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EFFECTS OF CLIMATE RESILIENCE ON HOUSEHOLDS' FOOD SECURITY IN GHANA

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BY

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JUNE, 2022

DECLARATION

STUDENT'S DECLARATION

I hereby declare that this thesis is the result of my original work and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature..... Date 02/08/2022

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SUPERVISORS DECLARATION

We hereby declare that the preparation and presentation of this thesis were supervised following the guidelines and supervision of the dissertation/thesis laid down by the University for Development Studies.

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ABSTRACT

The achievement of SDG 2 (ending hunger) and SDG 13 (climate action) across the Globe could enable developing countries to fight the menaces of food insecurity and climate change impacts. Resilience to climate change is a sine qua non in achieving sustainability and a food secured and environmentally friendly economy. This study sought to determine the resilience capacity of households in Ghana. It specifically examined the interactive effect of shocks and resilience capacity and how these interactions influence household food security. The study employed Ghana Living Standards Survey round seven (GLSS 7) data from 14,009 households. Different econometric models and analytical procedures were employed to achieve the objectives of the study. These included the resilience index measurement and analysis II (RIMA II), endogenous switching regression with the ordered outcome, partial proportional odd models and logit regression, models. The study found that households within the rural area face the burden of food insecurity more than people in the urban area. In addition, the regions in Northern Ghana were more vulnerable to food insecurity than the other regions of Ghana. The marginal effect of resilience on household food security shows that a resilient household is less likely to be food insecure. Shocks had a negative influence on the household food security status. However, the interactions between these shocks and the household resilience capacity showed a decreasing effect on food insecurity. The findings further revealed that urban households are more resilient and more food secure than rural households. Besides, the study found that while household resilience capacity positively influences the food security status, households' exposure to shocks (both covariates and idiosyncratic shocks) negatively affected their food security. The study recommends that public investment in infrastructure will be required to deliberately reduce rural-urban migration, enhance households' resilience and bridge the food insecurity gap. This will require collaborations between and among institutions; both private and public.

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LIST OF ACRONYMS

1V1D	One Village One Dam
ABS	Access to Basic Services
AC	Adaptive Capacity
ADB	Asian Development Bank
AfDB	African Development Bank
AI	Anthropometric Indicators
AIDS	Acquired Immunodeficiency Syndrome
AST	Asset
ATE	Average Treatment Effect
ATT	Average Treatment on the Treated
BIVN	Bivariate Normal Distribution
CAADP	Comprehensive Africa Agriculture Development Programme
COVID-19	Coronavirus Disease of 2019
CPS	Current Population Survey
EA's	Enumerated Areas
ECOWAS	Economic Community of West African States
ESR_OO	Endogenous Switching Regression with Ordered Outcome
EU	European Union
FA	Factor Analysis
FAO	Food and Agricultural Organisation
FASDEP	Food and Agricultural Sector Development Policy
FCS	Food Consumption Score
FGD	Focus Group Discussion
FIES	Food Insecurity Experience Scale

FSIN	Food Security Information Network
FS-UNEP	Frankfurt School United Nation Environmental Programme
GAC	Ghana Aid Commission
GLSS	Ghana Living Standards Survey
GOLM	Generalised Ordered Logit Model
GOLOGIT	Generalised Ordered Logit
GSFP	Ghana School Feeding Programme
GSS	Ghana Statistical Service
HDDS	Households Dietary Diversity Scores
HHS	Household Hunger Scale
HIV	Human Immunodeficiency Virus
ICNDC	Intended Nationally Determined Contribution
IDDS	International Development Design Summits
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
LGA	Local Government Area
MBI	Medical and Biomarker Indicators
MDG	Millennium Development Goal
MEST	Marine Engineering Science and Technology
MIMIC	Multiple Indicator Multiple Causes
MMP	Malabo Montpellier Panel
MoFA	Ministry of Food and Agriculture
NCCP	National Climate Change Policy
NDC	Nationally Determined Contribution

OECD	Organisation for Economic Co-operation and Development
OLM	Ordered Logit Model
PCA	Principal Component Analysis
PCD	Partnership for Child Development
PFG	Planting for Food and Job
PPO	Partial Proportional Odds
RCI	Resilience Capacity Index
REDD+	Reducing Emission from Deforestation and Forest Degradation
RIMA	Resilience Index Measurement and Analysis
RMTWG	Resilience Measurement Technical Working Group
RSM	Resilience Structure Matrix
SADA	Savannah Accelerated Development Authority
SDG	Sustainable Development Goals
SSA	Sub-Sahara Africa
SSN	Social Safety Net
SSU's	Secondary Sampling Unit
SUN	Scaling Up Nutrition
TANGO	Technical Assistance to Non-Governmental Organisation
ULV	Unobserved Latent Variable
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
USD	United States Dollar
USDA	United States Department of Agriculture
USSD	Unstructured Supplementary Service Data

VNR	Video News Reel
VOH	Voice of the Hunger
WB	World Bank
WFP	World Food Programme
WHO	World Health Organisation
WMO	World Meteorological Organisation

CHAPTER ONE

INTRODUCTION

1.1. Background

Agriculture being the mitochondria of many economies, its importance to human survival and well-being cannot be overstated. Agriculture performs a variety of responsibilities in different countries. It is known as the basis on which stable communities are constructed because of its ability to provide jobs (Adesina & Favour, 2016). It was projected by Dittoh & Akuriba, (2018), that if agriculture is properly exploited, it could contribute to the well-being of economies and people in developing countries. Agriculture generates 20-50 percent of Africa's GDP and employs approximately 60 percent of the people, and it is severely impacted by changes in climate (Ozor et al., 2012). Agriculture provides food and fibre, maintains sustainable natural resources, creates and preserves habitats, conserves biodiversity, and contributes to socio-economic activity in both urban and rural areas, among other things (Salvo, 2013).

Agriculture also generates roughly 20% of Ghana's national GDP and is the primary source of employment for the poorest households (World Bank, 2017). However, recently, the Ministry of Food and Agriculture (MoFA) (2021) updated that agriculture provides about 38.3% of the national employment and 19% to the national GDP of Ghana. According to Cornille et al. (2022), Ghana's agriculture industry has performed admirably and is regarded as one of Africa's success stories. Although, Ghana is one of the few countries which reached the Millennium Development Goal (MDG) of halving poverty and hunger by 2015, yet it remains

impoverished, with more than a quarter of the population living below the US$ 1.25 poverty line (FAO, 2015). Due to Ghana's lower contribution of the public expenditure allocated to food and agriculture, it has not been able to achieve the comprehensive African agricultural development Programme (CAADP) second objective of a 6% growth rate in agriculture. Despite the aforementioned, agriculture in Ghana is still characterised with the use of undeveloped technology, rainfed and subsistence in nature.

The contributions of agriculture to the economy of Africa and Ghana notwithstanding, the sector is faced with challenges resulting from shocks such as pest and disease, price shocks, death of a household member or illness and climate change or weather variability. Climate shocks remains the most pressing challenge to agriculture which could influence productivity and affect the food security status of the households. Agriculture, on the other hand, cannot thrive in unfavourable weather and climatic circumstances and can only manage with a certain amount of unpredictability. However, if the conditions are at the extreme (for example, heavy rain, high temperature, flooding, or prolonged droughts) and beyond the coping strategy, significant impacts such as dryness, lodging, and abortion of flowering agricultural plants can occur, posing a substantial danger to productivity and livelihoods (Alexander et al. 2012). Agricultural activities, in general, are more and highly vulnerable to climate variability/change than other sectors in any economy (Kurukulasuriya et al., 2006). This is due to the fact that agricultural production is influenced by weather conditions (Mendelsohn et al., 1999). Despite the fact that it is vulnerable to climate change, agriculture is also seen as one of the factors contributing to it (Sarpong & Anyidoho, 2012).

Climate change is one of the world most pressing challenges today. Its effects and impacts through shocks such as wildfire, flooding, drought, cyclones which are caused by temperature, rainfall patterns, wind direction among others is a reality that is being felt today (Tubiello et al., 2007). It could have a beneficial or negative impact on agriculture. This can be quantified in terms of crop growth, soil water availability, soil fertility and erosion, drought, pest and disease incidences, and sea-level rise (Butterworth et al., 2010; Onyekwelu et al., 2006; Semenov, 2009; Ziervogel et al., 2008). Furthermore, the effects of climate change on agricultural production may be generated directly or indirectly by human intervention or by the natural climatic cycle (Ziervogel et al., 2006). Changes in climate pose a hazard to both the agricultural and non-agricultural sectors, but agricultural activities are the most vulnerable to the effects of climate change (Kurukulasuriya et al., 2006). Shocks which influence both the off-farm and on-farm activities of the developing nations and vulnerable rural poor constitute a major threat to their food security. (Ansah et al., 2020). Climate shocks continue to be the greatest significant threat to agriculture, posing a threat to productivity and family food security.

Food security is a key component of Sustainable Development Goal 2 (SDG 2), which aims to eradicate hunger. The absence of hunger is defined as food security. It's defined as a scenario in which "all individuals have physical, social, and economic access to sufficient, safe, and nutritious food that fits their dietary needs and food preferences for an active and healthy life at all times (FAO, 2010). Hunger occurs when there is limited accessibility, availability, stability, affordability and utilization of food (Steiner-Asiedu et al., 2017).

Nkegbe et al. (2017) have reported that there are 578 million hungry people in the Asia-Pacific area, 239 million in Sub-Saharan Africa, 53 million in Latin America and the Caribbean, 37 million in North Africa, and 19 million in industrialized countries. While over 5% (1.2 million) of Ghana's population is food insecure, with another 2 million at risk (MoFA, 2007). According to the European Commission EU (2012), resilience could be a long-term solution to food security in developing countries. This has resulted in a paradigm shift and shift in researchers' perceptions of how household food systems respond to shocks. (Constas et al., 2014; D'errico et al., 2016; Pingali et al., 2005). Shocks in the food supply, such as price shocks, pest and disease outbreaks, illness or death of a household member, and climate change or weather in the home, can all lead to food insecurity in the home (Ansah et al., 2019). Ayifli, (2017), identified rainfall as a major determinant of fluctuations in the food output of the households and Ghana as a nation thereby resulting in household food insecurity which can transcend into poor communities and even become chronic in the distressed areas. Shock is a disturbance that sets the system into unrest and the extent to which it affects a system, an individual or a household could be determined by its vulnerability (Adebimpe et al., 2018).

As noted by Ozor et al., (2010), Agriculture's susceptibility is defined by a combination of the societal capability to cope with and/or recover from environmental changes, not by the form and amount of environmental stress such as climate change. While environmental changes influence coping ability and degree of exposure, they are also influenced by societal factors such as land use and cultural behaviours. Because developing countries have fewer resources, such as social,

technological, and financial resources, they are the most exposed to the effects of climate change (UNFCC, 2007). A system is said to be vulnerable when it is susceptible to and unable to cope with the negative effects of climate change. (IPCC, 2007). Vulnerability is an important part of climate resilience since the people who are most likely to be affected by climate change are also the ones least capable of creating robust and comprehensive climate resilience and response mechanisms (Asian Development Bank, 2009). Adapting resilience entails determining how multiple sectors, such as catastrophe risk reduction, climate change adaptation, social protection, working in fragile environments, and humanitarian readiness and response, may complement and strengthen one another.

The volume of disruptions that a system may withstand without passing its thresholds is referred to as resilience. (ADB, 2009). It can also refer to a system's ability to cope with and adjust to uncontrollable events, as well as its ability to accommodate a disturbance (Adebimpe et al., 2018). Resistance, adaptability capacity and recovery are the three dimensions of resilience. (Thywissen, 2006; Mayunga, 2007). The concept of resilience is founded on these three elements (Carpenter & Altmann, 2015; Maguire, 2007; Schwindt & Thieken, 2009).

Climate change resilience refers to a system's ability to tolerate the effects of climate shocks without breaking down. Improving resilience will have a wide range of consequences for the agricultural sector, particularly in terms of production. Climate change resilience refers to a person's ability to cope with the effects of climate change. Adaptation and mitigation techniques are the two key variables that are utilized to enhance climate resilience. Adaptation refers to any modifications in

practices or structures made in response to expected or actual climate change in order to maintain the capacity to deal with current and future changes and/or seize new possibilities that may arise (Okoli, 2014). Weather fluctuations have an impact not just on agricultural development but also on people's lives. Various strategies are being created for adaptation to the changing scenario in which resilience development is highly important in a sustainable manner in order to provide answers to the devastation produced by climate change in agriculture. One of the adaption tactics used to counteract climate change is resilience. This becomes a problem as a result of the human system's requirement to control its interactions with ecosystems in a sustainable manner (ADB, 2009). In achieving sustainability at all levels in the midst of unreliable and erratic climate shocks, resilience becomes critical (Alhassan, 2020).

A functioning ecosystem and food security are required to sustain life on Earth. People have equitable physical, economic, and social access to safe and nutritious food that fits their dietary needs and food preferences for a healthy life when they have food security (FAO/WHO, 2009). As a result, a household is food secured if it can acquire safe and secure food in a socially and environmentally acceptable manner (Hyacinth & Kwabena, 2015). According to Alinovi et al. (2010); Grebmer et al. (2013), Africa accounts for nearly a quarter of the world's hungry people, and Sub-Saharan Africa ranks second after South Asia on the Global Hunger Index.

About 5% of adults and 12% of children on research conducted on some selected districts in 4 out of the 10 regions of Ghana sleep with hunger (Ghana Aids Commission (GAC, 2019). Although Ghana has been commended for reducing hunger between 1990 to 2015 by about 75%, hunger and malnutrition are still major

challenges that could increase as a result of an unstable food production system that is still prevalent within the country (Steiner-Asiedu et al., 2017). According to USDD (2014), climate shocks may be connected to undernutrition and food insecurity.

1.2. Problem Statement

Climate change, pandemic challenges, and the occurrence of locusts, which have caused food shortages in several poor nations, particularly in Africa, are now important research concerns. The subject of food security arose from the failure to ensure that everyone has equitable access to high-quality food that must be available at all times. The second SDG objective of putting end to hunger and ensure equal access to nutritious food which is yet to be achieved are issues of concern in research. Also, climate change is a global phenomenon in which its reality is now with us. The SDG 13 of climate action is instituted to combat this. However, climate change and variability still pose bigger challenge which requires a bigger attention than ever. In Ghana, there is increasing level of vulnerability and food insecurity among households as a result of shocks induced by climate shocks, weather variability, illness and sudden death of the bread winner in the family. When people are confronted with shocks, some will be able to recover, some will lose their jobs, and others will be unaffected. Resilient people are those who bounce back from setbacks and remain unfazed. As a result, we must ask: when a household is robust, how long can it be sustained? Hunger, malaria, and malnutrition are the three pandemics that have been killing Africans for decades.

The majority of persons who are most vulnerable to the COVID-19 pandemic are those who are suffering from one or more diseases that can be connected to nutrition and climate change, according to research. According to Havelaar et al. (2015), the burden of foodborne infections is comparable to HIV/AIDS, and impoverished countries suffer the brunt of the burden. COVID-19 will leave us, but its consequences in terms of poverty, food scarcity, and food inaccessibility, which could lead to hunger and malnutrition, will linger for decades. This is because the lockdown and closing of borders have damaged the food production chain, either directly or indirectly.

A drop in oil prices as a result of the pandemic and technological changes, combined with hunger as a result of the unavailable nature of food during COVID-19 lockdown, has given rise to confrontation amongst civilians and law enforcement agencies in some regions. This has further underlined Africa's poverty and food insecurity. Furthermore, most African countries' economies have shrunk, turning the continent into beggars for palliatives, revealing our levels of thoughtfulness, poverty, and hunger (Anyanwu et al., 2021; AfDB, 2021). Hunger, poverty had been with us before the pandemic and may not leave us at any time soon. It is a pandemic which has lived with us for centuries. Poverty, hunger, malnutrition, malaria, violence, and changes in climate are serious pandemics that can kill more people and require immediate intervention. These have caused shocks in diverse ways at various periods. Shocks can be idiosyncratic, such as disease or illness impacting households, or they can be covariates, such as natural disasters or human-induced events that hit a vast area at the same time (Ansah et al., 2019).

Shocks which could be both covariate or idiosyncratic and affect food security are central to this study. These shocks are very important to the study of climate resilience. According to FAO, (2018), idiosyncratic shocks are shocks that could affect the resilience level and the food security status of the household. These shocks include the death of a household member or livestock, illness of a household member, amongst others. While the covariate shocks affect people in the geographical location, region or continent and this includes drought, price shock, erosion, conflict etc. Central to this study are shocks resulting from the death of a household member, illness of a household member and experience of conflict of war, conflict, flooding and drought. These shocks are very important as their presence could impede the activities of the household, loss of livelihood, lives and food insecurity. The validity of the forgone in relation to food insecurity will be established in this study and the influence of a household's resilience capacity on food security. In understanding this, it is important to establish the vulnerability of households to food insecurity and the relationship with household resilience capacity. Investigating how resilient and vulnerability of a household is to food insecurity, is essential in understanding the welfare of households in Ghana. Shocks are a very crucial aspect in understanding the economic and nutrition problem of the household like food insecurity experience scale and poverty(Gutierrez et al., 2017).

Naudé et al. (2009), noted that most recent development studies have come out clearly to say that poverty cannot be easily dealt with without dealing with vulnerability first. This is contingent because understanding what makes people vulnerable that is; the sensitivity and exposure could give a better understanding in dealing with poverty issues. When you are poor, you are vulnerable and when you

are vulnerable, you are poor. Poverty and shocks, both variables and idiosyncratic shocks, such as climate change, death of a household member, prolonged hunger with poor nutrition, and so on, could all contribute to vulnerability. Vulnerability in this context will be in relation to the household's resilience capacity and food security.

Food security refers to a household's ability to obtain sustainable food that will adequately and healthily nourish them (Pinstrup-Andersen, 2009). The agricultural sector's resilience to climate shocks becomes crucial to concerns of economic, environmental, social, and institutional significance in mitigating climate change and guaranteeing food security. Ghana is a middle-income country with unpredictably bad weather and agriculture that is reliant on rain. Because agriculture is such an important part of Ghana's economy, as well as its sensitivity to climate change and contribution to emissions, climate change resilience is a hot topic. Since then, a large and growing body of research has focused on resilience, to determine which attributes make a country, community, or household resilient, as well as establish the principles and processes that strengthen resilience, allowing populations to better withstand and recover from disasters.

Various policies, plans and Programmes have been embarked upon by different organisations and governments in different places either collectively or separately at the global level, continental level and national level to ensure food and nutrition security and a safer ecosystem.

SDG at the global level, CAADP and African Development Bank (AfDB) High 5 at the continental level and several Programmes in different countries of the world. In

Ghana, different, strategies have been adopted giving the impact that food insecurity and climate change could have on the nation's economic development.

Since 1991, Ghana has been involved in the discussion on climate change issues and has worked at ensuring a friendly environment and policies which are further divided into Programmes on climate change to achieve food security (MEST, 2012). It has signed the United Nations Framework Convention on Climate Change (UNFCC) in 1992 with other countries, although it is still dealing with climate change and variability. Voluntary National Reviews (VNR) Report (2019), noted that several programmes have been put together to improve climate mitigation/adaptation and resilience across the sectors in Ghana, among such programmes, an implementation plan for nationally determined contribution, projects and strategies such as; National REDD+ Strategy, 2016-2040, green climate change fund adaptation programme, national climate change master plan, implementation fund project, At the subnational level, capacity building and mainstreaming climate change into medium-term plans, implementation of the national low carbon implementation strategy, national climate change policy, and national forestry plantation strategy, and the medium-term development policy framework are all priorities (2018-2021). There is also a plan in the works to involve the commercial sector in climate change mitigation initiatives. Furthermore, since the start of the 2019/2020 academic year, climate change has been included in the school curriculum to be taught in elementary, junior, and senior high schools. Again, climate change has been implemented in roughly four universities for climate change research and policy analysis.

Likewise, at achieving food and nutrition security in Ghana, programmes, plans and policies channels at achieving zero hunger among others; Ghana school feeding Programme (GSFP), planting for food and jobs (PFJ) resulting from the quest to modernise and transform agriculture (Ministry of Food and Agriculture (MoFA), 2021). Also, one village one dam (1V1D), food and agricultural sector development policies (FASDEP I and II), medium-term agricultural sector investment plan (METASIP I and II), district water policy, promoting the production and full utilization of locally grown and nutrient-dense food, scaling up nutrition (SUN), and food and nutrition security research and development (FNS), tax holidays as incentives for agricultural processing and production businesses, as well as exemptions on import levies on agricultural inputs, are just a few of the initiatives in place to maintain Ghana's food and nutrition security [(VNR) Report, 2019)]. Since 2006, the United Nations World Food Programme has collaborated with the Ghanaian government to ensure that meals are delivered to students in a number of schools (World Food Programme (WFP, 2019). This was motivated by the high level of hunger and vulnerability among Ghanaian schoolchildren. It was later transitioned to the Ghana School feeding Programme (GSFP) based on the agreement between the government and WFP. The Programme was supported by the partnership for child development (PCD) to monitor the cooks and the caterer so that the aim of the Programme is achieved. Nonetheless, hunger has still being a serious challenge across the country with variations in the level of hunger across the regions.

Conversely, Malabo Montpellier Panel (MMP, 2017), estimated that one in five every Africans is still chronically malnourished, making the continent more vulnerable to food insecurity. MMP noted that climate change together with other

factors could increase child malnutrition and hunger thereby inverting the achieved gains towards the objectives of SDG and Malabo Declaration agenda 2063.

Several studies (Abukari & Tok, 2016; Adu-boahen, 2019; Adzawla et al., 2020; Alhassan et al., 2019; Amikuzuno, 2011, 2012; Ansah et al., 2019, 2020; Asamoah & Ansah-Mensah, 2020; Azumah et al., 2017, 2020; Donkoh et al., 2014; Ibe & Amikuzuno, 2019; Issahaku & Abdulai, 2017; Issahaku & Abdulai, 2020b; Laube et al., 2012; Lolig et al., 2014; Mabe et al., 2021; Nkegbe et al., 2017; Nkegbe & Kuunibe, 2014; Shaibu et al., 2020; Tetteh et al., 2019; Zakaria et al., 2020) among others have examined resilience, climate change, food security and shocks in Ghana either separately or together. However, to the best of the researcher's knowledge, little or none of the existing literature studied the influence of resilience concerning climate shocks and food security at the national level. They also not extensively examined the effects of shocks and their dynamics on households' food security and resilience capacity. Furthermore, there is a small amount of study on resilience and food security in Ghana utilizing Resilience Index Measurement and Analysis (RIMA II). As a result, this study will fill in the gaps and add to the existing literature on household food security and resilience in relation to shocks in Ghana.

As a result, the importance of researching the effects of household resistance to climate change on food security in Ghana cannot be overstated. While the focus of this study is on climate change resilience and food security and their impact on households, the importance of the respondents' vulnerability to climate change in Ghana must also be taken into account.

1.3. Research Questions

The major question that this research sought to address is, what are the consequences of households' resilience to climate shocks and its impact on food security in Ghana? The pertinent specific research questions to this study are;

i. What are the factors determining household resilience capacity to food security?
ii. Does household resilience capacity have any effect on its food security?
iii. What is the interactive effect of shocks and resilience capacity on household food security? and
iv. What are the effects of shocks on resilience capacity?

1.4. Objectives of the Study

The main objective of this study was to assess the effects of households' resilience to climate change and its impact on food security in Ghana. The specific objectives of this study are to;

i. Assess the determinants of household resilience to food security,
ii. Examine the effect of household resilience capacity on their food security,
iii. Assess the interactive effect of shocks and resilience capacity on household food security, and
iv. Examine the effect of shocks on the resilience capacity index.

1.5. Justification of the Study

Resilience is the ability of individuals and the agricultural ecosystems on which they rely to reduce risk by increasing their adaptability capacity, which ensures that the present and future food needs of farmers are met while coping with uncertainty and

change (Adger et al., 2003). Meeting current households needs could be attained through resilience and using appropriate adaptation strategy (Okoli, 2014). However, it is worthy to note that, it is not all methods that are available to farmers. Also, it is not all techniques available that are often successful in protecting household food security from climate change. Majorly, Adaptation's goals include: lowering the damage risk, increasing the ability to deal with inevitable damages, and taking advantage of possible opportunities that may come with shocks (Ozor & Nnaji, 2011). The two known goals of agriculture are to ensure food security for all and employ the best agricultural practices which could mitigate the influence of climate change. The system's capability to cope and correct itself to be less vulnerable to shocks is being influenced by the political, economic, social and cultural interactions which drive their vulnerability to both food insecurity and shocks vis-a-viz sensitivity and exposures (Alexandre et al. 2012). This is best described by the term resilience. Thus, resilience is the capacity, ability and ability of a system to bounce back to its status quo after it has been exposed to shock(s).

The ideal technique to quantify resilience has long been a point of contention. Each strategy has its own set of advantages and disadvantages. The FAO proposed an approach that corrects for the majority of the flaws in resilience measuring uncovered by researchers. It has been refined multiple times, and as a result, this study will apply the method of analysis for households' food security resilience in Ghana. Ansah et al. (2020), noted that the preceding research examined resilience as an indication of food security rather than as an independent entity, making the distinction between the two problems. They also failed to consider the consequences of shocks and how they affected households. According to D'Errico (2016), Since

resilience cannot be quantified directly, various resilience measurements have been proposed. Household resilience to food security was measured using Resilience Index Measurement Analysis (RIMA II). According to the FAO's RIMA II blueprint, this will assist policymakers in identifying and ranking households from the most resilient to the least resilient, as well as providing information to policymakers for optimal policy decisions.

More studies on the vulnerability status and the various strategies that have made a household more resilient to shocks resulting from climate events and food security in Ghana are needed to realise SDGs 2 and 13 in 2030, as well as the Malabo Declaration goal, the African Union commission's Agenda 2063, and the African Development Bank's High 5 objectives of feeding Africa. By harmonising multiple definitions across disciplines and distinguishing between the two concepts in terms of measurement and otherwise, this study will add to current literature and expand the frontier of knowledge on household resilience and vulnerability. In addition, the analysis will be based on the cross-sectional data set. This study adds to the literature on household resilience capacity, food security in Ghana and contributes to the understanding of SDG's 2 and 13. It will also help development partners to appreciate the relationship between household resilience and food security. They will be able to determine how vulnerable and exposed they are to climate shocks.

The study will also improve stakeholders' understanding of the impact of climatic shocks on their food security and resilience capacities. As a result, it is expected that the findings of this study will contribute to the creation of the Climate Change Resilience Program, allowing policymakers to establish policies that would benefit

everyone. In addition, the outcome of this research could 2support policy on food security in Ghana.

