# UNIVERSITY OF GHANA, LEGON

**ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT OF GHANA**

**BY**

**ELIJAH MUNANKAN**

**(11006924)**

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY (M.PHIL) DEGREE IN GEOGRAPHY AND RESOURCE DEVELOPMENT**

**DECEMBER 2025**

## DECLARATION

I, ELIJAH MUNANKAN, the author of "ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT OF GHANA," do hereby declare that this work is the product of my own research and efforts in the Department of Geography and Resource Development, College of Humanities of the University of Ghana, Legon, and that no portion of this work has been submitted by anyone in this institution or any other institution for consideration for an academic award or in any other capacity, and that any work by other authors that was referenced or quoted was done so correctly. Therefore, in the unlikely event that there is a defect, I am the sole person to be held liable.

ELIJAH MUNANKAN ____________________ 10/12/2025

*(Student)* *Signature* *Date*

**Certified by;**

PROF. ALEX BARIMAH OWUSU ____________________ 10/12/2025

*(Principal Supervisor)* *Signature* *Date*

PROF. ALEX BOAKYE ASIEDU ____________________ 10/12/2025

*(Co-Supervisor)* *Signature* *Date*

# DEDICATION

I dedicate this work to the Almighty God who has supported me during my years of study by giving me good health and strength. In addition, I would like to dedicate this work to my parents, Rev. and Mrs. Joseph Minnow Bart-Plange, of the Evangelical Lutheran Church of Ghana for their good counsel and unwavering support and role in my education, as well as to all of my siblings and acquaintances who helped me in many ways to complete this work.

# ACKNOWLEDGMENTS

First and foremost, I would like to express my profound gratitude to the Almighty God, who has been my guide and strength during this research project. Additionally, my appreciation goes to Konrad Adenauer Stiftung (KAS) for sponsoring me throughout this program. My sincere gratitude again is extended to my principal supervisor, Prof. Alex Barimah Owusu, of the Department of Geography and Resource Development, who has helped make this work a success with his advice, recommendations, and most importantly, his patience in going through my scripts. I would also like to thank my co-supervisor, Prof. Alex Boakye Asiedu, also of the Department of Geography and Resource Development, University of Ghana, Legon, for all his insightful feedback, suggestions, and advice that helped with my thesis. I sincerely thank all of the excellent and dedicated lecturers at the University of Ghana's Department of Geography and Resource Development for their wonderful deliveries of lectures and tremendous efforts in making geography an interesting course. Furthermore, I would like to thank my colleague students, who were supportive during seminars, fieldwork, and group discussions.

I also thank the people and officials of the Bawku West District Assembly for their warm reception, particularly the District Directorate of Agriculture for providing me with the needed data, without which this work would not have been possible.

I finally pour out my gratitude to the Acting General Secretary of the Evangelical Lutheran Church of Ghana and the Resident Pastor of St. Peter's Lutheran Church, Madina, Rev. Edward Sereko-Younge for his periodic words of motivation and encouragement, as well as the congregants of the Church for their moral, physical, and spiritual support during the period of my studies.

May the Lord shower His blessings upon you all.

## ABSTRACT

Land degradation is a serious environmental problem with significant implications for food security, particularly in areas where agriculture is the primary industry. Focusing on the Bawku West district of Ghana, this study examined the dynamics and the degree of land degradation and their direct and indirect effects on food security. In the study area, land productivity is directly related to food security, which was measured in terms of food availability, accessibility, and stability of food supply. The research again evaluates how much soil erosion, deforestation, overgrazing, and other types of land degradation exist and their effects on agricultural productivity through using of field surveys, remote sensing, and interviews with farmers in the district. Land degradation was evaluated using bio-physical indicators of land degradation, such as erosion and decreased soil fertility, and their connection to agricultural results. The study sought to establish the relationship between degradation and food security. Crop yields decrease as land quality deteriorates due to soil erosion, nutrient depletion, and vegetation loss. In the study, both primary and secondary data were collected from smallholder farmers and agricultural extension officers in six major communities (Zongoyiri, Widnaba, Sapeliga, Boyaa, Binaba, and Zebilla) in the district, as well as the agricultural directorate of the District Assembly respectively. Thirty-five questionnaires each were administered in five of the major towns (Zongoyiri, Widnaba, Sapeliga, Boyaa, and Binaba), whilst Zebilla, being the district capital, had twenty-nine persons filling out the questionnaires. The primary data were analysed using the chi-square test of SPSS. Tables and charts were generated and interpreted using same. Also, remote sensing imagery of the study area were downloaded from the USGS website and used in classifying the Bawku West District. The method of classification that was employed here was the supervised classification. Envi 5.3, a digital image processing software was used to pre-process and analyse the spatial data using the object based image analysis whilst ArcMap 10.8 was used in designing maps. The district's food insecurity is seen to be made worse by the findings, which show a notable decline in soil fertility, lower crop yields, and increased susceptibility to climate variability. Out of the working population of 133,889, 107,111 people representing 80% are engaged in agricultural-related activities. The research also finds socioeconomic variables that contribute to unsustainable land use practices, such as issues with land tenure and poverty. Finally, 407.0583km² of land was found to be degraded during the 20-year period (2002 and 2022). This represents 38.0428% of the total land area in the district.

The study analysed land degradation and its impact on food security in the Bawku West District. Factors such as inadequate rainfall, lack of agricultural land, high temperatures, population growth, poverty, poor farming methods, excessive grazing, and insect infestations make achieving food security difficult. In order to improve food security in the area and rehabilitate degraded lands, the research emphasizes the necessity of integrated land management strategies that include afforestation, soil conservation methods, and policy interventions. It is recommended that government measures must provide citizens a sense of control and ownership over their lands in order to address the problem of land degradation and enhance food security. It makes rational sense for adopting a community-based approach to land oversight, in which government employees and agencies work with the local population, as the local leaders have both jurisdiction and ownership of the land. Encouragement of sustainable agricultural methods and education of farmers about their advantages are also necessary. Crop rotation, shifting cultivation, the use of cover crops and conservation tillage to prevent soil erosion, and organic farming to preserve soil health are a few examples of these sustainable farming methods. The Bawku West District residents advocate for rehabilitation of degraded areas and enforcement of environmental laws against illegal activities. They also suggest purchasing land parcels for agricultural use due to the potential urbanization, thereby enhancing the district's and the country's food security.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AI | Artificial Intelligence |
| ASM | Artisanal and Small-scale Mining |
| BECE | Basic Education Certificate Examination |
| BWD | Bawku West District |
| CCoLD | Continuous Cycle of Land Degradation |
| CFSVA | Comprehensive Food Security and Vulnerability Analysis |
| COVID 19 | Corona Virus Disease of 2019 |
| DGRD | Department of Geography and Resource Development |
| ELD | Economics of Land Degradation |
| ERP | Economic Recovery Program |
| EU | European Union |
| FAO | Food and Agricultural Organization |
| FMNR | Farmer Managed Natural Regeneration |
| GAP | Good Agricultural Practices |
| GIS | Geographic Information System |
| GNA | Ghana News Agency |
| GSGDA | Ghana Shared Growth and Development Agenda |
| HCES | Household Consumption and Expenditure Survey |
| ICP | International Coffee Partners |
| IFAD | International Fund for Agricultural Development |
| IMF | International Monetary Fund |
| LDC | Less Developed Countries |
| LI | Legislative Instrument |
| LMICs | Low and Middle Income Countries |
| LULC | Land Use Land Cover |
| MSLC | Middle School Leaving Certificate |
| MoFA | Ministry of Food and Agriculture |
| NADMO | National Disaster Management Organization |
| NGO | Non-Governmental Organization |

| | |
|---|---|
| OBIA | Object-based Image Analysis |
| PFJ | Planting for Food and Jobs |
| QUAC | QUick Atmospheric Correction |
| RS | Remote Sensing |
| RFJ | Rearing for Food and Jobs |
| S4T | Saving for Transformation |
| SADP | Savannah Agricultural Value Chain Development Program |
| SAM | Spectral Angle Mapper |
| SAP | Structural Adjustment Program |
| SAPIP | Savannah Zone Agriculture Productivity Improvement Project |
| SIP | Savannah Investment Program |
| SDG | Sustainable Development Goals |
| SHS | Senior High School |
| SSS | Senior Secondary School |
| SOM | Self-Organizing Maps |
| SPSS | Statistical Package for Social Science |
| SVM | Support Vector Machines |
| UER | Upper East Region |
| UN | United Nations |
| UNCCD | United Nations Convention to Combat Desertification |
| UNICEF | United Nations Children's Fund |
| USGS | United States Geological Survey |
| WB | World Bank |
| WFP | World Food Program |
| WHO | World Health Organization |
| WWF | World Wildlife Fund |

## CHAPTER ONE: INTRODUCTION

### 1.1 Background of the Study

Land degradation may be defined as "the aggregate diminution of the productive potential of the land including its major use (rain-fed, irrigated, arable cropping, rangeland, inland fishery and forestry), its farming systems (e.g. smallholder subsistence) and its value as an economic resource" Mganga (2022, pp. 273-300). Degradation of land is as a result of both natural events such as drought, flood, rainfall variability and intensity, and anthropogenic factors including indiscriminate logging of trees without replacement, overgrazing, illegal mining of natural resources, and bad farming practices (Ali et al., 2024). In fact, adverse climatic conditions are increasingly seen as a major cause of land degradation (Farooqi et al., 2024). All types of life on earth primarily rely on the land for their sustenance (Abate, 2020). One of the most valuable resources is soil due to its supports to plants and vegetation, which give food and nourishment to all living things (Lal et al., 2021). The demand for food has significantly increased over the past decades as a result of the increasing world population, rising per capita income, changing dietary patterns, accumulation of food waste, and transmission losses. As a result of habitation, roads, and urban infrastructure, a sizable portion of arable land has been destroyed (Baude et al., 2019). Intensive farming, excessive grazing, deforestation, water pollution, and increased use of pesticides and fertilizers have all contributed to the degradation of the top soil, which has resulted in increased salinization, loss of fertility, soil erosion, and desertification (Ayub et al., 2020). The degradation of soil is being accelerated further by the significant increase in water use, the contamination of rivers, lakes, and groundwater aquifers, as well as the increased discharge of industrial effluents, municipal sewage, and non-biodegradable trash. Soil degradation is also a result of frequent droughts, flooding, and other extreme weather events brought on by global warming and climate change (Kumar et al., 2022). As a result of soil degradation, during the past six (6) to seven (7) decades, pressure on the land has increased significantly. According to research, 35% of agricultural land has degraded to varying degrees since 1950 attributable to human-induced activities (Hossain et al., 2020). At the World Food Summit in Rome in 1996, it was recognized that poverty, not a lack of resources required for food production, is the main cause of the food security issue that affects less developed countries (LDCs). People are underfed, not because farmers cannot produce more food, but because they do not have enough money to buy what they need. The number of malnourished people worldwide decreased from 941 million in 1969–1971 to 781 million in 1988–1990 (Kim et al., 2023).

The goal of Sustainable Development Goal (SDG) 2 (Zero Hunger) is to eradicate hunger by 2030 and ensure that everyone has year-round access to enough nutritious food. Initiatives from International Coffee Partners (ICP) promote sustainability, good agricultural practices (GAP), and the development of a variety of crops. On the one hand, this leads to increased and more effective agricultural output, increasing food security and availability. Diversification promotes the development of food crops in addition to cash crops, especially in hard times, and ensures food security.

Therefore, it is imperative to note that in achieving SDG 2, we cannot compromise our efforts in the fight against land degradation as it is a major determining factor as far as ending hunger and improving nutrition are concerned. Land degradation is a pressing environmental issue with far-reaching consequences for both ecosystems and human well-being (Atieku & Segbefia, 2024). In the context of agricultural-dependent nations like Ghana, land degradation poses a significant threat to food security, exacerbating existing challenges in meeting the nutritional needs of the population (Orach et al., 2024). The Bawku West District, located in the Upper East Region of

Ghana, is one such area that has been adversely affected by land degradation (Azumah et al., 2023), leading to potential implications for food production and availability.

This study aims therefore, to delve deeper into the issues of land degradation and its dire repercussions on food security in the Bawku West District of Ghana and how these impacts can be mitigated.

**1.2 Problem Statement**

Many concerns have been raised for decades in relation to the rate of land degradation in the Upper East Region (UER) of Ghana. Substantial land degradation was noticed in Ghana's northern savannah region, including the UER (Dahan et al., 2023). As a result, early land-planning and soil-erosion procedures were implemented in those areas, concentrating on the agricultural use of land, water, and grazing resources. The occurrence of land degradation is driven by both natural and human factors (Huang et al., 2023). Climate factors such as rainfall unpredictability and intensity, drought, flood, temperature, and wind are examples of natural causes (Seneviratne et al., 2021). In fact, adverse climatic conditions are increasingly seen as a major cause of land degradation (Tunçay & Başkan, 2022). Together with additional uses brought on by population growth, other social and economic issues that contribute to land degradation include poverty, unequal land resource distribution, and inappropriate land use and farming systems. Also, there have been several unsuccessful and occasionally worse attempts to regulate and counter the threat of desertification in this area. For instance, Nsiah-Gyabaah (1994) argued that the Structural Adjustment Program/ Economic Recovery Program (SAP/ERP) of the International Monetary Fund (IMF) and World Bank, with its associated export promotion, currency devaluation, and withdrawal of agricultural subsidies, was one of the worst development policies in terms of aggravating land degradation in Ghana. Its interconnectedness with social, economic, technical, political, and environmental systems, which function as exacerbating factors, has made it even more intricate.

Though, there have been scholarly works undertaken by learned personalities including Ashaley (2012), Benneh (1994), Owusu et. al (2013), Cervone (2015) and Beach and Luzzadder-Beach (2013) on similar subject matter. However, little knowledge is known about the spatio-temporal extent of land degradation, the rate of land degradation, and the impacts of these on food security in the area. Food security in Bawku West District is being threatened by land degradation (Yiran et al., 2022). Despite the district's potential for agriculture, the negative consequences of land degradation have decreased agricultural production and harmed local people's capacity to meet their food demands (Azumah et al., 2023). The degree and effects of land degradation on food security in the Bawku West District have not, however, been thoroughly examined. This position is equally shared by (Boateng et al., 2016) as they are of the view that the alarming rates of land degradation occurring in Ghana's Bawku West District, is significantly affecting the locals' access to food. The scope and severity of land degradation are growing despite efforts to stop this phenomenon, endangering the wellbeing of the local populace. To inform policy measures that can enhance food security and livelihoods, it is necessary to understand the root causes and effects of land degradation in the district. This study focuses on the Bawku West District as an attempt to conduct a thorough analysis of the spatial extent and degree of land degradation and asses the causes and effects of land degradation, as well as its implications for food security.

## 1.2 Research Objectives

The study seeks to examine land degradation and its impacts on food security in the Bawku West District of the Upper East Region of Ghana.

**The specific objectives for this study include:**

- To examine the spatio-temporal extent of the degree of land degradation in Bawku West District using vegetation availability as an early warning indicator.
- To estimate the rate of land degradation in the Bawku West district from 2002-2022.
- To analyse the degree of association between land degradation and food security.

### 1.2.1 Research Questions

- What is the spatio-temporal extent of land degradation in Bawku West District?
- How much land area is degraded in the Bawku West District over the period of the study?
- What is the degree of association between land degradation and food security in the area?

## 1.3 Hypothesis

1. Null Hypothesis ($H_0$): There is no association between land degradation and food security in the Bawku West District.
2. Alternative Hypothesis ($H_a$): There is a significant degree of association between land degradation and food security in the Bawku West District.

## 1.4 Significance of Study

Land degradation, which is a critical global environmental concern, directly affects agricultural production, the livelihoods of millions of people, and food security. The Upper East Region of Ghana is regarded as the region with the worst degraded land in the country, with emphasis on the Bawku areas (Edaku et al., 2023). In terms of regional distribution, the Upper East has the worst level of food insecurity, with up to 28% of its population facing food security issues (Wudil et al., 2022). This phenomenon calls for more attention to be given to the area in terms of good farming practices, land management and restoration. This study provides insight on the distinct dynamics and effects of land degradation in a localized context by concentrating on the Bawku West District in Ghana.

Policymakers can create evidence-based plans and actions to lessen the detrimental consequences on food security by assessing the causes, severity, and implications of land degradation in the Bawku West District. This study can aid in the creation of focused policies and action plans to encourage sustainable land use behaviors and increase the region's agricultural resilience. This study can help to better understand the intricate relationships between land degradation, agricultural systems, and food security by conducting a thorough analysis and producing empirical data. The results can be used as a guide for future research projects, assisting in the development of more focused studies and provide a foundation for comparative analyses in comparable geographic or contextual contexts. The results of this study can be shared with stakeholders, farmers, and local communities to assist them understand the value of sustainable land management techniques.

The study can inspire collective action and promote cooperation between many players, including farmers, community-based organizations, non-governmental organizations, and governmental agencies, by emphasizing the clear connections between land degradation and food security. Through cooperation, programs that address land degradation, improve ecosystem resilience, and protect food production can be developed and put into action locally. Important information about the connection between land degradation and agricultural productivity in the Bawku West District may be found in the study. This research can aid in the creation of context-specific agricultural practices and procedures by helping to better understand the unique difficulties experienced by local farmers, such as soil erosion, nutrient depletion, and water shortages. By adopting sustainable land management practices, maximizing resource allocation, and enhancing crop yields, farmers and agricultural extension services may increase the district's food security with the help of this information.

In conclusion, it is of utmost importance to look into assessments of land degradation and how it affects food security in Ghana's Bawku West District. The study has the potential to influence policy choices, improve agricultural methods, increase awareness, encourage collaboration, and advance scientific knowledge—all of which are essential steps toward achieving local, national, and international objectives for sustainable land management and food security.

### 1.5 Limitations

There were a number of limitations that were encountered when carrying out this research work. One of these had to do with time constraints. The topic "Land degradation and its implications for food security" are long term processes, and may have not been covered within the timeframe of the study. Ample time is needed to monitor the area and draw undeniable conclusions. Allocating short time for a study as this may tend to miss critical patterns and processes. Another challenge posed by this research work was the acquisition of data, particularly from established institutions. Acquiring agricultural data in the district was quite herculean. Modern ways of storing data were lacking as they were kept on the shelves rather than on the computer. Monetary payment sometime would have to be made to get access to some data. Language barrier was also another challenge posed. This necessitated the hiring of a translator who helped particularly with the interviews and questionnaires, in translating the local language (Kusaal) to English and vice versa. Lastly, the conflict between the Kusasis and Mamprusis was also another limitation during the study period. Though, there were no major incidents between the two factions during the period of the study. Despite the fact that the conflict was mostly centered in the Bawku municipal, there were a large number of Kusasis living in Zebilla, where I lodged and a considerable number of Mamprusis living there as well. And since the conflict was between the Kusasis and Mamprusis, there was the likelihood that the conflict could have sprung up in Zebilla.

### 1.6 Organization of the Study

The thesis consists of six main chapters. The background of the study is briefly reviewed at the beginning of Chapter 1, which is then followed by the problem statement, the research objectives, its hypothesis, the relevance of the study, and the organization of the thesis. The relevant literature on the study objectives is reviewed in the second chapter. A conceptual framework relevant to the study is also adapted and talked about in this chapter. The third chapter provides the methodology for the research, details on the study area, data collection and sample procedures, and data analysis techniques. The fourth chapter contains the results and a discussion of my first two objectives. Chapter five covers the results and discussion of my objective three, hypothesis testing, and also a linkage of the work to the conceptual framework. The summary of the study, conclusion, and recommendations based on the research findings are presented in the sixth and last chapter.

In this chapter, I have given an overview of land degradation and its causes. I have established how land degradation affects agricultural land, food productivity, and contributes to poverty and malnutrition. Therefore, there is an urgent need in fighting against land degradation in order to end hunger and improve nutrition. I have outlined the motive behind this study, which is to examine the spatio-temporal extent of land degradation, the rate of land degradation, and its effects on food security.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Introduction

In chapter one above, I have discussed land degradation and how it affects food security both locally and globally. The problem statement is further discussed, as the study seeks to examine the spatio-temporal extent of land degradation, the rate of land degradation, and the impacts of these on food security in the study area. I went on to deliberate on the significance of the study, emphasizing the socio-economic and ecological implications for local livelihoods. The limitations of the study and organization of the study were later discussed.

The literature review emphasizes how land degradation, especially in Ghana's Bawku West District, has a major influence on food security. It emphasizes how urgent it is to solve this problem with sustainable land management techniques and laws that strengthen food security and encourage agricultural resilience. In Ghana and other similar contexts, future research should concentrate on tracking and assessing the efficacy of interventions and investigating novel tactics to counteract land degradation and its detrimental impacts on food security. By reviewing the literature, this review will highlight some definitions of land degradation and identify the major causes of land degradation in the Bawku West District, including both natural causes like climate change and human-caused causes like deforestation, excessive grazing, and poor land management techniques. The review will look at the various ways that land degradation affects food security, including decreasing crop yields, a drop in agricultural revenue, a rise in susceptibility to climate shocks, and poorer nutritional outcomes for the local population. This review will also investigate potential mitigation and adaptation techniques that have been proposed or put into practice to lessen the negative effects of land degradation on food security in the study area. Agroforestry, soil conservation techniques, and community-based programs are a few examples.

Lastly, this literature review will highlight areas in need of additional research in order to develop a more thorough understanding of the complex relationship between land degradation and food security in the Bawku West District. It will also identify gaps in the existing literature. This literature review aims to inform policy makers, researchers, and practitioners about the difficulties and opportunities for addressing land degradation and enhancing food security in the Bawku West District, ultimately contributing to the sustainable development of the area and the well-being of its residents. It does this by giving a thorough overview of the current state of knowledge on this crucial issue.

## 2.2 Land Degradation

With centuries-old historical roots, land degradation is a complicated and continuous environmental problem. It is a process that occurs when the quality and productivity of land decline, frequently as a result of a mix of natural and human-caused factors (AbdelRahman et al., 2023). With the advent of agriculture came the clearing of forests and the practice of slash-and-burn farming, which is when land degradation can be traced back to (Hands, 2021). Soil erosion and nutrient loss were frequent results of these activities. While ancient agriculture was crucial to the growth of early human civilizations, it also had unforeseen consequences that accelerated the degradation of the soil. Although the extent and effects of ancient agriculture varied between areas and eras, a number of similar behaviors and events contributed to the degradation of the soil.

The reduction or loss of biological or economic productivity and complexity of range, pasture, forest, woodlands, rain-fed cropland, or irrigated cropland due to land uses, or a process or combination of processes, including processes resulting from human activities and habitation patterns, is known as land degradation. Examples of these processes include: (i) soil erosion brought on by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation. Therefore, processes that result in surface salt accumulation and waterlogging in places affected by salt are incorporated in land degradation (Bolo et al., 2019). According to this definition, land degradation is a result of both natural and human-caused processes, which makes sustainable land management and productivity difficult. Extreme weather, especially drought, is one of the many factors that contribute to land degradation (Hermans & McLeman, 2021). Human actions that degrade or deteriorate soil and land utility quality are also responsible for this. It has a detrimental impact on livelihoods, food production, and the creation and delivery of other ecosystem products and services. According to the WHO (2020), land degradation in the 20th and 21st centuries has increased as a result of agricultural and livestock production (over-cultivation, overgrazing, and forest conversion), urbanization, deforestation, and extreme weather events like droughts and coastal surges, which salinate land. In addition, the FAO defines land degradation as the loss of production capacity of land in terms of loss of soil fertility, soil biodiversity, and degradation of natural resources (Ekka et al., 2023). According to Ekka et al. (2013), land degradation is caused by soil water erosion (46%), wind erosion (36%), loss of nutrients (9%), physical deterioration (4%), and salinization (3%). However, Slayi et al. (2024) attribute land degradation to overgrazing (49%) followed by agricultural activities (24%), deforestation (14%), and overexploitation of vegetative cover (13%) in rural areas. Land degradation is the continual decrease of a land's production capacity, which may be developed by any combination of multiple interconnected processes, such as soil erosion, deterioration of soil nutrients, loss of biodiversity, deforestation, or declining vegetative health (Viju & Nambiar, 2023). All the definitions above point to the fact that land degradation is as a result of both natural and anthropogenic factors which are capable of rendering the land infertile for agricultural purposes. Therefore, in this context, land degradation can be defined as the activities of man and natural processes and phenomena that adversely affect the quality of soil such that it is incapable of supporting the growth of crops.

Land is a vital resource for humankind, much like air and water. Land degradation, defined as the deterioration or loss of the productive potential of the soils for the present and the future, affects everyone in different ways, including food insecurity, rising food prices, climate change, environmental hazards, and the loss of biodiversity and ecosystem services. Globally, the productivity of croplands and rangelands is declining at an alarming rate due to land degradation.

The results of the desertification hazard model, as presented in a research article by Mensah et al. (2015) indicate the risk levels of land degradation in all ecological zones. The study found that low risk areas are the evergreen forest and moist semi-deciduous ecological zones, while high risk areas are primarily found in the Sudan and Guinea savanna ecological zones in Ghana's northern, upper east, and upper west regions.

Land degradation, one of the planet's most pressing environmental problems, will get worse if immediate remedial action is not taken. Roughly 25% of the land on Earth has deteriorated.

(Gupta, 2019). Scientists recently warned that unsustainable agricultural practices are primarily to blame for the annual loss of 24 billion tons of fertile soil, and that if current trends continue, 95% of the Earth's land areas are at risk of degradation by 2050 (Ganivet, 2020). Land degradation is one of the primary causes of climate change because it releases carbon and nitrous oxide from the soil into the atmosphere.

