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URBANIZATION AND AGRICULTURAL LAND LOSS: IMPACT ON PERI-URBAN HOUSEHOLD'S FOOD SECURITY AND WELFARE IN NORTHERN GHANA

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BY

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APRIL, 2026

DECLARATION

Student

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

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We hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

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ABSTRACT

Rapid urban expansion in Northern Ghana is increasingly converting peri-urban agricultural land into built-up infrastructure, raising concerns about the implications for farming households whose livelihoods and food security depend on access to farmland. In cities such as Tamale, Wa, and Bolgatanga, residential and commercial development has intensified pressure on croplands, potentially undermining staple crop production, food access, and household welfare. Despite these concerns, empirical evidence linking farmland loss to food security and welfare outcomes in Northern Ghana remains limited. This study investigates the extent of peri-urban farmland loss to urban built infrastructure and its impact on household staple crop production, food security, and welfare using a mixed-methods cross-sectional design. Data were collected from 389 peri-urban farming households through a multi-stage sampling procedure involving purposive selection of the three cities, purposive selection of two peri-urban communities from each city, proportionate sampling of households within communities, and simple random sampling of households. Households were categorized into those experiencing farmland loss and those retaining their farmland. The study combines GIS-based land-use analysis (1994–2024) to assess farmland transformation, Residualized Quantile Regression to estimate the distributional effects of farmland loss on maize yield, Extended Ordered Probit Regression to examine food security outcomes measured by Food Consumption Score (FCS) and Household Food Insecurity Access Scale (HFIAS), and Principal Component Analysis with multivariate regression to analyze household perceptions of urbanization's welfare effects. The results reveal substantial cropland decline alongside rapid urban expansion across the three cities. In Tamale, cropland declined by 50.8% between 1994 and 2004 while built-up areas expanded by 103.7%, with further cropland loss of 26.4% between 2004 and 2014. In Wa, cropland declined by 42.6% between 1994 and 2004, while

built-up areas expanded by 55.1%, followed by a 339.5% expansion between 2004 and 2014. In Bolgatanga, cropland declined by 16.3%, 26.9%, and 18.6% across successive decades as urban infrastructure expanded. Residualized Quantile Regression results indicate that farmland loss negatively affects maize yield across all quantiles, with stronger effects among median and high-yield farmers (50th and 75th quantiles). Food security analysis indicates significant vulnerability among households experiencing farmland loss. Only 16% of households fall within the acceptable food consumption category, while 9.2% and 25.3% fall within borderline and poor consumption categories respectively. Similarly, 67.6% of households are less likely to be food secure, with 32.7% and 34.9% falling within moderate and severe food insecurity categories based on the HFIAS. Perception analysis shows that while urbanization may improve access to services such as education, healthcare, and road infrastructure, households remain skeptical about its potential to generate formal employment and small-scale industrial development. The diagnostic statistics of the Kaiser-Meyer-Olkin (KMO) value of 0.841 indicated the suitability of the data for Principal Component Analysis (PCA). The PCA extracted three main components namely; economic opportunity and market integration, access to basic services and livelihood diversification and social capital, which jointly explained 63.9% of the total variance. Overall, the study provides new empirical evidence on how peri-urban farmland transformation affects agricultural productivity, food security, and household welfare in Northern Ghana, highlighting the trade-offs between urban expansion and rural livelihood sustainability. The findings underscore the need for land-use governance by the Land Use and Spatial Planning Authority (LUSPA), the Lands Commission, and Metropolitan and Municipal Assemblies to safeguard productive agricultural land through integrated spatial planning and enforcement of zoning regulations. In addition, the Ministry of Food and Agriculture (MoFA) should promote livelihood diversification and climate-resilient urban and peri-urban agriculture programmes to support households affected by farmland loss and strengthen food security in rapidly expanding cities.

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DEDICATION

I dedicate this thesis to my two adorable children, Emmanuel Naa and Emmanuella Ziema Nyuor.

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LIST OF ABBREVIATIONS

AFA	Anxiety About Food Adequacy
AGR	Annual Growth Rate
ALL	Agricultural Land Loss
ASABE	American Society of Agricultural and Biological Engineers
ATE	Average Treatment Effect
ATET	Average Treatment Effect on the Treated
CAADP	Comprehensive Africa Agriculture Development
CBD	Central Business District
CDF	Cumulative Distribution Function
COVID	Corona Virus Disease
CQR	Conditional Quantile Regression
CSI	Coping Strategy Index Development- Food and Agriculture Organization
DFID	Department for International Development
DPRK	Democratic People's Republic of Korea
DRC	Democratic Republic of Congo
EFM	Eating Fewer Meals in a Day
EIU	Economic Intelligence Unit
ELF	Eating Less-Preferred Foods
ELV	Eating Foods of Limited Variety
ENVI	Environment for Visualizing Images
ESA	Eastern and Southern Africa
ESM	Eating Smaller Meals than Needed
FAOSTAT	Food and Agriculture Organization Statistics
FASDEP II	Food and Agriculture Sector Development Policy II
FCS	Food Consumption Score
FFK	Failing to Obtaining Food of Any Kind
FIES	Food Insecurity Experience Scale
FS	Food Secure
FSS	Food Self Sufficiency

GDNEA	Going the Whole Day or Night Without Eating Anything
GDP	Gross Domestic Product
GESI	Gender Equality and Social Inclusion
GFSI	Global Food Security Index
GIS	Geographic Information System
GLSS	Ghana Living Standards Survey
GSS	Ghana Statistical Service
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HHS	Household Hunger Scale
ICRISAT	International Crops Research Institute for the Semi-Arid
IELPF	Inability to eat even less-preferred foods
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMPACTS	International Model for Policy Analysis of Agricultural Commodities and Trade
IV	Instrumental Variable
JSR	Japan Sea Rim
KMO	Kaiser-Meyer-Olkin (KMO) Test
LLH	Land Loss Households
LULC	Land Use and Land Cover
MAD	Minimum Absolute Deviations
MFI	Moderately Food Insecure
MoFA	Ministry of Food and Agriculture
MMDAs	Metropolitan, Municipal, and District Assemblies
NLLH	Non-Land Loss Household
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PFJ	Planting for Food and Jobs

POU	Prevalence of Undernourishment Programme
PSM	Propensity Score Matching
QR	Quantile Regression
QTEs	Quantile Treatment Effects
QUAC	Quick Atmospheric Correction
rCSI	Reduced Coping Strategy Index
ROI	Region of Interest
RQR	Residualized Quantile Regression
SADA	Savannah Accelerated Development Authority
SDGs	Sustainable Development Goals
SFI	Severely Food Insecure
SRID	Statistics, Research, and Information Directorate
SSA	Sub-Saharan Africa
SSF	Self-sufficiency in Food Production
TFA	Thick Frontier Approach
TIV	Triangular Instrumental Variable
TLU	Tropical Livestock Unit
UK	United Kingdom
UN	United Nations
UNFPA	United Nations Fund for Population Activities
UPA	Peri-Urban Agriculture
UQR	Unconditional Quantile Regression
USAID	United States Agency for International Development
USGS	United States Geological Survey
WFP	World Food Program
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background

Urbanization, fueled by human activity, is reshaping landscapes at an unprecedented pace, swallowing vast stretches of agricultural land and transforming rural ecosystems into bustling urban hubs (Berkum, 2023; Hailu *et al.*, 2024 and Yang *et al.*, 2024). Although urbanization has long been anticipated, its major consequence is that land does not expand in proportion to human population growth, posing a significant threat to peri-urban agriculture (Kuusaana & Eledi, 2015). Given that 9.7 billion people are expected to live on Earth by 2050, with about 70% of them living in cities, it is imperative to comprehend the connection between urbanization and the loss of agricultural land (Rikolto & RUAF, 2022).

The amount of agricultural land available for staple crops like wheat, rice, and maize has decreased due to the conversion of farmland into built environments brought about by urban expansion worldwide. According to recent studies, urban population growth is expected to reach 2.4% per year, which is almost twice the 1.2% global estimate (United Nations, 2023). The effects of this expansion are noticeable in many different nations. In the United States, urbanization has resulted in the loss of approximately 18 million acres of agricultural land, with further reductions anticipated by 2040 (Xie *et al*., 2023). Similar trends have been seen in China, where over 40 million peasants have been forced to leave their homes and agricultural land, and yet an estimated 3.9 to4.9 million hectares are likely to be lost by 2050 (Zhang *et al*., 2021; Tu *et al*., 2023). In Germany, Japan, and Vietnam, urban sprawl has also led to a significant loss of agricultural land. Between 2000 and 2020, Vietnam's urbanization caused about 235,000 hectares of agricultural land to change, which had a significant impact on the country's rural residents who depend on farming (Nguyen *et al*., 2020). The expansion of built-up areas has led to significant agricultural land loss in industrialized countries; Germany lost about 500,000 hectares of farmland between 2000 and 2020, while Japan lost over 1.2 million hectares between 1990 and 2020 (Kobayashi *et al*., 2022; Schmidt *et al*., 2021).

In developing countries, urbanization has caused irreparable transformations in land use, moving farmers off their land and adding pressure to food security (Liu *et al*., 2025; Nuissl & Siedentop, 2020). Urbanization has become much faster in Africa, where the urban population has reached over 700 million as of 2024 and is expected to triple in 2050, resulting in an increase in the total population of urban areas globally by 22% (United Nations, 2023). Sub-Saharan Africa has the fastest pace of urban growth in the world, with 42.39% of the population living in cities as of 2022, according to Toure *et al*. (2016). Studies point out that urban sprawl and swift urbanization are also contributing factors to massive land use alteration, which is replacing agricultural communities and increasing food security concerns (Nuissl & Siedentop, 2020). The residential and commercial development in peri-urban areas tends to interfere with the traditional agricultural activities, which causes land scarcity, fragmentation, and environmental degradation (Ode & Fry, 2016; Bonye *et al.*, 2020).

In most parts of Ghana, urbanization has resulted in a significant loss of agricultural land.
For example, Takoradi experienced an urban growth of 12.5% (312 ha) to 19.6% (490 ha) in built-up areas between 2007 and 2013, whereas Bolgatanga witnessed an increase of 30.4% (Kleemann *et al*., 2017). According to a survey conducted in the Wa metropolis by Bonye *et al.* (2020), 66% of the respondents reported loss of land, mainly through government acquisitions. In Tamale, a

survey involving 300 households, 76% of the respondents have lost 999.5 acres to urban development (Abubakari *et al*., 2022). The fact that prime farmlands have been transformed into housing and commercial purposes has changed the food production patterns, resulting in reduced dependency on local staples while increasing food imports to satisfy urban population needs (Abdulai, 2022; Bavorova *et al*., 2023).

The world cereal trade has increased two-fold in the first two decades of 2000-2019, with its volume of trade increasing to over 500 million tons in 2019, compared to 250 million tons in 2000. The OECD-FAO Agricultural out-look predicts that by 2028, the production of cereals will be 3,053 million tons, with the production of maize, wheat, and rice expected to increase significantly giving that the pace of urbanization is kept at an acceptable level (Zimmerer *et al*., 2021; Fei *et al*., 2025). Urbanization in West Africa has dramatically changed the food consumption patterns, as people prefer imported cereals like rice and wheat to maize, which is still a staple in the region (Dossa *et al*., 2011; Bonye *et al*., 2020).

In the fast-growing cities, food security has been a significant issue, as the traditional farming methods are failing to keep up with the processes of urbanization. Urban and peri-urban agriculture has become one of the solutions to food shortages, yet governance policies have not assessed its potential on a large scale (Sangwan & Tasciotti, 2023). Currently, 704 million people worldwide suffer from acute food insecurity; this number is particularly high in Southern Asia and Sub-Saharan Africa (FAO, 2023). A study in Ghana found that 66% of peri-urban households complain about decreased food availability because of loss of farmland, which make them increasingly dependent on food purchases (Abdulai, 2022). Similarly, food insecurity among West African peri-urban households exist for over 40% of households as a result of declining agricultural lands (Sangwan & Tasciotti, 2023).

The process of urbanization has also affected the dynamics of the welfare of households and has transformed the economic stability and access to resources. Although urban growth might result in the development of economic opportunities, it may also increase inequalities, as wealthy families with higher incomes are enjoying in urban areas while poorer households are unable to afford food or are being displaced (World Bank, 2023). According to a study in Ethiopia, urban development has a positive impact on the welfare of households, particularly in smaller cities, where diversification of the economy raises the standard of living (Abay *et al.*, 2023). On the contrary, Bonye *et al*. (2020) affirm such a situation in Ghana, where 66% of peri-urban households find urbanization threatening to their economic security, citing land tenure insecurity and lower agricultural productivity. Regardless of these difficulties, urban development has enhanced more people's accessibility to basic needs like education, healthcare, and infrastructure, and this has generated varied perceptions in the impacted communities (Bavorova *et al.*, 2023).

1.2 Problem Statement

Urbanization and agricultural land use change have emerged as key issues in global development (Bonye *et al.*, 2020), especially in areas undergoing rapid population growth and spatial expansion of urban areas. Africa, Asia and Central and South America now harbors the fastest urban growth areas in the world. The world has experienced a gradual slowdown in population growth since the mid-1980s, but Africa still continues grow at the fastest rates with projection that the continent could double its population and increase built-up area threefold (Kaba, 2020; Zimmer et al., 2020). These demographic trends have important implications for land use patterns, agricultural production systems and food security outcomes.

Over the past decades, the pace of urbanization has considerably accelerated in Ghana. Ghana's urban population has expanded more rapidly than its total population, with the share of people living in urban areas increasing consistently from 2021 to 2024 at an estimated annual rate of approximately 2.9–3.0% (World Bank/UN, 2025). In West Africa, approximately 42% of the population lived in urban area as at 2010 and this has been increasing rapidly (OECD, 2018). This fast urban population growth has directly stimulated the spatial expansion of cities and the transformation of surrounding farmlands into residential and commercial infrastructure.

The nature of urban growth is clearly evident in the northern part of Ghana where such cities like Tamale, Bolgatanga, and Wa have experienced high population growth and spatial development in the past decades. among these three cities Tamale emerged as fatest growing city in the West African sub-region, which has experienced a population growth of 233,252 to 749,488 in 2010 and 2021, respectively (GSS, 2014a; GSS, 2021). Similarly, Bolgatanga Municipality has witnessed substantial urban land expansion, with built-up areas increasing from 499.49 hectares in 1984 to 1525.14 hectares in 2016, representing an annual growth rate of 6.4% (Steinhübel & von Cramon-Taubadel, 2021). In Wa Metropolis, what once consisted largely of clusters of rural settlements two decades ago has rapidly transformed into an expanding urban center (Osumanu *et al.*, 2019).

Although the urbanization process can be associated with the provision some economic opportunities and increasing access to infrastructure, the process has immense effects on the peri-urban farming households whose livelihood relies heavily on the availability of agricultural land. The peri-urban areas usually experience rapid urban growth leading to conversion and fragmentation of farmlands which reduces the size of land used in agricultural production and disturbs the traditional land tenure system. These changes are of significant concern in the northern part of Ghana where agriculture is the main livelihood source for many households.

Peri-urban agriculture plays a crucial role in supporting livelihoods and urban food systems. Globally, approximately 51.1% of Africa's rural population is engaged in agriculture (FAOSTAT, 2020), while a growing share of urban and peri-urban populations in Sub-Saharan Africa participate in urban and peri-urban agriculture. Estimates suggest that more than 11 million households in Sub-Saharan Africa are engaged in urban and peri-urban farming activities (FAO, 2007). Scholars such as Drescher and Iaquinta (2002) describe the growth of urban and peri-urban agriculture as one of the most significant demographic and economic developments associated with rapid urbanization. Urban agriculture has been widely recognized as an important livelihood strategy and a life-support system for many urban and peri-urban residents (Brown & Carter, 2003).

Evidence from Ghana further underscores the importance of peri-urban agriculture for household livelihoods. Ayamga (2006) reported that peri-urban agriculture accounts for approximately 64% of urban and 70% of peri-urban household incomes in Tamale. At the global level, Thebo, Drechsel and Lambin (2014) estimated that about 68 million hectares of cropland, representing approximately 15.7% of global irrigated and rain-fed cropland, are located in urban and peri-urban areas. These farming systems play an important role in supplying fresh produce to urban markets, generating employment opportunities, and contributing to biodiversity conservation in rapidly expanding cities (De Bon *et al*., 2010; Orsini *et al*., 2020).

Despite these benefits, the capacity of peri-urban agriculture to sustain livelihoods is increasingly threatened by the rapid conversion of agricultural land to non-agricultural uses. Urban expansion often leads to declining land availability, insecure land tenure, and reduced access to water resources, all of which undermine agricultural productivity (Gyasi *et al*., 2014). Agricultural land conversion has also been identified as a major threat to food security and ecological sustainability (Govindaprasad & Manikandan, 2014). In Wa, for example, significant portions of peri-urban agricultural land have been converted into residential housing sites (Eledi & Kuusaana, 2014).

For farming households, land represents not only a productive asset but also a primary source of livelihood and wealth creation (Sitko & Jayne, 2014; Muyanga *et al*., 2013). Consequently, the loss or fragmentation of farmland may have profound implications for agricultural production, income generation, and household welfare. Lerise *et al.* (2004) note that when agricultural lands are converted to urban uses, farming households face declining production capacity, particularly for staple cereals such as maize, rice, millet and sorghum that form the backbone of household food stocks.

Agricultural productivity remains a critical driver of economic development and food security globally (World Bank, 2007). However, Africa continues to lag behind other regions in agricultural productivity growth due to structural constraints affecting smallholder farmers (Bravo-Ureta *et al*., 2017; Ogundari, 2014; Pardey *et al*., 2010). Crop yields across much of the continent remain below 25% of their potential levels due to limited access to improved inputs, technologies, and extension services. Climate variability, including frequent droughts and floods, further compounds these challenges, contributing to persistent food insecurity and malnutrition (FAO, 2022).

These challenges are particularly evident in Ghana, where the production of major cereals, especially maize, has experienced fluctuations and recent declines due to a combination of structural and environmental constraints (Eledi & Kuusaana, 2014). Domestic maize production currently stands at approximately 2.3 million tonnes, representing a 36% reduction from the previous year (Steinhübel & von Cramon-Taubadel, 2021). At the same time, national maize consumption for the 2024/2025 season is estimated at about 3.5 million tonnes, with approximately 2.8 million tonnes expected to be consumed by humans (USDA, 2024). This widening gap between production and demand highlights growing pressures on Ghana's food systems.

Urbanization further complicates efforts to close this production gap because much of the agricultural land being converted lies within peri-urban areas that historically served as important food production zones for nearby cities (Gyasi *et al*., 2014). The transformation of farmland into residential and commercial land uses often results in land scarcity and weakened land tenure arrangements, which negatively affect cereal production and long-term farming investments. In many cases, farming households displaced by urban expansion are forced to abandon agriculture and seek alternative livelihoods in the non-farm sector (Abubakari *et al*., 2022). However, limited access to capital and skills often constrains their ability to successfully transition into alternative economic activities or relocate farming operations to more distant rural areas.

These challenges are occurring within a broader context of increasing food insecurity in northern Ghana. The March 2025 Food and Nutrition Security Situation Report by the Ministry of Food and Agriculture (MoFA, 2025) highlights a growing trend of food insecurity in northern Ghana driven by climate variability, land degradation and declining agricultural productivity. Similarly, the Alliance for a Green Revolution in Africa (AGRA, 2025) identifies inadequate irrigation infrastructure, poor rural infrastructure and rising poverty levels as key drivers of food insecurity in the region.

Although several studies have examined the effects of urbanization on agricultural land use and rural livelihoods, the relationship between peri-urban farmland loss, agricultural productivity, food security and household welfare remains insufficiently understood. Existing studies generally fall into three main categories: those examining urban growth and food security among peri-urban households (Bonye *et al*., 2021; Appiah *et al*., 2019; Chagomoka *et al*., 2018); studies analyzing the livelihood impacts of urbanization (Bonye *et al*., 2020; Abdulai, 2020; Iddrisu *et al*., 2023); and research focusing on the effects of urban expansion on agricultural output (Naab *et al*., 2013; Abass *et al*., 2018; Abubakari *et al*., 2022; Gyasi *et al*., 2014; Toku, 2018; Mumuni *et al*., 2017).

However, despite these research efforts, limited empirical evidence exists on how peri-urban farmland loss specifically affects cereal productivity, food security and welfare outcomes among farming households in rapidly expanding cities of northern Ghana such as Tamale, Bolgatanga and Wa. In particular, little is known about how households directly affected by farmland loss differ in their food security outcomes from those that remain less affected by urban land conversion. This study addresses this gap by empirically examining the effects of peri-urban farmland loss on cereal productivity, household food security and welfare outcomes, and by comparing households experiencing farmland loss with those that are less affected by urban land conversion.

Beyond this geographical limitation, there is also a significant methodological gap in the literature. Many previous studies rely on descriptive approaches or conventional mean-based regression models, which may mask heterogeneous effects across different productivity and welfare levels.

Few studies have applied distribution-sensitive econometric techniques such as residualized quantile regression to examine how peri-urban farmland loss influences maize yield across different yield levels. Similarly, limited research has employed advanced categorical response models such as the extended ordered probit model to rigorously assess the multidimensional effects of farmland loss on household food security status.

Furthermore, although spatial studies have documented urban expansion patterns, there remains limited integration of GIS-based land use change analysis with household-level econometric models examining food security and welfare outcomes. Household perceptions of welfare effects are also often analyzed descriptively, with limited application of statistical dimension-reduction techniques such as Principal Component Analysis (PCA) to systematically examine the perceived effects of urbanization on welfare.

Therefore, this study addresses both the empirical and methodological gaps by integrating GIS techniques to quantify farmland loss, residualized quantile regression to examine heterogeneous effects on maize yield, extended ordered probit models to analyze household food security outcomes, and PCA to evaluate household perceptions of welfare in the context of urbanization.

In a quest to fill the above gap, the study sought to primarily answer the question of how household food security and welfare are impacted by the loss of peri-urban farmland as a result of urbanization.

Specifically, the study seeks to address the following research questions:

1. What is the extent of peri-urban farmland loss to urban built infrastructure over the last few decades in Tamale, Bolgatanga and Wa?
2. What is the effect of peri-urban farmland loss to urbanization on household staple crop production in the selected cities?
3. What is the impact of peri-urban farmland loss on household food security in the selected cities?
4. In what ways do households perceive the impact of urbanization on household welfare in the selected cities?

1.3 Research Objectives

The main objective of this study is to examine the effects of peri-urban farmland loss resulting from urbanization on cereal productivity, household food security, and welfare among farming households in selected cities in northern Ghana.

Specific Objectives

The specific objectives of the study are to:

1. Estimate the extent and spatial patterns of peri-urban farmland conversion to urban built infrastructure over the past few decades in Tamale, Wa, and Bolgatanga, in northern Ghana.
2. Quantify the effect of peri-urban farmland loss on household staple crop productivity, particularly maize yield, among farming households

3. Analyze the impact of peri-urban farmland loss on household food security status using established food security indicators in the selected cities.
4. Examine household perceptions of the welfare effects of urbanization and identify the key factors influencing these perceptions among peri-urban farming households in the selected cities.

1.4 Significance of the Study

The significance of this study lies in its contribution to empirical evidence, methodological advancement, and policy understanding of the effects of peri-urban farmland loss on agricultural productivity, household food security, and welfare in northern Ghana.

This study provides new empirical evidence on how peri-urban farmland loss resulting from urban expansion affects cereal production, household food security, and welfare outcomes among farming households in northern Ghana. By focusing on the rapidly urbanizing cities of Tamale, Bolgatanga, and Wa, the study generates location-specific insights into how cropland conversion and land fragmentation influence maize productivity, household food security conditions, and perceived welfare outcomes. In addition, by comparing households directly affected by farmland loss with those less affected, the study offers a clearer understanding of the distributional impacts of urban expansion on peri-urban farming communities. This evidence helps fill an important gap in the literature where limited household-level analysis exists for peri-urban areas in northern Ghana.

The study also contributes methodologically by integrating spatial land use analysis with household-level econometric modelling to examine the socio-economic implications of urban expansion. Specifically, it combines GIS-based analysis to quantify long-term farmland conversion with advanced econometric approaches to analyze household outcomes. The application of distribution-sensitive techniques to examine the effects of farmland loss on maize yield allows the study to capture heterogeneous impacts across different productivity levels. Similarly, the use of categorical response models to analyze food security outcomes and principal component analysis to evaluate welfare perceptions provides a more comprehensive analytical framework than conventional descriptive or mean-based regression approaches. This integrated methodological approach contributes to the growing body of research seeking to link physical land use changes with socio-economic outcomes in peri-urban environments.

From a policy and practical perspective, the findings of this study provide useful insights for institutions involved in urban planning, agricultural development, and food security interventions. For metropolitan and municipal planning authorities, particularly in Tamale, Bolgatanga, and Wa, the study provides evidence on the long-term extent and implications of farmland conversion, which can inform more balanced land use planning and urban growth management strategies. For agricultural agencies such as the Ministry of Food and Agriculture (MoFA), the findings highlight the implications of farmland loss for cereal production and household food security, thereby supporting the design of targeted programs aimed at protecting agricultural livelihoods and strengthening food systems in peri-urban areas.

Non-governmental organizations (NGOs) and development partners working on food security and rural livelihoods can also benefit from the study by using the evidence to design targeted interventions that enhance livelihood resilience among vulnerable peri-urban farming households. In addition, peri-urban communities themselves may benefit from the findings by gaining a clearer understanding of the potential impacts of urban expansion on their farming systems, food security conditions, and household welfare, thereby enabling them to make more informed livelihood and land use decisions.

Finally, the study contributes to academic discourse by expanding the body of knowledge on the interactions between urbanization, agricultural land use change, food security, and household welfare in developing country contexts. By providing empirical evidence from northern Ghana and applying an integrated analytical framework, the study offers a useful reference for future research examining the socio-economic implications of land use change in peri-urban regions.

1.5 Organization of the Study

The main concerns of peri-urban land loss and its effects on peri-urban households in northern Ghana are covered in each of the five chapters that make up this thesis. The study's context is provided in Chapter 1. The literature on empirical studies on the effects of peri-urban land loss on the production of staple crops, are reviewed in Chapter 2. It also examines the concepts and measures of food security, and how households view urbanization and how it affects their general well-being. The study's theoretical and conceptual underpinnings, as well as its hypotheses, are further reviewed in this chapter. The research methodology employed, including the study design, data gathering techniques, and data analysis techniques, are described in Chapter 3. Chapter four (4) presents the results of the study which include assessing the effects of peri-urban land loss on the production of staple maize, changes in land use by comparing the amount of peri-urban farm land lost to urban built infrastructure, peri-urban land loss and its impact on household food security in northern Ghana and finally how households view urbanization and it perceived impact on the general well-being of peri-urban households. Finally, chapter five presents summaries of the main findings/conclusion, policy recommendations, contribution of the study to practice, policy and academia.

1.6 Delimitation/Scope of the Study

In this study, the geographical coverage was restricted to a few selected cities (Tamale, Wa and Bolgatanga) and two communities each that were selected out of these cities because of their intense urban growth and agricultural practices. The sample population was the farming household, and 400 respondents were sampled. The data were collected in the June to September, 2023/ 2024 cropping season, when the agricultural activities were at their peak and historical land use and agricultural data (1994- 2024) were analyzed using GIS and remote sensing approach. The research concentrated on key important variables such as loss of farmland, crop production, food security of households, welfare, and percetions of the consequences of urbanization. The research methodology involved GIS/remote sensing analysis, household surveys, interviews, and focus groups, and was limited to peri-urban smallholder farmers. Financial constraints, lack of access to some land data, and time constraints were other limitations that also had an effect on the scope and depth of the study. These delimitations define the self-constraints of the study, ensuring that findings are specifically contextualized to the selected peri-urban communities and their agricultural dynamics.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter Two reviews the relevant literature that underpins the study. Section One provides the historical background of land acquisition and agricultural land loss in Ghana, highlighting how land tenure systems, urban expansion, and policy developments have shaped patterns of farmland conversion. Section Two presents definitions of key concepts used in the study, including urbanization, peri-urban areas, farmland loss, food security, and household welfare.

Section Three reviews empirical studies on the relationship between urbanization, agricultural land loss, and food security. Section Four examines the extent of farmland loss to urban built infrastructure, focusing on how expanding settlements and infrastructure development contribute to the conversion of agricultural lands. Section Five discusses the trend of household staple crop production in Ghana, while Section Six reviews literature on the effects of peri-urban farmland loss on household staple crop production.

Section Seven introduces the concept of food security and its various dimensions, while Section Eight examines the food security situation in Ghana. Section Nine reviews different approaches used in measuring food security, including commonly used indicators and indices. Section Ten explores the effects of urbanization on food security at the household level.

Section Eleven reviews literature on the relationship between urbanization, agricultural land loss, and household welfare. Section Twelve presents the theoretical frameworks underpinning the study, including relevant theories explaining land use change, household welfare, and access to food resources. Section Thirteen presents the conceptual framework that illustrates the relationships among urbanization, farmland loss, household food security, and household welfare. Finally, Section Fourteen provides a summary of the chapter by synthesizing the key issues discussed in the literature.

2.2 Historical Background of Land Acquisition and Agricultural Land Loss in Ghana

Agricultural land loss resulting from land acquisition has long determined the Ghanaian landscape, shaped by legal reforms, economic policies, and urban growth. In the past, customary systems governed the right to access farmland, and the land acquisition process was typically informal (Bugri & Yeboah, 2017; CARITAS GHANA, 2016). However, colonial policies following independence led to the formalization of land acquisition, which in turn led to significant investments in mining, infrastructure development, and agriculture.

These changes transformed tenure systems, which in many cases displaced smallholder farmers, changing the traditional land use patterns (Senu, 2014; Wemegah *et al*., 2014).

The Poll Tax Ordinance of 1852 was one of the most important colonial policies that forced peasant farmers to find wage employment or switch to export crop production to earn money to pay taxes (Boakye, 2016). On the same note, the 1894 and 1897 Crown Lands Bills saw the use of lands considered as "waste lands" or "public lands" used for gold mining operations, which further restricted access to farmland (Nti, 2013).

Large-scale mechanized agriculture was promoted by government-backed initiatives throughout the post-independence era (1957–1966), at the expense of conventional smallholder farming. Mechanized farming, which increased commercialization of land, was encouraged by institutions such as the United Ghana Farmers Council, State Farms Corporation and Ghana State Fishing Corporation (Aryeetey *et al*., 2004).

These trends have been extended in recent legislation, which has had an impact on land commodification and urban sprawl. Ghana Free Zone Act (1995), Administration of Lands Act (1962), and the Minerals and Mining Act (2006) have streamlined individual and corporate acquisition of land for various uses such as biofuel production, industrial development, and speculative investments (Narh *et al*., 2016; The Lands Commission Act, 2008; World Bank, 2013). These policies have increased the rate of agricultural land being turned into urban infrastructure, raising serious concerns about food systems and rural wellbeing.

The processes of urbanization in Ghana, where fast population expansion has fueled residential and commercial development, have contributed to the loss of agricultural land in peri-urban towns. Researchers cite towns such as Tamale, Wa, and Bolgatanga, where extensive conversions of agricultural land have restricted access to productive grounds for several farming households (Abubakari *et al*., 2022; Bonye *et al*., 2020). This trend has enormous ramifications for rural welfare, staple crop production, and household food security, necessitating policy interventions that balance urbanization and sustainable agricultural production.

2.2.1 Land Ownership and Acquisition in Ghana

Customary land tenure still holds sway in Ghana, despite a number of legislative changes aimed at curbing the massive acquisition of land and paving the way for individual land ownership. About 78 percent of all land is under the control of the traditional authorities, which are made up of kings, chiefs, and elders; only 2 percent is privately owned. Public lands make up the remaining 20%. These are owned by the President on behalf of the people and are administered by the Ministry of Lands and Natural Resources through some agencies, such as the Ghana Geological Survey

Authority, the Forestry Commission, the Lands Commission, and the Minerals Commission (Kasanga & Kotey, 2001; ISSER, 2013).

Given the complexity of Ghana's diverse land tenure structure, there is widespread agreement that land administration reforms are necessary. The World Bank has acknowledged the implications of such a system on investment and economic growth and has assisted the Government of Ghana (GOG) in undertaking two stages of the Land Administration Project that would streamline land administration (World Bank, 2013).

However, the process of identifying, acquiring, registering, and enforcing land rights is still fraught with difficulties. The lack of standardization in land acquisition practices has made it possible for foreign agribusinesses and domestic investors to buy and enclose large tracts of land at the expense of the local populace. The consequences of such acquisitions on food cultivation and availability are immense because agricultural land is being subsumed into non-agricultural enterprises, posing a challenge to the livelihoods of smallholder households and peri-urban communities.

2.2.2 Customary Land Tenure and Agricultural Land Loss in Ghana

Large-scale land development for farming is not new in Ghana, but it became more prevalent following the 2008 financial crisis and rising food and crude oil prices worldwide. By 2009, the total amount of land deals that had been approved had reached 452,000 hectares due to the increased demand for land for commercial plantation development (Cotula *et al.*, 2009). A new era of commercial land transactions between investors, both domestic and foreign, and traditional authorities overseeing customary lands was brought about by this increase. These acquisitions have been made possible in large part by the traditional land tenure system.

In Ghana, land is traditionally owned by family heads among the Ewes and Dangbe tribes, Earth Priests ("tendamba") in the Upper East and West, and chiefs (skin or stool) among the Dagombas, Mamprusi, Gonjas, Nanumbas, and Akan groups. Although these custodians have the power to distribute land, chiefs frequently go beyond their traditional responsibilities by participating in commercial land transactions as landowners, negotiators, and recipients of compensation (Fonjong, 2017; Senu, 2014). Chiefs frequently avoid community consultations, which contributes to the sharp rise in large-scale land acquisitions, according to a study by Ahmed, Kuusaana, and Gasparatos (2018).

Under the customary system, land transactions are frequently informal; acquisitions are made orally rather than formally registering with the Lands Commission. Use rights, which are not always legally protected, are usually the foundation of land rights in rural areas (Kasanga, Cochrane, King, & Roth, 1996; Civic Response, 2017). Since chiefs usually ignore the environmental impact, the absence of standardized procedures reduces the cost and bureaucracy of land acquisition for investors. Since chiefs usually ignore environmental impact assessments before closing deals, the absence of standardized procedures reduce the cost and bureaucracy of land acquisition for investors (Fonjong, 2017). These unofficial procedures are exploited by both traditional authorities and investors, resulting in commercial land transactions that frequently force local farming communities to relocate (Nyari, 2008).

Boamah (2014) demonstrates how chiefs in Northern Ghana formalized land transactions through informal means, making problems like inadequate documentation, repeated land sales, and ownership disputes worse (Alhassan, 2006; Fiadzigbey, 2006; Senu, 2014). About 70% of land in Africa is under customary tenure, which attracts a lot of investors (Civic Response, 2017). Particularly in Ghana, 78% of the country's land area is managed traditionally, which has attracted a lot of interest from both domestic and foreign investors (Kasanga & Kotey, 2001; ISSER, 2013;

Cotula *et al*., 2014). According to Cotula *et al*. (2014), one of the main factors affecting commercial land transactions in the Northern and Brong Ahafo regions was land availability. A report on large unused land areas in Northern Ghana prompted Biofuel Africa Limited to purchase the land for commercial use (Boamah, 2010).

Land acquisition patterns are still shaped by the traditional land tenure system, which also affects food security, peri-urban household welfare, and agricultural land loss. Concerns regarding equitable land access and sustainable land management are raised by the conversion of farmland for residential and commercial development as urbanization picks up speed. Addressing these challenges requires policy interventions that balance urban expansion with agricultural land preservation, ensuring that land tenure systems support both economic development and food security.

2.3 Definitions of Concepts

Urbanization is the process of transforming rural areas into urban settlements due to increase in population, the development of infrastructure, and economic processes (UN-Habitat, 2020). Agricultural land is being converted into residential, commercial, and industrial lands in this process, limiting the land area available for food production (Angel *et al*., 2011).

Farmland loss can be described as the long-term or short-term loss of a viable agricultural land through urban development, industrialization, deforestation and environmental degradation. With the expansion of cities, agricultural land is usually developed into residential, business, and industrial areas thus reducing the available space designated for farming (Lambin & Meyfroidt, 2011). Among the most common causes of land loss is rapid urbanization that is encroaching on fertile land and interfering with local food system (d'Amour *et al*., 2017).

Farmland Loss in Ghana: In Ghana, infrastructure development, illegal mining (galamsey) and urban development play the leading roles in destroying farmlands (Acheampong & Abdulai, 2018). There has been an escalating land conversion in cities such as Accra, Kumasi as well as Tamale, Bolgatanga and Wa, at the expense of farming communities, leading to a decline in food production (Owusu, 2013; Yeboah & Shaw, 2013). Moreover, unsustainable agricultural activities and deforestation, have worsen long-term land scarcity (Kasanga & Kotey, 2001).

Affected and Non-Affected Land Loss Households.

For the purpose of this study, **affected households** refers to those households that have lost farmland usually through urban sprawl, industrialization, environmental degradation or through state-driven land conversion. This is because their means of livelihood is broken, which can lead to economic instability, reduced farm earnings, loss of employment, and extreme food insecurity (Satterthwaite *et al.*, 2010).

Non-affected households are those that do not sell their farmlands and are able to carry out their farming activities without any major disruption of the land. Such households have an ongoing food production and financial stability, which is a positive result in ongoing agricultural production and preserved land resources (Xu *et al.,* 2021). They are also not threatened with instant livelihood losses as a result of land loss as do affected households and tend to be more economically resilient.

2.3.1 The Concepts of Urban and Urbanization

The term *urban* comes from the Latin word *urbanus* referring to the characteristic of, or about, the city (Macionis & Parrillo, 2007). In the interpretation of the term urban, the issue of measurement with regard to the extent of urban growth comes to mind as there is no standard definition globally, in a country setting and often based on the nature of the local considerations and how the transformational changes might have taken place over time. Most nations refer to people as urban residents based on data and administrative concerns because there is no universal agreement on what constitutes an urban inhabitant (Addo-Fordwuor, 2014). Thomas (2008) defines urbanization as the rise in the percentage of a nation's population living in urban areas and utilizing the urban and peri-urban environments.

Muggah (2012) noted that most countries utilize a core set of characteristics, such as a demographic threshold and an index of urban functions that excludes agricultural land and rural development, despite differing opinions on what defines an urban area from country to country and city to city. For instance, the United States of America and Kenya defined an urban area as having a population of 2500 or more (Tamakloe, 1997). Countries might be classified as either primarily urban or rural depending on these criteria (Muggah, 2012). Ghana's population was just over 50% urban in 2010 (GSS, 2012). For Ghana, the threshold for defining an area as urban is 5000 residents regardless of the nature of infrastructure, economic activity, or administrative status (GSS, 2021). According to Addo-Fordwuor (2014), an urban area often consists of features of human habitation with high population density, social and economic organization, and the built environment. It's observed that the world is rapidly becoming more urbanized which is seen as an opportunity for livelihood creation (Safavi, 2012), though this observation is becoming problematic over the last two decades due to the significantly rapid global proportion of urban growth(United Nations, 2014). Adjei (2014) rightly noted that even though urbanization comes with enormous benefits, it has also been identified as the main factor strongly linked with the destruction of urban green spaces and impacting greatly on peri-urban crop production. Urbanization, often used interchangeably with urban expansion, occurs in two main directions: horizontally and vertically. Horizontal expansion refers to the outward spread of urban physical structures into surrounding rural or undeveloped areas, typically resulting in the transformation of farmland, forests, and natural landscapes into built environments. Vertical expansion, on the other hand, involves the upward growth of urban infrastructure such as multi-storey buildings and high-rise complexes within existing urban boundaries to accommodate increasing population density. Both forms of expansion, driven by population growth, contribute to the loss of suitable farmland, natural beauty, rangelands, forests, parks, and scenic environments.

Demographically, Satterthwaite *et al*. (2010) define urbanization where the share of a greater proportion of a country's or region's population residing in urban centres with a resultant declining trajectory of its rural areas. The primary causes of urbanization in literature have been identified as rural-to-urban migration, natural increase (thus through births minus deaths, net rural to urban migration), and reclassification (where areas formerly known as rural settlements now become urban or where settlement boundaries expand coupled with population increases). According to Potts (2009), nations with slow economic growth are linked to extremely high rates of population growth, which are primarily found in developing nations with varied degrees of urbanization, such as China, North America, and Europe today.

Rapid urban expansion or urbanization in a manner referred to as disorganized, uncontrolled, and uncoordinated is seen as emerging menace on the livelihoods (including agricultural production) of peri-urban dwellers in Ghana in recent times. This phenomenon has compelled the government of Ghana in 2012 to formulate the urban policy to minimize the growing threat of urbanization and its impact on development (MLGRD, 2012). The process of urbanization in Ghana has a significant negative consequence on the food system due to the rapid conversion of large tracts of suitable lands for agricultural production into non-agricultural uses such as urban infrastructural development. In such circumstances the most affected areas are the urban periphery where land prices keep escalating (Gantsho, 2008). In acknowledgement of the fact that urbanization is necessary, Zana *et al*. (2013) opined that it should not occur to the point of denying the rural dwellers of their major source of livelihood, which is agriculture. Commercial development along major routes connecting cities and rural areas has increased due to urbanization surrounding peri-urban areas (Sullivan & Lovell, 2007). This is because population policies and programs have often skewed to urban centres creating gaps in livelihood opportunities and impacting negatively on food production of some urban farmers. Rapid urban growth, population pressure, infrastructure, shelter, industrial, and commercial demands of rapidly growing cities have stretched the land delivery system to the breaking point, (Lerise *et al*., 2004). Peprah (2014) confirmed that this has had a detrimental effect on development efforts in many Ghanaian cities, leading to massive sand winning activities and agricultural land conversion.

2.3.2 The Concept of Peri-Urban

According to Narain and Nischal (2007), the term *peri-urban* has been variously defined in the context of either as ‘a place, concept or processes. They defined peri-urban as *a place* to refer to the process of moving goods and services between physical spaces and the process of changing from rural to urban contexts *as process* and the interface between rural activities, institutions and perspectives as *a concept*. Similarly, Adam Gashu (2007) stated that, the term *urban* and *peri-urban* agriculture (UPA) could be used to denote a “place’ or “concept”. As a place, it can mean a rural agriculture area, located between urban built areas in cities and predominately rural agriculture areas, and as a “concept”, ‘peri-urban could be seen as an interface between rural and urban agriculture activities”. This definition fit into the operational definition of this study as it satisfied the conceptual consideration of the study. The original idea of peri-urban is said to have come from Europe to describe rural-urban interface. According to Davis (2005), peri-urban zones were originally regarded as places of dependency and colonization; power stations and waste landfills, cultivating and empty lands or service areas for low-cost housing for workers as well as their dependents or for the purposes of public housing schemes in 'peripheral estates' but has often been disturbed by the process of urbanization. Ravetz *et al*. (2013) opined that peri-urban goes beyond the fringe in-between a city and a countryside to include transition zones, as well as serving as a multifunctional territory for the increasing urban population. These zones are transitional areas between urban and rural areas, which inhabit a diversity of populations, exhibiting different characteristics of land uses, the morphological conditions and densities of built-up areas. The multidimensional functional relations and changing social structure are what defined a peri-urban area (Allen, 2001; Tacoli, 2001). The cumulative effects of these complex functional relations of peri-urban areas is the drastic reduction of arable lands suitable for agriculture (Zeng *et al*., 2005; Pam, 2005) which also changes the natural resource base, transforming lands to new uses due to the expanding nature of cities.

In Ghana, the prevalence of peri-urbanization exists where people move from the inner cities or immigrant from outside the cities to areas outside the city for land for residential or commercial purposes (Appiah *et al*., 2014). Eventually, it becomes difficult to differentiate clearly the boundaries between urban and the countryside or fringes areas as time goes on (Jones & Visaria, 1997). It is therefore obvious that due to the inherent characteristics of peri-urban interface, as the cities expand the immediate surrounding (peri urban areas) also expand which in many cases (as in unplanned city setup) impact on peri-urban crop production (Pam, 2005; Ravetz *et al*., 2013).

Concept of peri-urban household; for the purpose of this study, peri-urban households denote those households where inhabitants originate from the study communities. The status of the inhabitants is by birth and early settlement of their grandparents who owned land and other natural resources in the study communities.

2.4 Review of Studies on Urbanization, Agricultural Land Loss and Food Security

2.4.1 Urbanization in Global and Sub-Saharan Africa Context

Urbanization can be viewed from different perspectives, one in which it occurs through rapid economic growth and relatively low rates of natural occurrences (as in China) in past decades and those other countries with little or no economic growth and high rates of natural increases (as in many SSA nations in the 1990s) influenced by differences in fertility and mortality rates (Potts 2009). In the past, a greater proportion of the human population lived in rural areas, where the world urban population was only 14% of the total population and Africa then was only 1.5% of the global population, particularly in the 1900s (Davis, 1955). From this time onwards, global human urban population began to rise gradually in which by the end of the 1950s, the world's urban inhabitants rose to around 30%, and continue to rise to 50% in the year 2012 (UN, 2012). In the not distance past, urban share of the global population was estimated at 54% (UN, 2015) and its projected to rise up to 6.3 billion or about 60% of the total world population by the year 2030 (Seto *et al*., 2011) and further estimated at 6.4 billion or about 70% by 2050 (UN, 2012). With the continue increase in urbanization, the major concern is that, this process is taking place in developing countries. In developed economies such as Europe, North America, China and others have over 50% of its population residing in urban areas, whereas in Africa, only 39% of its population live in urban areas. Although Africa is considered the least urbanized region, the rate of urbanization of SSA is rapid with growth of about 2.46%, which is ten times compared to the developed nations and is three times the rest of the developing world, which according to Barrios *et al*., (2006) has been a major concern. Around the mid-1990s, only 28 cities in Africa had its residents over one million and by the later part of 2005, the number of African cities had increased to 43 with over one million residents (UN-Habitat, 2008), which further rose to 55 cities by 2015(UN, 2016). Following the rapid rate of urbanization in SSA, the urban share of the total population is expected to reach a magical rate of 50% (UN, 2013). Some SSA countries such as Angola, Nigeria and Botswana have already grown past the 50% mark of urban population, with some few other countries like Gabon (84.7%), Djibouti (87.0%) and Réunion (93.1 %) with extremely high proportion of urban population growth. A growing concern is that urbanization will drive the majority of global urban population growth over the next 50 years, primarily in developing economies such as Sub-Saharan Africa and Asia (UN, 2012; WHO, 2010). Notably, more than 50% of the world's population increase between 2015 and 2050 is projected to occur in Africa (UN, 2015).

2.4.2 Extent of Urbanization in Sub-Saharan Africa

The rate and extent of urban land expansion in SSA have been significant in quantitative terms. According to estimates, the average rate of urban land expansion was between 3.7 and 4.32% (Seto *et al*., 2011), which is twice as high as the 1.6% population growth rate (Angel *et al.*, 2011a; Angel *et al*., 2011b; Tan *et al*., 2005). This phenomenal growth of spatial expansion occurs not only in megalopolis which directly linked urban region (Baigent, 2004) but also takes place in small cities and rural communities. The UN-Habitat (2008) has identified the aggregation of the quickly expanding small peripheral urban areas and urban corridors as the main cause of urban area expansion in the megalopolis. Globally, cities such as Kinshasa in DRC and Lagos in Nigeria are the current additional list of megalopolises, with more to be expected from SSA. The reason is that, urban growth is projected to grow continuously at an increasing rate, doubling in the next two decades. As a result the extent of spatial growth of urban land cover is predicted to increase from

38,316 km^2 in 2010 to 333,493 km^2 by 2050 (Angel *et al.*, 2011a). This means that about 295,177km^2 (more than seven times) of the land will be lost to urban development in the same period through conversion. That aside, SSA will continue to experience a significant yearly urban land expansion of more than 2.7% beyond 2050 (see Table 2.1).

