UNIVERSITY OF CAPE COAST

SPATIO-TEMPORAL ANALYSIS OF THE IMPACT OF OIL AND GAS PRODUCTION ON LAND USE LAND COVER IN ELLEMBELLE DISTRICT

BY

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DECLARATION

Candidates' Declaration

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

Candidate's Signature................................ Date........................

Name: Blay Macbeth Kwame Index: SS/PGR/19/0013

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of projects laid down by the University of Cape Coast.

Supervisor's Signature........................... Date........................

Name: Dr. Eric Kojo Aikins

ABSTRACT

Ghana's oil discovery is surrounded by very poor local communities whose primary sources of income are farming and fishing. Evidence from other countries shows that massive land alterations and degradation occurs after the discovery and exploration of oil and gas, which undermine traditional means of livelihood. The purpose of the study was to assess the impact of oil and gas production on land use land cover in the Ellembelle district. Landsat images for the years 2000, 2010 and 2021 were acquired to model the land use land cover changes before and after the production of oil and gas using spatial analytic tools in GIS software. For effective data collection, different but complementary instruments, which included household questionnaires, in-dept interview guide and observation check list were adopted for the study. The findings of the study revealed that the rate of LULC change was intense in the second time interval (2010-2021), indicating that land transformations in Ellembelle district were becoming increasingly intensive since the production of oil and gas in the district. Oil and gas activities, population growth, urbanisation, and farming activities were identified as the major drivers of LULCC in the district. The locals see the oil and gas industry as having affected their livelihood both positively and negatively. The assessment of some basic infrastructures shows that road networks, communication sector, Education and banking institutions as well as electricity and water supply have seen a facelift in the district. However same cannot be said about the health and cultural institutions. The study recommended that there is the need to undertake an integrated urban planning framework for Ellembelle district.

KEYWORDS

Ecology

Employment

Geographic Information System

Land cover

Land use

Land use land cover change

Livelihood

Mangroves

Oil and gas

Remote Sensing

Spatio-temporal

Urbanisation

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DEDICATION

To my late mother, Juliana Kwofie

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LIST OF ACRONYMS

LMICs	Low and Middle Income Countries
OG	Oil and Gas
GPT	Growth Pole Theory
LULC	Land Use Land/Land Cover
LULCC	Land Use/Land Cover Change
SMEs	Small and Medium Enterprises
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
SPSS	Statistical Product for Service Solution
GSS	Ghana Statistical Service
USGS	United State Geological Survey
GIS	Geographic Information Systems
RS	Remote Sensing

CHAPTER ONE

INTRODUCTION

Background

Ever since the Industrial Revolution, energy has been a key factor of production (Stern & Kander, 2012). For decades, oil and natural gas have been the world's primary sources of energy accounting for about 55% of the global energy consumption. Also, oil and gas have helped in the advancement in quality of life and economic development, from residential lightning, heating and cooking to industrial manufacturing and transportation. Energy acts as lifeblood of the modern world's economy, with oil and natural gas covering most of its area (Trench & Miesner, 2006). In this current peak period of oil consumption and exploding global population, the demand for oil and natural gas continues to increase, making them an even more coveted resource.

As a result of the significant earnings associated with the exploitation of large oil and gas deposits, countries with large reserves are typically considered wealthy (Adusah-Karikari, 2015; Amoasah. 2010). For many oil and gas producing economies globally, the sector is a major source of jobs and revenue. Currently, there are more than 100 oil-exporting countries in the world.

The west central coast of West African, along the Gulf of Guinea, is said to be rich in hydrocarbon deposit, which is a source of oil and gas. oil and gas extraction and production in this region (which is expected to have around 547 offshore oil and gas structures) has the capacity to meet the European Union's and the united states' energy demands (Ayoade, 2002; IMF, 2005). In this region, Nigeria, Angola, Gabon, Equatorial Guinea, and Ghana are already producing crude oil.

The extractive industries have shaped the economies, societies, and politics of many nations, for better or worse. Rich countries owe at least some of their high living standards to extractive industries. For example, in the US, shale gas production account for a considerable portion of the total natural gas produced annually (Baihly, Altman, Malpani, & Luo, 2010) and generates a significant amount of revenue (about 8% of the country's Gross Domestic Product in 2019) for local, state, and federal governments (World Bank, 2020). Nigeria, the largest oil producing country in Africa, has about 9 percent of their Gross Domestic Product coming from the oil sector. oil and gas have consistently accounted for about 90% of Nigeria's export revenue since 1970.

