In search of a new theory of food (in)security: Evidence from Tanzania

by

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B.S., National University of Benin, 2011
M.Sc., Ouaga II University, 2014

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2019

Abstract

Words have meaning, and meanings influence actions and responses. For decades, food insecurity has been increasingly connected to other concepts, primarily hunger, as if they are congruent. A challenge to the congruence of the meaning of these two concepts is the primary motivation for this research. The study hypotheses that if they are, indeed, congruent, then their antecedents would be statistically the same. Moreover, if they were different, there is a need to explain why researchers, policymakers and others have continued to use them interchangeably and what effect that "error" has had on the ability to address problems presented by food insecurity and hunger.

To test the hypothesis of congruence, we conducted a systematic review of the literature focusing on the origin, etymology, and mixed use of both concepts in the context of economic development. We found that while hunger is defined as a sensation or pain that results from the want of food especially after hours of fast, food insecurity, instead, shall be referred to as the lack of security about food. It means worrying or fearing that one may not have food or enough food to eat, which does not include necessarily hunger. We then leveraged the foundational meaning of the concepts from an applied perspective and developed a new interpretation showing that hunger and food insecurity are not synonyms. They may, however, be placed on a continuum that transforms hunger into food insecurity under certain conditions. The study provided an empirical analysis of this transformation using the Living Standards Measurement Survey dataset for Tanzania (2014-2015). For robustness check, a comparison was made with the findings from Tanzania's previous years' survey data, i.e., a two-years' panel (2010-2011) and (2012-2013).

The results show that, even though they are related, hunger and food insecurity are not congruent, and treating them as synonyms in policymaking creates measurement hurdles that are already evident in the results from seven decades of attempts to ameliorate food security and address hunger. First, the summary statistics indicate that more than 30% of respondents were food insecure, i.e., "worried about food" even though they were not hungry. Meanwhile, more than 90% of those who were hungry were also food insecure. Next, we reject the null of congruence and conclude that factor explaining household food insecurity were statistically different from those anteceding hunger at a 5% significance level of the Wald test. Finally, we were also able to establish the threshold at a minimum of two days ($H \geq 2$), which turned hunger into food insecurity. Beyond two days of hunger, people begin to worry and become food insecure.

Based on the foregoing, we recommend, for policy discourse, to acknowledge household hunger continuum and the threshold at which it turned into food insecurity. Besides, to enhance household food security in Tanzania, we argue for the need to strengthen household resilience to shocks leading to food insecurity and hunger such as drought, a massive rise in food prices, and loss of asset ownerships like livestock due to diseases. Similarly, policies that improve their food expenditures and asset ownership, i.e., livestock, poultry, and agricultural equipment, would effectively mitigate the likelihood of food insecurity. The significant contribution of this research to the literature is that hunger may be a contributing factor to household food insecurity but not a sufficient condition, thereby negating the congruence under $H < 2$ days.

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Dr. Vincent Amanor-Boadu

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Table of Contents

List of Figures

List of Tables

Acknowledgments

In my journey towards this degree, I have found a teacher, an inspiration, a role model, and a pillar of support in my major professor, Dr. Vincent Amanor-Boadu. I am very thankful for all the long hours spent in conversation to help me sharpen and deepen my conceptual, theoretical, and empirical skills. He has taught me to think creatively, which is an excellent asset for conducting outstanding research. I have learned the importance of developing a research philosophy about my passions. Throughout the process of completing this dissertation, Dr. Amanor-Boadu has provided me with, not only technical guidance but most importantly, great personal and professional growth tips. My way to achieving my objectives has been long and unpredictable, but through each up and down, Dr. Amanor-Boadu did not miss any occasion to remind me how he believes in me and in my ability to succeed.

Also, I would like to thank my supervisory committee members made of Dr. Kara Ross, Dr. Aleksan Shanoyan, Dr. Philip Gayle, and my outside chair, Dr. Christopher Lake. They have each contributed their insights in enhancing the quality of this work. I want to particularly acknowledge the consistent and tremendous support I have received from Dr. Ross over the course of my Ph.D. program here at Kansas State University. My acknowledgment would be incomplete without thanking all the professors and graduate students in the Department of Agricultural Economics and Department of Economics, who helped me through classes or better understand my assignments. I am very thankful to the staff of the Department of Agricultural Economics, especially Ms. Judy Maberry, Ms. Deana Foster, and Ms. Amy Schmitz, for their enthusiasm to help me and to all those who have contributed to this achievement behind the scene.

Dedication

To:

My Almighty God, for giving me the opportunity and strength to complete my Ph.D. degree.

My mother, Reine, and my late father, Aurelien Kotchofa, for always believing in me. I will

forever love you both.

My dear siblings Euloge, Ariane, Tatiana, and Kenneth Kotchofa, for their unconditional support

and prayers during the course of my studies.

Chapter 1 - Introduction

1.1. Background

As with most concepts with vernacular and technical meanings, as well as potential local and international implications, food security has defied a coherent, pragmatic, and compelling definition and measurements since it entered the policy stage about seven decades ago (Shaw, 2007). For the first three decades, it was perceived, in most cases, in a macroeconomic context, leading to attempts to measure and address it from a national perspective. For instance, national food security focused mainly on food supply, and was understood as the ability of a country to be self-sufficient, i.e., the state produces the food which its population demands (Pinstrup-Andersen, 2009). However, it was discarded as self-sufficiency did not necessarily mean that all people have food security even if the country claimed self-sufficiency.

Subsequently, in the past four decades, the definitions and understandings of the concept have shifted focus from national food supply to household and individual demand and food access. The demand and food access definitions emphasize the ability of individuals or households to access the food they demand and are measured using various indicators and proxies (Jones et al., 2013; Pérez-Escamilla et al., 2017). However, in this shift from self-sufficiency to demand and access, food security has become increasingly connected to other concepts, including hunger and undernourishment (Barrett, 2010; Jones et al., 2013), making it difficult to provide a clear and compelling definition that is independent of, and uniquely different from, other concepts. Jones et al. (2013) argue that one of the reasons for such tight relationship with "hunger" may be perhaps due to the emotive strength associated with the concept of hunger which has frequently been sufficient to move many to action.

The coupling of food security to these other concepts, primarily hunger, has affected the sense-making that researchers, advocates, and policymakers have brought to their understanding and solutions to the problem associated with food insecurity. As the challenges differentiating these concepts became evident, a group of multidisciplinary experts in the United States (U.S.) came together in the late 1980s and early 1990s to develop a set of eighteen ethnographic and self-assessment questions in an attempt to provide more precise definitions. They labeled their product the U.S. Household Food Security Scale Survey Module (HFSS-SM) (National Research Council, 2006; Jones et al., 2013; Pérez-Escamilla et al., 2017). This scale has, over time, served as the foundation for what is now known as household and individual Experienced-Based Food Insecurity Scales (EBFIS) (FAO, 2012; Pérez-Escamilla et al., 2017)[1]. Their significant contribution to the literature is their recognition of food insecurity as a broad concept incorporating both cognitive experiences, i.e., worry or uncertainty about inadequate food supply, and non-cognitive ones such as decreasing quality and quantity of food consumed, conscious skipping meals, as well as levels of hunger (Coates et al., 2007; Coleman-Jensen et al., 2015; Smith et al., 2017; Pérez-Escamilla et al., 2017). However, the main limitation of the EBFIS is their failure to clearly distinguish food insecurity from hunger. Thus, in spite of all these advances, food insecurity defined based on the results of the FIES, which already includes levels of hunger, continues to be used interchangeably with hunger (WHO, FAO, IFAD, WFP, 2015; 2018).

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[1] Besides the US HFSS-SM, popular EBFIS include the Household Food Insecurity Access Scale (HFIAS) (Deitchler et al., 2010); Household Hunger Scale (HHS) (Ballard et al., 2011); and the most recent one, i.e., the Food Insecurity Experience Scale (FAO, 2015).

Given the difficulty exhibited in the literature and in policy discourse in separating food insecurity from other food-related challenges, such as hunger, this study is premised on the assumption that, despite being related, food insecurity is substantially different from hunger. The preceding premise is tested to justify a need for producing a unique and independent definition for food security, or more appropriately food insecurity. To establish the difference, we build upon the EBFIS literature (National Research Council, 2006; Leroy et al., 2015; Pérez-Escamilla et al., 2017) on the importance of recognizing the cognitive dimension of the food insecurity experiences, i.e., worry and uncertainty about inadequate food supply to uniquely define the concept independently from hunger. Thus, this study seeks to produce a better understanding and also policies solutions that are more tangible to address the challenges associated with food insecurity and hunger.

1.2. Problem statement

Words have meaning, and meanings influence sense-making and actions (Weick et al., 2005). How researchers and policymakers have described food insecurity also affected how they have perceived, measured, and tried to address it. Security is defined as a state of mind, a sense of violation, or potential violation of one's safety (Walt, 1991). The American Institute of Nutrition defines hunger as the uneasy or painful sensation caused by a lack of food (Anderson, 1990; Jones et al., 2013). The problem confronting this research is to separate these two concepts and provide evidence of not only their difference but also under what conditions can these be considered congruent. Addressing this problem, we believe, will improve researchers' and policymakers' understanding of the antecedents of food insecurity, and help them develop more effective policies.

1.3. Research question

The research problem specified above engenders the following research question: What are the antecedents of food insecurity and to what extent do they differ from those of hunger, and do these antecedents converge at some point? This question challenges us not only to develop a stronger conceptual elucidation of food insecurity and hunger but also to develop empirical models to test them for congruence. The critical contribution of this research is the possibility of confirming the existence of a relationship between food insecurity and hunger. More accurately, the issue offers an opportunity to show it, and when hunger transforms into food insecurity. Therefore, this work does not argue against using food insecurity and hunger together but challenges using them interchangeably to mean the same thing.

1.4. Research objectives

The overall objective of this research is to test if there is a difference between food insecurity and hunger and determine the point at which hunger transforms from a physical sensation into food insecurity, a mental health challenge. The specific objectives are as follows:

1. Identify, organize and critically evaluate the literature on food security as it has been conceived over the past seven decades with the view of examining its sensemaking potentiality and its effect on the development of effective policies to address the challenges of food insecurity and hunger.

2. Develop a reconceptualization of food insecurity using its etymological roots and explore the effect of this reconceptualization on its measurement and the development of policies to solve its embedded challenges.

3. Evaluate the uniqueness of the differences between food insecurity and hunger by empirically testing the extent to which their antecedents are the same as well as the conditions under which hunger transforms into food insecurity.

4. Evaluate the policy implications emanating from the foregoing analyses and provide evidence-based directions for future policies that may be used to ameliorate food insecurity and address hunger.

1.5. Overview of methods

Objective 1 is achieved using a systematic review of the literature. This method involved an extensive search and review of all relevant publications on the subject of food security over the past seven decades that it has been in use in policy and advocacy circles. Objective 2 is achieved using the etymological component of the concept of food security as well as the literature on security, and insecurity or mental health. To this summary is added the EBFIS's literature on cognitive experiences related to food insecurity. Objective 3 is achieved through the estimates of logit and seemingly unrelated bivariate probit models on the 2014-2015 Tanzanian household survey data of the World Bank's Living Standards Measurement Study (LSMS). For consistency and robustness check of the above-listed models' results, a comparison is made with the same country's previous years surveys data, i.e., a two years panel of 2010-2011 and 2012-2013. Objective 4 is achieved based on the results of the empirical analysis completed in Objective 3.

1.6. Dissertation outline

This introduction chapter provided the background and motivation for the research. It defined the research problem as a need to separate food insecurity from hunger and provide evidence of not only their difference but also conditions under which they can only be considered congruent. The research question is to identify the antecedents of food insecurity and to what extent do they differ from those of hunger. Also, do antecedents of both concepts converge at some hunger level? The overall objective is to test if there is a difference between food insecurity and hunger and determine the point at which hunger transforms from a physical sensation into food insecurity, a mental health challenge.

Chapter 2 describes the evolution of the concept of food security, focusing on how and when it became seemingly synonymous with hunger as well as with the other food-related challenges. It also presents the reconceptualization of food insecurity from household or individual's sense of security about food. Chapter 3 provides information on the study area, data, and methods used, as well as the empirical assessment of its congruence with hunger. Chapter 4 presents the results of the analysis. Chapter 5 discusses opportunities for enhancing the effectiveness of policies and outcomes if perspectives about food insecurity and hunger are changed to match the ideas presented in this research. It illustrates the sensemaking reorientations separating food insecurity from hunger to facilitate targeting of policies in achieving results. Chapter 6 provides a summary and conclusions from the study. It also identifies the potential weaknesses and opportunities for future research in this area.

Chapter 2 - Evolution of food security and hunger over the past seven decades in policy and academic literature

2.1. Background

Over the past seven decades or so, there have been several attempts to develop a more precise concept of food insecurity. The most recent of these attempts was the introduction of the Experienced-Based Food Insecurity Scales (EBFIS) which originated in the mid-1990s from the United States Department of Agriculture's (USDA) study titled the U.S. Household Food Security Scale Survey Module (U.S. HFSS-SM) (National Research Council, 2006; Coleman et al., 2015). Over two decades, these scales have been used in Latin America, Africa, Europe, and in the U.S. to measure of household and individual food insecurity experiences (Pérez-Escamilla et al., 2017).

The concept of food security has generally been discussed at a macro level. However, as we seek to redefine food insecurity from individual or household "security" perspective to provide a better understanding of its leading factors and to develop effective policies to address its outcomes, we begin our historical discussion of the concept from the macro to the micro level. Specifically, we conduct a systematic review of the literature starting with the concept's origin and historical development. To ensure broad coverage of the literature we searched various databases with the following keywords: "food security"; "food insecurity"; "food security definition"; "theory of food security"; "experience-based food security" and "worrying about food." The database included Google Scholar, EconLit, AgEcon Search, IBSS, Scopus, JSTOR, Science Direct, AGRICOLA, Harvest Plus, AGRIS, and IDEAS providing access to electronic archives of journal articles, working papers, reports, and governments documents. Also, we used the information found on

websites of international organizations dealing with food insecurity including the FAO, the World Bank Group, the World Food Programme, and The International Food Policy Research Institute (IFPRI). Additional documents were found by emailing directly relevant universities faculties, public officers at the USDA and the United States Agency for International Development (USAID), for more recent documents. Most of these documents and authors were found by tracking citations and key documents' reference lists.

This chapter is organized into three parts. The first focuses on understanding how the concept of food security has been conceived and measured over the past seven decades, and the policy recommendations emanating from most food security studies. The second introduces the idea of "worry" into the food insecurity discourse, tracing its origins, rationale, and effects. The final section of this chapter reviews food (in) security studies at the individual or household level through concepts such as worry and anxiety as indicators and compare their results with those using hunger. We also review those studies that do not distinguishes between food insecurity and hunger in the final section of the chapter.

2.2. Food security: an aspirational and continually evolving concept

On January 6, 1941, President Franklin D. Roosevelt delivered his eighth State of the Union, now known as "the four freedom speech."[2] In it, he stated, among other things:

> *In the future days, which we seek to make secure, we look forward to a world*
> *founded upon four essential human freedoms. The first is freedom of speech and*

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[2] Franklin Delano Roosevelt had served as the 32nd President of the United States of America (USA) from 1933 until his death in 1945.

*expression – everywhere in the world. The second is the freedoms of every person to worship God in his way – everywhere in the world. **The third is freedom from want…everywhere in the world.** The fourth is freedom from fear…anywhere in the world. That is no vision of a distant millennium. It is a definite basis for a kind of world attainable in our own time and generation."*

This speech may have set the tone for the concept now known as "food security" (Shaw, 2007). The "four freedom speech" is reputed to have led to the establishment of the Food and Agriculture Organization (FAO) in 1945 with the mandate the attainment of "freedom from want" goal everywhere in the world concerning food and agriculture (Shaw, 2007). "**Freedom from want"** was understood as a "secure, adequate, and a suitable supply of food for every human" (Shaw, 2007). At its first session held in Quebec City, Canada from October 16 to November 1st 1945, one crucial purpose assigned to the FAO was to raise the levels of nutrition and standards of living by securing improvements in the efficiency of the production and distribution of all food and agricultural products in the world (Shaw, 2007). Particular attention was given to bettering the condition of rural populations living in developing countries.

From its very origin, food security was conceived at the global level with a focus on the availability of food everywhere, most importantly, in developing countries where hunger and famine were rising. Meanwhile, famine was defined as a "widespread food shortage leading to a significant rise in regional death rates" (Blix et al., 1971). Brown and Eckholm (1974) also defined famine as a "sudden, sharp reduction in food supply resulting in widespread hunger." However, just like food security, famine was also viewed as the result of a disruption or a food supply failure. This perspective concentrated efforts on the physical availability of food, to be distributed in times of emergencies. Most of the 1950s witnessed a series of discussions about some forms of

international management of global food reserves to mitigate threats of localized famine. FAO initiated intergovernmental consultations aimed at providing "prompt, concerted and effective assistance" (FAO, 1996; Shaw, 2007), leading to the creation in 1954 of the concept of "World Food Reserve" (WFR). This was also made possible by the fact that food supply was reaching high records in developed countries and exceeding markets demand while food scarcity was making headlines in the developing countries. The WFR was intended to redirect those excess supplies to be used for hunger and starvation relieve where needed. This strategic understanding has led the development of food aid for developing countries. Overall, the first two decades after President Roosevelt's "four freedom speech" saw a focus on freedom from hunger policy discourse with a focus on increasing food supply, storage and distribution to needy areas, i.e, the developing world: Africa, Asia and Latin America (Leathers and Foster, 2004; Jarosz, 2011; Kneafseay et al., 2013).

The third decade mainly witnessed the world food crisis of the 1970s and the World Food Conference of 1974 and its outcomes. Amid the discussions about the WFR and its usefulness, "food security" emerged officially as an operational concept following the rapid surge in international food and oil prices in the early to mid-1970 (Coates, 2013). These prices spike triggered global food crises (Shaw, 2007; Maxwell and Smith, 1992; World Bank, 2008; Coates, 2013). West African Sahel was devastated by multiple years of drought, causing widespread famine while the developed countries such as the U.S. was setting records in grain sales to the Soviet Union which triggering concerns about the global food security (Jarosz, 2011).

At the 1974 World Food Conference (WFC), "food security" was then defined as the "availability at all times of adequate food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (Shaw, 2007).

Food security indicators emphasizing national and international food production and availability were measured using food balance figures in aggregate form (Coates, 2013). Public policies intended to increase domestic food production and mitigate global price surges became the ultimate tools for every nation seeking to achieve national food security. Food self-sufficiency policies were thriving in many developing countries, especially in African countries, i.e., like Rwanda, Zimbabwe, and Nigeria. For example, with the support of international NGOs, like the Catholic Relief Services, Rwanda was able to build dozens of grain storage silos of grain foods across rural areas which contributed to a reduction in post-harvest losses, price stabilization, and support self-sufficiency objectives (Jarosz, 2011). Many countries strived to achieve "food self-sufficiency," which represents the ability of a country to produce enough food to feed its populace through domestic production channels only (Coates, 2013). The Malthusian trap may have influenced the focus of the definition of increasing food availability and supply[3]. Consequently, after the Green Revolution in the late 1970s, the abundance of food and drop in commodity prices led the gradual dissipation of worries of an impending global food shortage (Coates, 2013).

Fourty to fifty years after President Roosevelt's speech engendered significant advance in the understanding of the food security and most importantly, progress about its measurements. For instance, the Nobel prize-winning work of Amartya Sen indicated that the lack of resources, rather than a lack of food availability, was the most significant factor in deaths from the series of famine in Bengal, Ethiopia, the Sahel, and in Bangladesh (Sen, 1982; Coates, 2013). Sen's contribution induced a paradigm shift, diverting attention from the national food availability to households and

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[3] Malthusian theory indicates that as population growth rate is ahead of agricultural growth rate, there must be a stage at which food supply will be inadequate for feeding the growing population (Malthus, 1878).

individuals' "accessibility" to food. According to Sen (1982), famine does not result from droughts or food supply, but instead, from the inability of marginalized social groups to access food. This inability to access food may be social, economic, and political. From these developments, FAO in 1983 updated the food security definition by adding the term "access" to the 1974 WFC definition. Food security was then defined as "ensuring that all people at all times have both physical and economic <u>access</u> to the basic food that they need" (Clay et al., 2003).

The World Bank's (1986) report, "*Poverty and Hunger: Issues and Options for Food Security in Developing Countries,*" provided new evidence. First, the report highlighted the temporal dynamics of "food insecurity and hunger" by distinguishing between chronic food insecurity – associated with problems of continuing or structural poverty and low incomes, and transitory food insecurity, which involve periods of intensified pressure caused by natural disasters, economic collapse or conflict (Clay et al, 2003). This distinction was necessary to guide adequate interventions that address the underlying and primary causes of each food insecure subgroups. Secondly, the World Bank redefined food security by adding the following underlined terms. "… access of all people at all times to enough food for an active, healthy life". Thirdly, the report initiated the implementation of the World Bank interventions described as "Top-Down" (Shaw, 2007; Jarosz, 2011) on the developing countries through the Structural Adjustment Policy (SAP) and investments aiming to accelerate their economic growth, alleviate poverty, and to coordinate food aid and other financial assistance (Jarosz, 2011) [4].

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[4] The SAP also came along with currency devaluations mandated by the World Bank as debt restructuring policies (Shaw, 2007; Jarosz, 2011).

Following Sen's (1982) recommendations and the implementation of the World Bank and FAO's interventions and policies described above, the definition of food security shifted focus from global and national level to household and individual ones (Shaw, 2007). For instance, the International Fund for Agricultural and Development (IFAD) argued that a shift in level was necessary because defining food security at the national "self-sufficiency" level it could bypass the poorest as a large segment of a population which may be living in hunger despite national self-sufficiency. In other words, food adequacy at the aggregate level may not necessarily translate into food security at the household or individual level. The updated definition incorporated food safety, their nutritional balance, and introduced the interrelationships among food composition, diet, and nutrient requirements as necessities for active and healthy lives (Clay et al., 2003).