Table 2. 1: Projected Decadal Percentage Change of LULC for the World Regions 2000-2050

	Urban land cover projections (% annual increase)				
	2000-2010	2010-2020	2020-2030	2030-2040	2040-2050
Eastern Asia	3.07	2.29	1.56	0.97	0.58
Southeast Asia	3.79	2.66	1.91	1.42	0.99
South &Central Asia	5.61	2.49	2.28	1.94	1.53
Western Asia	6.35	1.69	1.50	1.20	0.91
Northern Africa	3.04	2.73	2.28	1.86	1.45
Sub-Saharan Africa	**4.18**	**3.92**	**3.65**	**3.22**	**2.74**
Latin America &Caribbean	2.00	1.52	1.11	0.79	0.51
Europe &Japan	0.21	0.17	0.17	0.08	0.00
Developed Countries	0.79	0.64	0.57	0.42	0.30
World Total	2.19	1.55	1.34	1.11	0.88

Source: Adapted from Angel et al., 2011

2.4.3 Urbanization and its Consequences on Peri-Urban Agriculture

Urbanization has a profound and multifaceted impact on household food security. As urban areas proliferate, agricultural land is progressively repurposed for urban infrastructure, presenting obstacles to food production and accessibility. Comprehending the significance of urban and peri-urban agriculture (UPA) in the global food system is essential, especially in developing economies where it plays a vital role in food security.

Research shows that urban and peri-urban agriculture (UPA) is of more importance to food security in less developed countries than advanced economies, as it remains the main source of crop production in such countries (Fei *et al.*, 2025). More specifically, in Sub-Saharan Africa

(SSA), urban and peri-urban agriculture are common, and it is found that households participating in UPA are usually more food-secured than those in rural areas (Crush & Frayne, 2011).

Current studies show that UPA is a feasible way to overcome the concerns of urban food insecurity. However, a study in Ethiopia shows urbanization affects agriculture through eviction of peri-urban households from their farms (Tura, 2018; UN-Habitat, 2020). Besides that, urbanization is changing how people obtain and consume food by adjusting their demand, supply, and market access, thus presenting both challenges and opportunities for accessing affordable and nutritious diets (FAO, 2023).

The role of technology in UPA is being looked at more and more as necessary for solving the problem of food insecurity in big cities. Advances in space utilization, resource recycling, and land management have the potential to mitigate urbanization's adverse effects on agriculture (Fei *et al.*, 2025). It is estimated that about 40% of the population of Africa is involved in UPA serving as a stable source of nutrient-rich food that would otherwise be lacking (Corbould, 2013). In West Africa, it is estimated that more than 20 million people are engaged in UPA, which provides about 60 to 100% of fresh vegetables needs (Cohen and Garrett, 2010). It has also been reported that between 35-40 million people in East Southern Africa rely on UPA for part of its food requirement as of the year 2020 (Lee-Smith, 2010).

In Ghana for instance, a large proportion (about 60%) of the rural and peri-urban communities are engaged in agricultural production (IFAD 2012). Despite the significant role of peri-urban agriculture, the process of rapid urbanization has been a major impediment for peri-urban food producing households because of its negative consequences in agricultural land losses and its potential food insecurity implications.

Agricultural land loss is an essential factor with direct impact on food security (Barati *et al*., 2015; Gutzler *et al*., 2015; Kraemer *et al*., 2015). There is a global consensus that the major driver of agricultural land loss is urbanization caused by human activities over the past decades across the world (Pandey & Seto, 2015; Pribadi & Pauleit, 2015). A large proportion of agricultural land, which include cropland, forest, and grassland, have been transformed into artificial or impervious surfaces (Gutzler *et al*., 2015; Zhong *et al*., 2011; Ricards, Walker & Arima, 2014). The uncontrollable manner in which per-urban farmlands are given away to urbanization by land owners in desperation for urban development would have serious implications on peri-urban food production and sustainable food security of peri-urban poor households **(**Acheampong &Anokye, 2013; Bonye *et al*. 2020a).

The characteristics of the rural dwellers of a rising human population, deprived economic opportunities, unemployment, migration along the surroundings and expansion of city periphery and adjoining rural areas, diminishing agricultural land, and changes in land use have become a reality today (Mandere *et al*. 2010; Naab *et al*. 2013; Bonye *et al*. 2020b). Abass *et al* (2013) have observed that land scarcity within the urban land use setting would increase the index of livelihood vulnerability of peri-urban poor resource-endowed farmers, since land uses for the built infrastructure, and cultural purposes have become dominant over agricultural lands in the urban space (Naab *et al*. 2013). Meanwhile, there is a continuous increase in human population with a corresponding food demand taking place in the face of a continuous decline in cultivable farm lands (Zana *et al*. 2013; Kleemann *et al*., 2017). Most land owners along the urban and peri-urban areas are more concerned about the economic value of lands where they invest in landed property with potential future returns compared to agriculture (Mandere *et al*. 2010). Perhaps, they do not have adequate knowledge of their role as critical assets for city development in terms of food production (Apte 2008) and how detrimental that is, to food security (Kavita, 2015). Cohen and Reynolds (2014) have suggested that there should be increased investment efforts in terms of new regulations on agricultural land use practices that would promote efficient land management and use practices for agriculture. The connection between urban and peri-urban agricultural land loss and uncontrolled urbanization in Africa has been clearly established by Kuusaana and Eledi (2015) and Mandere *et al*. (2010). Urbanization has resulted in increased pressure on highly populated agricultural land in peri-urban communities, especially in developing nations which subsequently lead to increased demand for food, poverty and environmental degradation (Bonye *et al*. 2020a; Pribadi & Pauleit 2015). According to Kuusaana and Eledi (2015), there has been a growing interest in the past decade in food research because of the enormous challenges the world is facing with regards to meeting food demands of its increasing population. This interest comes at the back of numerous persistent food production constraints including urbanization with food production, distribution, storage, processing, consumption and management. Ensuring effective food systems is vital in facilitating food security, therefore uncontrolled urbanization and ineffective land use planning systems would have serious negative consequences for systems and food security.

In the context of Ghana, Urbanization and agricultural land loss is evident from the intense land use competition between lands originally used for agricultural activities and urban expansion leading to dislocation of smallholder farmers outside their present locations where they are presented with so many production challenges (Ayambile *et al*., 2019; Kuusaana & Eledi 2015; Abass *et al*. 2018). These production challenges of peri-urban farm households would limit their ability to meeting their own food needs, including the food needs of urban population.

2.5 The Extent of Farmland Loss to Urban Built Infrastructure

Globally, the amount of agricultural land lost to urbanization is concerning, and regional differences underscore particular difficulties in controlling urban growth (Seto *et al.*, 2012; Bren d'Amour *et al.*, 2017). Risks to food security and socioeconomic inequality will increase as farmland continues to disappear, making it even more urgent to implement efficient spatial planning and legislative measures to protect agricultural resources (van Vliet, 2019; Lambin & Meyfroidt, 2011). Urbanization, in effect, has changed the usage of land on a global scale and as a result, vast areas of agricultural lands are lost. The massive movement of people from rural to urban areas has led to not only rural depopulation (Li *et al*., 2016) but it has also prompted a wide extent of research in land use and land cover changes (Cegielska *et al*., 2018; Padonou *et al*., 2017; Ramachandran *et al.*, 2018; Yu *et al*., 2011). Due to the fact that the main cause of uncontrolled urban infrastructure expansion often referred to as urban sprawl remains the leading contributor to the loss of peri-urban farmland (Abass *et al*., 2018; Liu *et al*., 2017b) and displacement of agricultural activities (Du *et al*., 2014; Zhao *et al*., 2014).

Worldwide, urban sprawl continues to alter landscapes for years. In the period between 1982 and 2003, the United States lost 76 million acres of cropland, rangeland, and pastureland, while urban land expanded by 36 million acres (Wu, 2008). Future projections indicate that 18 million acres of agricultural land may be lost by 2040 due to urban development pressures (Farmland Information Center, 2023). In China, urbanization accelerated between 1990 and 2020, leading to large-scale farmland conversion. Liu *et al*. (2023) found that 99.236 km² of cultivated land (5.6% of total agricultural land) was converted due to rural residential expansion. Similarly, Minghong et al. (2005) reported that 70% of new urban land in China during the 1990s was converted from arable land, with significant variations across regions. In their analysis of Beijing's urban growth, Hu *et* *al.* (2018) found that between 1980 and 2015, farmland losses ranged from 12.6 km² to 41.11 km² annually.

Beyond China, farmland loss is a growing issue in India. Amin and Fazal (2012) investigated how urban sprawl in Srinagarhad developed over the last 30 years (1980-2010). They discovered that the areas with buildings had grown from 24.16 km² to 62.51 km² leading to a combined area of 39.59 km² of lost farmland. The combined factors of population increase and migration from rural to urban areas have been the main driver of this process, resulting in high demand for residential as well as commercial spaces.

Urbanization in Sub-Saharan Africa is growing at a fast pace, contributing immensely to the changes in land use. Toure *et al*. (2016) have suggested that there is need for the use of remote sensing in monitoring changes in land cover change due to urban expansion in cities. In the case of Ghana, Yeboah *et al*. (2017) research has shown that built-up of Accra had increased from 65.1 km² in 1985 to 145.4 km² in 2010 mainly due to the growth of infrastructure and rising population. Among other causes, population growth remains the leading cause of land transformation. Braimoh and Vlek (2004) predicted average annual population growth in Accra at 3.4% and around 10% in the peri-urban districts. The study indicated a significant increase in land use: the area covered by forest has reduced from 9.2 km² in 1985 down to 6.1 km² in 2010, while cultivated and irrigated agricultural land has also decreased from 94.7 km² to 69.2 km², which is 16.3% decline in the total study area. Change-detection analysis also revealed that built-up areas have grown by 59.35%, whereas the areas of forest, agricultural land, and water bodies have reduced by 33.61%, 48.07%, and 3.22%, respectively.

2.6 Trend of Household Staple Crop Production in Ghana

Ghana's food security depends on the production of cereals, but low yields, a reliance on imports, and insufficient input use continue to be problems. One important industry that makes a substantial contribution to the national GDP is agriculture (World Bank, 2023). In northern Ghana, maize has supplanted millet and sorghum as the most widely grown and consumed staple (SRID-MoFA, 2023). Over the previous ten years, maize production has risen steadily, rising from 3.3 million metric tons in 2022 to 3.6 million metric tons in 2023. Despite being the most common cereal in Ghana, yield variations persist because of soil erosion, climate variability, and irregular input availability (Adu *et al*., 2023).

Urban consumers now prefer imported aromatic varieties of rice, which has become a dominant staple (MoFA, 2023). Ghana imported 516,104 metric tons of rice in 2023, mostly from Vietnam (436,715 metric tons). Research showed that 76% of the world's rice consumption still comes from imports, even though local production reached 1.28 million metric tons in 2022 (Rondon & Ashitey, 2023). Although yields have increased as a result of government initiatives to increase domestic production, processing and market competitiveness issues still exist.

Third among cereals, sorghum is mostly grown in northern Ghana (Offei *et al*., 2023). Although production increased slightly over the course of the decade to 401,500 metric tons in 2022, problems like striga infestation, poor soil fertility, and unpredictable rainfall still exist (Kudadjie *et al*., 2023).

Similarly, pearl millet, which makes up 29% of cereal farmland, grows well in regions that are prone to drought (FAO & ICRISAT, 2023). In 2025, 220,000 metric tons of millet were produced, a minor increase over prior years. Although millet is a vital crop in arid areas, it is mostly grown for domestic use with little market integration (Kasei *et al*., 2023).

Similar to other countries in Sub-Saharan Africa, Ghana's lack of cereal production has resulted in a significant reliance on imports (Ankrah *et al*., 2023). Ghana imported 2.13 million metric tons of cereals in 2023, representing a 13.03% annual growth rate (World Data Atlas, 2023). Overall yields are still less than 40% of what is possible, even with encouraging trends for rice and maize (SRID-MoFA, 2023).

Ghana's Fertilizer Subsidy Policy (FSP), which was implemented in 2008, is one initiative aimed at increasing cereal production. With an annual growth rate of 7.15%, the initiative raised fertilizer use to 132 kg/ha (Banful, 2023). Given that 90% of farmers own croplands with an average size of 2 hectares or less, agricultural modernization is still a top priority (SRID-MoFA, 2023). Improved input distribution, stress-resistant cultivars, increased irrigation, and focused policy changes to lessen reliance on imports and increase food security will all be necessary to close the yield gap.

2.7 Effect of Peri-Urban Farmland Loss on Household Staple Crop Production

The encroachment of peri-urban agricultural and forest lands is one of the major problems of rapid urbanization, as it compromises the resilience of social-ecological systems (Guzy *et al*., 2008). This phenomenon has been partly attributed to the sharp increase in the global urban population (Seto, Güneralp, & Hutyra, 2012). A key driver of this growth is the large-scale migration from rural areas to urban centers, accompanied by significant flows of goods and capital. This movement, often come about as a result of global economic fundamentals, which directly affects land use and land cover changes (Seto *et al*., 2011). It is therefore obvious that the constant rise in urban expansion as well as global economic growth is a main driver of urbanization of towns, which significantly increases built-up areas. Large hectares of farmlands at the periphery of urban centers is worsening land scarcity (Lambin & Meyfroidt, 2011). It is estimated that about 3.7% of global farmlands could be lost because of the processes of urbanization by year 2030 (Jiang & Cheng, 2020; D'Amour *et al*., 2017). Farmland loss is a serious trigger of food security challenges at the local, regional, and global landscape (Seto, Güneralp, & Hutyra, 2012).

Productive croplands allocated for staple crop production around peri-urban towns are increasingly being transformed into non-agricultural uses. Croplands surrounding urban areas have been rapidly disappearing over the past three decades, with an estimated 1.2 million hectares lost each year (van Vliet, 2019). This trajectory is expected to continue going forward, mainly due to rapid urbanization (United Nations, 2018). This process of urban expansion would encroach various land classes, resulting in biodiversity as well as water resources losses, supported by these ecosystems (Mulyani *et al*., 2016; Lark *et al*., 2020).

It has been observed that weak land administration processes of urbanization could be blamed for the continuous cropland losses (Jabeen *et al*., 2017). The high appetite for urban lands for purposes of residential as well as commercial development has increase the pressure on available agricultural land, reducing its use for food production. As a result, global share of farmers has decline while climate change and other environmental issues further strain land productivity (Hussain *et al*., 2018). As town continue to develop, urban sprawl rapidly facilitates agricultural land loss, resulting in serious threat to food security across the world (Kuddus *et al*., 2020). Approximately, nearly 60% of the world's irrigated cropland is found around urban areas, causing high competition among farmers and real estate developers (Thebo, Drechsel, & Lambin, 2014).

The impact of urban expansion on available cropland has significantly declined in the past 30 years, especially in countries such as China, the United States, Egypt, Turkey, and India (Ahmad *et al*., 2016; Bagan & Yamagata, 2014; Chen, 2007). Even though issues of food production as well as livelihoods have been on the rise, the future implications of urban expansion on croplands particularly in mega urban centers, remain insufficiently understood (Brook & Dávila, 2000).

Urban expansion is estimated to range 1.8–2.4% loss of croplands globally by 2030**,** where 80% of this loss would occur in Asia and Africa (D'Amour *et al*., 2017). Those affected croplands are mostly two times as productive as national averages, projecting the impact on food security even more severe. Furthermore, productive land encroachment is expected to continue considering the increasing competition for land for food production and infrastructure development (Jabeen *et al*., 2017). Empirical evidence of the effect of urban expansion is varied across the world.

Shen *et al*.'s (2023) extensive study in Japan looked at the connection between urbanization and grain production in the Japan Sea Rim (JSR) region, which includes the Chinese provinces of Heilongjiang, Jilin, and Liaoning, the Russian Far East, the Democratic People's Republic of Korea (DPRK), Korea, and Japan (Ding *et al*., 1990; Lo & Yeung, 1995; Wang *et al*., 2019). Urban growth between 1992 and 2050, its effects on cropland net primary productivity, and grain production trends were the main topics of their study. The results demonstrated that, at an annual growth rate of 2.46%, the amount of urban land in the Japan Sea Rim region doubled between 1992 and 2020, from 21,509 km^2 to 42,502 km^2. They saw an increase from 1.08% to 2.13% in the share of urban land to total land area. Japan had the largest urban land expansion of the five countries studied, growing from 16,378 km^2 to 25,384 km^2 at an annual growth rate (AGR) of 1.58%, or 42.90% of the total new urban land. Next came China, where urbanization increased at an annual growth rate (AGR) of 6.93% from 1,489 km² to 9,719 km², accounting for roughly 39.21% of the new urban land. With only 198 km² of new urban land, or 0.94% of the region's total increase, the DPRK saw the least amount of urban expansion. With an estimated AGR of 0.65%, urbanization in the JSR region is expected to continue, increasing from 42,501 km² in 2020 to 51,647 km² by 2050. It is anticipated that the share of urban land in relation to total land area will increase from 2.13% to 2.59%. According to projections, China's urban land will increase from 9,719 km² to 13,642 km², or 42.89% of all new urban land. In a similar vein, urban land in Japan is predicted to increase by 40.06%, from 25,384 km² to 29,048 km². Grain production would drop by 2.21 million tons between 1992 and 2020 as a result of the detrimental impact on cropland. According to additional projections, cropland conversion is expected to continue between 2020 and 2050, resulting in an additional 1.68 million tons of grain output loss. It is anticipated that China will suffer the largest grain loss, making up 62.93% of the JSR region's overall decline.

Abdulai (2022) studied how urbanization pressure affected the production of staple food crops among smallholder farmers in Wa metropolis, in the Upper West Region of Ghana. Based on the results of 408 surveyed farmers, the study concluded that urbanization has adverse impacts on the production of staple crops by lowering the availability of farmland, decreasing crop production, and abandoning of some crops. Two important observations were made; 98% of the respondents said the availability of land has decreased whereas 94.6% indicated that the natural reserves have also reduced. These results are consistent with the study by Ahmed *et al*. (2022), who have found that the built-up area of Wa has increased to 4509.94 ha in 2019, compared to 471.92 ha in 1986. Also, urbanization has compelled farmers to abandon the production of certain crops (Afriyie *et al*., 2020; Bonye *et al*., 2021). An analysis of 2011-2021 crop production has shown that the production of maize, millet, beans and rice decreased statistically with urban expansion, further heightening worries about the effects of urban expansion on food security.

José *et al*. (2021) compared the yield potential of newly cultivated and converted croplands in China, Indonesia, and Nigeria in order to investigate the effects of urbanization on the production of staple crops. According to their findings, one of the main causes of cropland change is population growth. Between 2000 and 2010, China's farmlands surrounding expanding cities that are used for major cereals drastically decreased. When more land is needed to replace lost rice production, the difference in cropping intensity between transformed and recently cultivated land is the cause of this decline. In Indonesia, too, rapid urbanization has resulted in the massive land transformation of highly fertile irrigated rice fields in West and Central Java, while rice farms have spread into unproductive areas with slower rates of population growth, such as South Sumatra and South Kalimantan. The study equally found that newly cultivated maize areas had drastically reduced and less stable yields compared to new converted farmlands. Aside yield losses, urban transformation into croplands has wider environmental implications, plus the conversion of rainforests and grasslands, with potential threats on biodiversity and ecosystem services. In addition, encroachment of irrigated croplands and cropland transformation into regions that rely on rainfed production where fluctuating rainfall patterns heighten food production vulnerabilities to changes in climatic conditions (Mereu *et al*., 2015; Rondhi *et al*., 2019). In the face of urbanization challenges research findings suggests that there is an increasing national demand for rice in China as well as Indonesia (Agus *et al*., 2019; Deng *et al*., 2019) and maize in Nigeria (van Ittersum *et al*., 2016). The study finally revealed that in countries with significant variations in crop yield potential between converted and newly farm land, strong policies are required to guard productive farmland for major crop production in peri-urban areas.

In a related study conducted in Malaysia, Zhuo and Salleh (2021) investigated the relationship between residential land use conflicts and the rapid urban expansion on the cultivation of food crops. At the global level, it was discovered that there was a negative correlation between urbanization and residential land disputes, indicating that urbanization lessens land conflicts. Additionally, they discovered a strong positive correlation between the production of food crops and urban growth, suggesting that in certain nations, higher food production is linked to greater urbanization.

Opoku (2019) in a case study on urbanization and land use in the Ga East Municipality, Accra, Ghana evaluated how urbanization affects the availability of farmlands for crops cultivation. The results showed that urbanization had deprived 58% of the farmers of their farmland mostly because of real estate development, whereas 36% had been deprived of their farmland by landowners. The research found a significant positive relationship between household income and farm size, which implies that loss of farmland has a direct impact on the production and income of farmers and that 69% of women farmers were severely impacted. The study concluded that the loss of arable land in the last 15 years has been intensified which has resulted in land shortage limiting crop production.

Tokula and Ejaro (2018) used farmer surveys and spatial data covering 29 years (1986–2016) to investigate agricultural land loss and its effects on crop yield in Ankpa, Kogi State, Nigeria. According to their research, there were notable changes in land use between 1995 and 2016, as evidenced by the 53.1% decrease in farmland size. While natural vegetation and agricultural lands decreased, built-up areas grew quickly. Over the course of 29 years, the study discovered a strong inverse relationship between crop production and farmland loss with the steep drop in yields occurring between 1995 and 2016. The decline in crop yields was as follows; maize (78.5%), cassava (57.2%), yam (27.4%), okra (28.6%), melon (38.9%), groundnut (51.1%), cowpea (32.8%), and bambara nut (64.4%). The trend analysis revealed that the loss of farmland was directly related to yield losses. Tokula and Ejaro (2018) explained this decrease in yield to rapid urbanization, which came as result of the creation of Local Government Headquarters (1979), Kogi State College of Education (1981), and residential and commercial infrastructure. Their results are in line with Oyinloye (2013) who found drivers of urban growth to include the establishment of states, local governments, universities, and commercial investments in Nigeria. Urban sprawl is a danger to food security because, as witnessed in Asaba, Nigeria, where agricultural land is encroached by urban growth (Enaruvbe & Atedhor, 2015). The loss of farmlands slows down the potential of food production, which increases the problems of food supplies (Murali *et al.*, 2017; Njungbwen & Njugbwen, 2011). It is expected that farmers must increase peri-urban cultivation in order to achieve future food demands (Smith, 2013).

Abassa *et al*. (2018) examined the loss of arable land through peri-urbanization in Kumasi Metropolis, Ghana, between 1986 and 2016 (30 years) to determine urban encroachment on non-urban land use. They found out that land use cover has increased by 54.6% and the area covered by farmlands has reduced by 31% over the study period. Satellite imagery analysis revealed that there was an inverse correlation between urban sprawl and the availability of arable land, providing a strong evident that urban sprawl has caused a large reduction in farmland. Their findings were consistent with those of the Ministry of Food and Agriculture (MoFA), which showed a decreasing pattern in staple food crops area such as maize, rice, cassava, yam, cocoyam, and plantain between 2001 and 2015, and a similar reduction in output.

China has had its own share of the impact of urbanization on peri-urban farmlands just as most other countries. For instance studies have investigated the effects of urban expansion on grain production and consumption, examining scenarios that project China's urbanization rate to reach 65.4% by 2025 (Lu Wen-cong *et al*., 2017). It is observed that urban growth would negatively affect self-sufficiency in major staple cereals. It is projected that urbanization would increase grain shortages by 6.4 million tons, reducing self-sufficiency levels by 1.2%**.** In the same study, in cases of under urbanization scenarios, China's cereals production as well as consumption are estimated to reduce by 1.6% and 0.4%**,** respectively, as against a baseline levels. This implies that production decline would outpace consumption, resulting in an increased grain shortage. The rapid growth of urban areas will likely put further pressure on grain security in China. Nevertheless, China is expected to maintain a 95.7% self-sufficiency rate in major grains, to support its food security initiatives by 2025.

D'Amour *et al*. (2016) in their study investigated the consequences of urbanization on lands allocated for crop production, where its overall impact on countrywide levels to identify potential conflicts and strategies for sustainable urban growth. Their study focused on cropland vulnerability, prime farmland loss, and the economic significance of agriculture across different regions. Analyzing 16 major nutritional crops, they narrowed their focus to four staple crops—maize, rice, soybean, and wheat and three cash crops—cacao, oil palm, and sugarcane under three urbanization scenarios: low, medium, and high. According to their findings, urbanization is most likely to take place in cultivated areas, with 43–55 million hectares of cropland or 3.2% (3.0–3.8%) of all cultivated land worldwide, expected to become urbanized by 2030. A total of about 30 million hectares (27–35 million hectares) of cropland will be lost, with losses of 5–10% in China, Vietnam, and Pakistan. Regional differences are substantial, even though the overall effects of urban growth are thought to be minor. Eighty percent of the world's cropland loss will occur in Africa and Asia, affecting 24 million hectares. Cropland loss in Asia will be concentrated in river valleys and coastal areas, such as the Yangtze River Delta, Bohai Economic Rim in China and Java in Indonesia, and Nigeria, Egypt, and the Lake Victoria Basin in Africa. One-fourth of the world's cropland loss will occur in China alone. Croplands lost to urbanization are 1.77 times more productive than the global average, and urbanization is predicted to reduce total crop production by 3.7% (3.4–4.2%). Africa and Asia will account for 84% of the world's production losses as a result of urbanization. A 3% loss of cropland will result in a 6% decrease in crop production in Asia and a 9% decrease in crop production in Africa, with Egypt and Nigeria bearing the brunt of the effects. The report also identifies specific crop losses: Africa is predicted to lose 11% of its soybean production, 14% of its maize, and 19% of its wheat, while Asia is predicted to lose 10% of its maize, 9% of its rice, 7% of its soybeans, and 13% of its wheat. Furthermore, 0.1 to 1.2 million hectares of prime farmlands in Mega Urban Regions (MURs) are at risk of conversion, making them extremely vulnerable. These results support earlier research (Ahmad *et al*., 2016; Bagan & Yamagata; 2014; Chen, 2007) and raise questions about how urbanization may affect agricultural sustainability and food security.

Iheke and Ihuoma (2015) provided an analysis of the effects of urbanization on agricultural production in Abia State, Nigeria, using 10 staple crops as the subject of investigation. They discovered that urbanization and crop productivity have a strong negative relationship, which means that the more urban expansion, the smaller the size of farmlands, and the less agricultural output. On the other hand, they found that there is a positive relation between farm size and farm productivity implying that the bigger the farm size the higher the output. The findings concluded that further urban sprawl would lead to loss of more farmlands and further decrease cultivated lands. Besides, land use intensification can occur, and in the absence of necessary technological support and effective use of inputs, agricultural productivity might dwindle. Their results highlight the importance of strategic land-use planning in order to reduce the negative impacts of urbanization on food production.

2.8 Concept of Food Security

The concept of food security is view as complex and evolving which continue to undergo significant transformation since its early definitions. The USAID (1992) report indicate that, food security is achieved when "all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life". With the evolution of time, the scientific community as well as policymakers have expanded its scope to include multiple dimensions such as availability, accessibility, utilization, and stability (Pieters *et al*., 2013).

Following the World Food Conference in 1974, at the initial stage of food security dialogue placed premium on global food supply and price stability, where concerns were raised on the need for adequate food availability to prevent hunger (UN, 1975). However, this strategy did not prove sufficient, as national and global food sufficiency did not necessarily eliminate hunger. Sen's (1981) entitlement strategy, which shifted the emphasis to individual access to food, had to be adopted as a result. The definition of food security was reexamined at the World Food Summit in 1996 to include wholesome food that satisfies dietary requirements and desires for an active and healthy life.

According to more recent studies, food security is a complex idea that needs to be examined from every angle (Lele *et al*., 2016). This definition has been generally used in studies, such as the works by Fawole and Ozkan (2017) and Magrini and Vigani (2016). Further considering its multidimensionality, this research used the definition of the World Food Summit (1996) definition, which guarantees a comprehensive approach to the evaluation of food security among peri-urban households.

The food security dimensions have changed considerably compared to the 1970s, probably shaped by the global food crises that focused on food availability and price stability at the onset (Berry *et al.*, 2015). The focus on food production in order to solve protein-energy imbalances, which afflicted more than a quarter of the world's population by 1974 (United Nations, 1975), was underscored by the World Food Conference (1974).

2.8.1 Availability Dimension of Food Security

In order to ensure a sufficient supply at the household, regional, national, or international levels, food availability includes both locally produced food and food aid and imports (WFP, 2009). After 1974, the idea was broadened to encompass economic access in addition to availability, acknowledging that vulnerable groups still face difficulties obtaining food even when there is a sufficient supply (Berry *et al.*, 2015). Food security was redefined by the FAO in 1983 to mean "ensuring that all people at all times have both physical and economic access to the basic food that they need." A time-scale dimension was also introduced by the World Bank (1986), which distinguished between acute food insecurity brought on by natural or man-made disasters and chronic food insecurity, which is associated with poverty (Berry *et al.*, 2015).

2.8.2 Accessibility Dimension of Food Security

In contrast to availability, which is evaluated at larger scales, the accessibility dimension guarantees that food reaches consumers through effective transportation infrastructure and is measured at the household and individual levels (WFP, 2009b; Magrini & Vigani, 2016; Pieters *et al.*, 2013). Families can obtain food through food assistance, market purchases, their own production, or a mix of these (WFP, 2008, 2009b). According to Pieters *et al.* (2013), food access is significantly influenced by household assets, including human, material, social, financial, natural, and political assets. Furthermore, socio-political factors influencing food security are influenced by gender inequality, social discrimination, and ethnic considerations (Jayne *et al*., 2001; Dohrmann & Thorat, 2007).

In order to ensure that food is culturally acceptable and to provide social protection for populations with limited resources, socio-cultural access is also essential. As food security develops further, tackling political, economic, and infrastructural challenges remains vital for ensuring sustainable access to food globally.

2.8.3 Food Utilization Dimension of Food Security

Food utilization is defined by the World Food Programme (WFP, 2009b) as the ability of a household to obtain food and the ability of an individual to effectively absorb and metabolize nutrients. In a similar vein, food utilization is defined by the United States Agency for International Development (USAID, 1992) as the actual food consumed, including its nutritional value, preparation, and storage methods. Nutrition and food utilization are fundamentally related (Khalid & Schilizzi, 2013), with dietary intake and the body's capacity to absorb nutrients being highlighted (Pieters *et al*., 2013).

Food utilization guarantees that people eat enough food in both quantity and quality to sustain their health and reach their maximum potential (WFP, 2007). It has two main components: socioeconomic, which affects dietary preferences and household food distribution, and biological, which establishes the body's capacity to convert food into energy. Among the factors influencing food utilization are food prices, resource availability, health practices, caregiver education and knowledge, individual health status, and intra-household food distribution (Pieters *et al*., 2013; Lele *et al*., 2016). Food use is also impacted by housing, waste management, water supply, sanitation, and environmental factors. Dietary intake and nutrition levels are influenced by the internal distribution of food within households, which is frequently influenced by gender and educational inequality (USAID, 2011; Sassi, 2018).

2.8.4 Stability Dimension of Food Security

The stability dimension, which was established as the fourth pillar of food security at the World Summit on Food Security (2009), focuses on the capacity of states, communities, households, or individuals to endure shocks to the food system brought on by natural disasters (e.g., earthquakes, climate change) or man-made crises (e.g., wars, economic downturns) (FAO, 2009). When availability, accessibility, and utilization are sustained over time, stability is attained (Fawole & Ozkan, 2017).

Stability, according to the United States Agency for International Development (USAID, 2011), is the capacity to obtain and use food in a suitable manner while preserving nutritional levels over time. The term "at all times" in definitions of food security reflects the temporal nature of stability. Some researchers, like Pieters *et al*. (2013), go beyond stability to include resilience and vulnerability. Resilience is the amount of time needed to recover, while vulnerability is the chance of experiencing food insecurity after a shock (like changes in food prices).

Three major factors; risk production, risk mitigation, and risk coping—influence the detrimental effects of food and nutrition vulnerability. Diversified food production, migration, healthy eating, asset management, withdrawal of savings, short-term work, stopping school, and dietary changes all have an impact on these factors (Pieters *et al.*, 2013). Conversely, resilience relies on actions taken to lessen vulnerability, guaranteeing that a household or community can reach or exceed pre-shock levels of food security.

2.8.5 Emerging Fifth Dimension: Sustainability

Sustainability, which addresses long-term ecological, biodiversity, climate change, and socioeconomic factors, is being proposed as a fifth dimension of food security in recent discussions (Berry *et al*., 2015). Sustainability guarantees that food security is preserved for future generations as well as sustained over time.

In summary, there are several levels at which food security functions: national availability, household accessibility, individual utilization, and stability as a time-based dimension that impacts all levels. While sustainability takes into account regional and global environmental and socioeconomic factors, a comprehensive framework for food security integrates all four dimensions (Berry *et al*., 2015).

2.9 Food Security Situation in Ghana

According to Agyeman and Osei-Kojo (2022), Ghana's fast urbanization and population growth are among the main causes of the country's ongoing food insecurity. Food security issues have gotten worse due to the loss of agricultural land to urban expansion, especially in northern Ghana where farmland and food production are severely impacted by rural-urban migration, climate variability, and infrastructure development (Addo & Addo, 2010; Pribadi & Pauleit, 2015). Food insecurity is disproportionately concentrated in the five northern regions: Upper East (48.7%), North East (33%), Northern (30.7%), Upper West (22.8%), and Savannah (22.6%) (GSS, 2023). According to recent data from the Ghana Statistical Service, districts like Bolgatanga East (66.3%), Jirapa (61%), Chereponi (60.3%), and Tempane (59.2%) are among the hardest hit (GSS, 2023).

Ghana's agricultural industry has experienced a decline in production, according to the Ministry of Food and Agriculture (MoFA, 2023). Food and nutrition security continue to be major issues, especially in the Savannah Zone where agricultural production is falling, according to the 2025 Cadre Harmoncé (CH) report (MoFA, 2023). Ghana is among the worst afflicted nations in West Africa, with food insecurity rising by 58.4% over the previous year, according to the AGRA Food Security Monitor (May 2025) (AGRA, 2025).

Food insecurity still exists despite policy interventions like FASDEP II and alignment with the Comprehensive Africa Agriculture Development Programme (CAADP, 2003) (MoFA, 2007). This is especially true in northern Ghana, where 16% of households are categorized as severely or moderately food insecure (Lisa & Wuni, 2012). Due to land degradation, climate change, and inadequate irrigation infrastructure, Tamale, Bolgatanga, and Wa have worse rates of food insecurity than southern Ghana, demonstrating the continued severe north-south gap (IFAD, 2012; IMF, 2012). To address these issues and lessen the impact of urbanization on food security, sustainable land management techniques, enhanced irrigation systems, and climate-resilient agriculture are needed (World Bank, 2023).

2.9.1 Recent Government Interventions to Enhance Food Security

Ghana has undertaken a number of initiatives over the last five years to improve food security in the face of issues like urbanization, climate change, and falling agricultural output. The Feed Ghana Programme, launched in 2025, seeks to modernize agriculture through farmer service centers, increased grain production, and urban farming initiatives (Ministry of Food and Agriculture, 2025). Additionally, the Planting for Food and Jobs (PFJ) Initiative, which began in 2017, significantly contributed to food security by increasing maize production by 71% between 2017 and 2020 and providing employment for over 1.5 million farmers, although climate change and market instability remain hurdles (MoFA, 2024).

The government has recognized the effect of climate change on agriculture, by launching climate-smart agriculture in 2024, which encourages the use of drought-resistant crops, enhances irrigation systems, and promotes sustainable agricultural practices (World Bank, 2023). This project is in addition to the increased irrigation activities, whereby the government has developed lands in 19 irrigation sites in northern Ghana, in order to create food production resilience by decreasing rain-fed agriculture (AGRA, 2025).

The government has worked on the construction of warehouses to store food, better food preservation, reduction of wastes, and stabilizing the markets for farmers in order to address post-harvest losses (GSS, 2023). Food security, nevertheless, has become a problem, particularly in northern Ghana, where Upper East, North East, and Northern are disproportionately impacted by unpredictable weather patterns and land degradation (IFAD, 2023). The need to enhance climate-resilient agriculture and boost local food production continues to be critical in ensuring sustainable food security in Ghana (IMF, 2024).

2.9.2 Food Security Status by Farm Size

The size of a farm is an important factor in household food security because a smaller farm may find it difficult to generate adequate food and hence food security becomes more insecure. According to the latest statistics released by the Ghana Statistical Service (2023), it was found that 49.1% of the population of Ghana faces food insecurity, and this is more common in the rural areas where the average size of farms is smaller. According to the Comprehensive Food Security and Vulnerability Analysis (CFSVA, 2020), approximately 3.6 million individuals (11.7% of the population) were food insecure, and the Northern Region had the most food insecurity with 598,704 people.

According to the Ministry of Food and Agriculture (MoFA, 2025), smallholder farmers, who comprise the majority of Ghana's agricultural workforce, are experiencing a major problem of land fragmentation, climate variability as well as urban expansion which is decreasing farmlands. Food insecurity in Ghana is disproportionately high in the north (wher farm sizes are smaller), and is highest in the Upper East, North East, Northern, Upper West, and Savannah areas (GSS, 2023).

Additionally, the AGRA Food Security Monitor (2025) notes that food insecurity in Ghana has increased by 58.4% compared to the previous year, largely due to declining agricultural productivity and shrinking farm sizes. Food shortages have been made worse by climatic factors including droughts and unpredictable rainfall, especially in regions where smallholder farmers depend on rain-fed agriculture.

2.10 Measurement of Food Security

By simplifying food security's four primary dimensions; availability, access, use, and stability, the World Food Summit (1996) established the framework for evaluating it (FAO, 2006). To evaluate predetermined goals, any food security analysis, program, or monitoring endeavor needs accurate and valid assessment. However, due to its non-observable character, its complex and changing dimensions, and its continuum of conditions, which render binary classifications insufficient, quantifying food security continues to be difficult (Maxwell, 1996; Izraelov & Silber, 2019). Measuring food security presents two basic challenges: what is being measured and how it is measured (Cafiero *et al*., 2014). Choosing suitable indicators for various dimensions, like availability, access, utilization, and stability as well as components; like quantity, quality, safety, and cultural acceptability, is referred to as the "what" question. The methodology utilized to calculate these indicators, including data collection, analytical procedures, and modeling strategies, is the subject of the "how" inquiry.

Governments, academic institutions, and international organizations have not yet reached a consensus on a consistent measurement framework, despite requests for harmonization (Carletto, Zezza & Banerjee, 2013). The inadequacy of a real-time global assessment system for severe food insecurity was shown during the COVID-19 pandemic, according to the Scientific Group for the United Nations Food Systems Summit (Hertel *et al*., 2021).

Since there is not a single "best" indicator for food security, many organizations employ different metrics: Food and Agriculture Organization (FAO): Food Consumption Score (FCS); United States Agency for International Development (USAID): Household Food Insecurity Access Scale (HFIAS); World Food Programme (WFP): Prevalence of Undernourishment (POU) and Food Insecurity Experience Scale (FIES); Economic Intelligence Unit (EIU): Global Food Security Index (GFSI). Carletto, Zezza, and Banerjee (2013) contended that relying on a Comprehensive assessment Approach rather than concentrating only on the national, regional, or household levels, effective food security assessment should take into account all four aspects at the individual level. They emphasize that only a few indicators satisfactorily address all dimensions while remaining practical and easy to collect. Some of the standard indicators for measuring food security include the self-sufficiency in food production (SSF), food consumption score (FCS), household food insecurity access scale (HFIAS), household dietary diversity score (HDDS), coping strategy index (CSI), vulnerability index, household food expenditure, total expenditure, water sources, sanitation and access, reduced coping strategy index (rCSI), and household hunger scale (HHS) have been proposed by the World Food Programme (WFP, 2009b). It is obvious that the application of different methods is only an indication of lack of universally accepted indicator to capture all dimensions for food security. According to Fawole & Ozkan, (2017), each of the proposed indicators have their own weaknesses and fails to capture all dimensions of food security. Abdullah

(2021) has observed that based on the objectives of measuring food security and prevailing circumstances, a combination of various indicators have been applied in several studies. Take for example Mango *et al*. (2014) examined the factors of food security in Zimbabwe by combining HFIAS and HDDS. Makate *et al*. (2016) applied the food consumption score (FCS), household food insecurity access scale and household dietary diversity score to measure food security also in Zimbabwe. In Tanzania, Magrini and Vigani (2016) integrated consumption expenditure, average maize yield, average daily calorie consumption, diet diversity index, source of drinking water and food preparation, vulnerability index and access to storage structure in an effort to determine the impact of agricultural technologies on food security in multiple dimensions. Shiferaw *et al*. (2014) used FCS and subjective responses as measures to explore how improved wheat varieties adoption can affect food security in Ethiopia.

Given that both methods have their merits and demerits, this research uses FCS and HFIAS due to their extensive use in the analysis of food security. Food security is well measured by the Food Consumption Score (FCS) and Household Food Insecurity Access Scale (HFIAS) because they have strengths in measuring the diversity of diet and access to foods. FCS, considers food frequency and dietary sufficiency, which is why it suits the monitoring of long-term food consumption patterns on a regional level (FAO, 2013). FCS is also affordable and simple to implement, though it fails to capture intra-household food allocation. HFIAS, assesses household experiences of food shortage and coping, which offers a continuous scale of food insecurity severity (Coates *et al*., 2007). Unlike FCS, HFIAS captures psychological stress and household coping strategies, making it sensitive to short-term food insecurity fluctuations (Maxwell *et al*., 2008). While other indicators such as Prevalence of Undernourishment (POU) and Food Insecurity Experience Scale (FIES) exist, POU is more suited for national-level assessments, and FIES is perception-based, potentially missing actual food consumption patterns (Leroy *et al*., 2015). The combination of FCS and HFIAS guarantees both a balanced and comprehensive methodology, merging the diversity of diet with household access to food which makes them the best in the evaluation of food security in the northern regions of Ghana.

2.11 Effect of Urbanization on Food Security

Urbanization is associated with many good developments, including monumental change of the urban space into a more productive form far much better than rural ones and so it forms a key catalyst to economic growth and development (Overman & Venables, 2005). Nevertheless, the pace of urbanization as it is experienced in most developing countries may exert strong pressure on the ability of these cities to accommodate and absorb the continuously rising population. Consequently, the direct correlation between urbanization and food security as a result of the rise of slums tend to contribute significantly to the threat of all food security dimensions (Schmidhuber & Muller, 2008).

Empirical research has demonstrated that uncontrolled urbanization significantly impacts food security across multiple dimensions. One of the most critical effects is on agricultural production, which directly influences food availability. With urban populations (which are net food purchasers) steadily increasing, their food demands must be supplied locally by peri-urban producers or by imports. Nevertheless, rapid urbanization presents a significant threat to peri-urban agriculture because of the increased competition in land use. Agricultural zones are becoming residential or industrial areas, which restrict the ability of peri-urban farmers to produce food (Ruel *et al*., 2017). This is particularly noticeable in areas where urban sprawl is encroaching on fertile agricultural land, which reduces the production of local foods leading to increased dependence on food imports (Wei *et al*., 2025).

Weak tenure arrangements, as pointed out by the Food and Agriculture Organization (FAO, 2023), continue to drive agricultural production to less productive lands resulting in the loss of yield (FAO, 2023). Urban development requires more food to be transported and distributed within the cities but the inefficiency of the transport and distribution systems especially in developing nations is a major challenge to food security (FAO, 2023). Recent statistics show that over 3.1 billion people worldwide were unable to afford a healthy diet in 2021 and that food insecurity was getting worse in Africa (FAO, 2023). Economic resources are a major determinants of food access. Urban residents, who are more of net food purchasers, need cash earnings and work opportunities in order to buy food, whiles rural and peri-urban residents are more dependent on self-sustainable agricultural production (Maxwell *et al.*, 2000; Ruel & Garrett, 2004). The farmland is an important resource base that supports human growth. Therefore, any changes in the amount and quality of planted area considerably influence the production and security of food in the region (Skinner *et al.*, 2001; Kastner *et al.*, 2012; Uddin & Oserei, 2019). The latest global food security report underscores that urbanization is transforming agrifood systems, affecting food affordability and accessibility across the rural-urban continuum (FAO, 2023).

In Lahore, Pakistan, Anwar *et al.* (2023) quantified these effects of urbanization, revealing a drastic reduction in farmland from 50% in 2001 to 34% in 2020, while urban built-up areas expanded from 14% to 42% over the same period. The study has consistently showed the rise in the rate of urbanization with a steady decreasing agricultural output, which has an immediate bearing on the availability of food to peri-urban and urban families. High rates of rural and peri-urban migration to urban centers have significantly contributed to the increasing urbanization rate, escalating the issue of resource distribution, food supply issues and degradation of biodiversity. In Jiangsu Province, China, Kang *et al.* (2023) studied the effect of urbanization on food security by developing an index of cultivated land pressure to analyse spatial patterns. Urbanization and food production have always been a controversial topic and two main points of view have emerged. The first argues that urban expansion leads to a negative correlation, where cultivated land decreases, weakening food supply capabilities (Wang *et al*., 2020; Leng & Fu, 2014). According to Kang *et al.* (2023), the second indicates a positive or balanced relationship at the national level in China. In order to assess the impacts of urbanization, it divided into three categories: land urbanization, industrial urbanization, and population urbanization—collectively referred to as total urbanization. According to their findings, Jiangsu Province's cultivated land pressure was not significantly affected by overall urbanization. However, because changes in rural populations affected food production, urbanization had a negative impact. In a similar vein, land urbanization improved the cultivated land pressure index, whereas industrial urbanization had a negative impact. Despite these findings, the study observed a decline in cultivated land quantity and quality between 2005 and 2019, leading to reduced food production and increased pressure on arable land.

Again, Duan *et al*. (2021) also in China investigated farmland loss due to urbanization and its implications for food self-sufficiency in the Yangtze River Delta Urban Agglomeration over a 20-year period. Their findings revealed a 166.8% increase in built-up land and a 23.7% reduction in farmland area between 2000 and 2020. The research also discovered that deficits of farmland remained in many study units which affected food self-sufficiency. By 2020, the demand for farmland surpassed supply, which created a shortage of 5.14 million hectares, posing threats to food security, and necessitating a possible need to import grains.

Bonye *et al*. (2021) studied the effects of urbanization and agricultural land use changes on food security of households in the Wa Metropolis of the Upper West Region of Ghana. They found that built-up areas grew considerably in the 2000s, having reached 14.8 km2 in 2000 and 29.2 km2 in

2016, at the cost of peri-urban farmland (Korah *et al*., 2018; Ahmed *et al*., 2020). Migration contributed 98% of urban growth in the metropolis between 1960 and 1984, according to Ghana Statistical Service (2010). Bonye *et al*. (2021) discovered that reduced farmland denied farmers the opportunity to produce food crops in large scale resulting in a looming food security crisis. The decreases in farm size over a 30-year period were matched by the decrease in yields of staple crops like maize, millet, guinea corn, rice, groundnuts, and beans. In a survey of peri-urban communities, over 75% of the participants reported low food production because of changes in agricultural land use. There were food shortages with 31% responding to inadequate food, 49% not eating regularly and 51% food insecurity in the last 12 months. The research also noted that the high competition on land use due to residential as well as commercial and infrastructural development has contributed to a further rise in food security issues. The existence of educational institutions like the University of Business and Integrated Development Studies, Wa Technical University as well as other senior high schools have resulted in farmland been lost (Kuusaana & Eledi, 2015; Abass *et al*., 2018; Appiah *et al*., 2019; Chandra & Diehl (2019).

On the same note, Chandra and Diehl (2019) conducted a study on urban agriculture, food security, and policy development in Jakarta where they found that urban agriculture is losing its space in the urban periphery. Their research concluded that urbanization-induce farmland loss would have dire consequences on the food security with respect to food availability, access, and utilization.

Palanisamy and Parthasarathy (2016) in India carried out a review of urbanization, food security and agriculture, which revealed that urbanization alongside population growth, globalization, climate conditions, and disease outbreaks played a role in food security pressures. Such issues are especially strong in developing countries, where they influence the access of people to adequate and healthy food by influencing livelihoods, income, and food prices. Also, urbanization affects food stability because of food processing, packaging, and transportation inefficiency, which may aggravate food insecurity and expose urban centers to more infectious and waterborne diseases.

2.12 Urbanization, Agricultural Land Loss, and Household Welfare

Although urbanization has been associated with economic development (Satterthwaite *et al*., 2020), it also increases inequalities, specifically in peri-urban areas where land tenure disputes and displacement are common. Agriculture is still one of the basic sources of livelihoods especially in peri-urban society where it contributes a lot in terms of food security and poverty alleviation (World Bank, 2008). MoFA (2016) explains its importance in defining the livelihoods of farm households that are poor in resources. But agricultural lands is being progressively invaded by urban sprawl causing a breach in the conventional livelihood patterns. Research shows that urban development has led to considerable loss of agricultural land and directly impacting tenure security and household wellbeing (Nguyen & Kim, 2019; Appiah *et al*., 2019).

