021; Herrero et al., 2020; Zurek et al., 2021). Without doubt, a primary driver of the lower rates of food insecurity in most developed countries compared to developing countries is their advanced food system processes. So, what pathways exist for this food system transformation in developing countries?

Technological innovations that increase crop yield are an important first option, especially for poor and vulnerable farmers in rural areas. Increased investment in and adoption of improved crop germplasm, crop water systems (irrigation) and application of integrated soil fertility management technologies are important avenues that can lead to increased crop productivity and overall food supply (Manda et al., 2016; Shiferaw et al., 2014). Empirical results from chapter 4 as well as simulated policy scenarios results from Chapter 5 of this thesis highlight that improved crop stocks, for instance, due to enhanced crop productivity and general food supply, increase households' resilience to price and income shocks affecting their food demand. The Government of Ghana (GoG), for example, in response to the United Nations' SDG of zero hunger, has launched a flagship Investment for Food and Jobs strategy. Within this strategy are two programmes dubbed 'Planting for Food and Jobs', and 'Rearing for Food and Jobs'. Within the 'Planting for Food and Jobs' programme, the government supplies improved crop varieties, fertilizer, and extension services to farmers to increase their productivity and overall production. The results of this thesis encourage the GoG to commit more efforts and investment in those initiatives, as chapters 4 and 5 show that improved crop buffer stocks enhance resilience and reduce household demand sensitivities to price and income shocks.

A second pathway for food system transformation for better household food security resilience links with technological innovations that sustainably increase livestock production and consumption (Davis and White, 2020; Tricarico et al., 2020). Broaddus-Shea et al. (2020) argue that increased livestock production is associated with improved household consumption of dairy products which are an important source of proteins ensuring better nutrition and human capital outcomes, particularly for children. The last two chapters of this thesis support the call to develop or reinforce livestock production systems among poor and vulnerable households on a more sustainable basis. These two chapters show that households with more livestock tend to be less sensitive to price and income shocks affecting their food demand.

A third feasible pathway for food system transformation to increase resilience to food security shocks, which is complementary to the first two pathways, involves scientific innovations that can meaningfully reduce food loss and waste (Shafiee-Jood and Cai, 2016). In developing countries, the occurrence and economic costs of food loss and waste have been variously discussed (Lemaire and Limbourg, 2019; Sheahan and Barrett, 2017; Spang et al., 2019). Poor production and storage infrastructure lead to extensive food losses at each stage of the food supply chain. The less food that is lost through efficient food supply chain management processes and effective buffer systems the more food is available for households to depend on during tough times.

6.3 Critical reflection and suggestions for future research

6.3.1 Assumptions regarding selection of resilience indicators

Whether one sticks to indicator-based measures such as the RIMA and TANGO resilience capacity index, or to the empirical approach as used in this thesis, the debate continues as to which indicators truly constitute or reflect resilience (Béné et al., 2015b; Carpenter et al., 2005). Each method makes specific assumptions regarding the indicators that represent resilience, and the reliability of the outcomes depend crucially on these assumptions. The unobserved and multidimensional nature of resilience creates the danger that researchers tend to focus on combining a gamut of potential variables. While not discounting these debates, this thesis argues that a theoretically grounded choice of indicators renders model outcomes more credible. While being cautious in the conclusions derived from the models we use in this thesis, we believe that further research to validate our approach is worthwhile. First, future research should replicate our approach using different datasets as well as considering different resilience-building strategies. This would contribute to verifying the external validity of the approach used in this thesis. Second, comparing outcomes using different resilience-building strategies is needed to help understand the indicators improving household food security the best.

6.3.2 Costliness and accuracy of data collection

Accurate and high-quality data for resilience analysis continues to be a challenge for years to come. There is no convergence yet on the most informative indicators of resilience. Due to this, the next challenge is that researchers do not know which resilience indicators to collect data on. Since there is no focus of specific indicators, coupled with the fact that resilience has temporal dynamic properties which need longitudinal data, resilience data collection remains costly. Collecting panel data is obviously more costly than collecting cross-sectional data.