Organisation of the Study

This study is divided into about 5 sections. The first chapter is the introduction, contains the following information: the study's background, problem description, research question, research objectives, justification, and organization. The second chapter examines the research on resilience, climate change/vulnerability, and food security in Ghana, the study region. The third chapter contains the research technique, which includes a description of the study area, data sources, and a detailed analytical framework and analysis with tables on *a priori* expectations for the usage of various models. The fourth chapter contains a description of the data, as well as an interpretation and discussion of the findings. In chapter five, the study's results, conclusions, and policy recommendations are summarized.

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

This chapter is a review of relevant literature on climate resilience i.e., the shocks, resilience capacity and food security in Ghana. An empirical, methodological, theoretical and conceptual review was done concerning climate change, climate resilience, food security amongst others. The Chapter focused on the theories and the concepts of climate resilience, food security and household resilience capacity. This study adapted approaches inter alia; socio-ecological, vulnerability and portfolio approaches for understanding the rationale behind the theoretical and the empirical analysis for the study. Various studies which were reviewed had established a close linkage between food insecurity, the vulnerability of households to shocks that is; idiosyncratic and covariates and climate resilience. Understanding climate resilience resulting from shocks such as flooding, war, conflict, fire, drought among others with how it influences food security status and resilience capacity of the households becomes paramount in this research. The novelty of this research is in its combination of different approaches employed in measuring household resilience capacity as proposed by the United Nation Food and Agricultural Organisation (UN-FAO) combined with other approaches to synchronise outcome variable which depicts the household welfare that is the food security status and various shocks at the national level for proper planning and strong policy formulation.

2.1 Food Security

Challenges resulting from food insecurity became a global problem in the 1940s and this gave birth to the creation of the United Nations Food and Agricultural Organisation (UN-FAO) in 1945 and a universal declaration called human rights which has food security as a measure of the standard of living as its core (UN, 1948). Canada and the USA who were the donor countries established a bilateral agency in charge of shipping overseas their surplus agricultural products in the 1950s to countries who need them. Not far from this period, these countries observed that food aid could impede a country from being self-sufficient and this result in the establishment of food development in 1963. But, the period of the surplus came to an end and this resulted in a food crisis in the 1970s. The increment in food prices resulting from the worldwide food crisis of 1972 to 1974 rekindled the interest in food security which birthed the World Food Conference intending to make every country to be self-sufficient to feed the ever-increasing population.

The food crisis within this period was a result of the fluctuations in the price of the food supply. The attempt at achieving food sufficiency has still not been achieved by most developing nations. Food security had since been defined, redefined, and viewed in different ways by different organisations i.e., government and non-governmental organisations, policymakers, various disciplines such as agriculture, sociology, economics, anthropology amongst others, and researchers (Jones et al., 2013). Smith et al. 1993 cited in Maxwell, (1996); Napoli et al. (2011), before 1993, there have been about 200 different definitions of food security. This shows that people have different approaches and views about food security.

Smith noted that using security in relation to food i.e. food security depicts some level of food crisis being experienced by developing economy especially the rural poor. UN (1975), defined food security as the situation whereby food that can sustain life is available at all times in the quantity that is needed through the world supply of basic foodstuff in other to offset production and price fluctuations through expansion of food consumption. Kracht (1981), defined it as the situation for maintaining a healthy life, growth, procreation whereby everyone has sufficient quantity at any time to eat. The definition of FAO (1983), supported this by seeing it as a condition that ensures both physical and economic access to the needed food at all times. It is also having enough to eat (Zipperer, 1987) or when there is no malnutrition and hunger (Kennes, 1990). More also, when there is assurance food to meet all season need, it is also food security UNICEF (1990).

The various use of the term food security signals its importance and the problem that people faced with regards to food insecurity in developing nations. Wood Food Summit (WFS, 1996), defined food security as the condition whereby all people at at all times have economic, physical and social access to sufficient, nutritious and safe food that meet the dietary needs for a healthy and active life. Ministry of Food and Agriculture (MoFA) being an authority in Ghana defines food security in the Ghanaian context as good quality nutritious food, hygienically packaged, elegantly displayed, available in adequate quantities all year round and located at the correct place at affordable prices (MoFA, 2007). This definition by MoFA commemorates the generally acceptable World Food Summit's definition of food security and also extends it by adding modality for packaging and presenting the food which could be termed the value addition on the food and its product. This explains, peoples' access

to the required amount of food with the needed quality in terms of nutrients which could meet the household dietary needs for a vigorous life and sound mind i.e., having access to a stable balanced diet, is considered as food security. But when people are not having the right quantity of food to eat, such according to Sen (1981), is said to be food insecure. This definition extended the scope of the opinions of the different researchers by incorporating starvation resulting from the inability to access the food rather than being unavailable. In 1996, food insecurity became one of the objectives of the world food summit.

Millennium Development Goals (MDG) succeeded this with the aim of seeing an end to hunger and poverty between the years 2000 and 2015 in the whole world at the united nation Millennium Summit. The inability of the developing nations in which Ghana was not excluded to achieve the MDG's birthed the development of the Sustainable Development Goals (SDG) which is a global strategy built on MDG's to see an end to hunger and food insecurity and malnutrition between 2015 and 2030. However, Ghana was applauded for being able to reduce hunger by half in 2015 but it is still noted problems of food insecurity with which many of the citizens still sleep with hunger (Ghana Aids Commission (GAC, 2019). Yes, there are close linkages between hunger and food security but it is good to differentiate between the two. Hunger is an advanced state of food insecurity. It is sometimes captured by food insecurity measurement when such measures capture the household or individual deprivation of food Owino *et al*. (2014) resulting from the non-availability of food or its non-affordability which makes it inaccessible and unavailable. Food insecurity is the polar opposite of food security, and it has always been a concern when it has been used as a metric for gauging household wellbeing.

The authors also noted through Cook & Frank (2008), that the effect of food security could result in poor health challenges, malnutrition, deficiencies in some micronutrients such as iron deficiency, increase hospitalisations, aggression, disorder, anxiety, and attention deficit. The level of food insecurity which is a global problem and its disproportionate nature across countries and continents and not specific to any location (Kwame & Musah, 2020), is a major threat to the global populace. Kwame & Musah (2020), observed that Africa remains the most vulnerable to food insecurity as compared to other continents as it housed the poorest countries of the world. Sub-Saharan Africa is the most heated by the incidence of food insecurity and malnutrition and 60% of the worse food insecure in the world are in the Sub-Saharan region of Africa.

Ghana's new designation as a lower-middle-income country (LMIC) suggested the countries less likelihood of receiving foreign development assistance, which has previously funded FNS needs. According to the Ghana Statistical Service (GSS, 2014), agriculture is an income source for roughly 71% of the people in the rural area, who farm crops or rear livestock. In both the Upper East and the Upper West, this figure can reach 95%. Agricultural products, notably food, account for a major portion of household budgets in both urban and rural areas.

2.1.1 Food Security Dimensions

The dimensions of food security are; food availability, stability, utilisation, and accessibility. Food availability refers to the situation where food is present physically which is enough to meet the people's needs (FAO, 2006). Food availability is determined by how food is produced, distributed and exchanged, as well as a variety of other factors vis-a-vis land availability, land rights access, tools,

skills, water, production and processing technologies, pests, transportation and information; and markets and market exchanges. Also, policies and regulations governing food production and markets impact food availability (FAO, WHO, 2003; FAO, 2019). Access to food refers to one's ability to buy food based on financial resources and costs, as well as the classes and amount of available food in the marketplaces. This is a function of the consumer's preferences for specific types of diets, which may be influenced by religious beliefs, tastes, seasonality, conventions, gender, advertising, age, preparation requirements amongst others. Affordability, allocation, and preference are thus the primary determinants of food access.

The human's system ability to utilise the ingested food is emphasized by the term food utilization. Food value in terms of the nutritional content, its worth socially, and safety are all factors that define food utilisation. Food utilisation is the variety and quality of food ingested, hygienic food preparation culture, cultural customs, community and household relations, standards, regulations, and practices to ensure food safety at each step within the food system, and standards, regulations, and practices to ensure food safety at each step within the food system. According to USDD (2014), climate change may be connected to undernutrition and food insecurity.

For food system research, determining the unit of analysis (individuals, families, communities, regions, or countries) is critical since it defines the spatial and contextual elements of the analysis. In this study, the unit of analysis is the household is unit of analysis and the reason for this is because the household is the point at which most decisions are made.

2.1.2. Food Security Measurement

Determining the number of people who are food secure to lessen the prevalence of hunger and improving the households food and nutrition security, a very good measurement of food security level is essential (Huang et al., 2015). The authors categorised the measurement of food security into one-dimensional indicators [i.e., FAO Indicator of undernourishment (FAO)], the dietary diversity score, food consumption score, anthropometric indicators (AI) (it uses height, weight i.e., both under-weight and over-weight), Medical and biomarker indicators (MBI) for measuring nutrient deficiency.

Households Dietary Diversity scores can be defined as the number of classes of foods that are being consumed by an individual (IDDS) or by any member of the household within a reference period (FAO, 2008; Koppmair et al., 2017). This reference period could be the amount of food class consumed in the past 24 or 48 hours or 7 or 14 days. HDDS is a proxy for measuring the dimensions of food security such as availability accessibility (Cordero-ahiman, 2018).

Nkegbe et al. (2017) observed Households' Hunger Scores (HHS) as a possible method of measuring food security reliably. In food-insecure areas, HHS measures the prevalence of hunger. Its major difference and strength, when compared to the other food security measurement indicators, is its development and validation for ethnic inclusiveness (Nkegbe et al., 2017). Among others according to Ballard et al. (2011), HHS assesses food situation in the region or a country and also supplies indications for policies development and implementation with programmes that address hunger and food insecurity. Nkegbe et al. (2017) viewed that, HHS is used

to specify the percentage of households that is being affected by three HHS via-a-vis; little to no, moderate and severe household hunger.

According to Karpynudeledu et al., (2020), the study on the occurrence of hunger in Bahama and the reliability of the instrument used in measuring food insecurity i.e. households food insecurity experience scale (HFIES). The study revealed that FIES is a valid instrument for measuring hunger experience in the Bahamas with the majority being food insecure. The result concluded that a significant number of Bahamians living in Nassau are severely food insecure. FIES' reliability and validity can be easily and formally assessed (Carlo Cafiero et al., 2015).

2.1.2 Measurements of the Determinants of food Security

Several methods as shall be discussed subsequently have generally been used in different places to quantify the drivers of food security at different levels over time. Akbar et al., (2020), assessed the drivers of food insecurity of households together with the severity dimension in Pakistan. The authors used a partial proportional odds model (PPO) for this study using national representative data. It was found out that variables such as; income of households, employment, donations, income from agriculture, together with some households' characteristics remained the major factors improving the level of household food security. It was concluded that population growth observed through household size and dependency ratio were major causes of insecurity to food in Pakistan. Similarly, Sultana & Kiani (2011), evaluated the causal elements of food security among Pakistani's Households using microdata analysed by a binary logistic regression model. They found education to be among the factors influencing a household's food security while the household geographical location i.e., household living in the urban area had an adverse

influence on food insecurity. They attributed this to a low asset, seasonality of employment and dysfunctional system in the urban areas.

Akbar et al. (2020) used Per capita daily calorie intake to measure the state of household food security. Akukwe (2020) measured household food security with Food Security Index (FSI). It was calculated through the per capita monthly expenditure. Akukwe, (2020) examine the drivers of food security in some selected states in south-eastern Ghana only from the dimension of food accessibility. Logistic regression analysis was employed to examine the drivers of food security of an agrarian community of South-eastern Nigeria. The study revealed that the higher number of households in the South-eastern side are food insecure with little variations across the Local Government Area (LGA) and the communities. Among the major factors driving this are educational level, household head marital status, the dependency ratio, the distance to market etc. Noting that these factors jointly combine to determine the level of food security rather than individual variables.

Maharjan & Joshi (2011), assess the drivers of the household food security level in Nepal. Binary logistic regression analysis was deployed to capture this. The study found out that among the sample households only about 10.2% are found to be chronically food insecure which cannot meet their calorie requirement either through their production or purchase. The major variable of influenced to household's food security status was; household size, dependency ratio, illiteracy amongst others. It was concluded that targeted programs towards the landless or small land holding farm and occupational caste will be efficient at reducing food insecurity.

Muhammad & Sidique (2019), examine the determining factors of household food security in Nigeria using a multinomial logit regression model. The study noted that the education level of the household head, the size of the household, food and non-food expenditure were the influencing factors of the household food security in Nigeria. In recent times, persistent increase in hunger and poverty together with inadequate access to food remains amongst the most pressing problems facing the world (FAO IFAD WFP WHO, 2019). Food security determinants were examined among the rural households in Ethiopia using the food surplus index (FSI) and food insecurity gap (FIG) (Beyene & Muche, 2010). The study found asset and income diversification as the major determinant of household food security in Ethiopia. This could either be directly or indirectly depending on whether the farmer engages in sharecropping or renting

Tuholske et al.(2018), researched the households food security level in the urban area of Ghana; its measures and determinants. A logit regression model was used to fit in the determinants of food security among middle and low-income households in Accra. It was found out that the households in the urban area of Ghana could not assess the food that could meet their body nutrition requirement, it is safe, and sufficient for a healthy life.

Obayelu (2012), uses PPO to identify the factors influencing household food security in the North-central of Nigeria. The research found that 16% were food secure and 21% were food insecure with severe hunger. As one of the important factors responsible for this were agricultural land holdings, dependency ratio, household head occupation, total expenditure and geographical location. The author concluded that decisions involving policies and programs must take into

considerations all these factors which were found to be influencing household food security in the north-central of Nigeria.

Ordered logit regression was used by Nkegbe et al. (2017) to examine the determinants of food security in the Savannah Accelerated Development authority SADA zone of Ghana. The food security measurement employed was the household hunger scale (HHS). The findings of the study show that food insecurity is still prevalent at an unanticipated rate in the area. the factors driving this were; literacy, location of the household, food consumption expenditure, yield, education, agricultural crop amongst others.

However, it could be deduced from the above measurements of the drivers of food security, especially from the ordinal outcome that the partial proportional odds model is more appropriate due to its advantage in taking care of the parallel line assumptions.

2.2. Conceptual Framework

Connections between the household food insecurity, shocks and their resilience capacity can be seen in Figure 1 below. Contextually, vulnerability and resilience are based on discipline i.e., health, agriculture, engineering or economics and social sciences. Figure 1 below shows the interlink between the resilience capacity of a household (household) and its interactions with climate shocks and food security.

Households being considered here is important as it is the unit with which most decisions are taken and intervention with policies are targeted (FAO, 2020b). It is assumed that climate shocks which are both idiosyncratic and covariates such as the

death of a household member, illness of a household member, experience of drought, conflict, war, fire, flooding amongst others could influence the food security of the household and their resilience capacity. When any of these shocks occur or in combination with one another or with resilience capacity, the household responded through either their asset, adaptive capacity, social safety net or access to basic services.

In addition, shocks such as death, illness of a household member, fire, drought, war and flooding are predicted to influence the resilience capacity of the household. The postulation is that, when a household experiences illness or death or a household i.e., an idiosyncratic shock, it could erode household accumulated assets and preclude them from having access to basic service. The covariate shocks from fire, drought, war, conflict, flooding amongst others perform similarly. This could reduce the household adaptive, transformative and absorptive capacity to cope and bounce back to their original state.

Food security measured in this study are household food consumption score (FCS) and the food insecurity experience scale (FIES) being an indicator of household wellbeing were assumed to be influenced by both the resilience index capacity and the shocks. Shock(s) could reduce the quantity of food being able to access by the household, its availability and stability. This could lead to severe hunger in extreme cases, skipped the meal as a coping strategy, worrying over what to eat and even having to sleep with hunger. It is also assumed that when a household is faced with any of the following, he used either his asset, social safety net amongst others to combat this.

Thus, the household resilience capacity made of pillars of assets, access to basic services, adaptive capacity and the social safety net which is assumed to have a significant influence on both the household food and climate shocks is said to be an important constituent of a household. The more resilient the household, the more the chances of being food secured and the less the likelihood of the household being exposed to shock. Shocks is not leading to food security but it is affecting food security of the household negatively by limiting the food security of the household through flooding, war, conflict, death a household member and illness of a household member.

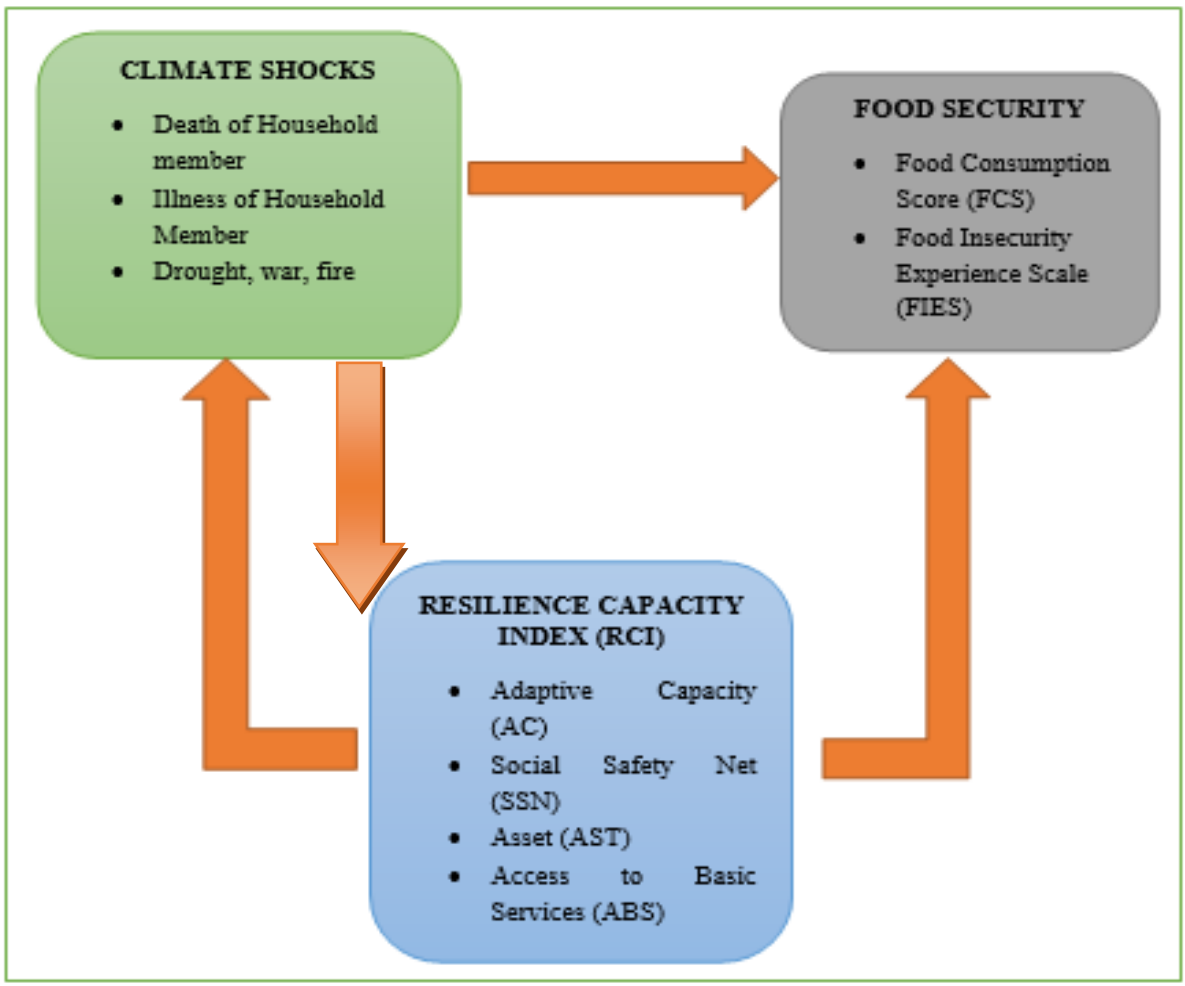


Figure 1: Conceptual Framework For The Connections Between Food Security, Shocks And Resilience

Source: Author's Construction, (2021).

2.2.1 Policies, Programmes and Projects towards Food Security and Climate Change

The majority of Ghana's 16 flagship projects is aimed at achieving SDGs focused on food and nutrition security and combating climate change. "*Planting for Food and Jobs*" program to boost revenue and food production; "*One Village, One Dam*" initiative will ensure an all-season farming, particularly in Northern Ghana were among the policies aim at achieving food insecurity, Voluntary National Review (VNR) Report, (2019).

Selected Government Interventions: Scaling Up Nutrition (SUN); Advancing food and nutrition security research and development (FNS); District Warehousing Policy; this aim to encourage the production and amassed the opportunities of local production to feed our factories and nutrient-rich food; Planting for Food and Jobs (PFJ), One dam, one village (1V1D); Import duty exemptions for agricultural inputs and Affordably priced tax breaks which are introduced as incentives for agricultural producers and processors.

Ghana's establishment of the National Climate Change Policy (NCCP) and also a Low Carbon Development Strategy to help in NCCP's mitigation goal implementation. Recently, all policies in Ghana relating to environmental, energy, transportation, wildlife conservation, forest, public-private partnership (PPP) amongst others have been formulated to be climate-friendly. Also, the creation of a

climate change strategy and action plan was aimed at improving resilience, adaptation and mitigation to climate change across the sectors.

Ghana has filed its nationally decided contributions, national communication, and biannual update reports to the United Nations Framework Convention on Climate Change, outlining the country's progress on climate adaptation and mitigation measures. It has made its contribution known through its biannual report on the progress recorded at achieving mitigation and adaption to climate change to the UNFCCC. Currently, Ghana has documented some strategies at achieving climate change

The country currently has the following strategic documents to taking care of climate change challenges amongst others in addition to the earlier stated ones are; National Climate Change Master Plan; Nationally Determined Contributions (NDC) plan; National REDD+ Strategy, 2016-2040; National Climate Change Adaptation Strategy; National Forestry Plantation Strategy and the Medium-term Development Policy Framework (2018-2021). Ghana's Intended Nationally Determined Contribution (INDC) classifies initiatives that can reduce emissions resulting from transportation, agriculture, energy, forestry and land use, waste, and industry sectors to be implemented between 2020 and 2030.

Also, incorporation of Climate change in the curriculum from the Ghana education board especially in the elementary school beginning in the 2019/2020 academic year, with junior and senior high schools following in the following years is a plus for the country. The goal of this effort is to improve students' knowledge and help modify children's and adults' attitudes toward the environment, assisting in the country's struggle to minimise exposure to climate change.

Some of the interventions from the Government of Ghana at achieving Goal 13 of the SDG as highlighted by Voluntary National Review (VNR) Report, (2019);

1. Capacity building and mainstreaming climate change into medium-term plans at the sub-national level
2. Implementation of National Adaptation Planning Framework
3. Green Climate Change Fund Adaptation Programme
4. Adaptation Fund Project
5. Implementation of National Low Carbon Development Strategy

2.3. Resilience Theory

Holling (1973), used the word "resilience" in his research on ecosystem stability and resilience. And this made him the first person to use it. It since then spread to other fields of study to include engineering, epidemiology, psychology, social sciences and specifically within the context of socio-ecological systems (d'Errico et al., 2018). A socio-ecological system is a system that integrates both the sociological and the economic systems (Folke, 2006). The Social-Ecological System (SES) is a model that depicts the interconnections and complexity of nature and civilization (Berkes & Jolly, 2002).

Ecological resilience implies the ability of an individual and stakeholders to absorb and adapt to the unpredictable nature of the ecosystems. It becomes imperative to understand ideas that underpin the study, such as resilience theory, in order to comprehend household resistance to shocks of various origins. There is a strong association or relationship between vulnerability and resilience, according to

research. To begin, resilience can be viewed as the ability which enables a system of economic, social, and environment to respond or reorganize so as to help them perform their function optimally, their identity, and at the same time sustaining their adaptive, transformative and absorptive nature-given hazardous event, trend and disturbances. Resilience is a term used to describe a person's ability to adapt, absorb and transform when faced with shocks (IPCC 2014). The number of disturbances that an ecosystem can absorb without losing its structural form through variables modification and processes which influences behaviour (Holling & Gunderson, 2002). This indicates ecosystems' ability (i.e. the underlying mechanisms) to retain services in the face of changing environmental conditions and human disturbances (Carpenter et al., 2001; Folke et al., 2002).

According to Branco and Waldman (2016), Understanding how the physical, social, and ecological systems interact is critical to understanding resilience. Because socio-ecological resilience theory considers systems to be continuously evolving unpredictably, it becomes a particularly valuable tool in addressing the occurrence of impending climate events (Rodin 2014; Tyler & Moench 2012). The amount of disruptions and distortions that a system can absorb and remain in a given condition is defined as resilience in an SES (Carpenter et al., 2001; Folke et al., 2002). Also, SES is the intensity to which a socio-ecological system may organise itself to preclude external influences (Carpenter et al., 2001).

The food security assessments are somewhat based on Amartya Sen's entitlement theory of hunger. According to the entitlement theory, the majority of hunger deaths are caused by people's incapacity to get food through purchase, trade, or distribution

uncertainty (Sen, 1981; Young et al., 2001). Ecosystem resilience theory has been used in this research to describe the social systems features for example food systems (Clark et al., 2021), institutions and social network systems (Anderies et al., 2006). Vulnerability studies which aim to identify the proportion of the household given a particular indicator or context could be integrated into the study of resilience. Thus, resilience is the proportion of the disorderliness that a system can bear without altering its original state or even bounce to the original state. Resilience shows the behaviour of a dynamic system far from equilibrium. Ecosystem resilience is an emergent trait linked to the behaviour of certain ecosystems throughout time in a self-organised manner. Self-organization in this context means a structural interaction and process that transform to system evolution irrespective of its original states.

There are four major pillars of resilience vis-à-vis; asset (AST), adaptive capacity (AC), social safety net (SSN) and access to basic service (ABS). Adaptive capacity in ecosystems is defined by the potential for innovation that emerges following a disruption. It refers to the ability for learning and adaptation that occurs within socio-ecological systems (Carpenter et al., 2001). Ecosystem resilience is a helpful indicator of environmental sustainability, with the conclusion that economic activities are only sustainable if the life-support ecosystems on which they rely are resilient (Anderies et al., 2006). Further research is needed, according to Levin, to determine whether our key systems have sufficient resilience capacity (Levin, 1998). The processes that contribute to the system's memory of those involved in regeneration and renewal that connect that system's present to its past and its neighbours build ecological resilience.