Urban centers in Sub-Saharan Africa are fast growing into peri-urban towns representing enormous challenges as well as opportunities. Some studies have associated urbanization with an improvement in household welfare because of the growth of non-farm activities (Abay *et al*., 2019). urban growth in Nakuru City, Kenya, improves livelihoods but limits access to vital natural resources (Cherotich *et al*., 2024).A study found that tripling the intensity of nightlights in a village in Ethiopia, is associated with a 42-46% increase in household welfare (Mezgebo *et al*., 2023). But urbanization also raises food prices and makes inequality worse. In order to maintain productivity on declining farmland, farmers in Wa have been compelled to restructure their agricultural methods using strategies including crop rotation and fertilizer use (Toku *et al*., 2021). Access to land has been made more difficult by land tenure disputes in peri-urban Accra, and the number of players in the land market has increased due to privatization (Asafo, 2020).

Urbanization is causing significant changes in land usage in West Africa. According to studies conducted in Ghana, between 2008 and 2016, settlements grew by 120.29% while thick vegetation dropped by 226.98%. This shows how urban sprawl affects ecological sustainability and farming livelihoods (Agyeman, 2018).

Even though agriculture is the main source of income in many peri-urban areas, farm households nevertheless struggle to make ends meet (Babatunde, 2013). According to research, 5.7% of the world's agricultural land will disappear by 2050, with losses in Asia and North Africa being especially significant (Lasisi *et al.*, 2017; Rimal, 2013). Farmland depletion brought on by urbanization is still a major issue in many areas, particularly in Southern Africa, where peri-urban growth puts a burden on municipal infrastructure (Ingwani *et al*., 2023). In the same vein, rural inhabitants in Lesotho continue to rely on agriculture, whereas urban households have embraced a variety of livelihood choices (Monts'i, 2001).

Unregulated urbanization has failed to provide sustainable alternative livelihoods for peri-urban households in Ghana (Cobbinnah & Amoako, 2018). While construction-related jobs such as masonry, carpentry, and plumbing have emerged, these are often temporary and require specialized training, limiting accessibility for those displaced by land loss. Women and children, in particular, face heightened vulnerabilities, as farmland depletion leaves them with fewer economic opportunities.

2.13 Theoretical Frameworks of the Study

This study is grounded in theories that explain the interaction between urban expansion, land-use change, agricultural production, and household welfare outcomes**.** In particular, the study draws on the insights of Bid Rent Theory, The Agricultural Land Use Theory, and Entitlement Theory. These theories collectively provide a conceptual basis for understanding how urban growth influences farmland availability and how such changes affect agricultural production, food security, and the welfare of farming households.

2.13.1 The Agricultural Land Use Theory

The agricultural land-use theory is based on Johann Heinrich von Thünen's model, developed between 1783 and 1850. However, its broader application began in 1966 after its translation into English. Professionally, von Thünen was both an experienced farmer and a skilled economist. His model aimed to demonstrate how the availability of markets influence agricultural land use in different locations. It also established a critical relationship between land cost and transportation expenses, explaining how these factors shape land utilization and farming decisions. The idea was that the proximity of the land to the city, so the price of the land increases. In other words, urban expansion influences the value of the land. Von Thünen explained again that there is an existence of concentric rings of agricultural products, implying that when the price of purchasing the land to cultivate and transport agricultural products decreases, lot of the demanded products will be produced. However, when the cost of producing those crops become expensive, as a result of increase in land price and transportation, the producers will change to the next crop in the ring purported to be more beneficial. The process goes on until such a time that agricultural land is converted to residential uses because the cost of using it for production is no longer attractive. Von Thünen further observed that as the cost of keeping the land becomes expensive farmers turn to put value on building residential properties rather than farming. Putting it in another way von Thünen (1966), stated that as conditions change, so shall the boundaries also change. For example, there is a correlation between rising urban income or population and rising housing demand, which causes the urban land zone to migrate outward and has a trickle-down impact across other agricultural zone boundaries.

Von Thünen Model came into existence before the spring up of industrialization with some fundamental assumptions based on the following: First there is assumption that urban center is found in the middle part of a country or ‘’Isolate State’’ that is self-sufficient and is not influenced by external factors. These areas (isolated state) are also areas for marketing agricultural products and refer to these areas as wilderness because they are not occupied. Therefore there is the presumption that soil as well as climatic conditions around the city or wilderness (isolated state) is fertile, good terrain which support agricultural production as a result motivating farmers to act on the bases of profit maximization. Von Thünen then hypothesized that as the city center grows outward, there is an emergence of pattern of rings developed surrounding the city. The rings developed are agricultural activities surrounding the city which come in four successions. Von Thünen observed that the city is the marketing point of the agricultural products where consumers demand for products such as fruits, vegetables, perishable products and milk (diary product). Farming activities intensify near the city, forming the first ring of agricultural development. This ensures that perishable products remain close to consumers, minimizing transportation costs, preservation challenges, and risks associated with fragility. The next ring that will emerge around the city forming the second zone of agricultural activity is what von referred to as the forest. The forest serves as a resource base for timber products and fuel wood and housing materials for the city or isolated city. Staple grains for bread and other commodities grown in large fields are examples of the third zone of agricultural activity. The location of the third zone is largely due to the fact that grains can last longer during transportation compared to dairy products and less in weight than fuel, thereby resulting in reduction in transport costs, justifying the location of the third zone. Finally, ring zone four for agricultural activity is the areas for livestock rearing or ranching. This zone is usually located at the outskirt of the city largely due to health hazards related to living close with animals. Von Thünen further realized that areas initially allocated for dairy products production suddenly being transformed into housing lands as population growth occurs due to increase demand for residential accommodations. The gradual transformation into other uses from their original activity will begin to shift to such a time that it become very expensive for farming activities to continue around the city compelling the farmer to either quit or relocate a distance away from the city. This will therefore affect the availability of some particular agricultural activities like the dairy farming which will decline and face out eventually due to relocation of farmers far away from the city into the uncopied land referred to as the wilderness from the city.

Based on Von Thünen's land use theory, agricultural land located closer to urban centers is expected to face greater pressure for conversion to built-up infrastructure. In this study, the dependent variable is crop productivity and the independent variable is peri-urban farmland loss, , and the expectation is that farmland loss will be more pronounced in areas nearer to the city centers of Tamale, Bolgatanga, and Wa which will impact household food supply.

2.13.2 Bid-Rent Theory

The urban bid-rent theory broadens the understanding of how urbanization occurs geographically in terms of changes in land value and land use. Put differently, it depicts the overall urban land use pattern. By specifying the distance to the urban area as location, the bid-rent theory or model can forecast the land use pattern in advance (Alonso, 1964; Deng *et al*., 2008). It implies that as one gets farther away from the Central Business District (CBD), the demand for houses and land would shift. This also implies that the cost of land is more expensive when closer to the CBD. The theory pointed out there will be a fierce competition between different actors in the land market for lands located close to the city center. The biggest motivation for retail establishments is profit maximization, where they are prepared to pay more for lands close to the CBD and less for lands distance from CBD. There is an assertion that the bid-rent theory gives credence to the depletion of agricultural activities proposed by von Thünen Model of Agricultural land uses theory which indicate that because farmers motivation for production is to maximize profit, they will always quit their job anytime it becomes less profitable as the isolated state expands (in Niang, 2019) . It connects the trade-off between lower land rentals and higher transportation costs because of the increasing distance to an urban area. The model shows that land uses will defer as the distances from the urban area increases (Alonso, 1964; Deng *et al*., 2008). According to White (1988), recent scholars have included income, transportation, and natural resources to expand the bid-rent model. The paradigm of urban bid-rent theory has given researchers a way to analyze urban land use patterns and investigate how urbanization affects the conversion of agricultural land (Seto & Kaufmann, 2003; Jiang *et al*., 2012; Deng *et al*., 2015). For instance, factors such as income, cost of transportation and agricultural land rent were key in bid-rent model estimation in urban growth studies (Brueckner & Fansler, 1983). In a similar vein, research by Deng *et al*. (2008) demonstrated that industrialization and income had a significant impact on urban land expansion, supporting the bid-rent model. They did not draw many conclusions about how urbanization affects farmland transformation because their study focused on the elements that contribute to urban expansion. Due to the lack of non-market and missing elements, the model could only partially explain how urbanization affected farming. Where land allocations are mostly governed by the government, the model's applicability may be restricted. Research has shown that the actions of local governments have an impact on the growth of urban land (Huang & Du, 2018b; Huang & Du, 2017a; Tian, 2015).

The bid-rent theory predicts that land users willing and able to pay higher rents, such as urban developers, will outcompete agricultural producers for peri-urban land. Accordingly, the study expects that peri-urban farmland, particularly near urban markets, will be increasingly converted to non-agricultural uses, linking urban expansion (dependent variable) to farmland loss (independent variable).

2.13.3 Entitlement Theory in Relation to Household Food Security

Entitlement theory fundamentally explores the mechanisms through which individuals access resources essential for sustenance, particularly food. Fundamentally, the theory contends that deprivation occurs when individuals lose access to important endowment sets, such as agricultural land, which hinders their capacity to obtain resources required for existence (Sen, 1981). Entitlement theory, which was initially developed by Amartya Sen in 1977, offers a historical and theoretical framework to understand the causes of famine and poverty, relying on some of the most famous examples of famine, including the Bengal famine of 1943, the Sahel famine (1968-73), the Ethiopian famine (1972-74), and the Bangladesh famine of 1974 (Sen, 1981; Osmani, 1995). These incidences illustrated that food insecurity does not only come as an outcome of food scarcity but also due to socio-economic constraints which limit the capacity of people to possess the available food resources. This point is supported by Osmani (1993) and Devereux (2001), who argue that those who possess inadequate entitlements that could be due to poverty, loss of farmland, or socio cultural constraints are more vulnerable to food insecurity, even where food is still available.

One of the fundamental prescriptions of the entitlement theory is the notion of the set of endowment, that is, the initial stock of resources, such as land, skills, labor and social capital, which is possessed by an individual (Sen, 1981, 1986; Osmani, 1993). According to Sen (1981), the endowment set is made up of all the assets that an individual is legally entitled to, which are influenced by institutional frameworks and established social norms. To elaborate, Osmani (1993) and Nayak (2000) point out that these endowments could consist of both intangible assets like knowledge, technical competence, labor capacity, and community attachments as well as real assets like agricultural land, equipment, and cattle. How people obtain and preserve these resources is also heavily influenced by social and customary rights (Seaman, Sawdon, Acidri & Petty, 2014). In this context, having access to farmland is essential since it allows households to make a living on their own. However, people experience extreme deprivation and become more reliant on outside assistance when they lose their agricultural land as a result of economic pressures, environmental changes, or land expropriation.

The entitlement set, which stands for the different goods and services that a person can acquire with their primary endowments, is the second fundamental principle of entitlement theory (Ravallion, 1992). This idea emphasizes how livelihoods are transactional, with resources like farmland being used to produce food or traded for other necessities (Sen, 1984). In addition to direct production, people can obtain a living through market exchanges, community-based transfers, or entitlements from state assistance programs. However, researchers like Kabeer and Aziz (1990) and Kabeer (1991) stress that social institutions and household agreements determine access to entitlement sets, especially land. This suggests that intra-household dynamics, economic inequities, and more general policies may be the causes of differences in land ownership and access. Furthermore, Gasper (1993) builds on Maxwell and Smith's (1992) argument that entitlements change as a result of production and trade processes by supporting the inclusion of financial capability in entitlement sets. Land-dependent people's entitlement set is severely undermined when they lose their agricultural assets, which makes it harder for them to sustain a steady income and makes them more susceptible to food insecurity.

Entitlement mapping (E-mapping), which describes the connections between owned resources and the goods or advantages that people can obtain through trade and production, is the third pillar of entitlement theory (Sen, 1981, 1986). E-mapping is defined by Osmani (1993) as the connection between the endowment set, which consists of labor, land, and other assets, and the entitlement set, which contains the commodities and services that can be obtained from those resources. In essence, E-mapping establishes how quickly a person can transform their assets into goods that support their way of life (Nayak, 2000; Osmani, 1993). According to Gasper (1993), legislation, socioeconomic conditions, and institutional processes that control how people assert their rights all influence e-mapping. This principle's essential premise is that individuals should be allowed to use their assets, like farms, to secure basic necessities like food, housing, and income (Sen, 1981, 1986; Nayak, 2000; Osmani, 1993). However, people's ability to sustain livelihoods is seriously jeopardized when they encounter obstacles in this process, such as land loss due to dispossession, environmental deterioration, or economic shifts.

The entitlement failure, a phenomena that occurs when individuals or families lose access to resources necessary to maintain their way of life, is a related tenet of the entitlement theory (Musolino & Nucera, 2016). In particular, entitlement failure occurs when people are unable to engage in productive activities like farming to obtain food for consumption or sale, which lowers household income and stability. According to Maxwell and Smith (1992), a person will find it difficult to sustain a livelihood if their entitlement set does not include a substantial commodity bundle to cover fundamental necessities. They added that things like falling agricultural productivity, job losses, and changes in the cost of staple foods can lead to entitlement failure. In this sense, Gasper (1993) emphasizes that people are more susceptible to malnutrition and even death when they are unable to meet their basic needs, especially during times of famine.

According to Sen (1984), entitlement relations are the means by which people in a particular society acquire goods and services. Entitlement theory states that people use four primary methods to obtain food and other necessities: trade-based entitlement, production-based entitlement, own-labor entitlement, and inheritance or transfer entitlement (Sen, 1981). Food insecurity and socioeconomic suffering are exacerbated when these systems are interrupted, whether by environmental conditions, governmental changes, or economic collapse. This is known as entitlement failure. According to De Waal (1997), famines happen when people lose access to vital resources, like agricultural land, which are necessary for obtaining rights, rather than when food is scarce. According to historical analysis of famines in Bangladesh and Bengal, hoarding and insufficient regional food distribution were major causes of entitlement failures (Grada, 2007; Sen, 1981). These incidents highlight the more general truth that people may lose their ability to support themselves as a result of institutional, political, or economic acts in addition to environmental reasons.

According to Sen (1986), two major factors that determine a person's incapacity to obtain food in a market-based economy are pull failure and reaction failure. According to Sen (1997), pull failure occurs when economic shocks such as job loss, the loss of farmland, a decline in agricultural output, or a reduction in real wages prevent individuals from obtaining food. However, when supply and demand in the free market do not align, reaction failure takes place (Sen 1997). This mismatch is particularly noticeable in peri-urban areas, where landowners may decide to sell their property and look for alternatives to agricultural usage due to the rising demand for agricultural land. Sen (1997) contends that governments should focus on creating jobs and safeguarding important resources like land access for the underprivileged in order to solve such failures.

The necessity for preventive measures to prevent livelihood destruction due to pressures from urban growth is highlighted by the increasing demand for peri-urban agricultural land (Maasikamäe *et al*., 2014). According to Lentz and Barrett (2008), interventions need to be precisely targeted in order to prioritize providing support mechanisms to households that are at the highest risk. Similarly, Johnston and Bargawi (2010) suggest empowering policies that lend support to the impoverished communities' endowment sets, which include farm security for cultivation. Nevertheless, Musolino and Nucera (2016) warn that intervention without direct restoration of rights, such as access to land for production, will hardly address deprivation. The issue of targeted action, notably for the peri-urban communities affected by agricultural displacement, is thus underscored.

Even though entitlement theory is influential in emergency response and decision-making, it has been challenged in a number of ways. Devereux (2001) mentions that the theory ignores resources that are owned collectively and thus, this model has a restricted area of applicability when it comes to the analysis of famines. According to Fine (2004), entitlement theory is just a tool for enquiring into denied entitlements rather than a comprehensive framework for account.

Moreover, Rubin (2009) points out that the theory easily misses the processes of food production, laws that account for socio-political world that influence goods and services people have access to. Nussbaum (2011) goes a step further in criticizing the framework for ignoring the cultural aspects of the ways through which people get their entitlements. The assumption that all the loss of entitlements is due to external forces without considering the individuals who voluntarily give up their assets like land for the sake of other businesses is the other limitation of the theory.

Though being criticized from various angles, entitlement theory remains a foundational instrument for studying how land has been lost in urban peripheries and the way this has impacted people's livelihoods. Johnson and Chakravarty (2013) observe that peri-urban land dispossession greatly limits landowners' capability to access the most vital resources.

Adam (2014) explains that local landholders in the Ethiopian peri-urban areas are mostly ignored during urban expansion processes, further increasing vulnerabilities. Similarly, Kleemann *et al.* (2017) examine Ghana's shifting land tenure systems, emphasizing that entitlement loss and uncertain user rights contribute to conflicts.

The findings of these study underscores the need for the protection of entitled rights considering the role of entitlement theory in empirical research and policy advocacy. Nevertheless, while the entitlement theory can reveal routes through which one can adjust to the issue of deprivation, it is not in full agreement with the view that people can adapt to change through training and knowledge acquisition, an area within the domain of human capital theory.

According to Sen's entitlement theory, loss of farmland reduces households' production-based entitlements, which can compromise their ability to access food. In this study, farmland loss is the independent variable, household food security measured by FCS and HFIAS are the dependent variables, and the expectation is that households experiencing farmland loss will have lower food security scores.

2.14 Conceptual Framework of the Study

In the context of this study, the term peri-urban farmland loss will be specific to the loss of previously cultivated agricultural land to non-agricultural land use, i.e. residential, commercial, or industrial infrastructure. Other related phenomena, including, but not limited to, fragmentation of land into smaller plots, tenure insecurity or partial access to land, are defined separately as being potentially interacting issues. Households that experienced actual farmland conversion are classified as land-loss households whereas households that did not undergo conversion are classified as non-land-loss households.

The concept of household welfare in this study is taken to mean a multidimensional concept that includes the objective measures of household welfare, including income, owning of assets, accessibility to food and services, and subjective measure, which is when households judge themselves about their well-being. Since the proposed study is based mainly on perception-based standards, the welfare will be operationalized in terms of the household-reported living standards, quality of life, and livelihood satisfaction, gathered through structured questionnaires.

Land-use change is mostly driven by urbanization, especially in peri-urban areas where farmlands are progressively being transformed into constructed infrastructure. The increasing demand for land is a result of migration, built-up expansion, population growth, and economic expansion, frequently at the expense of traditional agricultural livelihoods (Seto, Güneralp, & Hutyra, 2012). Households lose access to farmland as urbanization increases, which compromises their capacity to generate income, produce food, and maintain welfare.

Amartya Sen's Entitlement Theory, which portrays food insecurity as a failure of access rather than production, serves as the foundation for this study. Agricultural land serves as a fundamental entitlement in Ghana's peri-urban areas. Sen (1981) contends that entitlements; legal, administrative, and social procedures that enable people to command resources, are how people obtain food. In situations where land tenure systems are unregulated or informal, this approach is especially pertinent. Customary land tenure systems frequently conflict with formal urban planning in areas like Northern Ghana, making peri-urban farmers susceptible to eviction. According to research, urbanization has increased land tenure insecurity, which has resulted in disputes over land ownership and reduced agricultural households' capacity to support themselves (Tacoli, 2002). Thus, the entitlement theory offers a perspective through which to view how urbanization undermines food security and disturbs household asset portfolios. Academics like Kombe (2005) and Owusu (2008) point out that urban growth often happens without sufficient compensation, resulting in land fragmentation and tenure insecurity. Both community cohesion and conventional farming methods are disrupted by these processes.

Demographic increase, infrastructure development, and policy-driven planning have all contributed to the acceleration of urban expansion in places like Tamale, Bolgatanga, and Wa. Agricultural land has been transformed into residential, commercial, and industrial zones as a result of this change. The study uses GIS tools to trace the spatial extent of agricultural land loss during the previous decades in order to quantify this shift.

Household agricultural productivity is directly impacted by the loss of acreage, especially when it comes to growing staple crops like maize. This cascade is depicted in the diagram: urbanization causes farmland loss, which shows up as smaller farms, total land loss, and decreased production of crops and cattle as well as other domestic animals (Kleemann *et al.*, 2017; Osumanu *et al.*, 2019; Kusaana & Eledi, 2015). Food security is directly impacted by these agricultural effects, which lower food access, quality, and availability. The study measures the impact of land loss on maize yield using residualized quantile regression, accounting for farm characteristics, institutional access (such as loans and extension services), environmental factors (such as rainfall and soil quality), and geographic location. According to Jayne *et al*. (2014), farming systems in Africa are changing due to land pressures, with smaller plots producing lower resilience and production. Households in peri-urban areas, where land is becoming more limited and dispersed, must contend with decreasing yields and growing production costs, endangering both the supply of food and economic stability.

Beyond production, the study looks at how farmland loss affects household food security as determined by the Household Food Insecurity Access Scale (HFIAS) and Food Consumption Score (FCS). Changes in meal frequency, food-related anxiety, and dietary diversity are all captured by the Extended Ordered Probit Model. Food insecurity increases when agricultural assets are lost, according to Maxwell et al. (1999) and Smith *et al*. (2003). According to Maxwell *et al*. (1999), households who rely on erratic markets and unofficial networks frequently conceal urban food shortages. Land loss in Ghana's peri-urban areas decreases self-production and increases reliance on purchased food, which is frequently more expensive and less nutritious. The paradigm also takes into account how households perceive the effects of urbanization on welfare outcomes, such as decreased agricultural income and restricted access to drinkable water, healthcare, and education. In this study, 'household welfare' is understood as a multidimensional concept encompassing both objective indicators**,** such as income, asset ownership, and access to food and services, and subjective perceptions, which reflect households' own assessment of their well-being. Given that this study relies primarily on perception-based measures, welfare is operationalized as household-reported assessments of living standards, quality of life, and livelihood satisfaction, collected through structured questionnaires. Perceptions of urbanization, which the study gathers using Likert-scale surveys and PCA, exacerbate these. Both favorable (such as better roads, water, and education) and negative (such as job loss, rising living expenses, loss of cultural identity, diminished autonomy, and shifting social dynamics) experiences are reported by households. Urbanization frequently results in socioeconomic dislocation, according to Tacoli (2006) and Gough & Yankson (2011), particularly when peri-urban voices are left out of planning. Households in Northern Ghana claim that urban policies that put infrastructure ahead of livelihoods make them feel excluded. Designing inclusive urban development policies and comprehending the intangible aspects of welfare depend on these perspectives. Household perception are defined by institutional, socioeconomic, environmental and social networks among other factors.

When taken as a whole, the conceptual framework shows a multi-layered pathway: urbanization causes the loss of farmland, which in turn has an impact on household welfare, food insecurity, and agricultural productivity. All of these effects are mediated by entitlements like land tenure, institutional support, and ecological stability. Entitlement Theory is positioned as a strong lens for examining the socioeconomic effects of urbanization in peri-urban Ghana, thanks to its integrated structure, which is represented in the diagram. Although urban growth fosters economic growth, the livelihoods of peri-urban households are threatened by its unchecked nature. Policies that safeguard farmland and ensure displaced farmers have access to alternate sources of opportunities that improve food security and economic stability are essential.See figure 2.1.

Conceptual Framework of the Study

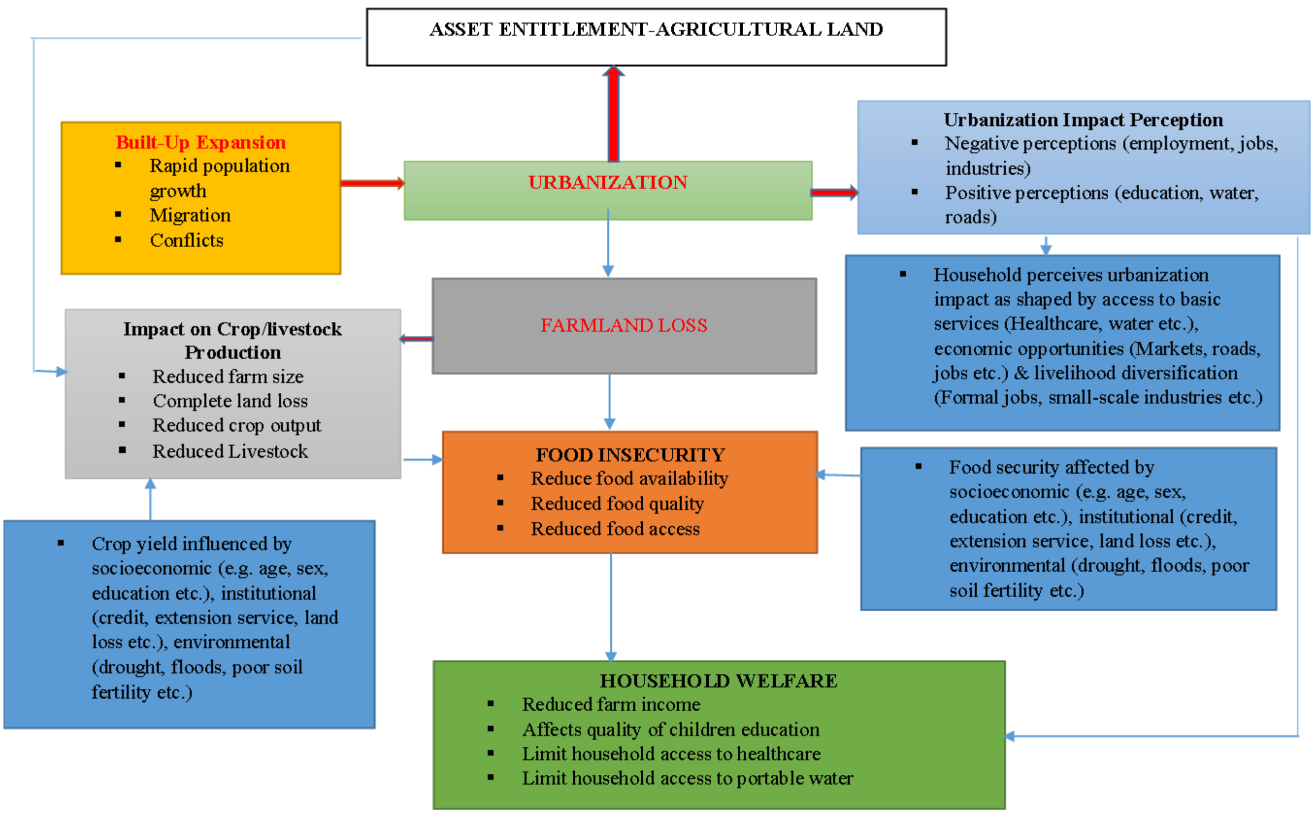

Figure 2. 1: Conceptual Framework of the Study, Author's Own Construct, 2025

2.15 Summary of Chapter Two

In this chapter, empirical review of literature was done around some thematic areas of the study. Literature on the processes of urbanization, agricultural land conversion, household staple crops cultivation, and household food security have been reviewed. It further reviewed the relationship between peri-urban farmland loss and urban expansion both empirically and theoretically.

The review also covered a broader perspectives of urbanization, historical events, trends, and factors reshaping current discussions, research and urban planning policies in the context of Sub-Saharan Africa, with much focus on Ghana's urbanization and agricultural land loss. The nexus between urbanization and agricultural land loss are understood according to some defining factors including the geography, the scale and its processes. The review also revealed a historical reflection of urban expansion on the current wave of land use patterns and how they are redefining household food production and food security.

With respect to how urban expansion impacts on staple crops production, review on the trends of cereal crop production was conducted. To understand how limited resources in the face of urban expansion, the review looked at how households diversify livelihoods by cultivating both crops and rearing livestock. It has been revealed that food production has been severely constrained by factors such as limited use of farm inputs, rapid urban growth that places limitation on agricultural land access. The review also uncovered factors like mode of institutional land acquisition, rising population growth, migration and conflicts as major factors responsible for rapid urbanizing cities in northern Ghana. Households identification was categorized into two namely; those that have lost land due to urbanization and those that maintain their lands for the purposes of conducting the relevant analysis. To quantify farmland loss, the study utilized approaches such as the quantile treatment effects QTEs models which can either take a binary indicators, continuous or both.

The consequences associated with the processes of urbanization and how it shapes households opinions led to mixed findings, thus there were those who express positive views whereas others thought urbanization negatively impacted their lives. These varied views are consistent with both empirical and theoretical literature. As some research findings highlight the negative impact of urban expansion on household access to farmland, crop productivity, limited farm investment, income, food security, others have found compelling evidence that suggest that urbanization has led to improvement in education, health, road network and other social services. Notably, these effects have not yet been quantified econometrically in previous research, especially when it comes to particular crops, household variances, or the wider spatial extent of urbanization. Furthermore, nothing is known about household attitudes of urban expansion, food security, and urban infrastructure.

This study aims to fill the knowledge gap created by the lack of a clear consensus in both empirical and theoretical literature regarding the effects of urbanization and agricultural land loss on peri-urban households, as well as the dearth of studies looking at its implications from the perspectives of key actors. A conceptual framework is created to investigate and assess the relationships between urbanization, agricultural land loss, staple crop production, food security, and household perceptions of urbanization's influence on general welfare based on this review and the discovered gap.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

There are seven sections in this chapter. Section 3.2, which gives background information about the research site in northern Ghana, comes after the introduction. While Section 3.3 describes the research design, Section 3.4 describes the general frameworks of the study. Section 3.5 presents the specific framework on farmland loss on household food security whereas Section 3.6 described the framework of urbanization effect on household welfare. Section 3.7 described data types and sources, sampling and selection procedure, data collecting techniques and the tools used to collect data and data analysis. Lastly, Section 3.8 describes the empirical frameworks of the study.

3.2 Location of the Research Site

Three regions of northern Ghana namely; Northern (Tamale Metropolitan), Upper East (Bolgatanga Municipal), and Upper West (Wa Metropolitan) were used for the study.

The Northern Region's regional capital, Tamale Metropolitan, serves as a significant administrative and economic center. The metropolis shares boundaries with Mion district to the east, to the south with East Gonja, to the southwest with Central Gonja, and to northwest with the municipality of Sagnarigu. It covers land area 731 square kilometers (GSS, 2021). Geographically, Tamale is situated at latitude 9°24′30.1′N and longitudes’ 0°50′25.63′W. it has a level topography with gentle undulating relief (Tamale Metropolitan Assembly, 2025). The two peri-urban communities suitable for this study are Wamale and Taha. An average annual rainfall is around 1200mm each year, running from May to October. At peak, temperatures could reach 40°C between March and April. Hamattan winds are predominate between November and February (Ghana Meteorological Agency. (2020).). Guinea Savannah woods makes up the vegetation, including predominant trees like acacia, baobab, and shea nut (FAO, 2016). As a hub for international trade, Tamale facilitates trade with Burkina Faso, Niger, Mali, and Togo (The Voice of Africa, 2025; Business Insider Africa, 2025). With a population of 374,744 in 2021 (50.6% female and 49.4% male), the city is still rapidly becoming more urbanized (GSS, 2021).

The Upper East Region's regional headquarters, Bolgatanga Municipality, is centrally placed and borders Bongo District to the north, Talensi and Nabdam Districts to the south and east, and Navrongo Municipality Kassena-Nankana West District to the west (MoFA, 2025). It is 729 square kilometers in size. The municipality, which is located at latitude 10°47′N and longitude 0°51′W, has mild slopes between 1% and 5%, with isolated rock outcrops and uplands having slopes greater than 10%. Yikene and Winkogo/Awaredone, two peri-urban areas, are experiencing substantial urbanization (Bolgatanga Municipal Assembly, 2025). With a wet season from May to October and a dry season from October to April, the region has a tropical climate. In addition to maximum temperatures of 45°C in March and April and minimum temperatures of 12°C in December, the average annual rainfall is 950 mm (MoFA, 2025). Shea nut, dawadawa, baobab, and acacia trees predominate in the Guinea Savannah woodland environment. The Bolgatanga municipality is noted for its historical role as a trans-Saharan commercial center (LiquidSearch, 2025). With a population of 142,509 in 2021 (74,659 females (52.4%) and 67,850 men (47.6%)), the municipality is still undergoing urban expansion (GSS, 2021).

The Upper West Region's regional capital, Wa Metropolis, is centrally placed and borders Nadowli District to the north, Wa East District to the east and south, and Wa West District to the west and south (GSS, 2021). It encompasses 579.86 square kilometers, or 6.4% of the region (GSS, 2021). Wa is a transportation hub with important roads connecting it to Hamile, Tumu, and the Upper

East Region. It is located at latitude 10°4′N and longitude 2°30′W (Tourism Resources Information Centre, 2025). The peri-urban areas of Kpongu and Bamahu are rapidly becoming more urbanized (Wa Municipal Assembly, 2025). With a wet season from May to October and a dry season from November to April, the city has a tropical climate. In addition to maximum temperatures of 40°C in March and April and minimum temperatures of 15°C in December, the average annual rainfall is 950mm (GSS, 2021). Shea nut, baobab, and acacia trees predominate in the Guinea Savannah woodland that makes up the vegetation (Aabeyir, 2012). Historically, the Wa metropolis serves as both administrative and commercial hub in the Upper West region (Tourism Resources Information Centre, 2025). As at 2021, the population of the region stood at 200,672, with 105,342 being females (representing 52.5%) and 95.330 men (representing 47.5%) (GSS, 2021).

Across the three regions, the main economic activities of most inhabitants is crop and livestock production (MoFA, 2025). Vegetables such as tomato and others are produced in larger quantities in the Upper East region, supporting processing businesses. Subsistence agriculture is associated with the Upper West region (Modern Ghana, 2025). Popular livestock include cattle, sheep, goats and poultry are reared in all three regions, northern region being the leading producers of cattle mainly due to the availability of vast grazing land (DFID Ghana MADE Programme, 2025; Afribary, 2021). Other commercial activities such as basketry, ceramics and leatherwork are mainly associated with Upper East region (MoFA, 2025).

The Guinea Savannah vegetation covers the three regions, composing of grasslands interspersed with trees that are characteristically resident to drought (Mensah *et al*., 2023). Shea nut, baobab, dawadawa, and neem trees are abundant in the Upper West Region and can be used as building materials, fuel, and charcoal (Modern Ghana, 2025). In order to increase soil fertility, farmers in the Upper East Region include cashew, mango, pawpaw, and moringa into the Sudan Savannah's grasses, bushes, and sporadic trees (Springer, 2020). Harmattan winds have a more detrimental effect on vegetation growth in the Northern Region than in the other two. However, its Guinea Savannah woodland supports shea nut, baobab, and acacia trees, which are economically valuable (Mole National Park, 2025).

All three regions share a strong agricultural base, with crop farming and livestock rearing as dominant activities. They also have Guinea Savannah vegetation, though with slight variations in tree cover. The Upper East Region has a stronger presence in handicrafts and agro-processing, while the Northern Region leads in cattle rearing and cross-border trade.

Despite their differences, these regions collectively contribute significantly to Ghana's agricultural economy, supporting food production, trade, and rural livelihoods. Figure 3.1 presents the geographical map of the study cities and the selected peri-urban communities as well.

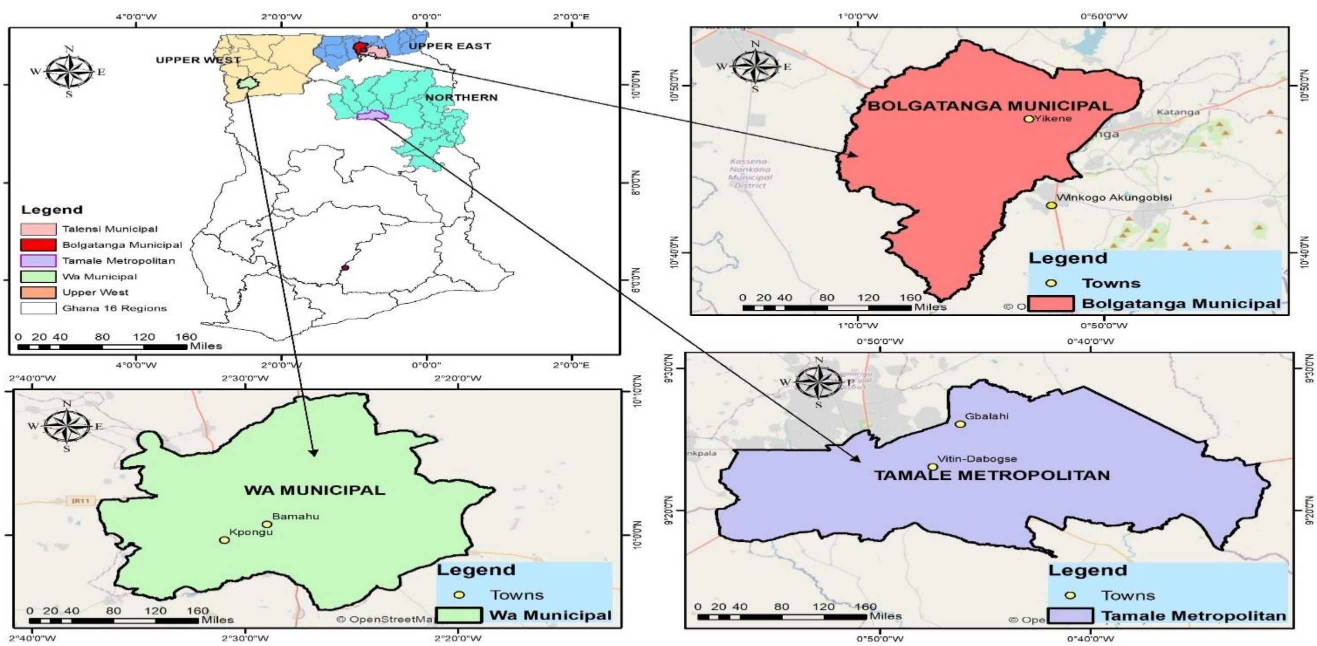

Figure 3. 1: Map of the Study Area

3.3 Research Design

A research design provides the overall blueprint that guides how a study answers its research questions and establishes the basis for drawing empirical conclusions. It specifies the logical structure for comparing groups, identifying relationships between variables, and determining how evidence will be used to address the research objectives (Creswell, 2009; Johnson & Christiansen, 2014).

This study adopts a *quasi-experimental research design* to examine how urbanization-induced agricultural land loss affects household food security and welfare among peri-urban farming households in Northern Ghana. A quasi-experimental design is appropriate when the researcher cannot randomly assign participants to treatment and control groups but seeks to estimate causal relationships by comparing naturally occurring groups (Shadish, Cook, & Campbell, 2002; Angrist & Pischke, 2009). In the context of this study, urban expansion functions as a natural intervention, where some households experience agricultural land loss while others do not.

The design therefore relies on a comparison framework between two groups of farming households:

Land Loss Households (LLHs) – households that have lost part or all of their agricultural land due to urban expansion.

Non-Land Loss Households (NLHs) – households that have not experienced agricultural land loss during the same period.

The *unit of analysis* is the farming household. Land loss is defined as the reduction or complete conversion of farmland previously used for agricultural production into non-agricultural urban uses. Households were classified into the two groups based on whether they experienced such land conversion over the past three decades, which corresponds with the period of accelerated urban expansion in the study areas.

The comparison between LLHs and NLHs provides the analytical basis for assessing how urbanization-induced land loss relates to differences in household food security and welfare outcomes. While this design allows for structured comparison between affected and unaffected households, the absence of random assignment means that causal interpretations must be made with caution. Potential differences between the groups may also reflect underlying socio-economic or institutional factors that cannot be fully controlled in a non-experimental setting.

Within these limits, the quasi-experimental framework provides a suitable approach for examining the implications of urban expansion for peri-urban agricultural households and generating empirically grounded insights into its effects on food security and welfare.

3.3.1 Study Philosophy

A positivist research philosophy is the premise of this study because reality can be identified, observed, and measured using empirical and scientific techniques (Saunders, Lewis, and Thornhill, 2019). The principle of positivism is that one can obtain knowledge through observable facts and that it can be scientifically investigated as social phenomena (Creswell, 2014). Positivism as a philosophical doctrine is traced back to Auguste Comte, who believed that knowledge has to be produced by systematic observation, measurement, and empirical validation instead of interpreting it subjectively (Bryman, 2016).

The positivist philosophy fits the study as it aims to investigate how agricultural land loss caused by urbanization affects peri-urban household food security and well-being using objectively measurable variables. They include variables like farmland size, maize yield, Food Consumption Score (FCS), and Household Food Insecurity Access Scale (HFIAS) which can be quantified and empirically tested to determine the relationship between the loss of farmlands and the outcomes of household welfare. Positivism embraces the fact that a structured collection of data and quantitative analysis are necessary to test hypotheses and develop empirical relationships between variables (Saunders et al., 2019; Creswell, 2014).

Moreover, the methodology of positivist studies focus on statistical and econometric methods of testing theoretical assumptions and generating generalizable conclusions (Wooldridge, 2020). Residual Quantile Regression and Extended Ordered Probit Models are the typical econometric models used in this research to quantify the impact of farmland loss on the outcomes of the household food security and welfare. These methods align with the positivist principle that relationships between variables can be objectively measured and statistically tested using empirical data (Greene, 2018). Quantitative models are more objective and increase the dependability and validity of the results (Bryman, 2016).

Furthermore, positivism presupposes that social and economic phenomena have systematic and predictable patterns that can be defined with the help of empirical research (Creswell, 2014). This assumption is relevant to the present study, as the relationship between farmland loss and household food security is expected to follow measurable patterns that can be estimated using quantitative methods. The use of econometric methods of household level data will produce objective evidence with regard to the extent and distributional impact of loss of farmlands on household crop production and welfare outcomes.

The positivism philosophy adoption also contributes to the improvement of the replicability, objectivity, and generalizability of the research findings (Saunders et al., 2019). Standardized indicators like FCS and HFIAS together with the strict econometric analysis provide the study with the assurance that it yields reliable and policy-applicable evidence. This approach is particularly important for informing urban land use planning, agricultural protection policies, and food security interventions in peri-urban areas of Northern Ghana..

On the whole, the positivism research philosophy offers a suitable platform to objectively study the causal impact of the loss of farmland on the peri-urban household food security and welfare based on quantitative data and econometric statistics.

3.4 Analytical Frameworks of the Study

In order to bring clarity to the path of analysis in this study, respective analytical frameworks or models relating to each of the study objectives' is discussed. These analytical frameworks include the Qunantile Treatment Effects models, Extended Ordered Probit, Multivariate Regression models and Principal Component Analysis; relating to the analysis of the factors that influence household perceptions of the impact of urbanization on household welfare are also discussed.

3.4.1 Analytical Framework of the Quantile Treatment Effects (QTEs) Regression

Quantile Regression (QR), introduced by Koenker and Bassett in 1978, is a robust statistical method used to model and analyze the conditional distribution of a response variable across various quantiles. Due to its powerful and intuitive nature, quantile treatment effects estimation provides an opportunity for researchers to discover the effects on the whole distribution of the outcome variable (Frölich & Melly (2010).

Until recently, over 90% of most applied econometrics have always concentrated on mean effects, even though the distributional impacts cannot be underestimated. It is important to emphasize that the distribution of the outcome variable could possibly change in several ways that are unlikely to be known or are partially revealed when examination is made on averages. For this and many other considerations most applied economists as well as policy think tanks are becoming increasingly interested in the distributional impacts rather than relying only on the mean or average effects. For the purpose of comparison, the ordinary least squares (OLS) concentrates only on the conditional averages, whereas QR offers a more detailed depiction of the whole of the distribution. Since average treatment effect is one overall summary information, QTEs enable researchers to delve into how treatments influence individuals differently, which is imperative to capture heterogeneity (Fro lich & Melly, 2010). This renders QR useful in capturing the subtle variations in distribution, shape, spread, and location to provide more than just central tendency of data. It also offers a deeper insight, including finding out whether the treatment effects are different among individuals who are more or less predisposed to some outcomes. This is the concept that unconditional quantile treatment effects (QTEs) as describe in Firpo (2007).

Because quantile regressions are of different types, the decision as to which quantile treatment effect regression approach to use would be based on the form of endogeneity or heterogeneity relative to the variable of interest (treatment) and the estimand. Specifically, there are four distinct scenarios, distinguished by whether the effects are conditional or unconditional and whether selection occurs based on observables or unobservable. Conditional quantile treatment effects

(QTEs) are defined relative to the values of the regressors, whereas unconditional effects represent the overall causal influence of a treatment across the entire population. Selection based on observables is commonly known as the matching assumption or exogenous treatment choice (exogenous given X). Conversely, selection influenced by unobservables is referred to as endogenous treatment choice (Frölich & Melly, 2010).

To estimate conditional quantile treatment effects (QTEs) under the assumption of exogenous treatment (conditional on X), the quantile regression estimators introduced by Koenker and Bassett (1978) can be utilized. However, the instrumental-variable (IV) method proposed by Abadie, Angrist, and Imbens (2002) can be used to estimate conditional QTEs if the treatment is endogenous.

A number of approaches have been put forth for unconditional QTEs with an exogenous treatment, such as those by Firpo (2007), Frölich (2007a), and Melly (2006). The weighted estimator from Firpo (2007) is presently being used. The method created by Frölich and Melly (2008) can be used to estimate unconditional QTEs when the treatment is endogenous. While conditional estimators need a parametric constraint to get the $\sqrt{n}$ convergence rate, unconditional estimators do not rely on parametric functional form assumptions. The emphasis is on parametric (linear) estimators for conditional QTEs, which are more useful for applied economics, because non-parametric techniques present dimensionality issues.

3.4.2 Estimation Framework Quantile Treatment Effect Models

The analysis situated within the QTEs context by concentrating on comprehending the influence of a binary treatment variable D on a continuous outcome variable, in accordance with Friedlich and Melly (2010). Two possible outcomes are defined for each individual: Y_i^1, which denotes the outcome if the person receives treatment (1), and $\mathrm{Y_i^0}$ which denotes the outcome in the absence of treatment (0). The observed outcome, $\mathrm{Y_i}$, can be written as:

$$\mathrm{Y_i} = \mathrm{Y_i^1 D_i} + \mathrm{Y_i^0}(1 - \mathrm{D_i})$$

The full distribution functions of $\mathrm{Y_i^1}$ and $\mathrm{Y_i^0}$ are identified and estimated as part of the process, with a focus on quantile treatment effects (QTEs), which offer an intuitive overview of the treatment's distributional influence.

In real-world situations, the outcome and treatment variables are frequently accompanied by additional features X. This allows QTEs to be defined either conditionally, based on covariates, or unconditionally, considering the population as a whole. Addressing the treatment choice, the framework distinguishes between selection based solely on observables and selection influenced by unobservables.

3.4.3 Conditional Exogenous Quantile Treatment Effects (QTEs)

Under the conditional exogenous scenario, the analysis begins with the standard framework of linear quantile regression, which models conditional effects under the assumption of selection based on observables. In this setup, Y is assumed to have a linear relationship with X and D.

Assumption 1. *Linear model for potential outcomes*

$$Y_i^d = X_i\beta^\tau + d\delta^\tau + \varepsilon_i \text{ and } Q_{\varepsilon_i}^\tau = 0$$

for $i = 1, \ldots, n$ and $d \in (0, 1)$. $Q_{\varepsilon_i}^\tau$ represents the τth quantile of the unobserved random variable ε_i. β^τ and δ^τ represent unknown parameters to be estimated. Specifically, δ^τ is the conditional quantile treatment effects (QTEs) at quantile τ. Here, the linearity assumption alone is insufficient to identify quantile treatment effects (QTEs), as the observed D_i could be correlated with the error term (ε_i). To address this, it is assumed that both D and X are exogenous.

Assumption 2. *Selection on observables with exogenous X*

$\varepsilon \perp\!\!\!\perp (D, X)$

The assumption $\varepsilon \perp\!\!\!\perp (D, X)$ states that the error term is independent of both treatment assignment D and covariates X. When combined with Assumption 1, this implies that the conditional quantile function of Y, given X and D, follows: $Q_Y^\tau | X, D = X\beta^\tau + D\delta^\tau$

This structure allows us to recover the unknown parameters of the potential outcomes from the joint distribution of the observed variables $Y, X, and\ D$.

3.4.4 Conditional Endogenous Quantile Treatment Effects (QTEs)

Treatment D is self-selected and possibly endogenous in many situations, suggesting that both the treatment assignment and the outcome may be influenced by unobserved factors. Therefore, if all pertinent factors are not observed, Assumption 2 might not hold. In these situations, an instrumental variable identification technique would be required to recover the genuine effects because the conventional quantile regression estimator would be biased. In order to solve this problem, we suppose that there is a binary instrument Z that permits two possible treatments, represented as D_z. The IV assumption, as described by Abadie, Angrist, and Imbens (2002), can then be used to guarantee accurate quantile treatment effect detection.

Assumption 3: Instrumental Variable (IV) Assumption

The instrument Z meets the requirements for identification for nearly all values of X, guaranteeing that the relationship between D and Y is appropriately taken into consideration. Under the IV framework, this assumption permits the use of Z to define possible treatments, D_z, and extract the genuine quantile treatment effects.