For data used in this thesis, the author did not participate in the design and collection of the information they contain. Consequently, it is difficult to guarantee data reliability and completeness. Nonetheless, this thesis demonstrates that the Ghana Statistical Service, responsible for collecting and documenting the Ghana Living Standards Surveys (GLSS) data, and similar institutions can make the data more useful for resilience studies by developing a panel structure for their data. Temporal resilience dynamics means that resilience may change from time to time. So, it is important to understand this timewise dimension to facilitate resilience planning. This thesis identified key resilience-building strategies, but lack of panel structure in the existing data did not allow studying any dynamic relations between the resilience-building strategies and food demand. Future research should look into the temporal dynamics of resilience and household food security using high frequency panel data (for example, recording data every month). Such data permits an analysis of changes in the resilience-building strategies across time periods and shock incidences.

6.3.3 Internal and external validity of findings

A critical issue to reflect in this thesis relates to the generalization of the findings. Roe and Just (2009) highlight that internal and external validity are important issues that confront empirical economic research. Internal validity relates to the methods used (e.g., can we make causal claims of our results?) while external validity typically concerns the data (e.g., can we extrapolate our conclusions beyond the specific population we study?). The internal validity of the methods used in chapters 4 and 5 has been established through rigorous econometric procedures to ensure that estimation results are consistent. We note however that the cross-sectional nature of the data used throughout the thesis sounds a word of caution in attributing pure causal interpretations.

Chapters 3 and 4 of this thesis use data that originate from Ghana. Chapter 3's data relates to farm households in northern Ghana while the data used in chapter 4 is a cross-section of the Ghanaian population. A valid question then is how generalizable are the findings and conclusions derived from these data, i.e., what is their external validity? While admitting that the data belong to only a cross-section of the Ghanaian households, the research design used for the data collection makes them representative of the population to which they relate (Ghana Statistical Service, 2018; International Food Policy Research Institute 2015). Likewise, nations in sub-Saharan Africa as well as other developing countries mostly share similar characteristics as the Ghanaian population. Therefore, the Ghanaian data characteristics are plausibly not unrepresentative to those of other subregions, hence we believe that the results can reliably be generalized.

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SUMMARY

Achieving food security is still a major challenge in developing countries as a result of negative effects of multiple shocks on household food systems. Consequently, resilience of food systems has become a central item on the agenda of both the international development community and governments of developing countries. A major barrier to achieving this is that resilience is unobserved and multi-dimensional, which means conceptualizing and empirically assessing it is difficult. There is therefore a limited understanding of the relationship between resilience, shocks and household food security. This thesis contributes to closing this knowledge gap.

Chapter 1 sketches a brief overview of food security concepts and issues in sub-Saharan Africa, as well as of shocks, resilience and of the connections among these three themes. Afterwards, the chapter explains the rationale for this thesis and outlines the overall goal. The specific objectives contributing to the overall research goal are motivated. Further, chapter 1 gives an overview of the methods and the data for achieving those objectives.

Chapter 2 to 5 constitute the core framework of the thesis. Chapter 2 contains a systematic literature review approach to analyze concepts, methods and evidence of the relationship between resilience and household food security. Findings from chapter 2 show that researchers diverge on conceptual and empirical frameworks for assessing resilience in the context of food security. Nevertheless, the chapter concludes that both conceptualization and methodological frameworks for analyzing food security resilience have gone through important phases of adjustments. Chapter 2 also finds a limited understanding of the causal pathways between resilience and food security and proses a framework to help address them.

Chapter 3 brings a new perspective to resilience and food security analysis by examining the relationship between several simultaneous shocks, coping strategy choices and household food security. It first analyzes which coping strategies are chosen when responding to multiple as opposed to single shocks. Further, the chapter assesses how these choices influence household food security using different food security measures. The central conclusion from this chapter is that coping with multiple shocks often requires different strategies than coping with single shocks. The chapter finds that productive assets such as livestock and non-productive assets such as crop buffer stocks are more likely to be depleted when households are faced with the negative effects of multiple shocks.

Chapter 4 focusses on understanding the relationship between selected resilience-building strategies and household food demand for various food items. Based on a quadratic almost ideal demand system, the chapter examines how ownership of assets, livestock and crop stocks influence the sensitivity of demand to unexpected changes in prices and household food expenditure. The core conclusion from this chapter is that resilience-building strategies have heterogeneous effects on the sensitivity of household food demand to price and income shocks. Increasing levels of household assets or livestock decrease demand sensitivity of protein foods such as dairy, meat and fish as well as of vegetables and fruits, to income shocks for poor households. Increases in crop stocks are associated with lower demand sensitivity of staples and pulses to income shocks for rural and non-poor households.