2.4.1 Climate Change

The meteorological conditions of a location throughout time are referred to as climate. The day-to-day atmospheric condition of a location is referred to as weather. Precipitation, temperature, humidity, air, hours of sunshine, relative humidity, and wind are some of the variables used to calculate this. Climate change is the oscillation in a location's average weather state through time. It was noticed by FAO (2008), that global climate change has been changing since 1850 due to the build-up in the atmosphere of the greenhouse gases resulting from the burning of the fossil fuels to meet industrial needs and expansion of agricultural land accompanied by deforestation to meet the demand for agricultural produce. In the past 4.5 billons years of earthly existence, there have been changes in the climate, but most of these changes has been insignificant and occur on astronomical or geological time scales which is too slow almost impossible to be observed on a human scale. Climate variability according to the meteorologist and the climatologist, is the short-term changes in the weather condition of a place which could be month to month or year to year within a range (WMO, 1992).

People's perception of climate change varies from person to person and across the countries which have resulted in the values that are being placed on the findings resulting from the scientific perception. However, views are not universally shared in this regard but it has been made known that its effects are global. It is still believed in some settings when either flood or temperature is high and it affects their produce that their ancestors or their gods are angry with them which must be appeased to reverse it. Also, responses to the effect of climate change in some areas are still

traditional and used the traditional method to predict the weather which may not be accurate and even able to detect the trends of the weather in the long run.

2.4.2. Climate Change Resilience

The world's poorest people are now confronted with a new set of shocks and pressures (Constas et al., 2014). Helping households cope with these shocks requires not only a precise assessment of their resilience to such shocks and stressors but also an accurate measurement of their "resilience capacity," or the underlying causes of resilience (D'Errico & Smith, 2020). Any capacity that ensures that shocks and stresses have little or no and short influence on the households refers to as resilience (Constas et al., 2014). The study of resilience in the development settings centres on either a household, a community, village, states, region or country is essential in a period of pandemics on pandemics (FAO, 2020b). The low adaptive capacity of the household in the developing countries resulting from its dependence on rain makes it more vulnerable to climate change. This has contributed to a serious challenge in human history (Carlson et al., 2012). Another major problem associated with climate change is the unpredictable nature of the climactic events which make it difficult to determine the beginning of the planting season.

2.4.3. Climate Resilience and Food Security

The reality of the effect of climate variation and changes is here with us with low and unreliable rainfall, high temperature, dry wind and changes in the planting season. While climate changes affect the environment and agriculture, their effects on agriculture are more. This is because of its over-dependence on climate variables. Climate change was observed by Bizikova et al., (2013), as a threat to food security

as observed through reduced yield and disruption of the infrastructures and systems with which people have access to food. The authors conceived climate resilience to imply a household's ability to observe shocks and stresses resulting from climate change without any need for emergencies.

Household resilience to changes in climate has become very important with the rising population which increased pressure on natural resources such as the supply of water and the unpredictable nature of the planting season. The effects of changes in climate such as drought, flooding have resulted in the destruction of household property and even hunger among the vulnerable such as women and children. Due to the usefulness of resilience at the national level in policy formulation, and for questions pertaining to the production at the local level, it becomes a topical issue of discourse among the researchers. Linking resilience to the food system remains a big challenge resulting in scanty information that is conceptually (Doherty et al., 2019; Savary et al., 2020). Food insecurity is prevalent in less industrialised nations with no well-developed non-agricultural activities and engages in a long agricultural value chain. Reynolds, (2016) and FAO, (2008a) argued that sometimes, household food security depends more on socio-economics characteristics than the agro-climatic variables and having access to food than its physical availability.

2.4.4. Vulnerability versus Resilience

Vulnerability is an important concept in understanding resilience and it is the stage preceding the household a system exposure to hazardous events (Kelly & Adger, 2000). Overall, three important aspects of climate change that require more analysis

are climate threat and impacts, climate vulnerability, and climate resilience. However, these are location-specific and thus vary from one area to another.

Vulnerability can be defined as a dynamic phenomenon that affects household welfare over time (Ahmed, 2010). It was observed in this study that risk does not directly affect the welfare of the households but does so when it is transformed into negative shocks. Shocks were reported to influence the vulnerability of the household in a post-conflict environment. According to him, vulnerability is a product of both exposures which occur as a result of the fragile environment surrounding a household and resilience of a household that is methods with which the households use to fortify themselves against shocks.

Exposure of the developing nations to the adverse effect of climate change or shocks could be found to have an adverse effect on agricultural production could expose the household to more danger and even food insecurity (FAO, 2008). Conversely, Malabo Montpellier Panel (MMP, 2017), estimated that one in five every Africans is still chronically malnourished, making the continent more vulnerable to food insecurity. MMP noted that climate change together with other factors could increase child malnutrition and hunger thereby inverting the achieved gains towards the objectives of SDG and Malabo Declaration agenda 2063.

Vulnerability has been considered by Løvendal et al. (2004), as exposure to risks. Some see it as the intensity to which a household is disposed and unable to adjust to the adverse effect of shocks (Awoyemi & Olajide, 2020; Madu, 2012, 2016; Opiyo et al., 2014). Vulnerability to food security has in recent times been the focus of research. Contextually, vulnerability is the intensity with which a household is

exposed to shocks and unable to adjust to this effect. It is the exposure to food insecurity experience, inadequate food consumption and low resilient capacity resulting from shocks without being able to cope or recover. Sensitivity is the level with which a system or a household is being predisposes to shocks or climate change stimuli, which could either be negative or positive. Whereas exposure is the kind and extent in which a household is susceptible to climate fluctuations (Zhang et al., 2019).

2.4.5. Shocks, Food Security and Resilience

Shocks; economic or natural catastrophes, violence, conflicts, etcetera, results annually in a loss of about USD 250 billion based on the 2017 report of SDG. These disturbances mainly affect the vulnerability of the developing nations especially the poor people in the rural area, farm and off-farm operations, posing serious concerns to their food security (Ansah et al., 2020). The author reviewed the interactive effect of shocks on welfare resulting from the coping strategies adopted viz-a-viz; *ex-ante* and *ex-post,* to combat multiple shocks as compared to those faced with the single shock.

Any occurrence that may disturb the usual functions of individuals, households, communities and their daily activities, offer problems and jeopardize the food security level of the household is referred to as a shock (Ansah et al., 2019). The study of different kinds of shock which affect households is very crucial as it could help us to determine the stages of vulnerability and what could be done to be resilient in the future. Interaction of shocks together with the impacts they are having on the welfare constitutes a fundamental reason for vulnerability (O'Brien et al., 2009). The occurrence of shocks in the future is anticipated and predicted to occur concurrently

with urbanisation and some other socio-cultural and economic changes which could impact the household resilience capacity and food security (FAO, 2016b).

Ansah et al (2020a) examined the relationship between shocks and the *ex-post* strategies of combating shocks i.e., both coinciding and the single shocks and the degree to which it relates to the household welfare in terms of security to food in Northern Ghana. The research employed a recursive model which allows multivariate and linear regression models. The authors observed that earlier than when the study was being carried out, there has been less research on the interactions between shocks which could positively or negatively influence the coping strategies of the household. The study found out that when multiple shocks combine or relate, the effect of the shocks is usually incremental. Also, notable among the strategies employed in coping with shocks in the region was consumption smoothing through asset depletion to increase consumption. According to Ansah et al. (2020b) note that in developing nations, households face a different kinds of shocks which may have been underreported and investigated, resulting in less than expected attention. This present study is well distinguished from this by examining the interaction of the shocks with the household resilience capacity at the national level concerning household welfare using different food security indicators.

Shocks that affect an individual unit or a household is considered as an idiosyncratic shock while or shock affects a two or more household in a given location that is regional or continental is the covariate shock (Ansah et al., 2020). The notable causes of shocks are climate or weather (flood or drought), human health issues (illness and death of household members), pests and diseases, and economic shocks such high price of commodities (Ansah et al., 2020).

Individual shocks, a sequence of two or more shocks that are independent of each other or related in a cascade-like manner, or two or more coinciding shocks can all affect households. A household that relies on agricultural production is subject to supply disruptions. Agriculture-dependent countries are subject to agricultural production shocks (Gitz & Meybeck, 2012). Due to the susceptibility of the agricultural dependent households or nations, it becomes difficult for the government to compensate in the event of a big shock. At various stages, agricultural production is exposed to a variety of risks or shocks. Smallholders, who eat a major portion of their production, are particularly vulnerable to risks influencing yield in main staple crops.

2.4.6. Influence of Resilience on Shocks

Campaign at ensuring that cities are resilient to shocks with adequate preparation to combat stresses and shocks must be in agreement with the effort geared towards developing urban areas and their sustainability (Leichenko, 2011). Achieving these is premised on understanding how sensitive and exposed that is the system vulnerability and propound a plan, programme and policies that could cater for the household vulnerability (Al-hassa & Jatoe, 2003). The agricultural industry is said to respond poorly in locations where weather shocks occur more frequently, such as cyclones and floods. (i.e., yield is reduced) (Zhang et al., 2019).

Jordan (2020) studied the link between shocks and micro-credit using interviews and discussions to elicit a response from the respondents. The study found out that shocks involving both climate-related and otherwise were found to result in the reduction in; assets and amount of food consumed, depletion of savings, debt

increase and default among others. Although, it was evident that micro-credit has been used to combat the effect of shock but may not be fully effective in this regard for climate shocks such as cyclone influence within the area of study and can be used with other adaption strategies to enhance adaptation.

However, involving in agricultural activities such as diversification into livestock rearing, fisheries poultry are the various means which reduces the vulnerability of household to shocks as this offer them some level of flexibility and help them to bounce back (Jordan, 2020). Also, the sales of household assets to offset bad times are of the adaptation strategy to shocks (Adger et al., 2004; Smith & Subandoro, 2007; Smit & Wandel, 2006). Depending on the degree and the intensity of the household exposure to shocks together with location and the period at which it occurs, it could deplete the accumulated asset of the household (Rahman et al., 2018). Fernando et al. (2021), summarised shocks which could emanate from the changes in climate to include, landslides, flooding, drought, wildfire, hurricanes, tornados, cold waves and eat among others. The impact of climate change has recently been felt in also financial market and this has stirred discussion on the influence it could have on market behaviour evaluation of the asset (Bolstad et al., 2020). The authors evaluated the long-term effects of physical climate risk on different sectors of diverse economies together with shocks on labour force and agricultural productivity. G-cubed model was then used to estimate the impact of climate change resilience.

2.4.7. Resilience Measurement

There is variation in the way in which resilience is be defined and used that is both normative and descriptive (Maru, 2010). According to Holling (2001), the system's capacity to withstand stresses and shocks while maintaining its status quo without losing its core structure and function is defined as resilience. Maru et al. (2014) stated that this was descriptive, with no aspect of normative vulnerability. Resilience being latent that is unobservable is usually difficult to measure. Different methods have been used to measure resilience in the time past. Amongst were Resilience Index Capacity (RCI), RIMA I which was proposed by (Alinovi et al., 2010; Pingali et al., 2005). But for this study, Resilience Index Measurement and Analysis (RIMA II) was adopted in which the model is described below.

Group of experts in resilience comprising of Food and Agricultural Organisation (FAO) of the United Nations and Technical Assistance to NGO's (TANGO) formulated Resilience Measurement Technical Working Group (RMTWG) to develop a framework and analytical technique for measuring resilience (D'Errico & Smith, 2020). This was achieved with the supports of the Food Security Information Network (FSIN) in a workshop which was to ensure consistency in the measure of resilience and resilience capacity (Food Security Information Network (FSIN), 2016). Indexes of resilience capacity by FAO-UN and TANGO are all structural equation modelling. The former is constructed based on the combination of the pillars of resilience and food security through multiple indicators multiple causes (MIMIC) and the latter is constructed with the indicators of resilience using factor analysis (FA).

The statistical process which reduces several variables with correlations to a lesser number that are uncorrelated is referred to as principal component analysis (PCA). It is one statistical process that reduces the variance of the minimum number of variables that contributed to the small unobserved group through components or factors. The essence of using this as a precursor for analysis is to give the variables equal weight. The factor loading of the first components is normally used to assign weight to the variables (Gbetibouo et al., 2010). Factor analysis (FA) perform a similar function are run in the same way with the PCA in Stata. However, FA is primarily different in that it is a measurement model for a latent variable while PCA is a linear combination of all the variables. The FA is the first stage of the RIMA II analysis but this is being handled in an app (ShinyAPP) developed by FAO for analysing RIMA II.

2.4.7.8 Resilience Index Measurement and Analysis (RIMA II)

RIMA II is used to estimate resilience to food insecurity. It explains why some households experience stressors and why others do not. Three pillars minimum and 4 pillars maximum are required to construct a resilience capacity index.

Some of the variables for measuring resilience as identified by Galarza (2019), for different components of RIMA II, are listed below;

ABS: distance to market, distance to school, improved light, improved wall, improved waste disposal, improved floor and improved roof.

AST: percentage of land area cultivated, agricultural wealth index (tools, machinery, and all other productive assets), wealth index (Domestic and personal appliances, mosquito nets, blankets, television, radio, mattress and vehicles that are used on the

farm and other Non-productive assets), percentages of land owned and the percentages of household's expenditure on agricultural products.

AC: access to agricultural advice, dependency ratio, and Households' income diversification i.e., sources of households' income over time and coping strategy index i.e., the frequency and consumptions strategy.

SSN (Public and Private Transfer): access to assistance, assistance from NGO and assistance from Government).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

Chapter three covers the; study area, data source, analytical technique and the description of the empirical model. The first part which is the study area, allows us to understand the context in which the study was conducted. The second part describes the method used in the study. It described how each of the models will be analysed from the descriptive that is; the food security indicators, resilience index measurement analysis (RIMA II), endogenous switching regression with the ordered outcome, probity model and the partial proportional odds model (PPO).

3.1. Study Area

The study area is Ghana. Ghana is a middle-income country and was the first nation to attain independence in Sub-Saharan Africa from the British Colonization in 1957. It has a diverse social, ethnic and religious group with nominal GDP of US $68.42 Billion in 2020 that is a mean annual growth rate of 10.14% (GSS, 2020). The Republic of Ghana lies within latitude 4º44’ N and 11º11’ N and 3º 11’W and 1º11’E which is positioned on the coast of the Gulf of Guinea. Ghana shares a boundary in the East by the Republic of Togo, the Gulf of Guinea to the south and the Republic of Côte d’Ivoire in the west, Burkina Faso (formerly Upper Volta) to the north-west and north. Ghana is about 750 km to the North of the equator. It has a total landmass of 238, 538 square Kilometres with a population size of about 31,000,000 (GSS, 2020). After Nigeria, Ghana is the second-largest economy among the West African States (ECOWAS) (Frankfurt School United Nation Environmental Programme

(FS-UNEP, 2016 & Alagidede. 2011). The old ten (10) regions were considered in this study because the data were collected before the creation of the other six regions to make sixteen regions in 2017.

Ghana had ten 10 administrative regions before the other six was created in 2017 as can be seen in Figure 2 below. The old ten 10 regions were; Greater Accra, Central, Western, Eastern, Ashanti, volta, Brong Ahafo, Northern, Upper West and Upper East. It had 197 districts i.e., 164 districts and 6 municipalities which contains 33 sub metros.

Ghana has a warm tropical climate with mean annual temperature ranges from 78 to 84 °F (26 to 29 °C) and the daily range only some 10 to 15 °F (6 to 8 °C) along the coast and some 13 to 30 °F (7 to 17 °C) in the north. Average relative humidity ranges from nearly 100 percent in the south to 65 percent in the north, although, during the harmattan season, figures as low as 12 percent have been recorded in the north and around Accra. The mean annual rainfall ranges from 800mm in the coastal agro-ecological zone, 1,000mm in the Sudan Savannah and 2,200mm in the rainforest agro-ecological zone. The growing season in the coastal, forest, transitional and deciduous zone is bimodal that is March to July and September to October while uni-modal which is a single growing season in Sudan and Guinea Savannah.

The agro-ecological zones of Ghana vary from Coast Savannah Zone, Rain Forest Zone, Transitional Zone, Semi-deciduous Forest Zone, Guinea Savannah and Sudan Savannah Zone and these similarities across the ecological zones makes it a

representative of African agro-ecological zone. Ghana has an undulating topography of slope less than 5% in some areas and most not above 1% with 70% suffering from severe to moderate soil erosion. It has a soil common to all ecological zones via fluvisols (alluvia soils) and leptisols (eroded shallow soils) resulting from a weathered parent material.

Agriculture remains one of the most important sectors to the economic development of Ghana. It has a significant influence on poverty reduction, cultural value, social stabilization, buffering economic shocks, rural development, environmental sustainability and cultural values. The sector is also dominated by smallholder activities with the majority having a farm size of fewer than 2 hectares (MoFA, 2021). The most common agricultural commodities in Ghana are; crops are cereals, root and tubers, tree crops such as oil palms, pawpaw, mango, shea vegetables, livestock and fisheries.

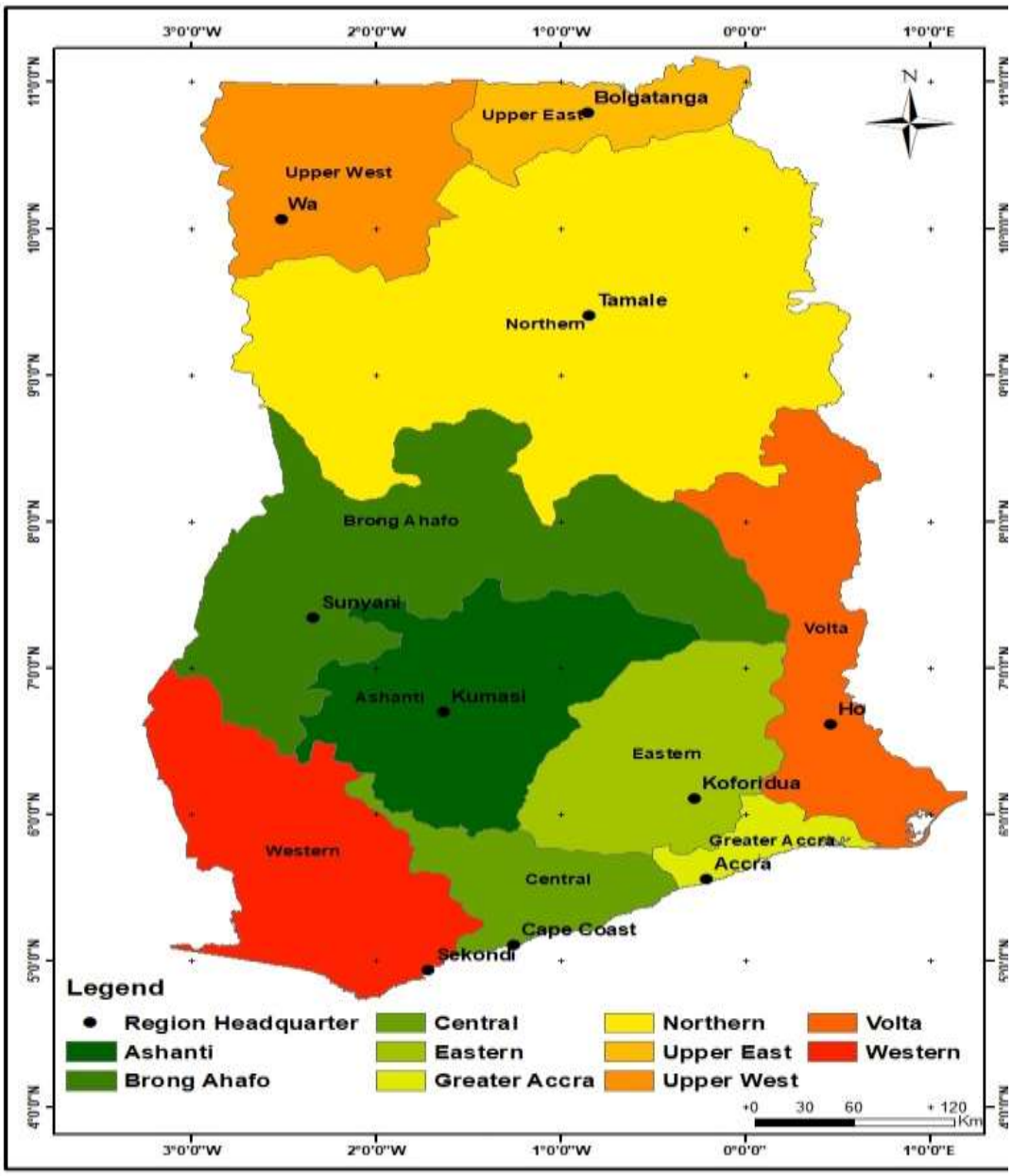


Figure 2: Ghana Map

Source: Author's construct 2021

3.2. Sources of Data

Secondary data obtained from the Ghana Living Standards Survey (GLSS 7) was used for this study. It is the 7th round of a nationwide household survey GLSS data that was collected between October 2016 and October 2017 by the Ghana Statistical Service (GSS) (GSS, 2019). It is a nationally representative household survey collected on an individual, household and community basis that was aimed to

provide reliable and disaggregated data to understand the living condition, aid research, keep track of the welfare system and helps in the development and programme planning and policy recommendations in Ghana. The collection of this data preceded the further division of the regions into 16. Thus, it was collected across the 10 regions. Across the 1,000 enumerated areas in Ghana, about 15,000 households were selected but only 14,009 households responded to make a 93.3% response rate. The survey adopted a two-stage stratified sampling technique. The selection of the enumerated areas according to the 2010 population and housing census that is 1000 EAs constitute the first stage which makes the primary sampling unit (PSUs). Out of these, primary sampling units (PSUs), 15 households were systematically selected and this constitutes the second stage (GSS, 2019). The secondary sampling units (SSUs) were constructed from the list of households in the rural and urban areas to which the EAs were further divided. This study employed the 14,009 households across the 10 regions to understand the resilience capacity and food security pattern of households in Ghana.

3.3. Analytical Technique

This study employed descriptive statistics such as; mean, percentage and frequencies and inferential statistics. Descriptive statistics such as frequency and percentages were used to describe the variables used in the models. Households Vulnerability Resilience Index Measurement and Analysis (RIMAII), Endogenous Switching regression with ordered outcome, Partial Proportional Odd models and probit regression analysis were used for the study. Food consumption score and food insecurity experience scale (FIES) were used as proxies for measuring food security.

3.3.1 Measurement of Food Security

Food Consumption Score (FCS) and Food Insecurity Expenditure Scale (FIES) were used as indicators to measure household welfare. This is because household welfare has different dimensions and thus requires a multidimensional measurement approach (Issahaku & Abdulai, 2017). These measures are essential in order to design a programme, an intervention and formulate a policy that could improve the food insecurity of the household (Broussard & Tandon, 2016).

3.3.1.1 Food Insecurity Experience Scale (FIES)

FIES is one of the measures of households' food insecurity developed by the United Nations-FAO Voice of the Hunger (VOH) department to capture lived experiences of either individuals or households with a reference period of either 30 days or 12 months (Karpynudeledu et al., 2020). Rome-based UN agencies recommended it as an indicator for monitoring the post-2015 SDG agenda (Ballard et al., 2015). FIES is important because it helps to monitor the progress on hunger eradication which was recommended for global use in the SDG framework. FIES measured the severity of household food insecurity. It is an experiential technique of measuring food insecurity which is now gaining popularity among researchers and policymakers in recent times due to the low cost of obtaining the data and ease of incorporating it into the existing survey to get information on the household or individual experience on food security over a while (FAO, 2013).

It elicits questions on the experience of the household on the food insecurity among children and women in the early 1990s. It was built on the food insecurity scale

formulated by the United States Department of Agriculture (USDA) in 1995 integrated into the Current population Survey (CPS) Food Security Supplement to assess the food insecurity and prevalence of hunger in the US, Canada and other Latin American Countries. Developing countries using food security experiential-based scales like the Latin America and Caribbean Food Security Scale and Household Food Insecurity Access Scale (HFIAS) of the Food and Nutrition Technical Assistance (FANTA). Then, FIES was built on this HFIAS and it is usually an 8 or 9 items question depending on the survey. The response is based on the experience and the behaviour of the household towards food access and this made a subjective of food insecurity than perception (Ballard et al., 2013).

GLSS 7 adopted the 8 items questionnaire to measure the food insecurity of the household in Ghana. According to Cafiero et al. (2018), FIES is the only method of measuring food security that allows for global comparability of the indicators used in measuring it. It was the only method used by FAO within the context of SDG 2 target 2.1. to measure the prevalence of food insecurity. It was meant to complement other dimensions of food security measurement such as food frequency and dietary diversity, food spending, self-assessment and consumption behaviour. The determinant of security in the Savanna Accelerated Development Authority (SADA) was analysed using the household hunger scale (HHS) by (Nkegbe, 2017) which is similar to FIES.

FIES as compare to the other estimator of food security is the most straightforward (Santeramo, 2015). HHS and FIES perform a similar function in that it can be used for comparison across the regions and culture but differs in the sense that, FIES measures from food secure to severely food Insecure while HHS only measures

severe food insecurity. Also, one of the strengths of FIES as noted by Brunellin et al., (2014), is its ability to disaggregate data by gender which make it appropriate for use in this study as it helps to understand the food security status of the household when they are resilient or not. This also follows Mabe et al., (2021), that used FIES to measure the household food insecurity status for farmers who were aware of SDG2 and otherwise.

GLSS 7 used a reference period of 12 months following the recommendation of the SDG in monitoring team as it helps to control for seasonal changes in food security to ensure comparability across regions, zones and different climatic zones. The 8 questions that was used to elicit response across the household is given in the table below. However, requesting people to recall what happened in the last 12 months could create problems of misreporting and unreliable data. To overcome these weaknesses FIES was used alongside with another measure of food security which ask the people to recall what they have consumed in the last 7 days.

Table 1: Food Insecurity Experience Scale (FIES) for Households in Ghana

	During **the last 12 MONTHS:**	**Code** Yes = 1 No= 0 Don't Know=2 Refused=3	**Item name**	**The severity of Food Insecurity**
1	Was there a time when you or others in your household worried about not having enough food to eat because of a lack of money or other resources?		Worried_Nenough	Mild
2	Still thinking about the last 12 MONTHS, was there a time when you or others in your household were unable to eat healthy and nutritious food because of a lack of money or other resources?		Uhealthy_Nutr	Mild
3	Was there a time when you or others in your household ate only a few kinds of foods because of a lack of money or other resources?		Few_KFood	Mild
4	Was there a time when you or others in your household had to skip a meal because there was not enough money or other resources to get food?		Skipped_Meal	Moderate
5	Still thinking about the last 12 MONTHS, was there a time when you or others in your household ate less than you thought you should because of a lack of money or other resources?		Ate_less	Moderate
6	Was there a time when your household ran out of food because of a lack of money or other resources?		Ran_OFood	Moderate
7	Was there a time when you or others in your household were hungry but did not eat because there was not enough money or other resources for food?		Hungry_DNeat	Severe
8	Was there a time when you or others in your household went without eating for a whole day because of a lack of money or other resources?		NAEat_WholDay	Severe

Source: GLSS 7 survey, (2017).