To put it simply, for nearly all values of X:

$$(Y^0, Y^1, D_0, D_1) \perp\!\!\!\perp Z|X$$

$$0 < P_r(Z = 1|X) < 1$$

$$E\,(D_1|X) \neq E(D_0|X)$$

$$P_r(D_1 \geq D_0|X) = 1$$

This assumption is generally accepted premise which implies that no individual acts as a defier and requires monotonicity. Additionally, a conditional independence requirement must be met by the instrumental variable (IV). Individuals for whom the treatment status increases due to the instrument are classified as compliers, as treatment effects can be identified only within this group.

3.4.5 Unconditional Quantile Treatment Effects (QTEs)

The estimators discussed earlier focused on conditional treatment effects, meaning they were analyzed based on a specific set of covariates. Now, to unconditional QTEs, which offer certain advantages over conditional effects. The unconditional QTE (for quantile τ) can be specified as:

$$\Delta^{\tau} = Q^{\tau}_{Y^1} - Q^{\tau}_{Y^0}$$

The definition of unconditional QTE remains unchanged regardless of the choice of covariates X. Although the goal is to estimate the unconditional effect, covariates X are still incorporated for two main reasons. First, they help strengthen the plausibility of identification assumptions. Second, they enhance estimation efficiency. Thus, covariates X are included in the initial regression step and subsequently integrated out. However, the unconditional QTE itself does not depend on the covariates, making it more robust compared to conditional QTEs, which vary with the choice of conditioning variables even when covariates are not necessary to satisfy the selection-on-observables or instrumental variable (IV) assumptions.

3.4.6 Unconditional Endogenous Quantile Treatment Effects (QTEs)

First, an examination can be done under the scenario where treatment is endogenous, using a binary instrumental variable (IV) Z. This framework also encompasses the case of an exogenous treatment as a special instance, where the instrument coincides with the treatment $Z = D$. Frölich and Melly (2008) demonstrated that $\Delta^{\tau}$for compliers can be identified under a slightly relaxed version of Assumption 3. Based on this, they introduced an estimator designed to recover the quantile treatment effects in this setting:

$$(\hat{\alpha}_{IV}, \hat{\Delta}_{IV}) = \underset{\alpha,\Delta}{argmin} \sum W_i^{FM} \times \rho_\tau(Y_i - \alpha - D_i\Delta) \quad [1]$$

$$W_i^{FM} = \frac{Z_i - P_r(Z=1|X_i)}{P_r(Z=1|X_i)\{1-P_r(Z=1|X_i)\}}(2D_i - 1)$$

This estimator applies a bivariate quantile regression framework with weighted adjustments. It is clear that $\alpha_{IV} + \Delta_{IV}$ is only found in observations with $D = 1$, whereas α_{IV} is only seen in cases with $D = 0$. Consequently, this method is essentially the same as carrying out two independent univariate weighted quantile regressions, one for the treated group $D = 1$ and another for the untreated group $D = 0$.

3.4.7 Unconditional Exogenous Quantile Treatment Effects (QTEs)

Given the covariates X, it is assumed that the treatment in this instance is exogenous. This condition, known as the selection on observables assumption, indicates that all possible confounding factors are taken into consideration within X. Furthermore, it must be assumed that the variables' support does not change between treatment groups. This guarantees that the conditional distribution can be calculated in a nonparametric framework without necessitating extrapolation outside of the observed range of covariates.

Assumption 4. *Selection on observables and common support*

$$(Y^0, Y^1) \perp\!\!\!\perp D|X$$

$$0 < P_r(D = 1|X) < 1$$

According to earlier research by Firpo (2007), Frölich (2007a), and Melly (2006), this assumption makes it possible to identify unconditional quantile treatment effects (QTEs). Interestingly, the treatment variable itself serves as its own instrument in Firpo's (2007) estimator, which is a particular case of estimator (4). Therefore, the weighting estimator for Δ^τ is;

$$\left(\hat{\alpha}, \hat{\Delta}^\tau\right) = \underset{\alpha,\Delta}{argmin} \sum W_i^F \times \rho_\tau(Y_i - \alpha - D_i\Delta) \qquad [2]$$

$$W_i^F = \frac{D_i}{P_r(D=1|X_i)} + \frac{1-D_i}{1-P_r(D=1|i)}$$

This method is based on the classic propensity-score weighting methodology, often known as inverse probability weighting. An initial estimate of $P_r(Z=1|X)$ is needed in order to implement the estimator. To get these initial probabilities, the ivqte technique uses the local logit estimator.

3.4.8 The Residualized Quantile Regression (RQR) Model

To estimate Quantile Treatment Effects (QTEs), the Residual Quantile Regression (RQR) approach uses a two-step process. To eliminate confounding, the treatment variable is first decomposed into two parts: a residual part that is independent of the observed control variables and a systematic part that is explained by them. Based on this decomposition, a bivariate quantile regression model is used in the second phase to estimate the QTE. Both confounding variables and random factors contribute to the variance in the treatment variable under the assumption of selection on observables.

Let E_i represent any other factors impacting the treatment, including random noise, and C_i represent the observed factors that concurrently affect the treatment and the outcome (i.e., the confounders).

$$T_i = f(C_{i,} E_i) \qquad [3]$$

The treatment variable T_i is broken down into two components: a residual component E_i and a component explained by the observed confounding variables C_i.

Assume the following data-generating procedure, where x_i is an observed confounder, e_i takes into account all other factors impacting the treatment, and T_i represents the treatment variable.

$$T_i = \delta_0 + \delta_1 x_i + e_i \qquad [4]$$

In this case, the treatment variable T_i only experiences linear position shifts due to the confounder x_i. The residuals $\widetilde{T}_i$ can be calculated using this streamlined data-generating procedure.

$$\tilde{\widetilde{T}}_i = T_i - \hat{T}_i = \delta_0 + \delta_1 x_i + e_i - \delta_0 - \delta_1 x_i = e_i \qquad [5]$$

by estimating simple ordinary least squares (OLS).

The decomposition of the treatment variable into two components; the part explained by $x_i(\widehat{T}_i)$ and the residual piece that is orthogonal to any function of $x_i(\widetilde{T}_i)$, will be the analysis's main takeaway.

The Conditional Expectation Function Decomposition property is the foundation of this decomposition (Cunningham, 2020, p. 56). It looks at the conditional expectation of the residuals T_i to show that, if the model is correctly specified, the residual component is mean-independent of x_i, derived from regressing $T_{i,}$ on x_i, given the observed control variable x_i:

$$E(\tilde{T}_i|x_i] = E(T_i - E(T_i|x_i]|x_i] = E(T_i|x_i] = 0 \quad [6]$$

When the model is correctly specified, the treatment residuals are mean-independent of the confounder x_i and any function thereof, such that $x_i(h(x_i)): E(h(x_i)\tilde{T}_i) = 0$. Consequently, the covariance between the residuals and the confounder, $Cov(\tilde{T}_i x_i) = 0$ is also zero. In this particular instance, where the confounder simply modifies the treatment's mean, the residuals are independent of the confounder at both the mean level and all higher-order moments. The decomposition becomes more complex if the confounder affects additional features of the treatment distribution, such as its variance. However, as explained in the following section, it may be demonstrated that treatment residuals stay independent of possible outcomes by utilizing the decomposition property and assuming selection on observables.

For this study the Residualized Quantile Regression (RQR) is applied to estimate the effect of farm land loss on staple maize yield. A novel technique called Residualized Quantile Regression (RQR) was developed to effectively estimate unconditional QTEs while resolving the drawbacks of previous models. The Residualized Quantile Regression (RQR) model is a useful addition to the quantile regression framework since it provides a number of noteworthy advantages over current Quantile Treatment Effect (QTE) estimating techniques. The ability of the RQR model to include high-dimensional fixed effects in the estimation of unconditional QTEs is one of its most notable features. In addition, the RQR model is computationally efficient, allows binary as well as non-binary treatment variables and is easy to run using software with conditional quantile regression

(CQR) or linear programming applications. In particular, it resolves the issue of potential sample heterogeneity, which influenced the decision to use RQR in this investigation.

A substitute for the widely used Unconditional Quantile Regression (UQR) model developed by Firpo *et al*. (2009) is the RQR model. Although the UQR model has been adopted by many, especially in disciplines such as sociology (Budig & Hodges, 2014; Cooke, 2014), educational science (Porter, 2015), and econometrics (Havnes and Mogstad, 2015), its initial idea was to investigate the effect of independent variables on the total quantile values. This often creates a mismatch between the UQR model employed in many studies and the research aim of identifying QTEs (Borgen *et al*., 2022). Such inquiries would be better addressed through a fast and intuitive model like RQR.

3.5 Analytical Framework of Farm Land Loss on Household Food Security

Agricultural production remains the main source of rural livelihoods, and is, however, closely linked to food security through various indicators, for example food self-sufficiency (SSF). The degree of self-reliance in food mostly depends on available land for agricultural purposes, especially in rural and peri-urban centres where agriculture dominates and market access for food purchases is limited. The conversion of farmlands into urban development threatens food self-sufficiency, thwarting food security and economic stability efforts of affected communities. The World Food Programme (WFP) Annual Report 2009 clearly states that urban growth is a key driver of food insecurity challenges as it cuts down the area of land available for cultivation. Additionally, Duangklad (2010) and Pieters *et al.* (2013) highlight the importance of land availability in ensuring food self-sufficiency, particularly in regions where agriculture is the dominant livelihood activity.

Reliable metrics that capture both production and access dimensions are necessary for evaluating food security in light of these problems. Therefore, this study utilized the FCS and HFIAS as primary indicators, enabling a comprehensive evaluation of how agricultural land availability impacts food production at the household level.

According to Sen (1981), we can assume that FS_i as a vector of HFIAS and FCS is also a function of agricultural land loss to urbanization and vectors of some other characteristics X_i which can be specified as $FS_{IJ} = \alpha_j X_i + \beta_i ALL_i + \varepsilon_{ij}$ [7]

Where FS_i is a vector of food security indicators (represented by HFIAS and FCS) for household i; ALL_i is a vector of the form of agricultural land loss (ALL); X_i is a vector of some other characteristics; α_j and β_i are the respective coefficients to be estimated; and ε_{ij} represents a random term.

3.5.1 Household Food Insecurity Access Scale (HFIAS)

The Household Food Insecurity Access Scale (HFIAS) is the second most significant measure of food security. The quantity and quality components of food access are closely related, according to Leroy *et al.* (2015). A household's opinion of their own diet over the last 30 days is called the HFIAS. By definition, it is a continuous variable that gauges a person's access to food security. According to Mango *et al*. (2014), the HFIAS indicator is predicated on the idea that households face food insecurity as a result of predictable responses that can be recorded and converted into a score. The score shows how frequently meals are skipped and less desired foods are consumed. To measure HFIAS, the current study will use the methodology of Swindale and Bilinsky (2006), Makate *et al*. (2016), and Mango *et al*. (2014). The first strategy was to record the answers to the occurrence questions in order to gauge the degree of rising food insecurity. Information was gathered from respondents using the nine questions about food insecurity. The reference period was the 2023–2024 cropping season, and it reflected the following: anxiety about food adequacy (denoted as (AFA Q1), eating less-preferred foods (ELF Q2), eating foods of limited variety (ELV Q3), being unable to eat even less-preferred foods (IELPF Q4), eating smaller meals than necessary (ESM Q5), eating fewer meals in a day (EFM Q6), failing to obtain food of any kind (FFK Q7), going to bed hungry (GH Q8), and going the entire day or night without eating anything (GDNEA Q9). The HFIAS was determined by adding the scores obtained from the answers to these questions.

HFIAS=(AFA Q1)(F1)+ (ELF Q2)(F2)+ (ELV Q3)(F3)+ (IELPF Q4)(F4)+ (ESM Q5)(F5)+ (EFM Q6)(F6)+(FFK Q7) (F7) + (GH Q8) (F8) + (GDNEA Q9) (F9). [8]

where F stands for how frequently a specific situation occurred over the preceding 30 days.The description of the conditions will take three forms namely; rarely, sometimes, and often. For a household to attain a minimum HFIAS must assume a value of zero and is gotten when a household respond is 'no' to occurrence and frequency of occurrence. When a household answers "often" to questions regarding the rate of occurrence and "yes" to all questions about occurrence, the greatest score is 27.

Considering that agriculture is the major livelihood activity, accounting for more than 57% of the households and directly linked to land (MoFA, 2013b), it's obvious that agricultural land loss due to urbanization will result in the occurrence of food insecurity situations described above. Variations in circumstances, such as shifts in dietary preferences, meal frequency, and food variety, particularly in areas where food consumption is directly related to agricultural output (Abdul-Hanan, 2021).

3.5.2 Food Consumption Score (FCS)

Yet another food security indicator is food consumption score recommended by the World Food Programme (WFP, 2009b) and supported by Leroy *et al.* (2015). A number of studies (for example;

Alamirew, Grethe & Wossen, 2015; Shiferaw, Menale Kassie, 2014; Makate *et al*., 2016; Mango *et al*., 2014; etc.) have used FCS to analyze food security situations among households. Dietary diversity, energy, and the macro and micro values of the food consumed are all reflected in FCS. The frequency or quantity of food categories consumed by an individual in a household throughout a reference period, typically seven days, is recorded in order to quantify FCS as a continuous variable. The FCS indicator takes into account nine food groups in its measurement (WFP, 2008, 2009b) which include : (1) Cereals and tubers which constitute food items such as maize, rice, sorghum, millet, bread, other cereals, cassava, potatoes and sweet potatoes; (2) Pulses such as beans, peas, groundnuts and cashew nuts; (3) Vegetables such vegetables, relish and leaves; (4) Fruits (5) Meat and Fish including beef, goat, poultry, pork, eggs and fish; (6) Milk including milk, yoghurt and other dairy products; (7) Sugars including sugar and sugar products, and honey (8) Oil such as oils, fats and butter; and (9) Condiments such spices, tea, coffee, salt, fish powder, small amounts of milk for tea. To calculate the score, each food group's frequency is multiplied by a predefined weight. The scores are added up to create a single composite score, which is used to calculate the FCS. FCS was computed using the following formula below:

$$FCS_i = \sum_{i=1}^{n} A_i B_i \quad [9]$$

where n is the number of food groups taken into consideration in the FCS calculation, A_i indicates the frequency of food consumption of food group i over the previous seven (7) days, B_i is the weight assigned to food group i indicating its relative nutritional value, and FCS_i reflects the food consumption score.

3.5.3 Choice of Explanatory Variables

The variables used to estimate how agricultural land loss due to urbanization affects food security were derived from both survey data and previous research. Table 3.4 presents the the variable definition or measurement approach.

3.5.4 Hypotheses to be tested

The following hypotheses were tested based on the entitlement approach propounded by Sen's (1981a) under situations of starvation and famines to establish the relationship between urbanization and agricultural land loss and food security, that;

I. H_1 =Land loss households and indirect land loss households will experience decreases in food consumption score (FCS).

II. H_2 =Land loss household and non-land loss households will experience increase in food insecurity access scale (HFIAS).

3.6 Analytical Framework of Urbanization and Household Welfare

Urbanization is a critical driver of socio-economic transformation, influencing household welfare through changes in livelihood opportunities, access to resources, and land use dynamics. Understanding perceptions of its impact requires a structured analytical approach that captures key dimensions of household welfare. Principal Component Analysis (PCA) is used in this study to identify the primary components that represent household welfare indicators from Likert scale survey responses on the consequences of urbanization. Principle Component Analysis (PCA) is a technique that frequently makes use of standard mathematical ideas to convert a collection of potentially linked variables into a small number of uncorrelated variables known as principle components. The method's capacity to simplify datasets while preserving nearly all of the original data has led to it being referred to as "one of the key outcomes of applied linear algebra" (Jolliffe & Cadima, 2016).

The principal effect of PCA is to dimensionally reduce large data sets for effective analysis. This is especially helpful when dealing with a large dataset. By transforming the original data into a space with fewer dimensions, PCA allows the scientists to unveil the hidden characteristics, the general behavior, and the points that deviate from the rest of the data more efficiently than if they had worked with the source data (Shlens, 2014). In addition, PCA enables signal processing for de-noising signals that blind source separation as well as data compression. As far as the financial sector is concerned, it ensures portfolio optimization by minimizing complexity of stock correlations, whereas in neurology its function is to support the detection of the nervous system activity pattern (Wold, Esbensen & Geladi, 1987).

PCA's capabilities have been expanded by recent advancements that include robust PCA methods to manage missing data, sparse PCA for feature selection, and kernel PCA for nonlinear transformations. The developments keep on revitalizing the effectiveness of PCA in modern data-driven applications (Zhang & Liang, 2021).

3.7 Types and Sources of Data

Both quantitative and qualitative data were gathered for the study. Both primary and secondary data sources were used to gather these information. Household semi-structured survey questions and interview guides were used to collect data from primary sources. The questionnaires administration was done through face-to-face interview with the identified households. Each peri-urban community had one focus group discussion with the goal of gathering qualitative information to supplement the information obtained from the household questionnaire and to act as a triangulation method to guarantee the validity of the data. The key data sources were designed to make accurate and access to reliable information pertinent to the study. Thirdly, geographical information system (GIS) approach was used to estimate the extent of peri-urban farm land loss to urbanization.

Secondary data were also collected to compliment the primary data. Secondary data sources included MMDAs on Urban Development, Land Commission, Land Survey Department, Department of Agriculture, Town and Country Planning Department Units of Tamale, Bolgatanga and Wa, Google Scholar, Research Gate, Books, Journals and Research Reports. These data were intended to provide relevant secondary information to facilitate the realization of the research objectives.

3.7.1 Target Population and Sample Size

The target population of the study included all farm households in the study cities. As at 2019, the total agricultural households engaged in crop production for the three cities in the respective regions was 455,504 (i.e Northern with 230,452; Upper East with 143800 and Upper West with 81251) GSS (2019). It is crucial to note that livestock households were not included in this study because the focus was on households that produce staple crops. Out of the target population, the sample size was determined based on the estimation method propounded by Yamane (1967) and cited in Visco (2008). Agricultural peri-urban farming households in the study's geographic regions made up the sample. The analytical unit was therefore those farming peri-urban households that lost their farmlands to urbanization refers to as the 'Land lost Households (LLH)' and those other households not affected also refers to as 'Non-land lost Households (NLH)'. In all, a total of 400 of 'Land lost Households (LLH)' and 'Non-land lost Households (NLH)' from the target population participated. The basis for settling on the sample size was that it satisfied the statistical requirement of 5% with 95% confidence level acceptable for this study and also for financial reasons. The sample size was determined according to Yamane, (1967) and cited in Visco (2008) as follows;

$$n = \frac{N}{1+N(e)^2} \qquad [10]$$

where n is the sample size or the total number of agricultural households used for the study, N (N=455,503) is estimated total population size and *e* represents the margin of error or the acceptable level of precision. By way of substitution, the sample size (*n*) becomes;

$$n = \frac{455503}{1+455503(0.05)^2}=399.65 \text{ or } \sim 400 \qquad [11]$$

Although the initial sample size derived from the candidate formula yielded a minimum sample below 400, the final sample size was adjusted upward to 400 farming households to ensure adequate statistical power and robustness of the empirical analysis. Increasing the sample size improved the ratio of observations to predictors, thereby reducing the risk of Type II errors and enhancing the precision and stability of parameter estimates. Larger samples are also recommended to ensure reliable inference and meaningful detection of effects (Joseph *et al.*, 2014).

Furthermore, the upward adjustment accounted for potential data losses arising from non-response and incomplete questionnaires, while still maintaining sufficient degrees of freedom for diagnostic and robustness testing. Consequently, the adjustment of the sample size to 400 is statistically justified on the grounds of improved power, estimation accuracy, and overall analytical rigor.

3.7.2 Sampling Procedure

The sampling method adapted in the study was a multi-stage sampling procedure, with a reduction process to progressively narrow the target population from cities to communities and ultimately to individual farming households. This approach ensured that the selected sample adequately represented peri-urban households experiencing varying levels of exposure to farmland loss resulting from urban expansion.

The purposive selection of three secondary cities in the North Ghana, i.e. Tamale, Wa and Bolgatanga was made in the first stage. These cities were chosen because they are experiencing rapid urban growth characterized by the expansion of built infrastructure into surrounding peri-urban areas, leading to the conversion of agricultural land to residential and commercial uses.

At the second stage, two peri-urban communities in each city were selected purposively, resulting in a total of six study communities. The selection of communities followed the reduction process described by Abdul-Hanan (2021), which involves identifying localities where urban expansion has significantly affected agricultural land. A scoping exercise was conducted in each city to identify communities that best represent land-loss households (LLHs). The identification of these communities relied on information obtained from key informants, including assembly members, traditional leaders, community elders, women leaders, staff of the Ministry of Food and Agriculture (MoFA), and officials from the Metropolitan, Municipal and District Assemblies (MMDAs). These stakeholders provided insights into areas where farmland conversion due to urbanization was most pronounced while also identifying communities where farming activities were still ongoing.

Following the selection of the communities, community entry activities were conducted to introduce the research team and explain the objectives of the study. Community forums were subsequently organized in each selected community. These forums involved traditional farmers and long-term settlers who shared their experiences regarding changes in land use patterns over the past three decades and discussed the perceived impacts of urbanization on livelihoods and welfare. Through these engagements, households that had lost all or part of their farmlands due to urban expansion were identified and compiled into a preliminary household list. At the same time, households that had not experienced farmland loss were also identified. This process helped to establish a comprehensive household listing that captured both land-loss households (LLHs) and non-land-loss households (NLLHs) within the communities. The household listing formed the sampling frame for the household survey and also served as the basis for selecting participants for subsequent focus group discussions.

After the household listing was completed, proportionate sampling was applied to determine the number of households to be selected from each community based on the total number of identified households. This ensured that communities with larger numbers of eligible households contributed proportionately to the total sample.

In the final stage, simple random sampling was used to select the required number of households from the household lists within each community. The lottery method was employed to minimize selection bias associated with non-probability sampling approaches. Under this method, two pieces of paper were used, one marked “Yes” and the other left blank. Eligible households randomly selected the papers, and those who picked “Yes” were included in the survey. The process was repeated until the required number of households was obtained. Both LLHs and NLLHs were randomly selected from the same communities to allow comparison between households affected by farmland loss and those that were not. In total, 400 farming households were selected for the survey. This sample size was considered adequate to support econometric analysis and ensure sufficient statistical power for the models used in the study.

In addition to the household survey, focus group discussions (FGDs) were conducted in each selected community to complement the quantitative data. FGDs provided qualitative insights that helped explain patterns observed in the household survey data, particularly with respect to perceptions of urbanization, farmland loss, food security, and household welfare. Participants for the FGDs were selected using purposive sampling to ensure that individuals with relevant knowledge and experience regarding land use changes in the communities were included. Each focus group consisted of ten participants, including men, women, and youth, to capture diverse perspectives on issues of food security, welfare, and future land use. The inclusion of different gender and age groups ensured that the study incorporated a broad range of community views regarding the impacts of urbanization on livelihoods and agricultural land.

Through this systematic multi-stage reduction process, from cities to communities and finally to households, the study obtained a representative sample of peri-urban farming households experiencing different levels of exposure to farmland loss resulting from urbanization.

3.7.3 Operational Definition and Verification of Agricultural Land Loss

In this study, agricultural land loss refers to the reduction or total conversion of farm land to other uses within the urban area, such as residential, commercial, and infrastructure development.

The households were categorized into two as follows:

Land Loss Households (LLHs): Households that have lost part or all of their farmland to urban encroachment in the last decade.

Non-Land Loss Households (NLHs): Households that have not lost farmland during the same period.

To improve reliability of classification, land loss information obtained from household surveys was cross-checked using community discussions and spatial evidence of land use changes in the study areas.

3.7.4 Data Collection

Generally, issues of land acquisition, holdings and use have always been a sensitive subject to deal with. This therefore require proper procedural approaches which may include getting the consent from the local authorities before embarking on such data collection (Nguyen, 2021). Obtaining information on land acquisition, utilization and its relationship with food security and welfare study has been a major challenge. One of the reasons being that farmers who do not have absolute right to land holdings may be afraid that providing sensitive information could lead to further dispossession of remaining land they are using (Nyantakyi-Frimpong & Kerr, (2016). Knowing the potential challenges, the researcher was likely to face, we ensured that all necessary procedures (such as ethical issues) were adhered to before starting data collection, particularly having in mind the multidimensional nature of food security issues that makes it extremely difficult to obtain complete information about farmers (Abdul-Hanan, 2021).

The main approaches to data collection for this study were household survey, focus group discussions and GIS-remotely sensing. For effective time management, tablets were used to capture the relevant data needed. This was complemented by writing other relevant information on note pads, and a voice tape recorder that household question may not include. The study was designed in a manner that allowed for interaction with participants.

The survey was conducted through in-person interviews with the respondents. To be able to do this effectively, 9 enumerators were recruited, three from each selected city and were trained to be able to administer the questionnaire to selected households. Data collection involved a number of steps to follow. First, all potential peri-urban communities were identified where urban expansion was visible on prime farm lands through literature search and also reconnaissance survey (where meeting with local stakeholders) were held. After the communities of interest were selected and targeted households identified, a pretesting of the questionnaire was done. The pre-testing was necessary as it provided a feedback on the accuracy of questionnaire design, average time spent on administering a questionnaire. Pre-testing also allowed for flaws and other deficiency identification with the questionnaires (Abdul-Hanan, 2021). Neutral communities outside the study communities were ideal for the pre-testing. Two communities, one from each study city was selected for the pre-testing.

Finally, the actual stage of the data collection started after ensuring that all necessary preparations (as mentioned above) were in place. The questionnaire was expected to capture information on urbanization activities, agricultural land loss as results of urbanization, effect of urban expansion on farm size, crop output and so on.

To estimate the consequences of farmland loss on agricultural production, food security status, and household welfare (livelihoods) information were collected from the three areas. This involved first collecting data on crop yields for 2023/2024 cropping season. Secondly, the proportion of land lost from the househlds that lost land (LLHs) was estimated. Then, take current production (yield/output) data from non-land loss households for the estimation.

For information with respect to land use or land use cover changes, the study combined GIS and ground survey to collect data on land use patterns in the last three decades (1994-2024), especially information on land use before and after farm land loss. Finally, information from all actors (gender, different age groups, land owners, state agencies responsible land administration) with regards to land transaction on their perceptions of the positive/negative impacts of farm land loss to urban expansion and its consequences on various sectors of society were solicited. All data for the entire research were collected within four (4) months period, spanning from July to October, 2024. Table 3.1 presents the selected districts, communities as well as the sample size by category.

Table 3. 1: Selected Districts, Communities and Sample Size by Category

District	**Community**	**Land Loss**	**Non-Land Loss**	**Total**
Bolgatanga Municipal	Yikene	56	16	72
Talensi	Awaredone	42	22	64
Wa Metropolis	Kpongu	31	23	54
	Bamahu	41	15	56
Tamale Metropolis				
Tamale south	Wamale	36	17	53
Sagnarigu	Taha	66	24	90

Source: Author's Compilation from field survey, 2024

3.7.5 Instruments for Data Collection

Semi-structured household survey questionnaires were the primary data gathering tools for quantitative data. These questionnaires were uploaded onto the Kobo Collect Toolbox with tablets according to the various sections of the questionnaire. This means that the Kobo Toolbox software compatible with Android tablets of each enumerator was installed.

Various templates on proposed literature (such as FAO, 2008; Makate *et al*., 2016; Mango *et al*., 2014; Swindale & Bilinsky, 2006; WFP, 2009b) for gathering data especially on food security indicators (i.e. FCS, HFIAS) were uploaded on the Kobo Toolbox. Also, information template regarding FCS and HFIAS calculation was installed.

For qualitative data, focus group discussion was used through an interview guide and also a voice tape recorder to capture responses from the participants. The interview guide was an open-ended questionnaires. The questions centered on information from both pre and post survey results where participant were asked to confirm or clarify certain findings from the survey about the various sections (effects of urban expansion on agricultural production, agricultural land loss, food security, household welfare, land use changes, actor's perspectives on land use and urbanization etc.) of the study.

Finally, GIS-remotely sensing procedure was used to capture and measure the various classes of land use (such as built-up, forest and cropland, bare lands and water bodies) contained in a demarcated geographical location.

3.7.6 Data management and Analysis

Data analysis proceeded with the necessary processes needed to ensure that results produced were accurate. Some of these processes included data cleaning, editing and sorting so as to detect missing data, faulty data as well as avoid inconsistencies from the data during data collection. After all checks, the data was imported into STATA 15.0 to analyse and generate the results for interpretation. Data was analyzed base on the thematic areas such as the effects of urbanization on crop (with focus on maize production), extent of peri-urban farm land loss to urban built infrastructure, food security and perception of urbanization impact on household welfare. From the above categorizations, the impact of the both affected and indirectly affected households were analyzed using descriptive statistics, t-test and means of central tendencies. To examine the impact of urban expansion associated with farmland loss, household maize production, food security, and welfare perception, several econometric models including the Residual Quantile regression, extended ordered probit, principal component analysis and multivariate regression techniques were employed. Geospatial analysis was done using GIS software to generate output of various land use classes embedded on a demarcated geographical location. The outcome of the GIS results were the the rate of urbanization (and express as a percentage) over the 30 years period. These models allowed the study to estimate the influence of urbanization-related land loss while controlling for relevant household socio-economic factors.

Data obtained from focus group discussion was coded based on the different topics and then input into STATA 15.0 software for analysis and results presented in percentages and frequencies. Focus group discussion was intended to supplement survey data in order to guarantee consistency and accuracy of the findings.

3.8 Empirical Frameworks of the Study

This section presents the empirical framework used to analyze the effects of peri-urban farmland loss on agricultural productivity, household food security, and welfare outcomes. The choice of empirical models is guided by the research objectives, the nature of the dependent variables, and the structure of the data collected from farming households. The study employed the Geospatial Information System (GIS) -Remotely sensing techniques to quantify the extent of farmland loss to urban built infrastructure.

To examine the effect of farmland loss on agricultural productivity, the study employs residualized quantile regression (RQR) to estimate the impact of farmland loss on maize yield across different points of the yield distribution. This approach allows the analysis to capture heterogeneous effects that may not be observable using conventional mean regression models.

Household food security outcomes are analyzed using an extended ordered probit model, with the Food Consumption Score (FCS) and the Household Food Insecurity Access Scale (HFIAS) used as ordered indicators of food security status. The model is appropriate for handling ordinal outcome variables and allows for greater flexibility in estimating category thresholds.

To analyze household perceptions regarding the welfare implications of urbanization, principal component analysis (PCA) is applied to Likert-scale perception variables in order to reduce dimensionality and extract uncorrelated components representing key perception domains. The resulting PCA components are subsequently used as dependent variables in multivariate regression models to identify the socio-economic factors influencing household perceptions of the impacts of urbanization on welfare.

Together, these empirical approaches provide a coherent framework for examining the multidimensional effects of peri-urban farmland loss on productivity, food security and household welfare.

3.8.1 Empirical Quantification of the Extent of Farmland Loss to Urban Built Infrastructure Over Three Decades

The study evaluated the land use and land cover changes (LULC) in three cities—Tamale, Wa, and Bolgatanga over various time periods using remote sensing and geographic information systems (GIS) methodologies. All of the image pre-processing, processing, and map compositions were done using ArcMap 10.8.2 and the Environment for Visualizing Images (ENVI). Data acquisition, image preprocessing, and image processing are among the procedures utilized.

3.8.2 Data Acquisition

Landsat imagery was acquired from the United States Geological Survey (USGS) website in order to evaluate the changes in land use and land cover of the chosen cities over different time periods. The images obtained from the USGS site covered 3 decades which was from the year 1994 to the year 2024. Since the images were large and covered other places either than our study area, the Ghana Districts administrative boundaries data was obtained from the DIVA-GIS website where the ROI (region of interest) was extracted after all pre-processes were carried out. Table 3.2 below details the information about the images downloaded and processed.

Table 3. 2: Details of Satellite Imagery Acquired from USGS Website

WA MUNICIPAL		
SENSOR TYPE	**PATH AND ROW**	**DATE**
Landsat 5 TM	195,053	1994 - 05 - 16
Landsat 7 ETM	195,053	2004 - 04 - 04
Landsat 7 ETM	195,053	2014 – 02 - 08
Landsat 9 OLI	195,053	2024- 05-10
TAMALE METROPOLITAN		
Landsat 5 TM	194,053	1994 -04-23
Landsat 7 ETM	194,053	2004-04-26
Landsat 8 OLI	194,053	2014-04-17
Landsat 9 OLI	194,053	2024-04-17
BOLGATANGA MUNICIPAL		
Landsat 5 TM	194,053	1994-07-12
Landsat 7 ETM+	194,053	2004-12-22
Landsat 7 ETM+	194,053	2014-18-12
Landsat 8 OLI/TIRS+	194,053	2024-21-12

3.8.3 Pre-Processing

In pre-processing the image, advanced image enhancement processes were performed on the various images in ENVI 5.3. Since Landsat 7 ETM is noted to have scan lines, gap fill was performed on them to do away with the scan lines. In order to improve the accuracies in the DN values and make it easier for them to be transformed into standards that are directly relevant to the study, all the images were further calibrated and then Quick Atmospheric Correction (QUAC) was performed on the images. Layer stacking was applied to each imagery by combining multiple preferred bands together to improve visibility and make them ready for modelling. Finally, our region of interest (ROI) was selected and clipped out using the sub-setting process.

3.8.4 Image Processing

In processing the imagery, the supervised classification utilizing the maximum likelihood algorithm was applied and the procedure executed in the ENVI 5.3 software. The supervised classification is a computer technique for grouping pixels inside an image into specified groups, allowing for the identification and mapping of certain land use and land cover types across a landscape. This study considered four land use and land cover classes: bare lands, water bodies, built-up areas, and forests and croplands. Table 3.3 below gives a description of the various land use and land cover classes.

Table 3. 3: Land use and Land Cover Classes and Description

Land Use/Land Cover Classes	**Description**
Forest and Croplands	Consists of a variety of plant types, such as shrubs, farm crops, woodland patches, etc.
Built-up Areas	It includes a variety of man-made components, such as paved surfaces, housing infrastructure and commercial structures. The natural habitats in this area have been altered by human activity.
Water Bodies	It consists of all forms of water bodies like rivers, lakes, ponds, dams, among others.
Bare lands	It consists of all land surfaces without vegetation. These include degraded lands, gravel pits, individual lands that are yet to be developed, school play grounds, refuse dams etc.

The technique of detecting changes was carried out by subtracting the first year's image from the last year's image after the images were categorized into the predetermined land use and land cover classes. The findings showed how quickly land use and land cover classes have changed over time. Finally, the results of the supervise classification were presented in maps using the ArcGIS 10.8.2 version and the area and percentages per land classes in tables. The change detection results were presented in tables as well.

3.8.5 Empirical Framework of the Effects of Peri-Urban Farmland Loss on Household Staple Crop Production

Estimating the effects of peri-urban farmland loss on crop production can be approached using various econometric methods. The commonly used approach in most impact studies is the average treatment effect, but the type of treatment effect methodology is often dependent upon the research objective. The application of treatment effect in the field of econometrics as other disciplines is crucial because of their pivotal role in establishing the causal effect of an intervention (Sun et al., 2021). The traditional models namely; the Propensity Score Matching (PSM) and the average treatment effect, normally based on the treatments' average effect. As a result, these models often fail to reveal the distributional differences of the response variable, especially in cases where heterogeneity is significant among different subpopulations. In order to address some of the limitations associated with the application of the traditional treatment effect methods, this study utilized the quantile treatment effect technique as it provides a comprehensive and specific results of how the treatment influence the distribution of the outcome variable. The application of the quantile treatment effect is especially appropriate in policy evaluation of interventions that seeks to establish the variations in distributional effects in households' income or productivity scale (Chen *et al*., 2020).

In this study, the residualized quantile regression was applied because of its ability to specifically deal with issues of endogeneity and covariate imbalances. For efficient assessment of the treatment effects devoid of the noises caused by confounding factors, the RQR is an advance strategy over the conventional QTE techniques (Giessing & Wang, 2023)

In the estimation procedure of the RQR, two steps are followed. The process first ensures that all confounding are removed from the treatment variable by decomposing it into two parts in which one is explained by the observed control factors and the second part that is not related these control variables. This process involves estimating the QTE with a bivariate QR regression model following this decomposition.

For the estimation process to adequately identify the QTEs, some fundamental pre-assumptions need to be met. One of such assumptions is confoundedness, which implies that the treatment selection process is appropriately described and which will ensure that all factors influencing the both treatment and the outcome thus confounders are observed. In particular, it is expected that, conditional on the covariates, the possible outcomes are independent of the treatment variable T_i (Assumption 1). This assumption is quite similar to the unconfoundedness assumption put forth by Firpo (2007) and the conditional independence assumption described by Powell (2020).

Assumption 1: Unconfoundedness: $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp T_i | x_i$

The unconfoundedness assumption's fundamental guarantee of possible outcomes' independence from treatment residuals is one of its main implications: $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp \tilde{T}_i$. This means that, conditional on the observed covariates, the treatment residuals do not influence the potential outcomes, maintaining the validity of the decomposition approach. To comprehend this relationship, decompose T_i into two parts: a residual component, $\tilde{T}_i$, and a systematic part, $E[T_i|x_i]$, which is a deterministic function of x_i. The conditional independence assumption can be represented as $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp (E[T_i|x_i] + \tilde{T}_i)|x_i$ based on this decomposition. Since $E[T_i|x_i]$ is fully determined by x_i, it provides no additional information about the potential outcomes once x_i is conditioned on, and can thus be excluded from the independence assumption. Furthermore, $\tilde{T}_i$ is mean-independent of x_i by construction of $x_i(E[\tilde{T}_i|X_i] = 0$. Since it captures the variance in T_i that cannot be explained by $\mathrm{x_i}$. This simplifies the independence assumption from $(\mathrm{Y_{i1}}, \mathrm{Y_{i0}}) \perp\!\!\!\perp \tilde{\mathrm{T}}_\mathrm{i}|\mathrm{x_i}$ to$(\mathrm{Y_{i1}}, \mathrm{Y_{i0}}) \perp\!\!\!\perp \tilde{\mathrm{T}}_\mathrm{i}$.

This reasoning shows that prospective outcomes are inherently independent of the treatment residuals if it is assumed that they are independent of the treatment conditional on the covariates. This independence logically derives from the unconfoundedness assumption.

Specifically, decomposing the treatment into $E[T_i|x_i] + \tilde{T}_i$ and assuming $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp (E[T_i|x_i] + \tilde{T}_i)|x_i$ implies that, after conditioning on x_i, both the systematic component $E[T_i|x_i]$ and the residual $\tilde{T}_i$ are independently unrelated to the potential outcomes. Therefore, the independence of treatment residuals is not an additional assumption but an implicit aspect of unconfoundedness.

However, because unmeasured confounders can skew estimates, the unconfoundedness assumption; that is, selection on observables, is strong. One significant difference from the Conditional Quantile Regression (CQR) model is the residualization of the treatment variable prior to estimating the (bivariate) quantile regression model. The no quantile crossover assumption (He, 1997) and the need for a continuously distributed outcome variable (Machado & Silva, 2005) are two further crucial requirements for the bivariate CQR model that also apply to the RQR model (Koenker, 2005).

Let (Y) represents the cumulative distribution function (CDF) and as continuous random variable.

$$F(y) = P(Y \leq y) \qquad [12]$$

If the CDF is strictly monotonically increasing, the quantile function $Q_Y(\tau)$ is defined as the inverse of;

$$F(Y): F^{-}(y) = \inf\{y: F(y) \geq \tau\} \qquad [13]$$

Assumption 2 (CDF is strictly monotonically increasing).

$$QY(p) = F_Y^{-1}(y) \quad [14]$$

Additionally, the rank invariance assumption is invoked to interpret treatment effects as individual-level Quantile Treatment Effects (QTEs). This assumption is widely adopted in quantile regression models, as noted by Firpo (2007), Koenker (2005), and Powell (2020). For the binary treatment variable T_i, let Y_{i0} and Y_{i1} denote the possible outcomes for $T_i = 0$ and $T_i = 1$ respectively. Further, let $r_i^0 \sim U[0,1]$ and $r_i^1 \sim U[0,1]$ represent the potential ranks relating to these outcomes. According to the rank invariance assumption, the potential outcomes' ranks are constant regardless of treatment status.

Assumption 3 Rank Invariance Assumption. $r_i^0 = r_i^1$

This assumption means that a person's status stays constant under various treatment circumstances.

3.8.6 Estimation Using Linear Regression

A particular technique for decomposing the treatment variable in the first stage is not required by the framework presented here. Alternative regression techniques can be used, however linear regression techniques provide a useful way to calculate treatment residuals. For example, models like logit or probit might be used as alternatives to the first regression step when the treatment variable is binary. However, a linear regression model is expected to yield a sufficient solution in most cases.

As previously explained, the first stage removes confounding in the treatment variable under the assumption of selection on observables in a well stated model. This makes it possible to employ residuals in the next phase as a stand-in for an as-if randomized treatment variable. As a result, the need to include control variables in the second step is eliminated by the process of residualizing the treatment variable.

In the second stage, linear programming methods are used to estimate coefficients. The algorithm, which is briefly described here, is covered in more details in Hao and Naiman (2007) and Koenker (2005). The quantile regression (QR) estimator, often known as the method of minimum absolute deviations (MAD), finds coefficients by minimizing the sum of weighted absolute residuals:

$$\sum_{i:y_i \geq x_i' \beta^{(\tau)}}^{N} \tau \left| y_i - x' \beta^{(\tau)} \right| + \sum_{i:y_i < x_i' \beta^{(\tau)}}^{N} (1 - \tau) |y_i - x_i' \beta^{(\tau)}| \qquad [15]$$

, where $0 < \tau < 1$, the superscript $\tau$is used to indicate that the coefficients betas can vary by quantile. In the two-step residual quantile regression (RQR) estimator, the coefficient matrix comprises only the residualized treatment variable and the constant term. Therefore, for estimating the p^{th}quantile, the task involves minimizing the weighted absolute deviation of the coefficients: the residualized treatment variable $\beta_1^{(\tau)}$ and the constant term $\beta_0^{(\tau)}$.

$$\sum_{i:y_i \geq \beta_{0+}^{(\tau)} \beta_1^{(\tau)} \tilde{T}_i}^{N} \tau \left| y_{i-} \beta_{0-}^{(\tau)} \beta_1^{(\tau)} \tilde{T}_i + \sum_{i:y_i < \beta_{0+}^{(\tau)} \beta_1^{(\tau)} \tilde{T}_i}^{N} (1 - \tau) |y_{i-}\, \beta_{0-}^{(\tau)} \beta_1^{(\tau)} \tilde{T}_i \right| \qquad [16]$$

The constant component in the second-step regression, which indicates the expected quantile value of the outcome when the treatment residuals are equal to zero, often lacks a meaningful interpretation. Additionally, there is a mechanical relationship, by construction, between the residuals $\tilde{T}_i$ and the original (non-residualized) treatment variable T_i. Consequently, regressing $T_i$on $\tilde{T}_i$ results in a trivial coefficient of 1.

If the unconfoundedness assumption is met, the adjustment-based two-step RQR technique produces objective estimates of unconditional quantile treatment effects (QTEs). But it's important to understand that this assumption is strict. As with other adjustment-based quantile regression models, including various QTE models, the UQR model, the CQR model, linear regression models, and propensity score matching techniques, the RQR coefficients may be skewed by the existence of unobserved confounders or a misspecified model.

The RQR model's capacity to include fixed effects, which take time-invariant unobserved confounders into account, is a key benefit. Only time-variant confounders that are either unmeasured or improperly defined are still problematic in this situation (Allison, 2009).

3.8.7 Standard Errors

The bootstrap process, which is preferred over the asymptotic approach, is commonly used to estimate standard errors in different quantile regression models. This preference is applicable to models like the PS-QTE model (Firpo, 2007), the UQR model (Firpo et al., 2009), and the CQR model (Hao & Naiman, 2007; Koenker & Hallock, 2001). Similarly, I propose utilizing the bootstrap procedure to compute SE in the RQR model, where both Step 1 and Step 2 described earlier are bootstrapped.

Drawing M re-samples of size N with replacements from the original dataset is known as bootstrapping. The treatment variable is decomposed for each resample, and then the as-if randomized treatment variable is used to estimate quantile regression coefficients. The standard deviations of the estimated coefficients across the resamples are used to calculate the standard errors of the RQR coefficients.

3.8.8 Empirical Franework of the Effect of Urbanization on Household Food Security

A structure that classified households into different food insecurity categories based on an ordinal scale is used to analyze farm land loss and its impact on household food insecurity. Models like the Ordered Probit/logit Regression Model can be used based on this classification.

Despite variations in food insecurity severity among households, multiple households may still fall within the same category. Consequently, this distinction allows for the assumption that the precise severity scores of household food insecurity remain latent or unobserved (y_i^*). In this empirical analysis, the observed food insecurity severity levels (y_i) are assumed to be linearly dependent on farm land loss (LL_i) as well as other exogenous covariates (x_i) as specified in equation (21).

$$y_i^* = y_i = x_i\beta_1 + LL_i\beta_2 + \varepsilon_i \qquad [17]$$

Additionally, the coding schemes for the observed food insecurity classes can be expressed as follows, given the cut-off points (c_j) on which the classes are created:

$$y_i = \begin{Bmatrix} 0\ if\ y_i^* \leq c_1 \\ 1\ if\ c_1 < y_i^* \leq c_2 \\ 2\ if\ c_2 < y_i^* \leq c_3 \\ 3\ if\ c_3 < y_i^* \end{Bmatrix} \qquad [18]$$

An Ordered Probit Regression Model would be ideal for examining the impact of land loss (LL_i) on household food insecurity if the underlying error term (ε_i) has a standard normal distribution. Since (ε_i) is predicted to have a zero mean and a unit variance it is assumed to be normally distributed. However, in relation to(LL_i), (ε_i) is not always autonomous.

This implies that certain factors such as government interventions could simultaneously influence land loss and household food insecurity but remain unaccounted for in the econometric estimation. As a result, there may be a correlation between (LL_i) and the ε_i, potentially twisting the normality assumption of (ε_i). This could introduce endogeneity, leading to bias estimate of the parameter for (LL_i). In this case, the error term (ε_i)consists of two independent components. The error term $(\varepsilon_i)$is specified as:

$$\varepsilon_i = u_i + v_i \quad [19]$$

where u_i represents the unobserved heterogeneity component contributing to endogeneity, and v_i is a distinctive component of the error term with variance σ_v^2(Wooldridge, 2010).

A triangular instrumental variable (TIV) strategy is used to address this endogeneity source (Imbens & Newey, 2009). Luckily, Stata's extended ordered probit model (eoprobit) includes an integrated TIV method. Stata versions 15 and later provide these methods (StataCorp, 2017). The eoprobit model enables sample selection, treatment effects, and combinations of endogenous covariates, whether they be continuous, binary, or ordered.

The eoprobit model with continuous endogenous covariate (EOPEC) is used in this investigation. This is due to the fact that household land loss (LL) can be measured as continuous even when it is fractional (0,1). The EOPEC model simultaneously estimates two distinct models: a second-stage ordered probit model that examines the impact of land loss on household food insecurity and a first-stage linear regression model that addresses the causes affecting land loss.

The specifications of the EOPEC model are as follows:

$$y_i^* = y_i = x_i\beta_1 + LL_i\beta_2 + \varepsilon_i \quad [20]$$

$$LL^* = LL = z_i\alpha + \varepsilon_i \quad [21]$$

where, z is a vector of exogenous variables including additional instruments for identification, β_1 and β_2 are vectors of parameter estimates, ε_i and e_i are error terms.

The instruments used for identification is distance *of the farmland to the city centre and type of land tenure*. The distance of one's farm to the city centre could increase the probability of losing the farm land to urban infrastructure due to its proximity to the CBD. This contributes to land tenure insecurity, limiting individual's access to agricultural assets as well as other benefits, which ultimately impacts the right own land to produce food and ensure food security.

In the Ghanaian setting, land tenure arrangements are customary in nature, limiting land ownership to some few individuals such as chiefs, "tendaamas" and to a limited extend private individuals. The closer the parcel of land to city centre the higher the demand for such lands and could influence land access and ownership patterns, affecting land loss at the household level.