For about a decade, Ghana has had some level of OG operations in the form of exploration, development, drilling, production, and transportation. These operations have generated significant revenues for both the Ghanaian government and the operating companies. According to the bank of Ghana, oil revenue was about US$431.56 million in the second half of 2019 (BoG, 2020). According to Palley (2003), while African oil producing countries benefit financially from this resource, it has done little to improve the quality of life for their citizens, particularly those who live near drilling sites.

Exploration of oil and gas reserves has not always been free of environmental consequences. Damaged lands, oil spills, accidents and fires, and air and water pollution incidents have all been documented at various times and locations. Oil activities have destroyed delicate marine ecology, which is the main source of livelihood in oil-bearing communities, as seen in most oil-producing countries such as Nigeria, Libya and Angola resulting in loss of fish catch, exacerbation of poverty, occupational disorientation, social conflict, population displacement, and violations of human rights (Ibabi and Olumati, 2007; United Nations Development Programme, 2006).

The environmental impact of oil and gas production activities are enormous and cannot be overlooked. These impacts tend to affect the ecosystem in the coastal regions in Ghana. In Ghana, some studies have reveald that the major socio-economic effects from the impact of oil and gas activities are loss of livelihoods, especially fishing and farming (through increasing number of immigration in search of non-existing jobs, which result in increased unemployment rate in the resource regions), inflation and increasing prices of items (such as food, accommodation, leisure), increased social vices (such as drug abuse, commercial sex work, crime), and negative health-related implications from pollution of oil and gas development (e.g pollution) (Nashiru, 2019; Manu, 2011; Freduah, Fidelman, & Smith, 2017; Amoasah 2010).

Furthermore, the discovery and exploration of natural resources tend to cause an influx of people to the resource regions, which is a major contributor to the phenomenon of urban growth and urbanisation. A typical example in Ghana is the Sekondi-Takoradi Metropolis, which is known as Ghana's oil city (the closest major city to the oil fields) and has drawn many visitors (both Foreigners and Ghanaians). According to a report published by the Sekondi-Takoradi Metropolitan Assembly (2011), the city is currently experiencing rapid growth in socioeconomic activities, with various infrastructure projects underway in the hospitality, health, industrial, commercial, and educational sectors. For example, the Sekondi-Takoradi Metropolis' 2010–2013 spatial development plan highlighted the changing physical landscape as a result of land pressures for various development projects following the commercial discovery of oil.

Mining regions (also known as resource regions) are distinguished by an abundance of economically viable mineral resources, according to Bridge (2004). As a result, such regions frequently experience abrupt and significant changes in land use. During oil and gas production, a sophisticated network of well pads, roadways, pipelines, and other infrastructure is built across the landscape. Globally, increase in oil and gas activities is associated with the conversion of land cover such as agricultural or forest land, to OG development infrastructure. This land disturbance can fragment land cover, resulting in the loss of productive forests and agricultural fields, as well as other resources like water and wildlife habitats.

Practically, these problems created by the changes of land use land cover are numerous and have serious consequences. As a result, the spatial dimensions of land use land cover that get changed need to be studied so that policy makers and scientists will be amply equipped to make informed decisions that would help reduce the negative spatial and economic (spatio-economic) implications of oil and gas production. According to Ringrose, Vanderpost, & Matheson (1997), land use and land cover change in Africa is rapidly accelerating and causing significant environmental problems and thus needs to be mapped and studied. This is significant because shifting land use and land cover patterns reflect shifting spatial and economic conditions.

Also, Land use and land cover data are important for a variety of planning and management activities involving the earth's surface (Lillesand and Keifer, 1994; Smits Schowengerdt, 1999), as they provide critical environmental information for scientific studies, resource management, and policy implementation. Understanding land management requires a thorough understanding of land use and land cover features (Dai & Khorram, 1998). As a result, a wide range of scientists and practitioners interested in land use and land cover change, including earth system scientists, land and water managers, and urban planners, want to learn more about the location, distribution, type, and magnitude of land use and land cover change (Stow, 1999).

Remote sensing technology advancements over the last three decades have enabled researchers to investigate physical changes in LULC and their associated patterns. Approaches based on remote sensing and Geographic Information Systems (GIS) provide data and tools for studying and comprehending changes in land use and land cover (LULC) over time. In different places of the world, GIS and remote sensing are becoming key tools for doing change analysis. Remote sensing data, particularly Landsat images, are an excellent choice for monitoring urban change and expansion, especially in developing countries where geospatial technologies are still in their infancy (Basnet & Vodacek, 2015). Remote sensing data, particularly Landsat images, are an excellent choice for monitoring urban change and expansion, especially in developing countries where geospatial technologies are still in their infancy. Evidently, some studies have been able to successfully quantify urban transformation, as well as its rate of change, using remote sensing data