Globally, 3.2 billion people are impacted by land erosion, mostly in rural areas, by smallholder farmers, and by the very poor (Barbier & Di Falco, 2021). The predicted increase in global population to 9.7 billion people in 2050 would result in a rise in the demand for agricultural products such as food, feed, fiber, and fuel. The loss of biodiversity has made agricultural production systems less resilient, and other natural factors like climatic variability and extreme weather events are adding to the burden on the world's land resource. Agro-ecosystem resilience and the stability of food production systems are threatened by the escalating differences in agricultural yields and revenue brought on by climate change.

The world's driest regions are where the issues are most acute. Around 40% of the world's total area is made up of arid regions, which are home to two billion people (Liu et al., 2023). A vast majority of those who depend on drylands live in developing countries, where women and children are especially vulnerable to the consequences of land degradation and drought.

In an attempt to minimize the effects of land degradation, the Initiative's Secretary Coordinator of the International Economics of Land Degradation (ELD), Schauer (2015) indicated that the ELD initiative is dedicated to demonstrate that it pays off to invest in sustainable land management. "We reveal the damage that the loss of fertile lands bring along which is up to $400 billion a year, and we show options to counteract land degradation through investment. With various studies from partner countries, we can prove that sustainable land management pays off. For every dollar I invest, I will get $5 back from harvest to water yields; even more when you include the value of carbon storage. It is cheaper to combat land degradation at an early stage than trying to fix the resulting damages later. There are many technical possibilities to improve the quality of degraded soil. However, these methods are more expensive than protecting the land in the first place."

More than 2 billion hectares of agricultural land worldwide, or roughly 52%, are moderately or severely degraded, negatively affecting 1.5 billion people, particularly women, children, and the poor in rural areas (Kay et al., 2022). European Environment Agency claims that Soils are under stress due to urbanization and population growth. Intensive farming is degrading soils, making them prone to erosion, while soil surfaces are sealed off as a result of growing urbanization and new infrastructure. Western and northern Europe's most industrialized and populous nations have degraded soil. Other significant factors contributing to soil deterioration include localized pollution and diffuse contamination brought on by the acidity of heavy metals.

Owusu et al. (2013), in their work, examined the cultivation and yield of eight food crops namely millet, guinea corn, rice, groundnut, maize, cowpea, sweet potato, and soybeans. Their study also compared the land area under cultivation with the yield per hectare for each crop. He discovered that almost every crop had seen a loss in yield per hectare during the same time period, despite an approximate 100% increase in the land area under cultivation. From 7,000 ha to 44,397 ha of land, rice was grown for cultivation; initially, the production per hectare rose as well, from 1.06 tons in 1987 to 2.6 tons in 1998 but like other crop yields, it fell very quickly in 2006, to roughly 1.6 tons. The area under cultivation of maize, one of the most significant food crops in the UER, increased from 4,000 hectares in 1987 to 18,000 ha in 2006. Contrarily, yields increased from roughly 0.8 tons/ha in 1987 to 1.6 tons/ha in 2000 before falling to roughly 1.1 tons/ha in 2006. The conclusion of the analysis therefore was that agriculture had been severely impacted by land degradation, necessitating farmers to cultivate additional area in order to support their families.

In their work, the Continuous Cycle of Land Degradation (CCoLD) contends that unregulated fire use and population growth—which led to an increase in population density—are the primary human-caused causes of land degradation in the UER. Increased farming and the elimination of vegetation (trees and grasses) made it worse, and intensive cultivation made it even worse. The term "continuous cycle of land degradation" refers to how illnesses spread as a result of additional tree loss and exposure, which exacerbated the deterioration. The data of his work from remote sensing indicated extensive regional degradation.

In an article published by Kusimi and Yiran (2011), the locals employed vegetation and soil as indicators of land degradation. Given that soil and vegetation are the primary resources for the local population, they both have the outward manifestations of land degradation and immediate consequences for them. Locals were able to identify degradation of the soil by both physical changes in the soil and changes in yields of crops. The people linked rainfall variability and soil nutrient depletion to a decrease in crop productivity. In their work, the farmers claimed that throughout the previous 20 years, agricultural productivity on individual plots of land had generally decreased. Less than 5% of farmers reported that there had been no change in agricultural output, while more than 95% reported that it was declining. In terms of physical changes in the soil, indigenous people recognized soil erosion and compaction as primary evidence of land degradation.

**2.3 Types of Land Degradation**

For the purpose of this study, the types of land degradation are going to be grouped into five main classes. These include water erosion, wind erosion, soil fertility decline, waterlogging, and deforestation.

### 2.3.1 Water Erosion

Water erosion refers to the process by which soil is separated, moved, and deposited as a result of surface runoff, rivers, floods, and rainfall. It is among the most prevalent and important types of soil erosion, particularly in regions with heavy precipitation, steep hills, or sparse vegetation. All life on Earth is anchored by the soil, which is the earth's delicate outermost layer (Paul & Frey, 2023). It is one of the most valuable resources for humans and is made up of many species that form a dynamic and complex ecosystem. Conversion of forests and grasslands into fields and pastures is encouraged by rising demand for agricultural products (Schils et al., 2022). When natural flora gives way to agriculture, the soil frequently cannot retain it, and many of these plants—like coffee, cotton, palm oil, soybeans, and wheat—may actually worsen soil erosion beyond what the soil can sustain (Ek, 2023). Over the past 150 years, half of the planet's topsoil has been lost. Aside from erosion, other factors in agriculture also have an impact on soil quality (Svoray, 2022). Compaction, loss of soil structure, nutrient degradation, and soil salinity are some of these effects. These are actual problems, sometimes serious ones. Fertile land loss is not the only consequence of soil erosion. Fish and other species have declined as a result of the increased pollution and sedimentation in rivers and streams, which have clogged these waterways (Iyiola et al., 2022). Additionally, degraded areas frequently have a lower capacity to retain water, which can exacerbate flooding. By reducing the effects of agriculture and livestock, sustainable land use can stop soil erosion and degradation as well as the loss of valuable land.

There are four main types of water erosion namely splash, sheet, rill, and gully erosion. Raindrops hitting the soil surface is the cause splash erosion (Marzen & Iserloh, 2021). The kinetic energy of the raindrops as they fall determines how severe the splash erosion is (Beczek et al., 2022). Soil particles become looser and more dispersed as precipitation fills the pore spaces

(Han et al., 2022). Impact of later raindrops striking the ground. Rain splash erosion causes the consistent removal of soil in thin layers from sloping terrain (Zambon et al., 2021). The primary source of sheet erosion is the breaking action of raindrops in conjunction with surface flow. When rainfall intensity surpasses the soil's capability for infiltration, surface runoff is created (Litt et al., 2020). This then leads to rill erosion, where erosion becomes irregular and channelization commences when runoff starts. Runoff water causes rill erosion, which is more noticeable than sheet erosion and results in tiny, linear depressions on the soil surface (Dunne & Aubry, 2020). When tillage is done on the land, these are simply removed. The final stage is the gully erosion. Gullies are created by tiny indentations that concentrate water and grow until many of them come together to form a channel. This is an advanced stage of rill erosion when the force of runoff water causes the channels to enlarge. The most striking signs of erosion are gullies. During routine cultivation, gullies are deep and cannot be eliminated using standard agricultural equipment. Unchecked cultivation gets challenging.

### 2.3.2 Wind Erosion

Wind erosion is the process by which soil, sand, or rock fragments separate and are carried by the wind (Jarrah et al., 2020). This occurrence usually happens in arid and semi-arid areas with strong wind speeds, loose soil, and little vegetation cover. Wind erosion has a variety of effects on soil productivity. A field's soil qualities vary more in areas affected by erosion and deposition, necessitating more expensive and ineffective soil management techniques (Blanco & Lal, 2023). Coarser elements remain in the soil after wind carries away the smaller clay particles and organic material. The quality of the soil is diminished by the ongoing loss of tiny particles. Reduced root zone depth and water-holding capacity are further effects of wind erosion in shallow soils and soils with a hardpan layer (Priori et al., 2020). Such alterations could be gradual and undetectable for many years, particularly if tillage-induced mixing obscures the consequences of wind erosion. Infrastructure, agriculture, and the landscape can all be significantly impacted by wind erosion. Wind erosion is a prominent contributor to land degradation particularly in the arid and semi-arid regions (Abdullahi et al., 2023). It contributes to the desertification process. The loss of plant nutrients concentrating on fine soil particles and organic matter in the topsoil lowers soil fertility (Mabagala, 2022). As a result, the soil's ability to sustain biodiversity and productive grasslands is diminished. The erosion of light-textured topsoil reveals deep clay subsoils; erosion at the base of bushes and plants can cause the plant to become isolated and the ground cover to thin down (Jafari et al., 2022). These bare regions are known as claypans, and they can span hundreds or even thousands of hectares. Their low permeability, frequently saline character, and absence of topsoil make them challenging to revegetate.

### 2.3.3 Soil Fertility Decline

Soil fertility is the ability of the soil to supply the nutrients, water, and air needed for plant growth and soil life and as well as guarantee soil stability (Bayu, 2020). It is the capacity of the soil to promote plant growth by supplying nutrients and establishing ideal growing conditions. Since the beginning of sedentary agriculture approximately 10,000 years ago, there has been concern about the reduction in soil fertility (Gowdy, 2020). In the majority of permanent agricultural systems, legumes were incorporated into cropping systems and manure and other organic substances were applied to maintain soil fertility (Kumar et al., 2020). When inorganic fertilizers were accessible in the 19th century, many farming methods and their conventional administration were altered (Gabhane et al., 2020). Under permanent cropping, production might be maintained and increased by applying inorganic fertilizers. The availability, application, and profitability of inorganic fertilizers have been extremely low in many regions of the world, while agricultural cultivation on marginal soils has increased and land usage has intensified (Csikós & Tóth, 2023). This has led to a decrease in soil fertility, which is thought to be widespread, especially in some tropical locations including Ghana.

Growing crops means that nutrients are taken out of the soil by crop wastes and agricultural products like food, fiber, and wood (Koul et al., 2022). If the soil is not sufficiently replenished with inorganic fertilizers or manure, nutrient withdrawal may cause the fertility of the soil to diminish (Aleminew & Alemayehu, 2020). Large population growth, nutrient mining of agricultural areas with corresponding produce shifts to cities, and intensification of agricultural activities without proper consideration for long-term fertility maintenance through fertilizer application, organic waste recycling, liming to combat acidification, fallowing, rotations, and prevention of large-scale soil erosion are all factors that contribute to rapid declines in soil fertility. Degradation and a drop in soil fertility have frequently been promoted by agricultural policy (Bardgett et al., 2021). Agricultural scientists will need to play a significant role in the formulation and execution of policy in the future.

### 2.3.4 Waterlogging

The term "waterlogging" describes the temporary or permanent saturation of soil with water (Liu et al., 2023). When soil is so saturated with water that its air phase is constrained and anaerobic conditions predominate, it is said to be waterlogged (Pang, 2023). Crop productivity is negatively impacted by waterlogged fields because the water table rises in the crop root zone, lowering oxygen levels and raising carbon dioxide levels (Pais et al., 2022). Waterlogging is thought to be a problem in areas where the water table is less than 2 meters below the ground, and it is a risk in areas where the water table is between 2 and 3 meters below the surface of the ground.

Waterlogging can lower the soil's agricultural and economic worth, resulting in lower yields or occasionally complete crop failures (Mohammed et al., 2022).

Leaching and denitrification—the process by which nitrogen is transformed into gaseous oxides of nitrogen—are the ways whereby waterlogged soils lose nitrogen (Robertson & Groffman, 2024). The older leaves turn yellow as a result of these losses as well as the plants' decreased capacity to absorb nutrients from saturated soil. Additionally, waterlogging directly lowers the amount of nitrogen fixed by pasture and legume crop nodules (Kebede, 2021). By increasing the amount of nitrogen available to the crop when it needs it, nitrogen applied shortly after waterlogging recedes can lessen the effects of waterlogging. Applying nitrogen to waterlogged crops at the right time can greatly boost yields and lower the cost of nitrogen fertilizer.

Waterlogging further inhibits plant growth by lowering oxygen levels in the root zone. Waterlogging alters the chemical balance of numerous elements and raises the soil's reduction potential, allowing those elements to enter the soil-water solution in their ionic forms (Rengel, 2023). Transient toxicities of certain soil nutrients that are typically harmless when soil is freely drained may be included in this alteration in chemical equilibrium, depending on the kind of soil (Terzano et al., 2021). These include iron and manganese compounds, which, in the presence of a high reduction potential, can be changed to free ions. After the saturated soil has drained, it may take a few days or more for the reduction potential to restore to normal levels. Frequent rainfall can result in recurring drainage cycles and waterlogging, and the soil may have a high reduction potential for extended periods of time (Rupngam & Messiga, 2024). Young seedlings and germinating seeds are more negatively impacted by waterlogging or flooding of the seedbed than are established plants (Kettenring & Tarsa, 2020). Well-established crops that were sowed earlier can withstand greater waterlogging than plants that are just starting to sprout.

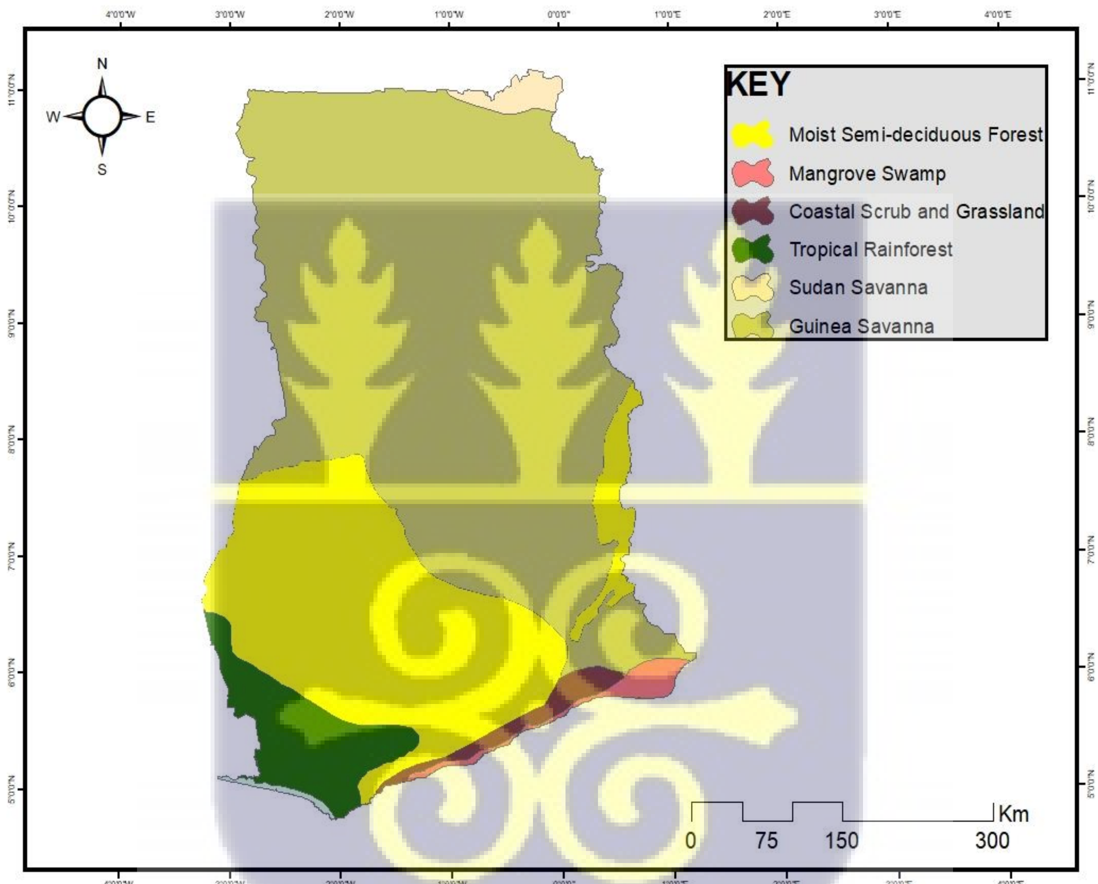
Within days, waterlogging kills the root tips. Following waterlogging, the loss of root tips restricts the intake of water and nutrients (Pais et al., 2022). Grain is frequently pinched as a result of soaked plants ripening early.

### 2.3.5 Deforestation

Deforestation can be defined as the loss or continuous deterioration of forest habitat brought on by either natural or man-made factors (Sithole & Agholor, 2021). Deforestation could be as a result of mining, petroleum exploration, urban sprawl, agriculture, and unsustainable forestry practices (Bodo et al., 2021). It usually occurs through the conversion of forests to non-forest uses, like road construction and agricultural activities. The world's forest cover has decreased by half in the past 10,000 years (Wibowo, 2022). The majority of this deforestation has happened in the past century. An increasing global economy and population have contributed to the tremendous increase in deforestation (Brown & Pearce, 2023). We have had to cut woods for commercial endeavors. Only when a tree is cut down does wood, which is necessary for so many things in our everyday lives, become available. In a similar vein, clearing the forest is necessary for major development projects like the establishment of industries, power plants, and mining operations. The indigenous communities that reside there and depend on the forest to support their way of life are also in danger as vast tracts of forest are being cut down, leaving exposed soil to decay and the habitats of countless species devastated. Their way of existence is directly and immediately impacted by the waning of trees. Many indigenous people rely on the forest for food, medicine, building materials, and cultural resources (Grebner et al., 2021). The loss of these resources presents numerous challenges to the health and well-being of these communities, many of which are situated in isolated locations within deep forests.

## 2.4 Causes of Land Degradation

As a result of variations in temperature, vegetation, soil types, and human activities, land degradation and its causes differ among the various ecological zones in Ghana. Some of these causes overlap in a number of ecological zones. Ghana's ecological zones include moist semi-deciduous forest, mangrove swamp, coastal scrub and grassland, tropical rainforest, Sudan savanna, and Guinea savanna.




**Map 2.1: Map of Ecological zones in Ghana**
*Source: Author, 2025*

### 2.4.1 Causes of Land Degradation in the Sudan Savanna Ecological Zone

The Sudan savanna ecological zone, within which my area of study falls will be looked at first. It is found in the country's far north-eastern section. It mostly encompasses portions of the Upper East Region, particularly the vicinity of the districts of Pusiga, Bawku, and Garu and Tempane, which are near the borders with Togo and Burkina Faso. Deforestation is one of the major factors contributing to land degradation in the Sudan (Andoh et al., 2024). This is a reference to the commercial and agricultural goals of tree felling. The removal of trees that protect the soil from desertification exposes the soil to the agents of erosion. Over the years, the zone has lost a huge portion of its forest covers, mostly as a result of indiscriminate logging and the conversion of forest land to agricultural use (Agariga et al., 2021). Clearing the current vegetation—in this case, the natural forest—is necessary for these activities. As a result, the biodiversity of the regions is disrupted, flowering vegetation is destroyed, and natural homes for birds and other terrestrial species are relocated. In the Sudan savanna ecological zone, deforestation is mostly done for financial benefit; the environmental effects are disregarded (Adom et al., 2024). In order to create structures for human habitation, urbanization, which includes the spread and increase of the human population, also results in the loss of the forest vegetation (Avtar et al., 2019).

Overgrazing is another significant contributing factor to land degradation in the Sudan savanna ecological zone (Atieku & Segbefia, 2024). The term "overgrazing" describes the overuse of land for animal grazing (Fang & Wu, 2022). Degradation of the soil, a decline in vegetation, and other adverse effects on the ecosystem may result from this. Overgrazing is a significant problem in Ghana that has exacerbated soil degradation and desertification (Owusu et al., 2024). An enormous pastoralist group that has historically depended on grazing for a living exists in the country's northern regions. The traditional pastoralist practices of rotational grazing and mobility have been replaced with sedentary grazing and animal overstocking due to increased population pressure and demand for livestock products (Jack et al., 2022). This has significantly contributed to the degradation of grazing lands and loss of vegetation cover. Excessive grazing has dire repercussions. It damages the ecosystem and fuels climate change by causing soil erosion, degrading water resources (such as rivers, streams, and the water table), and destroying biodiversity (Kolawole & Iyiola, 2023). Adebajo (2022) again identified the compaction of soil brought on by roving cattle under Fulani herding as another aspect of land degradation. All ecological zones are traversed by migrant Fulani livestock herders, who mostly come from Niger, Mali, and Burkina Faso. Farmers lament that hundreds or even thousands of cattle ruin crops and compact the soil, making it hard to plough the land. Compacted soil has less aeration, making it unsuitable for farming (Chamen et al., 2015). As a result, farmers are forced to move to more fertile forests and woodlands.

In the Sudan savanna, land degradation is again largely a result of climate change (Hailu, 2023). Due to their excessive reliance on rain-fed agriculture and the poor ability to prevent and adapt, the zone is extremely vulnerable to the negative effects of climate change. The economy and society of Ghana have been adversely impacted by alterations in climate patterns, in addition to the environment (Awuni et al., 2023). Rising temperatures are one effect of climate change that has aided in the desertification of the zone. The Sudan savanna is witnessing a continuous rise in temperatures as a result of climate change; lower crop yields as a result have exacerbated desert encroachment, increased evaporation, and increased water demand (Sambo & Sule, 2024). The zone is also being impacted by altered rainfall patterns, which have increased the frequency of droughts and floods and harmed infrastructure and crops (Derbile et al., 2022). It is impossible to overstate how bad things will be for subsistence farmers. The loss of biodiversity is another effect of climate change that is causing the zones to become more deserted. With the changing climate and patterns of rainfall, a large number of plant and animal species face extinction (Muluneh, 2021). Everyday many different species experience the loss of their habitats, which has a detrimental effect on the food chain and causes the deaths of those that are unable to survive (Almond et al., 2020). It is impossible to overlook how climate change is affecting the health of the people living in this ecological zone. Ghana is experiencing significant health effects from climate change, including a rise in heatstroke, malaria, and other illnesses linked to rising temperatures and altered rainfall patterns (Ansah et al., 2021). In 2015, the World Health Organization (WHO) stated that the effects of climate change in Ghana would exacerbate the country's already-existing problems with food insecurity, poverty, and infectious and vector-borne illnesses.

Moreover, the Sudan savanna's problems with land degradation have also been exacerbated by unsustainable agricultural practices (Tefera et al., 2024). The zone's economy heavily depends on the agricultural sector, which will employ more than half of the workforce and generate 20% of the nation's GDP in 2022 (Statista, 2022). Unsustainable farming methods, however, are negatively affecting both the environment and the livelihoods of the farmers who use them. Through a number of factors, such as excessive tillage, deforestation, overgrazing, and the misuse of chemical fertilizers and pesticides, improper farming practices directly contribute to land degradation. Reduced soil fertility and general land degradation result from these activities, which also degrade soil structure, deplete organic matter, expose soil to erosion, and pollute soil and water resources.



Clearing land for farming, gathering fuel wood, overgrazing, bush fires, and gathering poles for building all severely damage the ecosystem.  Young people's interest in mining has grown as a result of the gold resources discovered in the rocks south of Sapeliga and north of Zebilla (Atampugre, 2018). This is especially evident in the Widnaba-Teshie zone, where surface mining and stone quarrying are prohibited and cause significant soil degradation as well as surface water body pollution.

### 2.4.2 Causes of Land Degradation in the Guinea Savanna Ecological Zone

Much of Ghana's northern region is covered by the Guinea Savanna Ecological Zone, which is distinguished by undulating grasslands with sporadic trees (Awoonor et al., 2024). It facilitates a variety of human endeavors, including farming, raising cattle, and making charcoal. However, due to natural constraints and human activity, this area is seeing an increase in land degradation, endangering biodiversity, productivity, and the means of sustenance local of the inhabitants. Unsustainable farming methods are a major contributor to land degradation in the Guinea Savanna of Ghana (Mesele et al., 2025). The region is mostly dependent on rain-fed agriculture, which frequently entails cultivating the same area over and over again without proper soil fertility management. Soil stress and nutrient depletion are caused by improper crop rotation, excessive ploughing, and sparing application of organic or inorganic fertilizers. These methods weaken the fertility and structure of the soil over time, reducing its productivity.

Another significant factor contributing to the zone's land deterioration is bushfires. Intentional fires are frequently set by farmers and herders to clear land, promote the development of fresh grass, or evict game animals. However, frequent and uncontrolled burning lowers plant cover, erodes the ground, and destroys soil organic matter. Natural vegetation regrowth is hampered by the consequent loss of soil nutrients, which also reduces the land's potential for agriculture (Naorem et al., 2023).

Land degradation is also greatly exacerbated by cattle overgrazing. Vegetation cover is frequently removed more quickly than it can be restored as a result of growing livestock populations and poor grazing management. Compaction of the soil, decreased water infiltration, and heightened susceptibility to erosion result from this. Large areas of land deteriorate over time and lose their ability to support plants or animals. Deforestation and soil degradation in the Guinea savanna of Ghana are further exacerbated by the production of charcoal and the removal of wood for fuel (Peprah, 2022). When trees are felled without being replaced, vegetation that shields the soil from erosion by wind and water is lost. Additionally, deforestation disturbs the savanna environment's innate balance and lowers biodiversity. The Guinea Savanna's land degradation is made worse by climate change. Higher temperatures, longer dry seasons, and irregular rainfall patterns decrease soil moisture and make droughts more frequent. These alterations put plants and crops under stress, increasing the land's vulnerability to deterioration.

### 2.4.3 Causes of Land Degradation in the Moist Semi-Deciduous Forest Ecological Zone

The main causes of land degradation in Ghana's moist semi-deciduous forests are human-induced activities such as mining, illicit logging, and unsustainable farming methods (Boamah, 2020). Another factor is the rapid growth in population, which puts more strain on forest resources. Land degradation is also made worse by urbanization and infrastructural development. This ecological zone which is rich in biodiversity, fertile soils, and abundant mineral resources, spans portions of the Ashanti, Eastern, Western, and Central Regions. Regrettably, the expanding operations of unregulated small-scale miners have seriously harmed the environment, particularly in forested regions (Annan, 2024).