The linear prediction of the first-stage model (land loss) is computed and used as an independent variable in the second-stage model (food insecurity) by the TIV technique in the EOPEC framework. This linear prediction's computation and application guarantee that the food insecurity model takes into account all unobserved aspects of land loss, or potential causes of endogeneity. The IV method transforms the error terms (ε_i, e_i) into multivariate normal with zero means and variances as follows:

$$\begin{bmatrix}\varepsilon_i \\ e_i\end{bmatrix} \sim \mu\left[\begin{pmatrix}0 \\ 0\end{pmatrix}, \begin{bmatrix}1 & \sigma' \\ \sigma & \sum_e\end{bmatrix}\right]$$

where, σ is the covariance of $\varepsilon_i$and $e_i[cov(\varepsilon_i e_i)]$ and $\sum_e$is the variance of $e_i[var(e_i)]$. Now that ε_i in the outcome equation is normalized, the variance of $\varepsilon_i[var(\varepsilon_i)]$ is a unit variance.

The conditional density of food insecurity(y^{*}) at any class can be expressed as the conditional mean and variance of ε_i given the multivariate normality and equations (22) and (23). These are expressed as follows, respectively:

$$E(\varepsilon_i|L_{i,x_{i,}\,z_i})=\sigma'\textstyle\sum_0^{-1}(L_{i-}\,x^{*}\alpha-z_i\alpha)' \qquad [22]$$

$$Var(\varepsilon_i|L_{i,x_{i,}\,z_i})=\sigma'\textstyle\sum_e^{-1}\sigma \qquad [23]$$

Additionally, equation (26) can be used to express the conditional density of L_i on the instruments and other exogenous covariates:

$$f(L_i|x_{i,}\,z_i)=\boldsymbol{\phi}\left(L_{i-x_i^{*}\alpha-z_i\alpha,\sum_e}\right) \qquad [24]$$

Given the cut-off points for the food insecurity classes $\left(c_{j-1}\text{ and } c_j \text{representing the lower and upper limits respectively}\right)$, conditional variance of $\varepsilon_i$and the conditional density of L_i, the likelihood function can be specified as:

$$L=\prod\boldsymbol{\Phi}\left[c_{j-1,\,c_j,\sigma'}\textstyle\sum_e^{-1}\sigma\;\right]\boldsymbol{\phi}\left[L_i-x_i^{*}\alpha-z_i\alpha,\textstyle\sum_e\right] \qquad [25]$$

Taking logs of the likelihood function gives the log likelihood function specified as:

$$lnL=\textstyle\sum_{i=0}^{N}\omega_i\left\{ln\boldsymbol{\Phi}^{*}\left[c_{j-1,\,c_j,\sigma'}\textstyle\sum_e^{-1}\sigma\right]+ln\boldsymbol{\phi}\left[L_i-x_i^{*}\alpha-z_i\alpha,\textstyle\sum_e\right]\right\} \qquad [26]$$

The probability of a household being located in any food insecurity class is obtained from the likelihood function specified as:

$$Pr\left(y_{i=j}|L_i,x_i\right)=\Phi^{*}\left(c_{j-1,}\,c_j,\sigma'\textstyle\sum_e^{-1}\sigma\right) \qquad [27]$$

where, φ^{*} is the cumulative density function for the standard normal distribution.

Table 3.4 presents the factors that influence household food security as a result of urban expansion.

Table 3. 4: Variables Influencing Household Food Security of Peri-Urban Households

Variable	Definition/Measurement
Socioeconomic characteristics	
Sex	1 if male, 0 otherwise
Married	1 if married, 2 separated/divorced 3 otherwise
Age	Number of years
Farming experience	Number of years in farming
Household size	Number of people in the farming household
Education	Number of years of formal education
Farm Level Characteristics	
Farm Size	Number of hectares
Household income	Gross annual household income in GHS
ILU	International livestock units
Improved seed	Number of kilograms (kg) of improved seed used
Fertilizer	Number of kilograms (kg) of fertilizer used
Remittances	1 if received remittances, 0 otherwise
Institutional characteristics	
Land loss HHs	1 if household lost land, 0 otherwise
Non land loss HHs	0 if household did not lose land, 1 otherwise
Received credit	1 if received credit requested, 0 otherwise
Access extension	1 if has access to extension service, 0 otherwise
Market distance	Number of kilometers to city center (km)
Access health facility	1 if access to a health facility, 0 otherwise
Motorable road access	1 if road is motorable, 0 otherwise
Social organization	1 if member of social organization, 0 otherwise
Land tenure type	1 if tenure is customary, 0 otherwise
Land_city distance	Number of kilometers from farm to city centre
Environmental and Spatial factors	
Exposure to flood	1 if experience flood situation, 0 otherwise
Exposure to drought	1 if experience drought situation, 0 otherwise
Location variables	
Upper East Region	1 if locate from Upper East region, 0 otherwise
Upper West Region	1 if locate from Upper West region, 0 otherwise
Northern Region	0 if located from northern region, 1 otherwise

3.8.9 Empirical Analysis of the Perception of the Impact of Urbanization on Household Welfare

Most people believe that urbanization, especially in peri-urban areas, is a transformative catalyst that affects household wellbeing. The manner in which peri-urban households perceived the impact of urbanization on their welfare is largely influenced by their economic prospects, land use dynamics as well as access to essential services that come with urban expansion (Abay *et al*., 2019). To comprehensively analyzed these perceptions, the study employed a combination of methods namely; Likert scale-based descriptive statistics, and the Principal Component Analysis.

In this analysis, the likert scale was used to document how peri-urban households perceived urban expansion on their welfare. This methodology is particularly appropriate in social sciences for measuring subjective views such that the researcher is able to determine their level of agreement or disagreement with a particular claim (Monts's, 2001). The approach provides a descriptive summary of the respondent attitudes, emphasizing the significant trends of how households regard urban expansion.

After the summary statistics, responses from the survey questions were categorized into three main variables by applying the PCA. The Principal component Analysis is a standard statistical approach that classifies correlated variables as well as identifying observed trends such that complexity found in the data can be reduced (Chen *et al*., 2020). The PCA was used in this study to reduce the perceptions of households into three factors, where each factor relates to unique facet of welfare effect of urban expansion.

Following the identification, the variables in the PCA procedure, the analysis of the factors influencing these households' perspectives was done. The three identified variables namely; economic opportunity and market integration, access to basic services and livelihood diversification and social capital

The combination of these analytical procedures provided a resilient framework for understanding how peri-urban households perceived the impact of urbanization on their welfare. The likert scale survey questions used in the PCA procedure are presented in Table in 3.5.

Table 3. 5: Questions on the Perception of the impact of urbanization on household welfare

S/N	Perceived impact of urbanization
I	Do you agree that urbanization could lead to improved access to urban markets
Ii	Do you agree that urbanization could lead to the creation of formal jobs?
iii	Do you agree that urbanization improves access to portable water?
Iv	Do you agree that urbanization improve road network
V	Do you agree that urbanization improves quality of products for urban market
Vi	Do you agree that urbanization creates jobs in construction sector
vii	Do you agree that urbanization improve social network
viii	Do you agree that urbanization creates small scale industries
Ix	Do you agree that urbanization improve access to health care
X	Do you agree that urbanization lead establishment of educational institutions

3.8.10 Analytical Procedure of the Principal Component Analysis

Data Standardization: Since PCA is sensitive to the scale of the variables, the data should be standardized.

$$Z = \frac{X-\mu}{\sigma} \quad [28]$$

where $X$is the original data, $\mu$is the mean, and σ is the standard deviation.

Computation of the Covariance Matrix: Calculate the covariance matrix of the standardized data.

$$\Sigma = \frac{1}{n-1} Z^T Z \quad [29]$$

where Σ is the covariance matrix, and **Z** is the matrix of standardized variables.

Eigen Decomposition: Perform eigen decomposition on the covariance matrix to obtain eigenvalues and eigen vectors.

$$\Sigma v = \lambda v \quad [30]$$

where λ is an eigenvalue and v is the corresponding eigenvector

Selection of Principal Components: Select the top k eigen vectors corresponding to the largest eigen values. These eigen vectors form the principal components.

Transformation of the Data: Project the standardized data onto the principal components.

$$Y = ZV_k \quad [31]$$

Where V_k is the matrix of the top k eigen vectors.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics of the Data Used in the Study

This section presents descriptive statistics and bivariate analysis (Table 4.2) of the study as shown below. The descriptive statistics are in two parts- descriptive statistics of household characteristics and bivariate analysis (Mean comparison-t-test). In the first descriptive analysis, bar charts, pie chart as well as tables are used to present the results whereas, in the latter the data is sectioned into socio-demographic, farm-level, institutional, climatic, and location characteristics. Finally, the four objectives of the study namely; the effect of farmland loss on staple maize production, the extent of farmland loss to urban built infrastructure, the effect of farmland loss on peri-urban household food security, and household perception of the impact of urbanization on household welfare are presented and discussed.

4.1.1 Descriptive Statisitics of Household Characteristics

Understanding the socioeconomic characteristics of farmers is essential for assessing the broader implications of farm land loss on agricultural productivity. Key variables such as age, education, and sex play crucial roles in shaping farming decisions, adaptation strategies, and overall yield outcomes.

4.1.2 Sex Distribution of Respondents by Region

The sex distribution across Bolga, Wa, and Tamale shows significant variations. Wa has the highest male dominance at 92.73%**,** with females constituting only 7.3% of the sample. This extreme disparity may suggest male dominance in farming or other demographic factors affecting female participation. Bolga presents a more balanced gender ratio with 74.3% males and 25.7%

females, although males still outnumber females significantly. Tamale has the highest proportion of females among the three cities at 34.3%, indicating slightly greater female representation.

Overall, when considering the pooled sample, males constitute 76.3%, and females 23.**7%,** reinforcing the trend of male predominance across all locations (Figure 4.1).

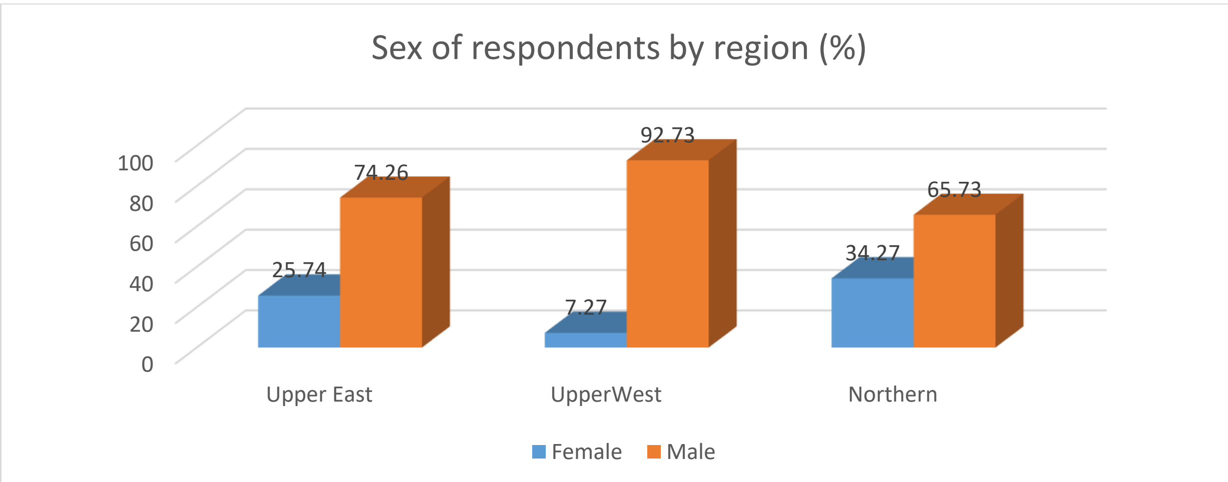

Figure 4. 1: Sex Distribution of the Respondents by Region

4.1.3 Age Distribution of Respondents

Age distribution reflects farmers' experience, resilience, and capacity to adopt modern agricultural techniques. Middle-aged farmers tend to dominate the sector, often demonstrating extensive knowledge and skill in land management. However, younger farmers may exhibit a greater willingness to embrace innovative farming methods, while older farmers may struggle with adaptation due to financial and physical constraints (Manzoor et al., 2025; Zhang et al., 2024). From the results (Table 4.1), majority (50.13%) of the respondents are found within the bracket of 36-55 years. the youth in the age category of 26-35 years formed 25.19% of the respondents, whereas the aged population was only 12.08%. only 6% of very young people between the ages of 10-25 years are actively involved in agriculture. For household heads from 66 years and above formed only 6.43% of the population

Table 4. 1: Age Distribution of the Respondents

Age group	Freq.	Percent
10-25	24	6.17
26-35	98	25.19
36-55	195	50.13
56-65	47	12.08
66 and above	25	6.43

4.1.4 Household Size of the Respondents by Region

Household size is key determinant of smallholder farmers in northern Ghana. It serves as a vital source of farmlabour, which influences labour availability. Larger households easily provide readily available which minimizes household reliance on hired labour thereby lowering cost of production (FAO, 2014). Much as household labour reduces production cost and enhances productivity, it also put pressure on household limited resources, especially in situations where landholdings are limited. In this study, northern region has the largest average household size of about 14 persons (see Figure 4.2). This is followed by the Upper West region with an average household size of about 10 persons per household whereas the average household size in the Upper East region was found to be about 8 persons. Household size in the context of peri-urban farm household has a dual effect of being an asset and a challenge. It support food production through the supply of family labour, and on the other hand can worsen food insecurity and overall welfare constraints in case where land available and financial resources cannot meet the needs of all members (IFAD, 2016 & FAO, 2012).

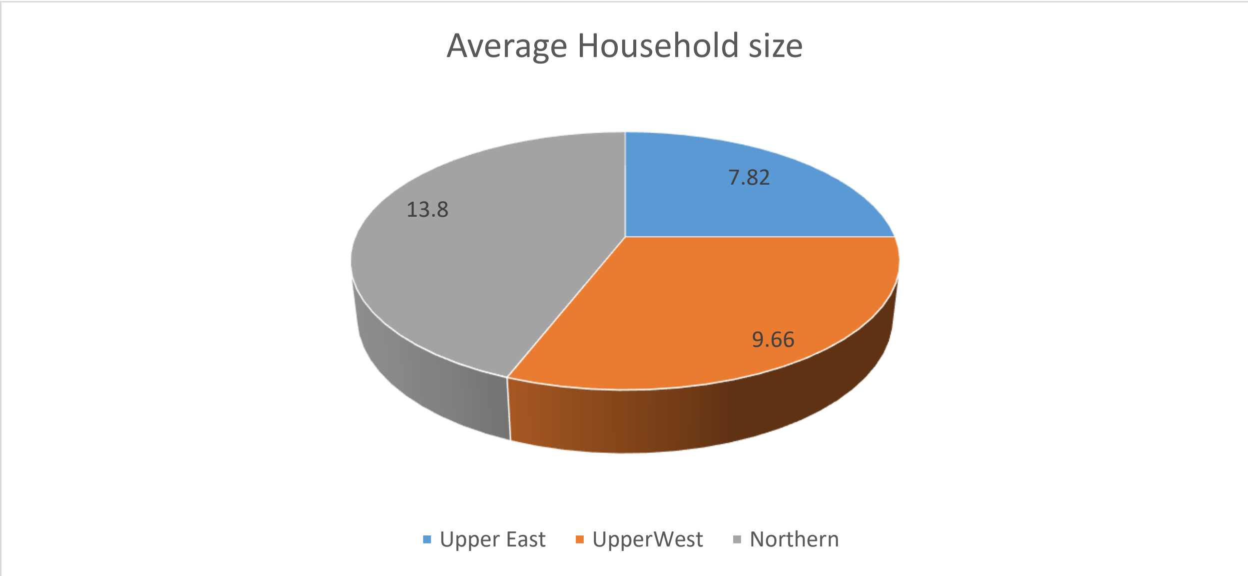

Figure 4. 2: Average Household Size of the Respondents

4.1.5 Educational Status of the Respondents

Education influences farmers' ability to navigate agricultural challenges. A higher level of education correlates with increased adoption of sustainable farming practices, access to improved technologies, and strategic decision-making regarding land use. Farmers with limited formal education may rely on traditional farming methods, which can affect their capacity to mitigate land loss impacts effectively (Tittonell & Giller, 2013).

The data reveals that a significant portion of respondents (52.96%) have no formal education, suggesting limited access to structured learning, particularly in rural areas. This aligns with studies showing that lack of education often correlates with reduced adoption of modern agricultural techniques (Feder et al., 1985).

Meanwhile, 16.45% completed primary education, and 12.85% progressed beyond primary school, implying moderate literacy levels among a portion of the respondents. Literacy plays a crucial role in technology adoption, especially in farming, where access to improved techniques can enhance productivity (World Bank, 2018).

Interestingly, only 5.91% reached tertiary education, a figure that underscores the limited higher education attainment among farmers. Research indicates that higher education is often linked to better farm management, resource allocation, and resilience against land loss (Tittonell & Giller, 2013).

Arabic education and other forms of training account for only 3.6%, demonstrating niche learning systems that may influence cultural practices and decision-making (see results in Figure 4.3).

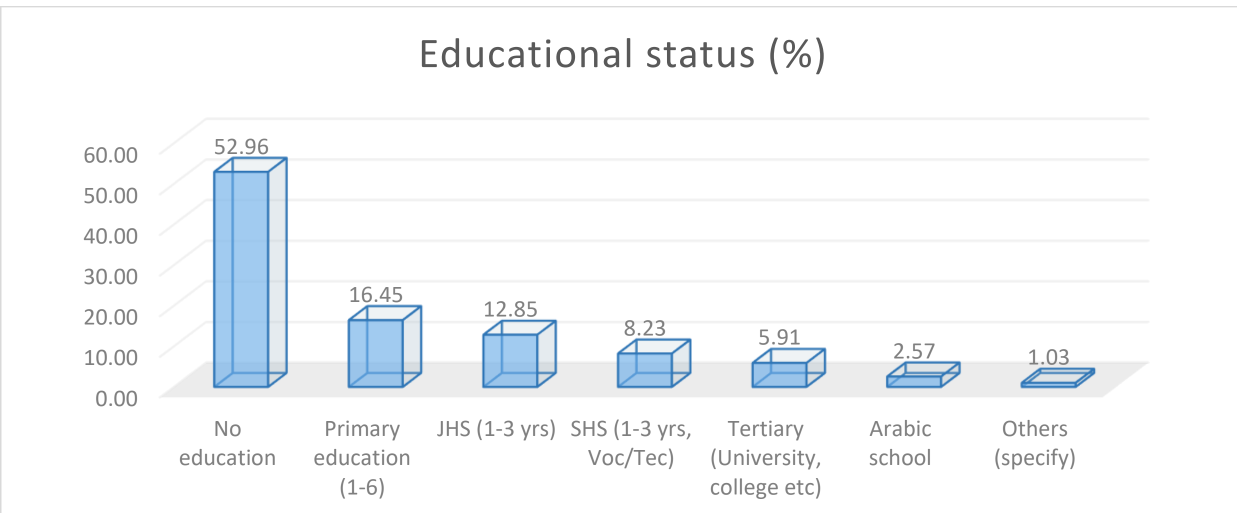

Figure 4. 3: Educational Level of the Respondents

4.1.6 Farmland Loss Situation in the Study Regions

Farmland loss was rampant in the Upper West region (72.73%) compared to Northern and Upper East regions with 69.93% and 65.44% of households that lost land respectively (Figure 4.4). for non-land loss households, 30.07% of households in Northern region did not lose their farmlands, whereas 34.56% and 27.27% of households in the Upper East and Upper West regions did not lose their farmlands respectively.

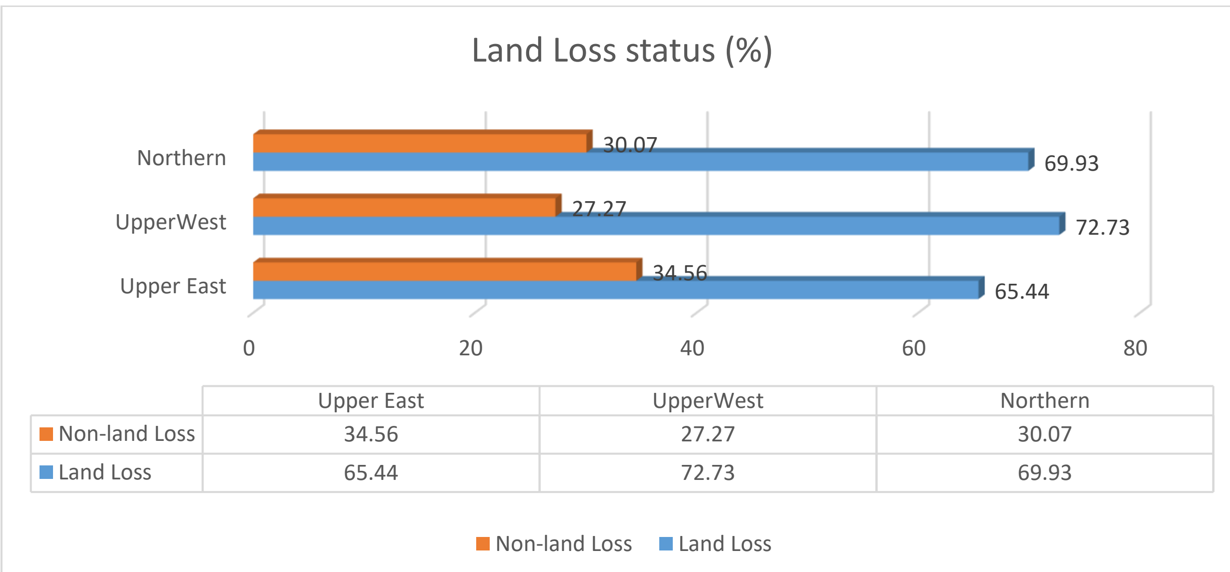

Figure 4. 4: Farmland Loss status of Respondents

4.1.7 Bivariate Analysis: Mean Comparison (T-Test)

Socio-demographic characteristics: Socio-demographic variables used across the study objectives include gender (sex), age, household size, educational status, farming experience, household income and marital status of the respondents (see Table 4.2). T-Test analysis is conducted on each variable disintegrated into households that experienced *farmland loss* (LL) and those households that did not lose land referred to as *non-land loss households* (NLL). Among the socio-demographic variables, only household income appeared as statistically significant. This aligns with existing literature that consistently identifies income as one of the strongest determinants of food security and welfare. Higher income households are better able to purchase food, invest in farm inputs and adopt coping strategies when land loss occurs (Barret, 2010). The variable sex also referred to as gender is insignificant in the descriptive statistics which indicates that male and female-headed households do not differ greatly, in terms of basic characteristics or exposure to land loss. However, its influence in the regression estimations indicates that gender helps explain variations in other predictors. Household size is not significant though it contributed to explaining variations in the dependent variables of the various regression models used in the study by acting as controls for labour availability and consumption needs. Although age, educational status, farming experience and marital status appeared statistically insignificant with negative t-values in the descriptive analysis, most of them became significant within the various regression models such as the multivariate and extended ordered probit models. This is an indication that, on their own they do not distinguish households in terms of land or basic outcomes. However, when combined with other explanatory variables, they exert meaningful influences by adjusting or moderating the effects of institutional, farm-level, climatic and locational factors. Thus these socio-demographic variables while not strong predictors individually, play important roles as control variables within the overall structure.

Farm Characteristics: Farm level characteristics included in the data throughout the analysis are farm size, maize yield, fertilizer usage, improved seed, land loss status, livestock ownership and soil fertility status. The average farm size (of 2.55 hectares) for households that did not lose land is relatively greater than those households that lost land (with an average farm size of 2.04 hectares). The anxiety surrounding the rapidly declining agricultural space in peri-urban communities are reinforced by the negative t-value of -2.589 and its statistical significance.

According to Yang *et al*. (2019), loss of farmland and land fragmentation can significantly reduce agricultural productivity, particularly staple crops yields.

The number of hectares put under maize production is comparatively constant for both household categorizes irrespective of farmland loss. The results show that those households that lost land allocated an average 0.86 hectares for maize production whereas non-land loss households allocated 0.91 hectares of land for maize cultivation. Even though there is land limitations, farmers may still prioritize maize cultivation, which may be the reason for the insignificant differences shown by the t-test value of -0.529. This is in line with Galani *et al*. (2022) who indicated that farmers frequently adjust by either increasing cultivation of smaller fields or adopting high yielding maize cultivars.

In terms of yield among the two households categorizes, a significant difference in yield exists. Households that are not affected by land loss had an average of 6096.84kg/ha of maize compared to an average maize yield of 2599.81kg/ha for households that lost land. It is evidently clear that the shrinkage of farmland had a significant negative impact on maize yield as revealed by t-test value of -3.778. This is in sync with findings by Kitinoja *et al*. (2019) who found that decline in access to land leads to lower yields largely because there is no room for practices such as crop rotation and other soil fertility management techniques that could enhance yield.

The mean value of land loss status for households that lost land is 0.985 compared to a negligible value of 0.025 for non-land loss households. This is as expected, giving the extremely significant difference exhibited by the t-value of 65.505. This is in consonant with Yang *et al*. (2019) assertion that land use changes that often results in land loss affect agricultural productivity mainly caused by urban expansion and land degradation.

Soil fertility, although is statistically insignificant, it indicates that variations in soil quality do not meaningfully explain household outcomes once land loss and other structural factors are accounted for. This suggests that the effects of urban expansion and land conversion outweigh the role of natural soil conditions in shaping peri-urban household welfare.

Two other important determinants of maize are the usage of fertilizer and improved seed. The descriptive statistics results reveal a significant difference between land loss and non-land loss households likely reflects access and affordability constraints that disproportionally affect households with reduced farmland. Recent evidence from longitudinal surveys across Sub-Saharan Africa shows that poorer farmers who often have less land are more likely to discontinue or reduce fertilizer use because they cannot afford it or access desired quantities, especially during periods of economic stress (Amankwah, *et al*., 2025). Additionally, land degradation and loss undermine soil fertility and reduce the expected return on fertilizer investment, leading farmers with smaller or degraded plots to under-apply inorganic fertilizer compared to non-land loss households.

Although fertilizer subsidy exhibits a positive coefficient, its effect is not statistically significant, implying that subsidy access alone may be insufficient to offset the productivity constraints associated with farm land loss (Duflo, Kremer & Robinson, 2011).

Also the non-significant and negative coefficient on improved seed use suggests that adoption of improved maize varieties alone did not result in higher yields among land loss households. Recent studies show that the yield benefits f improved seeds are highly conditional on the use of complimentary inputs, particularly fertilizer and proper agronomic practices, without which improved seeds may not outperform local varieties (Liverpool-Tasie *et al*., 2020, Sheahan & Barret, 2017). In addition, constraint related to seed quality, access, and limited extension support often reduce the effectiveness of improved seed adoption in smallholder systems, leading to weak or insignificant yield outcomes (Ragasa *et al*. 2021).

Livestock ownership exhibits a negative and statistical significance effect, suggesting that households with larger livestock holdings experience lower levels of food security or welfare in peri-urban areas context. This may reflect increased vulnerability to farmland loss, as livestock production in peri-urban areas is increasingly constrained by shrinking grazing land, rising feed costs, and conflicts with urban land uses (Thornton *et al*., 2009; Djurfeldt *et al*., 2018). Rather than acting as a buffer, livestock ownership under urbanization pressure may impose additional costs that reduce household welfare.

Institutional characteristics: The estimated coefficients for most institutional variables (such as credit access, extension services, market distance, presence of health facilities, road network, farm to city distance, membership of social organization) display expected positive and negative signs but are not statistically significant, indicating weak direct or indirect effects on food security or welfare. In contrast, market distance is negative and statistically significant, implying that greater distance to markets substantially reduces household welfare by increasing transaction costs and limiting access to food and income opportunities. This highlights market access as the most critical constraint facing peri-urban households under conditions of agricultural land loss.

The positive but statistically insignificant coefficient on land tenure suggests that more secure tenure may be associated with better outcomes in terms of land access, food production, and welfare; however, this relationship is weakened in contexts of rapid urbanization and agricultural land loss. Urban expansion intensifies land market pressures, tenure uncertainty, and land fragmentation, which often disrupt agricultural livelihoods and limit the welfare benefits typically associated with secure land tenure (Jayne *et al*., 2016; Chamberlin & Jayne, 2020). Consequently, land tenure security alone may be insufficient to safeguard food production and household welfare where agricultural land is progressively converted to urban uses.

Climatic factors: The climatic variables used in the study included whether households have experienced flooding and drought situations over the last five years prior to the study year (2023/2024 cropping season). Flooding shows a positive but statistically insignificant effect, while drought has a negative and insignificant effect, indicating that climatic shocks do not independently explain variations in household food security or welfare in the study area. This suggests that the impacts of urbanization and land loss outweigh short-term climatic influences in shaping peri-urban household outcomes.

Location factors: The location variables defined as Upper West and Upper East regions are not statistically significant, despite exhibiting negative and positive signs respectively. This indicates that regional location alone does not significantly explain differences in household food security or welfare once other socio-economic, institutional, and farm-level factors are controlled for.

It should be noted that, most of the variables individually do not show statistical significance. The fact that most of them are not significant at descriptive statistics is not a methodological issue, and it does not compromise the validity of the study findings. The descriptive analysis was conducted on a pooled sample of land-loss and non-land-loss households drawn from the same communities, implying shared agro-ecological conditions, market access, cultural norms, and institutional settings. This type of contextual similarity inherently constrains any observable variation in the essential socioeconomic and farm-level traits, which minimizes the probability of statistically significant differences in descriptive level means (Wooldridge, 2010; Gujarati and Porter, 2009).

In addition, the descriptive statistics are essentially exploratory and do not adjust or compensate confounding variables and interactions, and nonlinear associations. Variables which seem irrelevant in the context of an unconditional comparison can turn into important ones when conditioning variables are included in a model especially when the effects of outcomes are conditioned by simultaneous and interdependent processes (Cameron & Trivedi, 2005). This is particularly applicable in the land-loss scenarios, in which welfare and livelihood outcomes depend on a mix of tenure security, urban proximity, livelihood diversification, and market dynamics rather than isolated factors (Holden and Otsuka, 2014; Kuusaana and Eledi, 2015).

The absence of strong descriptive differences further suggests that households are structurally comparable at baseline, which strengthens internal validity and reduces concerns of bias arising from pre-existing heterogeneity (Imbens & Rubin, 2015). Consequently, the significant relationships identified in the extended ordered probit and RQR models reflect conditional and distributional effects that descriptive statistics are not designed to capture. This reinforces the appropriateness of relying on econometric modeling for inference and policy interpretation.

Table 4. 2: Descriptive Statistics of Mean Difference Tests between Farmland-Loss and Non-Farmland-Loss Households

Variable	**Land loss HH**	**Non Land Loss HH**	**Pooled Sample**	**t-value**
Socio-demographic characteristics				
Sex	0.227 (0.420)	0.258 (0.440)	0.237 (0.427)	0.6754
Age	44.335 (13.549)	44.108 (11.957)	44.265 (13.064)	-0.1576
Household size	10.476 (5.503)	10.692 (6.694)	10.542 (5.888)	0.3335
Educational status	0.480 (0.501)	0.450 (0.500)	0.470 (0.500)	-0.8129
Household income (logged)	7.977 (0.697)	8.783 (0.421)	8.226 (0.727)	12.8840***
Farming exp.	21.283 (13.470)	19.533 (12.252)	20.743 (13.112)	-1.216
Marital status	0.929 (0.257)	0.886 (0.322)	0.915 (0.279)	-1.5055
Farm characteristics				
Farm size (ha)	2.040 (0.2174)	2.550 (0.5390)	2.210 (0.2250)	-2.5893*
Area Maize (ha)	0.86 (0.1007)	0.910 (0.2180)	0.880 (0.0965)	-0.5292
Maize Yield	2599.81 (67.22)	6096.84 (543.39)	3672.48(175.74)	-3.7783***
Land Loss	0.9852 (0.0074)	0.0252 (0.0144)	0.6915 (0.0234)	65.5047***
Livestock (TLU)	0.946 (0.741)	0.041 (0.271)	0.667 (0.759)	-4.2126***
Soil fertility status	0.193 (0.396)	0.125 (0.332)	0.172 (0.378)	-1.6495
Fertilizer usage	4.110 (3.820)	5.330 (5.860)	4.480 (4.570)	2.450*
Improved seed	0.320 (0.470)	0.340 (0.490)	0.340 (0.470)	-0.910
Institutional characteristics				
Credit	0.506 (0.501)	0.592 (0.494)	0.532 (0.500)	1.5727
Remittances	0.279 (0.449)	0.242 (0.430)	0.267 (0.443)	-0.7631
Access to Extension	0.554 (0.498)	0.500 (0.502)	0.537 (0.499)	-0.9835
Healthcare	0.625 (0.485)	0.675 (0.470)	0.640 (0.481)	0.9564
Land tenure	0.223 (0.025)	0.283 (0.041)	0.242 (0.022)	1.282
Market distance	77.039 (33.437)	70.382 (33.638)	74.985 (33.597)	-1.8103*
Land distance to city	5.879 (4.461)	6.675 (4.626)	6.125 (4.521)	1.6067
Road network	0.227 (0.420)	0.208 (0.408)	0.221 (0.416)	-0.4037
Farmer org.	0.599 (0.491)	0.608 (0.490)	0.602 (0.490)	0.1823
Fertilizer subsidy	0.660 (0.470)	0.650 (0.48)	0.650 (0.480)	0.210
Climatic factors				
Flooding	0.721 (0.198)	0.792 (0.408)	0.743 (0.438)	1.4694
Drought	0.959 (0.198)	0.942 (0.235)	0.954 (0.210)	-0.7549
Location characteristics				
Upper West	0.297 (0.458)	0.250 (0.435)	0.283 (0.451)	-0.9574
Upper East	0.331 (0.471)	0.392 (0.490)	0.458 (0.283)	1.1607
Northern	-	-	-	-

*Figures in parenthesis are standard errors. ***, ** and * represents statistical significance levels of 1%, 5% and 10% respectively. TLU denotes Tropical Livestock Unit, livestock numbers are* *converted to a common units. Conversion factors are: cattle=0.7; sheep=0.1; goat=0.1; pigs=0.2; chickens=0.01. Note: t-values represent tests of mean differences between farmland-loss and non-farmland-loss households (Harvestchoice, 2015).*

Source: Author's computation from field survey, 2024.

4.2 Extent of Farmland Loss to Urban Built Infrastructure over the Last Three Decades (1994-2024)

The transformation of peri-urban communities within the last 30 years has been phenomenal. Landscapes are visibly reshaped leading to significant loss of farmlands to built infrastructure. Several factors accounted for this unprecedented transformation including high population growth, socioeconomic development as well as infrastructural growth, which threatens food systems and sustainable land management. Applying the GIS (Geographic Information System) techniques, allows for a systematic examination of the depth of farmland loss to urban built infrastructure, revealing a spatial and temporal perspective of land use changes that have taken place over the years.

The von Thünen's Agricultural Land Use Model formed the foundation of this analysis. The theory postulates that land use changes are influenced by the proximity to urban areas. Prime farm lands around urban centers are encroached upon as urban expansion takes place for housing, commercial and industrial development, thereby limiting land availability for food crop production (Thünen, 1826). This theory is further elaborated by the Bid-Rent Theory, which is of the view that the values of land increase near urban areas, speeding up land conversion from agricultural production to urban built infrastructure (Alonso, 1964)

With the application of the geographic information system, a comprehensive spatial analysis of the loss of farmland for three decades was conducted, where trends, hotpots as well as potential consequences for agricultural sustainability was identified. Once these land use patterns are well understood, it provides relevant stakeholders the opportunity to fashion out mitigation strategies to deal with the negative effects of urban expansion on food production and peri-urban livelihoods.

The results of the analysis are presented in Land Use and Land cover (LULC) changes maps, alongside change detection analyses for the three cities of Tamale, Wa and Bolgatanga.

4.2.1 Land Use and Land Cover (LULC) Changes in Tamale Metropolis from 1994-2024

The examination of LULC variations in these three cities across different time periods has revealed significant spatial changes brought about by urban growth and changing land-use dynamics. The study categorizes LULC into four main types: forest and croplands, built-up areas, water bodies, and bare lands**.** The results of this section are presented on region by region basis in the form of LULC maps together with their quantified details on figure's and tables in each case. For example the GIS results for Tamale Metropolis are presented in Figure 4.5 and Table 4.3. Figure 4.5 provides a pictorial view of land use patterns, in thirty years, while Table 4.3 details the quantification of the changes that took place within the same time frame.

The extent of changes in land use patterns varies across the three cities, indicating a unique local conditions and urbanization patterns. For example, the metropolitan city of Tamale has experienced a tremendous land use changes over the study period under consideration with respects to the various land use classes. Crop and Forest land has declined drastically from 229.4 square kilometers (representing 35.3% of total land size) in 1994 to 83.0 square kilometers (12.8%) in 2014, before slightly recovering to 106.1 (i.e recovery here refers to targeted efforts in land restoration and sustainable land management or the shift in land use changes occurring between land use classes excluding built-up class) square kilometers (16.3%) in 2024. The land use patterns observed in this study is in consonant with Namwinbown *et al*. (2025), who found a substantial loss of green spaces caused by urban expansion and land fragmentation in the Tamale metropolis. Another study by Arthur *et al*. (2024) highlighted the shifts in land use in Ghana that impacted on environmental sustainability where urban expansion is replacing agricultural lands. In a similar vein, Cooper *et al*. (2019) studied regions undergoing urbanization, highlighting how afforestation and the recovery of vegetation cover usually struggle with continuous infrastructure growth. The interconnectivity between urbanization and farmland transformation remains a major concern for sustainable food production in the face of rapidly expanding metropolises such as Tamale.

The processes of urbanization is visible as built-up areas have increased from 10.4 square kilometers representing 1.6% of the total area in 1994 to 32.6 square kilometers (5.0%) in 2024. This consistent expansion demonstrates infrastructure and population growth, corroborate with studies that revealed 131.7% rise in built-up areas in various parts of Ghana in the last 20 years (Forkuo *et al*., 2017). This trajectory in urban growth of residential and commercial infrastructure positioned Tamale as one of the fastest growing metropolises in Ghana in recent times (Antwi *et al*., 2014).

The impact of urban expansion also leads to alterations in water bodies. In 2014 the water bodies covered 3.4 square kilometers (about 0.5% of the total land area) but declined to 2.0 square kilometers (0.3%) in 2024. According to Arthur *et al*. (2024), such variations are usually as a result of changes in climate and human activities. The decline in water bodies raises serious concerns about the depletion of water resources and its management in the Tamale metropolis.

The other land use class that have witnessed significant expansion is bare lands, with 408.6 square kilometers, representing 62.9% in 1994 to 537.6 square kilometers (82.7%) in 2014. It however decreased slightly to 509.2 square kilometers (78.4%) in 2024. This observed patterns in bare lands point to widespread land degradation, vegetation loss, desertification and large scale land acquisition that are yet to be developed. This observation is similar to findings by Forkuo *et al*. (2017) who indicated that about 92.8% loss in bare lands across Ghana. Studies in land use changes by Namwinbown *et al*. (2025) further highlight the reduction of green spaces and increasing bare lands in Tamale because of urban sprawl.

Yet other research studies in Tamale further reinforce these changing patterns in land use. Take for example Dinye (2020) who examined the impact of urban expansion on farm lands and revealed a drastic loss of prime agricultural lands caused by population and infrastructural growth. According to Antwi *et al*. (2014), strategic hotpots in Tamale have been transformed mainly caused by urban-driven land use activities. Similarly, Mensah *et al*. (2020) studied the patterns of land use in secondary cities like the Tamale metropolis and have highlighted difficulties in balancing agricultural, infrastructural and industrial demands.

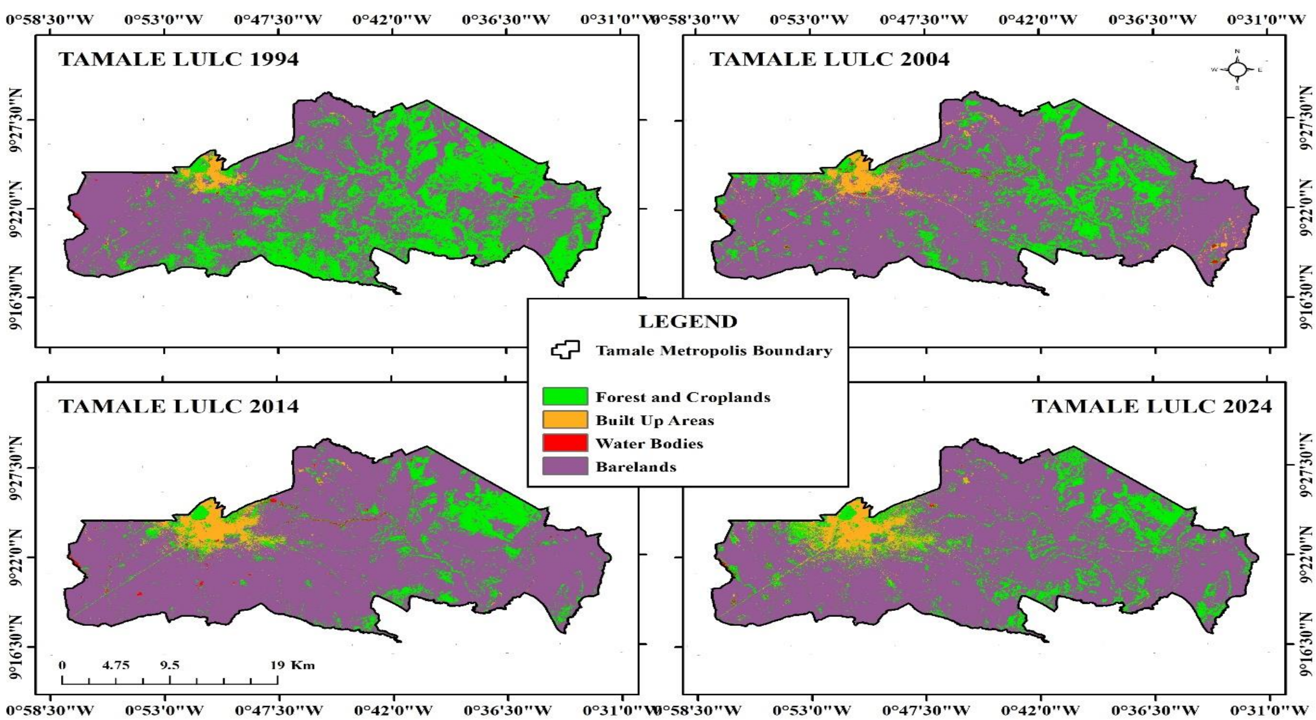

Figure 4. 5: Map of LULC for Tamale Metropolis from 1994-2024

Table 4. 3: LULC Classification for Tamale Metropolitan Area from 1994-2024

LULC Classes	**1994-Classif. Area (Sq/Km)**	**%**	**2004-Classif. Area (Sq/Km)**	**%**	**2014-Classif. Area (Sq/Km)**	**%**	**2024-Classif. Area (Sq/Km)**	**%**
F&CL	229.40	35.30	112.70	17.30	83.00	12.80	106.10	16.30
BU	10.40	1.60	21.20	3.30	25.90	4.00	32.60	5.00
WB	1.50	0.20	2.60	0.40	3.40	0.50	2.00	0.30
BL	408.60	62.9	513.50	79.00	537.60	82.70	509.20	78.40
Total A.	649.90		649.90		649.90		649.90	

Note: F&CL=Forest and croplands; Bu=Built-ups; WB=Water Bodies; BL=Bare lands

4.2.2 Change Detection Analysis for Tamale Metropolis (1994-2024)

The change detection results for Tamale metropolis shows that urban expansion, changes in the environment and land degradation have played a significant role in land use patterns over the past 30 years (see Table 4.4). The most affected land use class i.e. forest and croplands, which is the focal point of the study has witnessed a sharp decline of 116.7 square kilometers, thus about 50.8% of the total land area between 1994 and 2004. This decline in forest and croplands could be attributed to significant deforestation as well as the transformation of farmlands into infrastructural development. The second decade of the study period (ie between 2004 and 2014), forest cover declined by some 29.7 square kilometers (26.6% of the total land area), but at a slower pace. Kotir *et al*. (2024) in their study have indicated that vegetation cover in Tamale has declined due to urbanization primarily brought about by residential housing construction. Zezza *et al*. (2018) also highlighted the contribution of urban growth on land degradation and deforestation in Tamale.

In the last decade (i.e. between 2014 and 2024) however, crop and forest land have seen shift where the area expanded by 27.9% (representing 23.1 square kilometers). This change in land use could either be as result of afforestation or change in land management practices. This observation fall in line with the proposed urban green space policy in Tamale to mitigate climate change impact as indicated by Alhassan and LeBrasseur (2024). Nevertheless, Acheampong *et al*. (2022) have emphasized that infrastructural growth continue to encroach on farmlands, threatening long-term sustainability of urban and peri-urban food systems.

It is also visible to see the dramatic increase in built-up areas in the first decade (between 1994 and 2004) of the study period by 103.7% as a result of urban expansion in Tamale. Substantial increases in housing as well as commercial developments have been observed by studies conducted by Alhassan and LeBrasseur (2024) in Ghana's urban areas. Further research by Acheampong *et al.* (2022) indicate that the rapid rate of farmland transformation has been confirmed by the displacement of agricultural farms due to urbanization. A 22.2% increase in built-up areas occurred between 2004 and 2014, showing a consistent trend in urban infrastructural expansion. Again between 2014 and 2024, built-up areas increased by 26.2%, also confirming the increasing trend of urbanization in Tamale.

Over the entire study period (from 1994-2024), changes in water bodies has been erratic. In the first decade of the study period (1994-2004), area covered by water bodies rose by 68.7%, likely due to efficient water management and seasonal fluctuations. In the second decade (2004 to 2014), it increased by 32.8% and in the last decade (2014 to 2024), it drastically declined by 43.2%, raising concerns about how water resources are disappearing. Such changes are linked by Arthur *et al*. (2024) to human activity and climate change, especially in Ghana's metropolitan regions.

In the past 30 years, bare lands consistently expanded. They rose by 25.7% between 1994 and 2004, indicating worsening desertification and land degradation. The growth continued from 2004–2014, with an increase of 4.7% of total area. In the works of Fisher *et al*. (2018) they discussed how urbanization could results in land degradation and temporary loss of vegetation cover in Sub-Saharan Africa, a trend evident in Tamale. Interestingly, the area under bare lands had declined by 5.3% between 2014 and 2024 which could be attributed to reforestation or land reclamation activities or conversion of such lands into built-up sites. According to Namwinbown *et al.* (2025), urban sprawl has seen the disappearance of green spaces, even though recent conservation efforts have reduced the rates at which this has occurred.

The results of this study indicate a transition from natural landscapes to urbanized environments. Forests and croplands experienced initial declines before changes occurred within the land use classes in recent years. Forests and cultivated lands had initially decreased before an upswing in recent years. Built infrastructure also continued to expand in all periods, with a decrease in water bodies before drastically reducing. Bare lands saw an upsurge transformation among the various land use classes except built-up in the earlier decades but have recently decreased, possibly due to land restoration efforts.

Table 4. 4: Change Detection Results for Tamale Metropolian Area from 1994-2024

LULC Classes	Initial Area (Sq/Km)	Final Area (Sq/Km)	Changed Area (Sq/Km)	Change (%)
Change Detection 1994-2004				
Forest &Cropland	229.40	112.70	-116.70	-50.80
Built-up Area	10.40	21.20	10.80	103.70
Water Bodies	1.50	2.60	1.10	68.70
Bare Land	408.60	513.50	104.90	25.70
Change Detection 2004-2014				
Forest &Cropland	112.70	83.00	-29.70	-26.40
Built-up Area	21.20	25.90	4.70	22.20
Water Bodies	2.60	3.40	0.80	32.80
Bare Land	513.50	537.60	24.10	4.70
Change Detection 2014-2024				
Forest &Cropland	83.00	106.10	23.10	27.90
Built-up Area	25.90	32.60	6.70	26.20
Water Bodies	3.40	2.00	-1.40	-43.20
Bare Land	537.60	509.20	-28.40	-5.30

4.2.3 Land Use and Land Cover (LULC) Change Analysis for Wa Metropolis (1994-2024)

The LULC classification outcomes of Wa Metropolis in the last 30 years show that there are major changes in land use, which are indicative of urbanization, environmental alterations, and land degradation. Figure 4.6 presents GIS maps revealing land use transformation supported by the quantified (change detection) results in Table 4.5. Between 1994 and 2004, forest and croplands had reduced by a huge percentage (of 42.6%) as the area decreased from 433.3 square kilometers (74.6% of total land area) to 248.7 square kilometers (representing 42.8% of total land area). This reduction could probably be explained by urban growth, agricultural land degradation, and environmental pressures. Sahwan (2020) had observed that urban expansion could be the influencing factor in redefining LULC in Wa Metropolis due to population and infrastructure growth. Forest and croplands improved during the period between 2004 and 2014, and grew to 296.5 square kilometers (51.0%), which could be as a result of afforestation initiatives or a soil protection program. This trend increased between 2014 and 2024, where forests and croplands had increased to 324.8 square kilometers (55.9%), supporting the urban green space projects observed in some areas in Ghana (Alhassan and LeBrasseur, 2024). Nevertheless, this process of urbanization threatens long-term sustainability (Zezza *et al.*, 2018). Bonye *et al.* (2021) in their study emphasized on how urbanization affects the use of agricultural land in Wa and observed that there are two pressures of urbanization and restoration of the environment.