These interrelationships between diet, food composition, and nutrient requirements paved the way for the introduction of the term "food preferences," discussions to the social and cultural characteristics of individual and households into the conversation. All these updates appeared in the definition of food security at the World Food Summit (WFS) of 1996. "Food security, at the individual, household, national, regional and global level [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Clay et al., 2003; Shaw 2007). The 1996 WFS, along with the Millennium Summit of the United Nations of 2000, set global aspirations especially through the Millenium Development Goals (MDGs). The MDGs were eight international development goals adopted by all the 191 UN's member states and at least 22 international organizations to commit and orient their policies and overseas aid programs to end poverty and improve the lives of poor people by the year 2015. The MDGs became a powerful

tool for aid givers, NGOs, and the people to hold their respective governments to account. Much attention was given to the MDG1, which was set to eradicate extreme poverty and hunger[5]. The number of people living in extreme poverty, i.e., Target 1A, has been reduced from 1.9 billion in 1990 to 836 million in 2015, although the target of halving the proportion of people suffering from hunger was narrowly missed (UN, 2015).

The latest update of the food security definition was introduced in 2001 at the State of Food Insecurity (SOFI), setting "food preferences" into the social and cultural context of individuals and households. However, the most widely quoted definition of the concept of food security remains "a situation that exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food for an active and healthy life" (Shaw, 2007; Maxwell, 2012). After the SOFI (2001), there have not been any other significant improvements to the definition of the concept of food security. Some international conferences and summits have examined the concept but have only quoted and maintain the same WFS (1996) definition. However, at the 2015 United Nations General Assembly and based on the success and shortfalls of the MDGs, a collection of 17 global goals are set for the year 2030. These are called the Sustainable Development Goals (SDGs) and have been tracking global improvements. They have had the effect of focusing national government attention on issues such as poverty, hunger, and food security. The clear relationship between food insecurity and hunger has yet to be established. This missing relationship may handicap the development of effective solutions since the clarity of

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[5] The MDG1 is made of three targets such as 1A:Halve, between 1990 and 2015, the proportion of people living on less than $1.25 a day; 1B: Achieve Decent Employment for Women, Men, and Young People; and 1C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

their antecedents remains unknown. However, since the introduction of the U.S. Household Food Security Scale Survey Module (HFSS-SM) and the Experienced-Based Scales in general, numerous researchers adopted their approach which brings focus on household and individual food security experiences instead of the traditional aggregate approaches (National Research Council, 2006; Ballard et al., 2011). Figure 1 below summarizes this historical development of the concept of food security, including the main changes made to its definitions.

Figure 1- Food Security definition's timeline

Franklin Roosevelt 1940s: "Freedom from want" "secure, adequate, and a suitable supply of food for every man" (FAO, 1943, Shaw, 2007).

FAO 1983: World Food Security: A reappraisal of the concepts and approaches. "ensuring that all people at all times have both physical and economic access to the basic food they need" (Shaw, 2007).

FAO, 2001: The State of Food Insecurity in the World. "When all people at all times, have physical, **SOCIAL** and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Shaw, 2007)

1940s

Present

United Nations, World Food Council 1974: "availability at all times of adequate food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices". (UN, 1975; Shaw, 2007).

World Food Summit, 1996: "**at the individual, household, national, regional and global levels, when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"** (WFS, FAO, 1996; Shaw, 2007)
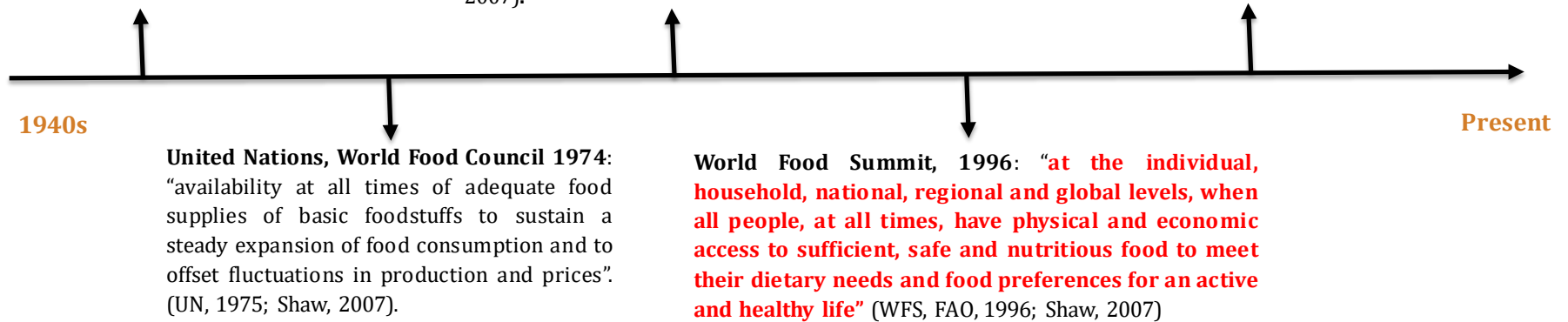
Source: Authors' reviews.

2.3. Food security conceptual framework

Many critics argue that the concept of food insecurity is too complicated and defied accurate measurements. Food security researchers and other practitioners commonly theorize the concept on three pillars: food availability; accessibility; utilization and stability. In this subsection, we explore the meaning of each of these pilars while explaining how they overlap in the measurement of the food security.

2.3.1. Food availability

This food availability pillar refers to the availability of food stocks for consumption in space and time. The World Food Program (WFP, 2009, p.170) defines availability as "the amount of food that is present in a country or area through all forms such as domestic production, imports, food stocks, and food aid." This implies the total amount of food available in a particular country which is made of both domestic production, imports, and food received as aid all measured using food balance figures in aggregate form (Coates, 2013). Thus trade and trade policies, meaning open borders, tariffs and quotas on imports influence the availability of food in a country.

Before Sen's (1982) work on individual or household's lack of entitlements, food availability was generally assumed to be synonymous to food security (Webb et al., 2006; Shaw, 2007). The green revolution, technological changes, and the industrial revolution have boosted agricultural production to the point where it outpaced population growth rate (Shaw, 2007; Simon, 2012). In the last fifty years, agricultural production has continuously grown faster than the population growth rate. The amount of food available based on the macronutrients content is sufficiently enough to feed more than today's global population. Yet, some people do not have

food regularly or fear they may not have enough in the future, raising issues related to the accessibility of food.

2.3.2. Food accessibility

Sen (1982) had pointed out that the main obstacle to food security was the accessibility, which is determined by poverty or lack of entitlements and social barriers instead of national food supply or availability. The WFP (2009, p. 170) defines accessibility as "a household's ability to acquire an adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts."

Accessibility of food also refers to three sub-dimensions: "…have physical, economic and social access…". 1996). The physical access refers to the logistical dimension of accessibility. To illustrate this aspect, we can imagine a situation of two regions or countries A and B with poor transportation and information infrastructures between them. Although food is abundantly available in country A, food may be limited in country B. In such a situation, food availability and accessibility issues in country B result from the physical location and infrastructure conditions between both countries and not because food is not available to be transported in country B.

Besides the physical accessibility, economic factors such as affordability can still influence food accessibility. It refers to the situation where people in country B may have or not the financial ability to obtain suitable amounts of food that meet their requirements (Simon, 2012). The economic sub-dimension relates to household food security whenever food commodities are available but not affordable to people who need it. Economic access is closely related to social science concepts of household well-being in regards of the range of food choices available to a household constrained to its income, food prices, and given safety net arrangements (Barrett,

2010). Purchasing power is crucial to food accessibility, and it is influenced by price policies and the dynamism of market integration, i.e., whether price signals are efficiently communicated spatially and temporally. Thus, food accessibility focuses on household demand for food and emphasizes on the issues related to income and factors such as periods of unemployment, price spikes, or the loss of livelihood-producing assets (Barrett, 2010). Different policies influence the accessibility to food in a particular region or country. Government commonly subsidizes staple food consumption to ensure their accessibility to the vast majority of the needy people.

The last dimension of food accessibility included in the WFS definition is related to social or socio-cultural aspects. This sub-dimension illustrates the accessibility of food where people have all the means to physically and economically access food commodities, but available foods are constrained by socio-cultural influences (Maxwell, 2012). These restrictions commonly target minority groups due to their gender, sexual orientation, religious beliefs, or social conditions, for instance. The social aspect is one of the accessibility dimension less studied in the current literature though it also has an essential influence on food security.

Overall, food accessibility is a multidimensional concept in itself, making its measurement equally tricky (Webb et al., 2006; Barrett, 2010). While physical accessibility can be approximated through the physical availability of food, economic accessibility's or food affordability's measurement is more challenging. In practice, researchers use proxies and combine various indicators to estimate accessibility (Barrett, 2010). Commonly, disaggregated or aggregated Household Consumption and Expenditure Survey (HCES) data are a great source of information to assess household food acquisition and consumption rates as well as significant socio-economic conditions that may influence those rates. A well-represented HCES dataset could also provide

information on poverty monitoring, food consumption database, and input consumer price indices (Smith et al., 2013). However, food accessibility using HCES can be biased due to structural issues in household consumption modules. For instance, some HCES do not provide information on food consumed away from home. Also, for most HCES recall periods can vary from 1-365 days, which raise potential reliability issue on recall bias.

2.3.3. Food utilization and stability

Food utilization is the last pillar in the food security definition provided by the WFS (2009, p. 170). It refers to food being "safe and nutritious, to meets their dietary needs." Food need to be safe and of good quality. Specifically, this third dimension goes beyond the quantity, monetary, and social aspects of food security, and focuses on the healthfulness of food, i.e., nutritional and dietary values. It has been organized into several sub-dimensions: (i) the selection of food commodities, (ii) conservation, (iii) preparation, (vi) and the absorption of nutrients (Simon, 2013). For instance, food utilization is also related to clean water, sanitation, and health care emphasizing food safety. The use of food also involves dietary quality, especially micronutrient deficiencies associated with an inadequate intake of essential minerals and vitamins (Barrett, 2010). The utilization dimension of food security can also be measured using household food consumption data captured in the HCES.

The WFP argues that people must be food secure at all times. This underscores the stability dimension. When stability is violated, food security becomes a threatening challenge. In the WFS definition, it emphasizes "**at all times,**" which is rarely operationalized in practice (Coates, 2013). The stability dimension involves the existence of chronic and transitory food insecurity in some

areas. Chronic food insecurity is described as a long-term or persistent inability to meet minimum food requirements while the transitory food insecurity is described as a short-term or temporary food deficit (Maxwell, 1996). These could also become cyclical due to the seasonality aspect of agricultural food production in most developing countries where farmers rely mostly on seasonal rains for production. Thus, the stability dimension applies to the three other dimensions: availability, access, and utilization.

2.4. Measurements of food security

Assessing the determinants of food security begins with the selection from its levels of analysis. Generally, food security is measured at the global, national, household, and individual level. Warr (2014), Jones, et al., (2013) and Pérez-Escamilla et al. (2017) have provided an extensive review of the food security proxies and indicators of measure used at each of these four levels of analysis. This section will focus primarily on their works.

Food security studies at the global level generally focus on international trends such as the food supply and its macronutrient sufficiency, trade and trade policies, and food prices. They do not necessarily focus on how aspects of food security affect individuals or households. Similarly, the majority of national food security studies evaluate the level of domestic food supply and imports to meet public demand (Warr, 2014). The most used indicators at the international and national level are the Prevalence of Undernourishment (PoU) and the Global Hunger Index (GHI). Since 1974, FAO has used the PoU to monitor global food security (Cafiero et al., 2014). The PoU mainly focuses on the concept of food deprivation by estimating parameters such as the mean level of Dietary Energy Consumption (DEC) or the cut-off point defined as the Minimum Dietary

Energy Requirement (MDER) (Pérez-Escamilla et al., 2017). The main advantage of this indicator is that it is affordable for countries to use in monitoring national food security. The second indicator widely used is GHI, which was developed by the International Food Policy Research Institute (IFPRI) to measure and track hunger at the global, and national levels (Pérez-Escamilla et al., 2017). The estimations of the GHI requires the use of data on the proportion of undernourished people, i.e., people who do not consume enough food to meet the daily minimum dietary energy requirements provided by the PoU.

However, global and national levels of food security indicators are aggregate in value, which do not necessarily highlight challenges at individual and household levels (Fouilleux et al., 2017). Also, most of the aggregate indicators frequently measure hunger and do not take into consideration the whole spectrum of food security experiences. To address these issues, household or individual scale analysis is critical to target and effectively provide the needed assistance to people experiencing food insecurity.

The literature identifies several indicators of measure estimated at the micro levels. HCESs provide a good source of information to measure household and individual food security experiences. HCESs offer a wide range of data on household or personal food consumption at home and away from home; estimate consumer price indices, and monitor poverty and household socio-economic status (Jones et al., 2013). Using HCES data, food security practitioners usually measure multiple foods and nutrition security indicators. One of the most estimated indicators is the Household Dietary Diversity Scores (HDDS) which measures household or individual food access based on their consumption within a given recall period based on a list of food groups. The HDDS was introduced by the USAID to evaluate the nutritional quality of household diets

(Deitchler et al., 2010). Household Food Consumption Score (FCS) is another indicator introduced by the WFP to monitor similar outcomes as the HDDS. The FCSs provide information on household dietary diversity, food consumption frequencies, and the relative importance of the different food groups regarding their nutritional content (Pérez-Escamilla et al., 2017). To understand household behaviors or strategies in the case of a threat of food deprivation, the Coping Strategies Index (CSI) was designed to assess how households cope with food restriction (Maxwell and Caldwell, 2008). According to Jones et al., (2013), CSIs are valuable when designing food aid programs and monitoring their impacts in emergencies.

While the PoU, GHI, HDDS, FCS, and CSI are all significant indicators of measure of food security, they only capture a limited aspect of an individual or household food security experiences. In response to this limitation or shortfall, experience-based food insecurity scales (EBFIS) have been developed and used over the past two decades to measure household level food security and insecurity experiences adequately. EBFIS are the only indicators that measure directly households food security experiences. EBFISs were first introduced in the 1980s and early 1990s in the U.S. and include experiences that range from psychological worry about not having enough food, decreasing both the quality and quantity of food intake, to household hunger.

The US Household Food Security Survey Module (HFSS-SM) is made of an eighteen item scale, which evaluates four experiences of household food security: 1) worry/anxiety about lack of household food consumption; 2) lack of quality or variety of food in the household; 3) reduction of adult food intake; and 4) reduction of food intake among children (Kennedy, 2002; Pérez-Escamilla et al., 2017). The HFSS-SM contains ten questions targeting adults and eight questions

on children about food security experiences over the previous twelve months before the survey[6]. All positive or affirmative responses to the eighteen questions are summed and then classified into three severity levels: 1) food secure, 2) low food security, and 3) very low food security.

The HFSS-SM is used as the foundation for the conception of several other household experience-based scales: the Household Food Insecurity Access Scale (HFIAS), Household Hunger Scale (HHS), Latin American and Caribbean Household Food Security Scale (ELCSA), and the most recent scale which is the Food Insecurity Experience Scale (FIES). Except for the HHS, which uniquely monitor hunger experiences, the majority of the EBFIS provide broader information on household food security experiences.

Using the EBFIS data, recent studies have shown that food security is a global challenge faced by both developing and developed countries (Coates et al., 2007; Kneafseay et al., 2013; Smith et al., 2017). EBFIS studies have been validated to adequately capture the severity of household or individual food security experiences. They have been used in the United Kingdom, Canada, Mexico, SSA, and Latin America, (Coates et al., 2003; Coates et al., 2007; Kneafseay, 2013, Smith et al., 2017). The EBFIS reports are ethnographic, cross-culturally validated (Ballard et al., 2011; Coates, 2013). The EBFIS report enables not only the identification of the food insecure people but also provide a deep insight into the determinants of their food insecurity (Nord, 2014).

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[6] The eighteen US Household Food Security Survey Module (HFSS-SM) questions are listed in the Appendix A.

Despite their usefulness in capturing individual and household food insecurity experiences, the EBFIS still fails to clearly distinguish among food insecurity, nutrition security, hunger and other dimensions of interest to researchers and policymakers (Barrett, 2010; Jones et al., 2013). For instance, for the majority of the EBFIS, hunger is considered as the extreme experience in the food security continuum (Coleman-Jensen et al., 2015; FAO, 2016) even though it is referenced in the literature that food security is different from nutrition security and so to hunger (Pangaribowo et al., 2013; Lele et al., 2016).

The lack of clarity in the literature about the difference between these different concepts: food insecurity and hunger is the primary motivation for this research. As shown in the results reviewed, without this clarity, it is difficult to determine what is being measured, identify how to interpret the results, and provide policy directions.

2.5. Reframing food (in)security

It is necessary to provide a clear definition of food insecurity that separates it from the understanding of other constructs. This distinction is essential as it enhances food insecurity conversations and policy outcomes on its challenges. To do so, we explore the etymological components of the concept: "food" and "security." First, food is defined as what is eaten or drunk to provide nutritional support for life and growth (Businessdictionnary, 2018). Security is defined as the state of being free from danger or threat of danger (Walt, 1991).

Security is often presented as a national or community issues, but it can also be analyzed at any level, i.e., individual or household. Usually, an issue is considered a "security issue" if it involves military force and if military force is not pertinent, such a problem is classified as a low

politics matter (Walt, 1991; Baldwin, 1997). For instance, the 9-11 terrorist attack in the U.S. has incorporated into its national security mindset a possibility that may have never existed before: flying airplanes into large buildings to create terror. Similarly, in response to threats of a military attack, most states develop prevention policies. These policies aim to provide "security" by lowering the probability that the attack might occur (Baldwin, 1997).

Although the security literature has primarily focused on nations and states, the concept of security is applicable, *mutatis mutandis,* to any level: individual, household, state, and international (Baldwin, 1997). For instance, while exploring the concept of security at the individual level, Ullman (1983) and Baldwin (1997) found that one may not realize what security is until threatened with its loss. People's awareness or consciousness about security is often non-existent until any danger or the probability of risk arises to threaten it. For instance, the use of home security systems is usually directed at potential burglars, given their likelihood of occurrence at a particular location or neighborhood. The likelihood of the violation of people's sense of security also influences the urgency of the search and implementation of solutions. Thus, security often emerges as a concern only when it is violated or under a threat of violation.

Lack of security engenders fear or worry. This often causes negative thoughts about oneself ability to reach specific goals. The condition is often accompanied by anxiety. For example, it is possible that when the large proportion of citizens in a particular country worry about their security and safety, they may not make adequate investment in economic development. We see this in war-torn countries. Likewise, the economic development of any country will be stunted if its people lack security about food and have to frequently worry about their food access instead of investing their resources in productive enterprises.

Here we use the link between national and personal security with and food security. Amanor-Boadu (2018) argued this in his conversation with the military. Using the foregoing construct as a foundation of the development of our understanding, we claim that food security often emerges as an issue or objective only when households or an individual have experienced or risk experiencing a threat of not having food or enough food. Such an understanding makes individual food security a concept that is structurally triggered by shocks or past experiences related to their food access. For instance, a small remote community that has lived in peace for generations may not have any sense of insecurity toward their food supply until some pest attacks cause a massive loss of food supply, supplanting in their mindsets the potential risk or fear of future unavailability of food. Thus, individuals worrying or fearing inadequate food consumption is classified as food insecure that he or she may not have food or enough food lacks by default food security (Amanor-Boadu, 2018). Food security, like any other personal security or information security, has been in existence since humans' sense of having unfettered access to food was interrupted by natural or human actions, such as drought, floods, pest attacks, loss of income, and war or conflicts.

Food security has not been constructed to be as succinct as presented above, and thus, the exploration of its antecedents, measurement, and consequences have often been challenging. An in-depth review of the current literature reveals that the ongoing construction of food security as the state of being free from the risk or from the threat of not having food is quite inexistent or absent. This absence can be explained by several reasons among which the very construction of food security in modern times. Food security is widely defined as a situation when all people, at all times, have physical and economic, access to sufficient safe and nutritious food to meet their

dietary needs and food preferences for a healthy and active life[7] (FAO, 1996). Such an understanding of food security is not only very holistic and multidimensional but it also very difficult to apprehend empirically in most household-level studies. As a result, food security has been used interchangeably with other related concepts such as hunger, undernourishment, and malnutrition (Barrett, 2010; Jones et al., 2013).

Also, food security has been presented as an aspiration (Barrett, 2010) at a supranational level, instead of a real challenge to mainly individuals and nations, making it challenging to provide its compelling understanding and measurement. For instance, at its early stages, knowledge about the concept of food security only referred to the production of food grain and its distribution into the developing world: Africa, Asia and Latin America (Leathers and Phillips 2004; Jarosz, 2011; Kneafseay et al., 2013) making food security a poor or developing country problem instead of a global microeconomic challenge. Thus, we argue that one of the reasons why food security remains a significant concern today, in both developing and developed countries (Coleman-Jensen et al., 2015; Smith et al., 2017), could be because it has always been interchangeable with hunger. For instance, someone could be eating a complete meal at a time, i.e., not feeling hungry, but still worrying about where its next meal might originate from. This situation could be explained whether by the individual's familiarity with a sense of food deprivation or hunger which he fears might occur again or simply due to the uncertainty and anxiety surrounding his future food access giving its current circumstances (National Research Council, 2006). The idea of worrying about future food access separates the two concepts into a

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[7] FAO (1996) Declaration on world food security. World Food Summit, FAO, Rome.

categorical manner. It also allows for the explanation of how hunger transforms into food insecurity, and provide an opportunity to develop effective solutions to address them independently.