The extensive loss of forest cover is one of the most direct consequences of illegal mining. The vegetation that protects the soil from erosion is lost when trees are felled to make way for mining activities. In addition to disrupting the natural habitat of several plant and animal species, the removal of forest canopy causes ecological imbalance and a decline in biodiversity. In the absence of vegetation, the bare soil is susceptible to erosion by water and wind. In addition to substantial land excavation, illegal mining involve miners searching for gold and other minerals by excavating trenches and deep pits. This leaves behind bare, unproductive land surface, disrupts the soil's structure, and destroys the nutrient-rich topsoil. Following mining, such land is frequently left fallow, rendering it unusable and hazardous for use in forestry or agriculture in the future. Abandoned pits can also gather stagnant water, which raises the risk of diseases like malaria, and they provide physical risks to both humans and animals.

Furthermore, land and water contamination are caused by illegal mining. Nearby rivers, streams, and groundwater sources are contaminated when dangerous chemicals like cyanide, lead, and mercury are used in the gold mining process. These harmful compounds penetrate into the soil, deteriorating its quality and harming animal and human health. In addition to discomforting aquatic life, soil erosion-induced siltation of water bodies lowers the amount of clean water available for home and agricultural usage (Rashmi et al., 2022). In Ghana's moist semi-deciduous forest zone, infrastructure development such as the building of roads, houses, and urban settlements is increasingly causing land degradation. Because of its rich biodiversity and soils, this forest zone is rapidly being cut for development projects. The natural vegetation that protects the soil is lost when trees are cut down to make way for highways, cities, and towns. This leaves the land vulnerable to erosion and less able to hold onto moisture and nutrients. Moreover, excavation of vast tracts of land is frequently a part of building operations, which can cause soil compaction and disturb the natural environment. This changes drainage patterns and impacts soil fertility, raising the possibility of floods and more erosion. The land's structure is permanently harmed by the use of large machinery and the loss of topsoil during development, making it challenging to restore for ecological or agricultural uses (Goud et al., 2022). Moreover, the expansion of infrastructure frequently promotes economic activity and human settlement, which can exacerbate pollution, deforestation, and unsustainable land use. When taken as a whole, these modifications lead to long-term land degradation, endangering the ecological stability and lowering the forest zone's production.

One of the main causes of land degradation in Ghana's moist semi-deciduous forest zone is unsustainable farming methods. This area is also largely dependent on agriculture, particularly the production of cocoa, plantains, maize, rubber, and other crops, due to its rich soils and abundant rainfall. However, a lot of farmers employ practices that gradually deteriorate the land, resulting in a reduction in the amount of forest cover and soil health. Slash-and-burn agriculture, in which forests are cut down and burned to make way for farming, is one of the destructive methods (Hands, 2021). Although this temporarily increases soil fertility, frequent use of the technique depletes nutrients, breaks down organic matter, and increases soil erosion susceptibility. Cropping continuously without appropriate crop rotation or fallow times also degrades soil fertility and structure, reducing the land's productivity (Desta et al., 2021). Also, excessive use of chemical pesticides, weedicides, and fertilizers without adequate soil management causes contaminants to accumulate and beneficial soil organisms to perish (Rathod et al., 2024). Erosion and nutrient loss are further exacerbated by inadequate irrigation practices and the lack of soil conservation practices like mulching and terracing. These unsustainable activities eventually lessen the land's ability to maintain flora, which leads to deforestation and long-term damage.

In Ghana’s moist semi-deciduous forests, land degradation is a complicated problem with many interrelated causes. A holistic strategy is needed to solve this issue, one that addresses the effects of climate change, encourages sustainable resource management, combats agricultural expansion, and supports the livelihoods of the populations residing in and near these forested areas.

**2.4.4 Causes of land degradation in the Mangrove Swamp Ecological Zone**

Ghana’s mangrove swamp ecological zone, which is mostly located along the coast and in estuary regions like the Volta Delta and portions of the Western and Central Regions, is essential for fisheries, biodiversity, and coastal protection. However, land degradation which is mostly caused by human activity and environmental pressures is posing an increasing danger to this ecosystem. Overharvesting of mangrove trees for building, fuelwood, and fish smoking is one of the main causes. The extensive tree-cutting weakens the shoreline, decreases vegetative cover, and increases the area’s susceptibility to erosion and flooding. Furthermore, cutting mangrove forests and reclaiming land is a common part of urbanization and infrastructure development, including highways, communities, and ports, which results in habitat loss and soil compaction (Sharma & Naik, 2024). Mangrove regeneration is hampered by sand winning and salt mining in mangrove zones, which also damage soil structure and change the natural hydrology. Additionally, pollution from plastics, oil spills, and household garbage contaminates the soil and water, harming aquatic and plant life. By changing the delicate balance required for mangrove development, climate change specifically, sea level rise and increasing salinity also leads to land degradation. Another increasing danger is pollution. The quality of the soil and water in mangrove regions is deteriorated by wastewater discharge, plastic pollution, and oil spills from adjacent communities and industrial operations (Chris et al., 2024). Pollutants harm aquatic and plant life by contaminating the surrounding environment and impeding the establishment of mangrove plants.

Lastly, there is a serious risk from climate change. The survival and reproduction of mangrove species are hampered by rising sea levels and rising salt (Kumari & Rathore, 2021). Degradation can also be accelerated by changes in storm frequency and rainfall patterns, which can flood low-lying regions and wash away topsoil.

In conclusion, unsustainable resource use, pollution, infrastructure development, and climate change are the main causes of land degradation in Ghana's mangrove swamp zone. These dangers jeopardize the lives and safety of coastal residents in addition to lowering the mangrove trees' ecological value. For Ghana's coastline to experience sustainable development, these habitats must be preserved and restored.

### 2.4.5 Causes of Land Degradation in the Coastal Scrub and Grassland Ecological Zone

The coastal scrub and grassland ecological zone, which encompasses cities like Accra, Cape Coast, and Takoradi is found at the country's coastline. This zone, which is characterized by low-lying topography, grasslands, sandy soils, and sparse vegetation, is especially susceptible to land degradation because of its high population density and ecological sensitivity. The land in this region has been severely degraded over time by a combination of human activity, rapid urbanization, and climatic instabilities. Urbanization is one of the main factors contributing to land degradation in this region. Large areas of land are being cleared for infrastructure, roads, industries, and housing as Ghana's coastal cities expand. Natural vegetation is frequently sacrificed for this development, which exposes the soil and causes erosion and compaction. Quarrying and sand winning also have a significant role. Sand is mined for building in many coastal regions, particularly in the vicinity of rapidly expanding cities. By destabilizing the land and removing the protecting topsoil layer, this method creates gullies and pits that are difficult to restore for productive use and are prone to erosion. Another concern is cattle overgrazing, especially in the zone's rural and peri-urban areas. The soil becomes barren and compacted as animals eat the little grass cover without giving it time to regenerate, reducing its capacity to hold onto moisture and nutrients. Erosion is accelerated and the soil structure is weakened.

Another significant contributing cause is uncontrolled bushfires. Deliberate fires are frequently set to flush out animals or clear land for crops. Frequent burning, however, destroys organic matter, ruins soil structure, and inhibits the regeneration of natural plants (Jameel et al., 2024). This eventually causes soil weakness and the emergence of bare areas. Soil fertility is further weakened by bad farming practices including over-cultivation, a lack of fallow seasons, and a restricted application of soil conservation methods (Indoshi et al., 2025). This zone's farmers frequently work marginal farms with little assistance, which causes soil erosion and nutrient depletion. The region's typical sandy and loosely structured soils, which are inherently more prone to deterioration, exacerbate the situation.

### 2.4.6 Causes of land degradation in the Tropical Rainforest Ecological Zone

The tropical rainforest ecological zone which is primarily located in the southwest of the country has rich biodiversity, excellent soils, and deep forest cover. This area is essential for regulating the climate, protecting water supplies, and sustaining the livelihoods of millions of people through tourism, forestry, and agriculture. However, unsustainable human activities and environmental pressures are mostly to blame for the zone's growing land degradation, endangering the long-term ecological balance. Deforestation is one of the main factors contributing to land degradation in the tropical rainforest zone. For the sake of agriculture, settlement growth, and lumber production, large areas of forest are cut. Both legal and illegal logging eliminates essential tree cover that keeps the soil fertile and prevents erosion. When trees are cut down, the exposed soil is more susceptible to the effects of rainfall, which can cause erosion, nutrient loss, and a breakdown in the structure of the soil (Paudel & Yadav, 2021). Destroying forest cover also lowers biodiversity and upsets zonal ecosystems. In this area, slash-and-burn farming and shifting cultivation are also common practices. Long fallow intervals made these traditional agricultural practices feasible in the past, but growing population pressure has shortened fallow cycles, causing soil deterioration and weariness. Burning plants repeatedly exposes the soil to erosion and reduces its organic content. Forest regeneration and agricultural output eventually suffer as a result.

In recent years, mining operations particularly illegal small-scale mining, have grown to be a major concern. These activities leave behind open pits and damaged, scarred ground after removing topsoil, flora, and occasionally entire wooded regions.

In addition to polluting soil and water, the use of dangerous chemicals like mercury in the mining of gold renders the area unusable for forestry and farming. By interfering with the forest's natural regeneration cycle, overharvesting of non-timber forest products including firewood, game, and medicinal plants also adds to land degradation. Forest ecosystems become less robust and more prone to deterioration when these resources are depleted. Furthermore, the development of infrastructure, such as roads and urban sprawl, causes soil compaction and further deforestation, which changes the natural drainage patterns and increases runoff and erosion (Weeraratna, 2022). The rainforest ecology is severely stressed by climate change, especially altered rainfall patterns and rising temperatures, which speeds up land degradation and lowers forest resilience.

The biophysical and human-induced causes of land degradation have been examined as themes in the analysis of factors that increase the risk of land degradation (Rahaman & Solavagounder, 2020). There are several biophysical factors that contribute to desertification and land degradation. For instance, when an area's slope angle is greater than 16%, as it is in regions where soil erosion occurs, the topography of that area is a sign of land degradation (Kogo et al., 2020). They proceed to posit that in comparison to the light-textured loamy soils in the evergreen forest and moist semi-deciduous ecological zones, areas of sandy soils with no vegetation cover, such as the Guinea and Sudan savanna ecological zones, exhibit enormous soil erosion. This is because soil texture affects erodibility, water retention capacity, crusting, and aggregate soil stability. According to their report, 66% of Ghana's soil is well-drained, compared to just 12.59% of poorly-drained soils, suggesting that drainage is not a major cause of land degradation and desertification in the nation. In contrast to poorly drained soils, which are defined by iron and manganese mottles concentrated in the top 30 cm of the soil layer, well-drained soils exhibit concentrations of these minerals at depths greater than 100 cm below the surface of the earth.

**2.5 Effects of Land Degradation**

The effects of land degradation on Ghana's population's socioeconomic, political, and environmental spheres are multifaceted. Among these effects are loss of biodiversity and arable land. Degradation and depletion of soil due to desertification lowers the soil's fertility and capacity to sustain plant life. Because it is extremely difficult for plant and animal species to flourish in the degraded environment, the end result is a loss of biodiversity (Hajian & Kashani, 2021). Reduced crop yields, a decline in ecosystem services, the disappearance of medicinal plants and other natural resources are only a few effects of biodiversity loss. The local inhabitants, who have depended on the land and its resources for their livelihood for millennia, may likewise suffer detrimental effects on their cultural and spiritual lives (Suzuki, 2022).

Water becomes scarcer as water resources are exhausted and the land becomes more arid (Saatsaz, 2020). People find it challenging to obtain drinkable water, for irrigation, and for other household needs as a result. Due to their inability to irrigate their crops, subsistence farmers suffer greatly. The water table is impacted by land degradation as well, falling and leaving less water accessible at the surface (Romman & Al Kuisi, 2023). Due to desertification, there is less water available, which has an impact on plant and animal life (Becerril-Piña & Mastachi-Loza, 2021). It can also cause community disputes among people because so many are compelled to travel in search of food, water, and other essentials for survival. People migrate from rural to urban regions due to the pressure of land degradation, which also strains urban social services and can lead to disputes among groups of people (Hoffmann et al., 2022).

Food insecurity in Ghana has also been exacerbated by land degradation, as the expansion of deserts limits the amount of arable land and water resources available for farming (Hossain et al., 2020). Food production and availability fall as agricultural and livestock raising become more and more challenging (Giller et al., 2021). Malnutrition, increased food costs, and food shortages come next. Vulnerable populations, including children, pregnant women, and the elderly, primarily impacted.

Ghana’s economy has suffered significantly as a result of land degradation and desertification (Aboagye et al., 2020). In communities where agriculture is the only source of income, this is abundantly evident. Ghana’s poverty has been made worse by declining agricultural practices, biodiversity loss, constant migration, and health risks like respiratory ailments brought on by dust storms, which raise healthcare expenses. Previously only worried about food and water, peasant farmers now have to locate to better arable land for their agricultural operations, healthcare for diseases brought on by dust storms, and a never-ending quest for water for irrigation. In Ghana, the effects of land degradation are extensive and pervasive.

### 2.6 Combating Land Degradation

The terms ‘afforestation’ and ‘reforestation’ describe the processes of turning land into forests (Pichler et al., 2021). It involves putting down trees and other vegetation on places that are empty or arid. On the other hand, replanting trees and other plants in an area that was formerly a forest but has since been damaged is known as reforestation (Brancalion & Holl, 2020). Increased water availability, better soil quality, and less soil erosion are all benefits of reforestation and planting. Because vegetation increases the amount of rainfall that percolates through the earth, revegetating fields can also aid in replenishing the soil (Liu et al., 2022). The Ghanaian government has started a number of afforestation initiatives, such as the Green Ghana Project (Nketia et al., 2022), which aims to plant five million trees in a single day, in order to improve livelihoods, beautify the environment, and instill in young people the values of planting and caring for trees and the benefits that come with them. While this is a positive start, the Ghanaian government should work to advance and put into effect laws that encourage sustainable land use and aid local populations in adapting to the changing climate.

The application of soil conservation techniques, such as crop rotation, terracing, and the use of cover, can significantly enhance soil quality and stop soil erosion brought on by agents of denudation such as winds on bare soil (Blanco & Lal, 2023). Increased soil fertility can also be achieved by farmers using organic farming practices (Barnwal et al., 2021). Also, good water management techniques, like collecting rainwater, conserving water, and using irrigation, can reduce soil erosion and enhance soil quality (Ahmad et al., 2020). Waste water recycling might also be advantageous. The Small Town Water Supply and Sanitation Project is one of the many programs the Ghanaian government has started to improve water management.

Furthermore, it is critical to implement sustainable land management practices, such as agroforestry, sustainable farming practices, and pasture management that support the preservation of soil and water resources in order to address the food insecurity brought on by desertification (Jain et al., 2024). Both the development of land production and the avoidance of soil degradation would benefit from this. Enhancing market accessibility and infrastructure can also assist farmers in getting their goods to market and expand consumer access to food (Stringer et al., 2020).

In order to combat overgrazing in Ghana, policies and management initiatives that support sustainable grazing methods and land use are required. This can entail establishing grazing reserves, encouraging rotational grazing, and putting laws in place that limit grazing in delicate or vulnerable areas. In addition, encouraging pastoralists to pursue alternate careers in agroforestry and beekeeping can lessen the strain on grazing areas and advance sustainable land use (Lutta et al., 2023). Promoting sustainable land use practices and halting further deterioration can be achieved also by teaching communities about the causes and adverse effects of desertification and including them in conservation initiatives (Monaco, 2024). To lessen the negative consequences of desertification, the local community and the government can collaborate on the development and implementation of these solutions. Furthermore, social safety net initiatives that support disadvantaged groups can contribute to guaranteeing that all individuals have access to enough food and nourishment (Barron et al., 2022). Together, the public and government can protect the environment for coming generations.

In summary, regeneration and afforestation, soil conservation techniques, water management, sustainable farming practices, reducing overgrazing, community involvement, and education are all necessary components of a multifaceted strategy to combat land degradation in Ghana. Ghana can safeguard its natural resources and advance sustainable development by putting these suggestions into practice.

## 2.7 Food Security

In the past 30 years, concepts of food security have changed to match shifts in public policy thinking (Gracia-Arnaiz, 2022). Food security was defined as the guarantee of the availability and price stability of basic foods at both the national and international levels during the 1974 World Food Conference; “Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices” (Lanna, 2023). This was when the term first came into use. The FAO conducted studies on food access in 1983, which led to the development of a formulation based on the equilibrium between the supply and demand sides of the food security equation. This ensures that everyone always has financial and physical access to the necessities of food (Das et al., 2023). In Ghana, the definition by the Ministry of Food and Agriculture (MoFA) for food security is “good quality nutritious food hygienically prepared and packaged, attractively presented, available in sufficient quantities all year round and located at the right place at affordable prices (Kolog et al., 2023).

The concept was revised to include the individual and family levels of food security analysis in addition to the regional and national levels of aggregation. The highly significant World Bank Report on Poverty and Hunger from 1986 focused on the temporal dynamics of food insecurity. (Gracia-Arnaiz, 2022). The research established a distinction between transitory food insecurity, which comprised times of increased strain caused by natural disasters, economic collapse, or conflict, and chronic food insecurity, which was linked to issues of ongoing or structural poverty and low earnings. Sen's theory of famine, published in 1981, added to this by highlighting the impact of individual entitlements—specifically, those based on production, labor, commerce, and transfer—on the availability of food.

Access, availability, usage, and stability of food are all included in the widely recognized definition of food security, which was adopted at the World Food Summit in 1996. Government initiatives that support and restore opportunities for making a living have been made feasible by it. Since their first popularization by scholars like Chambers and Conway in 1992, lifestyle approaches have been essential to the development programs of multinational corporations. These ideas, which also encompass the notions of vulnerability, risk coping, and risk management, are increasingly used in emergency situations.

In short, the understanding of food insecurity as a social and political construct has arisen as the link between food security, starvation, and crop failure fades into obscurity (Daoudy, 2020). The ethical and human rights component of food security has gained attention more lately. The concept of the right to food is not new; it was originally acknowledged in the 1948 UN Declaration of Human Rights. The official endorsement of the Right to Adequate Food in 1996 was a significant accomplishment for the World Food Summit participants. It suggested that a rights-based approach to food security would be possible. The right to food is currently protected by law in more than 40 nations, and according to FAO estimates, it may one day be upheld in 54 more (Steier et al., 2022). An Intergovernmental Working Group operating under the auspices of the FAO Council developed a set of voluntary guidelines in 2004 to facilitate the gradual achievement of the right to adequate food in the context of national food security.

Food security has four primary dimensions, according to the Comprehensive Food Security & Vulnerability Analysis (Mbow et al., 2020)

### 2.7.1 Food availability

This refers to how much food, both in terms of quantity and quality, is really physically present in a given location (Simelane & Worth, 2020). It refers to producing and guaranteeing that an appropriate supply of food is accessible, whether through personal farm production, purchases from local markets, or imports from other markets. This includes food obtained from the markets, food grown in backyard gardens or on nearby farms, and food given as presents or as part of food assistance. In food security analysis and measurement, food availability frequently continues to be the most important factor (Antamoshkina & Rogachev, 2020). National food balance sheets, animal ownership indices, and crop production and/or food production indices are some of the indicators used to gauge the availability of food (Movilla-Pateiro et al., 2021).

### 2.7.2 Food accessibility

Some people might not always be able to get to food, even when it is accessible. When communities, homes, and all people have adequate resources to buy enough food for a healthy diet through a mix of home production, stocks, purchases, barter, gifts, borrowing, or food help, access to food is secured (Drisdelle et al., 2020). Food accessibility means, broadly speaking, the alleviation and decrease of food poverty (Nomura & Feuer, 2021). When it comes to food accessibility, the food must be offered at the right time and place, and everyone must have the means to buy sufficient, wholesome, and secure food (Mhlanga, 2023). Food accessibility can be looked at from the economic, physical, and social access to food.

### i. Economic Access to Food

The ability of people and households to obtain or buy a sufficient amount of wholesome, culturally appropriate food for a healthy and active life is referred to as economic access to food (Carson & Boege, 2020). It entails having the resources and financial capacity required to get food in an environmentally responsible and decent way. Before the 1990s, proxies for food security originated from national-level research using measures of economic access, such as household income or the Household Consumption and Expenditure Survey (HCES) (Piperata et al., 2023). Some essential elements of economic access to food include income and resources. Economic access to food is contingent upon possessing a satisfactory income (Altenried, 2024). To purchase the food they require, people must have the necessary funds. This covers earnings from work, remittances, social aid, and other sources. Another key element is affordability. Food costs should be reasonable for both households and individuals. Even if food is physically available in the market, consumers may still have difficulty getting a sufficient and nourishing meal if it is too expensive (Paarlberg, 2023). Stability of price constitute another essential element of economic access to food. The consistency of food prices has an impact on economic access as well. The ability of consumers to plan ahead and budget for their food needs might be impacted by fluctuations in food prices (Aday & Aday, 2020). A more stable food supply helps to make things more predictable and safe (Béné, 2020).

### ii. Physical Access to Food

The availability and proximity of food sources and distribution routes that enable people and groups to get the nourishment they need for a healthy and active existence are referred to as physical access to food (Tanumihardjo et al., 2020). It is among the fundamental foundations of food security. Physical access highlights how crucial it is to have the resources to actually go to marketplaces and food outlets in order to have a diversified and nutritional diet. Understanding how food is distributed in the surrounding environment is necessary to comprehend the relative variations in physical access to food (Paiva et al., 2023). One strategy for researching how food is distributed throughout the physical terrain is to use geospatial methods (Hou et al., 2020). One popular method in urban settings is to geolocate food sources by combining data from databases with other sources.

**iii. Social Access to Food**

In the discourse surrounding food security and related subjects, the term "social access to food" is not frequently employed. It can, however, be understood in light of the social factors pertaining to food accessibility, affordability, and availability. Social variables are important in determining how well-equipped individuals and communities are to obtain a sufficient and nourishing food supply (Serchen et al., 2022). Access to food can be improved through establishing strong social support networks, which include friends, family, and community organizations (Webkamigad et al., 2020). In times of need, social ties can help people by offering assistance with food resources or by assisting the acquisition of food (Umubyeyi & Mtapuri, 2024). Recognizing the social aspects of food access is crucial for developing comprehensive solutions that address the complex nature of food security, even though social access to food may not stand alone in the standard definition of food security. The experiences that people and communities have with food are shaped by the intersection of social, economic, physical, and environmental elements (Camacho & Henderson, 2022). Therefore, social factors must to be included in larger initiatives to support fair access to wholesome food and food security.

### 2.7.3 Food utilization

Utilization of food is defined by the CFSVA as a person's capacity to get nutrients and energy from food in order to maintain a healthy lifestyle. Achieving optimal food utilization requires good child care procedures, a diet rich in energy and nutrients, safe drinking water, sufficient sanitation, knowledge of food storage and preparation, general health, and fundamental nutrition (Ketema et al., 2024). It means making sure the body's processes utilize the nutrients in diet as effectively as possible. A diversified diet, proper feeding and care practices, food preparation, and intra-household food distribution all help people consume adequate energy and nutrients (Gezimu Gebre, 2022). This affects both a person's nutritional status and how well their body metabolizes the food they consume.

### 2.7.4 Food stability

Stability is a fourth aspect of food security that encompasses both accessibility and availability. In order for a household to be considered food secure, it must always have access to food and should never be in danger of being hungry due to shocks or cyclical events like seasonal food shortages (Demont, 2022). Even if a household consumes enough food at one point, it may nevertheless experience food insecurity if access to or ongoing supply of food is restricted.

## 2.8 Food Insecurity

A situation known as "food insecurity" occurs when people or households do not consistently have access to an adequate supply of reasonably priced, nutrient-dense food (Angeles-Agdeppa et al., 2021). It is a complicated problem with many facets that can arise from a number of situations, such as unstable economies, poverty, high food prices, limited access to resources and knowledge, and environmental issues. Food insecurity can take many forms, from ongoing hunger to not being able to purchase wholesome, well-balanced meals (Nkurunziza et al., 2023). It includes concerns about food supply, usability, stability, and accessibility of food sources. Individuals who are facing food insecurity may turn to unhealthy coping mechanisms including missing meals, buying cheap, low-quality foods, or consuming fewer meals overall (Militao et al., 2022).

Food insecurity is a global issue that has a strong correlation with poverty (Mikalauskiene et al., 2018). Since 2014, the prevalence of moderate to severe food insecurity has been rising rapidly (Saccone & Vallino, 2025). Thirty percent of the world's population, or an estimated 2.4 billion people, were thought to be moderately to severely food insecure as of 2020 (van Meijl et al., 2020). Food insecurity affects those living in the world's wealthiest countries as well, even though the bulk of those experiencing food insecurity (96%) reside in low- and middle-income countries (LMICs) (Durao et al., 2020). For instance, Coleman-Jensen (2020) estimates that 14.8% of children in the USA live in homes where there is food insecurity. Food insecurity has far-reaching effects that can affect well-being in general, economic productivity, and mental and physical health (Beck, 2024). In order to alleviate food insecurity, it is common practice to combine short-term interventions, such food assistance programs, with long-term measures meant to address the underlying causes of inequality and poverty (Tezanos-Vázquez, 2024).