(Oluseyi, 2006; Korah, Nunbogu, & Akanbang, 2018; Essien, Etido, & Samimi, 2019)

Statement of the Problem

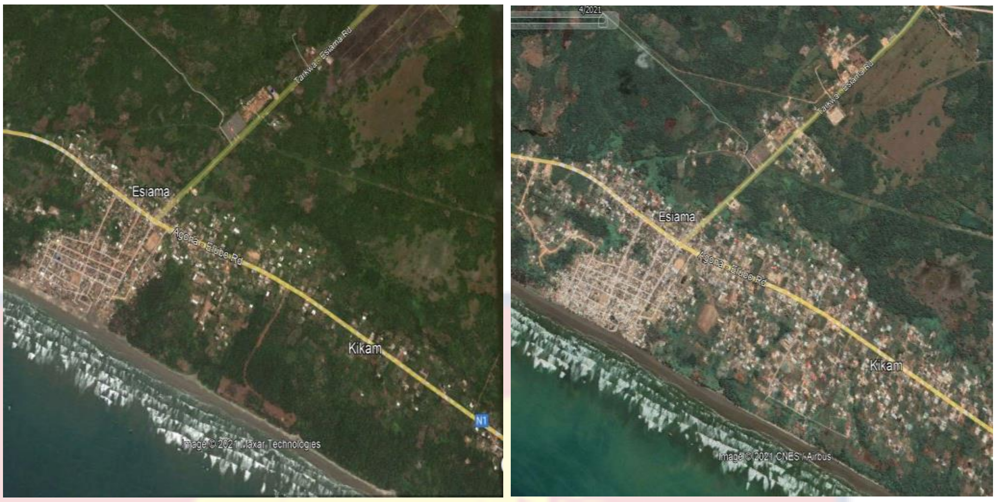
Like any other oil producing country in Africa, Ghana's coastal LULC has undergone rapid and extensive changes in recent decades as a result of significant transformations caused by human-environment interactions.

Although modification of land by humans to obtain livelihoods and other necessities, has been there for thousands of years, the extent, intensity, and rate of LULCC are far greater today than in the past (Nti-Asamoah et al, 2018). Several researchers have emphasized the significance of understanding the dynamics of LULC and its drivers in resolving environmental and socioeconomic challenges, as well as biodiversity conservation, reduction, and management (Geist & Lambin, 2001; Frimpong, 2015).

Unlike the urbanisation-development nexus, which is unsettled at both the empirical and theoretical levels, the oil-urbanisation nexus is without dispute (Obeng-Odoom 2009). Evidence from other countries shows that greater urbanisation occurs after the discovery and exploration of oil (Keizeiri, 1983; Jike, 2004). There is strong evidence that oil and gas production is attracting massive population migration into the Ellembelle district, particularly into the urban areas where majority of the district's economic activities are concentrated (Yevugah et al, 2017; Boadi et al, 2022; Boye et al., 2022).

According to Acheampong (2019), prior to the discovery of oil and gas, the Ellembelle district was naturally endowed with rich biodiversity, including timber, one of Ghana's major forest resource exports. Also, several hundred square kilometers of coastal ecosystems, including extensive mangrove forests, can be found in the Ellembelle district. However, the vulnerability of these ecosystems, like that of many other mangrove forests, is increasing as population and land use change. Because of recent oil discoveries in the offshore areas of the district, it is expected that the west coast in general will become a hub of industrial activity, resulting in social pressures and increased exploitation of mangrove forest and other coastal resources.

Recent social surveys shows that most of the communities in Ellembelle district are rapidly transiting from rural to urban with vast agricultural lands converted into residential areas and other land use types (Boadi et al., 2022). Just like most part of southern Ghana, there is also threat to the sustainability of the adjoining wetlands and forest of the landscape (Boye et al., 2022) emanating the observed rapid land conversion and overexploitation. The development pattern of the Ellembelle district over the past decade point to a worrying trend of its green and natural outlook. In most African communities, where the people are dependent on agricultural production for livelihoods, the relationship between oil and gas development and LULC change is an important issue. Thus, the spatial dimensions of land transformation need to be studied, so that policymakers and scientists will be amply equipped to make informed decisions that would help reduce the negative social, economic, and environmental implications of oil and gas production. Figure 1 shows the extent of land use change in the district.