Thus, food security can refer to as the state of being free from the danger or from the threat of not having food. When an individual finds himself in a situation where he feels uncertain, anxious, or worried about his food consumption, he lacks security about food and becomes food insecure. Food security from this operational perspective can be a current or future event but does not necessarily imply hunger or malnutrition. Referring to the classification of Perez-Escamilla et al. (2017), we could also argue that such definition and understanding is SMART (Specific, Measurable, Achievable, Relevant, and Time-bounded). Such knowledge of the concept addresses our foremost critic of the EBFIS. This definition is identifiable and idiosyncratic of the security that individuals express toward his or her food consumption. It also distinguishes food security from all other closely related concepts which tend to confuse.

Furthermore, defining food security as the state of being free from worry, anxiety, or uncertainty about food was recognized in the EBFIS studies. However, the literature review on the EBFIS did not indicate that researchers connected the potential showing how one may transform into the other. We could also use the same methodological approach, i.e., the item response theory (IRT) to measure individual or household food security, just like the case of the EBFIS.

Therefore, this research seeks to stop the trend and confusion between food security, malnutrition, and hunger by broadening the scope of the concept in a more focused manner, emphasizing singularly on individual psychological worry or sense of insecurity about his food

access. With the increasing awareness about the ubiquitous nature of mental health issues across nations (WHO, 2014), the importance of this research is further revealed as it incorporates both the traditional, i.e., non-cognitive dimensions of the concept and also emphasizes the cognitive ones in a way that facilitates the systemic and strategic approach to addressing the food security challenges. The novelty of this research is the different approach it brings to the conversation about food security and, hopefully, it could present a potential solution to such a global risk and not only to a region or a country per se. Figure 2 below shows the diagram of the concept of food (in) security.

Figure 2- Diagram of the concept of household or individual food (in) Security
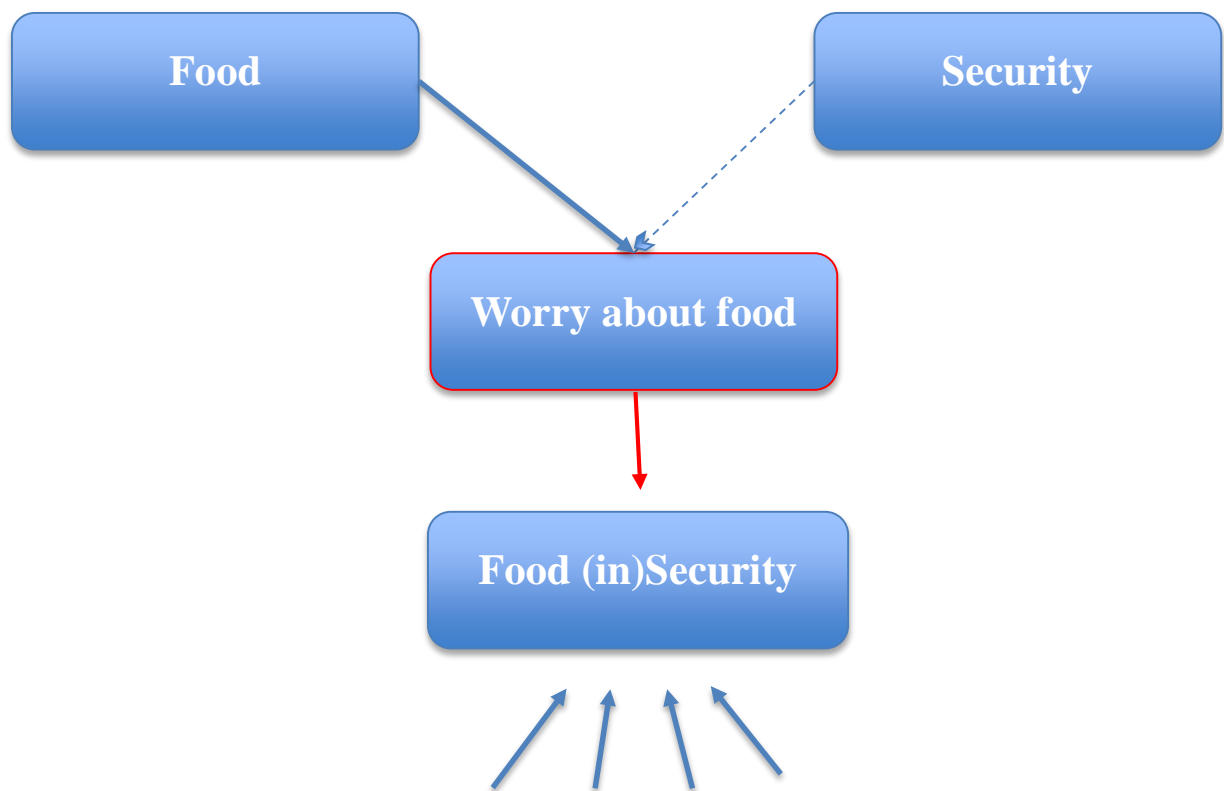
The dash line in the diagram indicates that household or individual lacks security about food, while the solid arrows indicate the directional effects.

2.6. Food insecurity as worry: From physical to a mental health challenge

This section links food security discourse with the literature on insecurity as the sense of a violation of one's "security" about food access from a mental health perspective focusing primarily on the concept of "worry" and "anxiety" about food. Here we define the concept of worry, how it is commonly measured in the literature.

2.6.1. Definitions and factors leading to worry

According to Borkovec et al., (1983, p. 10), worry is:

A chain of thoughts and images, negatively affect-laden and relatively uncontrollable; it represents an attempt to engage in mental problem-solving on an issue whose outcome is uncertain but contains the possibility of one or more negative outcomes; consequently, worry relates closely to the fear process."

Borkovec, Ray, and Stober, (1998) provided a slightly different understanding of the concept, focusing less on the series of images as indicated by Borkovec et al., (1983). For them, worry is "a predominance of negatively balanced verbal thought. These understanding of the concept have mainly originated from participants' self-reports of what they felt when worried. In response to the question, why they worry, patients answered that "*worry helps distract me from more emotional topics*" or "*prepare for the worst*" (Borkovec and Roemer, 1995; Makovac et al., 2018). Most people who worry tend to have an anxious apprehension for future centered on adverse events (Holaway et al., 2006).

Majority of studies about worry use the theory of cognitive avoidance to approach individuals' experiences regarding the neurobiological features of the concept. Worry interferes with various cognitive processes which determine the effectiveness of people's task performance

(Zeidner, 1998). Structurally, individuals' experiences of worry range from a general controllable or non-anxious state to a sick, pathological, and uncontrollable feeling described as part of the Generalized Anxiety Disorder (GAD). However, this process is not necessarily discrete, i.e., controllable versus uncontrollable, even though the normal and pathological worry represent two opposite ends of this continuum (Holaway et al., 2006). Individuals with GAD worry more frequently and worry more about diverse topics, and find their worry more difficult to control than their non-anxious counterparts (Holaway et al., 2006). Authors argue that anxiety and worry are generally accompanied with at least three of the following physical or cognitive symptoms: a) edginess or restlessness; b) tiring easily more fatigued than usual; impaired concentration or feeling as though the mind goes blank; c) irritability; d) increased muscle aches or soreness; and e) difficulty sleeping.

People struggling with any form of GAD spent a high percentage of their waking time worrying about something instead of investing in productive activities. Given the very importance of food for survival, worrying about food can quickly become a severe challenge which can become hard to control. People who worry may not necessarily worry about one single outcome like access to food but may degenerate into multiple and sometimes incoherent issues. Worry can be the results of many aspects or objective in life. Roemer et al. (1997) and Holaway et al. (2006) argued that people generally worry about: (i) work and school, (ii) family and interpersonal relationships, (iii) financial issues, (iv) illness, health, and injury, and (v) miscellaneous topics (e.g., minor matters, punctuality, home repairs).

2.6.2. Assessment of the concept of worry

Overall, the two most noticeable models used to assess individuals' worry experiences are the Intolerance of Uncertainty (IU) model (Dugas et al., 1997) and the Metacognitive model (Wells, 1999). The IU model suggests that individuals experiencing higher intensity in IU find uncertain or ambiguous situations extraordinarily distressing and that this will trigger a repetitive *"what if …?"* thinking style in their mind (Britton et al., 2019). The IU model offers the opportunity to evaluate how an individual can both create worry about an uncertain outcome but also lock himself in it (Koerner and Dugas, 2006). On the other hand, the metacognitive model (Wells, 1999) differentiates between worries labeled as Type 1 and Type 2. Type 1 worry refers to the positive beliefs derived from worry. That is worrying, clarifies my thoughts, and improve my concentration. Type 2 worry involves the negative opinions about the issues being worried about. That is worrying engenders tension and irritability. Thus Type 2 triggers a maladaptive and uncontrollable feeling about potential outcomes.

Regardless of the type of model used, worry and anxiety result from uncertainty, and they can be conceptualized as both (i) a stable and external trait and (ii) as a transient pathological mental state. Due to its intrinsic characteristics, most worry researches have primarily focused on assessing its external features (Buhr and Dugas, 2006; Britton et al., 2019). The element of worry represents an outgrowth of the more broadly-defined construct of trait anxiety, which is seen as a facet of the behavior super factor of neuroticism (Matthews et al., 2002). To assess the prevalence of worry, most researchers use the Penn State Worry Questionnaire (PSWQ) (Meyer et al., 1990) or the New York Cognition Questionnaire (NYC-Q; Gorgolewski et al., 2014, Sanders et al., 2017). The PSWQ has 16-item questions developed to assess the frequency and intensity of an

individual's worry. The NYC-Q questionnaire has established utility in neuroimaging studies, where self-generated verbal cognitions, across a large normative sample, are inversely associated with the engagement of regions of retrosplenial cortex closely linked to the hippocampus (Gorgolewski et al., 2014). Alternatively, worry has been studied via thought sampling (Smallwood et al., 2004), and measures with allied constructs, such as cognitive interference (Sarason et al., 1996), ad hoc indices, and other multidimensional state assessment (Matthews et al., 2002).

In the U.S. Household Food Security Scale Survey Module (HFSS-SM), National Research Council (2006) have used uncertainty as the primary trigger to households worry about their access to food. Their representation of "worry" about food did not involve any uncontrollable transient pathological mental state. We could argue that the Type 1 worry is used in the EBFIS in analyzing household food insecurity experiences.

2.6.3. Worrying about food

Limited studies in food security literature have tried to establish the relationship between individual food security and mental health issues. For instance, Hadley and Patil (2006) have examined the case of maternal anxiety and depression about their food insecurity in rural Tanzania. The results show a positive correlation between the high degree of vulnerability and exposure to mental distress and food insecurity. Such relation is established due to the significant influence of uncertainty, including those related to hunger and poverty on mental health. For instance, 75% of female respondents designated hunger as one of their most essential concerns that triggered their worry (Hadley and Patil, 2006).

Similarly, using data from a longitudinal sample collected in 2009 from rural farmer's households in Zambia, Cole, and Tembo (2011) have quantitatively assessed the relationship between adult mental health status and food insecurity. They focused on the contrast of agricultural production seasonality such as dry season, i.e., when households have food from their harvest and wet season when households experience food scarcity waiting for their upcoming harvests. They confirmed a positive relationship between food insecurity and high mental distress. The particularity of the study by Cole and Tembo (2011) is their use of qualitative ethnographic information in establishing the relationship between food insecurity and mental health distresses. They also emphasized on agricultural seasonality as the main factor leading to household mental health distress and food security status. Cole and Tembo (2011), and Hadley and Patil (2006) hypothesized that food insecure households would report elevated psychological distress compared to food secure households. Also, these studies concluded that rural populations and especially women heads of households involved in agricultural production were more likely to experience high mental distress in the growing seasons due to the pressure they have in ensuring the availability of food to their families.

Atuoye and Luginaah (2017) have also evaluated a similar relationship in the Upper West Region of Ghana. They also concluded that heads of households who suffered from moderate to severe food insecurity were more likely to report elevated mental distress compared to food secure households. Their study is built on Cole and Tembo (2011), and Hadley and Patil (2006) respectively in Tanzania and Zambia. However, in addition to the agricultural seasonality and socio-demographic factors, Atuoye and Luginaah (2017) also emphasized factors such as social cohesion and social support to significantly influenced mental health. For instance, they found that

households who needed to receive steadily any form of remittance were positively associated with high psychological distress. Also, those who were part of membership groups were negatively related to high mental health distress. Social groups generally provide social buffers and network systems for group members (Cohen et al., 1986; Atuoye and Luginaah, 2017). Commonly, social groups are formed for a specific objective such as religion, economic motives (e.g., farmer associations and women's business groups), and community development. Atuoye and Luginaah (2017) also established a relationship between wealth and mental health. For instance, they found that poor household heads were less likely to report high psychological distress in their household compared to their wealthier counterparts.

One striking difference across all the studies presented above is the heterogeneity in their mental health variables. Atuoye and Luginaah (2017) used the Duke Health Profile to construct their "elevated mental distress" outcome variable and the HFIAS as an indicator of food security. The DUKE Health Profile is made of a set of five questions summarized as follow: 1) I like who I am, 2) I give up too easily, 3) I have difficulty concentrating, 4) Feeling depressed or sad, 5) Feeling nervous. Cole and Tembo (2011) and Hadley and Patil (2006) both constructed their mental health variable using the WHO's Self-Reporting Questionnaire (SRQ), which is made of a 20-items questionnaire with responses that assess psychiatric symptomatology (WHO, and Calouste Gulbenkian Foundation, 1994). The SRQ contains both physical and somatic items such as headaches, loss of appetite, tiredness, and also psychological items like feeling unhappy, nervous, worthless (Cole and Tembo, 2011). Hadley et al. (2006) used the Hopkins Symptom Checklist (HSCL) to construct their mental distress variable. This instrument is intended to measure symptoms of anxiety and depression by asking respondents to rate their severity scale.

To measure household food security, these authors used modified versions of the USDA's HFSS-SM. While authors have reported consistent statistical parameters in establishing their relationship between food security and mental health, their result could raise some problems. For instance, people may report feeling sad, giving up early, not liking who they are, and other mental health characteristics which may not necessarily have any relationship with their food access. Also, the use of the HFIAS or revised versions of the U.S. HFSS-SM as a right-hand size variable could induce some potential biases in their estimations. These EBFIS already included mental health distress items like worrying about running out of food. Thus, to some extent, the left and right-hand sides variables may be capturing similar mental health distress effects.

Furthermore, using these food security scales as right-hand side variables kept on perpetuating the confusion between food insecurity and hunger. For the majority of the EBFIS, hunger is considered as the severest experience. It is essential to distinguish food insecurity from hunger clearly. To overcome the shortfalls of these estimations and specifications, we define food security as the state of being free from the danger or from the threat of not having food. From that definition, we argue that individuals who do not have that freedom from the want of food lack security about food and then worry or feel anxious about their food consumption. To evaluate factors that influence individual food insecurity experience, i.e., worry, we follow the methodological approach of Coleman-Jensen et al., (2015) and Smith et al., (2017).

Coleman-Jensen et al. (2015) have evaluated the prevalence of food security among U.S. households using the US HFSS-SM. They found that 98% of 6.9 million households responded yes to the question whether they worried their food would run out before they got money to buy more. Considering that households in the U.S. are on average made of 2.6 individual, these

statistics indicate that multiple millions of people worry they would run out of food. Smith et al. (2017) evaluated similar relationships using FAO's Food Insecurity Experience Scale (FIES) covering 134 countries. Using a binary variable labeled "food insecurity" that takes one if an individual experienced moderate or severe food insecurity and 0 otherwise, i.e., worried about food, authors found that, more than 70% of their world population sampled reported to have at least worried about their food accessibility. Consistent with Coleman-Jensen et al. (2015) findings, Smith et al. (2017) concluded that 98% of the sample covering developed countries, worried about their food access compare to more than 40% in developing countries. Smith at al., (2017) are among the few that conducted a comparable cross-country estimate on the commonalities and differences of individual food security determinants around the world. They estimated a series of multilevel linear probability models and found that the five factors associated with the most significant increase in the probability of experiencing food insecurity are: low levels of education, unemployment, low income, weak social networks, and less social capital. Formal education provides excellent opportunities for regular wages, which could cope with the vulnerability to food insecurity. The increasing breadth of studies has also found that education, i.e., literate individuals are less likely to be food insecure compared to illiterate ones.

While food insecurity is primarily a microeconomics issue, it can also result in some uncontrollable factors. Barrett (2010) indicates that seasonality event or random shocks such as weather events, deaths of an income provider, or social conflicts can engender individual food insecurity. Similarly, previous studies have also found that structural factors such as national poverty rate have the leading likelihood on individual ability to have adequate access to food (Barrett, 2010). For the most part, food insecurity results from a lack of economic means to access

food. The most significant improvements in alleviating food insecurity have happened in the developing world, due mostly to a determination to increase economic growth, individuals' income, and means to address undernourishment (FAO et al., 2013). Economic growth is necessary but is not a sufficient condition for household food security. Other determinants such as high food prices, social inequality, and the imbalanced supply of food within countries also affect national food insecurity and in its turn influenced individual prevalence rates (FAO, 2012). Thus, solving food insecurity may not be achieved through economic growth only (Haddad et al., 2003). These results show that while some common factors are anteceding individual food insecurity, country-specific policies may also be crucial in addressing food insecurity challenge.

Chapter 3 – Data and methods

3.1. Background

We started this research arguing that over seven decades of research and policies discourse about food security, it has not been possible to differentiate food insecurity from hunger in ways that allow for its precise measurements. As a result, the relationship between both concepts has not been established. This study attempts to address this problem. We used data from Tanzania, a low-income country, to address our empirical objectives. Thus, this chapter discusses not only the study area but also the data and methods used in meeting these objectives.

3.2. Study area

Tanzania is located in East Africa within the African Great Lakes region. It has significant natural resources such as lakes, forestry, and wildlife. Tanzania has its two most famous lakes, i.e., Lake Victoria and Tanganyika located both in the northwest side. Lake Victoria is the largest freshwater lake in Africa, and Lake Tanganyika is the second-deepest lake in the world. Tanzania borders Uganda to the north; Kenya to the northeast; the Comoro Islands in the Indian Ocean to the east; Mozambique and Malawi to the south; Zambia to the southwest; and Rwanda, Burundi, and the Democratic Republic of the Congo to the west. Tanzania is also the home country of the Mount Kilimanjaro, Africa's highest mountain. In 2017, Tanzania's population was estimated to be more than 57 million people (World Bank, 2017) with 67 percent living in rural areas and the remaining 33 percent living in urban locations. Agriculture accounts for 45 percent of its GDP, as well as the livelihoods of 80 percent of the country's population (WFP, 2012).

Figure 3- Tanzania on the African map

Source: CIA, The World Factbook. Country: Tanzania.

3.3. Data

Tanzania is selected for this study because of the availability of household survey data that provided information about households' food insecurity or worry about their food access. The

Tanzanian household survey data is managed by the World Bank LSMS-ISA team and the Tanzanian National Panel Survey (TZNPS) office and offers one cross-sectional dataset (2014-2015), and a two-years' panel dataset (2010-2011) and (2012-2013). The survey questionnaire provides comprehensive information at the individual and household levels. Household survey questionnaire includes 23 sections ranging alphabetically from A) to V) and covers sociodemographic characteristics, labor market participation, asset ownership and wealth, expenditure, public and private transfers, different types of shocks experienced by the household, and behavioral food security experiences. The demographic and socio-economic section include the place of residence, education level, marital status, transportation cost to the nearest market, health, and educational infrastructure. Agricultural households were also asked detailed agricultural information about their farming practices. The popualtion sample surveyed was deemed representative of the population of Tanzania and offers an opportunity to study household food insecurity experiences.

The first two questions in Section H: Food security of the survey questionnaire, labeled here as A and B, are of specific interest to our study.

A. **"In the past seven days, did you worry that your household would not have enough food?":** Yes or No.

B. **"In the past seven days, how many days you or someone in your household had to:**

a) Rely on less preferred foods?

b) Limit the variety of foods eaten?

c) Limit portion size at mealtimes?

d) Reduce the number of meals eaten in a day?

e) Restrict consumption by adults for small children to eat?

f) Borrow food, or rely on help from a friend or relative?

g) Have no food of any kind in your household?

h) Go a whole day and night without eating anything?

Question A relates directly to our definition of food insecurity as worry about food access. Therefore, it allows us to assess the likelihood of specific demographic and socioeconomic variables engendering that situation. Question B addresses our understanding of household's hunger directly. While each option of the question B provides an aspect of household hunger, we focus on the option h) as it gives the severity of these experiences illustrated by "the whole day and night with food." This question provides us with the opportunity to test the antecedent hypothesis of congruence and also determine if there is a switching point in terms of the number of days of hunger threshold that generates food insecurity.

Considering the National Research Council's (2006) item response theory (IRT) used for the HFIAS or FIES severity spectrum, we could argue that individuals who had an affirmative answer to questions B options a, b, and c compromised the quality and quantity of their food consumption; while those who said yes also to options d, e, and f skipped meals or consumed less to make food last longer. However, we argue that an affirmative answer to options g, and especially h are indicative of hunger and used households' responses to option h as a proxy of hunger in testing our research hypothesis.

3.4. Methods

3.4.1. Theoretical framework of household food security experiences

Two significant theories are considered in this analysis: the entitlement theory introduced by Sen (1982) in the studies of famines and the uncertainty, and the anxiety theory evoked by the National Research Council (2006) in developing the items included in the EBFIS. The two approaches or theories provide a foundation for studying household food insecurity and hunger.