### 2.8.1 Causes of Food Insecurity

A portion of the variation in the geographic distribution of food insecurity can be explained by historical colonization histories and contemporary geopolitical forces (Bjornlund et al., 2022). Conflicts, climatic unpredictability and extremes, and economic downturns and slowdowns are the main causes of food insecurity, according to Abdullahi et al. (2024). These factors frequently worsen already-existing geopolitical dynamics. Ethiopia, Nigeria, South Sudan, and Yemen are now the countries that are most severely affected by one or more of these factors, particularly conflict (Piperata et al., 2023). Humanitarian relief groups are reporting indications of acute food insecurity, sometimes approaching famine, in all four countries (Rother et al., 2022).

### i. Environmental Degradation and Climate Change

Environmental damage like desertification, contaminated water, and air pollution can reduce the quantity of food that an area can produce. (Smith et al., 2020). Human activities that have an adverse effect on the environment disturb the natural conditions that underpin effective agriculture. A decreased food supply then exacerbates food insecurity for people in the area. (Mbow et al., 2020). Climate change is another issue putting stress on our food supply. Rising temperatures are increasing the likelihood of extreme weather events like droughts and floods, which can seriously harm agricultural productivity (Seneviratne et al., 2021). Many areas may no longer be able to produce some of the main foods required to feed their populations because excessive heat causes damage to crops (Hassan et al., 2021).

### ii. Poverty

Food insecurity and poverty are strongly related, with poverty playing a significant role in the lack of access to appropriate, safe, and nutritious food. Food insecurity and poverty have a complicated relationship because food insecurity can be caused by poverty as much as by it (Mukhlis et al., 2021). Almost everywhere in the globe, getting the necessary food requires trading or money of some kind (Lang, 2020). A person who is poor may not have much money left over for eating. When someone is poor, it can indicate that they cannot afford to buy all the food they require or that there is insufficient variety to meet their nutritional needs. If food prices increase, someone may find themselves unable to afford the same amount of food even if they can currently afford to buy what they need. A person is therefore also food insecure because they are on the verge of not being able to meet their nutritional demands due to their precarious financial condition (Clapp & Moseley, 2020). Addressing food insecurity often involves comprehensive strategies that not only focus on providing immediate food assistance but also address the root causes of poverty, promote sustainable development, and enhance the economic resilience of communities. Social policies, economic development initiatives, and investments in education and healthcare are crucial components of efforts to break the cycle of poverty and food insecurity (Onyeaka et al., 2024).

**iii. Conflicts and Wars**

While few human endeavors can match the damage wrought by armed warfare, trade wars and political disputes can also result in widespread food shortages (Klein & Pettis, 2020). When there is an armed conflict, those who are displaced from their land in an attempt to escape the fighting may find themselves in food insecure circumstances; they are typically dependent on food assistance from organizations and are unable to care for their lands and jobs. Occasionally, the capability to acquire food is wielded as a weapon in itself, with adversarial groups purposefully annihilating food resources or striving to starve civilian populations (Conley & De Waal, 2019).

Trade conflicts arise when two nations attempt to hinder each other's trade activities, potentially leading to increased prices for goods and services, including food (Ben Hassen & El Bilali, 2022). Trade conflicts are particularly dangerous for a nation that imports food from other countries.

The recent invasion of Ukraine by Russia in February 2022 serves as an illustration of how conflict affects the availability of food. In addition to fertilizer, Ukraine is a significant producer and exporter of commodities such wheat, maize, barley, and sunflower seed oil (Nykolyuk et al., 2021). Local food security has been jeopardized by the invasion's catastrophic damage to food production (Ben Hassen & El Bilali, 2022). Being a significant food exporter, the influence goes far beyond the boundaries of the nation. Food security in import-dependent nations, particularly those in the Middle East and Africa, is currently threatened by the conflict's increase in food prices.

### iv. Natural Disasters and Outbreak of Disease

Natural disasters can cause major disruptions to agricultural systems, food production, distribution, and access, among other factors that lead to food insecurity (Mishra et al., 2021). Natural catastrophes can have both short-term and long-term effects on food security. Natural disasters including hurricanes, wildfires, droughts, and floods can seriously harm cattle and crops (Sukumaran, 2022). Droughts can cause water shortages, floods can submerge fields, and extreme weather events may destroy crops, all of which can cause significant losses and lower agricultural productivity. Also, critical infrastructure, such as highways, bridges, irrigation systems, and storage facilities, are frequently damaged by natural disasters (Paul, 2020). The shipment of food from production areas to markets may be hindered by this damage, resulting in supply chain disruptions. Moreover, communities may be forced to migrate or evacuate as a result of natural disasters, which would impair agricultural operations. Farmers who are displaced might lose their property, animals, and tools, which would mean a loss of livelihoods and a decrease in food output (Khan et al., 2020). A typical instance is the spillage of the Akosombo Dam, where nearby communities of some parts of the Volta, Eastern, and Northern regions were submerged by water, and hence residents had to flee and relocate to different areas. In a report to Ghana News Agency (GNA) on October 19, 2023, it was noted that the majority of the farms and the roads connecting to farms, according to Mr. Mark Achel, the Golden Exotics Limited Manager of Corporate Affairs and Administration, are currently under water. The farms that produce fish, rice, mangoes, and bananas along the Volta River were the most severely impacted, Mr. Achel told the GNA. "One commercial farm heavily affected by this spillage is Golden Exotics Limited, Ghana's leading producer of banana and exports over 90 per cent of bananas produced in the country," he stated. Over 2000 hectares of bananas are grown by Golden Exotics Limited, a Freezone Enterprise, which also operates one of the largest organic banana farms worldwide. According to him, the spillage has had a disastrous impact on the company's output, as they employed around 4,000 regular workers on their plantation. According to him, they have already spent more than 500,000 euros. The manager of corporate affairs and administration claimed that in addition to having parts of the farm flooded, they also had to deal with the destruction of expensively constructed farm road networks, dykes, culverts, and electrical installations at the packing and pumping stations. Within a week, he claimed, they had already lost more than 200 tons of bananas, and the floods were continually rising and lapping at the packhouse entrance.

Similarly, by upsetting regional markets and global food chains, causing economic loss, and endangering the health of individuals who produce food, the COVID-19 pandemic and its mitigating measures, which started around 2019, also made food insecurity worse. According to estimations, the pandemic actually increased the number of food insecure people by 161 million (Kharroubi et al., 2021). Data from LMIC nations show that the pandemic had a detrimental impact on the quality of diets, with women, low-income individuals, and workers in the informal sector most negatively affected (Picchioni et al., 2022). In high-income nations, minority and low-income groups also had greater effects (Woolf et al., 2021).

**v. Inadequate access to Infrastructure**

It is difficult for the peripheral regions of Africa to integrate into the national and regional economies due to the poor condition of development and maintenance of telecommunications, energy sources, and roads and transportation (Wolf, 2020). The countries in the region have some of the lowest rates in the world for access to water supplies and roads, as does the case with all other development indicators. According to a recent report, the disparity in infrastructure availability between Africa and the rest of the globe has reportedly grown during the last 15 years. Both emergency relief efforts and the commercialization of the rural economy are hampered by the lack of adequate roads and communications infrastructure (Yar & Yasouri, 2024). The region's road network density provides insight into the challenges faced by rural residents in accessing services and the obstacles they encounter while trying to get involved in the market economy. The majority of rural residents in Africa still lack access to a safe water source, despite the tireless efforts of development organizations and non-governmental organizations (Amutenya, 2024). The best that rural people can hope for are hand pumps and protected wells; piped systems are rare in these locations. Like so many other menial duties, collecting water is primarily the responsibility of women in the villages, who have to dedicate many hours a day gathering water from harmful sources (Agarwal, 2022).

**vi. Inability to access Credit and Marketing Systems**

Over the past ten years, as part of structural reforms to the economy, market liberalization has permeated all of the region's economies. Farmers with access to good land, irrigation, and markets have obviously benefited from this, but those with limited resources and those in isolated and low-potential places have essentially been left out (Zabel et al., 2019). In fact, many of these farmers might not be in as good of a situation now as they were before to the reform process, when some of them profited from subsidies through the use of state marketing agencies' pan-territorial prices for inputs and outputs. These folks are now stuck in a terrible situation where they are paid the lowest prices for their excess production but have to pay the highest prices for consumer items and agricultural supplies. Because fewer rural businesses seem to be profitable in the liberalized market, farmers are retreating into subsistence farming. The lucrative export market in the Gulf countries has helped a lot of pastoralists, although occasionally cross-border restrictions and disease outbreaks disrupt their commerce (Ahmed, 2020). Similar to marketing, larger and more accessible farmers are progressively gaining access to rural financial services as a result of the financial markets' gradual liberalization (Jayne et al., 2019). When it comes to formal credit, the poor—who are considered to be at high risk—have the least access to it (Moahid & Maharjan, 2020). As a result, when they need a loan, they must rely on friends, family, and local moneylenders. Due to high transaction costs and perceived risks, it is unlikely that institutions in the commercial financial sector would reach out to small farmers for many years to come (Ncube, 2020). As a result, these farmers are deprived of a crucial instrument for development.

### 2.8.2 Effects of Food Insecurity

There are many detrimental impacts that food insecurity can have on people, families, and communities. Numerous domains, including physical and mental health, education, and general socioeconomic circumstances, may be affected by these consequences.

#### i. Nutritional Deficiencies

People who experience food insecurity might not have access to a wide range of nutrient-dense foods, which could result in an insufficient intake of vital vitamins and minerals. Malnutrition and other health problems may arise from this, especially in young children, expectant mothers, and the elderly. The inability to access sufficient food undermines a person's capacity to satisfy their body's fundamental requirements for calories and nutrients (Balan et al., 2022). Children lacking sufficient caloric intake may undergo delayed growth and a deterioration in their general bodily operations (Rogol, 2020). In extreme cases, starvation can ultimately result in death. Many deficiency illnesses may arise when an individual does not receive an adequate amount of nutrients (Calder et al., 2020). The most prevalent nutritional deficiency worldwide is iron deficiency, which can cause anemia and cause weariness and disorientation (Shahy et al., 2021). Although the severity of nutrient deficiencies varies, they all often result in decreased living quality, subpar academic performance, and diminished general functioning.

**ii. Increase in Food Prices**

It is crucial to keep in mind that there are regional and contextual variations in the dynamic link between food prices and food insecurity (Ortiz-Miranda et al., 2022). Furthermore, because the world's food markets are interconnected, local food insecurity may have repercussions on the larger international food system, affecting prices globally. Through a number of interrelated causes, food insecurity can contribute to increases in food prices (Mbow et al., 2020). A multitude of economic, social, and environmental factors might have an impact on the complex relationship between food insecurity and growing food prices. Extreme weather, water scarcity, crop failures, and other production-related issues are common causes of food insecurity (Abdullahi et al., 2024). Reduced yields from reduced productivity might result in a reduction in the total supply of food items and drive up prices. Due to the need for additional inputs, such as fertilizers, pesticides, or water resources, to deal with problems like drought or pest infestations, farmers that face food insecurity may have to pay higher production expenses. The finished food products may cost more as a result of these increased expenses. The recent spillage of the Akosombo dam in nearby communities has caused an increase in the prices of tilapia owing to the vast destruction of tilapia farms in the surrounding towns. Farmers in the Eastern Region's Asutsuare town by the Lake were selling 50 kg of medium-sized tilapia for GH₵ 2,150, while the average size of tilapia was valued at the same amount (Kerkulah, 2023). Further research revealed that, following the spill, the price of a kilogram of tilapia, which was previously sold at the farm gate for GH₵ 31.00, had increased to GH₵ 41.00, according to Mr. Jacob Adzikah, CEO of the Chamber of Aquaculture Ghana. The Chamber of Aquaculture's research unit informed the GNA that they had noticed a minor price increase at the farm gate of roughly GH₵ 10.00 (Ignatiou et al., 2021).

**iii. Hunger and Poverty**

Food insecurity and poverty are intricately linked. This perspective highlights that poverty serves as the fundamental cause of food insecurity. When one is hungry, there is little that can be done. As a result, one will continue to be both impoverished and hungry. The interconnection between disease, poverty, and hunger is significant; hunger plays a role in the development of disease. It diminishes resistance to most illnesses and heightens vulnerability to them (Cunnane et al., 2020). Due to their inability to generate or buy enough food, the poor are more susceptible to illness. The inability to consistently obtain enough nourishing food leads to food insecurity (Kansiime et al., 2021). People or households that are unable to pay for a healthy meal because of financial difficulties become hungry because they are not consuming enough calories and vital nutrients. This increases the cycle of poverty since inadequate nourishment has an adverse effect on one's general health and well-being. Also, many people who struggle with food insecurity also work in low-paying or precarious jobs. Unpredictable earnings from an insecure employment may make it difficult to regularly buy food (Bowen et al., 2022). Food insecurity is made worse by the cyclical nature of unemployment and underemployment, which also accelerates poverty.

### 2.8.3 Solutions to Food Insecurity

A comprehensive approach that takes into account the several factors influencing the availability and accessibility of nutritious foods is necessary to address food insecurity. Achieving significant and long-lasting progress in tackling food insecurity at the local, national, and international levels requires integrating these solutions in a cooperative and integrated manner.

### i. Raising the Productivity of Agriculture

Globally, there is sufficient crop and production of food to sustain humankind (Devaux et al., 2020). Its geographic distribution is the issue; insufficient food is produced and supplied to the areas that use it most. More food can be produced by making investments in technology that support higher agricultural yields and productivity (Giller et al., 2021). There have been significant advancements in agricultural technology throughout human history; the most notable being the Green Revolution in the 1960s, which led to the widespread use of agrochemicals and the development of more productive crop breeds. Even more technology are available now to increase agricultural output, but some of the world's poorest regions lack the funds to purchase these innovations (Goralski & Tan, 2020). They are so losing out on the advantages that more recent technology can offer to agriculture. To ensure food security, farmers should receive additional subsidies and training on more efficient farming techniques.

### ii. Reducing Poverty

Reducing poverty is widely seen as an essential element in tackling and mitigating food insecurity (Sharma, 2024). Although it is not a complete remedy, lowering poverty can have a big impact on enhancing food security. Since poverty is one of the main drivers of food insecurity, eradicating it globally would significantly lessen the problem (Sukanya, 2024). Because there are so many variables that lead to poverty, eliminating poverty may be the most difficult strategy to reduce food insecurity. To elevate the most disadvantaged members of society and eradicate poverty completely on a global scale, all countries and international organizations must work together (Wade, 2020). Raising an individual and households purchasing power is a crucial step toward reducing poverty. This lowers their risk of hunger and malnutrition by enabling them to purchase a sufficient and nourishing food. Those who have enough money can buy a variety of healthful eating choices. Investing in rural development and agriculture is a common strategy for reducing poverty (Bernstein et al., 2019). Agricultural production can be increased by providing small-scale farmers with improved access to markets, resources, and technology (Dhillon & Moncur, 2023). Consequently, this leads to a rise in food production and accessibility.

**iii. Taking Action against Climate Change**

The current era of climate change and global warming is a result of greenhouse gas emissions from human activity (Bajoria et al., 2024). We must take steps to prevent climate change since it is making food insecurity worse. It is important to remember that while the effects of climate change are already being seen, this solution is more long-term in nature. However, if nothing is done, every country would face a very dire future full of widespread food insecurity. Promoting and putting into practice climate-resilient and sustainable agriculture practices is part of climate action (Islam et al., 2022). This covers methods for improving the health of the soil, using water efficiently, and using a variety of cropping types. By assisting farmers in adapting to shifting climate circumstances, these methods lessen the susceptibility of food production to severe weather conditions. The goal of climate action is again to lessen the effects of climate change, which includes extreme weather phenomena including storms, floods, and droughts. Agriculture is less vulnerable to interruptions when these events occur less frequently and intensely, resulting in a more steady supply of food.



## 2.9 Land Degradation – Food Security Nexus

There is an essential link between land degradation and food security, because damaged land reduces the ability of the ecosystem to generate food, sustain livelihoods, and uphold vital ecological functions. An estimated 20% of Africans are undernourished, and 57 million more have gone hungry since the COVID-19 pandemic began (Hart et al., 2022). Additionally, they projected that 868 million Africans faced moderate to severe food insecurity in 2022, with more than one-third of those individuals experiencing severe food insecurity. Approximately, 55 million people in West and Central Africa will find it difficult to feed themselves during the June–August 2024 lean season (Nchanji & Lutomia, 2021).

Land degradation is caused by both anthropogenic and natural direct factors, which are impacted by indirect drivers (Zucca et al., 2022). We can list earthquakes, volcanic eruptions, hurricanes, floods, landslides, typhoons, and recurrent pest and disease outbreaks as natural factors causing land degradation (Teh & Khan, 2021). Their periodicities range from years to millennia, and they occur episodically (Zhang et al., 2023). Food security is seriously threatened by the anthropogenic direct causes, which are directly related to human activity and can occur at local, regional, or global scales. The primary underlying causes of land degradation are indirect factors (Tadesse & Hailu, 2024). These factors stem from the ways in which human societies function, are structured, and interact with nature on different levels. Usually, indirect factors come from beyond the particular environment under study.

In the Bawku West District, agricultural productivity and food availability are seriously threatened by land degradation (Azumah et al., 2023). Its capacity to sustain the human food supply may deteriorate temporarily or permanently, depending on the degree of degradation (Ogunbode et al., 2021). In fact, disruptions to the food supply will occur more frequently if land fertility is threatened, creating the problem of food insecurity (Savary et al., 2020).

Land degradation significantly affects food security. It hinders access to arable land, lowers crop quality, and lowers agricultural production (Smith et al., 2020). It lowers the amount of water available and makes invasive species more common, both of which are detrimental to crop growth. In this sense, it is important to prevent land degradation so that there is healthy soil for growing crops and producing food efficiently. Restoring degraded land and preventing further land degradation require careful consideration of education, policy changes, and the application of technology for significant innovation (Briassoulis, 2019). Land degradation significantly reduces soil fertility, which lowers agricultural productivity. Reduced agricultural yields and food availability result from soil erosion, nutrient depletion, and the loss of soil organic matter, which all affect the ability of the land to support crop development (Hossain et al., 2020).

The decreased availability of arable land is another effect of land degradation (Prăvălie, 2021). Farmers are unable to find adequate land for cultivation as a result of land degradation, which makes it more difficult for them to produce enough food for their communities and themselves. Land degradation also affects grazing areas and livestock productivity. Livestock suffer from a lack of fodder due to degraded pastures, which has an adverse effect on their production and well-being (Michalk et al., 2019). Food insecurity is exacerbated as a result of the decreased availability of dietary items derived from animals, such as meat and dairy. Land degradation also has a negative impact on water resources. Water scarcity and poor water quality are caused by decreased groundwater recharge, increased runoff, and decreased soil water-holding capacity (Verma et al., 2023).

These variables reduce crop yields and food production, interfere with agricultural operations, and constrain irrigation. A chain of negative feedback that links degraded land to climate change and variability can potentially be triggered by land degradation. Climate change significantly compromises agricultural output and food security by making droughts, floods, and other extreme weather events more often and severe (Duchenne-Moutien & Neetoo, 2021). Developing comprehensive strategies to address these issues requires an understanding of the complex link between food security and land degradation. Policymakers and stakeholders should strive toward sustainable land management techniques that guarantee long-term food security for the Bawku West District and beyond by taking into account the several implications highlighted above.

### 2.10 Theoretical Framework

The Malthusian and Boserupian schools of thought have dominated the literature on the relationship between population growth, agriculture, and natural resources. Thomas Robert Malthus, an economist and demographer, and the proponent of the Malthusian theoretical framework avoids addressing land degradation in the conventional sense. The Malthusian theory of population is the notion of exponential population increase and arithmetic growth in the food supply (Unat, 2020). The link between population growth and the availability of resources, especially food, is the main emphasis of the Malthusian theory (Azam et al., 2020). However, when taken into account the possibility of resource constraints and environmental limitations, some features of Malthusian thought can be relevant to talks concerning land degradation. According to Malthus, in order to feed the growing population, the agricultural land must expand, and this expansion is expected to occur progressively over time on marginal regions with lower production (Bilsborrow, 2022). In his seminal essay "An Essay on the Principle of Population," Thomas Malthus contended that whereas resources, especially food production, expand at an arithmetic rate, population growth tends to be exponential. Malthus projected that this mismatch between growth in population and the availability of resources would result in hunger, sickness, and other natural disasters—all of which are unavoidable population controls (Hansson, 2022).

Malthus argued that one approach to responding to growing population pressure would be to increase the area under agricultural cultivation (Linnér, 2023). There are only two ways to grow land area: either by capitalizing on nearby lands or clearing more of one's own; or by migrating to other locations and clearing forests to create new land for agriculture, which causes deforestation. Neo-Malthusians have made a clear connection between Malthus' theory and contemporary environmental concerns by arguing that agricultural extension, or the growth of agricultural land area, must originate from forests and other vegetated areas and that this calls for deforestation, which degrades the environment. Malthus was of the view that positive and preventive checks may be used to create a balance between population expansion and food supply (Malthus, 2020). This situation of disequilibrium manifests when the growth rate of the population exceeds that of food production. People will not have access to adequate food, even for survival, as a result. There would not be enough food to sustain everyone. Malthus refers to these adversities—which include diseases, famines, wars, starvation, and other natural disasters—as positive checks (Sutter, 2022). Likewise, the principles of simple living, self-control, and the postponement of marriage exemplify preventive actions that assist in maintaining a balance between the growth of the population and the availability of food resources. These initiatives can prevent the harmful repercussions of positive checks while simultaneously controlling the rise in population.

The Malthusian framework can be applied to land degradation in various ways. One of these is population pressure on land. According to Malthusian theory, there is a growing demand for resources, such as agricultural land as a result of population growth (Montano & García-López, 2020). This might lead to land degradation by causing agriculture to become more intensive, extending into marginal areas, and overusing natural resources. Another one that could be looked at is limited agricultural productivity. According to Malthus, the amount of land and technological advancements available will determine how much more food can be produced (Pham et al., 2020).

Land degradation may result from decreased agricultural production if population increase exceeds the capacity to manage and cultivate land sustainably (Prăvălie, 2021). Moreover, the theory that a greater number of individuals living on land may trigger environmental stress is linked to Malthusian thought. Land and ecological degradation can result from actions like deforestation, soil erosion, and excessive use of water resources to feed a growing population (Wassie, 2020).

In contemporary discourses regarding land degradation, a wider array of issues are frequently taken into account, such as land-use practices, technological advancements, institutional structures, and sustainable resource management. Modern measures aimed at combating land degradation usually involve conservation initiatives, integrated and sustainable land management techniques, and laws that attempt to strike a balance between growing populations and ability of ecosystems to maintain human needs.

It is however crucial to remember that, despite offering insights into the possible problems brought on by population growth and resource scarcity, Malthusian theory has come under criticism for oversimplifying the nuanced relationships between humans and their environment.

One of the main criticisms leveled against Malthusian theory is its failure to take technological advancement into account. The theory failed to take into account how advancements in technology could boost agricultural output. Malthus projected that there would be widespread famine as population expansion outpaced food production (Valenze, 2023). But agricultural advancements like the Green Revolution have raised food supplies dramatically, casting doubt on the idea of inevitable food shortages (Belton et al., 2020). Also, Malthusian theory is predicated on the idea that resources, especially land, are static (Naso et al., 2020). It does not sufficiently take into consideration the capacity for human creativity and adaptation in the discovery of new resources, the creation of more effective production techniques, and the sustainable management of currently available resources.

The neglect of economic and social elements was one of the issues raised by the critics of Malthusian theory. Malthus' critics contend that he ignored the importance of economic and social elements in determining population dynamics in favor of concentrating solely on demographic issues. Population growth rates can be significantly impacted by factors including socioeconomic development, access to education, and income inequality (Harsono et al., 2024). The theory is also criticized for its failure to predict declining birth rates. The substantial drops in birth rates that took place throughout the world in the 20th century were not anticipated by Malthusian theory. Although the theory predicts unrestrained population growth, demographic shifts brought about by advancements in economic development, healthcare, and education have led to lower fertility rates in a number of places. Malthusian theory has come under attack for placing too much emphasis on population control as a means of addressing resource limitations (Montano & García-López, 2020). It has been considered unduly pessimistic and unethical to suggest that the only ways to contain the growth of populations are by positive checks (raising death rates) and preventive checks (lowering birth rates).

The theory also ignored the role of institutions. The significance of social and institutional elements in determining population and resource dynamics was not sufficiently taken into account by Malthusian theory (Bretschger & Pittel, 2020). Much of what was considered in the original theory was ignored, including institutions that control resource use, property rights, and government. Furthermore, the theory did not consider the worldwide variability in resource allocation. According to critics, Malthusian theory oversimplified the allocation of resources on a worldwide scale (As Sunny et al., 2024). It failed to take into consideration the reality that while some areas are resource-rich, others confront more serious difficulties. Localized resource constraints have also been lessened by international trade and the capacity to transfer resources across national boundaries (Luo, 2021).

One of the major critics of the Malthusian theory was a Danish economist and an agricultural economist by name Ester Boserup. She presented a theory about population growth and food production that is in contrast to the Malthusian viewpoint. The Boserupian theory was first proposed by her work, which is mostly contained in her book "The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure." She argued that as the population increases, land becomes scarcer and is exploited more intensely, leading to an increase in agricultural productivity. Boserup presented a positive perspective, highlighting the benefits of population growth and density-induced agricultural innovations that could boost output, restore the production of food, and prevent a decline in standard of living without necessarily expanding agricultural land area or decreasing forest cover. Agricultural advances do occur, though, even in the absence of population increase (Giller et al., 2021). For instance, labor shortage spurs innovations in the agricultural sector; consequently, agricultural intensification is linked to factors other than population expansion.