A. 2000 (before OG production) B. 2021 (After OG production)
Figure 1: Google Earth Images

Similar to Nigeria, Ghana's oil discovery is surrounded by poor local communities whose primary sources of income are farming and fishing. The local communities at the Niger Delta have endured many hardships as a result of the oil drilling operations since their reliance on ecosystem services for their livelihoods has been utterly destroyed (Adeola, 2001; Jike, 2004). It is therefore, widely feared that oil and gas development in the western coast of Ghana could seriously reduce ecosystem services provided to affected societies and threaten long-term sustainability.

Though Ellembelle district is one of the fastest-growing areas in Western region (GSS, 2021), adequate information on LULC change over a considerable period is limited. There is, therefore, the need to research into the socio-economic implications of LULC change on the district using remote sensing and GIS tools and techniques. Remote Sensing (RS) technology advancements over the last three decades have enabled researchers to investigate physical changes in LULC and their associated patterns on large scale over time (Lambin 2005). In most part of the world, geospatial technology has become key tool for performing change analysis (Daniels et al., 2008). Remote sensing data, particularly Landsat images, are an excellent choice for monitoring urban change and expansion, especially in developing countries where geospatial technologies are still in their infancy (Basnet & Vodacek, 2015). It is against this background that the current study uses RS and GIS tools and techniques to analyse the LULC changes of Ellembelle district before and after the commencement of oil and gas exploration in the region. The study further identified the factors causing LULC change and the associated socioeconomic implications. The results of the study would set the basis for developing a contingency plan for the district.

Purpose of the Study

The overall purpose of the study was to assess the impact of oil and gas production on land use land cover change in Ellembelle district.

Specific Objectives

Specifically, the study;

1. Examined the land use land cover changes before and after the extraction of oil and gas in the Ellembelle district.
2. assessed the drivers of change in the land use land cover of Ellembelle district.
3. analysed the effect of the changes in land use land cover on the livelihood of the residents of Ellembelle district.

Research Questions

Based on the problem statement of the study, the following questions were posed:

1. What is the pattern of change in the Land use Land cover of Ellembelle District before and after the extraction of oil and gas?

2. What are the drivers of change in land use land cover of Ellembelle District?
3. How has the changes in land use land cover affected the livelihoods of the people of Ellembelle District?

Significance of the Study

Although the discovery of oil will benefit the entire Ghanaian economy, the negative effects of oil exploration and production on oil producing communities should not be overlooked. Land use/land cover change analysis provides planners and policymakers with sufficient information on what needs to be done to achieve equitable, sustainable, and environmentally friendly development. Also, the findings of the study will contribute to the oil and gas LULCC literature with empirical evidence from the study (Ellembelle District). Finally, measuring Land Use/Land cover change between 2000 and 2020 would improve our understanding of the land dynamics before and after oil and gas extraction in the Ellembelle District.

Delimitation of the Study

Geographically, the study was conducted in the Ellembelle district in the Western region of Ghana. The study focused on the Greater Amanzule Landscape in the Ellembelle district. Data were drawn from five communities located in the study area namely, Kikam, Esiama, Aiyinase, Sanzule and Atuabo.

Definition of Terms

i. Oil and gas extraction: this is the exploration and production of petroleum and natural gas from wells. Generally, oil and gas extraction is not only limited to upstream processes, but it also includes midstream and downstream processes.

ii. Livelihood: The methods and means of making a living in the world are referred to as livelihood. A livelihood consists of the abilities, assets, and activities required for survival.

iii. Employment: Employment is a contractual relationship between two parties, one of whom is the employer and the other the employee. A corporation, for-profit or non-profit organization, co-operative, or other entity may serve as the employer.

iv. Land use: Land use refers to the arrangements, activities, and inputs that people make in a specific land cover type in order to produce, change, or maintain it.Simply put, land use describes how land is used.

v. Land cover: Land cover is the observed biophysical cover on the earth's surface, which literally means what is visible on a given piece of land.

vi. Land use land cover change: Briassoulis (2000) classifies LULC change as an increase or decrease in the area extent of a specific LULC type.

vii. Land use land cover classification (LULCC): Classification is an abstract representation of the field situation based on well-defined diagnostic criteria: The ordering or arrangement of land cover classes into groups or sets based on their relationships is referred to as LULCC.

viii. Spatio-temporal: The concept of space is referred to as spatial. The term temporal refers to the passage of time. When data is collected in both space and time, spatial-temporal data analysis is used. It describes an occurrence that takes place at a specific location and time.

Organisation of the study

This study is organized in five chapters. The first chapter looks at the introduction to the study, which includes the background to the study, statement of research problem, purpose of the study, research objectives and questions, significance of the study, delimitation and the limitations of the study. Chapter two follows to discus theoretical and conceptual framework as well as empirical review. Chapter three deals with the research methodology, which includes the research philosophy underpinning the study, the research approach and design, population, sampling size and sampling technique, data collection technique, ethical considerations and data management. Chapter four presents and discusses the study results in line with the study objectives. The final chapter summarizes the major findings of the study, draws conclusions and provides recommendations based on the findings of the study.