Sen's (1982) induced a paradigm shift from food security analysis as a food supply issue centered on the Malthusian approach of increasing food production to the individual and household food access centered on the framework of entitlements. The entitlements framework indicates that people's food security is constrained to market forces, which in turn are subject to socio-economic and political conditions prevailing in a given society. Mostly, Sen (1982) identified two major categories underlying his theory endowments and entitlements. Endowment refers to individuals' control and use of their assets and resources such as land, labor, and skills exchanged on the market to command the food they want. Entitlement refers to "*the set of alternative commodity bundles that a person can command in a society using the totality of right and opportunities that he or she faces*" (Sen, 1986, p. 497). Sen (1982) argued that even though food may be available, people with entitlement failure are more likely to experience hunger.

Thus following Sen's theory we also argue that people's food security can be analyzed through two significant ways: (i) Endowments such as direct ownership of food via all means of production such as crop and livestock or by (ii) converting their wealth, i.e., wages and assets into food. From such understanding, food insecurity could result from a set of shocks or losses of

endowment such as land and labor power. It could also result in the loss of food production through drought, flooding, pest attacks. Similarly, the rise in food prices, changes in trade policies, and unemployment leading to the fall in wages could also affect negatively people's ability to access the food they desire (Sen, 1982). Based on the entitlement theory, we assume that people sense of insecurity or worry or fear about their food access would be primarily subject to their wealth and specifically their ability to turn their wealth, private and public assistance, and assets or endowments into food. Thus, we would expect that an increase in wage or any valuable asset holdings to decrease the likelihood of experiencing worry or fear about food access. Similarly, cost generating factors such as the number of children or household size as well as the loss in endowments and assets would increase the likelihood of being food insecure.

Uncertainty about future adverse events such as illnesses and injuries may hurt individuals making them worry about or fear possible outcomes (Mischel, 1977). The possibility of uncertain adverse events may equally engender worry or fear, which could be about food access. People's uncertainty about their future food access could cause the feeling of insecurity or worry subjected to the amount of wealth they possess (National Research Council, 2006). Thus, we would expect that household that self-identified themselves as wealthy or financially stable to be less likely to experience food insecurity or hunger. In contradiction, we assume that poor households with limited to no valuable assets are more likely to be food insecure or hungry.

Hunger defined as a physical sensation of food craving, generally, resulted in hours of fast may not necessarily be accompanied by food insecurity. We would expect that an increase in food expenditure or the fall in food prices would reduce the likelihood for a household to experience food intake disruption for an entire day. Also, agricultural shocks such as drought, water shortage,

and crop diseases could affect the availability of food and subsequently negatively influenced households' accessibility to food, leading to hunger. However, we assume that wealth and valuable asset holdings could be used to command necessary food even in stressed accessibility time. Therefore, we would expect a negative relationship between the likelihood of being hungry and the wealth status and asset holdings of households.

3.4.2. Conceptual framework

3.4.2.1.   Outcome variables: insecurity about food (worry) and hunger

In this research, we are interested in determining whether food insecurity and hunger are synonyms. We argued that they are different. However, if they were synonyms, we hypothesize that their antecedents will be statistically the same. So we tested the hypothesis that all the above-described factors equally explained both food insecurity and hunger. However, we expect to reject this null hypothesis of congruence because of both concepts respective etymologies presented above.

We also argued that hunger might be a contributing factor for household food insecurity. Therefore, we may conceive a continuum that presents a threshold or a switching point at which hunger transform from a physical sensation to becoming an insecurity about food. We model the two outcomes variables as follow:

$$I = f(X)$$

$$H = g(X)$$

Where we refer I to food insecurity and H to hunger.

X is a vector of explanatory variables. The option h in question B was specified as a categorical variable accounting for the number of days that a household experienced a whole day and night without eating anything in the past seven days. To enable the comparative analysis between I and H, we turned the categorical variable in option h into a binary variable coded as one if the household responded "yes," and "zero" otherwise. Similarly, the variable I takes the value one if household responded "yes" to question A, and "zero" otherwise.

3.4.2.2. Independent variables

The vector of explanatory variables, X, used in this empirical analysis, is frequently referenced in the food security literature and is selected based on the theoretical foundation of the study. X is a vector of: (i) households' head demographic characteristics such as gender, age, marital status, education level, household size, number of children, and place of residence; (ii) economic features such as food expenditure, wage, employment, assets holdings, number of working adults; and (iii) social capital characteristics such as private and public assistance. Regions fixed effects are also included to this model. We used the same set of explanatory variables, X, for both dependent variables.

$$\textbf{\textit{I}} = \textbf{\textit{f}} \; (\textbf{Demographic; Economic; Social capital}; \textbf{Region fixed effect}) \qquad (\textbf{1})$$

$$\textbf{\textit{H}} = \textbf{g} \; (\textbf{Demographic; Economic; Social capital}; \textbf{Region fixed effect}) \qquad (\textbf{2})$$

For simplicity, we organize all the independent variables into household food access variables, namely: Physical Access (PA), Economic Access (EA), and Social Access (SA) to which we added the demographic characteristics (D) of the household, and the region fixed effect. Table 1 below summarizes these fitted variables and their format or structure.

Table 1- Summary of the fitted variables

Categories		Variables	Type of variable
Dependent variables			
		I (food insecurity) and H (hunger)	Binary (Yes/No)
Independent variables			
Physical Access (PA)	Food production	Household engaged in agriculture: farming and livestock.	Binary (Yes/No)
	Shocks	Drought or floods, severe water shortage, livestock died or stolen, loss of land, crop disease or crop pests, massive rise in agricultural input prices.	Binary (Yes/No)
Economic Access (EA)	Wealth & assets	Radio, poultry, telephone (mobile), livestock, television, bicycle, fan (air conditioner), hoes, fields (land).	Binary (Yes/No)
		Food expenditure, wage	Continuous
		Employment status, welfare self-assessment.	Categorical
	Shocks	Household business failure, loss of salaries/employment, significant fall in sale prices for crops, a massive rise in price of food.	Binary (Yes/No)
Social Access (SA)	Assistance	Government and NGOs supports, farmer organization, remittances.	Binary (Yes/No)
	Shocks	Death of family members	Binary (Yes/No)
Demographics (D)	Covariates	Household size, age, Squared (household size, age), number of children. gender, marital status, education, place of residence.	Continuous Binary (Yes/No)
	Fixed effects	Regions	Binary (Yes/No)

3.4.3. Empirical specification

To achieve the specific Objective 3, we estimate logit models for each outcome variable separately and interpreted the effect of their respective preceding factors. However, to test the hypothesis of congruence and the threshold point, we estimate some seemingly unrelated bivariate probit models by estimating equations (1) and (2) jointly. Below we present both models conceptual frameworks.

3.4.3.1.   Logit specifications

To assess factors that influence household food insecurity as worry, we specify the following logit model. The underlying assumption behind the logit model besides the standard logistic distribution is that it takes into consideration the existence of a real latent factor, F^* which can truly cause an individual to either become food insecure or hungry but which can can not measure. We defines F^* as follow:

$$F_i^* = \theta' X_i + \mu_i \tag{3}$$

where (μ_i) is a vector of systematic and random errors which we assume have a standard logistic distribution. X_i, a vector of explanatory variables of household i listed in Table 1.

$$X_i = \left\{ D(X_d)_i;\ PA\left(X_p\right)_i; EA(X_e)_i;\ SA(X_s)_i \right\} \tag{4}$$

where $D(X_d)_i$, $PA\left(X_p\right)_i$, $EA(X_e)_i$, and $SA(X_s)_i$ represents respectively the vector of household demographics characteristics, physical, economic, and social access previously listed in Table 1. For simplicity and economy of space let's define Y_i as the vector of dependent variables I and H.

$$Y_i = (I, H) \tag{5}$$

$$Y_i = F_i^* + e_i \qquad (6)$$

As we do not observe F^*, we can only use variables that approximate household food insecurity or hungry described here as X.

$$\begin{cases} Y_i = 1, & \text{if } F_i^* > 0 \\ Y_i = 0, & \text{otherwise} \end{cases} \qquad (7)$$

As a result, $\theta' X_i$ in equation (3) is no longer equals to $E(Y_i|X_i)$ as would have been the case in a linear probability model, but instead we have $E(FS_i^*|X_i)$ which is estimated using the following equations.

$$Prob\ (Y_i = 1|\ X_i) = Prob\ (F_i^* > 0|\ X_i) = Prob\ (\mu_i > -\theta' X_i|\ X) = 1 - F(-\theta' X_i) \qquad (8)$$

$$Prob\ (Y_i = 1|\ X_i) = 1 - F\left\{\theta'\left(D(X_d)_i;\ PA(X_p)_i;\ EA(X_e)_i;\ SA(X_s)_i\right)\right\} \qquad (9)$$

Furthermore, let's define F as the cumulative distribution function of μ_i. To estimate the relationships (9 and 10) we use a likelihood function L defines as follow.

$$L = \prod_{Y_i=0} F(-\theta' X_i) \prod_{Y_i=1} \{1 - F(-\theta' X_i)\} \qquad (10)$$

As we assume a standard logistic distribution of the error term μ_i are $IN(0, \sigma^2)$ we can then estimate the relation (10) as follow:

$$F(-\theta' X_i) = \frac{exp(-\theta' X_i)}{1 + exp(-\theta' X_i)} = \frac{1}{1 + exp(\theta' X_i)} \qquad (11)$$

$$\left(1 - F(-\theta' X_i)\right) = \frac{exp(\theta' X_i)}{1 + exp(\theta' X_i)} \qquad (12)$$

3.4.3.2. Seemingly unrelated bivariate probit specification

The seemingly unrelated bivariate probit models are specified to test the hypothesis of (i) congruence between food insecurity and hunger, and (ii) determine the switching point or threshold that transforms hunger from a physical sensation to food.

The bivariate probit model is an extension of the traditional probit model as it allows more than one equation, and correlated disturbances, in the same way as other seemingly unrelated regressions models. The general specification for a joint two-equation or bivariate probit model is:

$$\begin{cases} I_i = X'\beta_i + \varepsilon_i, & I = 1, if\ F_i^* > 0\ and\ 0\ otherwise \\ H_i = X'\delta_i + \epsilon_i, & H = 1, if\ F_i^* > 0\ and\ 0\ otherwise \end{cases} \tag{13}$$

Where X is the same set of explanatory variables included in Table 1 and used in both equations.

Also, $E[\varepsilon_i|X] = E[\epsilon_i|X] = 0$ (14)

$Var[\varepsilon_i|X] = Var[\epsilon_i|X] = 1$ (15)

$Cov[\varepsilon_i, \epsilon_i|X, X] = \rho$ (16)

ρ is the variance-covariance equation. They may be structured alternatively as:

Alternatively, $\begin{pmatrix} \varepsilon_i \\ \epsilon_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right]$ (17)

A Wald test on ρ which represents the correlation coefficient between the residuals of each of the two probits equations is generally performed to measure wthether there is a value in estimation both equation jointly or independently. If rho (ρ) is statistically significantly different from zero, then it is preferable to estimate the two equations simultaneously. However, If rho (ρ) is not statistically different from zero, then the joint estimation would not perform any better than the independent one.

Equation (13) is estimated using a maximum likelihood estimation. The bivariate normal

cumulative distribution function (CDF) is $\boldsymbol{\phi_2}$

$$Prob\ (\boldsymbol{X} < x_I, \boldsymbol{X} < x_H) = \int_{-\infty}^{X} \int_{-\infty}^{X} \emptyset_2(z_I, z_H, \rho)\ dz_I dz_H.$$

$$\emptyset_2(z_I, z_H, \rho) = \frac{e^{-(^1/_2)\left(x_I^2 + x_H^2 - 2\rho x_I x_H\right)\Big/(1-\rho^2)}}{2\pi(1-\rho^2)^{1/2}}$$

The subscript two (2) is used to indicate the bivariate normal distribution in the density $\emptyset_2$

also, CDF $\boldsymbol{\phi_2}$. Also, let define $z_{ij} = x_{IH}{}'\beta_i$ and $\vartheta_{ii} = q_{ii}z_{ii}$. While

$$Log\ L = \sum_{i=1}^{n} log\ \boldsymbol{\phi_2} \begin{bmatrix} (2FS_{iI} - 1)\beta'_1 x_{iI} \\ (2FS_{iH} - 1)\delta'_1 x_{iH} \\ (2FS_{iI} - 1)(2FS_{iH} - 1)\rho \end{bmatrix} \tag{15}$$

$$= \sum_{i=1}^{n} log\ \boldsymbol{\phi_2} \left[q_{iI}\beta'_1 x_{iI},\ q_{ih}\delta'_1 x_{iH},\ q_{iI}q_{iH}\rho \right] \tag{16}$$

To construct the log-likelihood, Greene (2003) suggests the following parametrization.

Let $\quad q_{iI} = 2FS_{iI} - 1$ and $q_{iH} = 2FS_{iH} - 1$. $q_{ii} = 1$ if $FS_{ii} = 1$ and -1 if $FS_{ii} = 0$ for j = 1 and

2. Let's consider again the equation (13) for the the first household, says i=1, we would have the

following exponential function:

$$\begin{cases} Prob\ (I_1 = 1 | x_I) = \boldsymbol{X}'\beta_i + \varepsilon_i = \beta_{1d}\ X_d^D + \beta_{1p}\ X_p^{PA} + \beta_{1e}\ X_e^{EA} + \beta_{1s}\ X_s^{SA} + \beta_{1z}\ X_z^Z + \varepsilon_1 \\ Prob\ (H_1 = 1 | x_H) = \boldsymbol{X}'\delta_j + \epsilon_j = \delta_{1d}\ X_d^D + \delta_{1p}\ X_p^{PA} + \delta_{1e}\ X_e^{EA} + \delta_{1s}\ X_s^{SA} + \delta_{1z}\ X_z^Z + \epsilon_1 \end{cases} \tag{17}$$

3.4.3.3.   Research hypotheses

We tested the following four hypotheses classified into A and B.

A. Our first hypothesis tested the congruence of meaning between food insecurity and hunger with hunger, indicating a minimum of a day without eating anything.

$$H_0: \beta_i = \delta_i$$
$$H_1: \beta_i \neq \delta_i$$

B. The second, third, and fourth hypothesis also tested the congruence of meaning between food insecurity and hunger, but for a specific number of days of hunger. The importance of these tests is to identify the minimum of days of hunger that may lead to a congruence.

$$H_0: \beta_i = \delta_i | H = T$$
$$H_1: \beta_i \neq \delta_i | H = T$$

where T takes three values as indicated here. $T = \{1, 2, or \geq 2\}$

Figure 4- Path diagram of households' food insecurity and hunger.

- Dummy variables

- Farm household (crop & livestock)
- Shocks (drought, flood, pests attack)

- Food expenditures
- Employment status
- Assets ownerships
- Welfare-Self-Assessment
- Shocks (job, losses, robbery)

- Public transfer (in-kind & cash)
- Private transfer (in-kind & cash)
- Shocks (death)

- Gender, Education
- Household size, Age
- Number of children
- Marital status
- Place of residence

Regions fixed effects

Physical Access (PA)

Economic Access (EA)

Social Access (SA)

Household demographics effects

- **Food (In)security** (worry)
- **Hunger** (# day & night)

Chapter 4 – Results

4.1. Background

This chapter has two sections. The first section presents the results of both the summary statistics and empirical analyses. The second section presents the hypotheses tested and its implications. Overall, this chapter shows how the results addressed the research objectives.

4.2. Descriptive analysis

The study uses Tanzanian LSMS cross-sectional data from 2014-2015 to determine the antecedent factors of food insecurity and hunger, and test whether they are synonymous. The results in Table 2 show that while 32.31% of respondents indicated worrying about not having enough food, only 3.19 % stated that they experienced hunger for at least a day in the past seven days of the survey.

Table 2- Proportion of households that responded "yes" to the food (in)security and hunger variables (N=3,352).

Variables	Proportion (%)	Observation (N)
Worried (yes) = 1	32.31	1,083
Hungry (yes) ≥ 1 day	3.19	107
Hungry (yes) = 1 day	1.37	46
Hungry (yes) = 2 days	1.49	50
Hungry (yes) = 3 days	0.21	7
Hungry (yes) = 4 days	0.09	3
Hungry (yes) = 5 days	0.03	1
Hungry (yes) ≥ 2 days	1.85	61

Pearson correlation (Food (in)security, Hunger): $\chi^2 = 177.51^{***}$ (statistically significant at 1%).

The proportion of households that experienced hunger for a day, two days, and at a minimum of two days are respectively 1.37%, 1.49%, and 1.85%. For the empirical analysis, we focus only on these three variables. The Pearson correlation coefficient of the two outcomes variables indicate a chi-squared statistics of 177.5, which is statistically significant at 1%, indicating that both variables are indeed correlated. This correlation is indicative of the existence of a threshold point where the hungry households may become food insecure, which we will test in the empirical analysis.

Figure 5 shows a more detailed visualization of the dataset and emphasizes the interaction between the two outcome variables. We first focus on the proportion of 96 % of respondents who did not experience hunger, i.e., who have reported H = 0.

Figure 5- Percentage of households' that are food insecure (worried) per days of hunger.
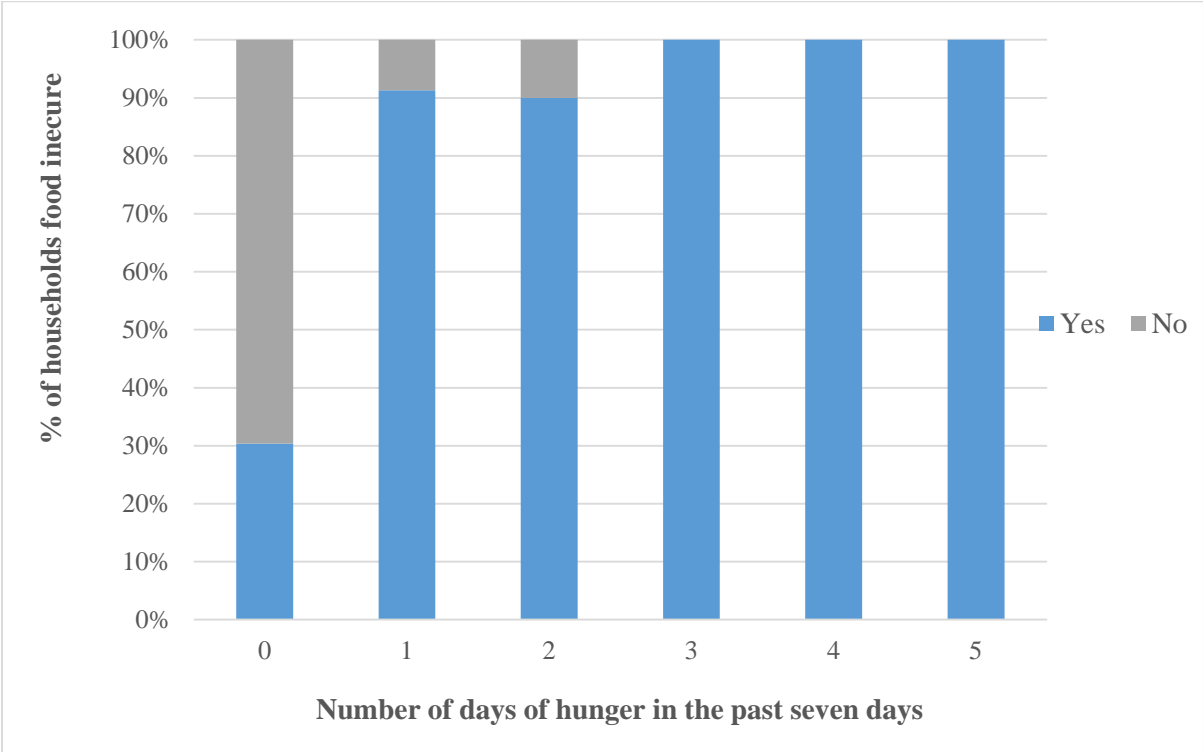
Figure 5 indicates that more than 30% of the respondents with H = 0 have worried that they would not have enough to eat in the past seven days of the survey. This current trend worsens as the number of days of hunger increases, i.e., H ≥ 1. The proportion of respondents that worried increased from 30% to more than 90% in the first couple of days of hunger and was constant at 100 % after the third day of hunger. In other words, after experiencing two consecutive days and nights without food, respondents became food insecure and worried about access to food.

Table 3- Distribution of household food insecurity and hunger (N = 3,351).

| | | Hungry for at least a day | | Total |
		Yes	No	
Food Insecure	**Yes**	98	985	1,083
	No	9	2,259	2,268
Total		107	3,244	3,351

Table 3 shows that more than 91% of those who were hungry were also food insecure, but only 9% of those who were hungry, were not food insecure. This result suggests that hunger may be a contributing factor or a past shock leading to household food insecurity but not a sufficient condition as not all hungry were necessarily food insecure. Also, about 69% of all respondents did not experience food insecurity nor hunger in the past seven days of the survey questionnaire.

Table 4 presents the summary statistics of the household demographic characteristics. It shows that the average household size is almost five members, including two children. Seventy percent of respondents are married or in a relationship, and 78% received some forms of formal education. The variable education is binary and captures household heads that reported having attended any formal schooling, i.e., at least the elementary or grade school. Also, 60% of respondents lived in

rural areas, and 48.74% practiced farming and other related agricultural activities. Agricultural production is the main economic activity reported in the sample.

Table 4- Summary statistics of households' demographics (D) variables (N = 3,352).