Built-up areas in Wa Metropolis increased from 5.2 square kilometers (0.9%) in 1994 to 8.1 square kilometers (1.4%) in 2004, indicating early infrastructure and settlement expansion. In line with rising urbanization and economic development, built-up areas increased to 35.4 square kilometers (6.1% of total land area) by 2014, representing a 339.5% rise over the last 30 years. Urban land increased to 49.0 square kilometers (8.4%) between 2014 and 2024, supporting the trend of city growth and rising demand for residential and commercial space (Acheampong *et al.*, 2022). In order to reconcile urban growth with agricultural and environmental requirements, Osumanu et al. (2018) highlighted the necessity of sustainable land use planning in Wa.

Changes in water bodies in the Wa metropolis over the study period have occurred. The first decade (1994-2004), saw an expansion in water bodies from 0.4 square kilometers to 9.0 square kilometers (1.4%) in 2004, representing an increase of 43.7% of the land area covered by water for the entire period. The rise in the area covered by water could be due to better management of water resources, the climate and or construction of dams for irrigation purposes. However, between 2004 and 2014, the area covered by water bodies shrank to 5.7 square kilometers (1.0%), which could be due to alterations of hydrological conditions caused by climate change or water management. Then, by the end of the last decade (i.e.2014-2024), the area under water bodies expanded once more to 9.1 square kilometers (1.6%), highlighting the effects of urban water initiatives and climate variability (Arthur *et al*., 2024).

With regards to bare land, the area under this land use class expanded by 122.1%, from 141.9(24.4%) square kilometers in 1994 to 315.1 square kilometers (54.2%). This phenomenal increase could either be as results of seasonal factors, namely loss of vegetation in the dry season or land degradation. Fisher *et al*. (2018), have corroborated this pattern in their findings where land degradation induced by urbanization was found across Sub-Saharan Africa. In the second decade (2004-20140) of the study period, bare land area declined to 243.2 sequare kilometers (41.9%) which could indicate a regeneration of degraded lands. Further in the last decade (2014-2024), the area under bare lands again decreased to 197.9 square kilometers (34.1%), pointing to continuous growth in urban settlement as well as strategies to reduce land degradation. Observing similar patterns, Mandere *et al*. (2010) have indicated this increase could trigger land use competition in peri-urban communities around the globe.

Generally, significant changes in land use has been witnessed in the Wa metropolis in the last three decades. These changes have transformed the agricultural space in peri-urban communities. Some studies including those of Bonye *et al*. (2021), Osumanu *et al*. (2018) and Sahwan (2020) demonstrated how urbanization impacts agriculture raising food insecurity concerns. Agricultural zones across Sub-Saharan Africa are frequently displaced due to urban expansion which underscores the need to integrate land use policies to slow agricultural land encroachment.

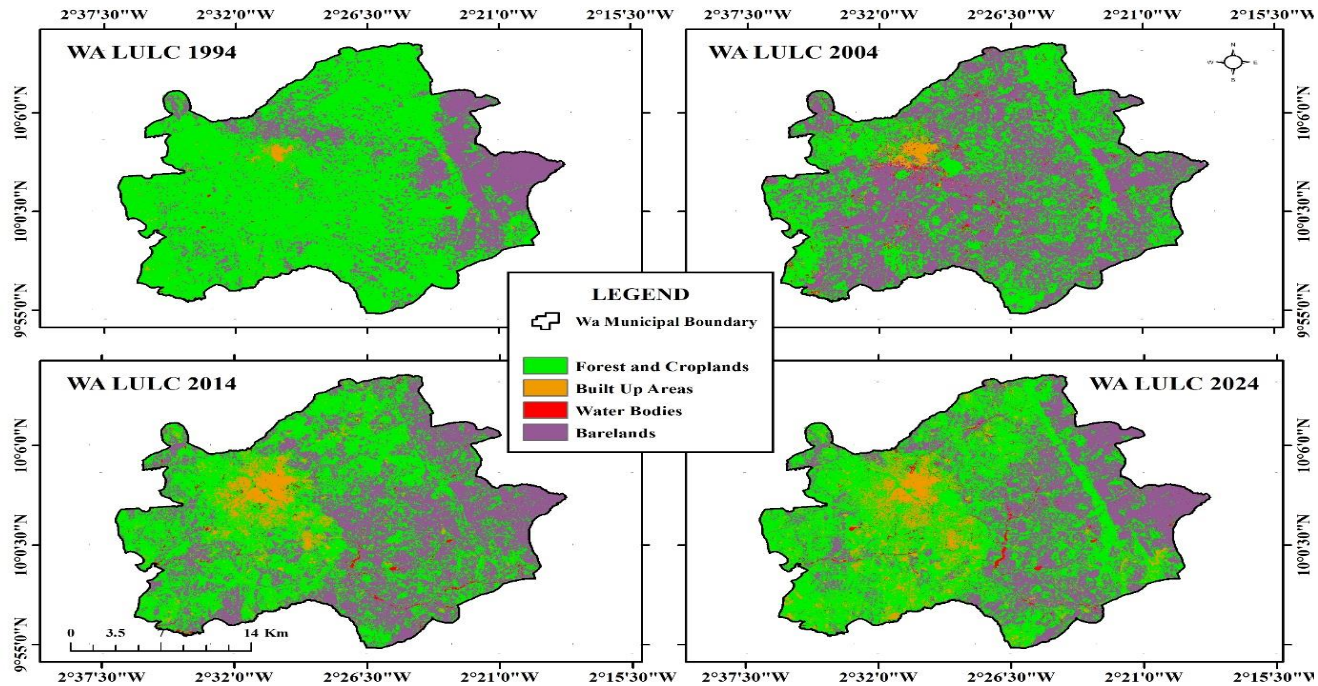

Figure 4. 6: Map of LULC for Wa Metropolis from 1994-2024

Table 4. 5: LULC Classification for Wa Metropolitan Area from 1994-2024

LULC Classes	**1994-Classif. Area (Sq/Km)**	**%**	**2004-Classif. Area (Sq/Km)**	**%**	**2014-Classif. Area (Sq/Km)**	**%**	**2024-Classif. Area (Sq/Km)**	**%**
F&CL	433.30	74.60	248.70	42.80	296.50	51.00	324.80	55.90
BU	5.20	0.90	8.10	1.40	35.40	6.10	49.00	8.40
WB	0.40	0.10	9.00	1.60	5.70	1.00	9.10	1.60

BL	141.90	24.40	315.10	54.20	243.20	41.90	197.90	34.10
Total A.	580.80		580.80		580.80		580.80	

Note: F&CL=Forest and croplands; Bu=Built-ups; WB=Water Bodies; BL=Bare lands

4.2.4 Change Detection Analysis for Wa Metropolis (1994–2024)

Table 4.6 presents the change detection results for the Wa metropolis over the 30 years periods under this study. Observed changes reflected the land use patterns caused by factors such as urbanization, land degradation and changes in environmental conditions.

Of particular interest in this study is forest and croplands encroachment by urban expansion. In the first decade (1994-2004), there was a precipitous decline in forest and croplands by 184.6 square kilometers, representing 42.6% of the total land area, suggesting pervasive deforestation and transformation of agricultural lands. The amount of bare land increased by 173.2 square kilometers (122.1%), indicating a worsening of desertification and land degradation. At the same time, built-up areas increased by 2.9 square kilometers (55.1%), indicating the beginning of urban growth. Water bodies expanded by 8.6 square kilometers (21.5%), probably due to better water management or seasonal changes (Sahwan, 2020; Fisher *et al.*, 2018).

The forest and croplands have expanded (47.8 square kilometers representing 19.2%) between 2004 and 2014, possibly due to afforestation programs or the changes in land use policies in favor of agricultural production. Land area under construction (built infrastructure) increased radically by 27.4 square kilometers (339.5%) which was the most intense period of urban growth in Wa. Water bodies reduced by 3.3 square kilometers (36.3%), which could be attributed to hydrological alterations or heightened human use. The area of bare lands shrank by 71.2 square kilometers

(22.6%), which could be as result of the successful land reclamation processes or infrastructural development (Bonye et al., 2021; Arthur *et al*., 2024).

Between 2014 and 2024, urban settlements had extended, where built-up areas had risen by 13.6 square kilometers (38.4% of total land area). At the same time, forest and agricultural lands have also increased by 28.3 square kilometers (9.5%), strengthening conservation efforts. But the water bodies recovered 3.4 square kilometers (58.5%), which is probably because of the better conservation efforts or more precipitation. However, bare lands were lost (18.8% or 45.9 square kilometers), for reasons that may include restoration efforts or infrastructural expansion (Zezza *et al.*, 2018; Mandere *et al*., 2010).

Wa Metropolis has undergone shifts in land use witnessing extreme deforestation and land degradation to periods of partial recovery, where urban growth continues throughout all decades. The previous years were characterized by fast deforestation and growth of bare lands, whereas the middle-to-end years were characterized by an afforestation process and further urbanization. The most dynamic processes of water bodies indicate that there are intricate interrelationships between climatic effects and human activities. The findings have highlighted the importance of sustainable land management in order to strike a balance between infrastructural development and environmental conservation.

Table 4. 6: Change Detection Results for Wa Metropolis from 1994-2024

LULC Classes	Initial Area (Sq/Km)	Final Area (Sq/Km)	Changed Area (Sq/Km)	Change (%)
Change Detection 1994-2004				
Forest &Cropland	433.3	248.7	-184.60	-42.60
Built-up Area	5.20	8.10	2.90	55.10
Water Bodies	0.40	9.00	8.60	21.50
Bare Land	141.90	315.10	173.20	122.10
Change Detection 2004-2014				
Forest &Cropland	248.70	296.50	47.80	19.20
Built-up Area	8.10	35.40	27.40	339.50
Water Bodies	9.00	5.70	-3.30	-36.30
Bare Land	315.10	243.20	-71.20	-22.60
Change Detection 2014-2024				
Forest &Cropland	296.50	324.80	28.30	9.50
Built-up Area	35.40	49.00	13.60	38.40
Water Bodies	5.70	9.10	3.40	58.50
Bare Land	243.20	197.90	-45.90	-18.80

4.2.5 Land Use and Land Cover (LULC) Change Analysis for Bolgatanga Municipal (1994-2024)

Between 1994 and 2024, Bolgatanga Municipality had witnessed significant changes in land use and land cover (LULC) change due to the dynamic interplay between urbanization, the environment, and agricultural activities. The GIS maps in Figure 4.7 show the transformation of land use supported by the change detection results in Table 4.7.

The LULC classification findings of Bolgatanga Municipal over the thirty years depict a steady reduction of forest and crop lands, high rate of urbanization, and rise in bare lands, which are indications of the current processes of urbanization, land degradation and environmental issues in the municipality. The loss of forests and croplands was tremendous at 138.67 square kilometers (42.54% of total area in 1994) to 68.95 square kilometers (21.15% of total area in 2024), representing 50.3% in the last thirty years. The sharpest reduction was between 2004 and 2014, when forest and croplands reduced by 31.3 square kilometers (26.9%), which was probably because of urban growth, conversion of agricultural lands and deforestation.

Research investigations in northern Ghana have shown that the loss of croplands has been caused by climate variability, changes in agricultural practices, as well as population growth (Acheampong *et al*., 2022). Besides, Zezza *et al*. (2018) emphasize that the growth of urban areas in developing countries directly cause deforestation and the loss of croplands. According to Kuusaana *et al.* (2022), the conversion of land into residential and commercial infrastructure puts urban agriculture in Bolgatanga at risk. According to their analysis, farmers are now compelled to use undeveloped residential properties and open space for food production because urban growth has significantly reduced the amount of agricultural space. This is a trend that is consistent with wider issues of food security and land competition in the quickly developing cities.

The processes of urbanization has been massive, with built infrastructure growing from 3.48 square kilometers (2.33%) in 1994 to 22.50 square kilometers (6.90%) in 2024, representing an over all 547% increase in urban land coverage. The most significant growth was between 2004 and 2014, in which built up areas increased significantly from 6.18 square kilometers (2.56% of total area) to 14.45 square kilometers (4.43%), indicating the development of infrastructure, housing, and commercial activities. As highlighted by Osumanu et al. (2018), Bolgatanga municipal like any other Ghanaian secondary cities, is undergoing an accelerated urbanization process with the most prominent outcome being the loss of farmlands. Land use planning in Bolgatanga municipal has been a problem as its complexity has been growing where limited available spaces are constantly competing across various land uses. Kuusaana *et al*. (2022) discovered that the city land parcels are unsustainably used to develop infrastructure, which puts the food system at risk. The research cautions that poor spatial planning systems do not safeguard urban agricultural lands, resulting in land fragmentation and eviction of farmers.

Although water bodies still form a minor land cover type, it has increased consistently over the years from 0.78 square kilometers (representing 0.24% of the total area) in 1994 to 2.30 square kilometers (0.71% of total area) in 2024. This accumulatively represents an increased of 194.9% over the 30 years period and this could either be attributed to climatic conditions or the construction of dams and reservoirs or natural hydrological fluctuations (Arthur *et al*., 2024). Nevertheless, even with the growth, water bodies still occupy a very low percentage of total land cover which is a cause for concern regarding water resource management in the municipality.

The expansion of bare lands has been predominant, rising to 232.19 square kilometers (representing 71.24% of total area) in 2024, from 26.9% or 183.01 square kilometers in 1994 within 30 years. Bare lands growth is a sign of land degradation, soil erosion, purchased but undeveloped lands and climate-induced desertification, an assertion similar to findings by Fisher *et al*. (2018).

The growth in bare lands between 1994 and 2004 was 19.82 square kilometers (10.8% of total area), which has increased more rapidly between 2004 and 2014 (22.67 square kilometers (representing 10.9%). According to Mandere *et al*. (2010), such trends are observed in peri-urban regions of the world, where the spread of urban areas reduce vegetation cover, and bare soils become more exposed.

The processes of urbanization in Bolgatanga Municipal has been characterized by consistent urban development, massive deforestation, and land degradation. Bare lands continue to expand whilst forest and croplands continue to reduce. The challenges of urban agriculture, where agricultural lands have been fragmented by urban development, compelling farmers to use undeveloped residential land and open spaces to cultivate food crops (Kuusaana *et al*., 2022).

These land use shifts correspond to the overall regional perspective, therefore necessitating the need for sustainable land management policies to conserve the remaining forested lands, control the urbanization process, and reduce environmental degradation (Antwi *et al*., 2014). Food-based urban planning would help the agricultural sector in Bolgatanga municipal to improve and address the food security issues and competition over land.

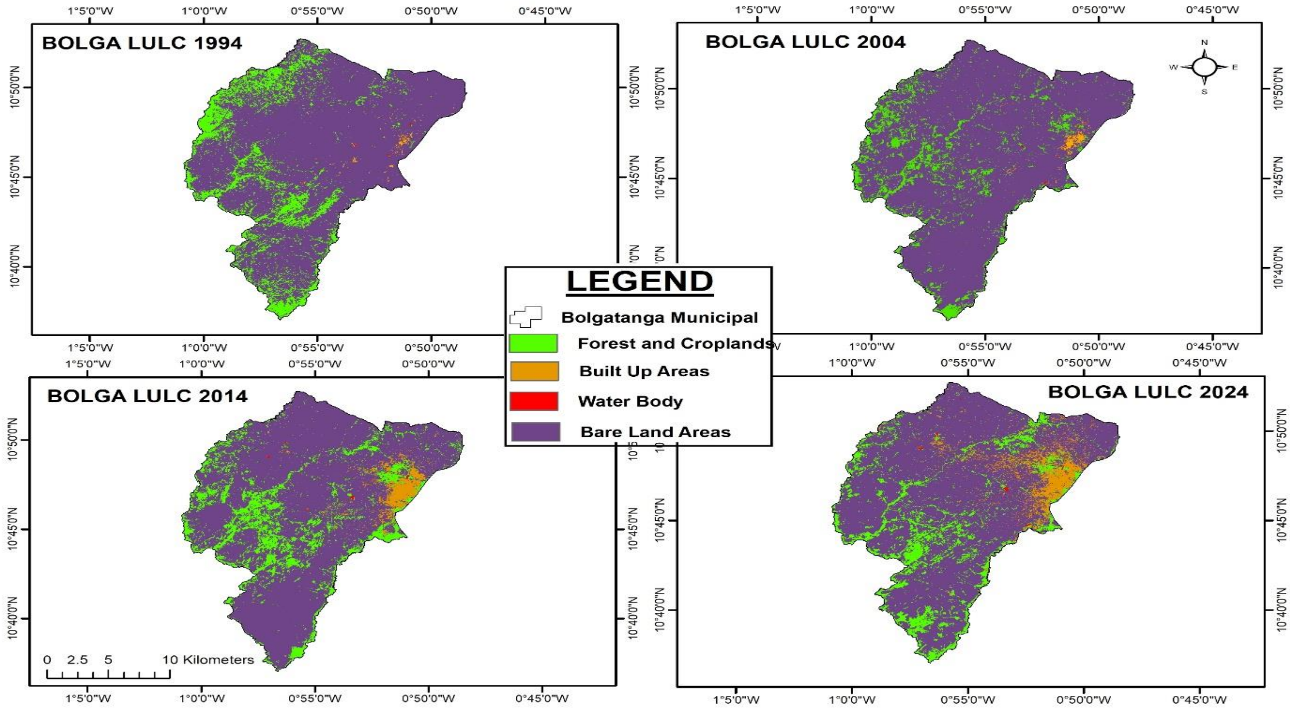

Figure 4. 7: Map of LULC for Bolgatanga Municipal from 1994-2024

Table 4. 7: LULC Classification for Bolgatanga Municipality from 1994-2024

LULC Classes	1994-Classif. Area (Sq/Km)	%	2004-Classif. Area (Sq/Km)	%	2014-Classif. Area (Sq/Km)	%	2024-Classif. Area (Sq/Km)	%
F&CL	138.67	42.54	116.03	35.60	84.73	26.00	68.95	21.15
BU	3.48	2.33	6.18	2.56	14.45	4.43	22.50	6.90
WB	0.78	0.24	0.90	0.28	1.26	0.39	2.30	0.71
BL	183.01	56.15	202.83	62.23	225.50	69.18	232.19	71.24
Total A.	325.94		325.94		325.94		325.94	

Note: F&CL=Forest and croplands; Bu=Built-ups; WB=Water Bodies; BL=Bare lands

4.3.6 Change Detection Analysis for Bolgatanga Municipal (1994-2024)

Table 4.8 presnts the results of the change detection of LULC. The reults reveal that built-up area has significantly expanded, directly shrinking forests and agricultural lands. Bare lands have increased significantly as influence by infrastructure development, population pressure, and environmental stress. Such patterns align with the entire trend in northern Ghana, where the process of climate change and urban expansion is reshaping land use patterns (Kuusaana et al., 2022; Akolgo-Azupogo *et al*., 2024).

Urban land conversion resulted in loss of forest and croplands by 16.33 %(22.64 square kilometers) between 1994 and 2004. Increased population pressures and land-based commercial activities accelerated deforestation, which minimized natural vegetation and cultivated lands (Antwi *et al*., 2014). On the other hand, permanent settlements grew by 77.59% (2.79 square kilometers) which indicated the initial urbanization, infrastructure development and settlement expansion. This growth is consistent with the regional investigations that show an increased land fragmentation and agricultural-urban development conflict (Osumanu *et al*., 2018). Water bodies grew by 15.38% (+0.12 square kilometers), possibly because of dam construction or changes in climate, whereas bare lands grew by 10.83% (+19.82 square kilometers), which is an indication of land degradation and loss of vegetation caused by growing urban areas (Fisher *et al*., 2018).

The last 30 years has been characterized by rapid urbanization and displacement of farmlands with the largest decline recorded in the forest and croplands of 26.98% (-31.30 square kilometers). This is an indication of growing pressure on land resources, as urbanization takes over agricultural lands. Built-up area rose by 133.82% (8.27 square kilometers for the entire study period) which solidifies the urbanization pressure in Bolgatanga municipal. This high growth rate of land loss to urban built-up corresponds to the general trends of urban growth in Ghana, as secondary cities become commercial and their infrastructure needs become increasingly high (Acheampong *et al*., 2022). There was an increase in the area covered by water bodies by 40% (+0.36 square kilometers) that may have been as a result of hydrological changes or urban water retention projects. An increase in bare lands of about 11.18% (+22.67 square kilometers) also occurred, leaving more land exposed to soil erosion, desertification and land degradation threats (Mandere *et al*., 2010).

Between 2014 and 2024, urban expansion continue to invade even more agricultural lands further reducing available forest and croplands by 18.62% (-15.78 square kilometers). However, the pace of decline was slow compared to the past decades, which could be explained by urban afforestation efforts and conservation programs to reduce deforestation (Zezza *et al*., 2018). The land use class covered by built-up expanded by 55.71%, representing some 8.05 kilometers square. This expansion in built-up area contributed to the ongoing housing and commercial development being witnessed in the Bolgatanga municipality and its periphery. Farm land displacement becomes obvious as demand for infrastructure continue to grow, raising concerns about the increasing urban footprint as questions lingered about land use efficiency (Osumanu *et al*., 2018). On the other hand the land use class representing bare lands expanded slightly by 3.0% (more than 6.69 square kilometers). The slow expansion in this land use class could be indicative of some land stabilization initiatives to reduce the land degradation. The area covered by water bodies also expanded significantly by 82.54%, representing more than 1.04 square kilometers, probably due to an improvement in water management and variation in climatic conditions as observed by Arthur *et al.* (2024).

The combine effect of deforestation, increasing activities of urbanization as well as bare land expansion drive the land use and land cover changes in Bolgatanga municipality. Research evidence attributed these changes to agricultural displacement, inefficient urban planning and land commoditization (Akologo-Azupogo *et al*., 2024;). The processes of urbanization limits access to farmlands which directly has a bearing on food insecurity and sustainability (Cohen & Munro, 2020). According to Antwi *et al*. (2024) and Acheampong *et al*. (2022), there is need for coordinated land use planning in Ghana to avert the uncontrolled urban expansion. Without sustainable land management policy, the issues regarding food system resilience, environmental stability and urban planning will encounter serious challenges.

Table 4. 8: Change Detection Results for Bolgatanga Municipality from 1994-2024

LULC Classes	**Initial Area (Sq/Km)**	**Final Area (Sq/Km)**	**Changed Area (Sq/Km)**	**Change (%)**
Change Detection 1994-2004				
Forest &Cropland	138.67	116.03	-22.64	-16.33
Built-up Area	3.48	6.18	2.79	80.17
Water Bodies	0.78	0.90	0.12	15.38
Bare Land	183.01	202.83	19.82	10.83
Change Detection 2004-2014				
Forest &Cropland	116.03	84.73	-31.30	-26.98
Built-up Area	6.18	14.45	8.27	133.82
Water Bodies	0.90	1.26	0.36	40.00
Bare Land	202.83	225.50	22.67	11.18
Change Detection 2004-2014				
Forest &Cropland	84.73	68.95	-15.78	-18.62
Built-up Area	14.45	22.50	8.05	55.71
Water Bodies	1.26	2.30	1.04	82.54
Bare Land	225.50	232.19	6.69	3.00

4.2.6 Trend of Farmland Loss to Urban Built Infrastructure in Tamale, Wa and **Bolgatanga**

In the last 30 years, the metropolitan cities of Tamale and Wa, and the Bolgatanga municipality have witnessed tremendous land use transformation. This has resulted in steady decline in forest and croplands due to rapid urban expansion driven by infrastructure development. From the results of LULC and Change Detection analysis, a distinct trend in the loss of farmland is observed, emphasizing the challenges in balancing the processes of urbanization and agricultural sustainability (Achempong & Anokye, 2022; Cohen & Munro, 2020).

Across all three cities, forest and croplands has experienced drastic decline, where a formerly known agrarian communities are being encroached by urban areas. In the Tamale metropolis, a wave-like trend of farm land loss has been observed. A reduction of forest and croplands started from 229.4 square kilometers (35.3%) which occurred in 1994 to 83.0 square kilometers (12.8%) in 2014, it then rise to 106.1 square kilometers (16.3%) in 2024. Urban growth remains the major influencing factor in land use change, though afforestation efforts such as the Re-greening Africa

Programme aimed at helping achieve this modest rebound as highlighted by Dinye (2020) and Arthur *et al*. (2024). In the space of ten years, forest and croplands have witnessed a drastic decrease by 42.6% of the total land area, thus from 433.3 square kilometers (74.6 %) in 1994 to 248.7 square kilometers (42.8%) in 2004. Rapid urban expansion continue to be major issue, though croplands slightly expanded to 324.8 square kilometers (55.9%) in 2024. Some studies such as Bonye *et al*. (2021), have indicated that increasing land speculation couple with commercial development have affected farmers to the extent that they are compelled to relocate to urban peripheries or giving up farming completely. The decline in forest and croplands as observed in Tamale and Wa is not different from that of Bolgatanga municipal. Forest and croplands has witnessed a gradual reduction from 138.67 square kilometers (42.54% of the total area) in 1994 to as low as 68.95 square kilometers (21.15%) in 2024, accumulatively representing 50.3% for the entire study period. Farmland loss has been consistent for the entire three decades in the Bolgatanga municipality, compared to Wa and Tamale where shifts in land use have occurred between other land use classes. This pattern indicates that agricultural land is continuously being displaced primarily due to urbanization linked to infrastructural expansion (Kuusaana *et al*., 2022; Akologo-Azupogo *et al*., 2024)

Expansion in built-up land use class was consistent whereas area covered by farmland decreases, clearly demonstrating a unique pattern of land transformation from agriculture to infrastructure. Built-up area expanded from 10.4 square kilometers, representing some 1.6% in 1994 to 32.6 square kilometers (5.0%) in 2024. Overall built-up area in the Tamale metropolis expanded by 213.5% alongside rapid growth in peri-urban residential zones. Empirical evidence show that development of infrastructure such as roads, public infrastructure, and commercial transformations have been a major driving forces of farmland conversion (Arthur *et al*., 2024; Toku, 2018). Among the three cities, Wa metropolis experienced the highest built-up expansion with a leaping 841.1%, thus from 5.2 square kilometers representing just 0.9% of the total area in 1994 to 49.0 square kilometers (8.4%) in 2024, and positioning Wa as the rapidly urbanizing metropolis, compared to Tamale and Bolgatanga. Studies such as Acheampong *et al*. (2022) have found that land conflicts between farmers and real estate developers have become serious because the increasing demands for housing, municipal services and markets. In the case Bolgatanga, there is a slightly slower but consistent urban expansion compared to Wa and Tamale. Built-up areas expanded by 547% in three decades, from 3.48 square kilometers (2.33%) in 1994 to 22.50 square kilometers (6.90%) in 2024. Access to farmland has been severely affected by the unsustainable commoditization of urban land. As a result farmers are compelled to rely on small but irregular patches of plots that are not suitable for commercial food production (Akologo-Azupogo *et al*., 2024).

The findings from the LULC analysis revealed a general trend of farm displacement. Farmers have to deal with current land fragmentation in the face of ongoing urban expansion. Land fragmentation in the Tamale metropolis is visibly evident, especially in peri-urban communities. According to Dinye (2020) agricultural parcels have been sub-divided into residential and commercial developments. Many peri-urban farmers in Wa have been forced out to relocate to areas that are exposed to adverse climatic conditions in rural periphery because of rapidly urbanizing processes, limiting their access to other resources and vital markets (Bonye *et al*., 2021). In Bolgatanga, shortage of land and displacement of rural population have been worsened by the aggressive land commoditization usually involving the unofficial trading of farmlands for urban expansion.

The loss of farmlands in Tamale, Wa and Bolgatanga has been a serious concern as it undermines agricultural resilience, land conversion and household food security. Much as Mandere *et al*. (2020) have suggested that strategies in urban land management are necessary to protect farming communities, Cohen and Munro (2020) warn that if uncontrolled urban growth in Sub-Saharan Africa is not checked, could pose a long-term risk of food production system. In order to sustain food production resilience, Antwi *et al* (2014) and Acheampong *et al*. (2020) have put a suggestion that policy makers should integrate urban planning policies that would balance development and sustainable land use in Ghana so as to prevent farmland lost or reduce it.

These findings in land use and land cover changes reflect the narratives of how some respondents view urban expansion and its consequences in their well-being. Some of the views expressed by respondents are as follows;

I asked Mr. Abenne Akayoba how the farmland situation would be in the next five years from now, he remarked that five years is far because the danger posed by farmland loss is already looming. He indicated that the youth would not get land to produce food and for building. This assertion was supported by Mr. Agandaa Akayoba that times are going to be very tough, indicating that in the past, building a house did not require much land as compared to now. He noted that if nothing is done to manage population and land use management, peri-urban communities will suffer to survive. As to whether the impact of farmland loss was the same for men, women and youth, he replied ''the impact of land loss affect everyone, even if you did not sale land, because those who sold would end up depending on the limited available land from those who did not sell.

Mr Aboyine Atanga lamented that land loss has put him and his family in perpetual food insecurity. He recounted how his family members sold out all the land originally used for farming for building *infrastructure, with no compensation for him. Now the only option is to relocate to a distance location for farmland which is practically difficult because of lack of resources.*

A farmer in the Bamuhu community in the Wa Metropolis indicated that land loss has become so serious a problem that households are no longer at ease as they are always in constant fear of not being able to feed their families. He noted that most households rely on the University for Business and Integrated Development Studies land for food production. ''Every year we start the farming season with uncertainty as to whether the season would end because your farm crops can be destroyed at any point in the season for a building project. Despite these challenges, we still thank God for the university land because had not being the university acquiring the land we would not have had land to produce food, since all other lands in the community have been sold out to urban developers''

A farmer in the Wa Metropolis, Urban development has several benefits (such as new school buildings, road network, water provision, health facilities but are expensive for us) but for us farmers especially women farmers' urban expansion affect us in terms of producing food for our families because farming is our main livelihood activity.

A farmer in the Wamale community in the Tamale Metropolis stated that ''Here in Wamale community in the Tamale Metropolis, individuals do not own land and because of that land security is a big issue for us since ones farmland can be taken by the chief any time for sale to urban developers for infrastructural development. In fact right now all our farmlands have been sold out for urban development''.

4.3 The Effect of Peri-Urban Farmland Loss on Household Staple Maize Yield

The quantile regression estimation technique was applied in this section to examine the relationship between farmland loss and maize yield at the household level. Quantile Treatment Effects models were estimated since the objective was to understand the heterogeneous effects across different quantiles of the yield distribution. According to Firpo *et al*. (2009) quantile treatment effects methodology provides more clarity than the traditional average treatment effects methods. As the average treatment effect is known for producing a single estimate leading to their inability to capture variations at different levels of productivity, quantile-based estimation perfectly addresses such concerns especially in agricultural research where heterogeneity exist (Borgen *et al*., 2022).

The suitability of the RQR lies in its ability to remove confounding variables in its two-stage approach and estimating QTEs (Firpo, 2007). Its robust nature allows for handling high-dimensional fixed effects because it ensures that coefficients are not affected by observable covariates (Frölich & Melly, 2010).

To enhance the dependability of the estimated results, the RQR was estimated in three different scenarios. These three levels of estimation were based on whether controls, fixed effects variables or both, or no inclusion of controls at all. This provides avenue for thorough evaluation of treatment effects across different model specification as pointed out by Morgan and Winship (2015). First, the treatment variable (in this case, farmland loss) is broken down into two components: one that can be explained by the observed control variables and a residual component that is independent of these controls. This is the first step in the RQR procedure. Second, the outcome variable (maize yield) is regressed on the residualized treatment variable using the Conditional Quantile

Regression (CQR) technique. Table 4.9 below shows the variables used in the first step of residualized quantile regression (RQR).

Table 4. 9: Variables Used in First Stage Estimation of RQR

Variable	Definition/Measurement
Socioeconomic Characteristics	
Sex of respondent	1 if male, 0 otherwise
Age (years)	Number of years
Household size	Number of people in the farming household
Education (years)	Number years of education
Farming experience	Number of years in farming
Farm Characteristics	
Farm size	Number of acres
Household income	Gross annual household income in GHS
Fertilizer usage	Number of kilograms of fertilizer applied
Remittances	1 if received remittances, 0 otherwise
Improved seed	Number of kilograms of improved seed used
Institutional Characteristics	
Access to extension service	1 if has access to extension service, 0 otherwise
Access to credit	1 if received credit requested, 0 otherwise
Land tenure	1 if land tenure is customary, 0 otherwise
Membership of organization	1 if member of social organization, 0 otherwise
Market distance	Number of kilometers to city center (km)
Fertilizer subsidy	1 if received fertilizer subsidy, 0otherwise
Environmental and Spatial factors	
Market plot distance	Number of kilometers from farm to city centre
Land loss	1 if lost land, 0 otherwise
Flood	1 if experience flood situation, 0 otherwise
Drought	1 if experience drought situation, 0 otherwise
Location characteristics	
Upper West region	1 if locate from Upper West region, 0 otherwise
Northern region	0 if located from northern region, 1 otherwise

4.3.1 Estimates of the Second Stage of the Residualized Quantile Regression (RQR)

There are worries about how the fast growth of peri-urban regions may affect agricultural production because it has resulted in a substantial loss of acreages. This study looks at the association between farmland loss and maize yield across 387 observations using Residualized Quantile Regression. In order to guarantee the robustness of the estimated coefficients, a bootstrapping was done with 200 replications; this process also ensure that the coefficients are statistically accurate and unbias. Table 4.10 shows the Wald test statistic ($\chi^2 = 6.67$, $p = 0.0098$), which is highly statistically significant revealing the impact of farmland loss on maize productivity. Further discussions are presented in the following section with emphasizes on the relationship between land limitation and sustainable land use.

To understand the correlation between maize productivity and farmland loss, residualized quantile regression can be appropriately utilized. From the estimated results, it's observed that there was a consistent negative effect running through all quantiles. However, the highest impact was observed at the median (Q50) and seventy fifth quantile (Q75), suggesting that land limitation substantially reduces maize productivity of medium and high-yield households. Given that adaptation measures can vary, the consistent negative impact of the coefficients (at Q25 and Q90) re-emphasizes that both lower and high-yield farmers are all affected. These findings are similar to other findings confirming that farm productivity is affected by land fragmentation. For example, in Kiplimo and Ngeno's (2016) study, it was discovered that smallholder farmers in Kenya with fragmented landholdings are associated with lower efficiency, suggesting that productivity is disproportionately affected by the loss of farmland. When Acquah (2018) compared OLS and quantile regression approaches in Ghanaian maize farms, it was found that the quantile regression technique produces more comprehensive insight into the varying effects across different yield distribution levels. Furthermore, research conducted by Wang *et al.* (2023) to understand the impacts of land transfer and the distribution of income shows that land limitation can deepen farm income disparities.

Table 4. 10: Results of the Second Stage RQR Model

Maize Yield(kg/Ha)	Observed Coefficient	Bootstrap standard Error
Q.25		
Land Loss	-0.3672***	0.1422
Constant	6.4256***	0.0453
Q.50		
Land Loss	-0.4931***	0.0992
Constant	6.8095***	0.0446
Q.75		
Land Loss	-0.5155***	0.1099
Constant	7.2808***	0.0736
Q.90		
Land Loss	-0.4840***	0.1184
Constant	7.7799***	0.0715

Diagnostic statistics: *Sign. Levels of coefficients: ***, **, *, are 1%, 5% and 10% respectively. Note: Q=quantile*
Number of obs = 387; Replications = 200
Wald chi^2 (1) = 6.67; Prob>chi^2 = 0.0098

4.3.2 Residualized Quantile Regression (RQR) Under Different Estimation Scenarios

In this section, the residualize quantile regression was estimated under three different scenarios. The basis for this approach is to understand how the RQR estimation performed when control variables or fixed effect covariates or none at all are included in the estimation procedure. Following this the first model was estimated without both controls and fixed effects variables. This process created a baseline but left out confounding variables. In the second scenario the treatment effect estimate was refined by including variables that could influence maize yield. Lastly, both control variables and fixed effects covariates were included in the third model, which seems to be the most reliable model that could predict the effect of farmland loss as it accounts for unobserved heterogeneity (World Bank, 2020).

The impact of farmland loss on maize productivity distribution is dependent on the quantile a household is located as revealed by the RQR results presented in Table 4.11. In the first model, the direct correlation between the outcome variable ie maize yield and the treatment variable thus farmland loss are isolated by regressing the treatment variable on the outcome variable without control variables. The coefficients ranged from -0.288 in the Q25 to -0.651 in the Q75, revealing statistically significant but negative influence in all quantiles. It shows a unique consequences of limited access to land on maize production at different productivity levels, in which lower (Q25) quantile farmers suffer more losses mainly because of resource constraints that restrict their capacity to adapt practices that would enhance yield (Jayne *et al*., 2019). Larger farms or higher-yield farmers, equally experienced losses as shown by the negative effect at Q75 (with coefficient of -0.651). The consistent revelation of the negative impact even at Q90 (-0.560), raises concerns about the diminishing agricultural sustainability, suggesting that even the most efficient farmers could encounter challenges due to land loss (Abdulai & Huffman, 2014).

The relationship between the treatment and the outcome variables improves with the inclusion of the control variables in the 2nd model, indicating that other factors may influence maize productivity. It is observed that the results are consistent with model 1, with all coefficients statistically significant and negative in all quantiles. Nevertheless, the impact is found weaker at Q75 (-0.576) compared to model 1 ans 2. It is obvious that certain structural factors such as access to irrigation, availability of inputs, can results in yield loss to a significant extent, but do not entirely eliminate them(Sultan *et al*., 2019). Interestingly, the coefficient (-0.621) at Q90 remains statistically significant and negative, which emphasizes that even at higher quantiles farmers also encounter challenges caused by farmland loss. Therefore, with the persistent negative impacts revealed at all quantiles of the yield distribution, it's important for policies designed to support farmers affected by farmland loss at all levels (FAO, 2021).

The 3rd Model incorporates both control and fixed effects variables, which clearly enhances the results, particularly at the higher quantiles. However, the negative coefficients diminishes with no statistical significance at Q25 (-0.186), which is an indication that smallholder farmers may response differently to farmland loss. The results show that with the addition of structural impacts and fixed effects, mean quantile (Q50) do not have effect, suggesting that maize yield could stay steady at this level. With the appearance of a positive coefficients at Q75 (0.494) and Q90 (0.998), could be an indication that farmers at the higher quantiles of the yield distribution may be implementing certain mitigating practices (such as crop intensification or efficient land management) where yield losses could be restored (FAO, 2021). This resolve by farmers at the higher quantiles emphasizes the significance of having access to improved practices and technologies capable of preventing yield losses in the presence of limited access to land (Jayne et al., 2019).

Putting all together, the three models visibly revealed the complex relationship between limited land access and maize yield. The trend was changed by the addition of fixed effects in Model 3, especially at higher quantiles where adaptation practices could reduce yield losses, while Models' 1 and 2 consistently exhibit negative effects at all levels. The results suggest the necessity for policy measures that could support both smallholder and mid-tier farmers, and also how higher quantile farmers can use resources to increase productivity. According to Jayne *et al.*, (2019), policies on land conservation and tenure security ought to be considered topmost priority that would grant farmers access to steady land for a sustainable agricultural investment. Support programmes such as credit facilities, subsidies, and agricultural insurance could reduce the negative impacts of farmland loss on crop yield (Abdulai and Huffman, 2014). Investing in mechanization and infrastructure, such as better roads and storage facilities, would improve market access and price stability, lessening economic hardships of land loss households (FAO, 2021). Broadening the scope of agricultural initiatives such as Feed Ghana's Program with much emphasis on land conservation can sustain maize productivity. Ensuring continuous monitoring and evaluation of land policies will allow policymakers to make informed, data-driven adjustments to improve agricultural outcomes (World Bank, 2020).

Table 4. 11: Results of the Three Main Estimating Procedure of RQR Model

Model type	***Q25***	***Q50***	***Q75***	***Q90***
Model 1	-0.2877(0.1098) **	-0.5596(0.1163) ***	-0.6506(0.1159) ***	-0.5596(0.1199) ***
Model 2	-0.3604(0.1125) **	-0.5634(0.1161) ***	-0.5763(0.1139) ***	-0.6205(0.1241) ***
Model 3	-0.1860(0.2820)	0.0000(0.2785)	0.4937(0.2864)*	0.9976(0.2369) ***

Model without control variables; Model 2 with control variables; model 3 with control and fixed effects variables. Note: ******, **, **** *are statistical significant levels of* ***1%, 5% and 10%*** *respectively. Values in the brackets are standard errors.*

4.3.3 Comparative Analysis of Conditional, Unconditional, and Residualized Quantile Regression Models

The results of the various estimated QR approaches indicate that residualized quantile regression (RQR) produces more effective estimates of the QTEs compared to the conditional quantile regression (CQR) as well as unconditional quantile regression (UQR). As indicated earlier, RQR model is a two-step analytical approach which residualizes treatment effects first to eliminate confounding effects followed by quantile treatment effects estimation (Borgen *et al*., 2022). This approach can avoid bias of the estimated effects by the covariates that are observed, hence it is especially applied in high-dimensional fixed effects contexts (Firpo *et al*., 2009). CQR, on the other hand, measures the effect of treatments conditional on covariates, and this method may underestimate the actual effect because of its subgroup-specific form (Machado and Silva, 2018).

The performance of the various models as revealed in Table 4.12, indicate that the negative coefficients in CQR are weak thus indicating that it is not a strong measure of the unconditional impacts of loss of farm land on maize yield.

A unique attribute of the UQR is that, it's able to estimate treatment effects across the whole distribution without necessarily have to control for covariates, making more appropriate for population-wide effects (Firpo, 2007). Nevertheless, one major limitation of the UQR is its inability to adequately account for confounding factors, making its positive estimated coefficients prone to being bias (Powell, 2020). Despite the fact that it's easily estimated, its application in complex data is limited since it cannot account for fixed effects (Borgen *et al*., 2021). This is where RQR is more appropriate as it's able to produce accurate estimates through the removal of confounding variables from the treatment effects. With RQR, quantification and understanding of the effects of land loss on maize productivity is made easier at different quantiles (Morgan & Winship, 2015).

It is therefore safe to conclude that the RQR is most effective for estimating quantile treatment effects. Compared with CQR and UQR, the accuracy and relevance of RQR makes it ideal for policy adoption because its able to estimate and account for confounding and high-dimensional fixed effects factors (Frolich and Melly, 2010).

Table 4. 12: Comparison of the Main QTEs Models Estimates

Model	***Q25***	***Q50***	***Q75***	***Q90***
RQR	**-0.3672(.1408) ****	**-0.4931(.1017) *****	**-0.5155(.1122) *****	**-0.4840(.1211) *****
CDR	-0.2527(0.1387)*	-0.2835(0.1111)*	-0.2736(0.0898) **	-0.2199(0.0823) **
UQR	1.8281(0.5641) **	2.1335(0.2386) ***	1.9794(0.8246)*	1.9841(0.5828) **

*Statistical significant levels of the regression coefficients: p>1%***; p>5%**; p>10*. Values in the brackets are standard errors.*

The narratives of respondent with respect to farmland loss and its impact in this analysis is reinforced by the views of respondents in the study area.

When asked what the status of land availability for crop production in the Yikene community was, Mr. Akologo Atapnure indicated that the situation was very serious. He stated that ''now land renting is rampant and expensive because current land owners know that those looking for land are those who sold their lands and now looking for land and hence high prices. The implication for continuous land renting is serious because one can miss production in a particular year as land owners' deal with only the higher bidders, which may affect many less resource poor farmers. He suggested that measures by central government through the local authorities (Tendaanemas and chiefs) should formulate a policy that reserve farmland for future generation for food production''

Mr. Azaa Azagmogeri observed that urban expansion would make it very difficult for the youth to access land for farming and this could force them into social vices such as armed robbery and environmental destruction through illegal mining.

4.4 Peri-Urban Farmland Loss and Household Food Security

This section discusses household food security in relation to peri-urban farmland loss in the study cities of Tamale, Bolgatanga, and Wa. It examines how the loss of farmland affects peri-urban households' food security outcomes. In particular, the analysis focuses on how farmland loss influences household food consumption and access to food. Food consumption is assessed using the Food Consumption Score (FCS), while food access is measured using the Household Food Insecurity Access Scale (HFIAS). Together, these indicators provide insights into how farmland loss shapes the food security conditions of peri-urban households.

4.4.1 Descriptive Statistics of Household Food Security Indicators

HFIAS: The food security indicators reveal a high prevalence of food insecurity among peri-urban households in the study communities. Based on the Household Food Insecurity Access Scale (HFIAS), only 12.6% of households are food secure, while 87.4% fall into moderate (45.24%) or severe (42.16%) food insecurity categories, as presented in Figure 4.8.

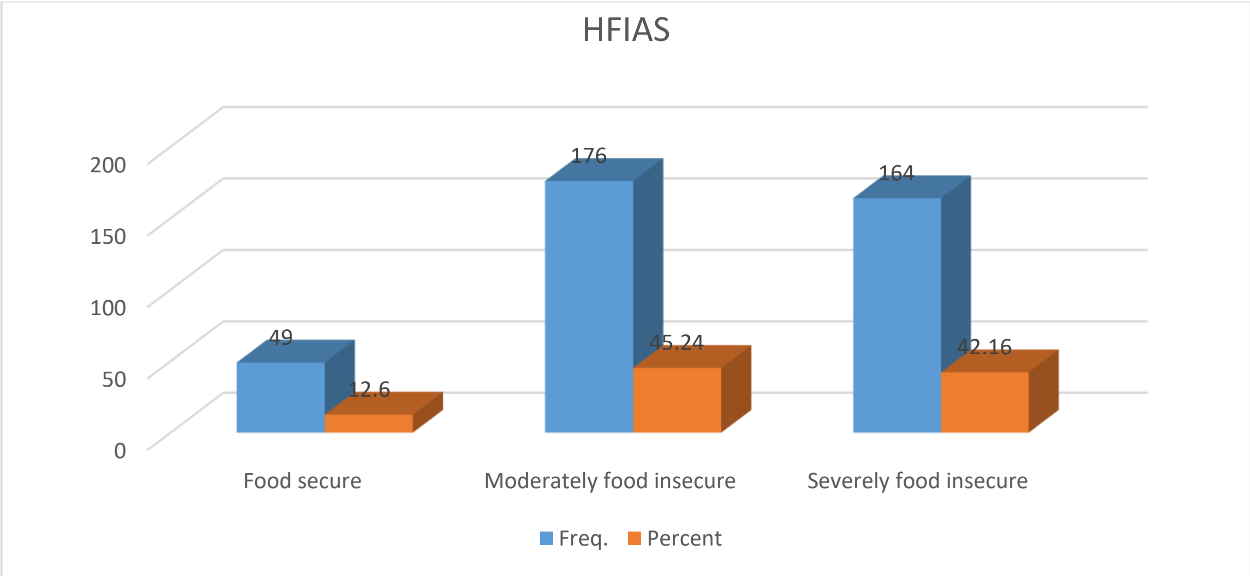

Figure 4. 8: Descriptive Statistics of HFIAS Used in the Study

FCS: Similarly, the results of Food Consumption Score (FCS) show that less than half of the households are food secure (acceptable: 42.16%), with a substantial proportion classified as borderline (25.71%) or food poor (32.13%) (See Figure 4.9). Together, these findings indicate widespread vulnerability, suggesting that agricultural land loss and urbanization pressures are significantly undermining household food access and stability.