The response was made a dummy in terms of 1 if affirmative and 0 if negative. The household response from the analysis was highly encouraging as most households answered the question as much as possible. This may be due to its simplicity and

easy to answer questions which does not demand too much racking of the brain. These responses were then used to generate the raw scale which ranges from 0 to 8. This raw score was categorised into three following Food and Agricultural Organisation of the department of Voice of the Hunger (FAO_VOH) cited in Wambogo et al. (2018) namely; 0-3 *=1 which is food secure (FS),* 4-6= 2, *Moderate/borderlin*e food insecure (MFI) and *Severe/poor food insecure (SFI) which has a score of 7-8=3*.

Applying the Rasch model to data made it possible to estimate the probability of being food secure in each of the food insecurity categories (FAO IFAD WFP WHO, 2019). Rasch Model employs Item Response Theory measurement model which uses a single parameter logistic model to assess and construct a scale for FIES (Hardouin, 2007). Rasch Model is based on the assumption that all; items discriminate in an equal way, items are conditionally independent and that the log-odds of respondent's answer (yes) to an item i is the difference between the respondent's r experience of severity of food insecurity and the item i which is given a linear function (FAO, 2016a).

However, when the assumption of items behaving discriminately equally, unidimensional and conditionally independent are met, the raw score can be used (Gordon, 2015; Schutte, et al. 2016). This is the rationale for the choice of raw score in estimating the food insecurity experience scale of the household in Ghana.

3.3.1.2 Food Consumption Score (FCS)

Food consumption score (FCS) is a composite score that is built on dietary diversity and frequency of food consumption based on the nutritional importance of the food groups. It is expressed mathematically as;

$$FCS = \sum WiXi \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 1$$

Where FCS is the food consumption score (FCS), different food group is represented by W_i, X_i is the frequency of consumption of the different food group over the past 12 months. Also, i is main staples (cereals and root and tubers), pulses, vegetables, eggs, meat/poultry, fruits, meat and seafood/fish, milk, legumes, sugar, oil/fat and condiments.

The implicit form of the above formula for FCS according to the World Food Programme, (2008), is written below,

$$FCS = W_{staple}X_{staple} + W_{pulse}X_{pilse} + W_{vegfru}X_{vegfru} + W_{meatfis}X_{meatfis} + W_{dairy}X_{dairy} + W_{milk}X_{milk} + W_{oil}X_{oil} \quad - \quad - \quad - \quad - \quad 2$$

Table 2: Food Consumption Score (FCS)

Food Groups	Food Items	Weight
Main Staples (Grains/ Flours, Tubers, Roots and Plantain)	Maize, millet, sorghum, yam, cassava, cocoyam, sweet potatoes, plantain, other grains, flour and food crops such as; porridge, pasta, gari	2
Pulse, Nuts and Seed	Beans, Bambara beans, Soya beans, groundnuts (roasted or fried), cashew nuts, palm nuts and all other nuts	3
Vegetable and Fruit	Pepper, tomatoes, okra garden egg, cabbage, lettuce, nkontomire, dawadawa, other leafy vegetable Bananas, watermelon, mangoes, pawpaw, pineapple, oranges and tangerine, avocado pears, other fruits	1
Meat and Seafood/fish	Chicken, Guinea Fowl, Mutton, Pork, Goat, eggs, fish and shellfish, snail	4
Milk	Yoghurt, milk, dairy products	4
oil	Cheese, butter, coconut oil, shea butter, perm kernel oil, other oil	0.5

Source: Adapted from WFP, (2008)

3.3.1.2.1 Procedure for the computation of FCS based on WFP, (2008)

- Food items were grouped into categories as can be seen in table 2 above,
- The frequency of consumption of each of the food groups was multiplied by its weight which is based on their nutritive content and
- FCS was then derived from the summation of the values of the consumption frequency and the assigned weight.
- To determine the food security status of the household, the thresholds are grouped into;

  0-21=Poor food consumption

  21.5-35=Borderline food consumption

  >35=Acceptable food consumption

  In using the above thresholds, it was born in mind that different countries have different thresholds depending on their daily consumption of sugar and edible oil, the study used the thresholds cut for Ghana which is as stated above based on (WFP, 2008).

3.3.2 Determining Household Resilience Capacity

3.3.2.1 Resilience Index Measurement and Analysis (RIMA II)

Resilience Index Measurement and Analysis (RIMA II) was adopted and used to estimate the Household Resilience Capacity (RCI) to food security. RIMA II comprises both direct and indirect methods of measuring resilience (FAO 2016). The direct method of measuring resilience comprises of both the resilience capacity index (RCI) and resilient structural matrix (RSM) which are all unobserved.

Resilience is not directly observable and thus measured through a proxy (Marco D'Errico, 2016).

RIMA II quantitatively measures households' resilience capacity through latent variables modelling. The estimation strategy in Figure 3 below for RIMA II is based on a two-stage procedure viz-a-viz; Factor Analysis (FA) in the first stage and Multiple Indicators Multiple Causes (MIMIC) in the second stage. In the first stage, FA identified the variables that contribute to households' resilience capacity index from the pillars and these are Access to Basic Services (ABS), Assets (AST), Social Safety Nets (SSN) and Adaptive Capacity (AC).

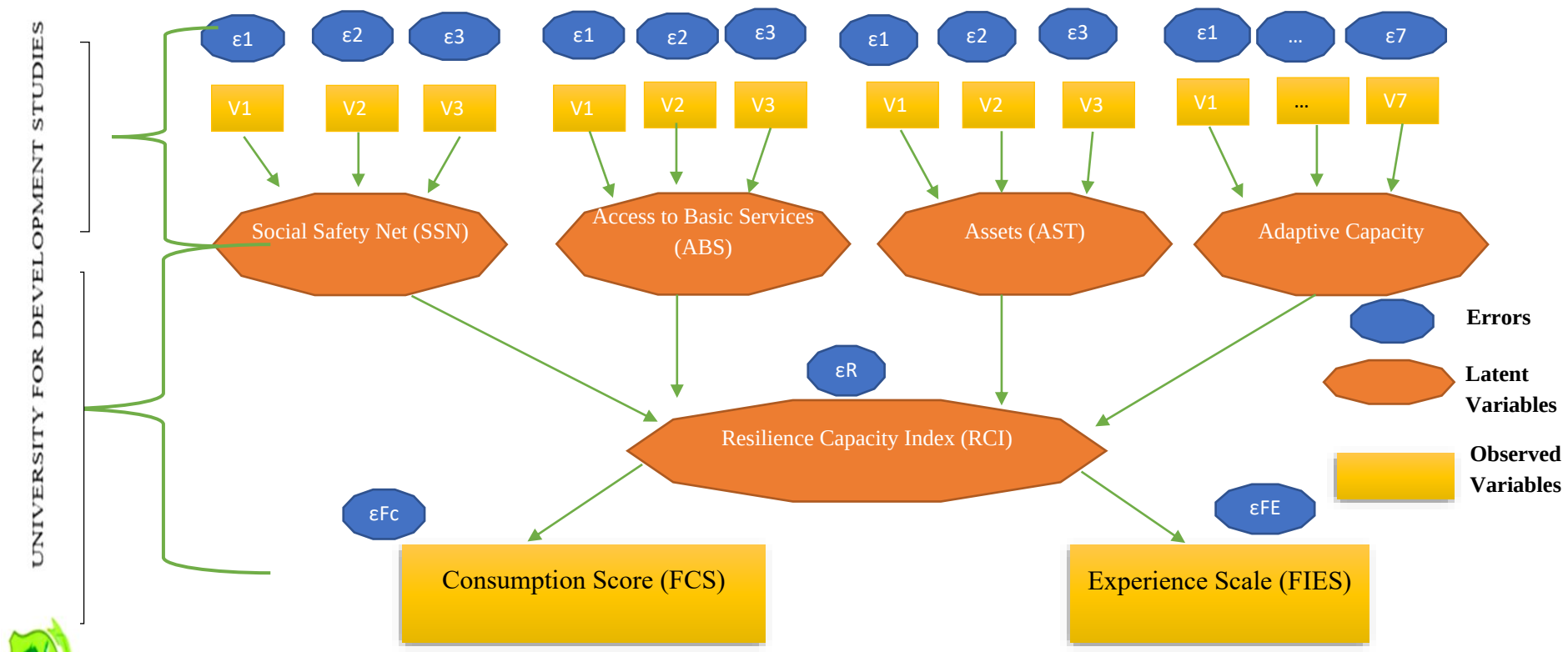


Figure 3:Rima II Estimation Strategy Adapted from D'Errico 2016

From Figure 3, foodInsexp is the food insecurity experience scale (FIES), Consumption score is the food consumption score (FCS), $\wedge_1$ and $\wedge_2$ are the factor loadings from the FA, RCI is the resilience capacity index and ε_1 and ε_2 are the error terms respectively.

RIMA II consists of four pillars and this can be mathematically expressed as follow;

$$\hat{R}_l = f(ABS_i + AC_i + AST_i + SSN_i) \quad - \quad - \quad - \quad - \quad 3$$

Where R_l is the estimated resilience index, ABS_i is access to basic service by households i (Whether households have access to potable water, improve wall, roof and floor; improve toilet, access to lightning, Improve toilet), AC_i is the adaptive capacity of households i (dependency ratio, level of education and source of diversification), AST_i is the assets of households i (Whether a household owns agricultural assets i.e. own agricultural land, own livestock and own agricultural equipment), SSN_i is social safety net of household i (Remittance, Food received and other goods received by a household). For each of the pillars, the factors which were able to explain to the minimum of about 95% of the variation were selected for the analysis.

At the second stage, the output of FA was used to compute the resilience index capacity (RCI) through the means of multiple indicators multiple causes (MIMIC) and resilience structure matrix (RSM). MIMIC is a system of equations constructed by expressing the relationship between unobserved latent variable (ULV), a set of outcome indicators (Food Security Indicators i.e., FCS and FIES) and a set of Pillars. FA assumes that the unique factors (errors) are uncorrelated with each other and are uncorrelated with the latent variable but due to the high intra-dimensional probability, the latter was not accepted in food security cases (d'Errico et al., 2018).

The two major components of MIMIC are measurement equations and structural equations.

$$\begin{bmatrix} FIES \\ FCS \end{bmatrix} = [\wedge_1, \wedge_2] \times [\eta] + [\varepsilon_2 \varepsilon_3] \quad 4.$$

Equation 4 shows that the indicators of food insecurity do not perfectly represent the indicators of resilience capacity.

$$[\eta] = [\beta_1, \beta_2 . \beta_3, \beta_4] \times \begin{bmatrix} SSN \\ AST \\ AC \\ ABS \end{bmatrix} + [\varepsilon_1] \quad 5.$$

Equation 5 is a form of the structural equation through which the estimated parameters were correlated.

Due to different scales of measurements employed in estimating resilience capacity index d'Errico et al., (2018), the coefficient of FCS and FIES loadings and their variances were pegged at one. The load equals one implies that when a standard deviation increases, RCI increases the food consumption by a standard deviation of 1. So also, is a unit increase in RCI will mean a 1 standard deviation increase in food insecurity expenditure i.e.

$$FoodInsexp = \Lambda_1 RCI + \varepsilon_1 \quad - \quad - \quad - \quad - \quad - \quad 6$$

$$Consumptnscore = \Lambda_1 RCI + \varepsilon_2 \quad - \quad - \quad - \quad - \quad - \quad 7$$

RCI was standardised using a Min-Max transformation technique proposed by d'Errico et al., (2018), given as follow;

$$RCI_h^* = \frac{RCI_h - RCI_{min}}{RCI_{max} - RCI_{min}} \times 100 \quad - \quad - \quad - \quad - \quad - \quad - \quad 8$$

h represents the h^{th} households, min is the minimum and max is the maximum.

For a synergy between food security and resilience measurement indicators, food security is conceived to be a function of some independent variables which affects

the food security status of the households which is our unit of analysis. This is given by;

$Y = f(X_1, X_2, \ldots X_n)$ - - - - - - - 9

food security is measured as a function of the household's resilience capacity index. Thus, this is mathematically expressed as,

$Y_i = f(R_i)$ - - - - - - - - 10

Where Y_i is the welfare indicators of interest that is food security indicators which comprise of food consumption score (FCS) and household food insecurity experience scale (FIES).

The assumption guiding equation 16 was that some characteristics make a household more resilience than the other and these characteristics are stated;

$Y = f[RCI(X_1, X_2, \ldots, X_m), X_{m+1}, X_{m+2}, \ldots X_n]$ - - 11

1-m are resilience correlates which affect food security status but does not affect resilience,

The subsequent analysis was done by another form of regression analysis.

FAO ShinyApp was used in estimating the resilience of households to food security. This application was developed by FAO to ease the analysis of the resilience of households to food security. The app allowed the user to upload all the attributes that form the pillar in excel format. It then processed the data to give the radar, the RCI and the RSM.

3.3.3 Assessing the Determinants of Household Resilience Capacity and its Effects on Household Food Security

3.3.3.1 Endogenous Switching Regression Treatment for an Ordered Outcome

The determinants of household resilience capacity and the effects of household resilience capacity on food security were captured with the aid of an endogenous switching regression treatment for an ordered outcome with the switchoprobitsim command in STATA. This is contingent because it is a two-stage procedure which separately handles both the untreated and the treated models. Going beyond the use of binary choice in measuring the effect of resilience on household food security becomes very much important as a result of the categorical nature of the outcome variable and the binary nature of household resilience capacity which is the treatment variable. Using the impact analytical method has been so rare in research due to the difficulty in interpreting the result of resilience capacity but this was accounted for by normalising the data using the min-max method (FAO, 2020a).

Also, another problem commonly associated with the use of the impact evaluation model which employed either non-experimental or non-observational data this is sample selection bias. The assumption underlines the use of ESR_OO was that there are some inherent ability/characteristics of the household which are unobservable that predisposes some of the households into different resilience categories. These household's characteristics make some households to be resilient while others are not. This according to Mabe et al. (2021), needs to be properly handled to prevent undue advantage which predisposes some households to food security not minding their resilience status i.e. resilient or not.

Several models can be used to handle this problem of sample selection biasness amongst others as noted by Shiferaw et al. (2014); Asfaw et al. (2016), heckman sample correction, generalised propensity score (GPS) and propensity score matching (PSM) in continuous treatment effects. This shows that these models are only good for continuous dependent variables which are unordered.

The outcome variable under consideration which is the food security status of the household is on ordered outcomes. Thus, Endogenous switching regression for an ordered outcome ESR_OO was used to model this outcome as propounded and recommended by Gregory, (2015), for modelling the treatment effects for ordered using maximum simulated likelihood.

It was assumed that different factors which affect treatment are not affecting the untreated. It has two equations and the first equation is

Using Switchoprobitsim in STATA, the selection equation is presented as follow;

$$ResCat_i = \begin{cases} 1 if\ Res_i^* = X_{ji}\beta_j + \varepsilon_i > 0 \\ 0\ if\ NotRes_i^* = X_{ji}\beta_j + \varepsilon_i \leq 0) \end{cases} \quad - \quad -- \quad - \quad 13$$

The above equations show the drivers of household resilience capacity. Where $ResCat_i$ is the household resilience capacity. It is (1 if the household is resilient and 0 otherwise). Also, X_{ji}=jth are the explanatory variables and ε_i=error term for the ith household.

The explanatory variables were: age, sex, HHsize, Literacy, employment_stat, Eng_in_farmin, Credit_Access, TOTEDUC, TOTFOOD, TOTHOU, TOTHLTH, Rur_urb, Dist_2_Sch and No_rooms_occ.

The second stage of this model performed just like every other endogenous switching regression model by explaining the factors which influence the food

security status of the household when they are resilient and when they are non-resilient. This is specified in equations 14 and 15 below for the 3 categories of the household food insecurity/security status;

Household food (in) security status for the resilient household.

$$FSL/FIL_{oi} = \begin{cases} 1\ if\ -\infty < \beta_0 Z_{0i} + \varepsilon_{0i} \leq \mu_{01} \\ 2\ if\ \mu_{01} < \beta_0 Z_{oi} + \varepsilon_{0i} \leq \mu_{02} \\ 3if\ \mu_{02} < \beta_0 Z_{0i} + \varepsilon_{0i} \leq \infty \end{cases} \quad - \quad - \quad -- \quad 14$$

Household food (in) security for the non-resilient Household

$$FSL/FIl_{1i} = \begin{cases} 1\ if\ -\infty < \beta_1 Z_{1i} + \varepsilon_{11} \leq \mu_{11} \\ 2\ if\ \mu_{11} < \beta_1 Z_{1i} + \varepsilon_{11} \leq \mu_{12} \\ 3if\ \mu_{12} < \beta_1 Z_{1i} + \varepsilon_{11} \leq \infty \end{cases} \quad - \quad - \quad -- \quad 15$$

The model also assumed that both outcome and the error term (ε_i) followed a bivariate normal distribution (BIVN). The selectivity bias and endogeneity are corrected by estimating a simultaneous equation which ensures that there is a consistent standard error.

Table 3: Description of the Variables used in Constructing Switchoprobitsim

Variables	**Description**	**Measurements**	***A priori* Expectation**
RCI	Resilience Capacity Index	Dummy (RCI<=0.5=Non-Resilient and RCI>0.5=1 Resilient	
FCS	Food consumption Score	Categorical (0-21=1Poor food consumption (PFC), 21.5-35=2 borderline food consumption (BFC) and >35=3 acceptable food consumption (AFC)	
FIES	Food insecurity experience scale	Categorical (0-3=1Food secure (FS), 4-6=2 moderately food insecure (MFI) and 7-8=3 severe food insecure (SFI)	
Age	Age of the household head in years	Continuous	+/-
Sex	Whether the head of the household is a male or female	Dummy (Male=1 and Female=0)	+
HHSize	Number of individuals in the household	Count	-
Literacy	Whether a household can read or write	Dummy (Yes=1 and No=0)	+
employment_Stat	Whether a household member is employed or otherwise	Dummy (Employed=1 and otherwise=0)	+
Eng_in_farmin	Whether the household engages in farming	Dummy (Yes=1 and No=0)	+

Credit_Access	Whether a household have access to credit	Dummy (Yes=1 and No=0)	+
TOTEDUC	The total amount that a household spent on education and it is measured in GHC	Continuous	+/-
TOTFOOD	The total amount that a household spent on food and is measured in GHC	Continuous	+
TOTHOU	The total amount that a household spent on housing and it is measured in GHC	Continuous	-
TOTHLTH	The total amount that a household spent on health and it is measured in GHC	Continuous	-/+
Rur_urb	Whether a household is from rural or urban	Dummy (Rural=0 and Urban=1)	-/+
Dist_2_Sch	The number of minutes that a household member cover before getting to school	Continuous	-
No_rooms_occ	Number of rooms occupied by a household	Count	+

Source: Author's Construct, 2021

Marginal Effects

The average treatment effect for the treated (ATT) and Average treatment effect (ATE) are the most specific estimated treatment effects. ATT estimated the effect of resilience on a household selected at random if the selected household was resilient. the ATT for an ordered outcome following Gregory, (2015) is given as follow;

$$ATT_K^j = \frac{1}{N}\frac{1}{S}\sum_{i=1}^{N}\frac{1}{E\{\varphi(\alpha X_{ik})\}}\left(\sum_{s=1}^{S}\sum_{\theta=0}^{\theta=1}\{I \times (FI_{ik} = \theta)\}\varphi(\alpha X_{ik} + \eta_{is}) \times\right.$$

$$\left[\varphi\{\varepsilon_{1j} - (\beta_1 X_{1ik} + \mu_{1k}\eta_{is})\} - \varphi\{\varepsilon_{1jj-1} - (\beta_1 X_{1lk} + \mu_{1k}\eta_{is})\} - \varphi\{\varepsilon_{oj} -\right.$$

$$\left.(\beta_0 X_{0lk} + \mu_{ok}\eta is)\} - \varphi(\varepsilon_{ojj-1} - (\beta_0 X_{0ik} + \mu_{ok}\eta\right] \quad - \quad - \quad -16$$

K is the number of groups or choices to which the dependent variable is categorised.

3.3.4 Determining the Interactive Effects of Shocks and Resilience on Household Food Security

3.3.4.1 Partial Proportional Odd Model (PPO)

The partial proportional odd (PPO) model was used to examine the determinants of households to food security. This is important as the dependent variable (household food security status) is both ordinal and categorical.

Although, food security is multi-dimensional but very key among its dimension is adequate access to food (FAO, 2016a). Households' food security status which is a categorical variable of ordered response was characterised based on their food security status that is; Severe hunger/poor food consumption, moderate hunger/borderline food consumption and mild hunger or Food secure/acceptable food consumption.

Given the categorical nature of the dependent variable, the standard ordered logit model should have been more appropriate provided the parallel line assumption is met. If this condition is violated, PPO is more appropriate, thus the essence of proposing the model. PPO is chosen because, in imposing or relaxing parallel line assumption, the ordered logit model can fit in three cases of generalised model viz-a-viz; the proportional odds/parallel-lines model, the partial proportional odds model, and the logistic regression model (Williams, 2006). Soon (2010), also noted that PPO is moderately parsimonious in parameter and flexible in assumption. Unlike the ordered logit model (OLM) and generalised ordered logit model (GOLM) which are high and low in parameters and also low and high in flexibility in assumption respectively.

The Wald test was used to test the validity of the model by testing the quality of the coefficient of each of the variables. It identifies which explanatory variables violate the parallel line assumptions. Parallel line assumptions underscore that all the parameters are the same across the individual parameter. The food security status of households which is ordinal was categorised into; (Acceptable food Consumption=1 or Food secure=1), (Borderline Food Consumption=2 or moderately food insecure= 2) and (Poor food Consumption=1 or severe food insecurity=1).

The formula for the model can be expressed as,

$$P(Y_i > j) = g(X\beta_j) = \frac{exp(\alpha_j + X_j\beta_j)}{1+\{exp(\alpha_j + X_i\beta_j)\}}, j = 1,2,\ldots,M \quad - \quad - \quad 17$$

Where M is the number of categories of the ordinal dependent variable.

The probability that Y will take on each of the values 1…, M are equal to

$$P(Y_i = 1) = 1 - g(X_i\beta_1) \quad - \quad - \quad - \quad - \quad - \quad - \quad 18$$

$$P(Y_i = j) = g(X_i\beta_{j-1}) - g(X_i\beta_j) j = 2, \ldots, M-1 \quad - \quad - \quad - \quad 19$$

$$P(Y_i = M) = g(X_i\beta_{M-1}) \quad - \quad - \quad - \quad - \quad - \quad - \quad 20$$

Y is an ordinal dependent variable of food security status. What it equals is determined by Y^* which is a continuous latent variable of food security status which has various threshold points.

$$Y^* = X\beta + \varepsilon \quad - \quad - \quad - \quad - \quad - \quad - \quad - \quad 21$$

The continuous form of RCI was used in this analysis for the ease of interaction with shocks. This is so as a dummy and a dummy cannot easily interact with each other. The list of variables for the model is listed in the table below.

Table 4: Variables for the Construction of PPO and the *Apriori* Expectation

Variables	Description	Measurements	*A Priori* Expectation
RCI			
FCS	Food consumption Score	Categorical (0-21=1Poor food consumption (PFC), 21.5-35=2 borderline food consumption (BFC) and >35=3 acceptable food consumption (AFC)	
FIES	Food insecurity experience scale	Categorical (0-3=1Food secure (FS), 4-6=2 moderately food insecure (MFI) and 7-8=3 severe food insecure (SFI)	
RCI	Resilience capacity Index	continuous	+
Illness_HH_Mem	Whether a household member was ill	Dummy (Yes=1 and No=0)	-
Death_HH_MM	Whether a household experiences death	Dummy (Yes=1 and No=0	-
Experience_flood_drou	Whether a household has experienced flooding, drought etc	Dummy (Yes=1 and No=0)	-
Illness_HH_Mem X RCI	When household experiences shock resulting from the illness of a household member and also resilient	Continuous	+
Death_HH_MM X RCI	When household experience shock resulting from the death of a household member and also resilient	Continuous	+

Experience_food_drou X RCI	When households experience shock resulting from flooding, war, conflict and also resilient	Continuous	+
Agey	The age of the household head in years	Count	+/-
Sex	Whether the head of the household is a male or female (Male=1 and female=0)	Dummy (Male=1 and Female=0	+
HHSize	Number of individuals in the household	Count	-
Marital_Stat	Whether the household head is married or otherwise (Married=1 and otherwise=0)	Dummy	+/-
Edu_Years	Number of years of education of the household head	Count	+
Rur_urb	Whether a household is from rural or urban (Rural=0 and Urban=1)	Dummy (Rural=0 and Urban=1)	-

Source" Author's Construct, 2021

3.3.4 Examining the Effects of Shocks on Household Resilience Capacity

3.3.4.1 Binary Logit Estimation

The effect of shocks on household's resilience capacity was measured using the Logit regression analysis. This is because of the dichotomous nature of the dependent variable. Household resilience index (RCI) was categorised into resilience if the RCI is greater than 50% (i.e., Ri>0.5) and otherwise if it is less than 50% (i.e., Ri <0.5). Thus, producing a dichotomous dependent variable. Empirically, the model is expressed as;

$$P_iF(Z_i) = 1 + \frac{1}{1+e^{-(\alpha+\sum \beta_i X_i)}} = \ln(\frac{P_i}{1-P}) = \beta_0 + \sum \beta_0 X \quad - \quad - \quad - \quad - \quad 22$$

The model is implicitly stated as

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k \beta_k + e \quad - \quad - \quad - \quad - \quad 23$$

And explicitly as;

$$RCI = \beta_0 + \beta_1 Illness_{HHMM} + \beta_2 Death_{of_{HHMem}} + \beta_3 Exp_{Warfir_{Flodr}} +$$

$$\beta_4 AGEy + \beta_5 Sex + \beta_6 hhsize + \beta_7 MaritaStat + \beta_8 Rur\_Urbs + e \quad 24$$

Table 5: Apriori Expectation of the Variable Used in Measuring the Effect of Shocks on the Household RCI

Variables	Descriptions	Measurements	*A Priori* Expectation
RCI	Resilience Capacity index of the household	Continuous	
Illness_HH_MM	Whether a household has suffered illness	Dummy (yes= 1 and No=0)	-
Death_of_HHMem	Whether a household lost a member of the household	Dummy (yes= 1 and No=0)	-
Exp_warfir_flodro	Whether a household experiences flooding, drought, conflict etc	Dummy (yes= 1 and No=0)	-
AGEY	Age of the household head in years	Continuous	+/-
SEX	Sex of the household head	Dummy (Male= 1 and Female=0)	+
hhsize	Number of individuals in a household	Count	-
MaritaStat	Whether a household head is married or not	Dummy (Married= 1 and otherwise=0)	+/-
Rur_Urbs	Whether the household is located in the rural or urban area	Dummy (Urban=1 and Rural=0)	+/-

Source: Author's Contsruct, 2021

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 INTRODUCTION

This section presented the result and the discussion on the socioeconomic characteristics of the respondents, household food security status and the resilience capacity of the household. Also, it goes further to present the determinants of resilience and the effect of the household resilience capacity on food security. This was to see which other factors influence the resilience of households aside from the one presented in the resilience index measurement and analysis (RIMA II). More also, it reports and discussed the interactive effect of shocks and resilience on household food security. This was necessary to ascertain what happened to the households when they are faced with shocks and are resilient in relation to food security. Finally, the chapter reported and discussed the examination of the effect of these shocks on household resilience capacity.