Variables	Mean	Std. Dev.	Min	Max	Median
Household demographics (D)					
Age (years)	44.42	14.99	16	100	42
Household size	4.86	2.85	1	33	4
Number of children	2.29	2.04	0	20	2
Gender household head (male = 1)	71.51%		0	1	
Married[8] (yes =1)	70.63%		0	1	
Formal education (yes = 1)	78.35%		0	1	
Employment (unemployed = 0)	3.71%		0	2	
Employment (paid work = 1)	47.55%		0	2	
Employment (own farm = 2)	48.74%		0	2	
Place of residence (rural = 1)	59.19%		0	1	

Table 5 presents the summary statistics of household physical access variables in terms of assets, shocks, and activities. It confirms that the majority of respondents are agricultural producers. For instance, 61.63% of respondents were crop farmers, and more than 40% raised livestock. In terms of assets, respectively 55.94% and 67.63% of respondents owned land and agricultural tools such as hoes. Also, 24.28% of respondents possessed some livestock. These results are in alignment with Tanzania's economy being centered on agricultural development. As reported above, the contribution of agriculture to the country's GDP was 45% in 2017.

On the other hand, Table 5 also indicates that respectively, 27%, 19.61%, and 15.28% of respondents experienced shocks such as water shortage, drought, and crop diseases or pest attacks.

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[8] The variable married takes into consideration households that are married either in monogamous or polygamous and also those living together while the alternative non-married includes separated, widows, divorced and singles.

One of the limitations of these shocks variables is the relationship between water shortage and drought. While it is challenging to tell the difference between both variables, it is also essential to mention that the literature review indicates Tanzania has experienced severe drought in the past years. The main reason why we keep both variables in our analysis is that they are among the most reported shocks.

Table 5- Summary statistics of households' physical access (PA) variables (N = 3,352).

Variables	Mean	Std. Dev.	Min	Max
Physical access (PA)				
Farm household (yes=1)	61.63%		0	1
Livestock producer (yes =1)	40.81%		0	1
Shocks: drought or floods	19.61%		0	1
Shocks: crop disease or pests	15.28%		0	1
Shocks: livestock died or stolen	13.16%		0	1
Shocks: a rise in agricultural input prices	14.83%		0	1
Shocks: severe water shortage	27.13%		0	1
Shocks: loss of land	1.61%		0	1
Assets: livestock	24.28%		0	1
Assets: poultry	35.35%		0	1
Assets: land	55.94%		0	1
Assets: hoes	67.63%		0	1

Table 6 presents the summary statistics of the economic access variables. It shows that the average household food expenditure is TSH[9] 29,412, and respondents' wages on average, is TSH 176,200. However, only respondents with a paid job reported wages. We avoided using wage in our empirical analyses as it would lead us to lose more than 50% of the observation from our sample. As a result, we use households' food weekly food expenditure, assets holdings, and a welfare self-assessment variable to capture their income and finance level.

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[9] TSH stands for Tanzanian Shilling. 1 USD = TSH 2305.10 converted on 5/3/19

Table 6- Summary statistics of households' economic access (EA) variables (N = 3,352).

Variables	Mean	Std. Dev.	Min	Max	Median
Economic access (EA)					
Food expenditure (TSH/week)	29,412.66	26,081.42	0	220,720	22,576
Wage[10] (TSH/month)	176,200.4	410,493.8	0	7,001,000	30,000
Welfare self-assessment (poor =0)	63.32 %		0	2	
Welfare self-assessment (managed =1)	63.32 %		0	2	
Welfare self-assessment (rich =2)	6.05 %		0	2	
Shocks: loss of salaried	1.67 %		0	1	
Shocks: household business failure	3.64 %		0	1	
Shocks: hijacking/robbery/burglary	7.13 %		0	1	
Shocks: fall in sale prices for crops	20.26 %		0	1	
Shocks: large rise in the price of food	37.39 %		0	1	
Assets: air-conditioned	12.56 %		0	1	
Assets: refrigerator	14.02 %		0	1	
Assets: television	26.88 %		0	1	
Assets: bicycle	38.34 %		0	1	
Assets: radio	52.86 %		0	1	
Assets: houses	68.79 %		0	1	
Assets: mobile phone	80.22 %		0	1	

The welfare self-assessment variable captures respondents' appreciation about their financial situation categorized as poor, manageable, and rich. The summary statistics of this categorical variable indicates that 63.32 % of them self-classified as in the manageable while only 6% self-classified as rich. This shows that 30.63% of them self-classified as poor. In terms of assets holdings, Table 6 shows that 80.22%, 68%, and 52.86% of respondents owned respectively, a mobile phone, houses, and a radio. Similarly, 26.88%, 14.02%, and 12.56% of them possessed respectively assets such as television, refrigerator, and air conditioner.

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[10] Wage variable have fewer observation, n = 1460 because only limited household heads have a paid or salaries type of employment excluding almost 50 % of the sample that only work on their own farm.

Table 6 also shows that a rise in food prices is experienced by 37.39% of respondents, while 20.26% of them reported having experienced a fall in commodity prices. The particularity of these shock variables is they provide dual information about food prices, first as a rise which weakens purchasing power and a fall that either make food more affordable or reduce farm net income depending on whether the household is a net buyer or seller.

Finally, Table 7 presents the summary statistics of respondents' social access variables. In terms of assets, the results indicate that on average, respondents received TSH 127,114.8 per year through private assistance and TSH 2,547.86 in the form of public support. Private assistance refers to remittances, while public assistance is received from institutions like government or NGOs. The main shock used in this section is the death of a family member, which 28.37% of respondents experienced.

Table 7- Summary statistics of households' social access (SA) variables (N = 3,352).

Variables	Mean	Std. Dev.	Min	Max
Social access (SA)				
Shocks: death family member	28.37 %		0	1
Private assistance (cash & in-kind) (TSH/year)	127,114.8	539,469.7	0	1.50e+07
Public assistance (cash & in-kind) (TSH/year)	2,547.867	23,742.76	0	600,000

4.3. Results of the logit regressions

The logit regression models were estimated to determine factors that statistically influence both outcome variables, i.e., food insecurity and hunger, independently. The same set of explanatory variables, X, are considered in each regression. For convenience, the results of these independent logit regressions are presented in term of odds ratios which represent the relative risk or the ratio of the probability of success of an outcome variable over the likelihood of its failure. A logit specification is defined as the log base e (log) of the odds making the coefficient of the logit specification a simple transformation of the odd ratios estimates. Similarly to the presentation of the summary statistics, the results of the logit regressions are presented in four tables ranging from 8 to 11.

Table 8 presents the results of both independent logit regressions but focuses only on the household demographic factors. It shows that the odds of being food insecure for households with an additional member is 13% higher compare to households with no additional member. However, as household size keep increasing the odds of becoming food insecure may slightly decrease by less than 1%. The same directional effect is found for the variable hunger, even though these odds ratios estimated were not statistically significant.

Overall, most of the household demographic variables are not statistically significant in explaining the outcomes variables. In another word, the odds of being, either, food insecure or hungry, neither increase nor decrease statistically for individuals one year older or living in rural areas compare those younger or living in urban areas. These results indicate that factors explaining household food insecurity or hunger may not be statistically related to their demographic characteristics.

Table 8- Results of logit models on households' demographics (D) variables (N = 2,810).

Variables	Food Insecurity			Hunger		
Household demographics (D)	Odds R.	S.E	P > |z|	Odds R.	S.E.	P > |z|
Household size	1.129*	0.072	0.057	1.025	0.236	0.913
Household size squared	0.992**	0.003	0.016	0.983	0.018	0.353
Number of children	1.067	0.0561	0.214	1.111	0.181	0.517
Age (years)	1.00	0.018	0.995	0.987	0.045	0.775
Age squared	1.00	0.0002	0.848	1.000	0.001	0.964
Formal education (yes = 1)	0.979	0.162	0.898	0.639	0.236	0.225
Gender household head (male = 1)	0.945	0.191	0.781	0.581	0.293	0.281
Educated & Male (yes = 1)	0.993	0.209	0.974	2.175	1.156	0.144
Place of residence (rural =1)	0.852	0.112	0.223	1.412	0.521	0.349
Married (yes =1)	0.828	0.115	0.174	0.801	0.275	0.519
Employment (paid work =1)	0.953	0.231	0.841	1.134	0.771	0.854
Employment (own farm =2)	0.852	0.193	0.480	1.347	0.846	0.636

Standard errors are presented here in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Table 9 presents the results of both independent logit regressions but shows only the physical access factors. The results indicate that the odds of being food insecure or hungry are not statistically significant for households practicing either farming or rearing livestock compare to those who do not. While this result can be surprising, it also sheds light on policies that continuously stress the need to increase household food production to ensure their food security. Being an agricultural producer, per se, may not be very useful if agricultural production characteristics such as rainfall or irrigation, fertilizers, equipment or technologies, and proper storage facilities to carry commodities from periods of abundance to scarcities, etc. are not accessible.

The results also indicate that the odds of being food insecure or experiencing hunger for households who experienced drought are respectively 60% and 80% higher than those who did not experience such shock. Drought is the only shock that has a statistically significant effect on both outcomes variables. However, the odds of being food insecure for households that experienced losses of livestock either are 40% higher compared to those who did not experience loss of livestock. Also, the odds of being hungry for households that experienced severe water shortage are 78% higher compared to those who did not experience such shock. These results indicate the occurrence of climatic conditions such as drought or water shortage is more likely to increase the odds of being food insecure or experiencing hunger as it made households to worry about their accessibility to food. If these climatic conditions lead to crop failure, it can engender a food intake disruption and hunger.

Consistent with our assumption on asset ownership and food insecurity, the results show that the odds of being food insecure for households that owned livestock or agricultural equipment: hoes are respectively 36% and 28% lower compare to those who did not possess any of these assets. These findings can be explained by the proportion of household in the sample whose main economic activity is farming. While being a farmer by itself does not have a significant effect on the food security variable, being an equipped farmer is more likely to impact food production and then reduce food insecurity outcomes.

A counter-intuitive result is found for the asset land. The odds of being hungry for households that owned land are 80% higher compared to those who did not have lands. A possible explanation of such result could be that land ownership is costly just by itself. Also, while owning lands for farming purpose can be a good asset, it could be associated with high cost due to climatic conditions described above drought or water shortage. Thus, farming in such circumstances could

weaken households' ability to produce and earn enough, which may lead to hunger. However, the odds ratio estimated is only statistically significant at 10 %, which may indicate the need for further investigation about lands ownership in Tanzania.

Table 9- Results of logit models on households' physical access (PA) variables (N = 2,810).

Variables	Food Insecurity			Hunger		
Physical Access (PA)	Odds R.	S.E	P > |z|	Odds R.	S.E.	P > |z|
Farm household (yes=1)	1.139	0.224	0.509	1.708	0.935	0.328
Livestock producer (yes =1)	1.535	0.448	0.142	2.434	1.934	0.263
Farm & livestock household (yes =1)	0.687	0.188	0.170	0.472	0.36	0.325
Agricultural season (wet =1)	0.999	0.088	0.994	0.806	0.186	0.351
Shocks: drought / floods (yes =1)	1.630***	0.180	0.000	1.778**	0.461	0.026
Shocks: crop disease or pests (yes =1)	1.042	0.130	0.743	0.624	0.214	0.168
Shocks: livestock died, stolen (yes =1)	1.410**	0.189	0.011	1.350	0.477	0.396
Shocks: rise in ag. input prices (yes =1)	1.011	0.140	0.939	1.605	0.542	0.161
Shocks: severe water shortage (yes =1)	1.045	0.110	0.674	1.786**	0.451	0.022
Shocks: loss of land (yes =1)	1.395	0.432	0.283	1.823	1.103	0.321
Assets: livestock (yes =1)	0.636***	0.088	0.001	0.740	0.296	0.452
Assets: poultry (yes =1)	0.962	0.177	0.835	0.463*	0.213	0.094
Assets: land (yes =1)	0.938	0.123	0.625	1.821*	0.646	0.091
Assets: ag. tools hoes (yes =1)	0.711**	0.113	0.032	0.478*	0.203	0.083

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Table 10 presents the results of households economic access factors and their influence on both outcome variables. The odds of being food insecure for households that experienced an increase in weekly food expenditure of TSH 1000, or self-assessed as wealthy are respectively 0.01%, 29%, and 70% lower compared to those with no increase in expenditure or self-assessed as poor. In other words, an increase in expenditure will not necessarily take away the insecurity about food as households might remain still in the survival mode or vulnerable. However, when

households experienced enough wealth accumulation up to the point where they self-described as either rich or in a manageable financial situation, then we would expect that their insecurity about food would disappear.

Table 10- Results of logit models on households' economic access (EA) variables (N = 2,810)

Variables	Food Insecurity			Hunger		
Economic Access (EA)	Odds R.	S.E	P > |z|	Odds R.	S.E.	P > |z|
Food expenditure_1000 (TSH/week)	0.994**	0.003	0.020	0.986	0.009	0.118
Welfare self-assessment (managed =1)	0.712***	0.068	0.000	0.790	0.192	0.332
Welfare self-assessment (rich=2)	0.279***	0.072	0.000	0.231	0.239	0.156
Shocks: business failure (yes =1)	1.184	0.263	0.446	1.533	0.780	0.401
Shocks: robbery/burglary (yes =1)	1.265	0.216	0.169	1.394	0.614	0.451
Shocks: lost employment (yes =1)	1.385	0.428	0.291	1.333	1.01	0.704
Shocks: fall in crops sale price (yes =1)	0.898	0.116	0.403	0.442**	0.150	0.016
Shocks: rise in food price (yes =1)	1.447***	0.14	0.000	1.297	0.327	0.302
Assets: tables (yes =1)	0.931	0.089	0.455	0.932	0.236	0.781
Assets: refrigerator (yes =1)	0.412***	0.087	0.000	0.143*	0.153	0.069
Assets: television (yes =1)	0.784	0.119	0.107	1.653	0.725	0.252
Assets: Air-conditioner (yes =1)	0.840	0.170	0.389	0.927	0.589	0.905
Assets: bicycle (yes =1)	0.623***	0.063	0.000	0.819	0.229	0.476
Assets: radio (yes =1)	1.040	0.098	0.675	0.531**	0.141	0.017
Assets: house (yes =1)	1.056	0.128	0.649	0.913	0.286	0.773
Assets: utensils (yes =1)	1.901	0.860	0.156	1.431	1.525	0.737
Assets: phone (yes =1)	0.673***	0.079	0.001	0.880	0.243	0.644

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

Table 10 also shows the effect of specific shocks that statistically influence the outcome variables. The odds of being food insecure for households that experienced a significant large in food prices are 45% higher compare to those who did not experience such price spike. Also, the

odds of being hungry for households that experienced a significant drop in commodity prices are 56% lower compared to those who did not experience a similar situation. These results indicate that when food price trend upward, they made households to worry about whether they would have enough food even though they do not necessarily experience hunger. Also, when food commodity prices are down trending, households are less likely to experience hunger as foods become generally affordable.

Table 10 also indicates that the odds of being food insecure for households that owned assets such as refrigerator, bicycle, and phone are respectively 59%, 38%, and 33% lower compared to those who did not own any of these assets. Since most respondents live in rural areas, ownership of luxury kitchen appliances such as refrigerator can be an approximation of their wealth or livelihood conditions. For instance, the odds of being hungry for households that owned a refrigerator or radio are respectively 86% and 46% lower compared to those who did not have any.

Table 11- Results of logit models on households' social access (SA) variables (N = 2,810).

Variables	Food Insecurity			Hunger		
Social Access (SA)	Odds R.	S.E	P > |z|	Odds R.	S.E.	P > |z|
Private assistance_1000 (cash & in-kind) (TSH/year)	1.000*	8.26e-05	0.069	1.00	0.004	0.742
Public assistance_1000 (cash & in-kind) (TSH/year)	1.002	0.0017	0.236	0.999	0.007	0.851
Shocks: death family member(yes =1)	1.238**	0.120	0.027	1.140	0.288	0.603
Constant	0.567	0.375	0.390	0.0779	0.125	0.113

Standard errors in parentheses and *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11 presents the results of households social access factors and also their influence on both outcome variables. It shows that the odds of being food insecure for households that received some private assistances in the past twelve months, neither decrease nor increase compared to those who did not receive any. In other words, private assistance has a neutral effect on the likelihood of being food insecure. An intuitive explanation for such results could be the number of remittances received or the frequency of their occurrence. In the case that private supports come only non-frequently or unexpectedly, we would expect that they would not have a significant negative effect on households food insecurity. However, the odds of being food insecure for households that lost a family member are 24% higher compared to those who did not experience such a loss.

Figures 6 to 9 present the visual representation of the Tables 8 to 11 by showing respectively the odds rations for households demographics, physical access, economic access and social access of both independents logit regressions, i.e., food insecurity and hunger.

Figure 6- Odds Ratios of households Demographics (D) variables, (N = 2,810).
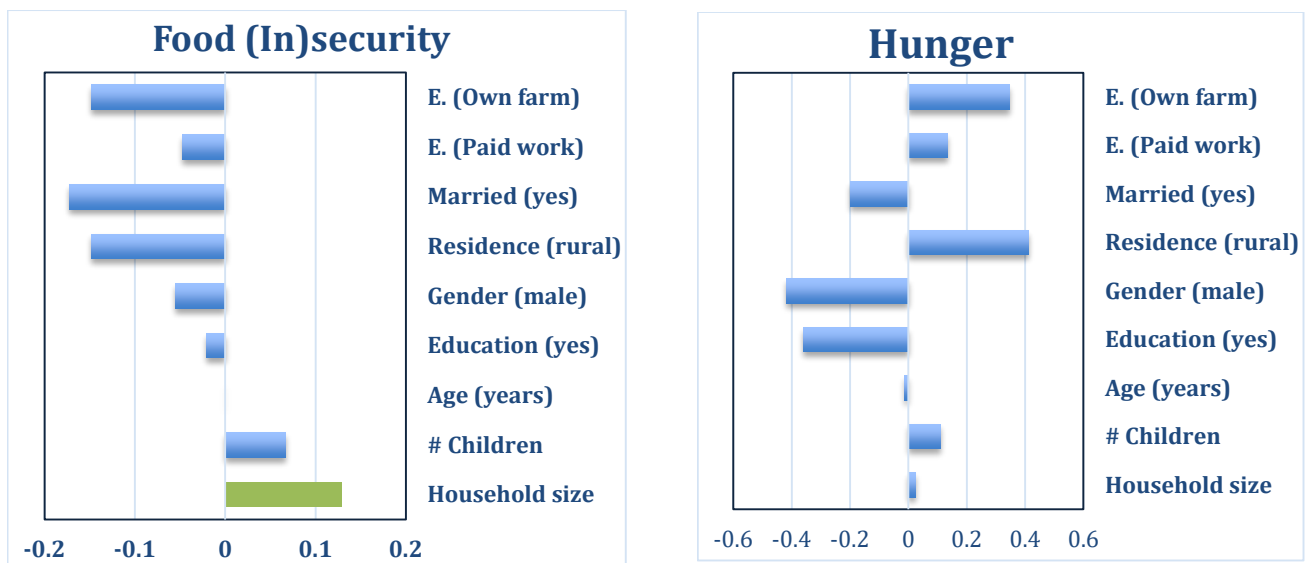
Colors green indicate that the estimates are at least significant at 5%, i.e., *** p<0.01 & ** p<0.05 while the color orange indicates a 10% significance level (* p<0.1). The color blue indicates that the estimate is not significant.