This is evident in modern-day agricultural production as fertilizers, insecticides, seed technology, and other aspects of agriculture are all impacted by technology (Raj et al., 2022). Crop yields have increased and pest resistance has been achieved through genetic engineering and biotechnology (Alemu, 2020). Mechanization has resulted in less manual work needing to be done and more efficient harvesting and tilling (Paudel et al., 2019). It is apparent everywhere that transportation and irrigation techniques have improved, and processing equipment has decreased waste. Moreover, robotics, blockchain technology, artificial intelligence, and precision agriculture are among the many topics covered by new age technologies. India, for example produced enough food grains to become self-sufficient in 1960 during the Green Revolution by utilizing contemporary agricultural techniques such as chemical pesticides and fertilizers, better-quality seeds, as well as suitable irrigation (Hazra & Basu, 2023).

There has been increased in productivity as a result of agricultural mechanization. The energy and productivity of manual labor and hand tools used in agriculture are limited, particularly in tropical climates (Mallareddy et al., 2023). A disruptive component is sometimes resistance to agricultural mechanization, especially among smallholder farmers owing to concerns about accessibility, cost, and upkeep. Combine harvesters are being used more frequently in order to decrease manual labor and speed up procedures. Small landholdings are the hallmark of farming, and utilizing contemporary machinery requires collaboration (Safdar & Gevelt, 2020). Future mechanization service acceptance will be higher if capacity of farmers is increased through handholding, new machinery is made available, especially to small farms, and policy is used to address affordability concerns (Khatri & Shrestha, 2023). Mechanization in agriculture has the ability to influence yields both directly and indirectly by decreasing post-harvest losses and increasing harvest gains.

Furthermore, the application of artificial intelligence (AI) in the field of agriculture represents a notable progress. Modern AI-driven tools and technologies facilitate data gathering, while also enhancing precision farming and informed decision-making. Farmers obtain essential information regarding temperature, precipitation, soil conditions, humidity, and various weather-related elements through the use of satellites, drones, and remote sensors that gather data on weather patterns in and around the fields as required (Sarkar et al., 2023). In most cases, high-yielding cultivars improve livestock, and genetic engineering leverages our understanding of DNA to find and work with traits to increase crop resilience to pests and diseases (Mueller & Flachs, 2022). The utilization of biotechnology in agriculture has yielded numerous benefits for both farmers and end consumers. In light of the evolving environmental conditions and the increasing global population, it is evident that safe biotechnology will significantly influence the future of agriculture, despite certain controversial methods that have led to hesitance in its adoption. Furthermore, the rapid advancement of communications technology has paved the way for the potential of smart farming (Tao et al., 2021). In light of the difficulties and environmental conditions facing farmers today, sensors are being employed in agriculture to offer data for crop monitoring and optimization (Saiz-Rubio & Rovira-Más, 2020). These electronically connected sensors can be used for a variety of activities, including detecting nutrients, airflow, soil composition and moisture level, and precise location. Farmers that use sensors save money on labor and chemicals while applying fertilizer more effectively (Paul et al., 2022). They let farmers use the least amount of natural resources while maximizing harvests.

## 2.11 Conceptual Framework

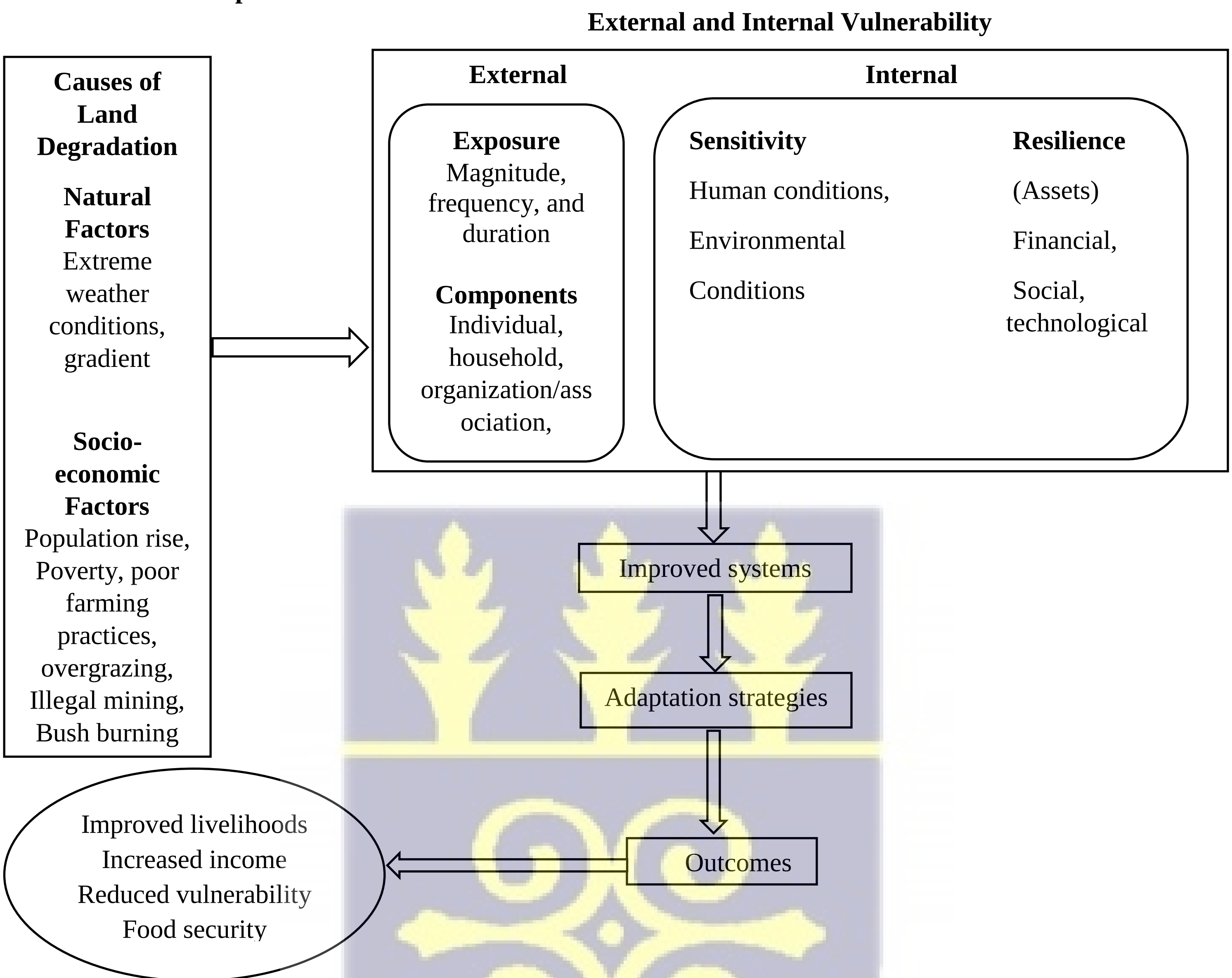



**Figure 2.1 Conceptual Framework Relating Land Degradation to Vulnerability and Food Security. Climate change, food security and livelihoods framework.**

*Source: Adapted from (Connolly-Boutin & Smit, 2016).*

The conceptual framework above in figure 2.1, Climate change, food security and livelihoods framework, originally postulated by Connolly-Boutin & Smit (2016) offers a broad overview of the variables and relationships that limit and impact the characteristics and dynamics of food security in a community. In this context, “community” could refer to any of a number of scales, including a home or a village. Every individual in a village, for instance, will have a variety of assets and be impacted by socioeconomic (social, economic, political, and institutional) and biophysical (physical, biological, and ecological) factors; however, the particular assets will probably differ among people and households, as well as their exposure to the factors. Similar to the fields of sustainable livelihoods and climate change, vulnerability is seen to consist of two interrelated components: one that is related to the coping mechanisms or ability to adapt, and the other that is related to the external risks, shocks, drivers, and stresses that communities are vulnerable to. Climate change is one of the biophysical drivers, along with other biological and physical factors like diseases and soil quality. Demographics, economy, institutions, and policies are examples of socioeconomic drivers. The overlap between the biophysical and socioeconomic forces, or stresses, suggests that they work together to have a synergistic effect on the community. Concepts related to climate change, land degradation, sustainable livelihoods, and food security are generally supported by this conception of drivers, dangers, contextual factors, or the livelihood environment.

The conceptual framework (figure 2.1) shows a linkage between land degradation and food security. The framework consists of three major sections with the first segment being the causes of land degradation. This section is subdivided into two parts; natural factors and socio-economic factors. These two are the factors which act to trigger vulnerability. It is generally agreed that a combination of interrelated stressors (biophysical and socioeconomic factors) create vulnerability; hence, focusing on just one would be insufficient (Malakar et al., 2023). Whereas the biophysical drivers are elements relating to biology and the physical environment, such as climatic variability and change, the socioeconomic drivers are factors like demography, economics, and culture (Muttarak, 2021).

In the second section of the conceptual framework is the vulnerability aspect. Vulnerability is the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (Schismenos et al., 2021). It can be categorized into two forms; external and internal vulnerability. Internal vulnerability is the term used to describe a system or community's innate weakness or susceptibility to the effects of a calamity (Talubo et al., 2022). It alludes to elements inside the system that affect its level of risk as well as its capacity to withstand and recover from a disaster event. Social, economic, and environmental factors frequently have an impact on internal vulnerability. External vulnerability on the other hand is where a community, area, or system's susceptibility to the effects of natural or man-made disasters are from causes outside of its immediate control (Huq et al., 2020). It includes all of the elements and circumstances that increase a population's or an area's vulnerability to harm, disturbance, or unfavorable effects in the event of a disaster. Important elements or drivers of vulnerability include market pressures, institutional structures and procedures, political conditions, and cultural norms. Vulnerability is largely dependent on the magnitude of the disaster (Choo & Yoon, 2024). Exposure, sensitivity, and resilience are the three elements that make up vulnerability (Lanlan et al., 2024). The first component (exposure) focuses on the external hazards, shocks, and stress that a system is exposed to, whilst the other two components (sensitivity and resilience) focus on the internal response and coping mechanisms.

Exposure refers to a region's population, infrastructure, housing stock, capacity for production, and other tangibly embodied human assets located in areas that are prone to hazards (Thomas et al., 2019). It is the nature and degree to which a system experiences stress. Two examples of exposure measures are the sorts of assets or people that are present in an area (Pant et al., 2018). These can be used with the particular vulnerability and capability of the exposed parts to evaluate the quantitative risks associated with a particular hazard in the region of interest (Kasperson et al., 2022). The stresses experienced by systems can be characterized by magnitude, frequency, and duration (Ho et al., 2022).

Sensitivity is the extent to which a system or community is harmed by exposure to natural hazards (Painter et al., 2024). It is how susceptible or vulnerable a system or an entity is to the effects of a disaster (Sun et al., 2022). It illustrates how sensitive or responsive a specific element or component is to the risks and stressors related to a disaster event.

Resilience/Adaptive capacity on the other hand refers to the ability of people, communities, organizations, and systems to adapt, learn from, and deal with the effects of disasters (Wen et al., 2024). It comprises having the ability to prevent disasters, respond to them, and recover from them (McEntire, 2021). It also involves having the flexibility to adjust and become more resilient in the face of shifting threats. Numerous researchers studying the vulnerability of climate change have made connections between adaptive capability and entitlements (livelihood resources or assets), especially in relation to social capital. A number of variables, such as social, economic, and environmental conditions, have an impact on adaptive capacity. Adaptive capacity is largely dependent on the available resources or assets to cope with the accompanying stress (Prati, 2024). The framework illustrates that a household's vulnerability is contingent upon its exposure to stressors, characterized by their magnitude, frequency, and duration. Additionally, it is influenced by the household's sensitivity to these stressors, which is determined by both human and environmental factors, as well as its resilience, which is reliant on the resources accessible to the household. Available resources could be in financial terms, social terms, or technological terms.

This framework also incorporates the sustainable livelihood framework, which outlines how structures of institutions and procedures can be gradually changed in order to adapt to stressors. The term "adaptation strategies" refers to the measures people take to deal with stress (Laue et al., 2022). They are actions taken by individuals or groups to adapt to shifting circumstances in order to preserve or enhance their well-being. These efforts are frequently accomplished by utilizing their asset endowment. Access to assets may be impacted by structural factors. For example, a cash crop's profitability may suffer from low commodity prices. As people use their strengths to adapt, they are the embodiment of adaptive capability. Transformational changes occur when thresholds are passed in sociocultural or political economy systems, or when higher-level adjustments are made to policies, programs, and institutions. Policies of government that dictate the locations of infrastructure or service investments may also facilitate or impede a community's access to help or markets. The improved systems and adaptations may result in a number of benefits, including enhanced livelihoods, food security, decreased vulnerability, and higher income.

It is evident that this conceptual framework shows a linkage between extreme weather conditions, population rise, poor farming practices, bush burning and other factors and land degradation in the study area. These have been elaborated further in this study as they were identified as some of the main causes of land degradation in the area.

This chapter discusses into detail land degradation, drawing references from individuals and organizations. It also explains the types of land degradation, its causes in the various ecological zones, its effects, and how combat land degradation. The chapter again discusses food security, food insecurity, its causes and how to curb food insecurity. The chapter lastly integrates theoretical framework and conceptual framework in the study.

# CHAPTER THREE: STUDY AREA AND METHODOLOGY

## 3.1 Introduction

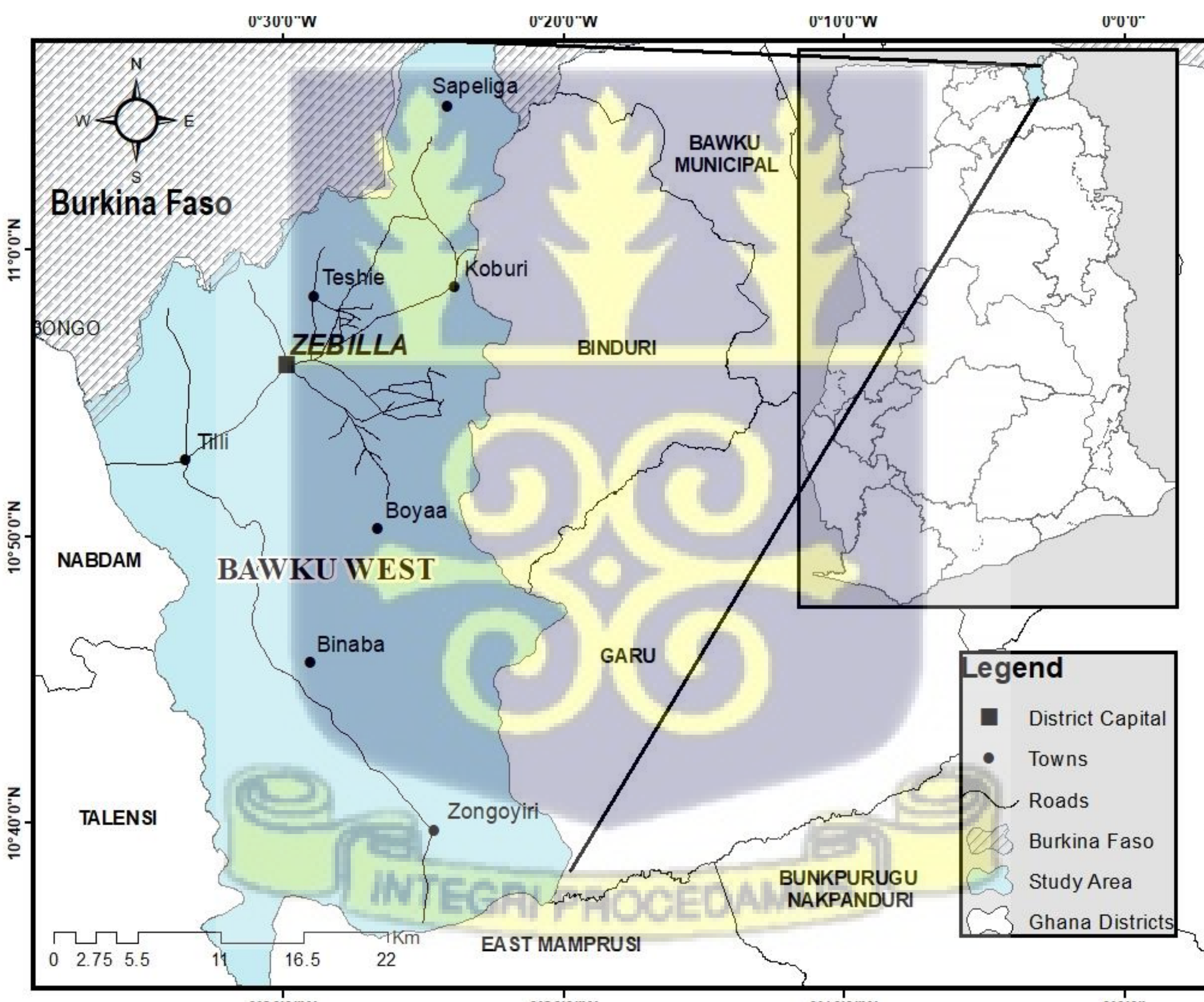
In chapter two, I have discussed into detail some definitions of land degradation and highlighted some of its causes, and how it affects food security. I also discussed possible mitigation and adaptation strategies that can be put into practice to lessen the negative effects of land degradation on food security. The climate change, food security and livelihoods framework was adapted in relating land degradation to vulnerability and food security Finally, I reviewed existing literature on the subject, identified gaps within the reviewed literatures and proposed solutions to inform policy makers, researchers, and practitioners on addressing land degradation and enhancing food security in the Bawku West District.

Study area is an important component that establishes the boundaries and defines the environment in which the research is carried out. The nature and features of the research area are explained in this chapter. This also applies to the area's representation in imagery. The stages and procedures used in the study are explained in full by the methodology. As a result, the chapter covers the research design, data requirements, data collection strategies, sampling techniques, and technologies selected for gathering information in the targeted populations as well as the data presentation.

## 3.2 Study Area

### 3.2.1 Location and Size

One of the fifteen districts and municipalities in the Upper East Region is the Bawku West District (Abanyie et al., 2019). The district's administrative capital is Zebilla, which is situated in the north-east of the area (Atubiga et al., 2025). The Republic of Burkina Faso borders it on the north, Binduri and Garu districts on the east, Talensi and Nabdam districts on the west, and East Mamprusi district on the south (Krugu et al., 2023). The White Volta and the Red Volta, two tributaries of the Volta River, run adjacent to the district’s eastern and western boundaries, respectively (Zakaria, 2022). The district lies on latitude 10º 55′ 54″ N and longitude 0º 30′ 1″ W. Legislative Instrument (LI) 1442, a local government law, established the district in 1988, carving it out from the old Bawku District (Akumbole et al., 2019). The district has a total size of around 1,070km², representing 12% of the Upper East Region’s total land area (Adu-Boahen et al., 2019). In terms of total land area, it is the fourth largest district in the region (Alogitega et al., 2024).




**Map 3.1: Study Area Map**
*Source: Author, 2024*

### 3.2.2 Socio-Demographic Characteristics

The district had a total population of 38,034 in the year 2000 according to the 2000 population and housing census in Ghana (Azumah et al., 2023). According to the 2010 population and housing census, the population increased to 94,034 people altogether, which represented 9.0% of the total population in the Upper East Region (Adu-Boahen et al., 2019). This indicates an increase in the population of 147% over the 2000 population and housing census. The population of the district is made up of 52% women and 48% men (Sulley, 2022). Among people who are eleven years of age and older living in the district, 61% are illiterate and only 39% are literate (Bashiru, 2024). The literacy rates of men are higher (48.0%) than those of women 31% at that moment (Sulley, 2022). As per the 2021 population and housing census, the district had 144,189 residents, comprising 70,781 males and 73,408 females (Lowe, 2025). This also indicates an increase of 53%. From the 2010 population and housing census which was 94,034. It has a population density of 134.7/km² and an annual change in population of 4.1% (Owusu et al., 2024). The population of the Bawku West District consists of 58,594 ranging from the age of 0-14 years old, representing 40.6% (Agyeman, 2020). People between 15-64 years of age consist of 77,278 which represents 53.6% while those above the age of 64 years are 8,317 representing 5.8%. Out of the total population, 122,458 which represents 85% live in rural areas whilst 21,731 live in urban centers representing 15% (Agyeman, 2020).

Kusaal is the most commonly spoken language and the largest ethnic group in the district (Tseer et al., 2022). The Bawku Traditional Area is thought to have been first inhabited by the Kusasi (DOKE, 2021). The Mamprusi are seen as warrior newcomers by the Kusasi, a major ethnic group in the region. There have long been disputes between the Kusasi and Mamprusi, two distinct ethnic groups with disparate languages and religions (Gasu, 2020). The bulk of people in the district are Kusasi, although there are also a good number of Basari and Mossi, Hausa, Fulani, and Frafra from neighboring kingdoms.

### 3.2.3 Economic Characteristics

There are close to 133,889 labor force in the Bawku West District working in both agricultural and non-agricultural sectors. 80% of this population work directly in agriculture, while the remainder being involved in other activities. In Zebilla, commodities and goods are traded on an open market every three (3) days (Azaare et al., 2020). Smaller townships along the Burkina Faso border, such as Sapeliga, experience the same thing. The Zebilla market is the biggest market in the district and is located in the district capital. Other minor markets include the Sapeliga Market at the Sapeliga Zone, the Binaba Market at the Binaba Zone, and the Tanga Market at the Tanga Zone. Following Zebilla market day, the smaller markets take place the day after or every other day. Zebilla is known for breeding animals. On most market days, guinea fowls, sheep, goats, and dogs are sold. The indigenous Kusasi people consider dog meat to be a delicacy.

Ghana's farming practices differ according to the agro-ecological zones (Dasmani et al., 2020). Nonetheless, a few universal characteristics can be seen across the regions. Wherever there is adequate space to allow a plot to recover its fertility after one (1) to three (3) years of cultivation, the bush fallow system is usually employed. While income crops are often monocropped, staple crops are frequently mixed crops (Amankwaa-Yeboah et al., 2023). The output of domestic livestock meat is minimal; in 2000, it totaled 66,283 metric tons, of which around 27% came from beef, 18% from mutton, 17% from goat and pig meat, and 21% from poultry. 13,700 metric tons of milk were produced domestically at that time. According to Henchion et al. (2021), 30% of the country's animal protein needs are met by the production of milk and meat. The country imports meat, milk, and cattle in order to make up for the deficiency in animal protein. But since most live imports from the northern neighbours—Mali, Niger, and Burkina Faso—are not documented, it is challenging to assess the quantity of meat and animals imported. 10,143.5 metric tons of chicken, 1,724.0 metric tons of beef, 757 metric tons of pig, 9,941.1 metric tons of dairy, and 362.7 other goods comprised the 22,727 metric tons of animal products imported in 1998 (via the major port at Tema).

The northern sector, where the primary food crops are sorghum, maize, millet, cowpeas, groundnuts, and yam, also relies heavily on cotton and tobacco (Danso-Abbeam et al., 2021). Rice plays a significant role in every zone. Although livestock production is an ancillary to crop cultivation, most rural households retain some kind of animals. While cattle production is concentrated in the Savannah zones, poultry production is more common in the south (Villano et al., 2019). Generally speaking, goat and sheep farming is extensive over the nation. A significant aspect of Ghanaian agriculture, livestock production helps to meet the country's food demands, supply draught power, maintain soil fertility and structure, and provide money, especially for farmers in the northern part of the country (Nkansah-Dwamena, 2024).

To mitigate interruptions in Ghana's food systems, the Savannah Agricultural Value Chain Development Program (SADP) is being implemented as a component of the post-COVID-19 recovery efforts. The Savannah Zone Agriculture Productivity Improvement Project (SAPIP) and the Savannah Investment Program (SIP) have successfully expanded maize and soybean cultivation from 80 hectares in 2018 to 14,000 hectares by 2021. It aims to build on these achievements. By 2026, it is anticipated that this program will have expanded rice, soybean, and maize output by an additional 8,000 hectares, building on the progress that has already been made. The SADP seeks to support industrialization, bring about jobs, and guarantee the nation's food and nutrition security (Barasa et al., 2021). It is anticipated that the project will promote Planting for Food and Jobs (PFJ) and Rearing for Food and Jobs (RFJ), help women and youth develop their skills and start their own businesses, support the government's industrialization agenda, and create resilient food systems in Ghana's northern and middle belt savannah regions (Sackey et al., 2025). Three elements will comprise the proposed project:

(i) development of a climate-resilient production system

(ii) development of a sustainable value chain

(iii) project management.

Key barriers to food security and the poultry and livestock feed industry are to be addressed by the PFJ initiative, which will be implemented in nine districts (including the Bawku West District) spread across five regions of the country (Mbowura & Bukari, 2025). In order to strengthen the poultry value chain under RFJ, this assistance will enable medium-sized commercial farmers and their out-growers to increase the area under cultivation for rice, soybeans, and maize under PFJ (Adams, 2024). Smallholder farmers, particularly women and young people, will benefit from the assistance of this integrated approach for aspects of large-scale growth and market outlets (Abdulai et al., 2024). The goals of this initiative are to support industrialization, provide jobs, and guarantee the nation's food and nutrition security (Osman, 2023). The goals are also to boost climate-resilient maize, rice, and soybean production to strengthen the poultry value chain, create jobs, raise farmer incomes, and improve household nutrition, particularly for homes led by vulnerable women. It is anticipated that roughly 50,000 beneficiaries will take part in the operations (Cudjoe, 2024). Support for "value chain actors" is a crucial component of this project in order to guarantee an integrated production-processing-marketing ecosystem. Based on the presence of an agriculture mechanization services center or its equivalent, as well as a critical mass of commercial farmers with a sizable land area and tenure security, target districts were chosen for the commercial production of rice, maize, and soybeans (Diedong & Abdullah, 2025).