4.1 Summary Statistics of the Variables

4.1.1 Continuous Variables

Tables 6 and 7 below contains the summary statistics of the discrete and continuous variables used in the subsequent models below. The average age of the head of the resilient households was 48 years while that of the non-resilient household was 52 years. The mean age of the household head in Ghana was about 48 years. This confirms the report of GSS, (2014) that the average age of a household head in Ghana is 48 years old. This means that household heads were in their middle and active age. Household heads in this age will do anything to survive in acquiring

assets in order to guild against the time of adversaries, shocks or stress. The household size for the resilient households was 4 persons and those that were non-resilient were about 3 persons per household. Averagely, the number of persons in the household was 4 persons. This confirms Donkoh et al.(2014) who found out that the average household size in Ghana was 4 persons. The mean number of years spent in school by the household head was 3 years meanwhile, the average years of education of the household head who is resilient were 3 years and for the non-resilient household was 2 years. This implies that on a general note, the household head in Ghana did not complete the basic schools.

Also, the average total expenditure on education was 1,245.58 GHC with a variation of about 3,303.90GHC. The total expenditure on education of the resilient household was 1,245.58 GHC and 3,701.45 GHC for the non-resilient household. More also, the average total expenditure on food was 4,929.64 GHC with a sizable variation of 4,116.25. On average, the total expenditure on food by the resilient household was 4,798.55 and the average total expenditure by non-resilient households was 7,833.92. Considering the average total expenditure on housing, it was 986.57 GHH with a variation of about 2,230.37 from its average. On average, the total expenditure on health issues was 80.28 GHC the mean total expenditure by non-resilient households was 96.25 GHC

The average remittance received by the household within this period from friends and family living outside the country wa6 million GHC with a considerable deviation of about 947.97 million Ghana GHC. The average amount of remittances received by the resilient household was 358.92 million Ghana GHC and 433.89 million Ghana GHC by non-resilient households. The mean value of food received

by the household from family and friends was 25,029.33 Ghana GHC with a substantial deviation of Ghc1,972,310. The resilient households received food worth 10,489.56 GHC and the non-resilient household received food of 25,029.33 worth. Other goods received was worth about 25728.13 on average with a deviation from the mean of about 1874110. The resilient household received about 11,220.33 GHC of other food and the non-resilient received other goods worth 34,7153.8 GHC from family and friends.

Table 6:Summary statistics of the Continuous Variable

Variables	Resilient		Non-Resilient		Pooled		T-test
Variables	**Mean**	**Stand Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**
Age	48.65	17.32	52.54	18.08	48.82	17.37	5.39***
Household Size	4.26	2.87	2.88	2.55	4.20	2.87	-11.60***
Education in Years	3.06	1.68	1.68	1.66	3.00	2.19	-15.38 ***
Total Expenditure on Education	1245.58	3361.89	370.15	1246.38	1245.58	3303.90	-6.67***
Total Expenditure on Food	4798.55	3720.49	7833.92	8772.95	4929.64	4116.25	17.94***
Total Expenditure on Housing	999.47	700.88	700.88	1498.60	986.57	2230.37	-3.22***
Total Expenditure on Health	80.28	308.06	96.25	263.79	80.97	306.29	1.25
Remittance	358.92	1973.09	433.886	1268.68	362.16	947.97	0.93
Food Received	10489.56	880815.40	347163.20	8537712	25029.33	1972310	4.11***
Other good Received	11220.33	885031.50	347153.80	8537712	25728.13	1974110	4.09***
Dependency Ratio	1.40	1.16	1.16	0.99	1.39	1.15	-5.06

4.1.2 Discrete Variables

Table 7 below shows the descriptive statistics of the discrete variables used in the analysis. The bulk (87.35%) of the household heads were male and while 12.65% of this were female-headed households. Regarding the non-resilient household, 3% of the total household who are non-resilient were male-headed and 1% were female-headed. About 84.25% of the resilient household were headed by a male while 11.44% being headed by a female. Also, 2.16% of each of the non-resilient household heads were married and not married respectively while 56.29% of the resilient household were married and 39.40% were not married. On access to credit, the majority (97.59%) of the households have access to credit and just 2.14% of the household do not have access to credit. The bulk (93.48%) of the resilient household do not have access to credit while 4.11% and 0.21% of the non-resilient household do not have access and have access to credit respectively. About 90.75% of the households engage in one form of farming or the other with only 9.25% not engaging in farming. About 87.49% engages in farming among the resilient household while 8.2 % do not. Also, of the non-resilient households, 3.26% engages in farming while 1.05% do not engage in farming. Also, the majority (79.15%) of the household member was employed with 20.85% were either unemployed, under aged or out of labour force. Taking the resilient households, 79.76% were employed and 19.92% otherwise. While 3.39% and 0.93% of the non-resilient are either employed or otherwise. This implies that the majority of the household were employed and in their active age. This commemorates the result in the above table which shows that majority of the household are in their active age.

The bulk (88.73%) of the household were having access to potable water and 11.37% had no access to improve water. While 85.07% of the resilient household had access to improve water and 10.61% did not, 3.66% of the non-resilient household had access to potable water and 0.66% had no access. Considering the household access to improve lighting, 74.68% of the households had access while 25.32 had no access to improve lighting. For the non-resilient household, 2.30% had access to improve lighting and 2.02% did not. Also, 72.38% of the household had assessed to improve lighting why 23.30% did not. The result on whether the household uses electricity as the main source of cooking shows that the majority (99.79%) of the households were not using electricity as their main source of cooking while about 0.21% were using it and this is not statistically different from who were resilient. Only 4.32% of the non-resilient household was not using electricity as the main source of cooking.

In Addition, about 86.49% of the households said they did not have access to improved toilet facilities while only 13.51 percent had access to the modern toilet facilities in Ghana. Amongst this, 3.96% of the non-resilient households had no access to improved toilets and 0.36% were having access while in the resilient household, 82.53% of the households also had no access to the improved toilet with only 13.15% having access. Again, around 54.19% of the households had access to improved walls while 45.81 did not and this is not statistically different from the resilient household. However, for the non-resilient households, 2.74% had none and 1.58% had improved walls. Further to this, the majority (87.99%) of the households had no access to the improved roof while 12.01% does and this is no different from the response of the resilient households but about 2.99% of the non-resilient household had access and 1.32% had none. Furthermore, almost all (92.68%) of the

household had access to improved roofs while 7.32% had no access to this. Amidst this, 89.11% of the resilient household had access to the improved roofs, 6.58% did not while just 0.74% and 3.58% of the non-resilient household had access to improve and non-improved roofs respectively.

More also, only 40.45% of the household own the agricultural land that they are using for farming and a larger proportion (59.55%) do not. Giving this, 57.80% of the resilient household had no land for farming and 37.88% while it is only 2.57% of the non-resilient household that is owning land that they are using for farming but 1.75% were not owning the land I which they are using for agricultural purposes. Considering whether a household is having livestock has an asset, the result shows that it is only 28.95 percent of the household that owns livestock while 71.05% are not. Also, 68.31% of the resilient household are owning their livestock and 55.89% do not. the result of the non-resilient household shows that of the total proportion of the households, only 2.74% possessed livestock while 1.58% did not. In terms of the agricultural equipment possession, 57.76% of the households which from the bulk do own agricultural equipment used in farming but 42.24% does. About 55% of the resilient households did not possess agricultural equipment while 39.80% did. Also, only 2.45% of the households that were non-resilient possessed agricultural equipment while 1.87% did not.

Table 7: Summary Statistics of the Discrete Variable

Variables		Non-Resilient		Resilient		Pooled	
		Frequency	Percentages	Frequency	Percentage	Frequency	Percentages
Sex	Female	170	1.21	1,602	11.44	1,772	12.65
	Male	435	3.11	11,802	84.25	12,237	87.35
Marital Status	Otherwise	303	2.16	5,519	39.40	5,822	41.56
	Married	302	2.16	7,885	56.29	8,187	58.44
Credit Access	No	575	4.11	13,085	93.48	13,660	97.59
	Yes	30	0.21	307	2.19	337	2.41
Engagement in Farming	No	146	1.05	1,143	8.20	1,289	9.25
	Yes	455	3.26	12,195	87.49	12,650	90.75
Employment Status	Otherwise	130	0.93	2,791	19.92	2,921	20.85
	Employed	475	3.39	10,613	75.76	11,088	79.15
Access to potable Water	No	92	0.66	1,487	10.61	1,579	11.37
	Yes	513	3.66	11,917	85.07	12,430	88.73
Access to Improve Lighting	No	283	2.02	3,264	23.30	3,547	25.32
	Yes	322	2.30	10,140	72.38	10,462	74.68
Electricity main source of cooking	No	605	4.32	13,374	95.47	13,979	99.79
	Yes	0	0.00	30	0.21	30	0.21
Access to Improve Toilet	No	555	3.96	11,562	82.53	12,117	86.49
	Yes	50	0.36	1,842	13.15	1,892	13.51
Access to improve wall	No	384	2.74	6,034	43.07	6,418	45.81
	Yes	221	1.58	7,370	52.61	7,591	54.19
Access to Improve Floor	No	185	1.32	1,498	10.69	1,683	12.01
	Yes	419	2.99	11,906	84.99	12,325	87.99
Access to Improve Roof	No	103	0.74	922	6.58	1,025	7.32
	Yes	501	3.58	12,482	89.11	12,983	92.68

Own Agricultural Land	No	245	1.75	8,097	57.80		
	Yes	360	2.57	5,307	37.88	5,667	40.45
Own livestock	No	384	2.74	9,569	68.31	9,953	71.05
	Yes	221	1.58	3,835	27.38	4,056	28.95
Own Agricultural equipment	No	262	1.87	7,829	55.89	8,091	57.76
	Yes	343	2.45	5,575	39.80	5,918	42.24
Death of a Household Member	No	590	4.21	13,023	92.96	13,613	97.17
	yes	15	0.11	381	2.72	396	2.83
Illness of a Household Member	No	365	2.62	8,309	59.58	8,674	62.20
	Yes	239	1.71	5,033	36.09	5,272	37.80
Experience flooding/Conflict/drought	No	336	2.40	8,271	59.04	8,607	61.44
	Yes	269	1.92	5,133	36.64	5,402	38.56
Location	Rural	430	3.07	7,561	53.97	7,991	57.04
	Urban	175	1.25	5,843	41.71	6,018	42.96

Source: Author's Construct, 2021

Considering the death of a household member in Table 7 above, during the period under consideration, only 2.83% of the household experienced the death of a household member while the majority (97.17%) did not. This is not statistically different from the resilient household. Also, about 4.21% of the non-resilient household did not experience the death of a household member while 0.11% did. In addition, the majority 62.20% of the household did not experience the illness of a household member while 37.80% of the household had and this is not statically different from the result of the resilient household. Giving the general household findings, 1.71% of the non-resilient household experienced the illness of a household member while 2.40% did not. The bulk (57.04%) of the households were situated in

the rural area while 42.96% were located in the urban area and this is not completely different for the resilient household but only 3.07% of the non-resilient household were in the rural area why 1.25% were in the urban area.

4.1.3 Distribution of the Households Based on Source of Income Diversification

Table 8 shows the distribution of households by the source of income diversification. The results revealed that 41.20% of the household income was from the non-farm and 29.10% from the agricultural activities that is through self-employment. Wage received from non-farm employment and rent was 15.85% and 10.40% respectively, while income from other sources and remittance constituted less than 5% of the whole household income.

Table 8: The Distribution of Households Source of Income Diversification

Various Source of Income Diversification	Frequency	Percentage
Wage	2,220	15.85
Agric	4,076	29.10
Non-Farm	5,772	41.20
Rent	1,457	10.40
Remit	242	1.73
Other	242	1.82
Total	**14,009**	**100**

Source: Author's Construct, 2021

Table A1 in the appendix shows the distribution of the household source of income diversification across the locality. It indicates that income from agricultural activities, non-farm activities, rent and remit are more among the household in the rural area while wage and other sources of income tend to be more peculiar to the household in the urban areas.

4.1.4 Distribution of the household food Security Status based on indicators

Table 9 below shows the distribution of households' food security status in Ghana. The food security in this study was categorised into three that is; poor food consumption (PFC), borderline food consumption (BFC) and acceptable food consumption (AFC) in the first panel and food secure (FS), moderate food insecure (MFI) and severe food insecure (SFI). Panel is used in this study to represent the output of a models for each of the food security indicators. The result in the first panel for the food consumption score shows that about 46.56% of the household were in the PFC, 25.64% BFC and 27.80% AFC category. This shows that about 46.56% of the households from their dietary recall measure do not consume enough calories within the reference period are said to be food insecure that is a low level of food consumption and about 25.64% and 27,80% are BFC and AFC respectively. Being in the BFC category suggests that some households agreed at a time, that they were having a problem not eating some categories of food and also sometimes having enough. The reason could be, as result of the seasonality in agricultural produce which makes it plenty at a time and sometimes almost not available and poor knowledge of food processing and inadequate facilities for storage which could help in making the right quantity and quality of food available at all times. Also, the inability to make an adequate budget based on the wage received to spread throughout the month could result in the non-availability of food at a particular time in the household. This agrees with the definition of FAO, (2010) on food insecurity that when individuals are unable to have physical, social, and economic access to sufficient, safe, and nutritious food that will at all times meet their dietary needs and food preferences for a healthy and active life. It could therefore be concluded that a higher number of the household falls within the borderline food secure to acceptable

food consumption category. Households falling within the borderline food category consumed more of the staples that are maize, millet, yam etc, vegetables with fat and oil and less access to other classes of food. While the food secures consumed the balanced diet that is a blended of all other classes such as meat and fish majorly while occasionally consuming milk and other dairy products (WFP, 2012).

Also considering the second panel in table 9 below on the experience of the household on their food insecurity experience, about 51.10% were in the FS, 23.04% and 25.87% were in the MFI and SFI category. 23.04% being mild food secure suggests that households sometimes worried about what to eat which had led them to skip a meal ate less and even ran out of food. Being severely food insecure implies that they have been sometimes during the reference period that a member of the household was hungry but did not eat for a whole day without due which could be due to financial challenges or other resources. The distribution of the food insecurity pattern is similar to the findings of (Mabe et al., 2021; Nkegbe et al., 2017).

The results of the two indicators of food security of households produced similar results. The variation in the level of food security status from the indicators could be attributed to the fact that the various indicators are considering different aspects of food security. While the food consumption score (FCS) measures the frequency of household food consumption, the food insecurity experience scale (FIES) measures the self-reported experience of the households on their food insecurity level. It could be seen from all the food indicators that food insecurity in Ghana is still a big challenge that must be addressed. The result revealed that a considerable proportion of the households in Ghana are food insecure. The results agree with Darfour & Rosentrater, (2016); Aidoo et al. (2013) that generally, Ghana is food secure but

faced with the prevalence of food insecurity resulting from inadequate livelihood support and resources.

Table 9: Descriptive Statistics of the Household Food Security Status

Food Security Status					
Panel 1			Panel 2		
Consumption Score	**Frequency**	**Percent**	**Experience score**	**Frequency**	**Percent**
Poor Food consumption (PFC)=1	6,522	46.56	Food Secure (FS)	7,158	51.10
Borderline Food Consumption (BFC)=2	3,592	25.64	Moderate FI (MFI)	3,227	23.04
Acceptable Food Consumption (AFC)=3	3,895	27.80	Severe FI (SFI)	3,624	25.87

Source: Author's Own Construct, 2021

Considering the food security status of the households across the locality as a location that is either rural or urban as presented in table 10 below using two different indicators as indicated earlier. The table indicated that considering the general food insecurity level of the households across the locality, in panel 1, about 32.36% of the household in the rural area are in the poor food consumption category, 14.43% and 10.25% respectively are in the BFC AFC category. Also, giving the general household food security, 14.19% of the households who live in the urban area are in the PFC category while 11.21% and 17.55% are in the BFC and AFC categories. This implies that households located in the rural area face the brunt of food insecurity by being more in the poorly food consumed than the households in the urban area giving this indicator. Considering the household experience of food insecurity, 22.27% of the households in the rural area falls within the FS category, 15.30% falls within the MFI and 19.47% in the SFI. In the urban area, 28.82% fall within the FS category while 1.74%, 6.40% falls in the category of MFI and SFI

respectively. It could still be seen that in the food insecurity category, households in the rural area are more as compare to the household in the urban area who are more in the food secured category. This is consistent with the findings of the World Food Programme, (2012) that food insecurity is prevalent in rural areas than in urban areas. This is could that households in the rural area are not consuming the required diet, although not considered as asset poor but will augment this as the seasonal changes in food access improve. While households in the urban area hardly faced challenges from this due to their ability to get engaged in a regular job which could offset the seasonal changes in food access.

The result however disagrees with the findings of Atuoye et al. (2017) that people in the rural area of the Upper East region of Ghana are food secure as compared to the household in the rural area. This was attributed to the fact that the household in the urban area was depending on the food produce in the rural area.

Table 10: Distribution of Household Food Security Status Across the Locations

		Panel 1			Panel 2		
Location		**Food Consumption Category**			**Experience Scale**		
		PFC	**BFC**	**AFC**	**FS**	**MFI**	**SFI**
Rural	**Frequency**	4,534	2,021	1,436	3,120	2,143	2,728
	Percentages	32.36	14.43	10.25	22.27	15.30	19.47
Urban	**Frequency**	1,988	1,571	2,459	4,038	1,084	896
	Percentages	14.19	11.21	17.55	28.82	7.74	6.40
Total		**6,522**	**3,592**	**3,895**	**7,158**	**3,227**	**3,624**

Source: Author's Own Calculation, 2021

Table 11: Distribution of Household Food Security Status Across the Locations

	Location				Location		
Food Security Status (FCS)	**Rural**	**Urban**	**Total**	**Food Security Status (FIES**	**Rural**	**Urban**	**Total**
PFC	4,534 (69.52)	1,988 (30.48)	6,522 (100.00)	**FS**	3,120 (43.59)	4,038 (56.41)	7,178 (100.00)
BFC	2,021 (56.26)	1,571 (43.74)	3,592 (100.00)	**MFI**	2,143 (66.41)	1,084 (33.59)	3,227 (100.00)
AFC	1,436 (36.87)	2,459 (63.13)	3,895 (100.00)	**SFI**	2,728 (75.28)	896 24.72	3,624 (100.00)
Total	7,991 (57.04)	6,018 (42.96)	14,009 (100.00)	**Total**	7,991 (57.04)	6,018 (42.96)	14,009 100.00)

Source: Author's Own Calculation, 2021

Table A2 in the appendix below shows the distribution of households based on their food security across the regions in Ghana. The result shows that the Upper West, Northern region and Upper East have poor food consumption scores (PFC) incidence of 8.09%, 6.26% and 6.10% respectively. Also, the food security experience shows that Northern Ghana, Upper East and Upper West are more hit with food insecurity as compared to the other regions of Ghana with 5.29%, 4.94% and 4.40%

respectively. This is in corroborate the findings of WFP, (2021) that, a household in northern Ghana are being faced with a high rate of stunting in the lean season of 2020 that is between July-August times by about 31% with 21,712 being food insecure. It also agrees with Quaye, (2008), and he noted this to be happening between the period of inadequate provisioning that is a period in between the time of the stock depletion and the following harvest. Also, (Fuller & Pretari, 2018), found out that food insecurity is a major challenge in Northern Ghana with the majority being food insecure and worrying about what to eat which makes them reduce their meal. The Greater Accra, Central region and Accra are fairly food secure based on both indicators. The Greater Accra had AFC, FS of 5.48% and 8.21%; 4.98% and 3.63 in the central and 3.70% and 5.73% respectively in the Eastern region. The pockets of food insecurity from the different categories especially in Northern Ghana could be attributed to limited access to alternative livelihood and poverty (Mabe et al., 2021).

4.2 Resilience Index Measurement and Analysis (RIMA II)

Resilience Index Measurement and Analysis (RIMA II) of FAO using a Shiny app to produce the multiple indicators multiple causes (MIMIC), resilience capacity index (RCI) and the resilience structure measurement (RSM). Figure 4 below shows the result of the MIMIC, which underlies RSM as can be seen in Figure 5 below. The numbers in Figure 4 are the factor loadings (we take the absolute value in the model) that represent the relative weights of each pillar in the RCI of the households in Ghana. Considering the absolute value, ABS has the highest weight, followed by AST, AC and SSN which is reflected by RSM in the figure 5 below.

4.2.1 Multiple Indicator Multiple Causes (MIMIC)

The RSM in Figure 5 below shows how different attributes which form the pillars correlates in building the RCI as underscored by figure 4. RSM shows that access to basic services (ABS) and assets (AST) were the most relevant dimensions in building the RCI. Adaptive capacity (AC) has negligible influence with the social safety net (SSN) being the least important. This implies that access to basic services (ABS) and assets (AST) are the key drivers of households' resilience capacity in Ghana.

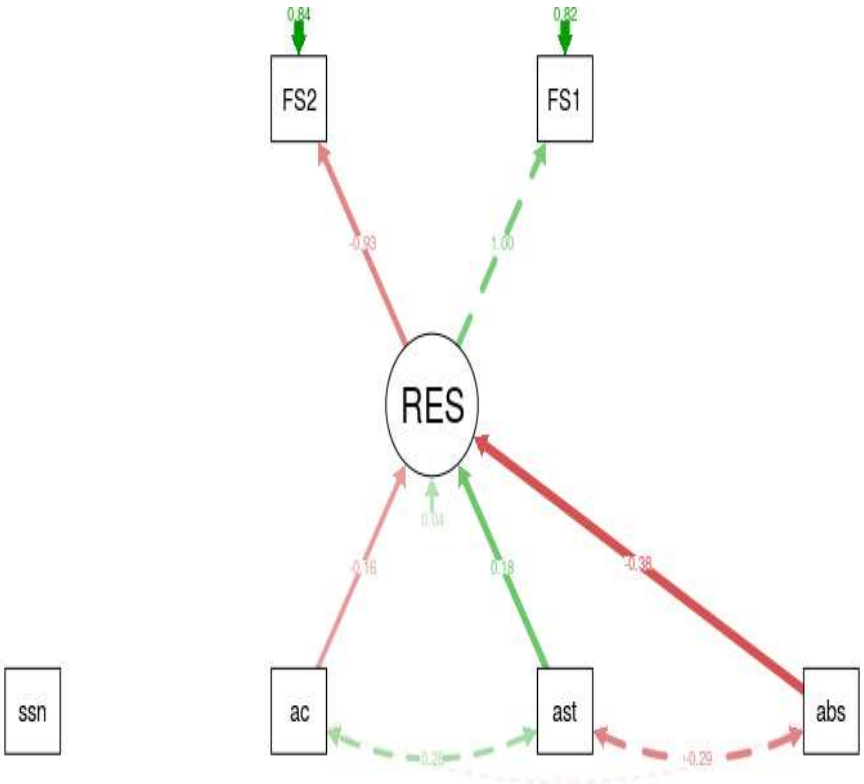
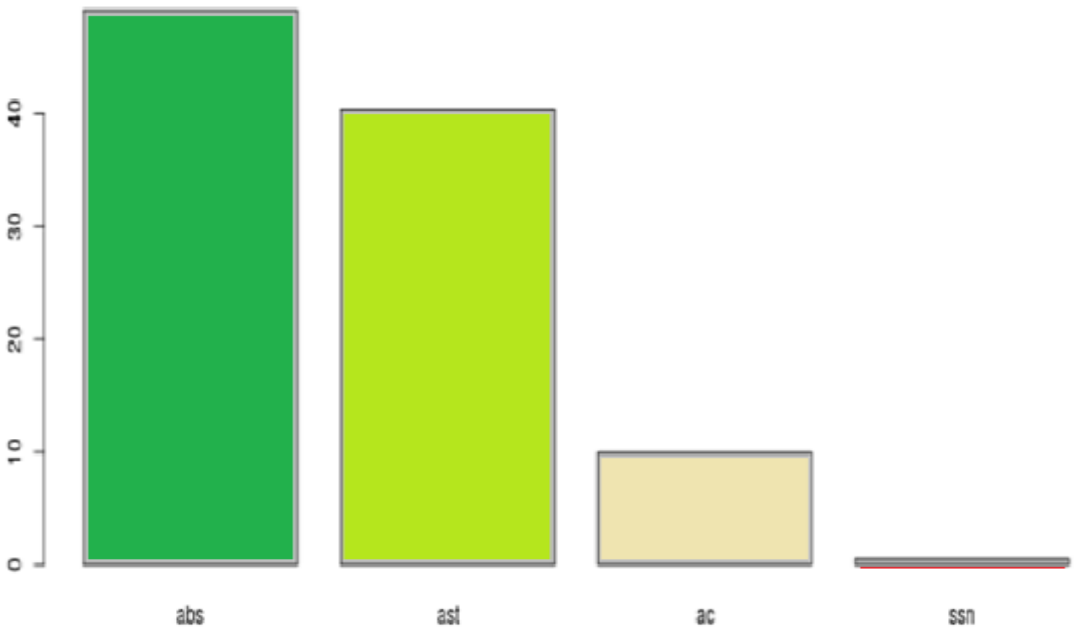


Fig 4: Multiple Indicator Multiple Causes (Mimic)

Source: Author's Estimation, (2021).



4.2.2 Resilience Structure Matrix

Figure 5:Resilience Structure Matrix
Source: Author's Estimation, (2021).