Figure 7- Odds Ratios of households Physical Access (PA) variables, (N = 2,810).
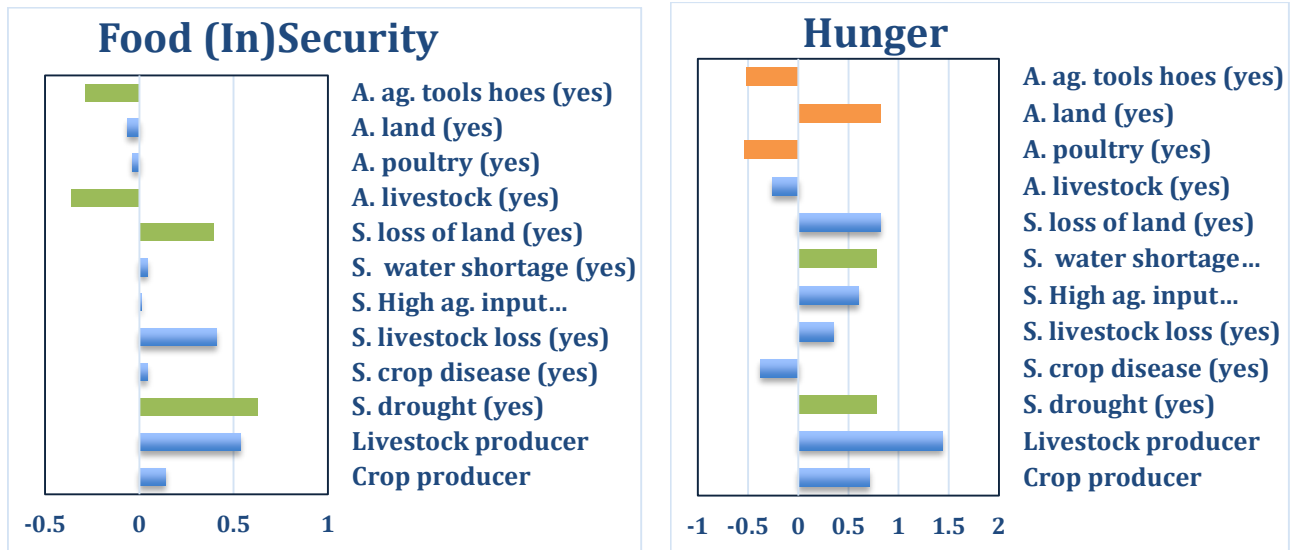
Figure 8- Odds Ratios of households Economic Access (EA) variables, (N = 2,810).
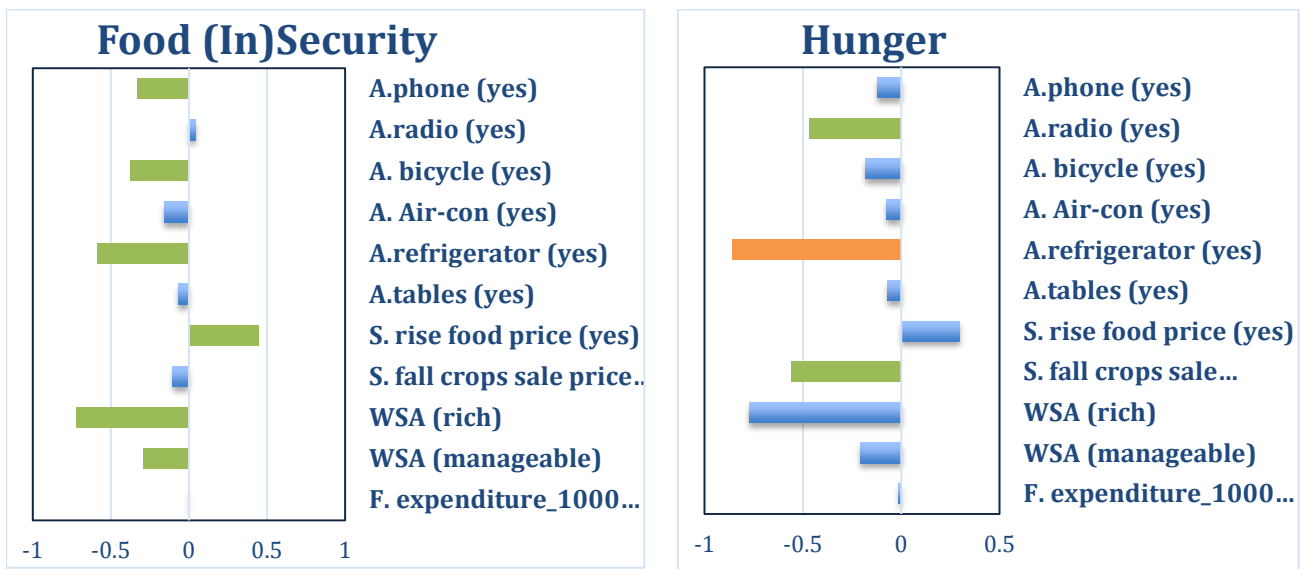
Figure 9- Odds Ratios of household Social Access (SA) variables, (N = 2,810).
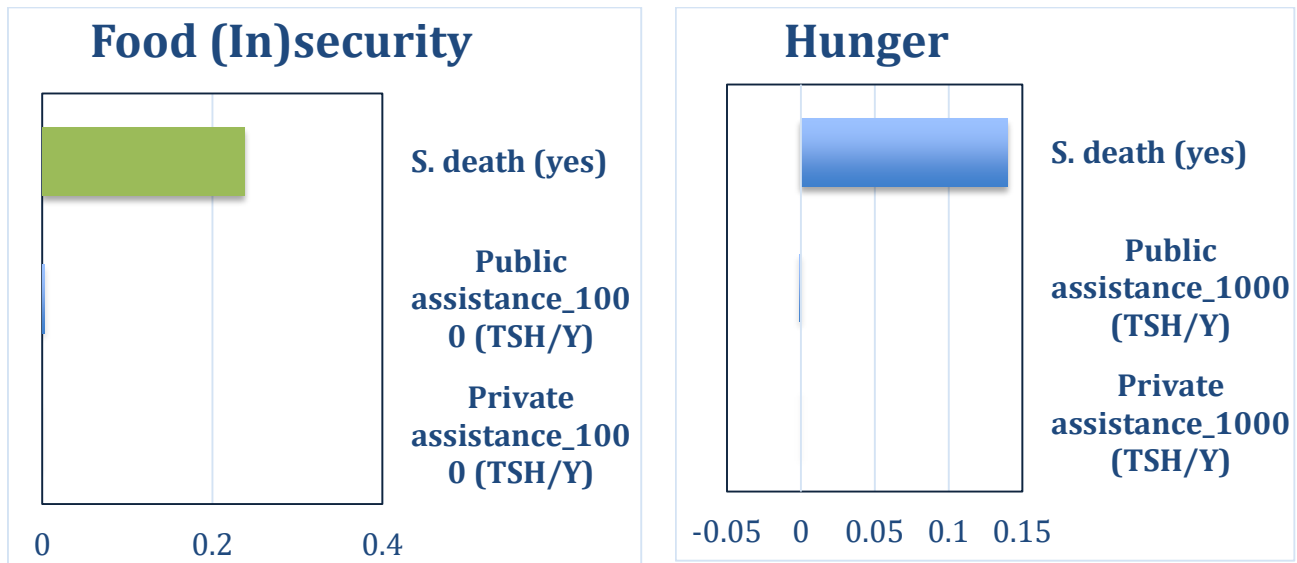
Figures 10 and 11 present the predicted margins of household food insecurity and hunger probabilities given future shocks or an increase in assets or wealth. These predicted margins are estimated from the independent logit regressions mentioned above. Figure 10 shows that households that experienced drought had a higher probability of being food insecure or hungry. Also, the probability for households to be food insecure or hungry decreases as their weekly food expenditure increases.

Similar predicted probabilities are found for households that experienced shocks such as an increase in food prices or loss of livestock. As household food expenditure increases close to TSH 200 per week, the probabilities that they would become hungry is nearly 0%. These results indicate that the ability of households to be resilient to shocks affecting either their availability or accessibility of food increases as their means to afford food or accumulate wealth increases.

Figure 10- Predicted margins of households' food insecurity and hunger given future shocks.
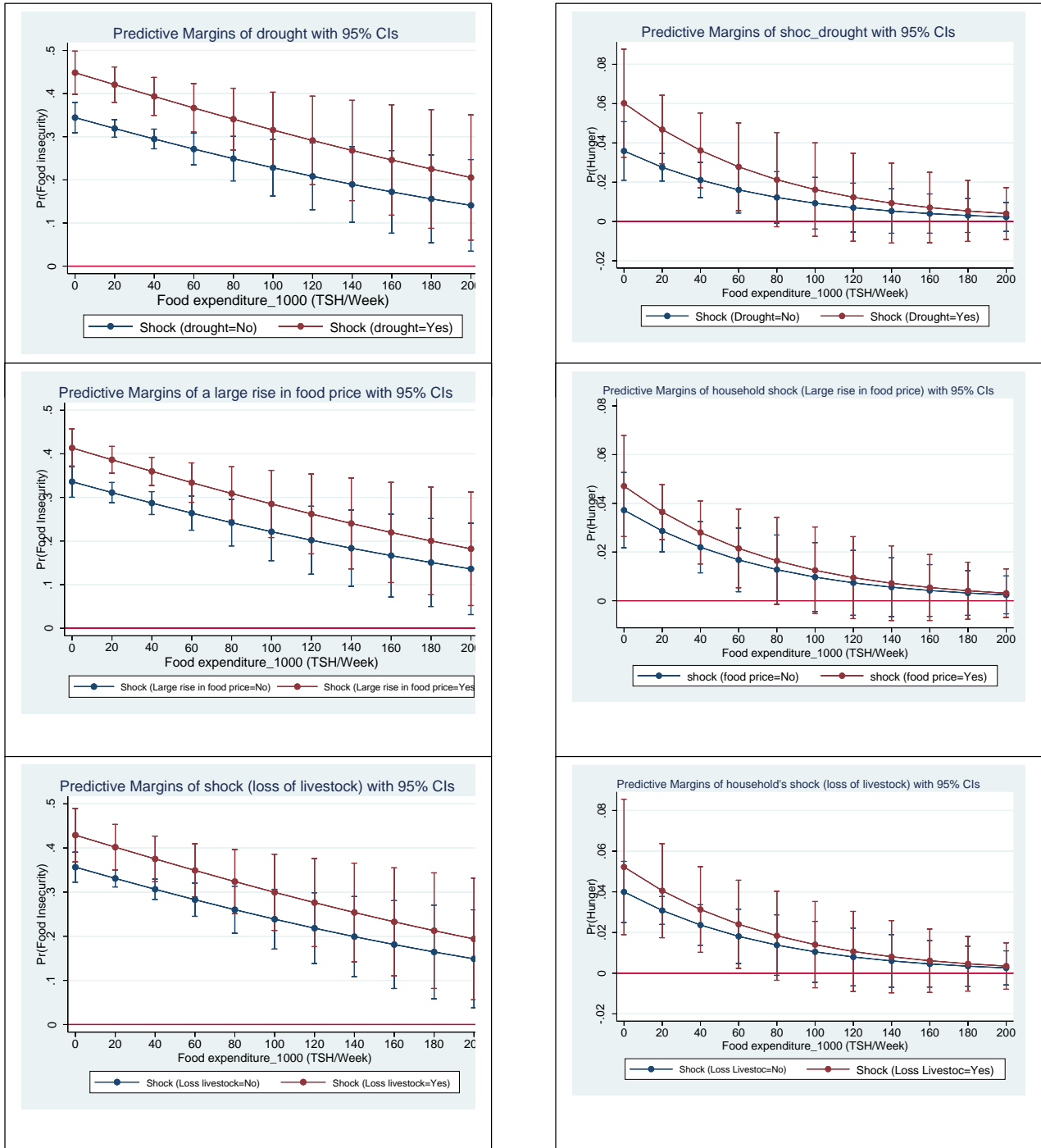
Figure 11- Predicted margins of households' food insecurity given future wealth or assets.
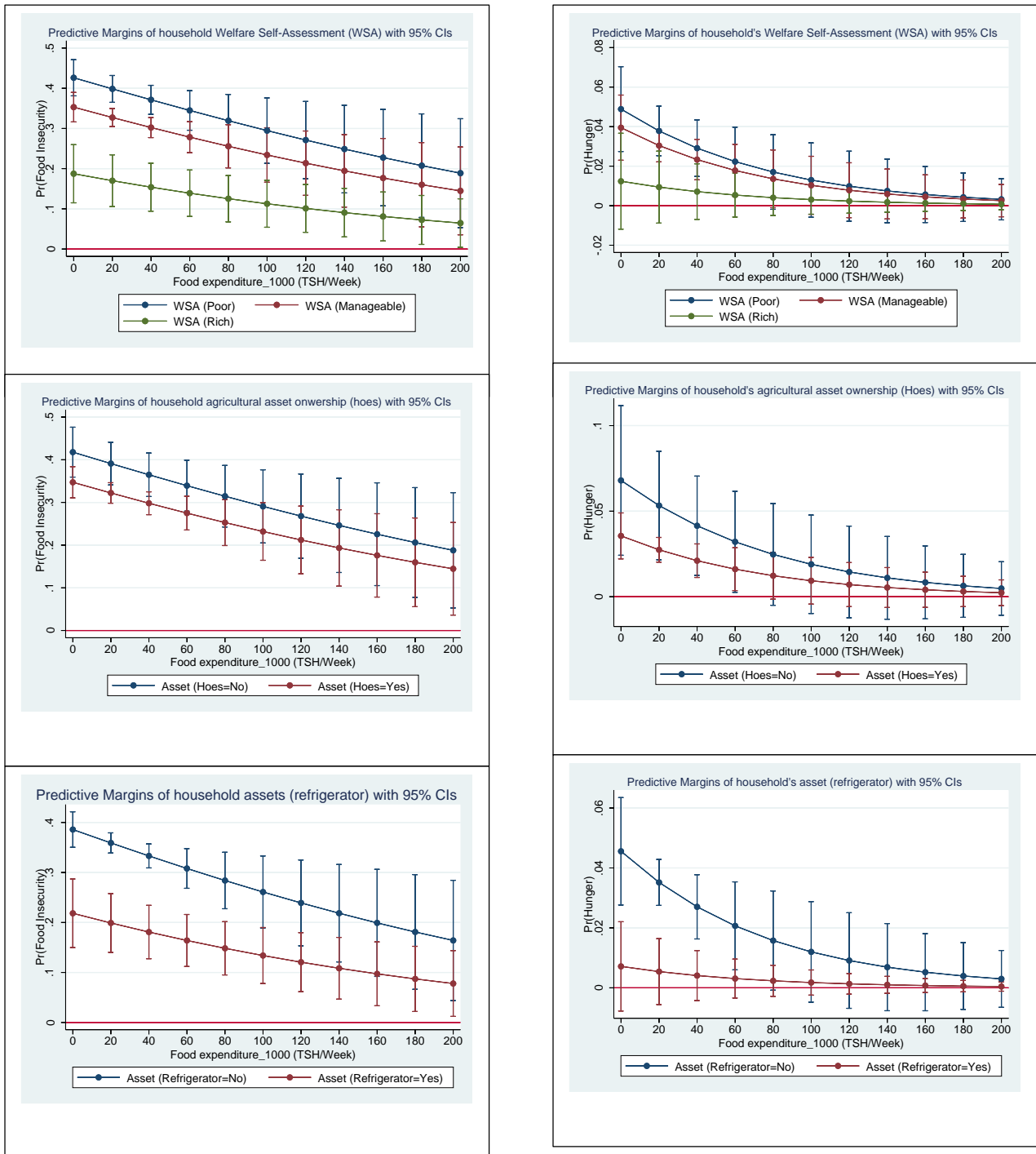
On the other hand, Figure 11 shows the predicted probabilities of being food insecure and

hungry, given a change in asset holding. It shows that the predicted probabilities of being food

insecure are lower for a household with wealth or valuable assets such as refrigerator or hoes

compare to household who did not own any. Specifically, the first top margin plots in Figure 6 indicates that the predicted probabilities of being food insecure decrease as a household move from self-assessed as poor to rich. In other words, the richer the household gets, the lower the probabilities the household has to be food insecure or hungry.

4.4. Hypothesis testing: results of the seemingly unrelated regressions.

In section (3.4.3.3.), we presented the set of hypotheses tested in this study classified into A and B. In (A), we hypothesize that food insecurity and hunger are congruent. In another word, if they are indeed congruent, we would expect that factors explaining household food insecurity would be statistically the same as those explaining hunger. In (B), we also tested the congruence between food insecurity and hunger, but for a specific number of days of hunger. The importance of the hypotheses in (B) is to identify the minimum of days of hunger that may lead to a congruence. The results of these hypotheses are summarized in Table 12 below.

Table 12- Summary of the hypotheses tested and their conclusions

	Hypothesis	Chi-squared (χ^2) statistic	Probability $> \chi^2$	Conclusion
A	$H_0: \beta_i = \delta_i$ $H_1: \beta_i \neq \delta_i$	Chi2 (46) = 62.84	0.049	RH_0
	$H_0: \beta_i = \delta_i \mid H = 1$ $H_1: \beta_i \neq \delta_i \mid H = 1$	n.a	n.a	n.a
B	$H_0: \beta_i = \delta_i \mid H = 2$ $H_1: \beta_i \neq \delta_i \mid H = 2$	Chi2 (46) = 53.23	0.215	Failed to RH_0
	$H_0: \beta_i = \delta_i \mid H \geq 2$ $H_1: \beta_i \neq \delta_i \mid H \geq 2$	Chi2 (46) = 53.29	0.2142	Failed to RH_0

To perform these tests, we estimated several seemingly unrelated bivariate probit regressions, which estimated both outcome variables simultaneously with the same set of explanatory variables. The regression used for the test of hypothesis (A), provides a Wald test statistic of 71.35 for ρ that is statistically different from zero at 1%. ρ is the correlation coefficient between the residuals of the two probits equations. This result supports the need to estimate the two probit regressions jointly. The results of this seemingly unrelated bivariate probit regression are presented in Tables 13 to 16 in the Appendix A.

Table 12 presents the summary of all four hypotheses tested in this study, along with their corresponding conclusions. The first hypothesis tested that for a minimum of one day without eating anything, factors explaining household food insecurity are statistically the same as those explaining hunger. The Wald test provides a chi-squared statistics of 62.84, which is statistically different from zero at the 5% significance level. Thus, we reject the null hypothesis of congruence and conclude that factors explaining household food insecurity are different from those explaining their hunger at a 5% significance level.

The second research hypothesis tested that after one day without eating anything, factors explaining household food insecurity are statistically the same as those explaining hunger. However, due to the limitation of the number of observation for $H = 1$, we were unable to perform this test.

The third research hypothesis tested that after two days without eating anything, factors explaining household food insecurity are statistically the same as those explaining hunger. The Wald test provides a chi-squared statistics of 53.23, which is not statistically different from zero at the 10 % significance level. Thus, we failed to reject the null hypothesis of congruence. In

another word, after going through two days and nights without eating anything, individuals started to worry about food and became food insecure. This result is also very consistent with the descriptive Figure 4, which shows that after two days, all households that reported hunger were also food insecure.

Similar to the last hypothesis tested that after a minimum of two days without eating anything, factors explaining household food insecurity are statistically the same as those explaining hunger. The Wald test provides a chi-squared statistics of 53.29, which is also not statistically different from zero at 10 % significance level. Therefore, we failed to reject the null hypothesis of congruence again.

Overall, based on the LSMS survey data for Tanzania (2014-2015), the results of these hypotheses show the existence of a minimum of two days of hunger that transformed households' hunger from a mere physical sensation into mental distress, i.e., worrying about food. While these results are very significant for policy discourse, it also relevant to highlight that they are specific to the current case study. In other words, the threshold at which hunger transformed into food insecurity may vary for one country to the another or from one region to another. However, it remains important to distinguish both concepts and intervene efficiently in ways that prevent hunger from becoming insecurity.

Chapter 5 – Discussion and policy recommendations

5.1. Discussion

For seventy years, addressing food insecurity and hunger have been a challenge for researchers, policymakers, and especially the poor as food insecurity is structurally related to poverty (WHO, 2018). In the 2018 State of Food Security and Nutrition in the world (SOFI), the World Health Organization (WHO) indicated that one in every nine persons in the world or nearly 821 million are undernourished (WHO, 2018). These two sentences summarize of a global phenomenon with significant scope, often, approximated with multiple concepts, used interchangeably, i.e., food insecurity, undernourishment, and hunger. In this dissertation, we challenge these vernacular congruence focusing on food insecurity and hunger by hypothesizing that if they are congruent, then their antecedents would be statistically the same. An empirical analysis is provided to test this hypothesis using the Living Standards Measurement Survey data collected for Tanzania in 2014-2015 and a two years' panel of 2010-2011 and 2012-2013 used for robustness check. The robustness check analysis are presented in the Apendix A section.

Our results indicate that more than 30% of respondents were food insecure even though they were not hungry. Whereas, more than 90% of those who were hungry were also food insecure. These results confirm the overlapping diagram of Jones et al. (2013) indicating that hungry people are mostly food insecure, but not all food insecure are necessarily hungry. Thus, hunger might be considered, to some extent, as a contributing factor for household food insecurity. With significant attention focused on hunger for the achievement of the SDG2, there is a considerable proportion of individuals experiencing food insecurity which are not being targeted because of the current understanding of hunger and undernourishment as the main indicators of household food security.

Secondly, using the logit and seemingly unrelated bivariate probit regressions, we found that factors explaining both concepts were not necessarily the same. Drought, food expenditure, and asset ownership influenced statistically and significantly, both outcome variables in the same manner. However, a loss of households' livestock increased the likelihood of being food insecure but did not necessarily increase the likelihood of being hungry. Also, a fall in sale prices for commodities crop reduced the likelihood of going hungry, as foods became relatively more affordable, but did not have a significant effect on food insecurity. Similarly, a rise in food prices increased the likelihood of being food insecure, as foods became relatively more expensive, but did not have a statistically significant effect on hunger. These two results highlight the need for policies to have a clear target in achieving household food security because they do not derive necessarily from the same factors. Policies set to attain either outcome variables should be implemented through factors that have a statistically significant effect of the particular outcome instead of assuming that trying to achieve one would eventually lead to achieving the other.

Thirdly, beyond showing that food insecurity and hunger are not congruent, we further the literature on food security by presenting a condition under which hunger may transform into food insecurity. Our results indicate that a minimum of two days of hunger led to households experiencing food insecure in Tanzania. As mentioned by Jones et al., (2013) and Meletta (2014), hunger, defined in term of the physical sensation of want of food is part of most people's daily life or everyday experiences and does not become an issue until it reached a certain threshold or switching point. These findings provide a precision that is lacking in the literature by connecting food insecurity to hunger empirically.

Over the past decades, food insecurity studies, and most importantly, international institutions have gradually gravitated toward the use of hunger or undernourishment as the primary

indicator in achieving the millennium or sustainable goals. Jones et al., (2013) argued that one of the reasons for such tight relationship between food insecurity and hunger is perhaps because of the emotive strength associated with the concept of hunger which has frequently and sufficiently been enough to move many to actions. Too often, images of the hungry, i.e., skinny, bony, stunted or wasted bodies are found in newspapers and television screens calling for philanthropic and humanitarian's actions to eradicate hunger. Thus, hunger may have become the face and word to use to inform and engage the masses about food security.

5.2. Tanzania's food security policies

Tanzania is still categorized as a developing country, even though it's GDP has steadily grown over the past two decades. According to the World Bank's statistics in 2017, Tanzania's GDP is currently more than USD 52 Billion, which represents a growth five times larger than its GDP in 2000. However, this significant economic growth hides disparities in term of food security and hunger outcomes. WHO (2018) indicates that the number of undernourished in 2000 was nearly 12 million and 18 million in 2017. These statistics show a significant rise of undernourishment in Tanzania with even a steep trend forecasting even higher statistics for the coming years. Tanzania is also among the few countries which did not meet any of the four indicators included in the MDG1 by 2015.

Nearly 70 percent of Tanzanian lives in rural areas and relies on agriculture and related activities as their primary employment and source of food. According to the FAO's statistics in 2016, nearly three-quarters of the country's undernourished and 80 percent of its hungry are also located in rural areas (FAO, 2016). Using the LSMS data for Tanzania in 2014-2015, we also confirm these statistics presented in Figures 12 and 13. Figure 12 shows that respondents from

regions in the top right such as Ruvuma, Lindi, Mftwara, and Rukwa had equally high proportions of hungry and food insecure households compared to other areas. The top right quadrant highlights regions with proportions of food insecure and hungry households respectively above the sample means of 32.31% and 3.19%.