The majority of the causal labor that can be used for work in both agricultural and non-agriculture in the district comes from young people (Bello, 2025). According to the Ministry of Food and Agriculture, 48,930 men and 58,181 women, or 107,111 farmers, are actively involved in agricultural production throughout the District (Agyeman, 2020). For the majority of farming operations, the rainy season is when labor demand is at its highest. Mostly, produce from farms is planted, harvested, stored, and marketed by women (Lelea et al., 2022). Along with helping the men with dry season farming, they also transport and market commodities including pepper, tomatoes, okra, onions, and others. The District engages women for a variety of jobs, including weaving, pottery, shea nut harvesting and processing, rice parboiling and processing, extraction of groundnut oil, charcoal burning, pito brewing, and firewood sales (Jagri, 2023). Zebilla, like a lot of other places in the north of Ghana, has very shallow soil and no organic fertilizer (Roan, 2023). The socioeconomic development of Bawku West District is significantly influenced by agriculture (Bawa & Jambedu, 2022). It provides more than 80% of the population with employment and income. There are 58,406 Ha of cultivable land and 33,687 Ha of uncultivable land (Akumbole et al., 2019). The district has an Agricultural Development unit which is mandated in ensuring food security and household incomes throughout the year (Edaku et al., 2023).

### 3.2.4 Climate



The district has a protracted dry season that lasts eight months of the year (September to April) in addition to a single rainfall maxima that lasts four months (May to August) (Siabi et al., 2022). The area sees considerable rainfall during this time, which supports the district's agricultural activity. The district experiences an annual temperature of 32.16ºC (89.89ºF), which is 3.3% higher than the average for Ghana. Bawku West experiences 83.16 wet days (22.78% of the time) and 45.48 millimeters (1.79 inches) of precipitation on average each year. The precise amount of rainfall can differ from year to year, and over time, variables like climate change can have an impact on the pattern of precipitation. There is a 19,255 mm difference between evapotranspiration and rainfall. With an aridity index of roughly 0.33 (annual precipitation to potential evaporation), the region falls into the UNCCD's range of 0.05 to 0.65, designating it as a desert (Ansah-Mensah & Asamoah, 2023). The weather in the district is harsh and there is little rainfall. The primary crops that thrive in the area include soy beans, bambara beans, rice, sorghum, groundnuts, and maize, sometimes referred to as 'Nara' (Fatondji et al., 2010).

### 3.2.5 Vegetation

The vegetation present in the Bawku West District is Sudan savanna vegetation made up of short, fire- and drought-resistant deciduous trees scattered among open savanna grassland (Adjabui, 2018). In most places, the ground is terribly barren and there is very little grass (Ogunbode et al., 2021). In the less eroded parts, common grasses are Andropogan gayanus; in the highly eroded sections, common grasses are Hyparhenia spp., Aristida spp., and Heteropogon spp (Ayariga, 2022). Common trees are Triplochiton spp., Acacia spp. (Thorn tree), and Anogeissus spp. Parkia filicoidea (Dawadawa), Butyrospermum parkii (Sheanut), Andansonia digitata (Baobab), and Ceiba pentandra (Kapok) are examples of economic trees (Sadat, 2022). The district encompasses the uninhabited forest reserve located in the eastern and southern parts of the Red and White Volta, extending from the Widnaba-Tilli region through Binaba-Kusanaba and Zongoyiri to East Mamprusi, in addition to the lightly populated Oncho-freed woodland and forest corridor (Ayariga, 2022).

### 3.2.6 Relief and Drainage

The district's topography ranges from flat to gently undulating, with slopes between one and five percent (Chegbeleh et al., 2020). Hills created by granite intrusions or outcrops of Birimian rocks, or greenstones, occasionally interrupt these plains (Brako et al., 2022). The Red Volta turns south-west from these ranges north of Nangodi in the Talensi/Nabdam area, and they border Burkina Faso to the north of Zebilla (Carrier et al., 2011). Both the White and Red Volta and their tributaries drain the District (Agodzo et al., 2023). During the rainy season, the rivers overflow their banks. Farmers are able to obtain water from the White Volta for irrigation since the Bagre dam consistently has an inflow of water during the dry season (Atubiga et al., 2023).

### 3.2.7 Soil and Geology

The district's total hectares that are ideal and unsuited for growing crops are 336,687 and 58,406, respectively. The primary soil types in the district are luvisols, lixisols, leptosols, gleysols, and fluvisols. Vertisols, plinthosols, cambisols, and regosols are some other, less common types of soils found in the area (Asiamah, 2008). They have evolved over granites, mixed-origin recent and old alluvia, and Birimian rocks. Many of the soils are sandy with clay limited to valley bottoms because these parent materials have coarse textures (Gyekye et al., 2021). Large tracts of rocky and shallow aggregated soils exist as well; these soil types are not very suitable for agriculture and cannot hold much water. Due to their development over extensively weathered parent materials, the majority of the soils are ancient and have been leached over an extended period of time. Because kaolinitic clay minerals make up the majority of their clay mineral composition, their buffering and cation exchange capacities are also relatively small (Okofo, 2023). As a result, the majority of soils have low levels of natural fertility. Phosphorus and nitrogen are the two nutrients that are most usually lacking. Regular burning of crop residues and usage of these residues for fuel, animal feed, or building purposes limit the accumulation of any amount of organic matter. The majority of the soils are also vulnerable to erosion during the rainy season because of the minimal vegetation cover during the dry season (Sekyi-Annan et al., 2021). This further aggravates the issue of low fertility.

The district's underlying rocks have a direct impact on its soils and water supply (Sunkari et al., 2024). The primary rocks are found in the Granitic and Birimian geological formations. The Birimian rocks, which are frequently connected to granites, are made up of volcanic and metamorphosed sediments that dip sharply (Senyah, 2021). Some of the phyllites, biotite schists, and quartzites that make up the argillaceous rocks of the Birimian formation can be found north of Zebilla, south of Sapeliga, and in the vicinity of Zongoyiri. The volcanic group consists of greenstones, hornblende schists, and phyllites. The rocks are located in Apodabogo and to the north of Zebilla as hill ranges. The Birimian formation is said to be underlain by gold deposits to the north of Zebilla and to the south of Sapeliga. Illegal gold mining is common in the Widnaba-Teshie zone, where it is also associated with significant land degradation. Since the majority of these mining operations take place on agricultural land, further land degradation would have a significant negative impact on agricultural production and household food security in the district if the activities of these illegal miners, who are becoming more prevalent, are not stopped. This would make the district's already dire socioeconomic condition worse because the majority of the population—more than 80% of them—are dependent on agriculture for a living.

### 3.3 Study Philosophy

Pragmatism is a research philosophy which stresses practical results, solutions-focused thinking, and real-world application of knowledge (Scott, 2024). Pragmatism, which emerged from the writings of philosophers like John Dewey, William James, and Charles Peirce, disputes the strict distinction between positivism and interpretivism (Voparil & Voparil, 2022). Instead, it contends that the worth of any concept or approach depends in its effectiveness in addressing a given problem (Hampson & McKinley, 2023). Pragmatism consequently prioritizes “what works” in providing credible, practical, and context-relevant information (Lazarus et al., 2025). At the basis of pragmatism is the concept that reality is diverse and dynamic. Human experiences, meanings, and observable occurrences all contribute to comprehending phenomena. Pragmatism therefore encourages methodological flexibility, enabling researchers to integrate qualitative and quantitative methods (Foster, 2024). Mixed-methods research is particularly connected with pragmatism since it allows the researcher to draw from numerous techniques, viewpoints, and data kinds to achieve a more thorough knowledge of difficult topics (Dawadi et al., 2021). Additionally, pragmatism acknowledges the intrinsic worth of research. Pragmatism recognizes that the researcher's values influence the choice of issues and techniques, but the validity of findings rests on their practical efficacy rather than asserting objectivity as absolute or embracing complete subjectivity (Sim et al., 2024). Knowledge becomes significant when it can provide solutions, guide decisions, and enhance practice.

There are several reasons why pragmatism is a valid research philosophy. First, rather than following certain philosophical traditions, it provides freedom in selecting methodologies that best fit the study subject (Dube et al., 2024). Because of this, it is perfect for researching intricate social, environmental, educational, and technical issues that are difficult to completely comprehend from a single point of view (Kanazawa, 2023). Also, pragmatism enables researchers to concentrate on results and ramifications, guaranteeing that study produces observable advantages for practice, policy, or society (Mulatu & Negash, 2024). In addition, by integrating many types of evidence, pragmatism strengthens the validity and variety of conclusions. Lastly, pragmatism provides a strong and flexible basis for applied research as it encourages a balanced understanding of reality by acknowledging both objective facts and subjective experiences (Elgeddawy & Abouraia, 2024).

### 3.4 Methodology

A research method is the organized process that scientists use to gather, examine, and evaluate evidence to find an answer to a question or verify a theory (Thomas et al., 2022). It is an organized method or collection of methods that directs researchers while they carry out studies (Tracy, 2024). Depending on the discipline, the type of research issue, and the favored theoretical and philosophical framework, research methodologies can differ greatly. For the purposes of this research, both the qualitative and quantitative (mixed) methods of research were employed. Approaching complicated research questions in a mixed-methods design has several benefits since it combines the philosophical frameworks of interpretivism and post-positivism, integrating qualitative and quantitative data to meaningfully explain research issues (Dawadi et al., 2021). Researchers can address research topics with adequate depth and breadth when they employ mixed-methods research designs, which also facilitate the generalization of findings and implications of the studied issues to the entire population (Sharma et al., 2023). In this workpiece, the exploratory type of study was employed, considering the limited knowledge of the topic in the study area. This ensured that the research topic is well understood, provide a basis for comprehensive study in the future, and suggest laudable policies and interventions.

#### 3.4.1 Sample Size and Sampling Techniques



The sampling technique employed include the cluster sampling, purposive and snowball methods, where farmers and agricultural extension officers in the area were the respondents. The cluster sampling method made it possible for the district to be divided into clusters to be able to administer the questionnaires and conduct interviews. Due to the large and sparse nature of the area, the district was divided into five clusters (north, south, east, west, and central). Six major towns were then identified from amongst these clusters, where interviews were conducted and questionnaires administered. Whereas the purposive sampling allowed for only a targeted group of people (farmers and extension officers) to be engaged, snowball gave the opportunity for other people in the same fields to be interviewed and administered questionnaires.

### 3.4.2 Data Collection and Analysis

#### 3.4.2.1 Qualitative Data Analysis

In collecting qualitative data, a total of twenty-two (22) farmers in the study area were engaged in in-depth interviews using interview guide to get their views on land degradation and how it has affected their yields of farm produce. This data was then transcribed.

#### 3.4.2.2 Quantitative Data Analysis

For the quantitative two hundred and four (204) persons were administered questionnaires in the form of semi-structured and open-ended questions out of the total population of 114,189. With the aid of Statistical Package for Social Science (SPSS), chi-square test was used for the analysis of the data. Agricultural data was also obtained from the Agricultural Directorate of the Bawku West District to analyse the trend of agricultural productivity in the district. Later on, spectral angle mapper classification and change detection analysis were carried out on the images. Change detection is given as;

$\Delta DN = DN2 - DN1$

Where: ΔDN is the change in digital numbers between the two images.

DN2 is the digital number of the second (current) image.

DN1 is the digital number of the first (former) image.

The supervised method of classification was employed in the classification process while the post-classification type of change detection was carried out. This made it possible to compare the classified images from different time periods. ArcMap 10.8 was also used to generate maps. Agricultural data on the production of major staples in the district including maize, rice, millet, and sorghum was also received from the District Directorate of Agriculture. Moreover, the Ghana districts shape file, the Ghana settlements shape file, and the Ghana roads shapefile were obtained from the Remote Sensing and Geographic Information Systems (RSGIS) Laboratory of the Department of Geography and Resource Development of the University of Ghana.

In testing the hypothesis, the correlation analysis was used, which helped in determining the degree of association between land degradation and food security in the area. For the qualitative data, I transcribed, read, and interpreted the interview recordings.

**Table 3.1 Number of questionnaires administered and interviews conducted**

| Towns | Number of questionnaires administered (Quantitative) | Number of interviews conducted (Qualitative) |
|---:|---:|---:|
| Zongoyiri | 35 | 4 |
| Widnaba | 35 | 4 |
| Sapeliga | 35 | 4 |
| Boyaa | 35 | 4 |
| Binaba | 35 | 4 |
| Zebilla | 29 | 2 |
| **Total** | **204** | **22** |

*Source: Field survey, 2024.*

From Table 3.1 above, it was noted that for the quantitative data collection, thirty-five questionnaires each were administered in five of the major towns (Sapeliga, Zongoyiri, Boyaa, Widnaba, and Binaba), whilst Zebilla, being the district capital, had twenty-nine persons filling out the questionnaires. Also, for the qualitative data collection, four interviews were conducted in each of the five major towns, with Zebilla recording only two of the interview sessions. The employment of the purposive sampling was to ensure that individuals who were engaged in farming activities, in one way or the other were the ones engaged with. This was to get the first-hand information and practical views from them. This was quite difficult since individuals were to be identified, pre-informed, and the interview scheduled. Due to this, the snowball method was also employed. This gave me the advantage of prospective respondents being recommended to me by those who had either partook in the interview session or filled the questionnaire.

**Table 3.2. Satellite Image Information**

| Spacecraft ID | Sensor ID | Date Acquired | Scene Sensor Time | WRS Path | WRS Row | Resolution (meters) | Cloud Cover |
|---|---|---|---|---|---|---|---|
| Landsat 7 | ETM | 2002-10-30 | 10:08:04 | 194 | 052 | 30x30 | 0.00 |
| Landsat 7 | ETM | 2002-10-30 | 10:08:27 | 194 | 053 | 30x30 | 0.00 |
| Landsat 7 | ETM | 2012-11-10 | 10:16:10 | 194 | 052 | 30x30 | 0.00 |
| Landsat 7 | ETM | 2012-11-10 | 10:16:34 | 194 | 053 | 30x30 | 0.00 |
| Landsat 7 | ETM | 2022-10-18 | 08:41:31 | 194 | 052 | 30x30 | 0.00 |
| Landsat 7 | ETM | 2022-10-18 | 08:41:55 | 194 | 053 | 30x30 | 0.00 |

*Source: Metadata files—2002, 2012, 2022*

### 3.5 Image Pre-Processing

In remote sensing, "image pre-processing" is a set of procedures used on unprocessed or raw remote sensing data to improve its quality, make geometric and radiometric corrections, and get it ready for further analysis and interpretation (An, 2024). Before collecting meaningful information from remote sensing data, the pre-processing stages are essential for increasing the accuracy and dependability of the data (Maharana et al., 2022). Six satellite images with paths and rows 194/052 and 194/053 were downloaded from the United States Geological Survey (USGS) website from the year 2002-2022, with a ten-year interval. They were then pre-processed using the ENVI 5.3 software. The first step here was to perform gapfill on the images. This process ensured that scan lines on the images were removed. Also the QUick Atmospheric Correction (QUAC) tool was applied on the images to eliminate atmospheric effects from the images. This process guarantees that the pixel values of the images correspond to precise and comparable measurements of surface reflectance (Jia et al., 2020). The images were then mosaicked and gapfilled. There was also atmospheric correction performed on the images, subsetting was subsequently done.

### 3.5.1 Mosaicking

Multiple overlapping images are frequently used to collect remote sensing data. Image mosaicking is fusing these isolated images to form a continuous composite image across a wider area (Maric et al., 2021). Due to the fact that the study area falls on two different Landsat images, the mosaicking tool had to be used to merge these images to be able to extract the study area. In this process, the seamless mosaic tool, which is limited to 10 bands was used to perform this function.

### 3.5.2 Atmospheric Correction

Electromagnetic energy travels twice through the atmosphere; one from the sun to the earth and the other from the Earth to the sensor (Kato et al., 2020). The sun’s downwelling radiation is irradiance whilst the upwelling radiation from the earth to the sensor is known as radiation

(Ferreira et al., 2020). Absorption produces a haziness impression while reducing intensity. Electromagnetic radiation in the atmosphere is then redirected through scattering, creating an adjacent effect whereby nearby pixels are shared (Rouhi et al., 2021). These two procedures have a significant impact on image quality and hence the impacts of these processes need to be removed through atmospheric correction. Atmospheric correction simply refers to the practice of controlling or eliminating atmospheric impacts on the reflectance values of images taken by satellites (Thompson et al., 2019). This procedure is necessary in image restoration because it allows for more precise monitoring and analyzing of environmental conditions (Richards & Richards, 2022). In carrying out this process, the QUAC which is found under the Radiometric Correction in the toolbox of ENVI 5.3 was used.

### 3.5.3 Subsetting

Subsetting, as employed in ENVI software, is the process of choosing and extracting a particular section or region of interest from an image or dataset for additional analysis (Sheykhmousa et al., 2020). When working with large or complex datasets, a subset of the data can be isolated and manipulated rather than the complete dataset (Senol et al., 2024). Subsetting in ENVI allows efficient minimize the amount of data and concentrates analysis on the areas or features that are important for a particular research or application (Kattenborn et al., 2021). Landsat image footprint covers an area of 185km by 185km which covers the entire upper east region and beyond. Subsetting tool was used to extract the Bawku West district as a region of interest from the entire image for further processing.



### 3.5.4 Classification

The process of classifying pixels or image objects in a remotely sensed image into multiple classes or categories based on their spectral, spatial, and temporal features is known as classification in remote sensing (Mehmood et al., 2022). In remote sensing analysis, it is a fundamental activity that is utilized to draw out useful data from satellite image or aerial photos. Each pixel or image item is classified by being assigned to a certain class or category of land cover type (such as vegetation, water, or urban regions). Delineating and differentiating land cover classes of a region of interest into categories we use classification algorithms. One useful classification algorithms commonly used in remote sensing is supervised classification and unsupervised classification (Foroughnia et al., 2022). Supervised Classification involves labeling each pixel sample with the appropriate class or category before using it to train the classification algorithm on a set of typical samples known as training data (Sen et al., 2020). To categorize the remaining pixels or picture element in the scene, the algorithm first learns the spectral patterns and properties of the training data. Support vector machines (SVM), decision trees, random forests, and maximum likelihood are examples of common supervised classification techniques (classifiers). In Unsupervised Classification, the classification algorithm automatically divides pixels or other visual objects into groups based on their statistical similarity without knowing the classes beforehand (Matci & Avdan, 2020). The technique allocates spectrally related clusters or regions and categorizes them into various land cover classifications. Following that, the user interprets these classes using their spectral properties. Self-organizing maps (SOM), hierarchical clustering, Isodata and k-means clustering are examples of unsupervised classification approaches or classifiers commonly used. There are other more sophisticated classification methods, such as object-based image analysis (OBIA), which increases classification accuracy by taking into account both the spectral and spatial characteristics of picture objects. OBIA algorithms examine collections of pixels that make up meaningful things, such as fields or buildings, and classify them according to their shape, texture, and environment (Hossain, 2023). In many remote sensing applications including land cover mapping, change detection, urban planning, environmental monitoring, and natural resource management, classification is vital. For this work, the Spectral Angle Mapper (SAM) classifier was employed, and land cover types that were used included farmlands, settlements, vegetation, water bodies, and degraded lands. The SAM was used to detect areas that have suffered land degradation based on vegetation availability.

In remote sensing and image processing, the SAM is a common spectral classification approach for classifying pixels (Gopinath et al., 2020). It measures the angular similarity between the reference spectra and the spectral signature of a target pixel, working based on the spectral similarity principle (Tripathi et al., 2019). The foundation of SAM is the notion that a pixel's spectral signature can be expressed as a vector in a multi-dimensional space, with each dimension denoting a distinct spectral band (Sharma & Verma, 2022). Then, the similarity between two vectors is calculated using their spectral angle. Applications for SAM can be found in many fields, including land cover classification, agricultural, geological research, and environmental monitoring. When analyzing a high number of spectral bands, such as in hyperspectral imaging, it becomes particularly helpful.

### 3.5.5 Change Detection

The term "change detection analysis" refers to a wide range of techniques for locating, describing, and quantifying differences between images that are taken at various periods or under various circumstances of the same scene (Tewkesbury, 2019). It involves locating and evaluating variations or changes in the Earth's surface over time using data collected by remote sensors (Asokan & Anitha, 2019). Identifying regions or features that have experienced major changes require the comparison of two or more satellite images or datasets obtained at various times. Consequently, in this study, the three Landsat 7 images obtained with a twenty-year interval

(2002, 2012, and 2022) underwent change detection analysis to ascertain the transformations that the area has undergone within these years. In ENVI 5.3 software, change detection analysis is expressed either as a pixel count, a percentage, or area in square meters. For the purpose of this study, the change detection analysis was expressed in square kilometers ($km^2$).

In summary, chapter three takes into account the location and size of the study area, its socio-demographic and economic characteristics. It goes on to discuss the philosophical underpinning of the study and its justification, the methodology that was employed, the sampling size and sampling techniques, and the data collection and analysis.

# CHAPTER FOUR: EXAMINING THE SPATIO-TEMPORAL EXTENT OF LAND DEGRADATION IN BAWKU WEST DISTRICT USING VEGETATION AVAILABILITY

## 4.1 Introduction

The location, size, socio-demographic, and economic features of the research area are all considered in chapter three above. The study's philosophy and rationale, the methodology used, the sample size and sampling techniques, and the data collection and analysis are all covered in chapter three. The objective of this chapter is to present and discuss the results. Emphases will be given to objectives one and two, which are to examine the spatio-temporal extent of the degree of land degradation in Bawku West District using vegetation availability as an early warning indicator and to estimate the rate of land degradation in the area from 2002-2022.

## 4.2 Socio-Demographic Profile of Respondents

The socio-demographic characteristics presented in this results section include age, sex, level of education, length of stay in the Bawku West District, ownership of farm (s), and number of years of experience in farming. The age of the farmers engaged ranged between 28 and 80 years, with an average age of 50.7 years. Table 4.1 indicates that the majority of the farmers are aged between 51 and 65 years, and represents 39.7% of study respondents. The data further shows that a lower percentage of respondents are within the age group of 20 and 35 years; this is usually referred to as the youthful group. This could be attributed to the fact that most of the people in this age group are in school since it is a school-going age. Another possible reason for this could be because of the unwillingness of the youth in the study area to engage in farming activities, and this is not different from other parts of the country as most youths do not show interest in farming (Osei et al., 2023). According to the data, 22.6% of the respondents who are aged between 66 and 80, has the second least representation of 46 people.

**Table 4.1. Age Distribution of Respondents**

| Age Group | Frequency | Frequency (%) |
|---|---|---|
| 20-35 | 27 | 13.2 |
| 36-50 | 50 | 24.5 |
| 51-65 | 81 | 39.7 |
| 66-80 | 46 | 22.6 |
| **Total** | **204** | **100.0** |

*Source: Field Survey, 2024.*

The result reveals that most of the respondents in the study area are males, who constitute 71.6% and females 28.4 of the respondents. This is indicated in Table 4.2 below. From the survey, 79% of the male farmers are engaged in the cultivation of crops such as maize, rice, and millet whilst 66% of the females are mostly into the cultivation of tomatoes, okra, pepper, and other vegetables. These are usually done on relatively smaller pieces of land within the communities.

**Table 4.2. Sex Distribution of Respondents**

| Sex | Frequency | Frequency (%) |
|---|---|---|
| **Male** | 146 | 71.6 |
| **Female** | 58 | 28.4 |
| **Total** | **204** | **100.0** |

*Source: Field Survey, 2024.*

Education plays a crucial role in the evolution of society, and educational attainment is regarded as a key indicator of human development as well as a measure of a nation's level of development. As such, one can assess a nation's extent of development by looking at its high literacy rate. The data collected shows that the level of education in the study area is quite low. From Table 4.3, there is a realization that most of the respondents have had formal education up to the primary level (42.2%). This is followed by those who have attained education to the Junior Secondary/Junior High School level, which represents 22.5%. From the data, 21.1% of the respondents in the Bawku West District have no formal education. From the study those with no formal education are mostly the aged people who are between the ages of 66 and 80. Respondents who have attained either Senior Secondary/Senior High School or Technical and Vocational Education and Training represents 10.8%, while 3.4% have attained tertiary education.

**Table 4.3. Educational Level of Respondents**

| Educational Level | Frequency | Frequency (%) |
|---:|---:|---:|
| Tertiary | 7 | 3.4 |
| SSS/SHS/TVET | 22 | 10.8 |
| JSS/JHS | 46 | 22.5 |
| Primary | 86 | 42.2 |
| None | 43 | 21.1 |
| **Total** | **204** | **100.0** |

*Source: Field Survey, 2024.*

The types of crops cultivated in the district are usually cereals and grains such as sorghum, maize, groundnut, beans (Bambara and soya), rice, and millet (Gyamerah et al., 2024). Table 4.4 below provides a list of some crops that are cultivated in the district. Most of the farmers cultivate one or more of these crops because of their ability to thrive there. Aside these crops, there are other crops that are being cultivated. These include tubers like potato, yam, and cassava (Abdullah et al., 2022).