4.2.3 The contribution of each variable to the pillars

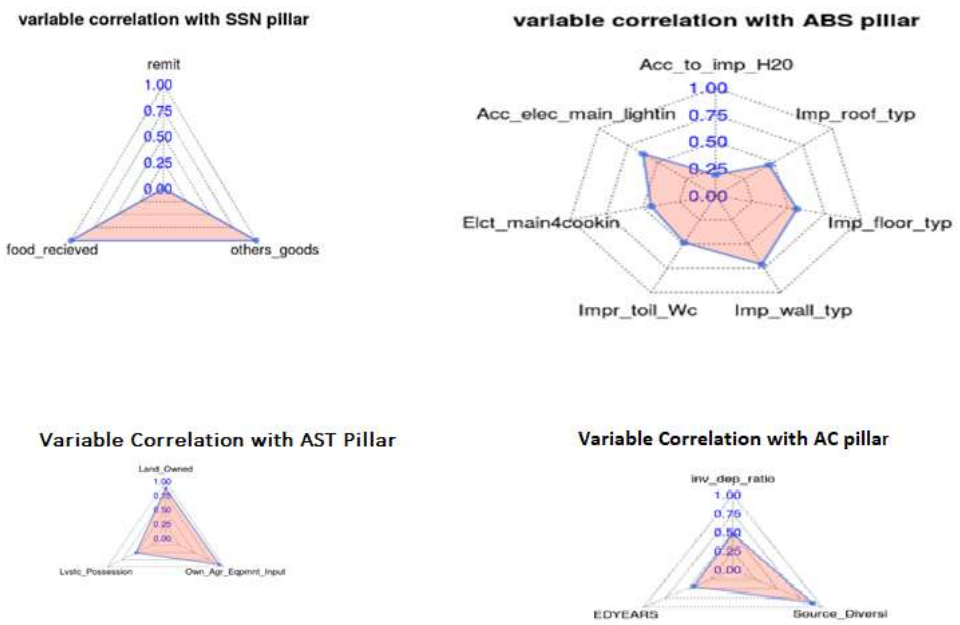
Figure 6 below is a radar graph produced automatically by the Shiny app. It presented the correlations between each pillar and their variables in order to identify the key aspect of households' resilience. It gives the detail of the most relevant variables that contribute to building each of the pillars that form the RCI. The higher and closer the score of the variable on the radar to 1, the higher the level of correlation and its contribution to the formation of the pillar.

The variables that were used to form the ABS pillar were household access to improve wall, roof, floor, toilet, electricity as the main source of lighting and also the main source of cooking. Access to improve wall is the variable that is most

explained ABS, followed by access to electricity. Whether a household lives in a house that is floored, roofed and uses electricity as the main source of cooking fuel, were the 2nd, 3rd and 4th variables respectively who contribute to this pillar with access to improved water being the least. Thus, ABS is mainly influenced by access to improve walls and roofs with access to potable water having a negligible influence on the household food security status. ABS in this context adopted from Lascano Galarza, (2019), refers to the household facility and living conditions. This is valid as the kind of wall, floor, source of fuel for cooking amongst others reflect the household access to the necessity of life which depicts better welfare and improve their resilience.

Three variables that constitute the asset (AST) pillar was possession of livestock, the proportion of the land owned and whether a household owns agricultural equipment. Whether a household own agricultural equipment contributes more to the asset of the household which was the second most important variable in the household resilience capacity construction. The second most important variable was land owned by the household with possession of livestock being the least. This is plausible because, when a household owns either agricultural equipment or land, it makes them safeguard against the day of adversity, which could help them to cope and recover easily from shocks or stresses that could come. This is consistent with the findings of Hesselberg & Yaro, (2006) that a fair distribution of land and wealth influences household resilience in Chiana village in the Upper East region of Ghana.

Figure 6: Radar Graph showing the contribution of each variable to the pillars



Source: Author's Estimation, (2021).

Also, adaptive capacity (AC) is the third influential variable on the household resilience capacity. It was explained by; the income diversification of the household, the dependency ratio and the number of years of education of the household head.

The household source of income diversification has a major influence on this pillar. The education of the household head and the dependency ratio had the almost same level of influence on the adaptive capacity of the household.

Moreover, the social safety net (SSN) was being majorly explained by food received and other goods received by the household within the reference period with little or no influence by the remittance received. This could be the reason why the level of correlation as can be seen in Figures 1 and 2 above was very low and equivalent to none. This could mean that households did not receive many remittances during this period and the insignificant influence it has in contributing to their resilience capacity. It is also worthy to note that, the square of remittance was also used to see whether it would influence the pillars more but was later removed because it had no significant value to the SSN pillar.

4.2.4 Household Resilience Capacity Status

Table 11 below presented the categorisation of the resilience capacity of the household to food security in Ghana. The result shows that the majority (95.68%) of the households in Ghana are resilient to food security with less than 5% being non-resilient. This means that generally, households in Ghana are resilient to food security. This is due to their access to basic services and assets acquired by the household as can be seen in Figure 5 above.

Table 12: Categorisation of the Household Resilience Capacity

Resilience category	Frequency	Percentage
Non-Resilient	605	4.32

Resilient	13,404	95.68
Total	**14,009**	**100**

Source: Author's Estimation, (2021).

Based on the location of the household in table 12a, 12b and 22 below, the majority (97.09%) of the households in the urban area are more resilient than the household in the rural area at 94.62%. Only about 5.38% rural area and 2.91% in the area are non-resilient. Similarly, considering the resilience of households across the regions shows that households in Ghana are generally resilient to food security.

Table 12b: Categorisation of the Household Resilience Capacity Based on Location

Resilience category	Location		Total
	Rural	Urban	
Non-Resilient	430	175	605
	(3.07)	(1.25)	(4.32)
Resilient	7,561	5,843	13,404
	(53.97)	(41.71)	(95.68)
Total	7,991	6,018	14,009
	(57.04)	(95.68)	(100)

Note: The figures in parenthesis represent the percentages

Source: Author's calculation, 2021

Table 12b: Categorisation of the Household Resilience Capacity Based on Locatio

Resilience category	The Resilience Capacity of the household		Total
	Non-Resilient	Resilient	
Rural	430	7,561	7,991
	(5.38)	(94.62)	(100)
Urban	175	5,843	6,018
	(2.91)	(97.09)	(100)
Total	605	13,404	14,009
	(4.32)	(95.68)	(100)

Source: Author's computation, 2021

4.3 Determinants of Household Resilience Capacity and its Effect on Household Food Security Status

4.3.1 Diagnostic Tests for the appropriateness of the model

Table 13 below presented the results on the determinants of household resilience capacity using the endogenous switching regression with ordered outcome i.e., switchoprobitsim. In order to ascertain the appropriateness of the model, the Wald Chi-square test, lamda, log pseudo likelihood ratio test and the test of the independence of treatment and outcome were estimated. The Wald chi-square had a value of 497.71 and 490.65 and were both scientifically significant at a 1% level. This depicts that, the model perfectly fits the data. The significance of lamdas at 1% also suggested that fitting the model separately would have probably produced a result which would have been inconsistent and bias. Also, the log pseudo likelihood ratio test for the two models had values of 13493.37 and 13883.89 and are statistically significant at 1%. This connotes that, the hypothesised alternative correlation between the error term of the treatment (Resilience) and the food security and insecurity levels is valid, that is, resilience affects the food security status of the household. The distribution of food security and insecurity level varies among the household head who were resilient and those who are not. The test of distinct regimes of the treated on the outcome was statistically significant at 1% signifies that is different factors affect the food security/insecurity level of the household who are resilient and those households who are not resilient.

4.3.2 Falsification Test of the Instruments

Finally, estimating endogenous switching regression treatment effect for an ordered outcome with *Switchoprobitsim* estimator/command on Stata involves controlling for endogeneity through the use of instruments. Having in mind that the instrument(s) must directly affect resilience but should not directly affect the food security which is the outcome variable. In selecting the appropriate instrument, a falsification test was performed following Di Falco (2014), and the distance to school and number of rooms occupied by the household were adopted as the valid instruments**.** The results in table 13 below show that the instruments jointly and significantly affect the resilience capacity of the household (model 1, χ^2=18.47; p=0.000 and model 1, χ^2=18.47; p=0.000) but not the food security status of those that are not resilient.

Table 13: Parameter Estimates-Test on Validity of Instruments

Variable	**Resilience to FS**		**Non-Resilient to FS**	
	Coeff	**SE**	**Coeff**	**SE**
Dist_2_Sch	-0.0065***	0.0016	0.0025	0.0035
No_rooms_occ	0.0336***	0.0131	0.0627	0.0872
Wald test on instruments	χ^2*= 18.47****		*F-stat=* 0.0000	
Observations	**14,009**		**13,404**	

Source: Author's Computation, 2021

4.3.3 Determinants of Household Resilience Capacity to Food Security

Colum 2 and 6 from Table 14 below shows the coefficient of the selected models that is the determinant of household resilience and their standards errors. It should be noted that all the variables that were used in generating the resilience index capacity were all excluded from the further determination of the drivers of the

household resilience. The demographic characteristics were statistically significant although at various levels.

The age of the household head has a negative influence on the resilience capacity of the household in both columns 2 and 6. It is statistically significant at 1%. This depicts that, when the age of the household head increases by 1 year, the probability of being resilient is less. The idea is this when the household head is younger, the household has a higher probability of being resilient. This is possible because when the head of the household is younger, he has the strength and would do anything at this age to survive through the adoption of the new technology, always ready to acquire the asset and even higher taste for the modern facility which could help them in building their household resilience capacity.

The sex of the household head has a positive influence on the household resilience capacity in both models and was significant at 1%. It reveals that, when the sex of the household was male, it increases the resilience capacity of the household. This could be explained by the fact when the household head was male, this could make the household to be at the advantage side in terms of access to input and freedom of association with no need for permission from anybody.

Table 14: Estimates of the Effect of Resilience on Household Food Insecurity (FCS/FIES)

Variables	Model 1 FCS			Model 2 FIES	
	Resilient	FCS Not-Resilient HH	FCSResilient HH	FIES Non-Resilient HH	FIES Resilient HH
Age	-0.0115*** (0.0022)	-0.0019 (0.0045)	-0.0005 (0.0008)	-0.0032 (0.0047)	-0.0012* (0.0007)
Sex	0.3118*** (0.0922)	-0.6191*** (0 .1674)	-0.3410*** (0 .0408)	-0.2274 (0.1761)	-0.0107 (0.0358)
HHSize	0.4391*** (0.0445)	0.3713 (0.0481)	-0.0020 (0.0063)	0.0602 (0.0511)	0.0819*** (0.0086)
Literacy	0.1983** (0.0869)	0 .3713** (0.1628)	0.0997*** (0.0294)	-0.7684*** (0.1748)	-0.4620*** (0.0324)
employment_Stat	-0.3425*** (0.1074)	-0.1252 (0.2224)	0.1788*** (0.0334)	-0.4574** (0.2216)	-0.3034*** 0.0319
Eng_in_farmin	-0.5510*** (0.0931)	-0.4083** (0.1798)	-0.3635*** (0.0492)	0.1441 (0.1906)	0.1330*** (0.0403)
Credit_Access	-0.4003** (0.1726)	0.1023 (0.3383)	-0.9426*** (0.1165)	0.2588 (0.3331)	-0.4544*** (0.0955)
TOTEDUC	0.0003*** (0.0001)	0.0003*** 0.0001	-9.08e-06 (9.13e-06)	-0.0001 (0.0001)	-0.0001*** (8.38e-06)
TOTFOOD	-0.0003*** (0.000014)	-0.00001 9.45e-06	0.0002*** (0.00001)	7.90e-06 (0.00001)	-0.0001*** 7.27e-06
TOTHOU	0 .0002** (0 .0001)	0.00002 0.0001	0.00004** (0.00001)	-0.0001 (0.0001)	-0.0001*** (0.00002)
TOTHLTH	-0.0003*** (0.0001)	0.0005* (0.0002)	0.0002 (0.0001)	-0.0002 (0.0002)	0.0001 (0.00004)
Rur_urb	0.7434*** (0.0001)	0.5900*** (0.1822)	0.3971*** (0.0385)	-0.7043*** (0.2322)	-0.2838*** (0.0271)
Dist_2_Sch	0.0029 (0.0046)				

No_rooms_occ	(-0.0884) *** (0.0257)
/lambda0	**0.7768***** **(0.0891)**
/lambda1	**-0.6189** **(0.1020)** ***
Observation	**13,730**
Wald Chi^2	**497.71*****
Log Pseudo Like	**-13493.369**
Test of independent treatment and outcome, treated group=	**36.82*****
Test of Regime	**112.47*****

Source: Author's Computation 2021
Note: Robust Standard Errors are in parenthesis and *p < .1, **p < .05, ***p < .01 respectively

Household Size which is the number of individuals in the household had a positive influence on the household resilience capacity. It was statistically significant at 1% which implies that, as the number of individuals in the household increases, the probability of the household being resilient increases with all things being equal. This is possible because, when the number of persons in the household increases, especially the active working age, this could lead to the increase in the household income and consequently improved welfare and helped in the building of their resilience capacity through asset acquisition. This disagrees with the findings of Hesselberg & Yaro, (2006) that, there is a positive association between household size and fragility.

Literacy obtained information on whether the household could read or write and otherwise. That is, it is a dummy variable coded as either yes or no. When the number of individuals that can either read or write has a positive influence on the resilience capacity of the household and is statistically significant at 5%, this could be explained as thus, when the household head could read and write, this could influence the adoption of innovations and technology, buying of shares, that can boost their productivity and increase their resilience capacity. This concurs with Alhassan, (2020) that education gives people the ability to use and process information that could help the household to cope with shocks resulting from flooding.

The employment status of the household head was statistically significant at 1% and negatively related to the resilience capacity of the household. This implies that, when the number of employed persons in the household increases, this could lead to the reduction of the resilience capacity of the household. This does not conform to our expectations as it reduces the resilience capacity of the household. However, this could result from the reason that, most of the households whose members were employed in a low paying job or underpay which could not cater for their needs.

Engagement in farming is a dummy variable for whether a household engages in agricultural activities or otherwise. It has a negative influence on the resilient capacity of the household and were statistically significant at 1%. This depicts that, when a household engages in farming, the probability of the household being resilient is low. This could be due to the smallholding and subsistent nature of the farming household in Ghana which has precluded the farming household from

building up their resilience capacity. That is the smallholding nature which debars them from having access to improve floor, wall, roof, electricity, agricultural equipment, land etc and even leads to the lack of interest in agriculture.

Credit access had a negative influence on the resilience capacity of the household and it is significant at 5% in the first panel and 1% level of significant but positive. This implies that in the first panel, when a household has access to credit increases with all things being equal, the chances of being resilient decreases. When the relationship was negative could be explained that when a household obtained access to credit and did not use it to acquire a productive asset, for productive or agricultural activities but rather used to marry more wives and for other non-productive activities could reduce the resilient capacity of the household.

Total expenditure on education had a positive relationship with the resilience capacity of the household and it is statistically significant at 1%. This implies that a cedi increase in the expenditure on education would probably lead to an increase in the resilient capacity of the household. This implies that, when there is a unit increase amount of money spent on education in the household, it increases the probability of the household becoming resilient. This could be that, the more the amount that is being spent on education, the more probable the number of years of education and this could increase the chances of the household member getting better employment based on the level of education. Thus, more income, increased asset, access to information and basic services which could consequently build up their resilience capacity. This agrees with Alagidede et al., (2013), that education was a major influence in securing a better job and also an agent of economic transformation.

Total expenditure on food had a negative influence on the resilient capacity of the household and was statistically significant at a 1% level. This indicates that, when the expenditure of the household increases by one cedi, the probability of being resilient decreases. This could mean that the household is spending the money that should have ordinarily been used in building the house resilience capacity on food. This could be influenced by the inadequacy of enough money in the household, persistent rise in the price of the commodity which could have increased the proportion of money that is being spent on food and consequently reduce their assets in the household such as agricultural equipment, percentage of the land owned and access to improve floor, walls etc.

Total expenditure on housing was statistically significant at 5% and had a negative influence on the household resilience capacity. This reveals that, when the amount of money spent on housing increases by 1 cedi, it increases the likelihood of being resilient. This is possible because, when any amount that is being spent on securing a living place that is habitable, that is having an improved floor, roof, wall and electricity. This enhances the household resilience capacity.

Total expenditure on health was negative and statistically significant at a 1% level. This shows that, when the expenditure on the health of a household member increases by 1 cedi, it could reduce the probability of a household becoming resilient. This means that, when the amount of money spent on the health of the household member increases by 1 cedi, it could lead to a reduction in the amount dedicated to acquiring an asset, access to basic services, social safety net.

The location of the household whether urban or rural was statistically significant at 1% and influence the resilience capacity in a positive direction. This shows that, when a household is located in an urban area, it increased the probability of being resilient. This could have resulted from the fact when a household is located in an urban area, it is susceptible to having assessed to first-hand information on new programmes, innovations, technology and employment that could lead to increased income which could improve household resilience.

Distance to school which is the number of hours spent before getting to school by a household member was insignificant and would have had a positive influence on the household resilience capacity of the household. This could have been explained that a kilometre increase in the distance that a household member spent before he gets to school could probably lead to an increase in the resilience capacity of the household. This contradicts our apriori expectation of reducing the resilience capacity but could be the reason for it not being significant.

The number of rooms occupied by the household was significant at 1% and had a negative influence on the household resilience capacity. This depicts that, when the number of rooms occupied by the household increases by one room, it reduces the probability of the household becoming resilient. This could be explained by the fact that when a household increases the number of rooms that they are using, it could come with more expenses which could reduce the amount of money that is being spent in acquiring an asset and other things and thus the resilience capacity.

4.3.4 Factors Influencing the Food Security of the Non-resilient Household

ESR_OO helped to identify the determinant of food security when the household was resilient and the determinants of food security when the household was not resilient. Column 3 in the table above shows the predictors of the non-resilient household to food security that is, the food security of the household when the household is non-resilient. These factors from panel 1 are; the sex of the household head the level of literacy in the household, engagement in farming, total expenditure and education, total expenditure on health and location of the household. Also in the second panel, Literacy, whether a household member is employed and the location of the household were the factors that significantly affect household food security.

The sex of the household head was statistically significant at a 1% level in model 1 column 3. Household whose head was male and was non-resilient is 61.91% less food secure than those whose households are resilient. This implies that when a household is not resilient and the head of the household was male, it was less food insecure than the household whose household head were female. This could be explained thus when a household is non-resilient, it has a low adaptive capacity (AC), access to basic services (ABS), social safety nets (SSN) and asset (AST). This agrees with Acheampong et al. (2021) that often, the female-headed households produces food crops which are usually consumed within the household. However, the fourth column of the table above, shows that the sex of the household had a negative association with household food security. This implies that a household that is resilient and the head of the household is male is about 34.10% less food secure than their counterpart. This placed the female-headed household on the advantaged side with the household being headed by females to be more food secure. This could

be that a female-headed household has been able to plan, acquire equipment, own land, a better roofing, flooring and wall materials with access to food, non-food items and remittance.

Literacy had a positive influence on the food security of the non-resilient household and was statistically significant at 5%. This signifies that the household that was literate and not resilient is 37.23 % more food secure than the household whose household was illiterate. Also, in column 4, the relationship between whether the household could read or write was positive and statistically significant at a 5% level. This means that, when a household is resilient and the household member could read and write, it had a 20.04% percent increase in their food security status than the housed whose member can neither read nor write. This is possible because, a household whose member is literate could access information and understand the content than the illiterate ones who could neither read nor write (Acheampong et al., 2021; Ngema et al., 2018; Nkegbe et al., 2017). This could also aid their adoption of technologies, new practices amongst others that could enhance their productivity and probably enhances their food security.

Whether a household engages in farming or not, this had a negative relationship with a household that was not-resilient and statistically significant at 5%. This shows that a non-resilient household whose member engages in farming had about a 40.83% decrease in their food security than their counterpart which does not. This could be that most of the household whose member engages in farming had been doing it on the subsistence level through which the production is only meant for the household consumption with little to sell. This could lead to making the household eat the

available rather than what is needed and may not even be able to have access to some other categories of food due to inadequacy of funds to make the food available for family consumption. Likewise in column 4, the relationship between whether a household engages in farming and resilience was negative at a 1% level of significance. This means that, when a household engages in farming and is resilient, it decreases the food security of the household by 36.35%.

The employment status of the household head was insignificant for the non-resilient household and had a positive influence on the food security status. However, an employed household head in column 4 had a positive influence on the food security status of the resilient household. That is, a household whose household head is employed and resilient was 17.88 more food secure than the household whose head was unemployed. This could be due to the fact that when a household member is employed, such can get means to take care of the family in terms of food provision, shelter with an improved roof, wall, and floor, possession of land, agricultural equipment among others. These could have a significant influence on household food security.

Considering column 4, whether a household had access to credit and resilience had a negative relationship with food security and was statistically significant at a 1% level. This implies that when a household has access to credit and is resilient, it decreases their food security by 94.26%. This does not conform with our apriori expectation as it was predicted that access to credit should enhance the food security of the household. The reason for this could be that the interest that is being paid on the credit is so high that it affects what the money is being invested on. Also, lack

of follow up and training on the use of the credit could lead to mismanagement and even possible diversion to another project rather than the proposed one. Yes, the household could be resilient in terms of asset owned and some other factors of resilience but not food secured. For the non-resilient household, access to credit is insignificant and positively related to food security.

Total expenditure on education was statistically significant at 1% and had a positive influence on the food security status of the household that was non-resilient but insignificant for the resilient one with a negative influence on food security. This shows in column 3 that, a cedi increases in the expenditure of the household who are resilient increases the food security by 0.03%. This could mean that the higher the sum of money spent on education, the higher the level of education attained which could lead to higher income and more assess to food and increase its availability and stability.

Total expenditure on food was insignificant on the food security of the non-resilient household but was statistically significant at 1% with a positive relationship with a resilient household. This implies that a cedi increases in the spending of the household when resilient on food items increases the household food security by 0.02%. This is reasonable because, it assumed the more money that is being spent on the consumption of food and food items, the more the food is likely to be accessible and available to the household as compared to the household that spends less.

The total expenditure on housing was also insignificant and had a positive influence on household food security. For the non-resilient household, the total expenditure on housing had a positive influence on the household food security and was statistically significant at 5%. This means that a cedi increase in the resilient household spending on food and food items will lead to a 0.002% increase in the food security of the household. This could be that, when the money is being spent on the housing property in the household, the household also increases its expenditure on food consumption. This does not conform with the *a priori* expectation that the increases in spending on housing could lead to a decrease in the amount of money that is being spent on food and food items. However, an increase in spending on housing could mean more income or earnings to the family which might have increased the amount of money allocated to the purchase of food.

Expenditure on health in column 3 for the non-resilient household was significant at 10% and had a positive influence on the household security but insignificant for the resilient household. This means that cedi increases in the amount of money spent on health, for a non-resilient household could lead to about 0.002% increase in food security as compared to the household which spends less on their household health. When a household spends more money on health, it could increase their productivity and active life which could have a significant influence on their income. This could further enhance their earnings and increases household income. This is plausible because good health ensures good food utilisation which ensures food security.

A household is located in the urban area for the non-resilient household was statistically significant at 1% and positively related to food security. This indicates that when a household was non-resilient and located in the urban area, it increases

household food insecurity by about 59.00%. Also, when a household is resilient, it was positive and statistically insignificant at 2% food security. This states that, when a household is resilient and located in the urban areas, it leads to a 39.71% increase in the food security status of the household. This implies that being located in the urban area could have predisposed the household to opportunities of a good job, access to information together with good networking which could improve their livelihood and consequently improve their food security. This agrees with Nkegbe et al. (2017) that a household that is located in the urban area are more food secure than their counterparts who live in the area. the authors noted that, although this area which is known to be the production centre for basic food should ordinarily have a culmination of food which could lead to food security but send most of their produce to the urban centre especially during the growing season in which the prices of most food items usually go up.

4.3.5 Factors Influencing the Food Insecurity of the Non-Resilient Household

Panel 2 in the Table above shows the drivers of food insecurity when the household was resilient and non-resilient with FIES. The drivers of food insecurity when the household is not resilient are; literacy, employment status and location while the determinants of food insecurity when the household was resilient includes; age, household size, literacy, employment status, whether a household engages in farming, access to credit, total expenditure on education, housing, food and household location.

In equation 1 of panel 2, the age of the household head had a negative influence on the food insecurity of the household but was insignificant when the household was non-resilient. In the second equation, age was statistically significant at 10% and had a negative influence on household food insecurity. This indicates that, when the age of the household head increases by 1 year for the resilient household, the food insecurity status of the household decreases by 0.12%. This could be that, as the age of the household head increases, due to experience which usually comes with age, the household had been able to plan and prepare for any eventualities which could make them be food insecure such as the death of the household member, illness of the household member, drought amongst others.

Household size had a positive influence on the food insecurity status of the household for both equations but insignificant for households who were resilient. It was significant at 1% for the household that was resilient. This implies that, when the household size increases by one person, the food insecurity status of the household increases by 8.19% for the resilient household. This is reasonable, as the household increases by 1 person, the responsibility of the household increases and the number of the mouth to be fed increases. Especially when this comes with the same income, it could lead to reducing the number of meals served per time, skipping a meal or get worried per time and thus becoming food insecure.

Whether a household head could read or write was statistically significant at 1% respective for both panels and had a positive influence on the household food insecurity. The second equation, thus implies that when the literacy of the household increases by 1 person i.e. a person increases in the number of people that could read

or write in the household decreases the food insecurity of the household by 76.84%. Also in the second equation, literacy had 46.20 decreases in the food insecurity status of the household. This could mean that, the more the number of the individual in the household who could read or write, the more exposed the household is and the more the household have access to information that could benefit the household and help improve their food security level. This is in tandem with the *a priori* expectation and agrees with Nkegbe et al. (2017) that when a household is literate, the chances of being food insecure reduces due to their high capacity for innovation and to adopt timely technology which could improve on their productivity and enhanced income than the non-educated household.

Furthermore, employment status of the household head was significant at 1% with a negative influence on the household food insecurity for both panel2 and 3 in model 2. In the second panel, this implies that, when the number of employed increases by 1 person and the household was not-resilient, the food insecurity status of the household decreases by 45.74%. When the number of employed for the resilient household increases, it had 30.34% less food insecure as compared to the unemployed or household with underemployed persons and were dependent. This is credible because, as the number of employed increases in a household for both the resilient household the non-resilient household, the more food secures the households are. When the number of persons employed in the household increase, the income of the household increases and the household is able to buy food especially quality ones rather than buying anyhow food that could not meet the dietary needs. Households with fewer persons working may not have the opportunity

to eat different varieties of food i.e., different classes of food when compared to their counterparts whose `members were unemployed.