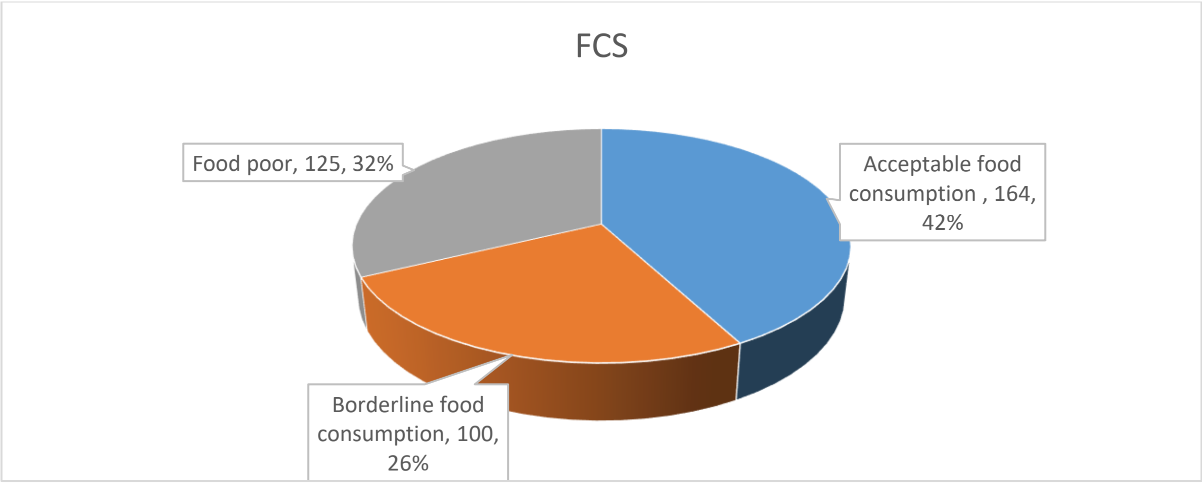

Figure 4. 9: Descriptive statistics of FCS used in the study

4.4.2 The Impact of Peri-Urban Farmland Loss on Household Food Security

The Household Food Insecurity Access Scale (HFIAS) and the Food Consumption Score (FCS), two important measures of food security, are examined in this chapter in relation to farmland loss. The analysis is placed in the context of the entitlement approach to starvation and famines developed by Sen (1981) which states that people become food insecure when their endowment fails either because their endowment bundle falls, or their exchange entitlement mapping changes adversely. Based on this framework, the study examines the premise that denial of access to land due to farmland loss contributes to food insecurity among households. In particular, two hypotheses are tested, the first hypothesis is that the loss of farmland reduces household food consumption scores (FCS). Second, such direct exposure to loss of farmland threatens household food security access (HFIAS). An extended ordered probit regression model was employed to quantify these correlations, and the results are shown in the following sections.

4.4.3 The Choice of Extended Ordered Probit Model

The extended ordered probit (EOP) model was chosen because the dependent variables (i.e., the food consumption score (FCS) and the household food insecurity access scale (HFIAS)) are measurements of household food security status and as such are measured as ordinal dependent variables that are ranked categories and not as continuous values (Coates et al. 2007; WFP 2008). Both FCS and HFIAS categorize households into mutually exclusive but ordered categories of food security that reflect an increasing level of adequacy or severity for the respective scale. The FCS ranks households' food consumption as poor, borderline or acceptable; with progress along this scale representing progressively improving dietary diversity, frequency and nutritional quality (WFP 2008). Likewise, HFIAS ranks households on the completion of their food security continuum as food secure, mildly food insecure, moderately food insecure and severely food insecure (Coates *et al.*, 2007). This ordering implies a natural ranking of outcomes, but the distances between categories are unknown and not equal.

Because of these characteristics, it would be inappropriate to use linear regression models because these assume a continuous, cardinal dependent variable with equally spaced outcomes Greene, 2018. In line with this, multinomial logit or probit models, though appropriate for categorical outcomes, do not take into account the intrinsic ordering in the food security categories and are thus statically inefficient for measuring FCS and HFIAS and conceptually inconsistent with this measurement structure (Long & Freese, 2014).

Ordered response models are specifically designed to accommodate such situations by imposing an unobserved latent variable, in this case, underlying household food security status, partitioned into ordered categories via estimated threshold parameters (Greene, 2018). The extended ordered probit thus maintains the ordinal character of food security indicators and allows us to apply a structurally valid approach in exploring their determinants. However, the conventional ordered probit model rests on its parallel-lines or proportional-odds assumption, which bounds the effects of explanatory variables upon all category thresholds to just one sameness (Williams, 2006). This is usually too strong an assumption in food security studies since socioeconomic and livelihood factors may differentially influence transitions between states of food security; for example, the effect on the transition from severe to moderate food insecurity may be different from that influencing the borderline to acceptable transition in food consumption (Asfaw et al., 2012).

The extended ordered probit relaxes this assumption and allows some covariates to vary across thresholds, thus allowing for heterogeneous impacts at different levels of food security (Williams, 2006). The extension proves helpful in the FCS and HFIAS analyses, where some determinants are expected to exert a differential impact across states of food insecurity.

The assumption of the extended ordered probit ensures a methodologically consistent assumption about the ordinal measurement of food security indicators; it utilizes all information contained in the ordered categories and, therefore, produces estimates of the factors affecting household food security status that are more robust and relevant to policy.

4.4.4 Diagnostic Analysis of the Extended Ordered Probit Model

As stated in the methodology, a thorough test was carried out to guarantee the validity of the instrument employed in the analysis of household food security. The test findings showed a statistically significant correlation between the outcome equations (food security indicators—FCS and HFIAS) and the error terms of the selection equation (agricultural land loss) in the first stage. These results validate the adoption of the EOPEC model over the regular ordered probit model for this investigation by confirming the endogeneity of farm land loss on family food security. Additionally, Table 4.13 shows that the Wald chi-square values are significant at the 1% level, suggesting that the independent factors together account for differences in household food security.

Furthermore, the results for the cut-off points across all food security indicators were statistically significant. This highlights the robustness of the model and its ability to capture subtle variations in household food security outcomes by clearly differentiating the various categories of food security indicators.

Table 4. 13: Diagnostic Statistics of the Mode for Household Food Security

Cut Off Categories	**FCS_LL Coeff.(SE)**	**FCS_NLL Coeff.(SE)**	**HFIAS_LL Coeff. (SE)**	**HFIAS_NLL Coeff. (SE)**	**LL Coeff. (SE)**	**NLL Coeff. (SE**
Cut 1	-1.419*** (0.330)	-0.316* (0.151)	6.634*** (3.705)	0.440*** (0.236)		
Cut 2	1.471*** (0.477)	0.664*** (0.310)	7.987*** (3.694)	2.265*** (0.247)		
Corr (e.Land_loss,e.FCS_category)					0.426** (0.198)	
Corr (e.Land_loss,e.HFIAS_category)						-0.504* (0.280)
Observations	398	398	398	398	398	398
Wald $chi^2(40)$ =117.27; Prob>chi^2 =0.0000						

4.4.5 Falsification Test for the Extended Ordered Probit Models (FCS &HFIAS)

The extended ordered probit (EOP) model employs distance to farmland and land tenure type as exclusion (identification) variables to address potential endogeneity arising from peri-urban farmland loss and its effect on household food security outcomes measured by Food Consumption Score (FCS) and Household Food Insecurity Access Scale (HFIAS).

Intuition for the Instruments: *Distance to farmland* is used as an instrument because it captures the extent of peri-urban farmland loss and spatial displacement of agricultural activities due to urban expansion. As urban growth converts agricultural land to non-farm uses, farming households are forced to cultivate plots located farther from residential areas. This increasing distance reflects farmland fragmentation, relocation, and outright loss, which affects household welfare primarily through reduced production efficiency, higher transport and supervision costs, and declining incentives to continue farming. Importantly, distance to farmland does not directly determine household food security status; rather, its influence operates indirectly through farmland loss and reduced agricultural engagement, making it suitable as an exclusion variable (Angel *et al.*, 2005; Kuusaana & Eledi, 2015; Abass *et al.*, 2017).

Land tenure type is included as a complementary instrument because tenure insecurity in peri-urban areas accelerates farmland loss by increasing vulnerability to land conversion, expropriation, and speculative development. Households operating under informal or insecure tenure arrangements are less likely to invest in land improvement and more likely to lose access to farmland as urbanization intensifies. The effect of land tenure on food security therefore operates through its impact on land retention, investment decisions, and exposure to farmland loss, rather than directly influencing consumption or food access outcomes (Place, 2009; Deininger & Jin, 2006).

Together, these variables are theoretically expected to influence farmland loss and land access dynamics, which in turn affect household food security, satisfying the relevance condition for valid instruments.

Relevance and Exogeneity Tests: The relevance of the instruments is supported by the joint significance (F/χ^2) test results reported in Table 4.14. Under the probit specification, distance to farmland and land tenure type are jointly significant, with a χ^2 statistic of *43.26 (p < 0.001)*. This result is analogous to a strong first-stage F-test and confirms that the instruments are highly correlated with the endogenous process associated with farmland loss and land access, thereby satisfying the relevance requirement.

The *exclusion restriction criteria*: When distance to farmland and land tenure type are entered directly into the food security equations, they fail to jointly explain food security outcomes.

Specifically, the joint test statistics are $\chi^2 = 4.60$ *(p = 0.1003) for FCS* and $\chi^2 = 3.74$ *(p = 0.1538)* for HFIAS, both of which are statistically insignificant at conventional levels.

The insignificance of these tests indicates that the instruments do not exert a direct effect on household food security once the structural relationships are accounted for. This provides strong empirical support for the exogeneity condition, confirming that distance to farmland and land tenure type influence food security only through their impact on farmland loss and land access pathways, and not through unobserved channels.

Table 4. 14: Falsification test of the EOP Model (food security-FCS&HFIAS)

	Probit model	
Instrumental variable	chi2 (2)	Prob>chi2
Distance &land tenure type	43.26	0.0000
	Extended Ordered Probit model	
	chi2 (2)	Prob>chi2
Distance & land tenure type (FCS)	4.60	0.1003
	Extended Ordered Probit model	
	chi2 (2)	**Prob>chi2**
Distance & land tenure type (HFIAS)	3.74	0.1538

Test of Instrument Relevance: First-Stage (F-Test) Results: To formally assess the relevance of the exclusion variables, a joint first-stage F-test was conducted on *distance to farmland* and *land tenure type* equation underlying the extended ordered probit framework.

The null hypothesis of the F-test states that the instruments are *jointly insignificant*, implying weak or irrelevant instruments. The alternative hypothesis is that the instruments are jointly significant predictors of the endogenous farmland-loss process.

The results indicate a strong joint explanatory power of the instruments: $F(2, 397) = 21.84$, $p < 0.001$ (see Table 4.15). This F-statistic is well above the conventional rule-of-thumb threshold of $F \geq 10$ for weak instruments, suggesting that distance to farmland and land tenure type are strongly correlated with farmland loss and land access dynamics. The result confirms that the instruments satisfy the relevance condition required for valid identification.

These findings are consistent with the χ^2-based joint significance test reported in Table 4.14 under the probit specification ($\chi^2 = 43.26$; $p < 0.001$), further reinforcing the strength of the instruments.

Table 4. 15: Instrument Relevance: First-Stage (F-Test) Results

Instrument (s)	**Intuition (Farmland Loss)**	**Literature**	**Relevance Test**
Distance to farmland; Land tenure type	Capture spatial displacement & tenure insecurity driving peri-Urban farmland loss	Angel *et al* (2005); Kuusaana & Eledi (2015); Abass et al. (2017)	**F (2, 397)=21.84** ***p<0.01**

4.4.6 Determinants of farmland loss on food security among peri-urban farm households in northern Ghana

Table 4.16 presents the coefficients of the determinants of peri-urban farmland loss on food security indicators among farm households in northern Ghana.under each food security indicator; thus FCS and HFIAS, both treatment and outcome equations are estimated. In order to put into perspective the consequences of farmland limitation on household food consumption and access, it's proper to compute the marginal effects which is easily relatable in empirical sense. Therefore, Table 4.17 rightly interpreted the marginal effects of the various food consumption and access categories.

Table 4. 16: Determinants of Farmland Loss on Food Security among Peri-Urban Households

VARIABLES	FCS_NLL	FCS_LL	Land_Loss	HFIAS_NLL	HFIAS_LL	Land_Loss
Sex	-0.595*	-0.053	0.498***	0.219	-0.050	0.505***
	(0.334)	(0.054)	(0.044)	(0.190)	(0.063)	(0.039)
Married	-1.280**	0.196	-0.130***	0.000	0.319**	-0.022
	(0.507)	(0.172)	(0.039)	(0.151)	(0.138)	(0.053)
Respondent's age	-0.044***	-0.019***	-0.046***	0.002	0.008**	-0.044***
	(0.003)	(0.004)	(0.002)	(0.004)	(0.004)	(0.003)
Farming experience	0.030***	0.027***	0.059***	-0.002	-0.002	0.056***
	(0.005)	(0.004)	(0.008)	(0.002)	(0.003)	(0.004)
Household size	0.046*	0.038***	-0.034***	0.023**	0.046***	-0.032***
	(0.024)	(0.007)	(0.007)	(0.010)	(0.001)	(0.008)
Education in years	-0.095	-0.026	0.482***	-0.069***	-0.005	0.035***
	(0.058)	(0.031)	(0.075)	(0.005)	(0.004)	(0.005)
Farm Size	-0.168***	-0.062***	-0.139***	-0.024*	0.007	-0.109***
	(0.027)	(0.004)	(0.023)	(0.013)	(0.010)	(0.006)
lnHousehold income	0.489***	0.061*	-1.442***	0.737**	0.142***	-1.413***
	(0.107)	(0.032)	(0.063)	(0.324)	(0.018)	(0.035)
lnTLU	1.031***	-0.343***	3.459***	-1.871***	-0.701***	3.268***
	(0.273)	(0.066)	(0.166)	(0.497)	(0.047)	(0.111)
Received credit	0.232***	0.217***	-0.128***	-0.473***	0.229***	-0.080*
	(0.053)	(0.027)	(0.047)	(0.120)	(0.033)	(0.047)
Access extension	-0.421***	0.121***	0.252***	-0.281***	0.258	0.209*
	(0.065)	(0.043)	(0.087)	(0.057)	(0.179)	(0.107)
Market distance	0.002	0.003***	0.001	-0.002	-0.000*	0.000
	(0.002)	(0.000)	(0.003)	(0.002)	(0.000)	(0.002)
Access health facility	-0.533***	0.286***	0.397**	-0.649***	0.162***	0.223
	(0.111)	(0.042)	(0.197)	(0.136)	(0.056)	(0.175)
Motorable road access	0.194	0.0560	0.042	0.954***	-0.603***	0.085***
	(0.162)	(0.091)	(0.079)	(0.114)	(0.152)	(0.023)
Social organization	-0.246***	-0.383***	-0.333**	-0.073	-0.070	-0.240
	(0.076)	(0.075)	(0.155)	(0.122)	(0.146)	(0.147)
Remittances	0.0249	0.145***	0.500***	0.405***	0.236***	0.424***
	(0.111)	(0.055)	(0.114)	(0.141)	(0.041)	(0.081)
Exposure to flood	-0.561***	-0.121***	-0.364*	-0.271***	-0.443***	-0.405***
	(0.168)	(0.038)	(0.189)	(0.079)	(0.027)	(0.092)
Exposure to drought	-0.548***	-0.217***	-0.507***	0.778***	0.250***	-0.344*
	(0.195)	(0.050)	(0.039)	(0.073)	(0.034)	(0.198)
Upper East Region	0.617**	-0.361***	-1.347***	2.135***	0.942***	-1.181***
	(0.279)	(0.047)	(0.130)	(0.181)	(0.061)	(0.107)
Upper West Region	1.942***	0.121	-0.039	1.758***	0.372***	-0.001
	(0.300)	(0.076)	(0.065)	(0.090)	(0.030)	(0.049)
			(0.065)			(0.049)
Land distance from city			0.006**			0.004***
			(0.001)			(0.001)
Land tenure type			-0.020***			-0.005***
			(0.001)			(0.001)
corr(e.Land_loss,e.FCS_category_)			0.426**			
			(0.198)			

corr(e.Land_loss,e.Hfias)						-0.504*
						(0.280)
Constant			13.61***			13.15***
			(0.198)			(0.628)
Observations	389	389	389	389	389	389

*** p<0.01, ** p<0.05, * p<0.1

4.4.7 Marginal Effects of the Determinants of Farmland Loss on Household Food Security in Northern Ghana

The impact of farm land loss factors on peri-urban household food security is displayed in Table 4.17. Losing a part or all of ones farmland has a direct consequences on food security in terms of access and consumption. The probability of experiencing a food security decline could reach 52.9% as a result of increasing a unit of land lost as indicated by statistical significance (1% level) in this study. There is great vulnerability for households that lose land making them highly susceptible to imminent food insecurity situations. The probability of falling within the brackets of moderate and severe food insecurity rises by 18.6% and 34.4% respectively. These findings reflects how farmland contributes to ensuring household sustenance. It also highlights the increasing risk of food insecurity because of limitations on resources in the context of changes in land use and relationship with food security, as corroborated with findings in Shaban *et al*. (2024).

The study finds a significant relationship between the loss of land and food consumption dynamics, which continues to highlight the interconnected effects of changes in land use. Increasing a unit of land loss raises the likelihood of being food poor by 9.1% and or found within the food borderline by 8.5%, and also being food secure decreases by a 17.6%. The findings indicate that not only do land loss affect the quantity of food consumed but also the quality and food types available to households. These findings are supported by Katambli (2021) who emphasizes the contribution of farmlandon dietary diversity in farming communities. These shifts in food eating dynamics could interrupt food systems of families at the verge of vulnerability.

Differences in gender roles in food security issues further shed more light in the complex nature of this analysis, given the inequalities created by farmland limitation. The outcomes of food security systemically creates gender inequities in response to farmland loss. There is a significant gender influence on food consumption. A female headed household is less likely to experience satisfactory food security situation by a 6.9% and highly likely to experience food poverty by 7.6%. In a study by Smith *et al*. (2023), households in Sub-Saharan Africa headed by females face more challenges in being food secure due to limited access to resources and participation in decision making. The findings of this study is also supported by Ahmed and Ochieng (2022) who highlight the dynamics of gender in agricultural livelihoods where differences disadvantage women in food security (dietary diversity). However, the effect of gender in household food insecurity access is not strong. This is in line with findings by Johnson *et al*. (2023) indicating that gender differences are usually more significant with respect food consumption in terms of dietary diversity compared to measures relating to food access. Gender disparities emphasize the need for gender specific policy relating to food production and security.

The age of a household head plays a significant role in food security in terms of food intake. This observation suggests that as ones' ages is most likely to be severely food insecure and also decrease the probability of being food secure or moderately food insecure. However the indicator for HFIAS did not indicate any significant effects. The result shows high correlation between age and food dietary needs. This implies that for every additional year in age increases the probability of falling into food poverty by 0.7% but reduces the possibility of being into the category of acceptable or borderline by 0.6% and 0.1% respectively. The findings suggest high vulnerability associated with old age and food poverty as well as differences in diet intake. These findings align with studies such as Beyene (2023) who disclosed that older individuals are confronted with high food insecurity challenges because of financial and reduced physical ability. The revelation of older people facing decline in acceptable food security levels is in line with Vasquez *et al*. (2018) who found that aging population encounter reduced access to food. According to Johnson *et al*. (2023), reduced dietary intake among the aged is as a result of their health and financial challenges. On the other hand Mwangi (2023), young individuals in Sub-Saharan Africa usually places premium on food allocation, while neglecting and exposing the aging population into food poverty.

The number of years in farming shapes household food security and directly influences consumption and serves as a shield against food shortages. The results suggest that every additional year in farming increases the chance of falling into acceptable food security category by equal proportion and also reduces the likelihood of falling into food poverty by 0.7%. The findings reflect the advantage of knowledge accumulation which enhances resource use efficiency, productivity, and proper utilization modern of technologies. The probability of being food borderline increases by 0.1%, which implies that experience farmers could face production bottlenecks that limits them from smooth transition from lower food poverty to acceptable food consumption. The results did not reveal any significant effect with respect to household food access (HFIAS), whereas FCS indicates the significant role farming experience had in food availability and diversity of diets. According to Ahmed and Ochieng (2022), knowledge obtained for being in farming for reasonable period promotes efficient management of resources and ensures adequacy of diet, an assertion supporting the significant and positive effects in this study. Another study by Mwangi (2023), provided evidence of how experienced farmers are able to adopt different cropping strategies to enhance food security resilience, a finding that is supported by Beyene (2023) who emphasized how farm experience provided avenues for farmers to access markets and guide against climatic impacts. The findings of this study provides relevant insight as to how farming experience contribute to redefining food system resilience.

The size of a household and level of education are two influencing factors on food availability (including access) and consumption, pointing to the intricate management of resources and household governance processes. The findings indicate that the chances of being food secure reduces by 0.5% while increasing the probability of severe food insecurity by 1.2%. This result implies that larger households find it challenging to have reasonable access to food. The results however show that there is safety net effect in which household size reduces food poverty by 1.4% but increase acceptable food consumption by 1.3%. The findings corroborate with the findings of Ahmed and Ochieng (2022) who observed that resource limitation could intensify food access and consumption, whereas larger households could take advantage of economies of scale to soften food insecurity as observed by Mwangi (2023). Also, the level of education of a household head serves as an important element in shaping food security. The results indicate that every additional year spent in education increases food security by 0.4% and decreases severe food access by 0.6%. An additional increase in education could increase the chances of falling within acceptable food security by 2.6% but decreases food poverty by 2.5%. The results of this study are in line with findings by Mutisya *et al*. (2016), who indicated that education has positive and significant effect in household decision making processes as well as income generation. Also, Rise Against Hunger (2022) reveal the contribution of education in enhancing food utilization and diversity of diets.

The number of acreages (as represented by farm size) cultivated by a farming household affects its access to food and dietary adequacy. For example the result from this study show that increasing farm size by a unit could lead to a reduction of being food insecure by 0.4% but increase the likelihood of being food secure by 0.3%. This findings imply that households with larger farms have the capacity to supply sufficient food and also serve as protection against severe or complete food deprivation. The results of FCS suggest that large farms improves diet diversity and thereby increasing the chances of being within the acceptable food category by 2.5% and reducing the likelihood of being food borderline as well as food poverty by 0.2% and 2.3% respectively. The findings aligns with studies by Acheampong *et al.* (2022) who highlighted that farm size had significant and positive association with farm output and the ability to stabilize household income, therefore ensuring food security. Similarly, Abay *et al.* (2022) revealed that households with large farms are able to cultivate different crops which enhances the diversity of diets. However, a study by Taale (2018) have indicated that the benefits drive from cultivating a large farm would mostly depend on equitable access to effective market linkages and farm inputs.

Other factors such as the income level of a household and livestock ownership play a crucial role in food access and dietary adequacy. Farm income enhances food security as it increases the food purchasing power of households, therefore minimizing the severe food shortages while improving diet quality. Financially stable households could reduce food poverty by 9.2% and raises food status to acceptable level by 8.7%, but contrarily, increasing the probability of being severe food insecure by 5.3%. This findings placed emphasizes on the vulnerability less resource endowed families could face due to financial inequalities. Empirical research supporting these findings include those of Atuoye *et al.* (2019) and Silvestri *et al.* (2015) who revealed that farm income plays a stabilizing role in household food resilience.

Yet another contributory factor that significantly shapes food access and consumption is the possession of farm assets such as livestock. The results indicate that adding a unit of livestock could raise the probability of being food secure by 13.6% while minimizing the severe food insecurity significantly by 22.4%. Also possessing livestock enhances diet adequacy by raising households to acceptable food consumption level by 8.0% while lessening food poverty situation by 8.1%. According to Staal *et al*. (2020), livestock ownership serves as a source of food and income. Similarly, Herrero *et al*. (2016), highlighted the contribution of livestock nutrition diversification among peri-urban residents. On the contrary, Abegaz and Asfaw (2022) have cautioned that over reliance on livestock could put families at high risks of disease outbreaks.

Another significant determinants of food access and consumption are institutional production resources such as credit, extension service and market accessibility. The findings show that with credit access, food poverty could be lessened by 7.4% while raising households to acceptable food consumption levels by 6.8%, which places emphasize on its role in facilitating farm investment and stabilizing consumption. Studies that provide support for these findings are those of Klapper *et al*. (2015) and Demirguc-Kunt *et al*. (2017) who stressed on the crucial role micro financial institutions play in closing the consumption gaps of families, which reflects the findings on diet adequacy enhancements in this study. Despite the weak statistical significance of the extension service variable in this study, Anderson and Feder (2007) found that it is often related with increased productivity and food access. According to similar findings by Chamberlin and Jayne (2013), being close to the market increases dietary diversity and reduces acute food insecurity by 0.1% (at 1% significance). The correlation between infrastructure and family resilience is multifaceted, as evidenced by the conflicting results of its association with peri-urban household food security. Access to good roads (motorable) reduces severe food insecurity by 5.4%. Lastly, Bhutta *et al*. (2013) stressed that health services have an indirect impact on improving nutrition, which may eventually affect food security outcomes, even if no significant correlation was found between access to health facilities and food security.

Market connectivity and regional disparities in food security: In order to improve household food security outcomes and market connection, motorable roads are essential. Chamberlin and Jayne (2013) emphasized that access to motorable roads significantly reduces severe food insecurity by facilitating food availability and market integration, a trend observed in this study. Zezza *et al*. (2018) also discovered that people living closer to roads have an advantage in accessing food, though regional disparities could affect these outcomes. An example is that the high moderate food insecurity observed in this study related to road access, is an indication that not all households may enjoy the same benefits, probably due to differences in regional infrastructure as well as socioeconomic conditions.

Regional differences are particularly pronounced when examining food accessibility (HFIAS). The Upper East region has serious problems with food security, as seen by the statistically significant declines in the likelihood of being food secure by 21.0% and moderate food insecurity by 16.2%. Given that the likelihood of severe food insecurity rises by a significant 37.3%, these results demonstrate the substantial danger of food insecurity in the area. On the contrary, the Upper West region has somewhat more optimistic perspective. Though food security is reduced by 15.2%, and moderate food insecurity decreasing by 9.2%, the likelihood of severe food insecurity rises by 24.3%, though not dramatically as in the Upper East. The food consumption trend in the Upper West region shows some substantial enhancements. Geographically, locating from the UWR increases the likelihood of falling within the acceptable food secure category by 17.6% but reduces food poverty by 19.5%. The differences in geographical patterns of consumption resilience and susceptibility exposes this contrary finding.

Other factors such as social and environmental challenges in northern Ghana affects food access and consumption. There are distinctive set of environmental and production constraints that aggravate food security in the arid savannah zones (UER and UWR) of the north. Research shows that the savannah regions are noted for food production challenges including inconsistent patterns of rains, low farm output, as well as climate related issues such as seasonal floods and droughts. These production and environmental challenges reflect the severe food situation observed in this study. The findings revealed that UWR exhibits greater food system resilience partly due to some interventions such as intensive use of modern agronomic techniques which minimizes food poverty and places it within the acceptable food bracket, as corroborated by Abdulai and Crole-Rees (2019).

Access to food as well as consumption challenges are attributable to both social and economic disparities. Poverty rates in the Upper East region are more severe. Market access is restricted raising food insecurity status as observed by Quaye *et al*. (2020). Studies (such as Al-Hassan *et al*., 2016) have emphasized on the advantages drive from social actions, and other development projects that enhances food availability and diversity. The findings of FCS, highlight substantial enhancements of households at the acceptable food consumption category, because of the stated interventions.

Deliberate interventions and infrastructural development could enhance food access and consumption. However, limited infrastructure such as road networks and healthcare remains major contributory factors to food availability and diversity of diets in the northern parts of Ghana. According to Chamberlin and Jayne (2013) motorable road network facilitates access to markets hard to reach areas resulting in decrease in food shortage. Nevertheless, food supply in the Upper East and West regions are hampered by limited infrastructure. It is therefore imperative that, improving infrastructural facilities like roads and healthcare could address these shortfalls while improving the resilience of households. Similarly, Abdoulaye *et al*. (2021) have emphasized on the need for a tailed solutions namely; sustainable farming practices, improved water management for food production, and improved market connectivity, so as to eliminate food vulnerability in regions of the north. It is important to ensure that planning are well intentioned in order to prevent more burden on scarce resources to guarantee equal access to prospects. Also, programs that provide support for vulnerable groups in the UER and UWR would help households lessen their food insecurity burdens.

Table 4. 17: Marginal Effects of the Determinant of Food Security among Farm Households in Northern Ghana

	HFIAS			FCS		
	FS	MFI	SFI	Food Poor	Borderline	Acceptable
Land loss	-0.529***	0.186***	0.343***	0.091	0.085***	-0.176*
	(0.076)	(0.035)	(0.044)	(0.081)	(0.030)	(0.102)
Sex	-0.018	-0.006	0.024	0.076**	-0.006**	-0.069**
	(0.023)	(0.015)	(0.038)	(0.032)	(0.003)	(0.030)
Married	-0.029	-0.045**	0.074*	0.060	-0.007**	-0.052
	(0.019)	(0.021)	(0.039)	(0.065)	(0.003)	(0.063)
Resp. age	-0.000	-0.001	0.001	0.007***	-0.001***	-0.006***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Farming exp.	-0.001	-0.001	0.001	-0.007***	0.001***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Household size	-0.005***	-0.007***	0.012***	-0.014***	0.001***	0.013***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Education	0.004***	0.002**	-0.006***	0.026***	-0.001**	-0.025***
	(0.001)	(0.001)	(0.001)	(0.008)	(0.001)	(0.008)
Farm Size	0.003***	0.001	-0.004***	0.025***	-0.002***	-0.023***
	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)	(0.003)
lnHH income	-0.039***	-0.014*	0.053***	-0.092***	0.006**	0.087***
	(0.009)	(0.007)	(0.005)	(0.012)	(0.003)	(0.012)
lnTLU	0.136***	0.089***	-0.224***	0.080***	0.002	-0.081***
	(0.009)	(0.013)	(0.007)	(0.008)	(0.002)	(0.008)
Received credit	0.012	-0.021***	0.009	-0.074***	0.006***	0.068***
	(0.012)	(0.006)	(0.018)	(0.011)	(0.001)	(0.010)
Access extension	-0.009	-0.034	0.043	0.014	-0.002	-0.012
	(0.020)	(0.028)	(0.048)	(0.010)	(0.001)	(0.011)
Market distance	0.000***	0.000***	-0.000***	-0.001***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Acc. health fac.	0.025	-0.012	-0.012	-0.012	0.000	0.011
	(0.016)	(0.010)	(0.025)	(0.020)	(0.002)	(0.018)
Motorable road	-0.009*	0.064***	-0.054**	-0.029	0.003	0.026
	(0.005)	(0.022)	(0.027)	(0.013)	(0.001)	(0.013)
Social orgn	0.015	0.015	-0.031	0.102***	-0.009***	-0.094***
	(0.017)	(0.020)	(0.036)	(0.015)	(0.001)	(0.014)
Remittances	-0.056***	-0.049***	0.105***	-0.024	0.003*	0.021
	(0.009)	(0.007)	(0.015)	(0.019)	(0.001)	(0.018)
Exp. to flood	0.066***	0.076***	-0.141***	0.045**	-0.003**	-0.042**
	(0.012)	(0.007)	(0.019)	(0.020)	(0.001)	(0.019)
Exp. to drought	-0.069***	-0.047***	0.117***	0.067***	-0.007**	-0.060***
	(0.004)	(0.011)	(0.014)	(0.017)	(0.003)	(0.015)
U E R	-0.210***	-0.162***	0.373***	-0.002	-0.001	0.003
	(0.012)	(0.004)	(0.011)	(0.006)	(0.003)	(0.005)
U W R	-0.152***	-0.092***	0.243***	-0.195***	0.019***	0.176***
	(0.012)	(0.002)	(0.013)	(0.033)	(0.007)	(0.027)
Land dist. city	-0.025**	-0.011***	0.013***	0.004**	-0.003*	-0.005**
	(0.010)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Land tern. type	0.006***	0.012**	-0.003**	-0.112***	0.001***	0.010***
	(0.001)	(0.001)	(0.001)	(0.020)	(0.000)	(0.001)

Note: dy/dx for factor levels is the discrete change from the base level.

4.4.8 Heterogeneous Effect of Peri-Urban Farmland Loss on Household Food Security

Food availability, access and consumption are severely affected by farmland limitation especially for communities whose main livelihood is agriculture. Land in agricultural settings serve as a singular most cherish avenue for wealth and existence. The consequences of land limitation caused by urban growth differs primarily due to varying social and economic situations of households which undermines their capacity to implement adaptive innovations. Due to the differences in effects, requires clear understanding of the particular impacts on affected households as well as the wider social effect.

To properly understand the depth of food situation in different forms in the instance of land limitation, two food security indicators namely; FCS and HFIAS were utilized (see results in Table 4.18). The analysis was conducted to identify the actual effects of land loss of households directly impacted through the ATET, whereas the ATE defines the variations in food insecurity for both land loss and non-land loss families. The HFIAS indicator was categorized into three classes namely; food secure, moderately food insecure and severely food insecure.

Food secure: With reference to the food security (FS) category, the coefficient of -0.531 of the average treatment effect (ATE) has the probability of being food secure by 53.1% taking into account households that did not lose land. These findings aligns with a study by Atuahene (2023), who highlighted the effect of forceful land displacement and capturing severely increase food insecurity and force farming households into food poverty.

Moderate Food Insecure: The findings reveal that comparing households that are not affected by land loss, loss of land raises the probability of falling within moderate food insecure (MFI) by 18.7% given the coefficient of ATE of 0.187. These findings are validated by Asante and Nyarko

(2021) who observed that anywhere land expropriation occurred in Ghana, food security situation is adversely affected, most especially in rural agrarian communities.

Severe Food Insecure: The likelihood of falling within severe food insecurity (SFI) category is increased by 34.4% in land loss situation given the coefficient of 0.344 of the ATE. Chen et al. (2020), who found that households with fully dispossessed lands were 1.7 times more likely to experience livelihood shocks than any other random household. This observation reinforces the results in this study.

With respect to ATET, measures the direct impact on households that suffered loss of land.

Food Secure (FS): The ATET coefficient of -0.676 (significant at 1%) demonstrates that households that have lost their farmlands are 67.6% points less likely to be food secure compared those who did not lose their farms. Similar trends were also reported by Koomson and Owusu (2022), when they revealed that farmland fragmentation had a detrimental effect on the household nutritional sufficiency.

Moderately Food Insecure (MFI): The ATET coefficient of 0.327 (significant at 1%) indicates that loss of land raises the likelihood of moderate food insecurity among households that are affected by 32.7% points. Deng and Zhang (2019) established that land consolidation and loss has significant impacts of shifting households towards food insecurity especially those with limited financial means.

Severely Food Insecure (SFI): The ATET coefficient of 0.349 (significant at 1%) indicates that households with land loss are 34.9% more likely to be seriously food insecure. According to

Sulemana *et al*. (2021), land expropriation leads to severe food deprivation, especially in agrarian economies that depend on subsistence agriculture.

Based on dietary diversity and nutritional sufficiency, the Food Consumption Score (FCS) divides households into three categories: acceptable food consumption, borderline food consumption, and food poverty.

Acceptable Food Consumption: The ATE coefficient of 0.097 indicates that the loss of farmland enhances the likelihood of households attaining acceptable food consumption by 9.7% points compared to households that did not suffer land loss. Nevertheless, the impact is comparatively minor and non-significant, which proves that there is no significant effect in the overall population in terms of food consumption patterns. Similar conclusions were made by Deng and Zhang (2019), who noted that some households can adjust to land loss by using alternative food sources, which contributes to preventing severe impact on the quality of the diet.

Borderline Food Consumption: The ATE coefficient of 0.081 (at 1% level) indicates that the loss of farmland raises the likelihood of households falling into borderline group by 8.1% points, which means that households that have suffered land loss are at higher risk of inadequate food intake. This is consistent with Koomson and Owusu (2022) who discovered that fragmentation of farmlands limits access to food which forces more households into borderline of food consumpttion.

Food Poor: Households which are classified as Food Poor, the negative ATE of -0.178 (at 10% significant level) implies that the loss of farmlands decreases the likelihood of falling into food poor category by 17.8% points across the general population. Though this is unlikely to be expected, Atuahene (2023) states that market dependency and food borrowing are the coping mechanisms that help avoid total food shortage at home. But this change in food consumption patterns does not always reflect food security, it is a change in food access and not the well-being of households.

The analysis of ATET gives an understanding of the direct influence of farm land loss on families that experienced it as opposed to households that did not experience land loss.

Acceptable Food Consumption: The ATET coefficient of 0.160 (at the 10% level) indicates that households, which are directly influenced by farmland loss, are 16.0% points more likely to maintain acceptable food consumption than other households who retained their farmlands. Although this effect is statistically significant, this effect may be caused by adaptive changes, including a changes in food composition, food assistance programs, or a greater dependence on purchased food, which was observed in Chen *et al*. (2020).

Borderline Food Consumption: Households that lost farmland are 9.2% more likely than non-affected households to fall into the borderline food consumption category, according to the ATET coefficient of 0.092 (significant at the 5% level). The findings from this study shows that access to food is uncertain for families that lost land. These findings corroborate with a study by Sulemana *et al*. (2021) who indicated that households that lost land are food insufficient and mostly rely heavily on less quality food for survival.

Comparing farmers who lost land and non-land loss, those land loss farmers have 25.3% less chances of becoming food poor giving the ATET coefficient of -0.253. These findings could imply that affected farmers could be changing the sources of their food to avoid going hungry. According to Asante and Nyarko (2021), farmers affected by land loss would ordinarily shift to food purchase to avoid falling into severe food poverty, though this could present them with long-term consequences since too much dependents on food purchase could put serious pressure on the limited resources.

Table 4. 18: Heterogeneous Effects of Farm Land Loss on Food Security

HFIAS	**ATE**	**Std err**	**ATET**	**Std err**
FS	-0.531***	0.059	-0.676***	0.093
MFI	0.187***	0.034	0.327***	0.063
SFI	0.344***	0.028	0.349***	0.033
FCS				
Acceptable	0.097	0.079	0.160*	0.085
Borderline	0.081***	0.030	0.092**	0.033
Food poor	-0.178*	0.100	-0.253**	0.112

The perspectives of some respondents regarding the effect of farmland loss on household food access and comsumption have validated the findings in this section.

For example, in the views of Mr. Abu Anarigede with respect to who is most affected by farmland loss, he noted that farmland loss affect even non-land loss farmers in terms food access and food consumption (both in quantity and quality). Land scarcity would limit food production by land owners who cannot even produce enough to make food available and affordable for landless households to buy. Women and youth are seriously affected as they would not get land to farm due to land scarcity and hence food shortage.

According to Mr. Paul Adenaba, farmland loss has created unemployment in the agricultural sector due to reduced farm land causing food shortage and could potentially increase crime rate among young people. He noted that land loss creates a heavy burden on the state to provide food for landless households.

Mr. Atanga Atampugre, lamented that land sale is a very painful experience as it put present and future generation at risk of food deprivation and potential food insecurity because most households cannot afford to look for farmlands outside their geographical location due to lack of resources. He said the youth and women are discouraged from going into farming because of lack of access to farmland.

Mr. Akanyerike Adongo, observed that farmland for the future generation is a huge challenge. Currently it threatened food security especially among women and the youth.

When enquired about how food production in the future would look like, Mr. Ayine Ayeliboba indicated that in the next 10years there will be no farmlands. ''There is high uncertainty about future food security in this community. The only option is for us to relocate outside the region to look for farmlands but we are limited by resources to do so. He said about 50% of the youth in agriculture will suffer. Women would not get access to farmland because of limited land available''. This observation was supported by Mr. Adongo Akumkgwerike who indicated that limited land for agriculture is breeding idle youth which can lead them into criminal activities such as prostitution, armed robbery, illegal mining, and drug addiction among others. He indicated farmlands in the community are already choked.

4.5 The Perception of the Impact of Urbanization on Household Welfare

Using a variety of indicators, such as the accessibility of services, household income, and the living conditions in general, the impacts of urban development on the lives of per-urban households are comprehensively researched. The analysis is based on the theory of urban transition, which focuses on the change of rural settlement to urban one, which typically offers households with an option to encounter the chances and difficulties of adapting to the new socioeconomic conditions.

On the positive note, the processes of urbanization can improve household welfare through increase access to education, provision of healthcare, infrastructure and creation of employment opportunities. However, urbanization also comes with enormous challenges which includes displacement of croplands, high cost of living and deepening of social inequalities. The study examine combined effects of these changes and how they relate with household welfare. To do this, two hypotheses were tested as follows: (I) that urbanization could positively impact household through enhanced access to economic and social resources; and (II) that Rapid urban expansion results in inequalities that has negative impact on vulnerable individuals due to decline in welfare.

In order to examine these relationships, empirical analysis was done with the application of relevant econometric models which include; principal component analysis and multivariate regression model. To provide a complete picture of how urbanization affects household welfare, the results are presented and discussed in the following sections, taking into consideration both observed and unobserved household factors.

4.5.1 The Likert Scale Analysis of the PCA

A Likert scale was used to obtain responses to relevant questions in order to investigate how urbanization is seen in relation to household welfare. Principal Component Analysis (PCA) was then used to minimize the dimensions of the responses where significant components represented several aspects of welfare, including socioeconomic, social, and economic welfare. In order to investigate the household characteristics influencing their perceptions, the identified components were included as continuous dependent variables in a multivariate regression model.

Certain pre-established intervals for classification are used to understand the responses from the Likert scale scores. The range is divided into the following categories using a five-point Likert scale: 1.00-1.800 = Strongly Disagree; 1.81-2.60 = Disagree; 2.61-3.40 = Neutral; 3.41-4.20 = Agree; and 4.21-5.00 = Strongly Agree. This structure provides a framework for easy interpretation of the data by assigning qualitative meaning to numerical values. The preliminary findings in Table 4.19 revealed unique responses of the perspectives of respondents.

The responses are categorized as follows: responses relating to agreement with specific questions viewed urbanization as potential catalyst for improving access to portable water with a mean =2.75 and SD=0.71, better road network with mean=2.60 and SD=0.72; enhanced access to healthcare with a mean=2.35 and SD=0.79; establishment of educational institutions with mean=1.68 and SD=0.77.

For those categorized under neutral; respondents expresses their neutrality on the processes of urbanization on improve access to urban markets with mean=2.81 and SD=1.03; enhance product quality for urban market with mean=2.98 and SD=0.96; job creation in the construction industry with mean=2.76 and SD=0.88; and strengthen social networks with mean=3.19 and SD=0.92

For the category under disagree, respondents expressed their strong disagreement with urbanizations' potential to generate formal or white color jobs with mean=3.49 and SD=1.08; and or creation of small-scale industries with mean=3.96 and SD=1.17.

Using the components (which include economic, social, and socioeconomic welfare) identified in in a multivariate regression analysis, revealed the key determinants that shapes the perceptions households have on urban expansion and how it relate to their living conditions.

Table 4. 19: Perceptions of the Impact of Urbanization on Household Welfare

S/N	**Perceived impact of urbanization**	**SA** Freq. (%)	**A** Freq. (%)	**SHA** Freq. (%)	**D** Freq. (%)	**SD** Freq. (%)	**Mean (Std. dev.)**
i	Do you agree that urbanization could lead to improved access to urban markets	48 (12.34)	84 (21.59)	171 (43.96)	64 (16.45)	22 (5.66)	2.81 (1.03)
ii	Do you agree that urbanization could lead to the creation of formal jobs?	10 (2.57)	74 (19.02)	94 (24.16)	138 (35.48)	73 (18.77)	3.49 (1.08)
iii	Do you agree that urbanization improves access to portable water?	24 (6.17)	145 (37.28)	199 (51.16)	18 (4.63)	3 (0.77)	2.57 (0.71)
iv	Do you agree that urbanization improve road network	20 (5.14)	145 (37.28)	198 (50.90)	22 (5.66)	4 (1.03)	2.60 (0.72)
v	Do you agree that urbanization improves quality of products for urban market	21 (5.40)	93 (23.91)	172 (44.22)	77 (19.79)	26 (6.68)	2.98 (0.96)
vi	Do you agree that urbanization creates jobs in construction sector	29 (7.46)	101 (25.96)	215 (55.27)	23 (5.91)	21 (5.40)	2.76 (0.88)
vii	Do you agree that urbanization improve social network	16 (4.11)	68 (17.48)	152 (39.07)	133 (34.19)	20 (5.14)	3.19 (0.92)
viii	Do you agree that urbanization creates small scale industries	15 (3.86)	49 (12.60)	39 (10.03)	121 (31.11)	165 (42.42)	3.96 (1.17)
ix	Do you agree that urbanization improve access to health care	48 (12.34)	182 (46.79)	137 (35.22)	18 (4.63)	4 (1.03)	2.35 (0.79)
x	Do you agree that urbanization lead establishment of educational institutions	189 (48.59)	144 (37.02)	47 (12.08)	9 (2.31)		1.68 (0.77)

1=strongly agree, 2=Agree, 3=somewhat agree, 4=disagree and 5=strongly disagree

4.5.2 Diagnostic Statistics of the Principal Component Analysis (PCA)

The principal component analysis's diagnostic results are shown in Table 4.20. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy: The KMO test is used to measure how suitable a dataset is for factor analysis. KMO value above 0.80 indicates that there are strong correlations between the variables and are therefore suitable in PCA or factor analysis. The data has a high sampling adequacy, as indicated by the KMO value of 0.841, which validates the dependability of additional statistical processing.

Cronbachs Alpha (Scale Reliability Coefficient: Cronbach's Alpha is an internal consistency metric that assesses how well the items measure a single underlying notion. A score of 0.8319 means that there is strong internal consistency, and a value greater than 0.7 means that the variables used in the study are good reflectors of the intended construct.

Average Inter-Item Covariance: It is the average shared variance of items. A moderate covariance means that the items are well related enough without being redundant, which means that the scale is well formed.

The statistical findings affirm that the data is very dependable and well suited to be used in the analysis. A high KMO value (0.841) justifies the use of the factor analysis and a high Cronbachs Alpha (0.8319) ensures internal consistency. All these factors contribute to the validity of this research, which is a good basis for meaningful insights.

Table 4. 20: Diagnostic Statistics of the PCA

Kaiser-Meyer-Olkin measure of sampling adequacy	***Kmo***
	0.878
	0.833
	0.875
	0.902
	0.877
	0.918
	0.878
	0.741
	0.846
	0.824
	0.631
Overall	**0.841**

Cronbach alpha test of reliability

Test scale = mean (unstandardized items); Average interitem covariance: 0.2525193; Number of items in the scale: 11 and Scale reliability coefficient: 0.8319

4.5.3 Principal Component Analysis of Urbanization Impact on Welfare

Given that the study focuses on households' perceptions of the impact of urbanization on welfare, Principal Component Analysis (PCA) was considered sufficient to identify and summarize the underlying dimensions of these perceptions. The PCA approach allows for the reduction of multiple correlated indicators into meaningful composite indices, thereby capturing the multidimensional nature of welfare without imposing causal assumptions. As such, further regression analysis was not pursued, as the primary objective is exploratory rather than causal.

The analysis identifies three key dimensions of welfare: economic opportunity, access to basic services, and livelihood diversification. These dimensions reflect the multifaceted nature of urbanization, which reshapes livelihoods, access to resources, and overall well-being, particularly in peri-urban areas of developing countries (Tacoli, 2017; United Nations, 2019).

4.5.4 Component Extraction and Variance Explained

The number of components retained was based on the eigenvalue-greater-than-one criterion. Three components with eigenvalues greater than one were retained, jointly explaining 63.9% of the total variance, indicating that the model adequately captures the underlying structure of households' perceptions (see Table 4.21). The first component explains the largest share, suggesting a dominant perception dimension.

Table 4. 21: Total Variance Explained

Component	Eigenvalue	Variance (%)	Cumulative (%)
Component 1	4.252	38.7	38.7
Component 2	1.775	16.1	54.8
Component 3	1.002	9.1	63.9

4.5.5 Rotated Component Structure

To improve interpretability, a Promax (oblique) rotation was applied. Only factor loadings of 0.30 and above are reported. Results are presented in Table 4.22 as follows;

Component 1: Economic Opportunity and Market Integration

The first component is characterized by strong loadings on market access, road infrastructure, product quality, and construction employment. This component reflects households' perception of urbanization as enhancing economic opportunities and market integration. This finding aligns with studies showing that urban expansion improves infrastructure and access to markets, thereby supporting income diversification and employment creation (Henderson et al., 2020; Jedwab et al., 2017).

However, as highlighted in the literature, these benefits are often unevenly distributed. The conversion of agricultural land into urban uses can result in farmland loss and livelihood displacement, particularly among farming households (Yeboah et al., 2017; Owusu, 2008).

Additionally, rising living costs may offset economic gains (Crush & Frayne, 2011; Tschirley et al., 2015).