Chapter 5 uses the data and models of the fourth chapter to simulate price and income shocks as well as policy options that can help mitigate the negative effects of price and income shocks and stabilize household food demand. This chapter finds that the effects of a price shock on household food demand are larger than that of an income shock, but simultaneous price and income shocks produce the largest effects. Further, the chapter finds that a policy instrument that simultaneously increases household assets, livestock and crop stocks offsets the negative effects when these shocks occur simultaneously and stimulates demand for all food items for non-poor households except staples. On the other hand, a policy instrument that targets only poor households' assets, livestock or crop stocks is more beneficial to the vulnerable and stimulates their demand for protein foods, staples and miscellaneous foods.

The overall results of this thesis confirm that household resilience to shocks affecting food security can be boosted and that household food demand can be stabilized through the development of household assets, livestock and crop stocks.

Chapter 6 synthesizes the results from chapters 2 to 5 and considers their implications to the state-of-the-art understanding of food security, shocks and resilience. It also critically reflects on the work done throughout this thesis path and provides suggestions for future research.

TRAINING AND SUPERVISION PLAN

Isaac Gershon Kodwo Ansah

Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Wageningen School of Social Sciences

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Theory and practice of efficiency and productivity analysis	WASS	2017	3.0
Systematic approaches to reviewing literature	WASS	2017	4.0
Writing PhD research proposal	WUR	2017	6.0
Quantitative data analysis: multivariate techniques, YRM 50806	WUR	2017	6.0
'Analysing developing country market integration with incomplete price data using cluster analysis'	3rd Global Food Symposium, Gottingen, Germany	2017	1.0
'Food system resilience: a review of concepts and empirical approaches'	EAAE XV Congress, Parma, Italy	2017	1.0
'Multiple shocks, coping strategies and food security'	Seminar Section Economics, WUR	2019	1.0
B) General research related competences			
WASS Introduction course	WASS	2017	1.0
Scientific Writing	Wageningen in'to Languages	2017	1.8
Scientific Publishing	WGS	2017	0.3
Reviewing 8 scientific articles	Food Security journal, Environment, Development and Sustainability journal, Applied Economics journal, journal of Agricultural and Food Economics	2018-2021	3.0
C) Career related competences/personal development			
Teaching Econometrics, Agricultural Policy and computer applications in Economics and Business	University for Development Studies	2017-2021	2.0
Supervision of students' dissertations (undergraduate) and thesis (postgraduate)	University for Development Studies	2017-2021	2.0
Writing Grant Proposals	Dyson School of Applied Economics and Management, Cornell University, USA	2019	2.0
Total			**34.1**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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ABOUT THE AUTHOR

Isaac Gershon Kodwo Ansah was born on August 9, 1976, in Takoradi, Ghana. He obtained his bachelor's degree in 2002 at the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana. After the bachelor's degree, he worked with Ghana Education Service from 2004 to 2010 as a tutor at Baidoo Bonsoe Senior High Technical School, in Agona Nkwanta, Ghana. In 2012, he obtained his master's degree in Management, Economics and Consumer Studies at Wageningen University. Afterwards, he was employed by the University for Development Studies in Tamale, Ghana, as a full-time lecturer where he has been working since May 2013. He has since taught courses in econometrics, computer applications, and agricultural policy and development. During his master's program, he became interested in the nexus between prices at the international and domestic markets in Africa and wrote the master's thesis on this subject. In November 2016 he started as a PhD student at the Agricultural Economics and Rural Policy Group, a department that has built a longstanding reputation in agricultural economics and rural policy analyses. The PhD thesis assessed the existing and emerging empirical approaches as well as indicators of household resilience to food security shocks. By the middle of 2021 he obtained his PhD degree. He continues to work as a lecturer and researcher at the Department of Economics, University for Development Studies. In his research, he aims at using recent findings and insights from the field of microeconomics, capability and political economy to study households' behaviour under uncertainty that have influence on their resilience to shocks affecting food security and other wellbeing outcomes.

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