Whether a household engages in farming, was insignificant for a non-resilient household and positive in the second and third panels. So, for the resilient household, it was significant at 1% and positively influence household food insecurity of the household. This implies that, when a household is resilient, the more a household engages in farming, the more food insecure they are. Ordinarily, it was expected that this has a negative influence on the food insecurity status of the household. But, being negative could be explained by the possibility that the household had been engaging in farming in the subsistence way. This might have precluded the household from eating the quantity rather than the quality. Meaning, they eat the available rather than what is needed to nourish their health. Also, when the location of the household could explain this as one season production could influence the food insecurity level of the household in a negative direction.

Access to credit also in the second model was positive when the household was resilient with a possible positive influence on the household food insecurity level of the household. however, access to credit was significant at 1% and had a negative influence on the food insecurity status. This agrees with our apriori expectation. It implies that, when a household has access to credit and is resilient, the food insecurity status decreases by 45.44%. This is plausible, as when the household had access to credit, he could have used it to support the family needs such as food, shelter, etc. This could improve the food security status of the household and reduce their worrying about what food to eat.

Total expenditure on education was insignificant and had a negative influence on the food insecurity of the non-resilient household. Total expenditure on education was significant and had a negative influence on the resilient household. This implies that, when the total expenditure on education increases by 1 cedi, the food insecurity level of the household decreases by 0.01% for a resilient household. This could mean that, as the expenditure on the household increases, the more the number of years spent in school which could be assumed to have come with bigger income and wage. Thus, increased household income could increase the amount of money that is being spent on foodstuff and therefore result in food security.

Total expenditure on food was insignificant in the non-resilient household and positively related to household food insecurity. Total expenditure on food was statistically significant at 1% and had a negative influence on the household food insecurity for the resilient household. This implies that when the household's total food expenditure increases by 1 cedi, the household food insecurity reduce by 0.01% when the household is resilient. This is plausible because a household whose expenditure increases should predisposes the household to improve on different classes that are being consumed. Thus, reducing household worry about what to eat, suffering from hunger, skipping a meal and compromising the quality of the food consumed and food security of the household. This corroborates the work of (Nkegbe et al., 2017) that when a household has higher consumption expenditure on food, the probability of suffering from hunger is less.

Total household expenditure on housing was statistically insignificant for the non-resilient household and had a negative influence on household food insecurity. Household total expenditure on housing was statistically significant at 1% and had a positive influence on household food insecurity as compared to the household who spend less on housing. This means that, when a household increases expenditure on housing such as accommodation, homes and houses, it reduces the food insecurity status of the household and likely become more food secure than the household that spends less on the housing. Although this was inconsistent with our *a priori* expectation the reason could be that, when a household spends more on housing, this could probably be associated with high wage receiver and earnings which make the household to be food secure as compared to the household which could not spend much on housing.

Location of the household i.e. being from the urban area has a negative influence on household food insecurity and is statistically significant for both resilient and non-resilient households. In panel 1 of the second model, the household being from the urban area was statistically significant at 1% and negative effect the food security of the household for the non-resilient household. this implies that, when a household is located in an urban area, it reduces the food insecurity level of the household by 70.43%. Also, the resilience that was located in the urban area negatively affect household food security. This implies that the household that was resilient and located in an urban area reduce by 28.38% the food insecurity status of the household. The reason could be that, when a household is located in the urban area wither from the resilient or the non-resilient household, it has the probability of being

exposed to a high paying job that could enhance the amount of money that is being spent on food to prevent the household from being food insecure.

4.4 Effect of Household Resilience Capacity on Household Food Security

The result in the third column and the sixth column shows that resilience capacity significantly influenced food security of the household.

Table 15: Estimates of the Effect of Household Resilience to Food Security

Effect	Panel 1			Panel 2		
	Food Security Level	Estimate	Standard Error	Food Security Level	Estimate	Standard Error
ATT1	ATT for 0-21 PFC	-0.3944***	0.0017	ATT for 0-3 FS	0.3157***	0.0010
ATT2	ATT for 21.5-35.5 BFC	-0.1447***	0.0010	ATT for 4-6 MFI	0.1255***	0.0004
ATT 3	ATT for 0-3 AFC	0.5391***	0.0017	ATT for 6-8 SFI	-0.1902***	0.0010
Observation			**13,404**			
ATE 1	ATE for 0-21 PFC	-0.4214***	0.0019	ATE for 0-3 FS	0.3570***	0.0012
ATE 2	ATE for 21.5-35.5 BFC	-0.1397***	0.0012	ATE for 4-6 MFI	0.1343***	0.0006
ATE 3	ATE for 0-3 AFC	0.5612***	0.0020	ATE for 6-8 SFI	-0.2227***	0.0012
Observation			**14,009**			

Note: ATT is the average treatment on the treated and ATE is the average treatment effect, *** represent significance at 1%
Source: Author's computation, 2021

The ATT in the above table is categorised according to the food security status of the household, in the first and second categories of the first panel, being resilient decreases the probability of being in the poor food consumption category and borderline food consumption category by 39.44% and 14.47% respectively.

Meanwhile, being resilient increases the probability of the household being in acceptable food consumption. That is being resilient increases the probability of being in the acceptable food consumption category by 53.91%. This implies that being resilient increases the likelihood of the household food security status while the less resilient household tends to be less food secured. That is, the resilience capacity of the household positively impacts their food security level. Thus, an increase in the resilience capacity of the household will lead to an increase in the food security status of the household from the poor food consumption to the acceptable food consumption category. This agrees with the findings of Alinovi et al. (2010); D'Errico et al. (2018) that an increase in the resilience capacity of the household by a unit will increase their food security status. This is consistent with the result on the first panel. Thus, it could be said that the resilience capacity of the household positively impacts their food security status.

The average treatment effect (ATE) in the third and the sixth column of the table estimates the difference in the average level of food security in which the household was resilient and non-resilient. The signs of the ATE helped to detect the direction of the effect of household resilience on food security. In the second part of the first panel, the ATE was negative for the poor food consumption (PFC) and the borderline food consumption (BFC) category. This implies that the households who were resilient were about 42.14% and 13.97% less likely to be in the poor food consumption category and the borderline respectively than their counterpart who was non-resilient. Meanwhile, the household who were resilient were 56.12% more likely to be in the acceptable food consumption category than their counterpart who

are less resilient. It could thus be inferred that the more resilient household is the more food secure than their counterparts who are less resilient.

Correspondingly, on the second part of the second panel, the ATE for the food secure (FS) and (MFI) were positive. This means that the household who were resilient was about 35.70% and 13.43% food secure and moderate food insecure respectively than their fellow households who were less resilient. More also, the resilient household was about 56.12% less severely food insecure than their counterpart whose households were non-resilient. This could be explained by the fact when a household is resilient, it is able to have access to some basic services which could improve the household food security level and even acquire an asset that can be used as security in the time of need.

This could be explained by the fact when a household is resilient, it is able to have access to some basic service which could improve the household food security level and even acquire an asset that can be used as security in the time of need.

4.5 Effect of Shocks and its Interaction with Household Resilience Capacity on Household Food Security Status

The result in table 18 below presented interactive effects of shocks and household resilience capacity on household food security status using FCS and FIES food dimensions. To validate the use of this model for both food security dimensions, instead of the commonly used models that is, the ordinal logistic (ologit) model, Brant test as can be seen in table 16 for the parallel line assumption was employed. Brant test reports whether the variables jointly or individually violate the assumption

of parallel line. The result from the table revealed that the joint test for model 1 which is food security status i.e. FCS has the Chi2 of 77.81 and is significant at 1% i.e., a p-value of 0.000. Also, in model 2 that is, the food insecurity experience scale (FIES), the Brant test has a Chi2 of 71.41 and a p-value of 0.000.

These showed that in both models, the parallel line assumption was jointly violated by all the variables. This implies that the coefficients (β's) are not all equal across the different panels. Due to the violation of the parallel line assumptions, using ordered logistic regression would have produced a bias, inconsistent, misleading and incomplete results (Williams, 2005, 2016, 2018).

In the frequency of food consumption category, table 17 shows that variables such as Age, Sex, Marital_Stat, Edu_Years and Rur_urb were significant at a 0.05 significance level. Using the Gologit 2 with autofit command in Stata. This implies that the constraints for parallel lines were not imposed on all the aforementioned variables. As a result, the coefficients in the first equation is not the same as the coefficients in the second equation. Perhaps, any other model had been used, this wouldn't be accounted for which could lead to biased judgement. Other variables; *Res_Cat, Illness_HH_Mem, Death_HH_MM, Experience_flood_drou, Illness_HH_Mem X RCI, Death_HH_MM X RCI, Experience_food_drou X RCI and HHSize* were insignificant at this level. This implies that the constraints for parallel lines were imposed on them. Thus, the coefficient for these variables was not added in the second panel of the model to avoid repetition. When the parallel line assumption is imposed on a variable, the coefficients of the variables are the same across the panels or equations.

In addition, in the other model for the effect of resilience and shocks on food security (FIES); *Illness_HH_Mem, Experience_food_drou X RCI, Agey, HHSize and Edu_Years* were statistically significant at 0.05 level. While other variables are insignificant. This implies that all the aforementioned significant variables violate the parallel line assumptions. While every other one has the same coefficients across the panels in the model. This explains the reasons why the significant variables were not added in the second panel to avoid duplications.

Table 16: Brant test for parallel regression assumption; Estimated Coefficients from Binary Logits

	FCS		FIES	
Variables	**Y>1**	**Y>2**	**y_gt_1**	**y_gt_2**
RCI	-0.438	-0.666	0.408	0.359
Illness_HH_Mem	0.622	0.526	1.256	0.511
Death_HH_MM	0.124	0.282	2.583	2.160
Experience_food_drou	1.431	0.740	0.756	1.915
Illness_HH_Mem X RCI	-0.004	-0.004	-0.012	-0.002
Death_HH_MM X RCI	-0.002	-0.002	-0.038	-0.032
Experience_food_drou X RCI	-0.029	-0.019	-0.010	-0.027
Agey	-0.000	-0.003	0.001	0.001
Sex	-0.651	-0.310	-0.016	0.131
HHSize	-0.181	-0.165	0.365	0.334
Marital_Stat	0.456	0.342	-0.357	-0.326
Edu_Years	0.434	0.392	-0.395	-0.399
Rur_urb	1.036	1.199	-0.814	-0.707

The FCS Chi2= 77.81 and for FIES Chi2= 71.41 with P>chi2=0.000 df=13. A significant test statistic provides that the parallel regression assumption has been violated.

Source: Author's Computation, 2021

Table 17: Brant Test of Parallel Lines Regression Assumption for individual Variable at 0.05 Level of Significance

Variables	P-Value for FCS	P-Value for FIES
RCI	0.046	0.680
Illness_HH_Mem	0.799	0.041
Death_HH_MM	0.896	0.738
Experience_flood_drou	0.072	0.001
Illness_HH_Mem X RCI	0.882	0.089
Death_HH_MM X RCI	0.985	0.746
Experience_food_drou X RCI	0.112	0.002
Agey	0.016	0.923
Sex	0.000	0.019
HHSize	0.286	0.040
Marital_Stat	0.008	0.467
Edu_Years	0.030	0.857
Rur_urb	0.000	0.010

Source: Author's computation, 2021

4.5.1 Partial Proportional odd Model

This model was used to assess the interactive effect of shocks and resilience on food security vis-à-vis food consumption score and food insecurity expenditure score as can be seen in Table 18 below. The Wald chi2 which perform a similar function as F-ratio and Chi2 ratio test the overall goodness of fit for the model i.e., the joint power of the regressors on the dependent variable (Food consumption category). The null hypothesis is that the regressors have no impact on the regressand. The significance of the Wald chi2 test at 1% with a value of 19.56 signifies the rejection of the null hypothesis and concluded that the regressors affect the household food security status. The regressand was ranked into three which result in the estimation of two models by PPO with the least coded i.e. food secure as the base category or reference group. The category to be interpreted in PPO are compared with the reference group as noted by (Williams, 2016). The signs on the coefficients show the direction of the likelihood of a household being in a particular category of food security or otherwise. This gives a similar result with the outcome of a binary logistic regression which categorises 1 to m as 0 and m+1 to j as 1. This suggests that an

independent variable with positive coefficients or odds ratio with a value higher than 1 increases the probability of a household being poorly food secure as compare to the reference base category i.e. food secure. On the contrary, if the coefficient or the odd ratio of the explanatory variable has a negative value and less than 1, there is a lower likelihood of a household falling in the food category group under consideration as against being in the reference group.

Table 18:Interactive Effect of Shocks and Resilience on Household Food Security

Variables	Model 1 Food Security Status (FCS)						Model 2 Food Insecurity Experience Scale (FIES)					
	Poor Food Consumption			Borderline Food Consumption			Food Secure			Moderate		
	Coefficients	RRR	P>|z|	Coefficients	RRR	P>|z|	Coefficients	RRR	P>|z|	Coefficients	RRR	P>|z|
RCI	-0.5144***	0.6592	0.000				0.3826***	1.5064	0.000			
	(0.1053)	(0.0764)					(0.1097)	(0.1753)				
Illness_HH_Mem	0.7292**	2.1815	0.035				-1.0605***	3.7200	0.000	-0.9396	1.6843	0.195
	(0.3291)	(0.8069)					(0.3325)	(1.3411)		(0.3306)	(0.6771)	
Death_HH_Mm	0.0919	1.2772	0.841				-2.4356**	17.6954	0.027			
	(1.1072)	(1.5571)					(1.1424)	(23.0202)				
Experience_Food_Drou	1.2083***	4.0181	0.000				-0.7944**	2.1257	0.032	-1.8711***	7.2447	0.000
	(0.3289)	(1.4348)					(0.3485)	(0.7463)		(0.4068)	(3.0031)	
Illness_HH_Mem X RCI	-0.0064	0.9930	0.254				0.0092**	0.9867	0.025			
	(0.0055)	(0.0061)					(0.0055)	(0.0059)				
Death_HH_Mm X RCI	-0.0002	0.9965	0.865				0.0363**	0.9574	0.045			
	(0.0186)	(0.0204)					(0.0193)	(0.0207)				
Experience_food_drou X RCI	-0.0258***	0.9720	0.000				-0.0106**	0.9901	0.085			
	(0.0054)	(0.0057)					(0.0057)	(0.0057)				
Agey	-0.0004	0.9997	0.761	-0.0039**	0.9960	0.003	0.0012	1.0012	0.282			
	(0.0011)	(0.0011)		(0.0013)	(0.0013)		(0.0010)	(0.0011)				
Sex	-0.6497***	0.5241		-0.3213***	0.7226	0.000	-0.0124	0.9897	0.861	0.1252*	1.1317	0.079
	(0.0604)	(0.0317)	0.000	(0.0672)	(0.0488)		(0.0591)	(0.0589)		(0.0695)	(0.0798)	
HHSize	-0.1739***	0.8375	0.000				0.3444***	1.4185	0.000	0.3444***	1.4065	0.000
	(0.0129)	(0.0113)					(0.0133)	(.0220)				

Marital_Stat	0.4460***	1.5660	0.000	0.3218***	1.3745	0.000	-0.3413***	0.7030	0.000			
	(0.0409)	(0.0643)		(0.0459)	(0.0633)		(0.0382)	(0.0289)				
Edu_Years	0.4196***	1.5256	0.000	0.3988***	1.4778	0.000	-0.3726***	0.6857	0.000	-0.4045***	0.6690	0.000
	(0.0166)	(0.0263)		(0.0169)	(0.0295)		(0.0162)	(0.0124)		(0.0169	(0.0121)	
Rur_urb	1.0494***	2.8582	0.000	1.1819***	3.2537	0.000	-0.8217***	0.4421	0.000	-0.6876***	0.4978	0.000
	(0.0407)	(0.1176)		(0.0431)	(0.1435)		(0.0391)	(0.0174)		(0.0471)	(0.0238)	

Note: *, **, *** represent 10%, 5%, 1% level of significance respectively. RRR = relative risk ratio. chi2(8) = 19.56, Prob > chi2 = 0.0000 and Pseudo R2 = 0.0862 for FCS chi2(6) = 15.62, Prob > chi2 = 0.0000 and Pseudo R2 = 0.0671 and chi2= 15.62, Prob > chi2 = 0.0000 and Pseudo R2 = 0.0671 for FIES

Source: Author's Computation, 2021

The result in table 18 above for the two models shows that all the variables meet our apriori expectation. It also indicates that being resilient, shocks resulting from the illness of a household member, the experience of a flood, drought, war, conflict, when experiencing shocks and are resilient, sex of the household head, household size, marital status, education in years and whether from urban or rural (the location) had a significant influence on the food security status of the household in the model 1. Other variables such as; death of a household member, illness of a household member when resilient, death of a household member when resilient together with age are insignificant in influencing the food security status of the household. Likewise in model 2, the results show that in panel 1, RCI, illness of a household member, death of a household member and their interactions except that of the experience of drought and RCI, household size, marital status, education in years and the location were all significant. Also, in the second panel of the same model, it is the only illness of the household member that was not significant among the variables that violated the parallel line assumptions.

Due to the difficulty in interpreting binary outcomes as observed by Cameron and Trivedi (2005), resulting in more interest in the marginal effect. The relative risk ratio was obtained and was rather interpreted as seen in table 18 above.

Resilience capacity Index (RCI)

Based on table 18 above, the result shows that when a household is resilient, it affects its food security status. The result from table 18 above depicts that, all things being equal, a resilient household has fewer chances of belonging to the poor food consumption category and the borderline than being food secured as compared to the less resilient households. The resilience capacity index is negative in both panels

and has a relative risk ratio (RRR) of 0.66 at a 1% significance level. Ceteris paribus, a resilient household are about 0.66 times less likely to be poorly food secured or be in the borderline category than the less-resilient households. This implies that households who are less resilient are more likely to be in the poorly food secure and borderline food category than being food secure. Furthermore, the second model in which the food security measurement was FIES, had an RCI that is statistically significant at 1% and positively influence the food insecurity experience of the household with a RRR of 1.51. This designate that, when there is a percentage increase in the resilience status of the household, there are about 1.51 times more likely for a household to be food secure (FS) and in the moderate food insecurity (MFI) than being in the severe food insecurity (SFI) when compared with the non-resilient household's category. According to Mabe et al., (2021), mild food insecurity is not all that a bad situation but shows that the household had worried about their inability to get food but it was considered being trivial and considered food secure in this study. Further, being in the MFI describes the fact the household had compromised the quality and the quantity of the food consumed in the household. Thus, the resilient household is more likely going to be FS and BFI than being in the SFI relative to the less resilient household.

This is because, when a household is resilient, it has access to basic services as can be seen in Figure 5 above and have assets in various forms which can be used to offset the bad times. That is, a resilient household is more likely going to be food secure as compared to a non-resilient household. Simply put, RCI has a positive influence on household food security. This confirms the study of Alinovi et al., (2010), d'Errico et al., (2018) that found out the existence of a positive relationship between food security and RCI in Uganda and decreasing the chances of future food

security loss by aiding the recovery after the loss had occurred. Also, this contrast same study in Tanzania in which RCI negatively affects food security except that the variables were insignificant. That is, when a household is resilient to food security, it is more likely going to have better welfare i.e., food secure as compared to the less resilient household.

Illness of a Household Member

This is a self-reported shock on whether a household lost a member during the past twelve months. It is a dichotomous i.e., coded either yes or no. It is positively related to food security and statistically significant at a 5% level with an RRR of 2.18. This indicates that all things being equal, the household whose member suffer illness especially of a breadwinner, has 2.18 more likely going to be poor food secure and be at the borderline in contrast to the household whose household never experience the illness of a household member. This could be explained by the fact that when a household member is sick, money will be spent on such persons and sometimes lead to selling of asset which could reduce the purchasing power of the household and decreases their access to food.

In the second model, whether a household member experience illness of a household member had a negative influence on food insecurity in the first panel and was statistically significant at 1% but insignificant and also negative towards the household food insecurity status in the second panel. In panel 1, the RRR was 3.72 and implies that when the number of persons who suffer from illness increase by one person within the period under consideration, it has 3.73 times fewer chances of becoming FS than being in the severe food category. Also in the second panel, if it had been significant, with an RRR of 0.9396, the household would have been 0.93

times less likely going to be in the MFI than being in the SFI category. This implies that an illness of a household member had an adverse influence or effect on the household experience of food insecurity. This is plausible because, when a household experiences shock such as an illness, the money is spent making sure that the health is restored to normal. When more money is being spent on health-related problems, it could lead to a serious reduction in the amount dedicated to food consumption. This consequently reduces food availability in the house, access, utilisation and stability. This buttresses the result of model one that socks resulting from the illness of a household member had a positive influence on the food security that is poor food consumed.

Death of a Household Member

The death of a household member is also a dummy variable that is coded yes or no. It is coded 1 when a household experiences the death of a household member and 0 otherwise. Although this variable is insignificant, it has a positive relationship with the food security status of the household with an RRR of 1.28. This implies that all things being equal, a household that experiences the death of a household member has about 1.28 times more likely to be poor food consumed and borderline food consumption as compared to their counterpart who has not lost their member than being food secure. This is because, losing a very important member of the family that is, a member who earns money to cater for the family can lead to jeopardy.

Considering the second model using the food insecurity experience, it shows that shock resulting from the death of a household member is statistically significant at a 5% level and had a negative influence on food security with an RRR of 17.70. This

portrays that, when the death of a household increases per person in the household, there is 17.70 times less likely for the household to be FS and even be in MFI than be SFI as compared to the household that has not experienced the death of a household member. This means that when a household loses a member, it will probably be in the SFI category than when it doesn't experience the death of a household member. This could mean that when a household lost its member, the burden of having many mouths to feed increases in the household by reducing the number of persons who fend for the household. This result in hunger or starvation resulting from the gap that has been created from the death of the household member. Thus, reducing their access to food, the proportion of food consumed the frequency of consumption and even reduced classes of food consumed. This agrees with the findings of Smith & Frankenberger, (2018), that shock such as the death of a household member has a negative influence on the food security status of the household. However, it is also worthy to note that, the Illness and death of a household are idiosyncratic shocks that affect a particular household.

Experience of flood, drought, war, conflict and famine

Whether a household has experienced flood, drought, war, conflict and fire outbreak over 12 months and it was coded into 1=yes and 0=otherwise. This is a covariate shock that could affect a region, a country and the whole world. Shock resulting from the experience of flood drought and famine has a positive influence on household food security, it is significant at 1% and has an RRR of 4.02 in both panels. This implies that every other thing being equal, a household faced with the challenges resulting from flood, drought and famine has 4.02 times more likely to be poor and be in borderline food security status than being food secure as compared

to the household who have not to experience any covariate shocks such as drought, flooding, erosion, conflict amongst others. This is true because, the experience of drought, flood, erosion, conflict, war, fire amongst others could lead to the ravaging of the source of livelihood, decrease productivity, health challenges and even poverty. It could lead to income uncertainty because according to Martin-Shields & Stojetz, (2018), most of the households in most of the areas where conflict, drought and erosion were experienced were mostly smallholder farmers who depend on the rainfall for their production and survival. This may consequently lead to poor access to food, even availability and stability and does poor food consumption.

In model 2, shock as a result of the household experience of flooding, drought, conflict to mention but a few were significant at 5% and 1% in panels 1 and 2 and was negative with RRR of 7.24 and 1.87 respectively. This implies that from the first panel, when the incidence of this shock increases, there is 2.13 times less likely to be FS than being severely food secure as compared to the household which experience less or no shock of this nature. Also, in panel 2, a unit increase in the experience of a household on flooding, drought etc will lead to about 7.24 times less likely to be in MFI as compared to other households who did not experience drought, erosion, flooding and fire than being in the SFI. This is expected, as the household experience of flooding, drought, conflict could predispose the household into the destruction of their source of livelihood and displace them from the area where they were previously located. That is, shocks of this kind could lead to loss of livelihood, loss of lives, migration amongst others. That is, this could lead to loss of welfare in the household, expose them to starvation or extreme hunger and thus food insecurity. This is in tandem with Devereux & Edwards, (1999) that the intensity of rainfall

could interrupt the growing season thereby consequential into complications. Kelly & Adgers, (2000) and Adger, (1999) also noted that shock resulting from flooding could be a serious threat to household livelihood vis-à-vis food production. Further, Baro & Deubel, (2006) presented that famine has a close link with conflict in the twentieth century.

Interaction of Shocks and RCI

Still from table 18 above, the interaction between shocks including both idiosyncratic shocks illness of a household member and the death of a household member and the covariate shock with resilience capacity index (RCI). All the shocks are negatively related to household food security which is directly opposite to the effect of shocks with only the interaction of resilience and experience of flood, drought and famine is significant. The insignificance of almost all the shocks signifies according to (d'Errico et al., 2018) the greater influence that the resilience capacity of the household is having on the shocks concerning food security. It shows that RCI is able to diminish the effect of shocks. This made the author conclude that RIMA which is a resilience measuring approach developed by FAO is able to ascertain the earlier definition of shocks which is the capacity of a household to withstand shock. The details of the interactions are discussed below.

Additionally, the signs of the interactions of shocks and RCI in model 2 and both panels show a sign directly opposite to what the shock is having on the food insecurity status. These interactions were all significant at 5% in both panels.

Interaction between Illness of Household Member and resilience capacity index

In the above table 18 above the interactive effect between illness of a household member and RCI to food security status. Although this interactive effect is insignificant in both panels, it shows a negative relationship. This implies that, when a household experiences the illness of a household member and is resilient at the same time, all things being equal, the household is about 0.99 times less likely to be poor and borderline food secure than being food secure. This is plausible and shows the strong effect of resilience at dampening the influence that this shock could be having on the household. a resilient household, with greater asset (AST), access to social safety net (SSN) and adaptive capacity (AC) is expected to be less food insecure and even bounce back after the shock.

Furthermore, the interactive effect between the illness of a household member and the RCI was significant statistically at 5% and positively influence the food insecurity status of the household with an RRR of 0.99. This implies that when a household experiences a shock from the illness of a household member, all things being equal, there is 0.99 times more likelihood of being in the FS and MFI category than being severely food insecure as compared to the household who are less resilient and are healthy. This means that, a resilient household that experience illness of a household has a more probability of skipping a meal and compromise the quality and quantity of food consumed. The opposite sign of the interaction shows that RCI influences the shocks. This still agrees with the result of FCS above.

Interaction between Death of a Household Member and resilience

Just as in the above, the interactive effect between the shock resulting from the death of a household member and the resilience capacity index was negative and also statistically insignificant. The signs of the interaction which is opposite to that of the shock (death of a household member) on food security status show that the resilience capacity of a household dampens the effect of shock on household food security. The result has a RRR of 0.99, which implies that ceteris paribus, a household that experiences the death of a household but is resilient has less likelihood of being poor food secure or fall in the borderline than the household which neither experiences death of a household member nor resilient. This may be because when a household experiences shock resulting from the death of a household member, he suffers food insecurity but when it happens to a resilient household, due to their AC of the household, their access to SSN, AST owned and access to ABS which formed the RCI could dampen the effect of this shock.