**Table 4.4. Some types of crops that are cultivated in the Bawku West District**

| | Crop | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Maize** | | **Rice** | | **Millet** | | **Sorghum** | |
| **Year** | **Area** | **Prod. (MT)** | **Area** | **Prod. (MT)** | **Area** | **Prod. (MT)** | **Area** | **Prod. (MT)** |
| 2002 | 2,684 | 2,174 | 2,395 | 3,113 | 11,267 | 9,013 | 10,663 | 12,795 |
| 2004 | 2,090 | 3,511 | 2,170 | 3,211 | 12,100 | 7,502 | 13,050 | 9,265 |
| 2006 | 2,040 | 2,203 | 2,529 | 3,287 | 11,081 | 12,189 | 10,462 | 10,462 |
| 2008 | 3,530 | 4,977 | 4,804 | 13,979 | 23,018 | 27,161 | 13,674 | 18,323 |
| 2010 | 6,140 | 8,596 | 5,616 | 15,724 | 10,154 | 12,794 | 10,980 | 15,372 |
| 2012 | 6,880 | 11,696 | 6,640 | 18,592 | 11,220 | 13,464 | 10,750 | 13,975 |
| 2014 | 7,043 | 9,860 | 6,934 | 19,276 | 10,900 | 10,573 | 10,700 | 11,556 |
| 2016 | 7,258 | 11,612 | 6,650 | 11,970 | 10,900 | 10,900 | 10,700 | 11,770 |
| 2018 | 8,519 | 12,778 | 3,111 | 6,844 | 6,521 | 7,173 | 7,621 | 9,145 |
| 2020 | 8,540 | 15,542 | 3,677 | 10,295 | 6,960 | 6,264 | 6,200 | 6,820 |
| 2022 | 7,450 | 11,994 | 3,740 | 10,472 | 6,920 | 6,366 | 7,005 | 7,845 |

*Source: Agricultural Directorate—BWD, 2024*

### 4.3 Spatio-temporal extent of land degradation in Bawku West District Using Vegetation Availability

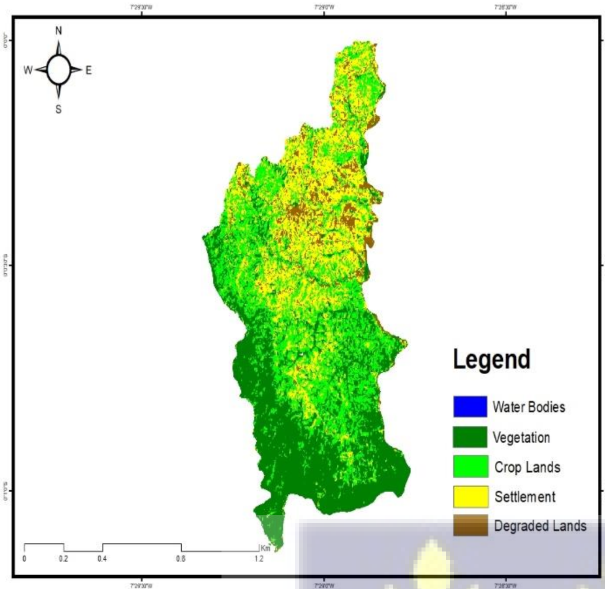



**Figure 4.1: LULC 2002**
*Source: Author, 2024*

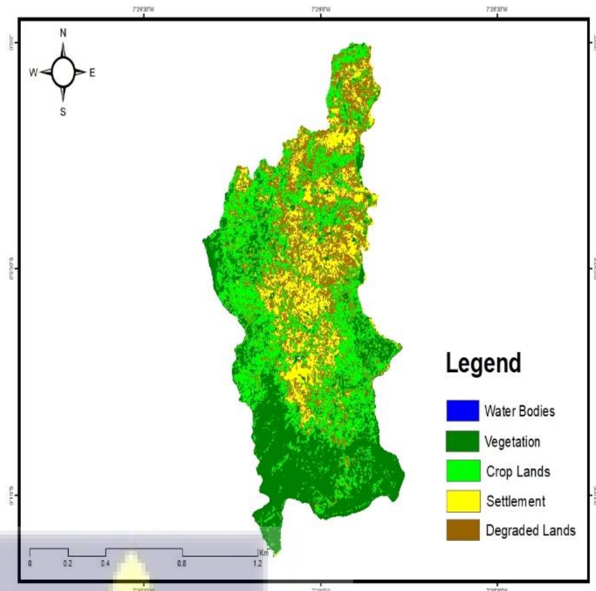



**Figure 4.2: LULC 2012**
*Source: Author, 2024*

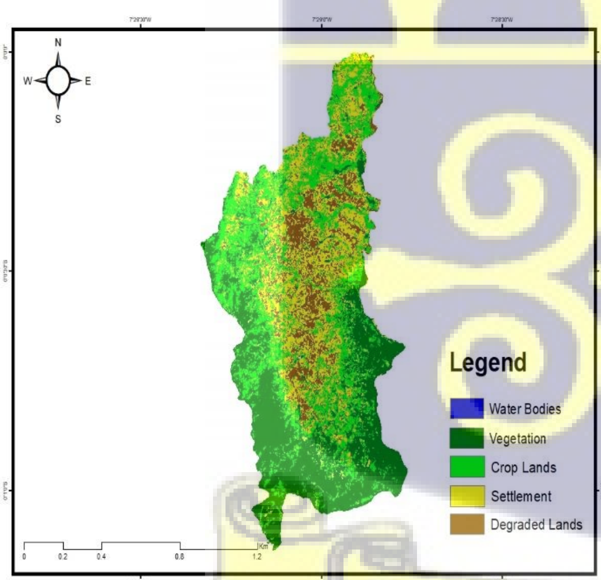



**Figure 4.3: LULC 2022**
*Source: Author, 2024*

From figures 4.1, 4.2, and 4.3, we notice a gradual increase in the level of degraded lands in the study area. Land degradation in the BWD has mostly been as a result of human activity that started with growth in population and uncontrolled bush fires. Extensive farming, the elimination of vegetation, and intensive cultivation made it worse. The number of farm plots per person has declined as population pressure increases. Thus, there has been insufficient time for natural land rejuvenation as a result of the fallow period being shortened. Bush fallow systems is therefore, no longer viable due to population pressure, which has compelled farmers to switch to continuous cropping. Respondents indicated that factors responsible for land degradation on their farm lands include bush burning, over-grazing, deforestation, illegal mining, soil fertility loss due to the excessive use of chemicals for farming, and the actions of hunters.

### 4.3.1 Accuracy Assessment of Classified Imagery for Spatio-Temporal Analysis of Land Degradation

The process of evaluating the reliability and accuracy of information obtained from remote sensing data is referred to as "accuracy assessment" in the context of remote sensing (Morales-Barquero et al., 2019). In remote sensing, accuracy assessment is an essential step in determining the quality and dependability of data obtained from satellite or aerial imagery. It entails assessing the accuracy of the satellite imagery by contrasting their findings with data that is grounded in reality (Kattenborn et al., 2021). Accuracy assessment is an important step in the process that determines the quality and precision of the data obtained from remote sensing applications, such as the mapping of vegetation, change detection, land cover classification, and other geospatial researches. In remote sensing applications, accuracy assessment is essential because it helps researchers, analysts, and decision-makers understand the limitations of the information obtained and make informed decisions based on the data's reliability.

In this instance, I carried out an accuracy assessment of the classification to ensure validity of geospatial data and maps, employing the confusion matrix using ground truth image to help in determining the overall accuracy as well as the kappa coefficient of the classification.

The overall accuracy and kappa coefficient of the datasets after the analysis were given as 75.1844% and 0.6467 respectively.

**Table 4.5. Producer and User Accuracy**

| Class | Producer Accuracy (%) | User Accuracy (%) |
|---:|---:|---:|
| Water Bodies | 66.98 | 71.73 |
| Vegetation | 80.37 | 78.67 |
| Crop Lands | 75.76 | 72.59 |
| Settlement | 77.98 | 69.96 |
| Degraded Land | 78.65 | 60.84 |

*Source: Satellite imagery—2002, 2012, and 2022*

The producer and user accuracy of the datasets are displayed in Table 4.5 above. The percentage of ground truth positive samples that the remote sensing classification algorithm successfully detects or classifies as positive is known as producer accuracy. Put otherwise, it evaluates the degree to which the classification technique is able to recognize real good cases. An algorithm that is more accurate in producing results is identifying the target features on the ground with accuracy, indicating a more reliable categorization procedure. The percentage of accurately identified or discovered positive samples. User accuracy is defined as positive samples when compared to ground truth. In other words, it measures the accuracy of the remote sensing classification by preventing false positives. Since the system of classification produces fewer false positives when user accuracy improves, the classification findings can be trusted.

### 4.3.2 Estimating the rate of Land Degradation in the Bawku West District from 2002-2022

**Table 4.6. Land Use and Land Cover Change Between 2002 and 2012**

| | Vegetation | Water Bodies | Degraded Lands | Settlement | Crop Lands | Row Total | Class Total |
|---|---|---|---|---|---|---|---|
| **Vegetation** | 126.7227 | 0.063 | 1.5048 | 7.0218 | 27.8397 | 163.152 | 178.7013 |
| **Water Bodies** | 0.0018 | 0.1557 | 0.009 | 0.0009 | 0.0000 | 0.1674 | 0.4311 |
| **Degraded Lands** | 23.6223 | 0.0387 | 3.7071 | 72.9657 | 112.283 | 212.617 | 221.0751 |
| **Settlement** | 11.7036 | 0.0351 | 7.2405 | 57.2697 | 72.5409 | 148.790 | 156.5946 |
| **Crop Lands** | 203.4432 | 1.3032 | 4.5738 | 77.9634 | 207.796 | 495.08 | 509.2812 |
| **Class Total** | 365.4936 | 1.5957 | 17.0352 | 215.2215 | 420.459 | | |
| **Class Changes** | 238.7709 | 0.5409 | 13.3280 | 157.9518 | 213.242 | | |
| **Image Difference** | -186.7923 | -0.266 | 204.0399 | -58.6269 | 88.822 | | |

*Source: Change Detection Statistics*

From Table 4.6 above, vegetation cover lost 186.7923km² between the years of 2002 and 2012. This indicates that annually, 18.6792km² of vegetation cover is lost. Within the same period, degraded lands gained a total area of 204.0399km², which is a red flag for land health and food production. This shows a yearly degradation of 20.4039km² within the ten-year period. This further indicates that the rate of land degradation per month for the period amounts to 1.7003km². Crop lands however, had a net increase of 88.822km².

**Table 4.7. Land Use and Land Cover Change Between 2012 and 2022**

| | Vegetation | Water Bodies | Degraded Lands | Settlement | Crop Lands | Row Total | Class Total |
|---|---|---|---|---|---|---|---|
| **Vegetation** | 17.3361 | 0.0000 | 0.0396 | 0.0954 | 1.0476 | 18.5193 | 19.0998 |
| **Water Bodies** | 0.1071 | 0.2511 | 0.0432 | 0.0750 | 0.1395 | 0.6174 | 1.2384 |
| **Degraded Lands** | 29.4723 | 0.0018 | 109.1205 | 26.0505 | 273.8331 | 438.4782 | 424.0935 |
| **Settlement** | 13.0536 | 0.1782 | 107.4285 | 127.8243 | 88.4232 | 336.9078 | 303.7716 |
| **Crop Lands** | 118.7316 | 0.0000 | 4.4433 | 2.5479 | 145.8378 | 271.5606 | 252.5616 |
| **Class Total** | 178.7013 | 0.4311 | 221.0751 | 156.5946 | 509.2812 | | |
| **Class Changes** | 161.3646 | 0.1800 | 127.5732 | 55.4598 | 383.5197 | | |
| **Image Difference** | -159.6015 | 0.8073 | 203.0184 | 147.1770 | -256.720 | | |

*Source: Change Detection Statistics*

Between 2012 and 2022, vegetation lost a total area of 159.6015km², indicating an annual loss of 15.9602km². Comparing the period between 2002 and 2012, and 2012 and 2022, we realize that the rate of land degradation had decreased by 2.719km². This could be due to the results of some measures that were put in place. A typical example is the "Regreening Africa" initiative which was introduced in 2017 to reclaim degraded lands in the district. This is also evident as degraded lands from Table 4.7 above gained a total land area of 203.0184km² as compared to the previous period (2002 – 2012) where it gained 204.0399km². It was rather unfortunate that crop lands lost 256.720km².

**Table 4.8. Land Use and Land Cover Change between 2002 and 2022**

| | Vegetation | Water Bodies | Degraded Lands | Settlement | Crop Lands | Row Total | Class Total |
|---|---|---|---|---|---|---|---|
| **Vegetation** | 13.7574 | 0.000 | 0.1422 | 0.3537 | 1.0224 | 15.2757 | 19.0998 |
| **Water Bodies** | 0.0018 | 0.5166 | 0.0000 | 0.0009 | 0.0054 | 0.5247 | 1.2384 |
| **Degraded Lands** | 137.6739 | 0.0162 | 3.0969 | 78.6222 | 187.108 | 406.518 | 424.0935 |
| **Settlement** | 41.2812 | 0.1593 | 12.9564 | 125.7192 | 150.076 | 330.192 | 303.7716 |
| **Crop Lands** | 172.7793 | 0.0045 | 0.8397 | 10.5255 | 82.2474 | 266.396 | 252.5616 |
| **Class Total** | 365.4936 | 0.6966 | 17.0352 | 215.2215 | 420.460 | | |
| **Class Changes** | 351.7362 | 0.1800 | 13.9383 | 107.4141 | 363.071 | | |
| **Image Difference** | -346.3939 | 0.5418 | 407.0583 | 88.5501 | -167.898 | | |

*Source: Change Detection Statistics*

From Table 4.8 above, there is the realization that vegetation had lost 346.3939km² between 2002 and 2022, representing a total loss of 32.3732%. These losses were made largely to crop lands and degraded lands which accounted for 172.7793km² and 137.6739km² respectively. Overall, lands degraded in the Bawku West District amounted to 407.0583km² for the twenty-year period (2002 and 2022), constituting 38.0428% of the total land area in the district. This gives an average annual gain in degraded lands 20.3529km² while vegetation loss accounts for an average annual loss of 17.3197km². With reference to the data above, it is manifested that within the period, 1.9021% of the land is degraded every year. In addition, 1.6186% of the vegetative cover of the area is lost per annum. According to the respondents, areas within the district which have been more affected by land degradation include Teshie, Binaba, Sapeliga, and Binaba. These are areas where activities of bush fires, sand winning, and illegal mining are predominant. The only areas where there is significant vegetative cover is Tilli, which is a forest reserve, and some parts of Zongoyiri.

### 4.4 Causes and Effects of Land Degradation in the Bawku West District

The district is renowned for its recurrent bush fires that occur throughout the dry season. For instance, the Tilli forest reserve witnesses annual bush fires from November to April during prolonged drought periods. These fires are typically ignited by local residents in their quest for game (bush meat), often disguised as efforts to drive away wild animals that venture near the communities, or as a consequence of employing fire in honey hunting. The result of these fires is that the land is stripped of its vegetative cover, as they burn grasses and trees, destroying pastures for livestock. One more reason why most farmers burn their farms is to clear the land for the next crop season. Bush burning is occasionally employed as a traditional agricultural technique to make land suitable for cultivation or to induce new growth. However, if not used appropriately, this procedure might be detrimental. The farmers were of the view that aside it being a quick method of clearing the land, there is essential nutrient which comes along with burning the farm land which aids in the growth of crops. They indicated that this nutrient, known as potash, is embedded in the ashes. *"Despite this, there are instances where burning of farm lands could get out of hands."* This statement was made a 63-year old famer in Binaba. He points out that sometimes when a farm land is set ablaze, it affects nearby farms which causes the fire to spread wide. He further reiterated that due to this, fire belts are always created to ensure that nearby farms are not affected by the fires. Also, bush fires caused by the actions of hunters was one of the issues raised by some of the respondents. A 58-year-old man in Widnaba lamented bitterly that he lost nearly half of his four-acre maize farm as a result of the activities of hunters. *"I was home when a colleague and neighboring farmer came to inform me that my farm is in flames. I quickly rushed to my farm and realized that people tried hunted for game using fire, after which they left the fire without quenching it. This spread on the farm, causing about half of it to be razed down."*

Bush burning contributes to habitat loss and deforestation, which could result in soil erosion, a decline in biodiversity, and ecological disruption (Driscoll et al., 2021). It contributes to climate change by releasing greenhouse gases into the atmosphere, including carbon dioxide. Bush burning can be less frequent by raising knowledge of its detrimental consequences and encouraging the use of alternate land-cleaning techniques like mulching or mechanical clearing (Roggema, 2022). For sustainable land management techniques to be implemented, community involvement and education are essential.

A major environmental issue known as overgrazing arises when pastures are grazed for prolonged periods of time without adequate recovery to allow for the regeneration of forage on pasture lands (Ibrahim & Usman, 2021). Without efforts to lessen the risks associated with overgrazing in pasture regions, the vicious cycle keeps getting worse. Overgrazing can lower ground cover, which makes the soil more susceptible to erosion and compaction from wind and rain, according to the World Wildlife Fund (WWF). This diminishes the potential of plants to grow and water to penetrate the soil, harming soil micro-organisms and causing substantial erosion of the land.

In Ghana's Bawku West District, raising livestock is a significant agricultural industry that supports the livelihoods of many locals (Azumah et al., 2023). The area is well-known for raising a variety of livestock, including sheep, goats, and cattle. There are also donkeys which are mostly used for agricultural and transportation purposes. The district suffers from the damaging impacts of overgrazing on its delicate ecosystem owing to its semi-arid climate and minimal vegetation (Owusu et al., 2024).

In addressing this issue, Regreening Africa, a program funded by the European Union (EU), aims to enhance resilience and revitalize degraded areas around the continent as a reaction. The program, which targets 500,000 households and one million hectares of land, is being carried out in eight African countries: Ghana, Senegal, Mali, Niger, Kenya, Somalia, Ethiopia, and Rwanda.

The program endeavors to tackle the urgent issues facing the savanna regions, such as extended and severe dry conditions, excessive grazing, uncontrolled bush fires, and indiscriminate felling of trees that results in dwindling forest cover, diminished native biodiversity, and reduced soil fertility. The objective of Regreening Africa for Ghana is to increase smallholder farmers' livelihoods, food security, and climate change resilience while restoring ecosystem services through the adoption of evergreen methods of agriculture on a larger scale (Kuyah et al., 2023). Community mobilization, radio campaigns, capacity building, partner field activity execution, multi-stakeholder engagement, campaigns, advocacy, and assistance for supplemental means of livelihood are all part of Regreening Africa's implementation strategy for Ghana. Regreening Africa has developed business strategies, established environmental governance systems and structures, trained farmers in Farmer Managed Natural Regeneration (FMNR) and bushfire control, and introduced Saving for Transformation (S4T) treatments, among other initiatives, with remarkable success.

Gold mining is a central pillar of Ghana's economy and has been for centuries, earning the country its historical name, the "Gold Coast." Ghana continues to be one of the major producers of gold in the world and Africa, drawing enormous investments and making a major contribution to the economic development of the nation (Dauda, 2020). The mining industry, especially gold, is essential to employment, development, and foreign exchange earnings. Ghana’s history of gold mining extends back to the pre-colonial era, when native people were already panning and exchanging gold before European colonialism (Tuffour, 2023). Commercial gold mining operations were established as a result of the British colonial period advancements in the mining industry. Gold mining has been booming in Ghana ever since the country’s independence in 1957, with both large-scale industrial operations and artisanal and small-scale mining (ASM) adding to the country’s production.

In recent years, gold mining has been characterized by unsustainable and irresponsible mining activities, leading to the destruction of land and forest resources, water bodies, as well as causing health implications to the citizenry (Mensah & Tuokuu, 2023). This could be as a result of the issuance of more licenses coupled with low to no supervision of these mining companies. As shown in figure 4.4 below, the issuance of mining licenses has seen a drastic increment. Between 1989 and 2009, a total of 43 mining licenses were issued. This increased to 201 between 2010 and 2019. Five years later, (2020-2024), a total of 1,933 mining licenses were issued. It is not surprising that the level of degradation of the nation’s land resources has been alarming.

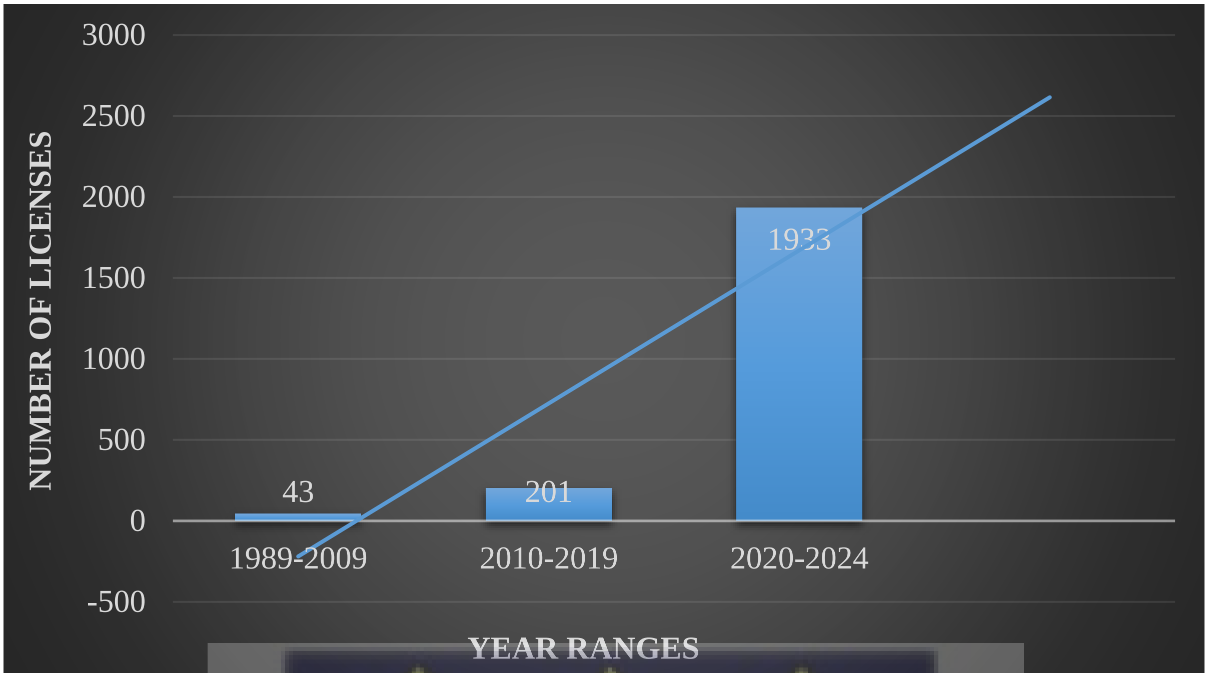



**Figure 4.4. Number of licenses issued from 1989-2024**
*Source: Ghana Mining Repository, 2024*

Illegal gold mining, also known as 'galamsey' (gather and sell), has become widespread in the areas of Widenba, Sapeliga, Zongoyiri, Binaba, and other small villages within the Bawku West District. Consequently, trees located on land containing gold deposits are being felled, extensive trenches and dugouts are constructed, rendering the land unsuitable for agricultural use. These illegal miners fail to reclaim the lands after mining talk less of replacing the felled trees. Certainly, a primary factor contributing to the severe land degradation in the district is the gold mining sector.

Out of the total number of mining licenses, 85 of them have been issued, giving permission for mining activities to take place in the Upper East region. Only one, out of the 85, has been given access to mine in the Bawku West District. Despite this low number of approved licenses in the district, illegal mining activities are still on the rise. This signifies the lack of supervision and enforcement of mining regulations on the part of constitutional bodies who are clothed the powers to do so. The miners have degraded approximately ten towns, leaving the majority of the residents vulnerable and preventing them from accessing their farmland. The affected communities include Sapeliga, Zongoiri, and Widnaba. The people who live in these settlements and their animals are now in danger because to the activities of the illegal miners. This was discussed at the 20th session of the Bawku West District Assembly’s first regular meeting, which was held in Zebilla.

Cutting fuel wood is arguably one of the most noticeable activities that contributes to the destruction of the land (Van Hensbergen & Cedergren, 2021). Previously, cutting was restricted to dry branches and rapidly developing shrubs, but increased urban needs have led to the inclusion of green trees and previously undesirable species. People are forced to cut branches off of green trees due to the lack of dry trees and the distance it takes to find them (Rival, 2021). Although the majority of fuel wood used in most parts of the district is firewood and millet stalks, charcoal is a common source of energy in the areas for both household and commercial uses. As a result, many different kinds of trees are cut down each year to make charcoal. Sadly, the most profitable tree, Buttyrospermun parkii, which is used in the production of shea butter, is well-known for its premium charcoal. The inhabitants are faced with a difficult decision on whether to fell the shea tree for the purpose of producing charcoal or to preserve it for its fruits. It is likely that the high price of liquefied petroleum gas makes this issue worse.

In this chapter, I have discussed the socio-demographic profile of the respondents in terms of their ages, sexes, and levels of education. I have outlined some major crops cultivated in the district with data from the Agricultural Directorate. With geospatial analysis, I have examined the spatio-temporal extent of land degradation and the rate of land degradation in the area. I went ahead to outlined some major causes and effects of land degradation with the collected data.

## CHAPTER FIVE: ANALYZING THE DEGREE OF ASSOCIATION BETWEEN LAND DEGRADATION AND FOOD SECURITY

### 5.1 Introduction

The sociodemographic profile of the respondents, including their ages, sexes, and levels of education, has been covered in chapter four. Using data from the Agricultural Directorate, I have listed some of the main crops grown in the district. I examined both the rate and spatiotemporal extent of land degradation in the area using geospatial analysis. Using the information gathered, I went on to list some of the main causes and consequences of land degradation. In chapter five, I will examine objective three, which involves analyzing the relationship between land degradation and food security, testing the hypothesis, and ultimately relating the findings to the conceptual framework.

### 5.2 Factors that Adversely Affect Food Productivity

This study consistently demonstrates a high correlation between land degradation and food security. Empirical data shows that soil erosion and declining fertility are significantly correlated with reduced crop yields and household food insecurity. From the qualitative interviews, participants attributed food shortages to land degradation, underscoring the direct and indirect processes mentioned in the Framework for Climate Change, Food Security, and Livelihoods.