Component 2: Access to Basic Services

The second component loads strongly on healthcare, potable water, and educational institutions. This component captures the basic services dimension of welfare, indicating that households perceive urbanization as improving access to essential services. This is consistent with the literature, which emphasizes that urbanization can enhance service provision through infrastructure development (Tacoli, 2017; UN-Habitat, 2020).

Nevertheless, such improvements are often uneven, particularly in peri-urban areas where rapid population growth can strain service delivery systems, leading to disparities in access.

Component 3: Livelihood Diversification and Social Capital

The third component is associated with small-scale industries, formal employment, and social networks. This reflects the role of urbanization in promoting livelihood diversification and social capital formation. The emergence of small enterprises and formal employment opportunities indicates a transition from agriculture to non-farm activities (Davis et al., 2017).

The inclusion of social networks highlights the importance of informal institutions in facilitating access to opportunities and supporting household resilience, even as traditional rural support systems evolve (Tacoli, 2017).

Table 4. 22: Rotated Component Loadings

Variable	Component 1	Component 2	Component 3
Urbanization improves access to markets	0.533	-	-
Urbanization improves road networks	0.483	-	-
Urbanization improves product quality	0.514	-	-
Urbanization creates construction jobs	0.313	-	-
Urbanization improves access to healthcare	-	0.550	-
Urbanization improves access to potable water	-	0.570	-
Urbanization leads to educational institutions	-	0.418	-0.441
Urbanization improves social networks			0.382
Urbanization creates small-scale industries			0.629
Urbanization creates formal jobs			0.446

Table 4. 23: Summary of Extracted Components

Component	Key variables	Interpretation
Component 1	Markets, roads, product quality, construction jobs	Economic opportunity and market integration
Component 2	Healthcare, water, education	Access to basic services
Component 3	Formal jobs, small-scale industries, social networks	Livelihood diversification and social capital

4.5.6 Distribution of Component Scores

Figure 4.10 presents the distribution of households along the first two principal components derived from the PCA. The scatter plot shows a concentration of observations within a moderate range of component scores, indicating that most households exhibit average perceptions of urbanization impacts.

The distribution along Component 2 (access to basic services) is largely positive, suggesting that households generally perceive improvements in access to services such as healthcare, water, and education. However, the presence of a few observations with relatively high scores indicates that some households experience significantly greater benefits from urbanization.

The absence of distinct clusters in the plot suggests that households' perceptions are not polarized but rather distributed along a continuum. This implies that the impacts of urbanization are experienced differently across households, depending on their specific socioeconomic and spatial conditions.

Overall, the scatter plot reinforces the PCA findings by illustrating the variability in households' perceptions while confirming the dominance of moderate and generally positive welfare outcomes associated with urbanization.

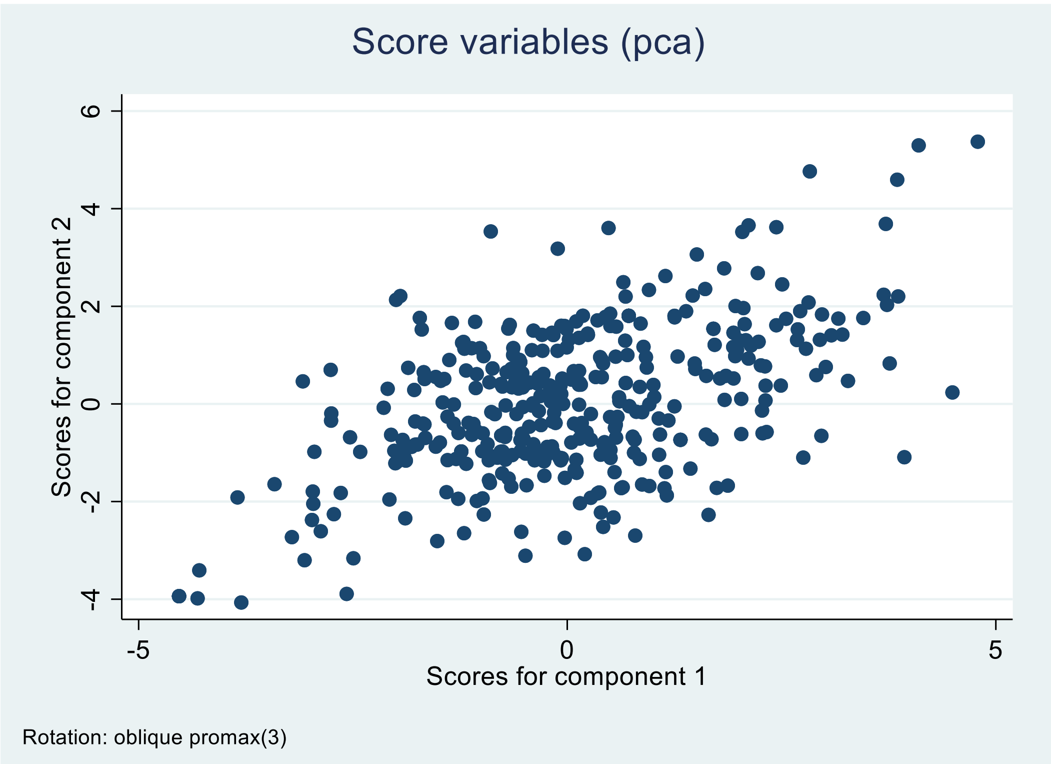

Figure 4. 10: Scatter Plot Diagram

5.5.7 Synthesis of Findings

The PCA results demonstrate that households' perceptions of urbanization impacts are multidimensional, encompassing economic, social, and structural transformation processes.

The dominance of the economic component suggests that market access and income opportunities are the most salient aspects of urbanization. However, access to basic services and livelihood diversification also represent critical dimensions of welfare.

These findings are consistent with the broader literature, which highlights the interconnected nature of urbanization impacts. For instance, improvements in infrastructure can enhance service delivery, while diversified livelihoods can mitigate economic and environmental risks (Davis et al., 2017; Tacoli, 2017).

Although an explicit environmental component did not emerge from the PCA, existing studies indicate that environmental changes remain an underlying factor influencing both economic and social welfare outcomes (Seto et al., 2012; Güneralp et al., 2017).

Overall, the results indicate that households perceive urbanization as a transformative process with multiple and interconnected welfare implications. While economic opportunities and improved service access are key perceived benefits, the need for livelihood diversification reflects the adaptive strategies households adopt in response to urbanization. These findings underscore the importance of integrated policy approaches that address economic development, service provision, and livelihood resilience in peri-urban areas.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

The main objective of this study was to analyze the consequences of urbanization on agricultural land, food security and household welfare in northern Ghana. First it was to understand how household staple crops (with focus on maize) production is affected by farmland loss as result of urban expansion, how food security is impacted in the past 30 years (1994-2024). Also, how households view the prospects as well as the challenges of urbanization on their welfare was also analyzed. Both qualitative and quantitative data was drawn from 389 households through a multi-stage sampling technique for this study. In order to determine the relationship between farmland loss and maize yield, the study utilized a preliminary statistical t-test and Residualize Quantile Effects regression models.

A comparison was made to justify the selection of Residualized Quantile Regression over Conditional and Unconditional Quantile Treatment Effects regression models**.** This method of analysis allowed for implicit appreciation of the impact of farmland loss on the productivity of staple maize on different quantiles of the yield distribution. Von Thunen's Location Theory, which explains how land-use patterns alter in response to urban growth and economic situations, serves as the foundation for the analysis. This theory is of the view that agricultural land closer to urban areas will have a greater chance of being transformed into non-agricultural development (built-up) as a result of increasing land values and other competing economic uses which can reduce agricultural production. This theoretical framework can be used to put into perspective the reduction in maize yield due to land conversion caused by urbanization.

Regarding the rate of peri-urban farmland loss to built infrastructure, the study investigated the impact of rapid urbanization on land use, the conversion of forest and cropland to built-up areas, the modification in water bodies as well as bare lands by use of Geographical Information System (GIS) procedures. Data for this analysis covered a 30-year (1994-2024) period, where change detection analysis and ground observation checks were used to determine the accuracy and reliability of the findings. The findings of the study are presented in LULC maps, tables and bar charts.

The foundation for the analysis is anchored on the Urban Expansion and Bid-Rent theories. The Urban Expansion illustrates how city boundaries extends over time, where rural surroundings are transformed with agricultural lands being encroached as urban built infrastructure expands due to increasing demand for space and services. The Bid-Rent on the other hand stresses on the competition for land utilization as cities undergo urbanization. Due to the increasing demand for land in both urban and peri-urban communities, agricultural lands become very expensive, which directly impacts food production and giving way to residential and commercial developments.

The study examined the relationship between peri-urban farmland loss to urbanization and household food security, with emphasizes on the distributional effects based on those who suffered land loss and those who did not. Food security was evaluated with the application of Extended Ordered Probit regression approach where food indicators such as FCS and HFIAS were measured. The framework for which this objective was analyzed is the Sen's (1981) entitlement approach to starvation and famines. The theory holds that individuals experience situations of food insecurity following the collapse of their endowments mostly for two reasons: one a decline their asset base or secondly, due to unfavorable change in the exchange entitlements. Household farmland loss represents a direct decline in their endowments portfolio, limiting their ability to cultivate staple crops such as maize which potentially exacerbate food insecurity.

The impacts of households' perception of urbanization processes on welfare was investigated with the application of approaches including; (i) Likert Scale which captures subjective views of households on the relationship between urbanization and welfare, (ii) Principal Component Analysis which identified key dimensions of the perceived impacts and (iii) a multivariate regression to examine statistical correlation between urbanization and indictors of household welfare.

The context under which this analysis was based is the urban Development Theory, which views urban expansion as dual purpose process with both opportunities such as jobs, urban development, and access to markets, as well as challenges relating farmland displacement, high cost of living, and environmental degradation. Urban development can also be related to this theory of livelihood diversification as rural and peri-urban livelihoods are shattered by urban growth, and thus have to rely on wage labor and entrepreneurial activities to sustain their lifestyle. These diversification processes may be affected by perceptions regarding the benefits of urbanization, which include easy access to markets and improved services and the negatives of urban growth, which include poor land tenure and loss of agricultural-based livelihoods.

This thesis provided a comprehensive insight into the perceived impact of urbanization on wellbeing and how it influenced food security by destroying farms. It highlighted the interrelation between household copying mechanism, farm productivity and urban growth. To assist policymakers to strike a balance between urbanization and food security and agricultural sustainability, the final section of the study contained summaries of the key findings, conclusions, and policy recommendations.

5.2 Summaries of Main Findings

The loss of farm land at all quantiles of the yield distribution was always negative on the production of maize; the largest effects were obtained at the Q50 and Q75 which exhibited significant reduction in the yield of both the median and farmers at high quantiles. The negative coefficients at Q25 and Q90 also underscore the fact that low and top-yield farmers are both impacted though their adaptation strategies may be different. The comparisons between the Residualized Quantile Regression (RQR), Conditional Quantile Regression (CQR) and Unconditional Quantile Regression (UQR) indicate that, RQR stands out as the strongest model to estimate QTEs under the conditions of heterogeneity.

The analysis of LULC transformations in Tamale, Wa, as well as Bolgatanga in the past thirty years (1994-2024) reveals significant spatial changes, caused by urban growth and changes in land-use patterns. Loss of farm land is widespread, mainly due to urban infrastructural development, even though the magnitude is not uniform across cities. For the entire period ranging from 1994 to 2024, Tamale metropolis has experienced significant decline in forest and croplands from 35.3% to 16.3%, with consistent expansion in built-up area by 1.6% to 5.0% within the same 30 years. The reduction in forest and croplands in Wa was about 42.6% between 1994 and 2024, with a corresponding built-up area expansion of 55.1%. In the case of Bolgatanga municipal, the experience was moderate but consistent significant land use shifts caused by the processes of urbanization, environmental management and changes in agricultural activities.

The effect of farmland loss on food security was negatively and significantly impactful, disproportionately hitting hard households affected by land depletion. This implies that households that directly lost part or all of their lands were more vulnerable in accessing food than households who maintain their lands.

Findings from the Extended Ordered Probit regression reveal that food insecurity is shaped by household socioeconomic, institutional and environmental factors. The heterogenous effects of farm land loss on household food security indicate that only 16.0% falls within the acceptable food consumption bracket, while 9.2% and 25.3% fall within borderline and food poor consumption categories respectively. Similarly, in the case of HFIAS, up to 67.6% are less likely to be food secure, whereas 32.7% and 34.9% are more likely to be in moderate and severe food security categories respectively

Household consumption patterns shifts due to farmland loss, repositioning households at borderline food security zones and reducing severe food poverty through adaptive mechanisms. These affected households rely heavily on market-based food sources to minimize food deprivation but creates heightened economic vulnerabilities in the long round.

Regarding how households perceive the impact of urbanization on their welfare, a Principal component Analysis technique was applied, which reveals the beneficial impact of urbanization in terms of improved access to portable water, education, healthcare, and road networks. Other households were however neutral in how they perceived urbanization effect and its potential for job creation and small-scale rural industries.

The Principal Component Analysis (PCA) results confirm that the data is suitable for factor analysis, with a Kaiser-Meyer-Olkin (KMO) value of 0.841 and individual values ranging from 0.631 to 0.918. The reliability of the scale is high, as indicated by a Cronbach's Alpha of 0.8319, while the average inter-item covariance (0.2525) suggests moderate correlation without redundancy.

Three components were extracted, jointly explaining 63.9% of the total variance. The first component accounts for 38.7% (eigenvalue = 4.252), the second 16.1% (eigenvalue = 1.775), and the third 9.1% (eigenvalue = 1.002), indicating that the first component is the most dominant.

The first component reflects economic opportunity and market integration, with strong loadings on market access (0.533), road infrastructure (0.483), product quality (0.514), and construction jobs (0.313). The second component represents access to basic services, with high loadings on healthcare (0.550), potable water (0.570), and education (0.418). The third component captures livelihood diversification and social capital, associated with small-scale industries (0.629), formal employment (0.446), and social networks (0.382).

The distribution of scores indicates that most households cluster around moderate values, with generally positive perceptions of improvements in basic services. The absence of clear clusters suggests that perceptions vary along a continuum rather than being polarized.

Overall, the findings show that urbanization is perceived as a multidimensional process, with economic opportunities as the dominant benefit, alongside improved service access and increased livelihood diversification.

5.3 Conclusion

This study examined the impact of urbanization-induced agricultural land loss on maize yield distribution, , household food security, perceived welfare impact of urbanization of peri-urban communities and quantified the extent of farmland loss to urban built infrastructure of Tamale, Wa and Bolgatanga, in Northern Ghana. The findings demonstrate that farmland loss has significant and uneven (distributional) effects across farming households and urbanizing landscapes. Therefore, the following conclusions can be made:

- First, the distributional analysis shows that the adverse effects of farmland loss cut across all quantiles of the maize yield distribution, but the impact is more pronounced among median- and high-yield (50th and 75th) farmers. This suggests that urban expansion does not only affect marginal producers; rather, it disproportionately constrains relatively productive farmers who are more commercially oriented and whose output contributes substantially to local food supply. The loss of productive cropland therefore has both efficiency and equity implications for peri-urban agricultural systems.
- Second, the GIS-based land use analysis reveals a consistent pattern of cropland and forest decline accompanied by rapid built-up expansion across the three cities over the 30-year period (1994–2024). In Tamale, cropland loss was particularly severe between 1994 and 2004 (50.8%) alongside a 103.7% expansion in built-up areas. In Wa, cropland declined by 42.6% between 1994 and 2004, with built-up areas expanding dramatically, especially between 2004 and 2014 (339.5%). In Bolgatanga, cropland loss was sustained across the three decades, with built-up areas consistently expanding at high rates. These trends

indicate that peri-urban expansion is largely occurring at the expense of agricultural land, with limited evidence of effective spatial control mechanisms.

- Third, the heterogeneous treatment effects show that farmland loss significantly worsens household food security outcomes. The heterogeneous effects of farm land loss on household food security (FCS) indicate that only 16.0% falls within the acceptable food consumption bracket, while 9.2% and 25.3% fall within borderline and food poor consumption categories respectively. Similarly, in the case of HFIAS, up to 67.6% are less likely to be food secure, whereas 32.7% and 34.9% are more likely to be in moderate and severe food security categories respectively. These findings confirm that farmland loss is not merely a land use issue but a critical livelihood and welfare concern in peri-urban Northern Ghana.
- Lastly, the perception of households on urbanization portrays a dual welfare story.The findings indicate that households generally perceive urbanization as a multidimensional and largely beneficial process, with impacts spanning economic, social, and livelihood domains. The dominance of the first component (explaining 38.7% of the variance) suggests that economic opportunity and market integration are the most significant aspects of welfare improvement, highlighting the central role of infrastructure and market access in shaping household outcomes.
- The second component (16.1% of the variance) shows that access to basic services, particularly healthcare, potable water, and education, constitutes an important dimension of welfare, reinforcing the view that urbanization can enhance service delivery. However, the variation in scores implies that these benefits are not uniformly experienced across households.

- The third component (9.1% of the variance) underscores the importance of livelihood diversification and social capital, indicating that households are actively adapting to urbanization by engaging in non-farm activities and leveraging social networks to improve resilience. Overall, the PCA results demonstrate that urbanization is perceived as a transformative process that improves welfare primarily through economic opportunities, while also facilitating better access to services and encouraging adaptive livelihood strategies. However, the continuous (non-clustered) distribution of perceptions suggests that the benefits of urbanization are unevenly distributed, depending on household-specific socioeconomic conditions.

Overall, the study concludes that rapid peri-urban expansion in Northern Ghana is undermining agricultural productivity and food security, particularly among relatively productive farmers, and that existing urban growth patterns lack adequate safeguards for agricultural land preservation and household welfare.

5.4 Recommendations

In light of the findings that peri-urban farmland loss significantly reduces maize yield across the distribution (with stronger effects on median and high-yield farmers), accelerates cropland decline in Tamale, Wa and Bolgatanga, and worsens household food security outcomes, the following thematic recommendations are proposed:

Recommendations for Practice

- The Ministry of Food and Agriculture (MoFA), under the District Departments of Agriculture, and in coordination with the Savanna Agricultural Research Institute should intensify the delivery of extension services in the peri-urban communities, by promoting improved maize varieties, climatic smart agriculture, soil fertility management, and small-scale irrigation technologies, so as to enable farmers maintain productivity on smaller land areas.

- Metropolitan, Municipal and District Assemblies (MMDAs), working with farmer-based organizations and NGOs such as SEND Ghana, should strengthen peri-urban farmer cooperatives to enhance collective access to credit, mechanization services, structured markets, and agribusiness training in order to cushion productive farmers against the welfare shocks associated with farmland loss.
- The National Board for Small Scale Industries (now Ghana Enterprises Agency) together with the Council for Technical and Vocational Education and Training should expand vocational and enterprise development programs targeted at land-affected households to facilitate livelihood diversification beyond agriculture.
- To reduce pressure on horizontal urban expansion, the Ministry of Works and Housing should promote vertical urban settlement development, including high-density and mixed-use housing schemes, particularly in rapidly expanding cities. Such an approach would help accommodate urban population growth while minimizing the conversion of productive agricultural land.
- Furthermore, the design and implementation of land redistribution and land readjustment schemes that integrate urban infrastructure with agricultural land use should be coordinated by the Land Use and Spatial Planning Authority**,** in collaboration with traditional authorities and local governments.

- Traditional Authorities, in coordination with land sector agencies, should strengthen transparency in customary land allocation processes to minimize speculative land conversion that accelerates cropland decline. The Ministry of Environment, Science, Technology and Innovation, in collaboration with the Environmental Protection Agency, should promote sustainable land-use practices and enforce environmental safeguards in peri-urban areas.
- To strengthen households' ability to benefit from emerging urban opportunities, the Ministry of Food and Agriculture (MoFA) in collaboration with farmer-based organizations (FBOs), NGOs, and Metropolitan and Municipal Assemblies (MMAs) should promote farmer cooperatives, climate-resilient urban and peri-urban agriculture, and small-scale agribusiness initiatives. These interventions will enhance social networks, improve market participation, and support livelihood diversification among peri-urban farming households affected by farmland loss.

Recommendations for Policy

- The Land Use and Spatial Planning Authority (LUSPA), in collaboration with the Lands Commission and MMDAs, should integrate legally binding agricultural land protection zones and urban growth boundaries into district spatial development frameworks in Tamale, Wa and Bolgatanga to regulate uncontrolled built-up expansion.
- The Ministry of Local Government, Decentralisation and Rural Development and the National Development Planning Commission (NDPC) should mandate food security impact assessments as part of urban infrastructure approval processes to ensure that future urban expansion does not undermine peri-urban food systems.

- The Lands Commission and MMDAs should reform compulsory land acquisition and compensation mechanisms by incorporating structured livelihood restoration programs, rather than one-time financial compensation, to safeguard long-term welfare of displaced farming households.
- Urban development policies should prioritize initiatives that directly enhance economic welfare, particularly in peri-urban areas experiencing rapid land-use transitions. The design and coordination of such policies should be led by the Government of Ghana, working through relevant economic, labor, and local government institutions.
- Environmental conservation policies are required to mitigate forest and cropland loss associated with rapid urban expansion and should be coordinated by the Government of Ghana through relevant environmental and planning institutions.
- Legal support for communities contesting unjust land acquisitions should be strengthened through the Office of the Attorney-General and Ministry of Justice, to enhance access to justice and procedural fairness.
- Challenges related to land ownership and use under rapid urbanization require legislative and institutional reforms led by the Government of Ghana through parliament to strengthen the protection of land rights.
- The Land Use and Spatial Planning Authority (LUSPA), Lands Commission, and Metropolitan and Municipal Assemblies (MMAs) should integrate peri-urban agricultural land protection and market infrastructure development into urban spatial planning frameworks. Strengthening zoning enforcement and safeguarding productive croplands will help ensure that urban expansion does not undermine the social welfare and livelihoods of peri-urban farming communities.

Recommendation for Academia

- The University for Development Studies, University of Ghana and Kwame Nkrumah University of Science and Technology, in collaboration with the Council for Scientific and Industrial Research (CSIR), should undertake longitudinal and panel studies to generate stronger evidence on the long-term effects of peri-urban farmland loss on maize productivity, income dynamics, and household food security transitions.
- These universities and research institutions should strengthen methodological innovation by integrating GIS and remote sensing techniques with advanced econometric approaches (such as distributional and heterogeneous impact models) to improve causal analysis of land-use change and welfare outcomes.
- Universities and policy research centers should further investigate youth vulnerability and agri-food value chain implications of declining peri-urban maize production, particularly its effects on urban food supply systems and price stability in Northern Ghana's secondary cities.
- Academic institutions should conduct gender-disaggregated studies to examine whether peri-urban farmland loss disproportionately affects women farmers in terms of land access, productivity, income control, and household food security, thereby informing gender-responsive land and urban policies.
- Universities and research institutions, particularly the University for Development Studies (UDS) and other Ghanaian research institutions, should undertake longitudinal and interdisciplinary studies on the gendered and institutional dimensions of peri-urban urbanization. Such research will deepen understanding of how social networks,

infrastructure access, and demographic factors shape household adaptation and welfare outcomes in rapidly expanding secondary cities.

5.5 Contributions of the Study

This study makes significant empirical, methodological, and policy-relevant contributions to understanding the interactions between urbanization, farmland loss, agricultural productivity, and household welfare in peri-urban contexts.

First, the study provides an empirical contribution by analyzing the impact of farmland loss on maize yield using Residualized Quantile Regression (RQR). The results indicate that farmland loss negatively affects maize productivity across all quantiles, with the strongest effects at the median (Q50) and upper quantile (Q75). This highlights that farmland loss constrains both low-yield and relatively high-yield farmers, demonstrating heterogeneous productivity impacts that are often missed by average-based models.

Second, the study contributes to the urban land-use change literature by documenting the rapid expansion of urban built-up areas and its consequences for forest and cropland decline over a 30-year period. Evidence from Tamale, Wa, and Bolgatanga shows that rapid urban growth has been a major driver of the reduction in agricultural and forested lands, underscoring the environmental and livelihood pressures faced by peri-urban communities. This provides rare longitudinal evidence of the scale and pace of urbanization-driven land transformation in northern Ghana.

Third, the study makes a methodological contribution by applying an extended ordered probit model to examine the effects of farmland loss on household food security, measured by FCS and

HFIAS. Accounting for the ordinal nature of these indicators and addressing endogeneity concerns, the analysis demonstrates that household food security is severely compromised by farmland loss.

Finally, the study contributes to the livelihood and welfare literature by highlighting mixed household perceptions of urbanization. While some households see benefits from improved infrastructure and market access, others experience farmland loss, declining agricultural livelihoods, and increased reliance on purchased food, revealing the heterogeneous welfare outcomes of urban expansion.

Overall, by integrating land-use dynamics, distributional productivity effects, food security outcomes, and household perceptions, the study offers a comprehensive and context-specific framework that informs urban planning, agricultural policy, and food security interventions in rapidly urbanizing peri-urban areas.

5.6 Suggestions for Further Research

This study recommends the following ideas for further research based on the findings. Although this study employs a mixture of spatial and household level data**,** further research is recommended to extend the temporal scope and analytical depth of existing evidence on farmland loss and agricultural productivity.

Specifically,

- Future studies could examine longer time horizons and additional panel waves to better capture dynamic farmer responses**,** such as the timing, persistence, and intensity of adoption of innovative practices used to maintain yields under increasing land constraints.

- Further research on how urban infrastructural development and agricultural sustainability could strike an equilibrium.
- Further research could assess how local governance and policymakers respond to public concerns about urbanization’s impact on household welfare and whether policy interventions address households' needs.

5.7 Limitations of the Study

Despite efforts to ensure rigor, this study faced several limitations that should be acknowledged:

- Data collection coincided with the peak farming period (July to October 2024), which limited farmers’ availability and may have affected the depth of responses.
- Some respondents were reluctant to provide sensitive information regarding land loss, as many did not formally own the land and feared that disclosing loss could jeopardize their remaining access.
- Data constraints and measurement issues arose, particularly with self-reported variables such as maize yields and household food security (FCS and HFIAS), which may introduce recall or reporting biases.
- While the study focused on Tamale, Wa, and Bolgatanga, the findings may have limited generalizability to other regions with different urbanization patterns, land tenure systems, or agricultural practices.
- The study was fully self-financed, which imposed financial constraints on the scale and scope of data collection, limiting the number of households, spatial coverage, and additional analytical tools that could have been employed.

- Inherent challenges in quantifying urban-driven farmland loss over time mean that some long-term trends may not be fully captured, despite using a combination of household and spatial data sources.

Overall, these limitations do not undermine the study's core findings but should be considered when interpreting the results and applying them to other contexts.

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APPENDICES

Appendix 1: Research Questionnaire

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

Department of Agriculture and Food Economics, Faculty of Agriculture, Food and Consumer Sciences

TOPIC: URBANIZATION AND AGRICULTURAL LAND LOSS: IMPACT ON PERI-URBAN HOUSEHOLD'S FOOD SECURITY AND WELFARE IN NORTHERN GHANA

Household Survey Questionnaire

UNIVERSITY FOR DEVELOPMENT STUDIES

FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES

DEPARTMENT OF AGRICULTURAL AND FOOD ECONOMICS

NYANKPALA CAMPUS

URBANIZATION AND AGRICULTURAL LAND LOSS: IMPACT ON PERI-URBAN HOUSEHOLD'S FOOD SECURITY AND WELFARE

IN NORTHERN GHANA

Inform Consent

My name is ………… I am a student of the University for Development Studies, Tamale. As part of the requirements for the completion of my course of study, I am conducting a study on the impact of urbanization household on food security and household welfare in selected cities of Northern, Upper West and Upper East regions of Ghana. The interview will last for not more than 1 hour.

Please if you agree to grant this interview, kindly sign or thumbprint below.

I,……………………………………..(name of farmer) consent to grant this interview and signed as below.

…………………………………..
Signature of Interviewee

PART I
General Information

Type of respondent:

Type of respondent 1=Land loss household [ ] 2=Non land loss household [ ]

Name of community	
Region	
District	
City	
GPS	
Date of interview	
Name of respondent	
Contact of respondent	
Name of enumerator	
Contact of enumerator	

Note: Cities include; 1=Tamale; 2=Bolgatanga; 3=Wa

Section A. Household Characteristics

No.	**Farmer Characteristics**				
1.	Gender of respondent (tick where appropriate)	0=Male		1=Female	
2.	Relationship of respondent to household head(in case respondent is not HH head):				
	1=Husband/wife	2=Father/mother…	3=Sister/brother…	4=Gdfather/gdmother ……	
	5=Uncle/aunty…….. Others (specify)………………………………………				
3.	Age (years) of respondent(tick)	1=18-35	2=35-65	3=Above 65	

4.	Absolute age of respondent:				
5.	Number of years in farming:				
6.	Highest level of education of respondent	1=None	2=Primary (1-6)	3=JHS (1-3)	
	4=SHS (1-3,Voc/Tech)	5=tertiary (training coll., Univ., Poly.	6=Arabic school		
	7=Others (specify) 8=Actual number of years in school…………				
7.	Marital status:	1=Single.....	2=Married	3=Widowed …..	4=Separated…..
	5=Others (specify)………………………				
8.	How many people are in your household (No. of people eating from one cooking pot)?				
	1=Male	2=Female adults	3=Boys	4=Girls	Total:
9	How many children in your household are of school going age?...				
10.	Are the children in your household going to school?	1=Yes	2=No		
11.	If yes to question 9, how many children are currently going to school?				
12.	What is the main household's economic activity?	1= Own farm	2=Salary work….		
	3=Petty trading	2=Daily laborer (farming/ non-farming activities)	5=Craftsmanship…..		
	6=Others (specify)…………………………………………………………………………………				
13.	Religious background of respondent:	1=Muslim	2=Christianity…	3=African Trad. Rel.	
	4=Others (specify)……..				
14.	How many people in your household earn monthly cash income? …..				
15.	What is the average monthly household income (GHS) from the various economic activities?				
16	What is the average household farm income?..				
17.	What percentage of the average household income come from farming? ………………….				

Section B: Household Assets

18. Indicate the household assets owned where appropriate

No.	Household Asset	Response 1=Yes 0=N	Number	Estimated Current value
i.	Car			
ii.	Motorbike			
iii.	Tricycle			
iv.	Tractor			
v.	Plough (tractor)			
vi.	Bicycle			
vii.	Bullock plough			
viii.	Drought animals			
ix.	Cutlass			
x.	Hoe			
xi.	Mobile phone			
xii.	TV			

xiii.	Radio			
xiv.	Fridge			
xv.	Heater			
xvi.	Gas cylinder			
xvii.	Storage facility			
xviii.	Others			

19. Do you or any household member receive remittances or support from anyone outside the Household? 1=Yes, 0=No

20. If yes to question 00, what was the average income received from relatives or outside the household?

21. Do you belong to any social organization in the community? 1=Yes; 0=No

How many household members belong to social organization?

22. Have you ever receive government support in time of crop failure/shock? 1=Yes; 0=No

23. If **No** to question 18, does such support exist? 1=Yes; 0=No

24. Has this community ever experience floods in the last 5 years? 1=Yes; 0=N0

25. Has this community ever experienced drought in the last 5 years? 1=Yes; 0=No

Section B: Farm/plot characteristics

26.	Do you own land?			1=Yes	0=No
27.	How did you acquire the land?	1=Inheritance	2=Gift…	3=Lease	
	4=Pledge	5=Loan	6=Purchase		7= others
	Note: Tick all that applied				
28	Do you have land for the following uses?[Tick all that applied] 1=Farming 2=Building				
	3=Grazing/Gardening 4=Recreational activities 5=Refuse dumping 6=Others (specify)				
29.	What is the distance of your land to the city center?				
30.	What is the dominant mode of land acquisition /transaction in the last 10 years (tick all that apply)				

	1=Inheritance	2=Gift	3=Sharecropping	4=Lease	5=Pledge
	6=Loan	7=Purchase		7= others	
31.	In the last 10 years, have you noticed any changes in the mode of land acquisition?			1=Yes	0=No
32.	If yes to question 27, what changes have you noticed so far in the mode of acquisition in the last thirty (10) years?				
	1…………………………………………………………………………………… 2……………………………………………………………………………………				
33.	What is the dominant type of land ownership in this community? (tick where applicable)				
	1=Family land	2=Stool/skin land	3=Private land	4= Government	
34.	What is your perception of tenure security of the plots of land you are cultivating?				
	1= Secured	2= Insecure			
35.	What is your perception of the fertility of your cultivated and unused plots?				
	1= Good soil fertility	2=Moderately fertile	3=Poorly fertile		
36.	What is your perception of the slope of your cultivated and unused lands?				
	1=Flat slope	2=Moderate slope	3=Steep slope		
37.	What is your perception of the depth of the soil of your cultivated and unused lands?				
	1=Shallow soil depth	2=Moderate soil depth	3=Deep soil depth		

Section C: Institutional Characteristics

No.	**Institutional characteristics**				
38	Do you have access to land commission?			1=Yes	0=No
39	Did you access this institution (s) in the last 2-3 years?			1=Yes	0=No
40	Why are you engaging with this/these institution (s)? ……………………………………………………………………………………………				
41	How long will it take you from your plot to the land commission (s) (mins.)?				
42	What is the nature of land governance in this community?				
	1=Customary	2=Statutory	3=Private	4 Both (1&2)	
43	What is the nature of your road network in this community?			1=good	2=bad
44	What is the time taken to main market (min)?				
45	Do you have access to extension services?			1=Yes	0=No
47	Do you have access to formal/informal financial institutions?			1=Yes	0=No
48	What is the time taken to formal/informal financial (min)?				
49	If yes to 47, have you ever received credit from any of these institutions?			1=Yes	0=No
50	If yes to 47, how much did you receive (GHS)? Total:				
	Did you get all the amount of credit you applied for			1=Yes	0=No
51	If yes to 47, do you save with these institutions?			1=Yes	0=No
52	Do you have access to good drinking water?			1=Yes	0=No

53	Do you have access to health facility?	1=Yes	0=No
54	What is the distance to the health facility (min)		

PART I

SECTION 1. Information on Land Acquisition

No.	**Information on Land Acquisition**				
55	Who is the owner of the plot you are cultivating?				
	1 =Community member	2=Own by Foreigner	3=Family	4=Others, specify:	
56	Have you loss part of your land to either individual who is an outsider, company or foreigner or any investor?			1=Yes	0=No
57	Which of the lands did you lose? 1=Farming 2=Building				
	3=Grazing/Gardening 4=bare land 5=Recreational land 6=Refuse dumping 7=Others (specify)				
58	If YES to 56, how many acres? ………………………………….				

SECTION 3. **Household Landholdings Before and after land loss**

59. Please indicate land usage before and after farm land loss

	Land usage	**Area before Land Loss**	**Area after Land Loss**
i.	Land under cultivation		
ii.	Unused /marginal land		
iii.	Borrowed land (acres)		
iv.	Land that was rented out (acres)		
v.	Land that was rented in (acres)		
vi.	Land under irrigation (acres)		
vii.	Average land value in this community		
viii.	Average fallow period		
60	What was your perception of the soil fertility before the land loss?		
	1 =Good soil fertility	2 =Moderately fertile	3 =Poorly fertile
61	What was your perception of the depth of your cultivated and unused lands before land loss?		

	1 =Shallow soil depth		2= Moderate soil depth			3= Deep soil depth		
62	What was the dominant type of land ownership in this community before the land loss? (tick what applies)							
	1=Family land		2=Stool/skin land		3=Private land	4=Government land		
63	What was the mode of land acquisition/transaction in this community before land loss? (tick what applies)							
	1= Inheritance	2=Gift	3=Lease	4=Share cropping	5=Pledge	6=Loan	7=Purchase	8=Others
64	What is your perception of tenure security of the plots before land loss?							
	1=Secured				2=Insecure			
65	Since when have you lost your farm land? Year…………………………………							
66	After losing part of your land, have you moved to acquire new land somewhere?						1=Yes	2=No
67	If no to question 96, why didn't you acquire another parcel to augment the lost part of land?							
	1=due long distance 2=Lack of resources 3=No land nearby 4=Difficult to relocate							
68	If yes to question 96, what is the distance of the land from your original location (Km)							

PART II

SECTION 1: CROP AREA AND OUTPUT

69. For each of the following crops, indicate the production information for the 2022/2023 cropping season

No.	**Crop**	**Area (acres)**	**Output (No. of bags /kg)**	**Unit price(100 kg bag)**	**Total value of output**
i.	Maize				
ii.	Sorghum				
iii.	Rice				
iv.	Millet				

70. Are you aware of the fertilizer subsidy program in the planting for food and jobs programme? 1=Yes, 2=No

71. Have you benefited from the fertilizer subsidy program in the 2022/2023 cropping season?

1=Yes, 2=No

72. For each crop provide input use details for the 2022/2023 cropping season

No.	Type of inputs by crop	Response	Quantity of input(kg)	Unit cost (GHs)	Total cost (GHs)
i.	Maize				
ii.	Did you use NPK Fertilizer? 1=Yes, 0=No				
iii.	Did you use Ammonia/urea? 1=Yes, 0=No				
iv.	Did you use Improved seed? 1=Yes, 0=No				
v.	Did you use Agrochemicals? 1=Yes, 0=No				
vi.	Did you apply FYM/compost? 1=Yes, 0=No				

PART II:

SECTION 2. LABOUR COST

73. For each of the following crops, indicate the labour cost for 2022/2023 cropping season

Crop	Activity	No. of persons	No. of days	Unit cost/day	Total cost
Maize	Clearing				
i.	Ploughing				
ii.	Harrowing				
iii.	Planting				
iv.	Weeding 1 &2				
v.	Spraying				
vi.	Harvesting				
vii.	Transportation				
viii.	Threshing				
ix.	Pest/disease control				
x.	Fertilizer application				
xi.	Bagging				
xii.	Input transport				
xiii.	Output transport				

PART III

SECTION 1: LIVESTOCK PRODUCTION

74. For each of the following livestock, indicate the production information before and after large-scale land acquisition

No.	Livestock	Number B4LL	Price per Animal	Current number	Price per Animal
i.	Chicken				
ii.	G. Fowl				
iii.	Ducks				
iv.	Turkey				
v.	Pigeon				
vi.	Rabbit				
vii.	Goats				
viii.	Sheep				
ix.	Cattle				
x.	Donkey				
xi.	Pigs				

PART V Food Security Information

Section A: Food Consumption Score (FCS)

75. Kindly recall the foods consumed by your household in the previous 7 days.

Item		Food Group	Weight (A)	Day Eaten in Past 7 Days (B)	Score (AxB)
i.	Maize, rice, sorghum, millet, bread and other cereals	Cereals and tubers			
ii.	Cassava, potatoes and sweet potatoes				
iii.	Beans, peas, groundnuts and cashew nuts	Pulse			
iv.	Vegetables, relish and leaves	Vegetables			
v.	Fruits	Fruits			

vi.	Beef, goat, poultry, pork, eggs and fish	Meat and fish			
vii.	Milk, yoghurt and other dairy products	Milk			
viii.	Sugar and sugar products	Sugar			
ix.	Oils, fats and butter	Oil			
				Composite score	

Section B: Household Food Insecurity Access Score (HFIAS)

112	In the last 30 days:				
i.	Did you worry that your household would not have enough food?			1=Yes	0=No
ii.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
iii.	Did you or any household member eat less preferred food because of a lack of resources?			1=Yes	0=No
iv.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
v.	Did you or any household member eat just a few kinds of food day after day because of a lack of resources?			1=Yes	0=No
vi.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
vii.	Were you unable to even eat less-preferred foods due to lack of resources to obtain other types of food?			1=Yes	0=No
viii.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
ix.	Did you or any household member eat a smaller meal than you felt you needed because there was not enough food?			1=Yes	0=No
x.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
xi.	Did you or any other household member eat fewer meals in a day because there was not enough food?			1=Yes	0=No
xii.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
xiii.	Was there ever no food at all in your household because there were no resources to get more?			1=Yes	0=No
xiv.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
xv.	Did you or any household member go to sleep at night hungry because there was not enough food?			1=Yes	0=No
xvi.	I f YES, how often?	1 Rarely	2 Sometimes	3 Often	
xvii.	Did you or any household member go a whole day without eating anything because there was not enough food?			1=Yes	0=No
xviii.		1 Rarely	2 Sometimes	3 Often	
113	How will you rate the food security status of your household?				
	1 Food secure	2 Marginally food insecure	3 moderately food insecure	4 Severely food insecure	

PART VI Perceived Impact of Urbanization on Household Welfare

114. Household perspectives of Peri-urban farmland loss to urbanization on household welfare

Variable					Response
115	**Perceived benefits of urbanization**				
i.	Do you agree that urbanization could lead to improved access to urban markets				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
ii.	Do you agree that urbanization could lead to creation of formal jobs?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
iii.	Do you agree that urbanization improve access to portable water supply?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
iv.	Do you agree that urbanization improve road network?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
v.	Do you agree that urbanization improve quality of products for urban market				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
vi.	Do you agree that urbanization creates jobs in construction sector?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
vii.	Do you agree that urbanization improve social network?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
viii.	Do you agree that urbanization creates small scale industries?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
ix.	Do you agree that urbanization improve access to health care?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree

x.	Do you agree that urbanization improve access to portable water?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree
xi.	Do you agree that urbanization lead establishment of educational institutions?				
	1=Strongly agree,	2=Agree	3=Somewhat agree	4=Disagree	5. Strongly disagree

Interview Guide for Community Forum

No.	**Interview Guide for Community Forum**					
1.	In this community, what are the main crops produced and consumed by all households?…………………………………………………………………………… …………………………………………………………………………………………					
2.	What is the production trend of these major crops over the last 10 years?					
	1=increasing	2=decreasing	3=stable trend			
3.	What factors account for the current observed trend?					
	1= Climate change	2=Farm land loss	3=Pest&disease	4=Poor soil conditions	5=Others (specify)	
4.	What is the land governance structure in the community?					
	1=customary	2=statutory	3=inheritance			
5.	What is the mode of land acquisition for members of the community?					
	1=upright purchase	2=inheritance	3=gift	4=renting	5= sharecropping	
6.	Have you observed any changes in land use patterns in the community over the last 10 years?	1=Yes	0=No			
7.	If yes to question 6, what are the changes observed?					
	1=Rapid urban expansion	2=farmland loss to urban development	3=massive land acquisition			
8.	If you have observed changes in land use patterns in the community over the last 10 years, in what ways do these changes affect you as farmers? ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………					
9.	With regards to land acquisitions in the community, who are the main buyers?					
	1=individuals	2=government/state institutions	3=companies	4=foreign investors	5=commercial farmers 6=real estate developers	
10.	What do people who purchase the lands use for?					
	1=Construction of educational facilities	2=Commercial farms	3=Health facilities	4=Agro-industries		

11.	Does changes in land use pattern over the last 10 years affect youth in the community differently?	1=Yes	0=No
12.	If yes to question 13, what are some of the impact of urbanization on the livelihood of the youth?……………………………………………………………………………… ………………………………………………………		
13.	How will households who loose land respond to changes in farmland access? ……………………………………………………………………………………… ………………………………………………………		
14.	How was the local food production before and after farmland loss? ……………………………………………………………………………………… ………………………………………………………		
15.	How was the food security before and after farmland loss? ……………………………………………………………………………………… ………………………………………………………		
16.	How does farmland loss impacting household income? ……………………………………………………………………………………… ………………………………………………………		
17.	What are some of the sustainable mechanisms after losing part of your farm land? ……………………………………………………………………………………… ………………………………………………………		

Appendix 2: Land Use Land Cover Change (LULC) Graphs for Tamale, Bolgatanga and Wa for Thirty Year Period (1994-2024)

LULC for Tamale (1994-2024)

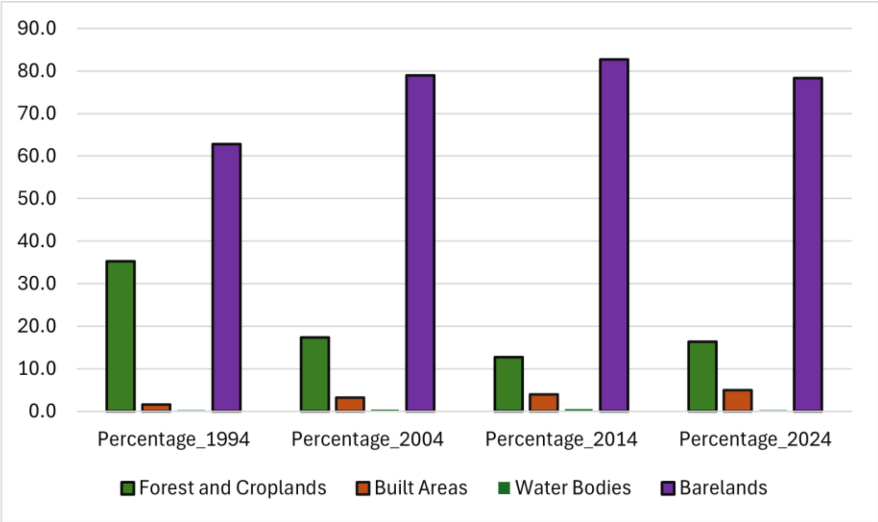

Figure 1: Graph showing percentages of land use and land cover classes of Tamale Metropolis from 1994 - 2024.

LULC for Wa (1994-2024)

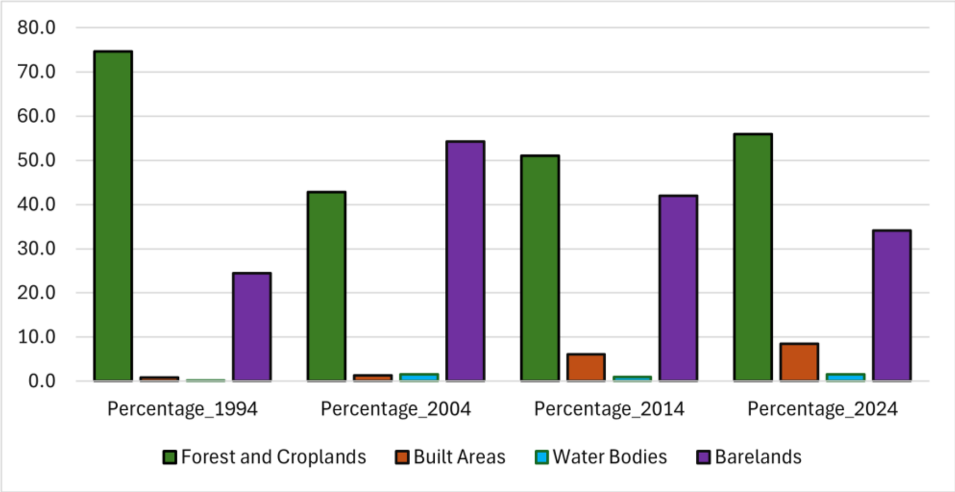

Figure 2: Graph showing percentages of land use and land cover classes of Wa Metropolis area from 1994 - 2024.

LULC for Bolgatanga (1994-2024)

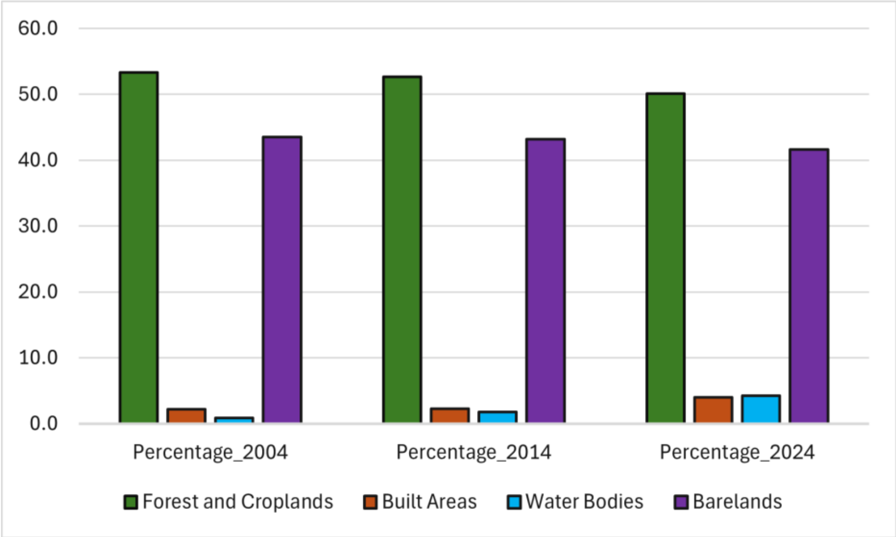

Figure 3: Graph showing percentages of land use and land cover classes of Bolgatanga Municipal area from 1994 - 2024.