In model two table 18 above, the interaction was positive which was opposite to the sign of the shock alone. It was statistically significant at 5% in both panels with an RRR of 0.99. this implies that, when a household experiences shock and there is an increase in the resilient capacity of the household, all things being equal, the household is likely to be 0.99 times more in the FS and MFI category than SFI as compared to their counterpart who were less resilient and had no experience of the illness of household member. This is credible because, a resilient household with access to SSN, strong AC, AST and ABS is expected to be able to cushion the influence of any effect that shocks could impose on the household.

Interaction between Household Experience of Flooding, Drought, War, Conflict and Fire (Hefd) and RCI

The result of the interaction between the household experience of drought, erosion, conflict and famine (HEFD) was significant at 1% and negatively affect the food security status of the household with a RRR of 0.97. This shows that holding every other thing constant, a household who experience a covariate shock such as HEFD and is also resilient at the same time is 0.97 less likely to be poor food secure or be at the borderline than being food secured when compared to the households who do not experience shocks from erosion, conflict, famine etc and less resilient. This was expected because a household that experience shocks but have AST and access to SSN which could dampen the effect of the shocks by helping them to cope and recover to the original state of food security after the disturbance.

Besides, in the second panel, the interaction was statistically significant at 5% and positively related to the food insecurity status with an RRR of 0.99. This details that, when a household experiences HEFD and is resilient at the same time, there is 0.99 times the likelihood of the household to be FS and MFI than being SFI as compared to the household which has not experience such, all things being equal. This implies that the less resilient household and those who had not experience HEFD might be severely food insecure. This is conceivable because, when a household is resilient, it is able to cope, adapt and recover from any shocks and still maintain its status quo. Generally, these findings imply that resilience has a strong influence in dowsing the impact of shocks on food security. This validates the definition of the resilience of FSIN, (2014), that resilience is the ability which makes stressors or shocks have little or no impact on the household or make shocks not to have a lasting impact on the

system. It also buttresses the findings of Smith & Frankenberger, (2018) and d'Errico et al. (2018)s that resilience has a levelling impact on shocks.

Age of the Household Head

Age of household head which is measured in years was not significant and have a negative relationship with the household food security using the frequency of food consumption. This implies that, as the age of the household increases, all things being equal, there are 0.99 times less likely to be food poor food secure and be in the borderline than to be in the acceptable food security category as compared to the households with younger households.

Moreover, in the second panel, the age of the household head was statistically significant at 5% with RRR 0.99. This shows that with a one-year increase in the age of the household head, there is 0.99 times less, likelihood that the household will be in the borderline food category than being in the acceptable category. This simply implies that a household whose household head has advanced in age has the likelihood of being food secure.

The age of the household head was not significant in the two panels of the second model and was positive. If it had been significant, a year increase in the age of the household head would have resulted in 1.00 times more like to be mild and moderately food insecure than being severely food insecure with all things being equal. This pictures that, a younger household, has the chances of being severely food secure as compared to the household who are older.

This is because, at that age, they might have been able to build up an experience, networks, asset and adaptive capacity to spread their consumption throughout the

year as compared to the household whose household head is young. This is in line with the findings of Oluyole et al. (2009); Abu, (2016), who found an increase in age to have a negative influence on the household food security status. The reason is that a household with a younger age has a lesser responsibility and a smaller household size which has a positive influence on the household food security.

Sex of the Household Head

The sex of the household head is a dummy variable that was coded 1 if Male and 0, otherwise. The sex as can be seen on the table above represent a male-headed household and it is significant at 1% and negatively related to the food security status. This implies that, when the sex of the household is male, keeping every other thing constant, there is 0.52 times less likelihood of being in the poor food consumption category in the first panel than being in the acceptable food security category than a female-headed household. Also, in the second panel, the sex of the household head was statistically significant at one 1% and negatively related to household food security with an RRR of 0.72. This implies that every other thing being equal when the sex of the household is a male, there are 0.72 times less likely going to be borderline food secure as compared to the households whose head of the household was female.

The sex of the household head in the second model was also not statistically significant in panel 1 but was statistically significant at 10% level in the second panel with RRR of 0.99 and 1.13 respectively. In the first panel, the sex of the household had a negative influence on the food security status of the household head while it exercises positive influence in the second panel. If the sex of the household head had

been significant in the first panel, the probability of the household head being male would have 0.99 times decrease the chances of the household being in the FS category than being in the SFI category. In panel 2, when the sex of the household head was male, there was a 1.13 times likelihood of being in the FS category than being in the SFI status. This could be explained by the discrimination that is obtainable in our society which makes the females to be more vulnerable and acquire fewer assets which could influence their food insecurity status.

Household Size

The household size is a count variable. It shows the number of individuals who may not necessarily be related in a household. In the above Table 18, household size is statistically significant at 1% and has a RRR of 0.84 with a negative influence on the household food security status. This suggests that a 1 person increases in the size of the household, all things being equal, will lead to 0.84 times less likely for the household to be poor food secure or borderline than being food secure. Meaning that a large household has a higher likelihood of being in the acceptable food consumption category than a household with fewer people. This could be explained by the reason that a larger household has more hands to work and fend for the family and not leaving the responsibility in the hand of a fewer or one person than a household that has a smaller number of persons in the household. That is, the household has a more diverse source of income as compared to a household with a smaller number of persons. This agrees with the findings of Smith & Frankenberger, (2018); Ngema et al. (2018) and Sekhampu, (2013), that a household with more number of persons has a higher chance of being poorer which could exert more pressure in terms of more mouth to be fed.

Model 2 from the above table shows that household size was statistically significant at 1%, positively relate to the food insecurity status with an RRR of 1.41 in the first panel. This signifies that, when a household size increases by a person, the household will be 1.41 times more likely to be in the FS category than being in the SFI category as compared to the household with a little number of persons. In the second panel of model 2, the household size followed the same pattern with panel 1, this implies that a person increase in the family size will increase the chances of the household being in the moderate food insecure category than being in the severe food insecure category relative to the households with fewer persons by 1.4265times. This means that fewer persons in the household could lead to starvation. The reason could be that, when the household size is large, there are more numbers of people who are probably of working age that is doing something to provide for the household food consumption. It could also be that, the larger the number of persons in the household, the more the number of active working age that could be useful in the farm. This agrees with the findings of Etwire et al. (2013) that an increase in the number of persons in the household could mean more labour for the agricultural activities which could improve household food security.

Marital Status of the Household Head

The marital status of the household is a dummy variable that represents whether a household is married (1) or otherwise (0). it is positively related to the household food consumption category and significantly at 1% at both panels. In the first panel, the result shows that increase in the number of households whose household heads were married will result in 1.57 times more likelihood of being in the poor food consumption category and a 1.47 times likelihood of being in the borderline food

category than being in the acceptable food consumption category. This could be elucidated by the fact that being married comes with more responsibility and increases the number of mouths to be fed which could reduce the proportion of income that is being dedicated to food. Thus, reducing food success, availability, stability and even utilisation.

Whether a household head was married or otherwise was statistically significant 1%, relate negatively to the household food insecurity and had an RRR of 0.70. this implies that when the number of households whose husbands were married increases by 1 person, the chances of being FS and MFI increase by 0.70 times than being in the SFI category as compared to the household who were not married, young and not of marriageable age. This could be due to the understanding that the household head is having of the responsibility in marriage which might have made him to be prepared and cater for family needs especially in terms of their food needs.

Education of the Household Head in Years

The education of the household head which is measured in years represent the number of years that the household head spent in school. It is positively related to the food security status and statistically significant at 1% in both panels. In the first panel, the RRR was 1.53 which implies that a year increase in the educational status of the household head will result in 1.53 times more likely to be in the poor food consumption category and 1.48 times more likely going to be in the borderline than being in the acceptable food category. This could be that, the more the number of years spent in school, the more the money that is being spent which increases the household expenses. Thus, reducing the amount that is being spent on food. Another

explanation could be that when a household member spent that long number of years in school, he finished without being able to secure a lucrative job that could fetch him money.

Moreover, in the second model, the number of years of education of the household head had a negative influence on their food insecurity and was statistically significant at 1% in both panels. Panel 1 had an RRR of 0.69 and 0.67 in the second panel. It implies that, in the first panel, the education of the household head increases by one year, the probability of the household being FS decreases by 0.69 times as compared to being in the SFI category. In panel 2, an increase in the year of education of the household head decreases the chances of being MFI by 0.67 times than being severely food insecure as compared to the household whose head spent a smaller number of years in school. This could be explained thus, the number of years spent in school results in securing a better job which gives more earnings and increases the amount is being allocated to food purchase or production.

Location

The location of the household is representing whether the household is located in the urban or in the rural area. Urban is coded 1 and 0 when rural. Thus, whether a household is located in the urban was statistically significant at 1% and positively related to the food consumption category in both panels with varying degrees of influence across the panels. In the first panel, when a household is located in an urban area has an RRR of 2.86. This implies that being located in the urban area with all things being equal, will increase the chances of the household falling in the poor food consumption category by 2.86 times than being in the acceptable category as

compared to the household which is located in the rural area. Also, in the second panel, it shows that when the household is located in the urban area, it has about 3.25 times more likely to be in the borderline food consumption category than being in the acceptable food category when compared to the household who is from the rural area. reasons being that, when a household is located in the city, it has access to less food and spend more on the non-food items such as transportation etc than it is being spent on food. Also, most agricultural activities are carried out in the areas which explains why the household that is located in this area should be more food secure.

The location of the household that is whether from the urban or rural was statistically significant at 1% with a negative influence on the food insecurity status of the household. it has the RRR of 0.44 and 0.49 in the panel 1 and 1 respectively. In panel 1, whether a household is from the urban area will result in about 0.44 times fewer chances of being mild food insecure than being in a severe category as compared to the household from the rural area. Also, in the second panel, there are 0.69 times fewer chances of being moderately food insecure than being in the severe food insecurity category as compared to the household in the rural area. This implies that household in the urban area has little food insecurity experience problems as compared to those in the rural areas. This could be that being in the city gives the household access to a better job and better pay.

4.6 Effect of Shocks on Resilience Capacity Index (RCI)

The effect of shocks on household resilience was analysed using a logistic regression model. This was very relevant as the resilience capacity of the household was being

categorised into resilient (1) and less-resilient (0). This is, it is a dichotomous dependent variable. This was analysed against the shocks and some socio-economic variables. Although the R^2 was low, the LR chi2(9) = 358.20 with the p-value of 0.000, the data was well fitted for the model. Among the 9 variables considered, 8 variables were found to significantly influence the household resilience capacity except for the death of a household member and this was the only variable that did not meet our apriori expectation. For ease of interpretation, decision and policymaking, the marginal effects were obtained (Aidoo et al., 2013). The result is detailed in Table 19 below.

Illness of a Household Member

The illness of a household member was significant at 5% and the coefficients depict that a household whose household suffers illness have a negative influence on the resilience capacity of the household with an odds ratio of 0.8071. This implies that a household whose member suffers from illness are less likely to be resilient than those whose household never suffers from illness, ceteris paribus. This implies that the probability of being resilient decreases by 0.8071 times when a household member suffers from an illness. A household whose member suffer illness is 0.8071 times less likely to be resilient than a household whose household member has not been suffering from sickness. This is plausible because the illness of a member of the household is a shock that could result in the loss of assets in order to see that the person gets treated. This could have a significant influence on the resilience capacity of the household. This is consistent with the findings of Walsh, (2016) that, illness of a household member is a stressor which can overwhelm the household, thereby

resulting in the loss of livelihood and vulnerability to shocks that could reduce the household resilience capacity.

Death of Household Member

The findings in Table 19 below reported the death of the household member was not significant and has a positive relationship with the resilience capacity of the household. Perhaps, the opposite relationship of the variable was responsible for the insignificant nature of the death of the household. Although the death of a household member was insignificant, it would have increased the probability of a resilience capacity of the household by 1.2256 times.

Experience of Flooding, Drought, Fire etc

Whether a household experiences flooding, drought, conflict etc was significant at 5% in the table below has a negative influence on the resilience capacity of the household with an odds ratio of 0.8375. This implies that when a household experiences flooding, war, conflict, with everything being equal, it decreases the chances of the household becoming resilient by 0.84 times. That is a shock resulting from the experience of a flood, drought, war, a conflict that could result in an adverse effect on the household resilience. The possible explanation is that shock which could lead to migration, loss of livelihood and thus consequently reduce the resilience capacity of the household.

Table 19: Logit Regression Model of the Effect of Shocks on RCI

Variables	Coefficient	Odds Ratio	P>|z|
Illness_HH_MM	-0.2143	0.8071	0.018
	(2.42) **	(2.42)	
Death_of_HHMem	0.2034	1.2256	0.468
	(0.75)	(0.75)	
Exp_warfir_flodro	-0.1773	0.8375	0.030
	(2.07) **	(2.07)	
AGEY	-0.0141	0.9860	0.000
	(6.01) ***	(6.01)	
SEX	0.5811	1.7879	0.000
	(5.30) ***	(5.30)	
Hhsize	0.2651	1.3036	0.012
	(11.22) **	(11.22)	
MaritaStat	-0.2422***	0.7849	0.001
	(2.53)	(2.53)	
Rur_Urb	0.7741	2.1687	0.000
	(8.24) ***	(8.24)	
Pseudo R^2	= 0.0702		
Log likelihood function	= -2312.4502		
No of Observation	=13,946		

Z-values in parentheses *** p<0.01, **p<0.05, *p<0.1
Source: Author's computation 2021

Age of the Household Head

The age of the household head from Table 19 above, is significant at 1%. The age of the household head had a negative relationship with the resilience capacity of the household with the odds ratio. This depicts that, a year increase in the age of the household, reduces the probability of the household being resilient by 0.98 times. This implies that, as the age increases by one year, the chances of the household becoming resilient decreases. This could be explained by the fact when the age of a household head is younger, such could

Sex of the Household Head

The sex of the household head was significant at 1% and had a positive influence on the resilience capacity of the household. It also had an odds ratio of 1.79 which implies that when the sex of the household head is male, it increases the chances of the household being resilient by 1.79 times. This means that a male-headed household is more resilient than its female counterpart. This could result from the discrimination that is being placed on the women in our society which have precluded them from benefitting from certain privileges such as inheritance of land property, access to input etc which might have consequently reduce their resiliency level as compared to the household that is being headed by the male household.

Household Size

The number of individuals in the household had a positive relationship with the resilient capacity of the household. It is statistically significant at 5% and had an odds ratio of 1.3036. This implies that a unit increase in the household size by 1 person, could likely lead to 1.30 times increase in the probability of being resilient with all things being equal. This could be explained by the fact that, when the number of individuals in the household increases by one person, it could increase the number of labour available for use in agricultural production. Also, a person increase in the number of persons working age and gainfully employed could increase the resilient capacity of the household through more income.

Marital Status

The marital status of the household head was catechistically significant at 1% and had a negative relationship with the resilience capacity of the household. Whether a

household was married or not had an odds ratio of 0.7849. this predicts that, when the marital status of the household was married, it has the probability of decreasing the resilience capacity of the household by 0.78 times. This could mean that, when a household head is married, he is faced with the responsibility of providing for the needs of his household, extended family and even the in-laws. This could to a large extent

Location

The location of the household, that is, whether a household is from either rural or urban areas was significant at 1%, had a positive relationship with the household resilience capacity with an odds ratio of 2.1687. This signals that ceteris paribus, a household located in the urban centre has 2.17 times the chances of being resilient than the households' in the rural areas. This is plausible because being in the urban area could expose the household to lucrative jobs with higher earnings for the family. Also, this could expose him to cooperative societies or other organisations which could aid their access to farm inputs, televisions, refrigerators which could build their adaptive capacity, social safety net, asset and access to basic services. The findings are consistent with the findings of Tawodzera, (2012) that urban households in Zimbabwe are more resilient than the households in the rural area and the reason is attributed to the flow of resources from rural to urban area which is higher than its flow from urban to rural areas especially food. This is in contrast with the findings of Thiede, (2016), that households in the urban area are less resilient than the household in the rural area. Also, Boukary et al. (2016) also agree that in Niger, the low resilience capacity of the households in the urban area is a result of the high

population, inequality between the urban and the rural area, poverty level with low adaptive capacity resulting in food shortage.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

Introduction

This chapter presents the summary of the research, conclusion drawn based on the findings and the policy recommendation in relation to resilience and household food security in Ghana and for future study.

5.1 Summary

Food insecurity has been with us for a very long time and might continue to exist if no drastic measures are put in place to avert it. This study aimed at determining the resilience capacity of the households in Ghana, and the effect of resilience capacity of the household on food security. It also examined the effect of shocks on the household resilience capacity, and the interactive effect of shocks and resilience capacity on household food security. The study employed the GLSS 7 data collected from 14,009 households across the country. Different models were employed to achieve the objectives of the study, including endogenous switching regression with the ordered outcome, partial proportional odd models and logit regression models.

The result shows that the mean age of the household head in the sample was about 48 years with an average household size of 4 persons. The Average total expenditure on education was 1,245.58 Ghana GHC with a variation of about 3,303.90 Ghana GHC. The mean amount of food received by the household from family and friends was 25,029.33 Ghana GHC with a substantial deviation of 1,972,310 Ghana GHC. The bulk (87.35%) of the household head were male and this is not significantly

different from the resilient male-headed households while 12.65% of this was female. The bulk (88.73%) of the household were having access to improve water and 11.37% had no access to improve water.

The study also revealed that the majority of the households in Ghana are resilient to food security. Contributing to this household resilience to food insecurity were mainly household access to basic services and assets with little contributions from household remittance and adaptive capacity. The variables that constitute the household's access to basic services pillar were; access to improve floors, walls, roofs, electricity as the main source of cooking and lighting. Also, the proportion of land owned by the household, livestock possession and ownership of agricultural equipment all had a high correlation with household adaptive capacity. Furthermore, variables such as the sex of the household head, household size, expenditure on education and housing and the locality with which the household is located had a positive influence on the household resilience capacity. While the age of the household head, employment status access to credit, total expenditure on food and health influenced household food security had a negative influence on the household resilience capacity. It was also revealed based on RIMA II that households in the urban area are more resilient than their counterparts that reside in the rural area.

The indicators of food security used in this study are Food Consumption Score (FCS) and food insecurity experience scale (FIES). The result of the frequency of food consumption shows that a higher proportion of the households are poorly food secure and suffers more from moderate to severe food insecurity based on the experience scale. The study also found out that household within the rural area faces

the burden of food insecurity than people in the urban area. Also, the regions in Northern Ghana shows more vulnerability to food insecurity relative to the regions in the transition and the forest zones of Ghana. The factors which predispose a non-resilient household in Ghana to food security in Ghana among others are; sex of the household head, household engagement in farming which negatively influence the food security status of the household in Ghana but literacy, employment status in terms of their food insecurity experience. Also, the factors with positive influence are; literacy level of the household head, total expenditure on education, health and its location. However, the factor which negatively influences a resilient household food security based on their frequency of consumption are; sex, household engagement in farming and access to credit but from their experience on food insecurity are age, employment status, access to credit, expenditure on education, food and location. This is positively influenced by literacy, employment status, total expenditure on food, housing and the location and also influenced based on the food insecurity experience scale by household size and engagement in farming.

The marginal effect of resilience on household food security shows that, when a household is resilient, there is less likelihood of being a poor food consumed or be in the borderline food consumption but rather increases the chances of being in the acceptable food category. The household experience of food insecurity also indicated that when a household is resilient, the likelihood of being food secure is higher.

Shocks such as the illness of a household member, death of a household member and the household experience of shocks such as drought, conflict, war, flooding

amongst others were found to be hindrances to food security based on the two indicators. That is, shocks have a negative influence on the household food security status. However, the interactions between these shocks and the household resilience capacity show the opposite. This means that a household that is resilient but is faced with shocks are able to dampen the influence of these shocks. This establishes the earlier definition of resilience as the capacity of a household to withstand shocks. Also, shocks such as the illness of a household member and experience of drought, flooding, conflict, war exert a negative influence on household resilience capacity to food security.

5.2 Conclusion

Based on the findings of this study, it can be concluded that food insecurity in Ghana still constitutes a serious threat that must be tackled with all the seriousness it deserves especially in the rural area. The determinants of household food security were; sex of the household head, household engagement in farming, literacy level of the household head, total expenditure on education and health, location, access to credit, age of the household head, employment status, expenditure on education, food and location.

Also, the regions in the Northern Ghana, including Northern Region, Upper West and Upper East Regions were more vulnerable to the incidence of food insecurity than the households in the other regions of the country. Generally, households in Ghana were found to be resilient to food insecurity with the urban household being more resilient than those in the rural areas. The drivers of household resilience capacity were; access to improve floors, walls, roofs, electricity as the main source of cooking and lighting, land owned by the household, livestock possession and

ownership of agricultural equipment, sex of the household head, household size, expenditure on education and housing and the location.

The resilience capacity of the household positively influences household food security. However, this is negatively affected by shocks of all nature that both is covariates and idiosyncratic. But resilience is able to reduce the influence of these shocks.

5.3 Recommendations

Based on the findings of this research, the following recommendations are therefore proffered;

1. Government, private organisations and other NGO's together with the individuals in the society should focus on the pillars of resilience which influence the households' resilience capacity and specifically;

i. Provision of stable and constant electricity which could help light the house and power agricultural equipment used in processing, preservation and storage of food.

ii. Agricultural equipment such as fertilizer and chemical dispensers, combine harvesters, tractors, hay and forage equipment amongst others should be made available to all those who want to use it for farming at a little or affordable cost to increases food availability and accessibility, and

iii. Good land administration and management policies that will ensure land is available to all members of the household who wish to grow crops or other, farm-related activities to improve household food security should be pursued by the government.

2. Educating and encouraging households to keep one form of animal or the other to either be used as security in times of need should be pursued by the government and other agencies to increase the household resilience capacity and improve their food security status.

3. Encouraging partnership among the government, the NGO's and the private individuals at generating employment opportunities should be a topmost priority as this could lead to an improvement in the household food security status.

4. Policies such as the creation of public infrastructures that will deliberately redirect people in the urban to the rural areas should be implemented by the government of Ghana. Private individuals, NGO's and Government should collaborate in this regard.

5. Policies that ensure that at least a member of the household is enrolled in school to acquire literacy should be pursued by the government. This is because when a household member could read and write, it could earn more income into the household through a corporate job and thus increases food accessibility, availability and stability in the household leading to less worry over what to eat and even eliminate hunger.

6. Government together with the private individual and the NGOs should collaborate to provide a health facility such as good health care, medical equipment for the health care, mosquitoes nets for the households both in the rural area or urban areas to reduce incessant illness among the household member which could reduce the resilience capacity of the household to food security.

7. Peacebuilding campaigns in the conflict and war-affected areas should be intensified by the government on the need to see one another as one and every resource as nature's gift for our benefits. That is, what binds us is more than what is separating us.

8. Early warning on climate events such as drought, flood amongst others will not only improved the household food security but also build their resilience capacity to food insecurity in Ghana. This can be achieved through a cooperation between the Ghana metrological agency and the telecommunication companies either through constant messages to update the household on the predicted climate events or the use of speed dialling to include the literates and the illiterate ones

Suggestion for Future Study

The data used in this analysis could not capture the time dimension of food insecurity because of the cross-sectional nature of the data set. Thus, the results from this study should be interpreted within this cross-sectional context. Further research on this topic using panel data could unravel factors and help in validating the findings of this study. Such data should also include covariate and idiosyncratic shocks which are important in getting a deep understanding, and to authenticate the existing literature on climate change resilience and shocks at the individual, household and community level to proffer good policies and resilience planning.

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APPENDICES

Table A1: Distribution of the Household Source of Income Based on Location

Income Category	Location		Total
	Rural	Urban	
Wage	860	1,360	2,220
	(6.14)	(9.71)	(15.85)
Agric	3,345	2,427	5,772
	(23.88)	(17.32)	(41.20)
Non-Farm	2,535	1,541	4,076
	(18.10)	(11.00)	(29.10)
Rent	1,014	443	1,457
	(7.24)	(3.16)	(10.40)
Remit	171	71	242
	(1.22)	(0.51)	(1.73)
Others	66	176	242
	(0.11)	(0.03)	(0.14)
Total	**7,991**	**6,018**	**14,009**
	(57.04)	**(42.96)**	**(100.00)**

Table A2: Descriptive Statistics of the Ordinal Categorical Dependent Variable Across the Regions

	FCS			FIES		
Region	**PFC**	**BFC**	**AFC**	**F S**	**MFI**	**SFI**
Western	695	328	308	623	352	356
	4.96	2.34	2.20	4.45	2.51	2.54
Central	266	355	697	508	369	441
	1.90	2.53	4.98	3.63	2.63	3.15
Greater Accra	359	271	768	1,150	167	81
	2.56	1.93	5.48	8.21	1.19	0.58
Volta	501	480	386	765	375	227
	3.58	3.43	2.76	5.54	2.68	1.62
Eastern	469	407	519	803	409	183
	3.35	2.91	3.70	5.73	2.92	1.31
Ashanti	681	578	476	1,319	294	122
	4.86	4.13	3.40	9.42	2.10	0.87
Brong Ahafo	686	365	267	910	243	165
	4.90	2.61	1.91	6.50	1.73	1.18
Northern	355	325	229	335	333	741
	6.10	2.32	1.63	2.39	2.38	5.29
Upper East	876	329	166	335	344	692
	6.26	2.35	1.18	2.39	2.46	4.94
Upper West	134	154	79	410	341	616
	8.09	1.10	0.56	2.93	2.43	4.40
Total	**6,522**	**3,592**	**3,895**	**7,158**	**3,227**	**3,624**
	46.56	**25.64**	**27.80**	**51.10**	**23.04**	**25.87**

Table A3:The Distribution of Household Resilience Capacity Based on Region

Region	Non-Resilient	Resilient
Western	61	1,270
	(0.44)	(9.07)
Central	68	1,250
	(0.49)	(8.92)
Greater Accra	35	1,363
	(0.25)	(9.73)
Volta	41	1,326
	(0.29)	(9.47)
Eastern	68	1,327
	(0.49)	(9.47)
Ashanti	66	1,669
	(0.47)	(11.91)
Brong Ahafo	58	1,260
	(0.41)	(8.99)
Northern	76	1,333
	(0.54)	(9.52)
Upper East	77	1,294
	(0.55)	(9.24)
Upper West	55	1,312
	(0.39)	(9.37)
Total	**605**	**13,404**
	(4.32)	**(95.68)**

EFFECTS OF CLIMATE RESILIENCE ON HOUSEHOLDS' FOOD SECURITY IN GHANA

ORIGINALITY REPORT

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