Members were asked to identify and list factors that they believed contribute adversely to food productivity. Among the factors listed include inadequate rainfall, land degradation, land scarcity, high cost of fertilizer, high temperatures, pests and disease infestation, bush fires, and excessive use of chemical fertilizers. There were a total of 529 responses out of which 182 respondents, which represented 34.4% attributed the increasing low level of food productivity to land degradation in the district. Among some of the factors identified by the respondents as contributing to land degradation include bush burning, sand wining, soil fertility loss, illegal mining activities, among others. Out of the total, 117 people which represented 22.1% attributed it to inadequate rainfall while 63 persons which amounted to 11.9% said that the low level of food productivity situation is as a result of high temperatures. Residents indicated that the amount of precipitation received has dwindled over the years, and that, rainfall pattern is currently unpredictable. This, they said, makes it difficult to cultivate their crops leading to low levels of food productivity. A 64-year old farmer in Zebilla said that *"I used to harvest close to eight bags of maize on my piece of land but at the moment, I am unable to harvest even four bags on that same piece of land due to inadequate rainfall."* He also stated that due to the single rainfall maxima in the district, the government or other NGOs should provide them with irrigation system to help with their farming activities all-year round. Respondents who cited high temperatures as a cause of low food productivity indicated that the intensity of the sun has gone beyond reasonable measures, making it impossible for crops to thrive in such harsh weather conditions. Most of them attributed this to the burning of bushes which releases greenhouse gases into the atmosphere, destroying the ozone layer that is meant to reduce the amount of heat produced by the sun unto the earth's surface. A total of 62 respondents, which represented 11.7% stated that this situation was as a result of the high cost of fertilizers. They indicated that they are unable to afford these fertilizers which would help increase the yield of their crops. The few respondents who were able to afford to buy fertilizers argued that these chemical fertilizers caused damage to the living organisms in the soil, which rendered the soil infertile in the short to long term. In addition, some of the respondents claimed that the quality of crops in terms of the taste and shelf life were negatively affected when chemical fertilizers are used in the cultivation process. They posited that crops that are produced with the use of organic fertilizers tasted better and have a longer shelf life as compared to crops that were produced using inorganic fertilizers. In addition, 11.2% of the respondents, representing 59 persons said that the low levels of food productivity was due to issues of land scarcity. According to some respondents, particularly those in the Zebilla town, getting access to land for agricultural purposes is sometimes difficult because some of the land owners were selling out their lands to other people for building purposes. This has adversely affected backyard farmers who are usually the aged. This category of people found it convenient to have backyard farms due to its proximity to their various homes. They mostly did not have the strength to site their farms far from their homes to be commuting to and fro. These people were also worried by cattle and other domestic animals such as sheep and goats, who go in to these backyard farms to destroy the crops.

Pests and disease infestation was another issue cited by some of the respondents. Forty-six (46) of the farmers which represented 8.7% argued that their crops get infested with pests and diseases, which reduces their crop yields. Some of them attribute this to the use of chemical fertilizers in the cultivation process. Chemical fertilizers have a variety of direct and indirect effects on diseases and pests when used in farming. Although the main purpose of chemical fertilizers is to increase nutrient availability, their application might change how susceptible a plant is to pests and diseases. A crop like maize is likely to be infected with stem borers when fertilizers containing large amounts of nitrogen are applied. This can lead to lush vegetative growth, which attracts stem borers that feed on the stems of maize and reduce yields. Similarly, high nitrogen levels can make maize plants more attractive to fall armyworms, leading to increased infestation and damage of crops. Increased nitrogen application also could promote tender, nutrient-rich leaves that attract aphids which feed on sap and consequently weaken the plants. Below is table 5.1 showing the distribution of factors contributing adversely to food productivity.

One individual whom I interviewed indicated that they are lacking the appropriate technology to engage in farming activities. He further stated that in most cases, rather than using ploughing machines in ploughing the land, they resort to the usage of cattle in doing so. Below is figure 5.1 which shows a piece of land that has been ploughed with the use of cattle.

**Figure 5.1: A back yard farm which has been ploughed located at Zongoyiri**
*Source: Field data, 2024*

**Table 5.1. Factors that adversely contribute to Food Productivity**

| | | Frequency | Frequency (%) | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Inadequate rainfall | 117 | 22.1 | 22.1 | 22.1 |
| | Land degradation | 182 | 34.4 | 34.4 | 56.5 |
| | Land scarcity | 59 | 11.2 | 11.2 | 67.7 |
| | High cost of fertilizers | 62 | 11.7 | 11.7 | 79.4 |
| | High temperatures | 63 | 11.9 | 11.9 | 91.3 |
| | Pests and disease infestation | 46 | 8.7 | 8.7 | 100.0 |
| | Total | 529 | 100.0 | 100.0 | |

*Source: Field data, 2024.*

### 5.3 Testing of Hypothesis

Hypothesis testing was carried out to ascertain whether there is an association between land degradation and food security. The statistical test that was used was chi-square.

**Null Hypothesis ($H_0$):** There is no degree of association between land degradation and food security in the Bawku West District.

**Alternative Hypothesis ($H_a$):** There is significant degree of association between land degradation and food security in the Bawku West District.

Table 5.2 below shows the observed values of land degradation and food security.

**Table 5.2. Observed Values**

| Land Degradation | High Food Security | Moderate Food Security | Low Food Security |
|---|---|---|---|
| Low | 6.35 | 7.20 | 21.45 |
| Moderate | 7.98 | 9.05 | 26.96 |
| High | 22.67 | 25.74 | 55.76 |

*Source: Field survey, 2024.*

**Table 5.3. Expected Values**

| Land degradation | High Food Security | Moderate Food Security | Low Food Security | **Total** |
|---|---|---|---|---|
| Low | 10 | 12 | 13 | **35** |
| Moderate | 12 | 13 | 21 | **44** |
| High | 15 | 19 | 91 | **125** |
| **Total** | **37** | **42** | **125** | **204** |

*Source: Field survey, 2024.*

**Table 5.4. Chi-Square ($x^2$)**

| Observed Values (O) | Expected Values (E) | (O-E) | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---:|---:|---:|---:|---:|
| 10 | 6.35 | 3.65 | 13.32 | 2.10 |
| 12 | 7.20 | 4.80 | 23.04 | 3.20 |
| 13 | 21.45 | -8.45 | -71.40 | -3.33 |
| 12 | 7.98 | 4.02 | 16.16 | 2.03 |
| 13 | 9.05 | 3.95 | 15.60 | 1.72 |
| 21 | 26.96 | -5.96 | -35.52 | -1.32 |
| 15 | 22.67 | -7.67 | -58.83 | -2.60 |
| 19 | 25.74 | -6.74 | -45.43 | -1.76 |
| 91 | 55.76 | 35.24 | 1241.86 | 22.27 |
| | | | | **$x^2$ = 22.31** |

*Source: Field survey, 2024.*

Degrees of freedom = (Columns – 1)   (Rows – 1)

= (3 – 1)   (3 – 1)

= 2   x   2

= 4

Level of significance (∝) = 0.05

$x^2$ tabular = 9.48

$x^2$ calculated = 22.31

Therefore, since the calculated value is greater than the tabular value, we reject null hypothesis, and accept alternate hypothesis. This result indicates that there is a correlation between land degradation and food security; in that, the more land is degraded, the more the area suffers food security and the less the land is degraded, the less the area suffers food security.

Alternative Hypothesis ($H_a$): There is significant degree of association between land degradation and food security in the Bawku West District.

### 5.4 Linking Land Degradation and Food Security to the Climate Change, Food Security, and Livelihoods Framework

Food security and sustainable livelihoods in the Bawku West District of Ghana are seriously threatened by the escalating problem of land degradation. The intricate link between land degradation and its direct and indirect effects on agricultural production, is examined in this thesis. Connolly-Boutin and Smit (2016) developed the Climate Change, Food Security, and Livelihoods Framework, which offers a strong and multidisciplinary perspective for analysing these processes and serves as a guide for this study.

The framework highlights how food systems, socioeconomic factors that influence livelihoods, and climatic stressors are interconnected. It draws attention to the ways that socio-political elements like resource accessibility, institutional support, and adaptive capability, as well as biophysical changes like soil erosion and declining soil fertility, influence vulnerability and food poverty. Land degradation, which is frequently caused by unsustainable agricultural methods, unpredictable rainfall, and rising temperatures, is both a symptom and a cause of livelihood stress connected to climate change in Bawku West. By taking into consideration both these environmental changes and the human behaviors that mediate their consequences, the framework enables a comprehensive analysis.

This thesis places land degradation within the larger processes of climate vulnerability and resilience by utilizing Connolly-Boutin and Smit’s framework. It investigates how local food systems become compromised by land degradation, impacting not just production but also access and utilization—two essential components of food security. Additionally, the paradigm facilitates the analysis of livelihood options, such as crop diversification, dependence, on aid or migration that families implement in response to environmental stresses. In the end, this approach facilitates a deeper understanding of how environmental degradation influences food security and the sustainability of livelihoods.

This framework, however fails to incorporate local or indigenous knowledge systems, which are essential for comprehending community-level resilience and food security. Traditional ecological knowledge and local coping strategies are often the first line of defence against impacts of land degradation, but they are neglected in the framework. For instance, some of the indigenes made it known that whenever their farmlands are being eroded, they practice "stone bonding," where stones or logs of wood are used as barriers to avoid the soil from being washed away. Also, they say that they mostly plant along waterways, and not across. These are all measures that are put in place by indigenes to minimize the dire consequences of land degradation.

This chapter has analysed the degree of association between land degradation and food security, which showed that the more land is degraded, the more the more the area suffers food security and the less the land is degraded, the less the area suffers food security. The chapter again draws a linkage between land degradation and food security to the climate change, food security and livelihoods framework.

# CHAPTER SIX: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

## 6.1 Introduction

In chapter five above, one of the specific objectives has been discussed. It analyzes the degree of association between land degradation and food security. It also links land degradation and food security to the climate change, food security and livelihoods framework. In this chapter (six), the principal findings of this study are summarized alongside the conclusions. Recommendations are offered based on these findings to assist stakeholders and policymakers in mitigating land degradation and enhancing food security and adaptation within the study area.

## 6.2 Summary

A major environmental problem that has a broad impact on ecosystems and human well-being is land degradation. Land degradation is an imminent threat to food security in the context of agriculturally dependent countries like Ghana, making it difficult to meet the nation's nutritional demands already. One such place where land degradation has had a negative impact is the Bawku West District in Ghana's Upper East, which could have a bearing on the availability and production of food. The land is the primary source of nutrition for all forms of life on earth. Because it nourishes plants and other vegetation, which provide food and nourishment to all living creatures, soil is one of the most valuable resources. The world population has been growing, per capita income has been rising, dietary patterns have changed, food waste has accumulated, and transmission losses have all contributed to a large increase in the demand for food during the past few decades. Since land degradation plays a significant role in determining the end of hunger and the improvement of nutrition, we must compromise in our efforts to combat it. The purpose of this study was to investigate land degradation in greater detail, as well as the detrimental effects it has on food security in Ghana's Bawku West District and potential solutions.

The study employed the mixed method of research. Farmers and local agricultural extension agents were the respondents in this cluster sample, purposive sampling, and snowball sampling study. Furthermore, discussions in focus groups consisting of eight to ten participants took place. This assisted in getting the information that was required from them. Additionally, 204 semi-structured and open-ended questionnaires were distributed, and the data was analysed using the Statistical Package for Social Science (SPSS).

Also, six satellite imagery, from 2002 to 2022, with path and row 194/052 and 194/053 were downloaded, spaced ten years apart, from the United States Geological Survey (USGS) website. The ENVI 5.3 software was then used to preprocess the images. The images were gapfilled and mosaicked. Additionally, atmospheric correction was performed on the images, and then subsetting was carried out. The images were then subjected to classification, change detection analysis, and accuracy assessment. Maps were generated as well using ArcMap 10.8. Additionally, the University of Ghana's Department of Geography and Resource Development's Remote Sensing and Geographic Information Systems (RSGIS) Laboratory provided the Ghana districts shape file, Ghana settlements shape file, and Ghana roads shape file.

According to the data, majority of the farmers, 81 individuals, which represented 39.7% of the total were between the ages of 51 and 65. The data further revealed that a smaller proportion of respondents are in the 20–35 age range, which is commonly referred to as the younger generation. This may be explained by the fact that, given their age, the majority of people in this category attended school. Another explanation for this could be due to the fact that the young in the area were reluctant to participate in farming activities; this is not unusual from other regions of the nation, where the majority of youth exhibit little interest in farming. The group with the second-least representation was made up of 46 respondents, which represented 22.6%, who were between the ages of 66 and 80. This may be because they belonged to the elderly population and hence, lacked the energy required for labor-intensive farming tasks, which could lead to complex health problems.

The results showed that 146 respondents, which amounted to 71.6% of the total, were males, and 58 respondents, representing 28.4% of the total, were females in the study area. According to the survey, the majority of male farmers were involved in the cultivation of crops like rice, millet, and maize, while the majority of female farmers engaged in cultivation of pepper, tomatoes, and okra. Because women were typically given smaller plots of land to farm on, usually by their husbands, these were typically carried out on relatively smaller areas of land within the community. On the flip side, because they owned the property, the males farmed on huge tracts of land.

In terms of education, the result revealed that the educational level of the residents in the study area was somewhat low. A small proportion of persons had completed their tertiary education, while there were many who have never had any formal education at all. It was discovered that the majority of respondents (42.2%) had completed their formal education up to the primary level. Those who had completed their schooling up to the junior secondary/junior high school level, which represented 22.5% of the total, came next. In the district, 21.1% of the respondents had never received any kind of formal education. Based on the study, the majority of these individuals were elderly, with ages ranging from 66 to 80. A total of 22 respondents, being 10.8%, had completed technical and vocational education and training, senior secondary/high school. Approximately 3.4% had completed postsecondary education.

In the research area, we observed a steady rise in the percentage of degraded lands. The majority of land degradation in the BWD had been caused by anthropogenic factors, which began with increasing populations and uncontrolled bush fires. It was made worse by intensive cultivation, extensive farming, and the elimination of vegetation. With rising population pressure comes a drop in the number of agriculture plots per person. The reduced fallow period had therefore left inadequate time for natural land renewal. Therefore, population pressure had rendered bush fallow techniques unviable, forcing farmers to transition to continuous cropping. According to the respondents, overgrazing, illicit mining, bush burning, deforestation, excessive use of chemicals for crops, and hunting activities were the reasons that contributed to land degradation on their farms.

The study found that between 2002 and 2022, vegetation lost 346.393 km². Crop lands and degraded lands accounted for 0.173 km² and 0.138 km² of these losses, respectively. Over the course of 20 years, between 2002 and 2022, the Bawku West District's degraded lands accounted for 407.058 km², which amounted to 39% of the district's total land area. As per the responses, Teshie, Binaba, Sapeliga, and Binaba were among the districts where land degradation has had a greater impact. These were the places where illegal mining, bush fires, and sand mining were mostly common. The Tilli forest reserve and certain regions of Zongoyiri were the only places with a substantial amount of vegetation.

**6.3 Conclusions**

The has investigated land degradation and its implications for food security, using vegetation availability as an indicator. Whereas the results indicate that land degradation is one of the major factors inhibiting the attainment of food security in the Bawku West District, there are other phenomena that make it difficult in the attainment of same. These are both natural and socio-economic factors such as inadequate rainfall, scarcity of land for farming, high cost of fertilizers, high temperatures, population increase, poverty, poor farming practices, overgrazing, and the infestation of pests and diseases on farm lands. The impact of these factors, causing the vulnerability or otherwise of these lands and the residents depend on internal and external factors. The social, economic, and environmental factors frequently have an impact on internal vulnerability. The ability to withstand or bounce back from the effects of these factors depend on the assets of the individual, which were in the form of financial, social, and technological. The external vulnerability largely depends on the magnitude, frequency, and duration of the factors acting to bring about land degradation. Localized degradation is prevalent, according to data from remote sensing. The field survey findings also point to extensive land degradation, which is corroborated by data on agricultural productivity.

**6.4 Recommendations**

Addressing land degradation is very paramount in ensuring food security. In order to solve the issue of land degradation and improve upon food security, sustainable farming practices need to be encouraged, and farmers educated on the positive effects of these sustainable practices. Some of these sustainable farming practices include crop rotation, shifting cultivation, the use of cover crops and conservation tillage to protect soil from erosion, and organic farming to maintain soil health. This is a sine qua non to ensuring that the environment is free from destruction.

Taking a cursory look at the Bawku West District, it is recommended that a fire-management policy that seeks to addresses burning, timing, and most importantly—the possible application of prescribed or controlled burning is required considering the frequent occurrence of fires in the area. Moreover, investments must be made in the restoration of lands. Degraded lands, in particular need to be restored in order to avoid further deterioration, with virgin lands protected from entry. Residents in the Bawku West District suggested for the enforcement of laws governing the indiscriminate felling of trees, bush fires, and illegal mining. They posit that people need to be called to order and prosecuted for violating environmental laws.

It is further recommended that considering the urbanizing nature of the district, parcels of land be acquired, and purposely designated for farming activities. Despite the rurality of the BWD, it is necessary that land parcels are, as a matter of urgency secured and used for mainly agricultural reasons, considering the fact that the district could be urbanized in no time. This will go a long way to help the district and the nation at large be food-sufficient.

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# APPENDICES

## Appendix 1 – Sample Questionnaire

**QUESTIONNAIRE FOR ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT**

I am Elijah Munankan, a second year MPhil student of the University of Ghana, Department of Geography and Resource Development undertaking a study on the topic **"ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT."** I would like you to share your views and opinions about what you know with regards to this topic by providing appropriate answers to the questions either by choosing or stating a suitable answer. This survey is purely an academic-based research work which is aimed at seeking the views of respondents on the effects of land degradation on food security in the Upper East Region of Ghana. This survey will not take much of your time as it is going to be between 12-15 minutes. Kindly take a few minutes of your time to provide answers to this survey. Be assured your responses shall be treated with utmost secrecy and anonymity.

**Circle the appropriate answer, and where necessary, state by writing.**

**SECTION A: BACKGROUND INFORMATION OF RESPONDENT**

1. Do I have your consent to conduct this exercise with you?

a) Yes b) No

2. Have you lived in the Bawku West District since 2012?

a) Yes b) No

3. Do you own a farm/farms?

a) Yes b) No

4. If your answer to question 3 is yes, how many years have you been farming?

……………………………….

5. Sex of Respondent.

a) Male b) Female

6. Age of Respondent.

……………………

7. Highest Educational level of Respondent.

a) Tertiary b) SSS/SHS/TVET c) JSS/JHS

d) Primary e) None f) Other: ………………………...

**SECTION B: EXAMINING THE SPATIO-TEMPORAL EXTENT OF LAND DEGRADATION IN BAWKU WEST DISTRICT.**

8. Which type of farming system are you engaged in?

a) Commercial farming (large scale) b) Subsistence farming (small scale)

9. List the crops you cultivate on your farm

a)

b)

c)

d)

e)

10. Could you identify particular places in the Bawku West District that you think are more vulnerable to land degradation? If so, could you kindly elaborate?

…………………………………………………………………………………………………
…………………………………………………………………………………………………

11. Do you think that the Bawku West District has seen more of land degradation from 2012 to 2022?

a) Yes b) No

12. What type of land degradation have you noticed in the Bawku West District? (Rank them).

| | 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|
| Water Erosion | | | | | |
| Wind Erosion | | | | | |
| Soil fertility decline | | | | | |
| Deforestation | | | | | |
| Waterlogging | | | | | |

13. On a scale of 1-10, with 1 being the least whilst 10 being the highest, how would you rank the level of degradation you see?

…………………………..

14. What type of land degradation have you noticed on your farm land? (Rank them).

| | 1st | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|---|
| Water Erosion | | | | | |
| Wind Erosion | | | | | |
| Soil fertility decline | | | | | |
| Deforestation | | | | | |
| Waterlogging | | | | | |

15. What do you think have been the factors responsible for land degradation on your farmland? (State as many factors as applicable). State factors in order of prominence.

a.

b.

c.

d.

16. Since when did you take notice of land degradation on your farmland?

………………………………….

17. How many farm plots do you own?

……………………………………

18. Approximately, how many plots of your farm has been affected by land degradation?

……………………………………

19. What is being done to help reduce this?

| Government | Non-Governmental Organization | Community Intervention |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

20. List some improvements you have observed.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

21. What are some of the challenges encountered?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

22. Are you doing something on your farm personally to reduce land degradation? Kindly elaborate.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

**SECTION C: ANALYZING THE RATE OF LAND DEGRADATION IN THE BAWKU WEST DISTRICT.**

23. List and rank the different ways by which land degradation has affected your farming activities.

a.

b.

c.

d.

e.

f.

24. Select all possible treatments you employ in conserving soil on your farmland.

| | | |
|---|---|---|
| 1. | Application of fertilizer | |
| 2. | Application of manure | |
| 3. | Mulching | |
| 4. | Cover cropping | |
| 5. | Crop rotation | |
| 6. | Shifting cultivation | |
| 7. | Strip cropping | |

25. In the last ten years (2013-2022), how many tonnes of crops have you harvested?

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop | | | | | | | | | | | |
| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| Quantity (Kg) | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop | | | | | | | | | | | |
| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| Quantity (Kg) | | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop | | | | | | | | | | | |
| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| Quantity (Kg) | | | | | | | | | | | |

26. Over the past ten years, how has the pattern of precipitation in the Bawku West District been?

| | Duration | Intensity | Frequency |
|---|---|---|---|
| Increased | | | |
| Remained the same | | | |
| Decreased | | | |

27. Over the past ten years, how has the temperature in the Bawku West District been?

| | Duration | Intensity | Frequency |
|---|---|---|---|
| Increased | | | |
| Remained the same | | | |
| Decreased | | | |

28. Has your land been affected by any extreme weather occurrences? Please indicate.

| | Duration | Intensity | Frequency |
|---|---|---|---|
| Drought | | | |
| Flood | | | |
| Heatwaves | | | |
| Wildfires | | | |

29. List and rank all factors contributing to land degradation.

a.

b.

c.

d.

e.

30. Have these factors intensified in recent times? Elaborate on it.

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

**SECTION D: ANALYZING THE DEGREE OF ASSOCIATION BETWEEN LAND DEGRADATION AND FOOD SECURITY AND THE STRENGTH OF THE LINKAGE**

31. What type of agricultural land use practices are predominant in your community?

a. Crop Production

b. Animal Farming

c. Mixed Farming

d. Other: ……………………………….

32. Do you know about food security? Kindly elaborate on it.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………...

33. How has land degradation in your area affected food production?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

34. Do you increase the land under cultivation in order to produce more food crops as you used to?

a) Yes b) No

35. On a scale of 1 to 5 (where 1 indicates no degradation, 2 indicates mild degradation, 3 indicates moderate degradation, 4 indicates high degradation, and 5 indicates severe degradation), how much of an effect has land degradation had on food production in your area?

……………………..

36. Have you observed any shifts in the availability or production of food that you link to changes in the condition of the land? If yes, kindly elaborate.

……………………………………………………………………………………………………

37. How much do you think land degradation impacts the livelihoods of the local residents?

a) Excessive impacts

b) Mild impacts

c) No impacts

38. What factors do you think have adversely contributed to food productivity? (List and rank them)

a)

b)

c)

d)

e)

39. How would you rank land degradation and food security using low, moderate, and high?

| Land degradation | High food security | Moderate food security | Low food security |
|---|---|---|---|
| Low | | | |
| Moderate | | | |
| High | | | |

40. What do you need in order to improve the land condition on your farm?

………………………………………………………………………………………………

41. What do you think farming in this area will be like in the next 10-20 years?

………………………………………………………………………………………………

………………………………………………………………………………………………

42. Is there any other thing I did not ask that you would like to say about land degradation and its effects on food security?

………………………………………………………………………………………………

………………………………………………………………………………………………

## Appendix 2 – Interview Guide

**INTERVIEW GUIDE FOR ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT**

I am Elijah Munankan, a second year MPhil student of the University of Ghana, Department of Geography and Resource Development undertaking a study on the topic **"ANALYSES OF LAND DEGRADATION AND ITS IMPLICATIONS FOR FOOD SECURITY IN THE BAWKU WEST DISTRICT."** I would like you to share your views and opinions about what you know with regards to this topic by providing appropriate responses. Kindly express your understanding about these issues. Be assured your responses shall be treated with utmost secrecy and anonymity.

**Question line**

1. **Qualification of Interviewees.**
    - Find out from interviewees if I have their consent to conduct this interview.
    - Probe whether he/she has lived in the Bawku West District since 2012.
    - Ask if he/she owns a farm and has been farming for the past ten years.
2. **Knowledge level of respondents on land degradation.**
    - Ask questions to probe if interviewees know what it means for a piece of land to have a decrease in its productive potential.
    - Find out from respondents if land degradation has occurred on their farm lands.
    - Ask to find out at what point interviewees realized the occurrence of land degradation in the Bawku West district.
    - Find out from respondents what they think are the causes of land degradation in the Bawku West district.

**3. Effects on Food Productivity.**

- Probe from them how land degradation has affected the productivity of food in the district.
- Investigate how land degradation has affected local farmers and their ability to cultivate crops.
- Probe whether respondents have made changes in the types of crops grown due to land degradation.

**4. Involvement of Government and Non-Governmental Organizations (NGOs)**

- Ask if there have been policies initiated by government, non-governmental organizations and individuals aimed at addressing land degradation in the area.
- Find out some of the successes of these policies, if any.
- Find out some of the challenges encountered or brought by as a result of these policies.

**5. Adaptation Strategies by Communities**

- Probe to find out if there have been local innovative measures taken by community members to mitigate and adapt to the effects of land degradation.
- Ask whether these innovative measures have yielded results.

**6. Food Security Concerns**

- Probe interviewees the correlation between land degradation and food productivity in the Bawku West district.
- Find out if interviewees foresee any challenges for food productivity if land degradation persists.

**7. Suggested Interventions**

- Ask for potential interventions to address land degradation and enhance food production.

**8. Any Recommendations?**