Figure 12- Distribution of the proportion of households food insecure and hungry across regions.
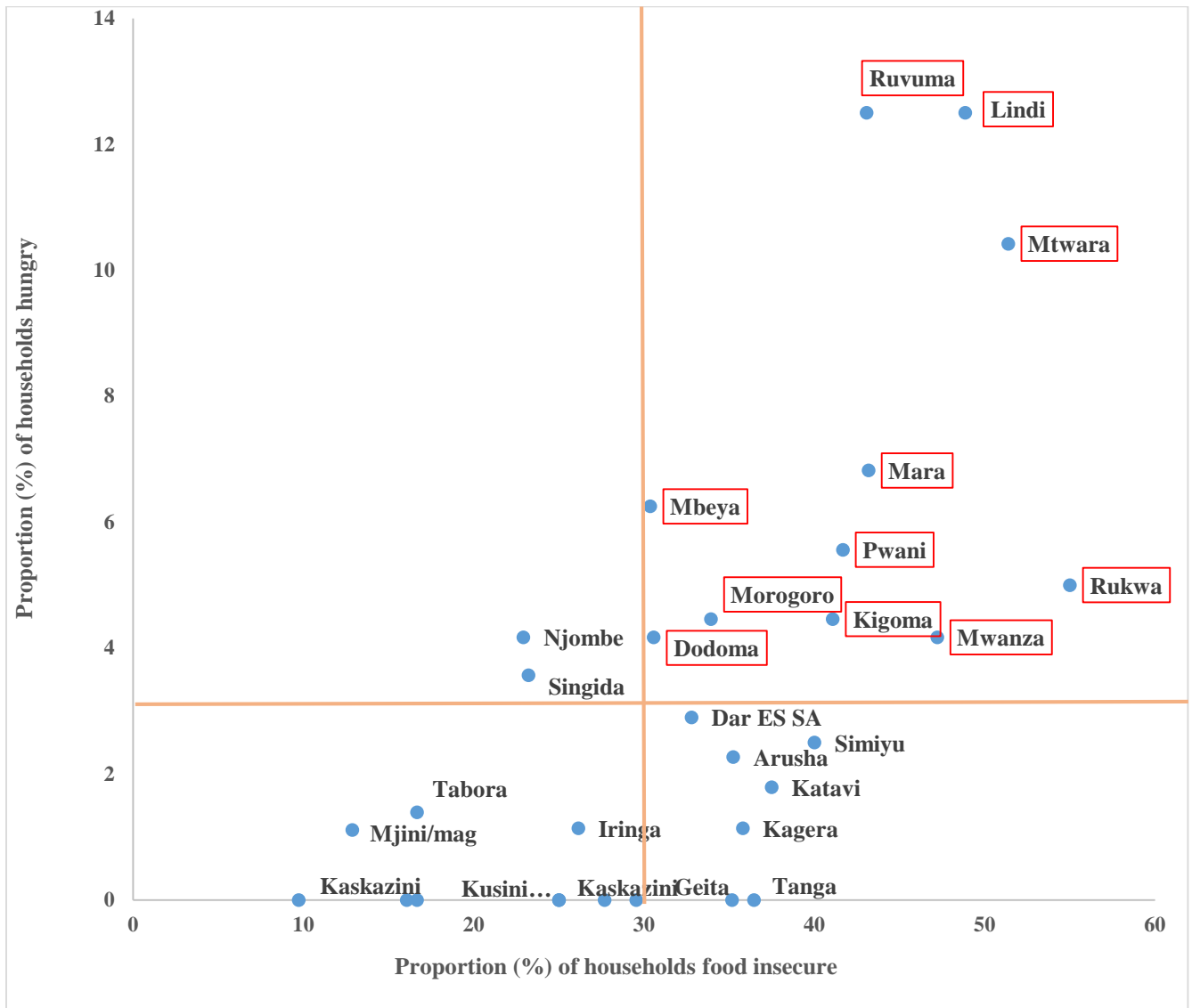
Figure 13 shows that most respondents from these regions live in rural areas suggesting the relationship between food insecurity, hunger, and rural regions.

Figure 13- Proportion of respondents living in rural and urban areas per region.
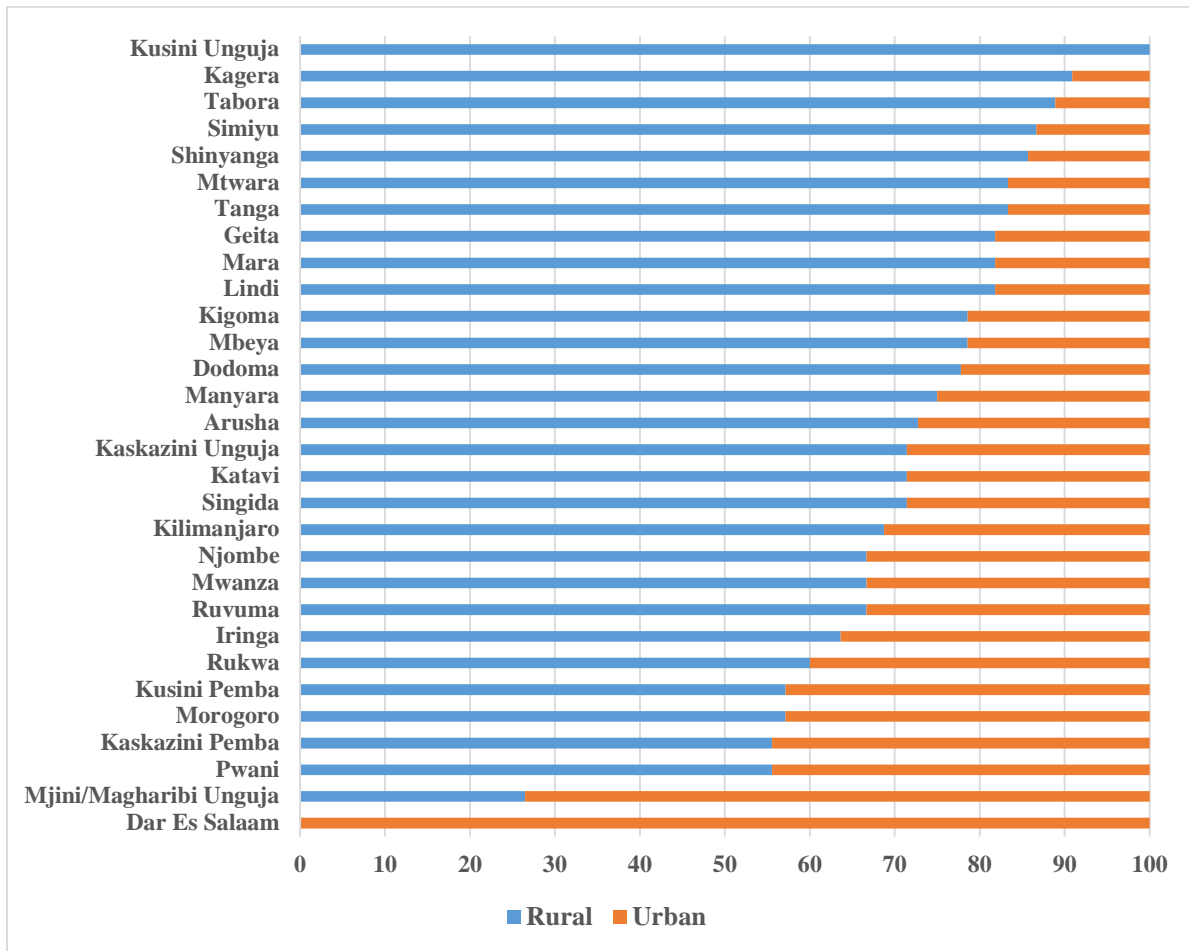
In the past decades, Tanzania has continued to address the severity of hunger and undernourishment. It has implemented numerous strategic programs rooted in various national development policies. These programs are summarized in the Tanzania Development Vision by 2025 (TDV 2025) (Kikwete, 2014) and focused primarily on two pillars. The first one is the agricultural development plan implemented through programs such as the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), Land Tenure Support Programme (LTSP), District Agricultural Development Plans (DADPs), the Agricultural Sector Development Strategy (ASDS), and the recent Comprehensive Africa Agriculture Development Programme (CAADP) of July 2010. The agricultural development plan aims to promote an increase in agricultural

production and productivity in the agricultural sector towards reducing poverty and hunger. The second pillar focusses on nutrition enhancement plans and is also implemented through programs such as the National Multi-sectoral Nutrition Action Plan (NMNAP), and the Tanzania Agriculture and Food Security Investment Plan (TAFSIP). Despite the implementation of these promising national policy programs, Tanzania is still dealing with a significant rise in undernourishment as most of these initiatives fell short of their promises.

5.3.   Revisiting Sen's Entitlement Theory

Sen's (1982) theory of entitlement, along with the theory of uncertainty (National Research Council, 2006) was used as the main theoretical foundation for the study. Based on the entitlement theory, we assumed that people sense of insecurity or worry about their food access would be primarily subject to the wealth they possess and their ability to turn this wealth, i.e., productions, asset holdings, assistance, and endowments in food. Therefore, based on the results of our empirical analyses, our policy recommendations mainly focus on the reestablishment of households' entitlements and endowments to improve their food security status.

In most developing countries and especially in rural areas, households' entitlement is generally made of: (i) small plot of land used for farming from which households derive food consumption and revenue from sales; (ii) other domestic productions, i.e., livestock, poultry; (iii) others source of income through some occasional labor market; and (iv) public or private assistance. Here we would primarily focus on the first two as evidence-based indicators to reestablish households' entitlement in improving their food security. Here we provide short, mid, and long term policy recommendations to address the prevalence of hunger and food insecurity in Tanzania.

In the short term, it will be imperative for decision makers to address the national prevalence of hunger with an emphasis on the regions highlighted in the top right quadrant of Figure 12 where the likelihood to be hungry and food insecure are both equally high. Thus, for those households that had spent two or more days without eating anything, the implementation of rapid food assistance programs can quickly ease their hunger. One rapid response program could be the in-kind distribution of food in areas where hunger is already severely acute. For this policy to create national welfare, it is essential for decision-makers to source foods from nearby smallholders to enhance local economies while alleviating cases of hunger.

Another rapid response program could be the implementation of a cash transfer program, especially as high food prices were reported as a positive statistically significant factor leading to food insecurity. A well-implemented cash transfer policy provides the recipients with the choice of selecting the food they desire compared to the restrictive in-kind food assistance, which only offers a specific diet for all hungry households. However, one of the downsides of a cash transfer program especially in developing countries settings is the inability of central governments to control the use of the amount of money gifted once received by recipients as some may choose to purchase imported food brands instead of those locally produced which may potentially reduce national welfare. Either policy, i.e., in-kind food distribution or cash transfer, can be sufficient to address an emergent situation but need only to be implemented in the short term as they can be very costly and not sustainable.

In the mid-term, policy recommendations shall focus onincome-generating activities. For instance, factors such as income approximated here through food expenditure and the welfare self-assessment variables had a negative statistically significant effects on both outcomes variables. Thus, higher income (wealth) levels are expected to be associated with lower probabilities of being

food insecure or hungry. Hence, our policy recommendations emphasize on income or wealth generating activities. For instance, farming, poultry, and livestock rearing were reported as the predominant activities for most respondents in rural settings. However, drought is also one of the factors that had a positive statistically and significantly influenced both outcome variables. Drought and flood are known to destroy crops, causing a significant spike in food prices, reduced grazing pastures for livestock, or even violent conflict over resources in pastoral areas forcing people to flee their homes, farms, and livelihoods. For instance, drought has often been declared a national disaster in countries such as Somalia, Djibouti, and Ethiopia due to their short and long-term consequences (WFP, 2018). For sustainability purpose, it is crucial that household being granted or entitled the ability to feed themselves through their own means instead of being dependent on food aid distributions in the absence of emergencies. Therefore, as a mid-term policy, we recommend several drought management solutions.

Tanzania can implement the use of heat or drought-resistant crop varieties, especially for staple crops due to their sensitivity. Drought resistant crop varieties can mitigate low productivity due to water-related concerns and contribute to stabilizing food prices. Implementing such a policy could improve the availability and subsequently, the accessibility of food in the areas where food remains a significant concern. Also, if we assume that demand for food is inelastic, implementing heat tolerant crop varieties could generate enough revenue or wealth to producers to afford their needs. While heat resistant seed varieties can improve both food availability and accessibility for humans, it can also do the same for livestock. Heat or drought-resistant varieties are among the set of public interventions that could effectively strengthen household's resilience capacity and coping mechanisms to survive such severe conditions that affect both humans and animals.

However, heat resistant or drought-tolerant crop varieties are considered Genetically Modified Organisms (GMO). In 2018, the Tanzanian's government did not only ban ongoing trials on GM seeds but also directed the Tanzania Agriculture Research Institute (TARI) to destroy evidence of the GMO research immediately. Thus, this solution may not be operational. Another solution to the drought that is simple, less costly, and yet effective could be the implementation of irrigation systems through Rainwater Harvesting Techniques (RWHT). In most developing countries, agricultural producers still rely heavily on rainwater to water their plants. RWHT can supplement water sources as they become scarce or poor quality like saline groundwater or polluted surface water in the rainy season. Thus, the implementation of RWHT could mitigate drought by making water accessible at least cost for households. Rooftop rainwater harvesting (RTRWH) is the most common technique of rainwater harvesting into natural reservoirs or tanks for domestic consumption storage. It can be implemented locally, and they do not require much investment.

Diversifying household sources of income is also another midterm policy recommendation to cope with future disruptions of food accessibility due to weather events such as drought. For instance, disease, death, or losses of livestock is another factor that had a positive statistically significant effect leading to food insecurity. Furthermore, holding assets such as livestock or poultry are associated with lower odds of becoming food insecure. Thus, we recommend diversifying household sources of income through the combination of crop production and livestock farming and even considering some non-farm activities. It is very relevant to implement the mid-term policies simultaneously with the short term responses to help households to regain their complete independence in regards to all food matters.

Strengthening households coping strategies and resilience capacity building will also be highly beneficial for households to prepare themselves to respond to further shocks. Thus, we suggest that as a long term policy, the implementation of education. Table 13 below shows the results of a logit regression on the odds of being in the upper two welfare self-assessment range, i.e., rich or in manageable financial situation. The results indicate that the odds of being rich or in manageable financial situation is 95% higher for educated households compared to those with no formal education or schooling. Hence, if decisions makers can invest in schooling, it can be beneficial for long term purpose.

Table 13- Logit regression of education on WSA

Variables	WSA (Rich & Manageable)		
	Odds R.	S.E	P > |z|
Formal education (yes)	**1.95***	0.179	0.000

Chapter 6 – Conclusions and future research

For the past seven decades, the understanding and measurement of food security have evolved significantly from food supply centered indicators to household and individual food access metrics. Through such a shift, the concept has been tightly connected to some closely related concepts such as hunger, diluting what "security" implies for the concept. Thus, it has become challenging to separate food insecurity from hunger.

In this dissertation, we explored both concepts and evaluated the extent to which our understanding and solutions to food security change when viewed from households' perception of their "security" about food, i.e., their freedom from worrying about accessing food. We conduct multiple evaluations to achieve the research objective. Firstly, we restructured the concept of food security by emphasizing household insecurity or worry about food. We argue that an individual who worries or fears that he may not have food or enough food lacks food security. Also, distinctly from food insecurity, hunger is defined as a physical sensation or pain that results from the want of food.

Secondly, we hypothesize that food insecurity and hunger are congruent. In other words, if they are indeed synonymous, we would expect that factors explaining household food insecurity would be statistically the same as those explaining hunger. Also, we strive to identify the minimum of days of hunger that may lead to a congruence. This threshold would indicate the number of days after which people became food insecure. To answer these questions, we used the World Bank LSMS-ISA survey data for Tanzania (2014–2015). We assessed factors that independently influence both outcome variables, hunger and food insecurity, using logit regressions. To test the

research hypotheses, we estimated several seemingly unrelated bivariate probits by estimating both outcome variables jointly.

Our results indicate that not all factors influencing household food insecurity influenced hunger. Drought, food expenditure, and welfare self-assessments variables are among those that statistically influenced both outcome variables. Based on the results of the bivariate probit models, we reject the null hypothesis of congruence between food insecurity and hunger and conclude that factors explaining household food insecurity are statistically different from those influencing hunger.

Subsequently, we identify the minimum of days of hunger (H) that transform hunger into food insecurity by testing the hypothesis of congruence for $H = \{1, \ 2, \ and \geq 2 \ \}$. For $H = 2$ and $H \geq 2$, we obtained chi-squared statistics (χ^2) of 53.23 and 53.29 respectively which are not statistically and significantly different from zero at 10%. We failed to reject the null hypothesis of congruence for a minimum of two days of hunger. In other words, after going through at least two days and nights without eating anything, households began to worry about food and became food insecure.

These results show the continuum on which hunger may transform from a mere physical sensation of the want of food to mental distress or insecurity about food. These results are significant because they shed light on the potential hurdle in policy discourses over the seven decades of attempting to address hunger and achieve food security. Using hunger as an indicator of food insecurity can potentially induce some biases if the threshold at which hunger becomes food insecurity is not accounted for. For instance, 30% of respondents were food insecure, even

though they were not hungry. Therefore, while hunger can be a contributing factor to household food insecurity, it is not a sufficient condition.

We noticed several limitations which could be addressed for further research. The main limitation is related to the variable approximating a household's lack of security or worry about food. Unlike the question about hunger, which provides not only the self-assessment but also includes the severity of the experiences in terms of the number of days in the past seven days that respondents experienced it. To strenghen these findings, it will be beneficial to have a dataset that has a similar severity component to capture whether the worry about food is transitory or chronic also in terms of periods. Also, several shocks variables were difficult to interpret. For instance, the "drought or flood" shock is hard to explain whether the household experienced either one, especially as they are the opposite event of each other. Similarly, the shock water shortage was hard to interpret because we could not tell the difference between drought and water shortage or how they relate.

Overall, the introduction of the U.S. Household Food Security Scale Survey Module (HFSS-SM) in the late 1980s provided a new opportunity in conceiving, defining, and measuring household food security. It is essential to highlight that while the results of this study are very significant for policy discourse, they may only be specific to the case of Tanzania. In other words, the threshold at which hunger transformed into food insecurity may vary from a region to the other, from a country to the other and similar may also vary through times. Therefore, it becomes crucial for further research to deepen these results by considering, for instance, different countries settings in identifying the threshold point at which hunger transform into insecurity. Also, it will be interesting to build a panel household survey data to monitor how past shocks influence the likelihood of for a household to develop insecurity about food and to what extents do households

mitigate those shocks on their ability. The time dimension from a panel data could also help to emphasize the period of adjustment or the time it takes for a household to recover their security about food once they lost it. The implementation of these new research questions could strengthen even more the need to refocus the understanding of the concept of food security on its original and singular objective which is households' perception of their security about food. It remains essential to distinguish the concept of food insecurity from hunger and intervene efficiently in ways that prevent hunger from becoming an insecurity.

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Appendix A - The U.S. Household Food Security Scale Survey Module (HFSS-SM) questionnaire (Coleman-Jensen, 2015)

1. "We worried whether our food would run out before we got money to buy more." Was that often, sometimes, or never true for you in the last 12 months?

2. "The food that we bought just didn't last, and we did not have money to get more." Was that often, sometimes, or never true for you in the last 12 months?

3. "We could not afford to eat balanced meals." Was that often, sometimes, or never true for you in the last 12 months?

4. In the last 12 months, did you or other adults in the household ever cut the size of your meals or skip meals because there wasn't enough money for food? (Yes/No)

5. (If yes to question 4) How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

6. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food? (Yes/No)

7. In the last 12 months, were you ever hungry, but didn't eat, because there wasn't enough money for food? (Yes/No)

8. In the last 12 months, did you lose weight because there wasn't enough money for food? (Yes/No)

9. In the last 12 months did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food? (Yes/No)

10. (If yes to question 9) How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

(Questions 11-18 were asked only if the household included children age 0-17)

11. "We relied on only a few kinds of low-cost food to feed our children because we were running out of money to buy food." Was that often, sometimes, or never true for you in the last 12 months?

12. "We could not feed our children a balanced meal, because we could not afford that." Was that often, sometimes, or never true for you in the last 12 months?

13. "The children were not eating enough because we just couldn't afford enough food." Was that often, sometimes, or never true for you in the last 12 months?

14. In the last 12 months, did you ever cut the size of any of the children's meals because there wasn't enough money for food? (Yes/No)

15. In the last 12 months, were the children ever hungry but you just couldn't afford more food? (Yes/No)

16. In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food? (Yes/No)

17. (If yes to question 16) How often did this happen—almost every month, some months but not every month, or in only 1 or 2 months?

18. In the last 12 months did any of the children ever not eat for a whole day because there wasn't enough money for food? (Yes/No)

Table 14- Bivariate probit model on households' demographics variables (N = 2,810).

Variables	Coefficients worry	Coefficients hunger
Household demographics (D)		
Household size	0.072*	0.052
	(0.04)	(0.103)
Household size squared	-0.005**	-0.009
	(0.002)	(0.008)
Number of children	0.035	0.027
	(0.03)	(0.072)
Age	0.001	-0.01
	(0.012)	(0.02)
Age squared	1.25e-05	6.66e-05
	(0.001)	(0.002)
Formal education (yes = 1)	-0.01	-0.236
	(0.101)	(0.17)
Gender household head (male = 1)	-0.044	-0.248
	(0.123)	(0.228)
Educated & Male (yes = 1)	-0.005	0.351
	(0.127)	(0.239)
Place of residence (Rural =1)	-0.093	0.139
	(0.079)	(0.168)
Married (yes =1)	-0.105	-0.149
	(0.084)	(0.161)
Employment (paid work =1)	-0.042	0.134
	(0.146)	(0.316)
Employment (own farm =2)	-0.0941	0.252
	(0.137)	(0.295)

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

Table 15- Bivariate probit model on households' physical access variables (N = 2,810).

Variables	Coefficients worry	Coefficients hunger
Physical access (PA)		
Farm household (yes=1)	0.0602	0.256
	(0.117)	(0.248)
Livestock producer (yes =1)	0.238	0.280
	(0.176)	(0.363)
Farm & livestock household (yes =1)	-0.215	-0.368
	(0.165)	(0.343)
Agricultural season (wet =1)	-0.006	-0.072
	(0.0526)	(0.104)
Shocks: drought or floods (yes =1)	0.297***	0.267**
	(0.077)	(0.120)
Shocks: crop disease or pests (yes =1)	0.015	-0.252*
	(0.077)	(0.15)
Shocks: livestock died, stolen (yes =1)	0.203**	0.074
	(0.081)	(0.159)
Shocks: rise in ag. input prices (yes =1)	0.00389	0.296*
	(0.083)	(0.158)
Shocks: severe water shortage (yes =1)	0.024	0.264**
	(0.063)	(0.118)
Shocks: loss of land (yes =1)	0.202	0.316
	(0.188)	(0.295)
Assets: livestock (yes =1)	-0.267***	-0.073
	(0.083)	(0.175)
Assets: poultry (yes =1)	-0.015	-0.210
	(0.111)	(0.215)
Assets: land (yes =1)	-0.041	0.301*
	(0.079)	(0.163)
Assets: ag. tools hoes (yes =1)	-0.191**	-0.362*
	(0.095)	(0.200)

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

Table 16- Bivariate probit model on households' economic access variables (N = 2,810).

Variables	Coefficients worry	Coefficients hunger
Economic access (EA)		
Food expenditure_1000 (TSH)	-0.003**	-0.007*
	(0.0016)	(0.004)
Welfare self-assessment (managed =1)	-0.209***	-0.150
	(0.059)	(0.110)
Welfare self-assessment (rich=2)	-0.738***	-0.676*
	(0.141)	(0.403)
Shocks: business failure (yes =1)	0.105	0.208
	(0.134)	(0.234)
Shocks: robbery/burglary (yes =1)	0.142	0.143
	(0.102)	(0.197)
Shocks: lost employment (yes =1)	0.194	0.105
	(0.186)	(0.352)
Shocks: fall in crops sale price (yes =1)	-0.058	-0.384**
	(0.077)	(0.154)
Shocks: rise in food price (yes =1)	0.226***	0.111
	(0.059)	(0.117)
Assets: tables (yes =1)	-0.041	-0.018
	(0.0576)	(0.115)
Assets: refrigerator (yes =1)	-0.515***	-0.776**
	(0.119)	(0.385)
Assets: television (yes =1)	-0.134	0.271
	(0.09)	(0.199)
Assets: Air-conditioner (yes =1)	-0.109	-0.069
	(0.117)	(0.272)
Assets: bicycle (yes =1)	-0.285***	-0.116
	(0.06)	(0.126)
Assets: radio (yes =1)	0.0278	-0.298**
	(0.056)	(0.118)
Assets: house (yes =1)	0.381	0.183
	(0.266)	(0.48)
Assets: utensils (yes =1)	-0.134	0.271
	(0.09)	(0.199)
Assets: phone (yes =1)	-0.244***	-0.087
	(0.072)	(0.127)

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

Table 17- Bivariate probit model on households' social access variables (N = 2,810).

Variables	Coefficients worry	Coefficients hunger
Social access (SA)		
Private assistance_1000 (cash & in-kind)	8.63e-05*	-0.0002
	(5.06e-05)	(0.0002)
Public assistance_1000 (cash & in-kind)	0.00122	-0.002
	(0.00105)	(0.004)
Shocks : death family member (yes =1)	0.132**	0.136
	(0.058)	(0.113)
Constant	-0.354	-1.488**
	(0.395)	(0.716)
Wald test of rho=0, chi2(1) = 71.35, Probability > chi2 = 0.0000		
Test [Worry = Hunger], common: chi2(46) = 62.84, Probability > chi2 = 0.049		

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

**Appendix B - Consistency and robustness check evaluation using a Tanzanian two years'
panel data of 2010-2011 and 2012-2013.**

In this section, we provide in tables and figures the results of the consistency and robustness
check analyses done in comparison to the results found using the cross-sectional survey data of
2014-2015. Tables 18 presents a comparative statistics summary of the two outcome variables,
i.e., food security as worry and hunger using the two sources of data. Based on both sample sizes,
respectively of 3,352 for the cross-sectional and of 7,606 for the panel sample, we found that a
minimum of 30 % of respondents reported they have worried that they would not have enough
food to eat in the past seven days of the survey. Also, the summary statistics using the panel data
indicates the within variation is 70.86 %, meaning that for a given household or individual over
time, the data capture a within change of more than 70 %. On the other hand, the statistics of
hunger, using both sample sizes, indicate that around 97 % of respondents reported that they did
not go through a whole day and night without eating anything.

Table 18- Comparison between proportion households who responded "yes" to the outcome
variables using the cross-sectional and panel data.

Years	(2014 – 2015)	Panel (2010-2011) & (2012-2013)		
Variables	Simple mean (%)	Overall (%)	Between (%)	Within (%)
Worried (yes) = 1	32.31	31.88	44.82	70.86
Hungry (yes) = 1 day	1.37	1.46	2.57	58.64
Hungry (yes) = 2 days	1.49	1.16	2.08	55.06
Hungry(yes) $\geq$ 3 days	0.33	0.45	0.80	58.82
Hungry (yes) $\geq$ 1 day	3.19	3.01	5.33	56.55
Observations	3,352	7,606		

Similarly, for all the binary variables approximating hunger, the within variations are all above
50 %, which represents an indication of the richness of the panel data. Figure 6 shows the

percentage of households that were food insecure (worried) per days of hunger in 2011 and 2013.

Both figures indicate that more than 30 % of the 97 % of respondents who did not experience hunger were worried that they would not have enough to eat in the past seven days of the survey.

Figure 14- Percentage of households food insecure (worried) per days of hunger in 2011 and 2013 in Tanzania.
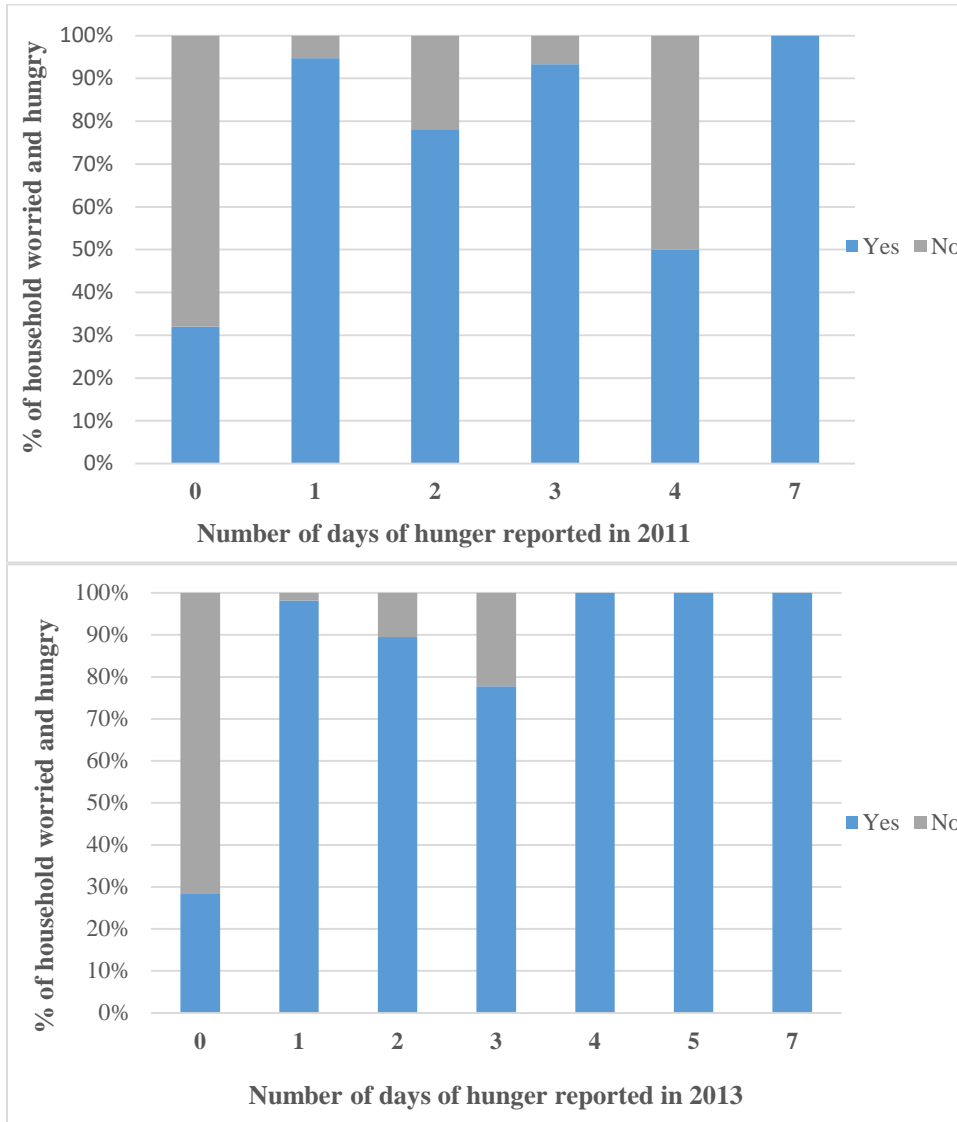
Again this proportion gets worse as the number of days of hunger increases, i.e., H ≥ 1. The percentage of worried rises from 30 % to more than 80 % in the first two days of hunger. These two years' figures confirm the 2014-2015 findings of how hunger and food insecurity.

Besides, consistently with the table format used in the primary documents, the results of the logits and seemingly unrelated bivariate probit regression models using the panel data are also presented in terms of access variables and demographic characteristics. Tables 19 to 22 present the summary of the random effects logit regressions outputs for both dependent variables using the two years' panel observations. Overall, the findings in these Tables are very consistent with those previously presented in Tables 8 to 11 using the pooled estimator or simple logit model. The likelihood-ratio test performed on the panel logistic regression, for each outcome variables, indicates the use of the panel data has significantly contributed in explaining the variation of the outcome variable, i.e., worry about food. However, the likelihood-ratio test performed on the hunger panel logistic regression indicates that the panel-level variance is not essential, and did not significantly enhance the estimator of the panel compared to the pooled estimator. One possible reason for such a result could be the proportion of respondents that reported hunger compares to those that indicated worried about food. On average, for each year of the panel data, about 30 % of respondents have worried about food while only less than 4 % have indicated being hungry for an entire day and night for at least a day.

Nevertheless, the results of Table 19 indicate that the odds of experiencing hunger for at least a day are reduced by almost 50 % for educated household head compare those that illiterate. Similarly, for male household heads, the odds of worrying about food are reduced by more than 35 % compared to female household heads. Also, the odds of being worried about food reduced by 35 % for households that farm and raise livestock. It is essential to mention that overall, the same variables are not statistically significant on both outcome variables.

Table 19- Result of the random effects logit model on households' demographics variables using panel data from (2010 – 2011) and (2012-2013) (N = 6,580).

Variables	odds ratio food insecurity	odds ratio hunger
Household demographics (D)		
Year fixed effect: 2013	0.849**	0.942
	(0.0576)	(0.157)
Household size	1.297***	0.996
	(0.0852)	(0.145)
Household size squared	0.984***	1.004
	(0.00411)	(0.00897)
Number of children	0.975	1.073
	(0.0714)	(0.197)
Age	1.011	1.039
	(0.0144)	(0.0303)
Age squared	1.000	1.000
	(0.000139)	(0.000280)
Formal education (yes = 1)	0.885	0.512**
	(0.126)	(0.140)
Gender household head (male = 1)	0.637***	0.690
	(0.107)	(0.229)
Place of residence (Rural =1)	0.952	1.607
	(0.162)	(0.559)
Married (yes =1)	0.921	0.792
	(0.0940)	(0.183)
Employment (paid work =1)	1.129	1.125
	(0.134)	(0.285)
Employment (own farm =2)	0.990	0.929
	(0.128)	(0.257)

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

While gender plays a role in household worry about food, it seems not to have a statistically significant effect on hunger outcome. Similarly, an increase in household size increases in the odds of worrying about food by 30 % even though it does not have a statistically significant effect on hunger. One reason for such disparities could be explained by the critical proportion of household that worried about food compared to those who were hungry.

Table 20- Result of the random effects logit model on households' physical access variables using panel data from (2010 – 2011) and (2012-2013) (N = 6,580).

Variables	odds ratio food insecurity	odds ratio hunger
Physical access (PA)		
Farm household (yes=1)	1.201	1.315
	(0.191)	(0.456)
Livestock producer (yes =1)	1.808***	1.082
	(0.374)	(0.577)
Farm & livestock household (yes =1)	0.657**	0.641
	(0.133)	(0.333)
Agricultural season (wet =1)	0.808***	0.945
	(0.0593)	(0.158)
Shocks: drought or floods (yes =1)	1.582***	1.394*
	(0.135)	(0.265)
Shocks: crop disease or pests (yes =1)	1.119	1.146
	(0.112)	(0.247)
Shocks: livestock died, stolen (yes =1)	1.045	0.756
	(0.107)	(0.187)
Shocks: rise in ag. input prices (yes =1)	1.193*	1.248
	(0.123)	(0.276)
Shocks: severe water shortage (yes =1)	1.041	0.945
	(0.0860)	(0.175)
Shocks: loss of land (yes =1)	1.453**	1.501
	(0.262)	(0.500)
Assets: livestock (yes =1)	0.730***	1.244
	(0.0754)	(0.320)
Assets: poultry (yes =1)	0.703***	1.024
	(0.0798)	(0.285)
Assets: land (yes =1)	0.815*	1.024
	(0.0931)	(0.270)
Assets: ag. tools hoes (yes =1)	0.822	0.712
	(0.102)	(0.204)

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

Table 21- Result of the random effects logit model on households' economic access variables using panel data from (2010 – 2011) and (2012-2013) (N = 6,580).

Variables	odds ratio worry	odds ratio hunger
Economic access (EA)		
Food expenditure_1000 (TSH)	0.999	0.992
	(0.00212)	(0.00618)
Welfare self-assessment (managed =1)	0.557***	0.647***
	(0.0410)	(0.108)
Welfare self-assessment (rich=2)	0.358***	0.730
	(0.0521)	(0.248)
Shocks: business failure (yes =1)	1.360**	0.536
	(0.204)	(0.223)
Shocks: robbery/burglary (yes =1)	1.287**	1.176
	(0.159)	(0.314)
Shocks: fall in crops sale price (yes =1)	0.812**	1.132
	(0.0841)	(0.259)
Shocks: rise in food price (yes =1)	1.577***	1.829***
	(0.125)	(0.345)
Assets: tables (yes =1)	0.736***	0.691**
	(0.0574)	(0.121)
Assets: refrigerator (yes =1)	0.559***	0.0952**
	(0.0899)	(0.0991)
Assets: television (yes =1)	0.594***	0.652
	(0.0754)	(0.215)
Assets: bicycle (yes =1)	0.714***	0.516***
	(0.0577)	(0.111)
Assets: radio (yes =1)	0.757***	0.592***
	(0.0568)	(0.105)
Assets: house (yes =1)	1.009	0.625**
	(0.101)	(0.139)
Assets: utensils (yes =1)	0.761	0.457*
	(0.215)	(0.202)
Assets: phone (yes =1)	0.719***	0.740
	(0.0619)	(0.146)

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

Table 22- Result of the random effects logit model on households' social access variables using panel data from (2010 – 2011) and (2012-2013) (N = 6,580).

Variables	odds ratio worry	odds ratio hunger
Social access (SA)		
Private assistance_1000 (cash & in-kind)	1.000	0.999
	(0.000170)	(0.00110)
Public assistance_1000 (cash & in-kind)	1.000	1.000
	(0.000427)	(0.00115)
Shocks : death family member (yes =1)	1.369***	1.402
	(0.158)	(0.332)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 23- Results of the biprobit model on households' demographics variables, using panel data from (2010 – 2011) and (2012-2013) with N = 6,580.

Variables	Coefficients worry	Coefficients hunger
Household demographics (D)		
Household size	0.143***	0.00491
	(0.0333)	(0.0652)
Household size squared	-0.00848***	0.00153
	(0.00210)	(0.00395)
Number of children	-0.0147	0.00561
	(0.0373)	(0.0805)
Age	0.00590	0.00791
	(0.00723)	(0.0132)
Age squared	-2.93e-05	-5.52e-05
	(7.08e-05)	(0.000127)
Formal education (yes = 1)	-0.0741	-0.240*
	(0.0733)	(0.128)
Gender household head (male = 1)	-0.242***	-0.179
	(0.0862)	(0.155)
Place of residence (Rural =1)	-0.0405	-0.0397
	(0.0520)	(0.106)
Married (yes =1)	0.0582	0.0698
	(0.0608)	(0.114)
Employment (paid work =1)	-0.0237	-0.0333
	(0.0677)	(0.125)
Employment (own farm =2)	-0.0699	-0.237**
	(0.0590)	(0.112)

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

Table 24- Results of the biprobit model on households' physical access variables, using panel data from (2010 – 2011) and (2012-2013) (N = 6,580).

Variables	Coefficients worry	Coefficients hunger
Physical access (PA)		
Farm household (yes=1)	0.0998	0.102
	(0.0830)	(0.164)
Livestock producer (yes =1)	0.315***	0.0666
	(0.108)	(0.238)
Farm & livestock household (yes =1)	-0.206*	-0.233
	(0.106)	(0.232)
Agricultural seasons (wet season =1)	-0.112***	-0.0154
	(0.0378)	(0.0766)
Shocks: drought or floods (yes =1)	0.246***	0.143
	(0.0449)	(0.0872)
Shocks: crop disease or pests (yes =1)	0.0666	0.0870
	(0.0527)	(0.0985)
Shocks: livestock died, stolen (yes =1)	0.0338	-0.124
	(0.0537)	(0.110)
Shocks: rise in ag. input prices (yes =1)	0.0847	0.119
	(0.0542)	(0.102)
Shocks: severe water shortage (yes =1)	0.0220	-0.00996
	(0.0435)	(0.0843)
Shocks: loss of land (yes =1)	0.223**	0.169
	(0.0965)	(0.163)
Assets: livestock (yes =1)	-0.181***	0.120
	(0.0535)	(0.115)
Assets: poultry (yes =1)	-0.191***	-0.00519
	(0.0596)	(0.125)
Assets: land (yes =1)	-0.114*	-0.000328
	(0.0598)	(0.123)
Assets: ag. tools hoes (yes =1)	-0.111*	-0.147
	(0.0651)	(0.132)

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

Table 25- Results of the biprobit model on households' economic access variables, using panel data from (2010 – 2011) and (2012-2013) with N = 6,580.

Variables	Coefficients worry	Coefficients hunger
Economic access (EA)		
Food expenditure_1000 (TSH)	-0.00115	-0.00329
	(0.00108)	(0.00276)
Welfare self-assessment (managed =1)	-0.327***	-0.193**
	(0.0386)	(0.0759)
Welfare self-assessment (rich=2)	-0.567***	-0.179
	-0.327***	-0.193**
Shocks: business failure (yes =1)	0.165**	-0.269
	(0.0795)	(0.182)
Shocks: robbery/burglary (yes =1)	0.138**	0.0696
	(0.0653)	(0.124)
Shocks: fall in crops sale price (yes =1)	-0.107**	0.0258
	(0.0543)	(0.104)
Shocks: rise in food price (yes =1)	0.241***	0.270***
	(0.0414)	(0.0845)
Assets: tables (yes =1)	-0.156***	-0.188**
	(0.0403)	(0.0783)
Assets: refrigerator (yes =1)	-0.295***	-0.818**
	(0.0805)	(0.346)
Assets: television (yes =1)	-0.279***	-0.222
	(0.0645)	(0.146)
Assets: bicycle (yes =1)	-0.175***	-0.260***
	(0.0414)	(0.0926)
Assets: radio (yes =1)	-0.139***	-0.244***
	(0.0388)	(0.0783)
Assets: house (yes =1)	0.000910	-0.210**
	(0.0516)	(0.101)
Assets: utensils (yes =1)	-0.151	-0.444**
	(0.150)	(0.219)
Assets: phone (yes =1)	-0.200***	-0.130
	(0.0444)	(0.0879)

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

Table 26- Results of the biprobit model on households' social access variables, using panel data from (2010 – 2011) and (2012-2013) with N = 6,580.

Variables	Coefficients worry	Coefficients hunger
Social access (SA)		
Private assistance_1000 (cash & in-kind)	-0.000141	-0.000373
	(8.67e-05)	(0.000376)
Public assistance_1000 (cash & in-kind)	0.000227	-8.39e-05
	(0.000233)	(0.000571)
Shocks : death family member (yes =1)	0.166***	0.153
	(0.0606)	(0.112)
Regions (n =25) for fixed effects.		
Constant	0.0344	-0.762*
	(0.249)	(0.432)
Wald test of rho=0; chi2(1) = 131.979 and Prob > chi2 = 0.0000		
Test [worry_food=Hunger]; common chi2(71) = 118.87 and Prob > chi2 = 0.0003		

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