CHAPTER TWO

REVIEW OF RELEVANT LITERATURE

Introduction

This chapter reviews relevant literature on the impact of oil and gas activities on land use land cover changes and how these changes affect local livelihoods. Mainly, it reviews literature based on concepts, theories and empirical evidence on oil, urbanisation, land use change and livelihoods nexus. Issues discussed here includes the history, hopes and fears of oil exploitation in Ghana, oil and urbanisation nexus, environmental and socioeconomic impact of oil extraction, oil and gas extraction and related landscape alteration, and the drivers of land use land cover change. Also, this chapter discussed the growth pole theory and its linkage to the study. Lastly, the chapter discusses a conceptual framework to serve as a guide to the study.

History, Hopes and Fears of Oil Exploitation in Ghana

While oil extraction has not been as important in Ghana's history as mineral mining, it is not a completely new development option because oil exploration has a long history. According to Hagan (2014), the lack of success in oil discovery in previous years was primarily due to technological constraints. According to him, the process of oil exploration in Ghana can be divided into four major phases: 1896-1969 (phase one), 1970-1984 (phase two), 1985-1900 (phase three), and 2000-present (phase four).

Phase one started on shore as a result of evidences of oil seepages in the Tano Basin in the Western Region. According to Dickson (2011) and Osei-Boakye (2012), The West African Oil and Fuel Company (WAOFCO) was the first oil company to pioneer oil exploration in the then Gold Coast in the year 1896. WAOFCO drilled five big wells within a five-year period (Dickson, 2011; Osei-Boakye, 2012).

The promise of commercial quantities of oil discovery attracted the attention international firms such as Société Française de Petrole (SFP). Between 1909 and 1913, the SFP followed in the footsteps of WAOFCO into the Gold Coast. According to Hagan (2014), the SFP dug six wells and produced seven barrels of oil per day during its operation. Following the SFP's exploits, the African and Eastern Trade Corporation dug two additional wells in onshore Tano between 1923 and 1925.

The Gulf Oil Company was the next to explore for oil within Ghana's borders during the country's independence, specifically between 1956 and 1957. Their exploits, like those of those who came before them, were not particularly prosperous. According to Dickson (2011), despite numerous business disappointments, the excitement and optimism about the discovery of oil in commercial quantities was never lost.

The second phase of Ghana's oil activities began in 1971, when the Busia administration staged a public display of locally discovered oil. Despite the fact that offshore exploration was deemed risky at the time, the first minor offshore production of hydrocarbons in the Saltpond Basin was recorded in 1975, during the administration of General Kutu Acheampong (Dickson, 2011; Hagan, 2014; Osei-Boakye, 2012). Oil exploration activities shifted away from onshore exploration, which had previously dominated early prospecting efforts toward offshore shallow water explorations. According to Osei-Boakye (2012), the Petroleum Department of the Fuel and Power Ministry was in charge of the petroleum sector.

At this point, it was undeniable that the Ghanaian government was completely interested in the country's petroleum exploration and production activities. Major changes happened in Ghana's petroleum sector as it transitioned from the second phase to the third phase. As a declaration of purpose, Ghana enacted its first petroleum law, the Ghana National Petroleum Corporation (GNPC) Law (PNDC Law 64) in 1983. The GNPC was established and staffed by professionals from the Petroleum Department of the Ministry of Fuel and Power. GNPC's objective was to encourage technology-driven investments in Ghana's oil industry in order to explore and develop hydrocarbon resources, and it was tasked with accelerating oil exploration and production initiatives (Dickson, 2011; Hagan, 2014).

By the start of the final decade of the 20th century., the GNPC had successfully entered into various agreements on behalf of Ghana with a number of foreign companies. One of these agreements, as reported by Dickson (2011), was with the American oil corporation, Amoco. By the middle of 1992, oil had been discovered in an offshore Tano Basin well through exploratory work done by multiple corporations, and it was producing roughly 6,900 barrels per day. In the same time frame, the Tema Lube Oil Company commissioned a new oil blending plant, which the GNPC joined as a stakeholder. This facility was intended to generate about 25,000 tons of oil annually. Other prominent international companies including Dana Petroleum, Nuevo Energy, AGIP, Santa Fe Energy, and Fusion Oil later became interested in the GNPC. The operations of these firms produced extremely significant data that was helpful for further operations into the fourth phase (Dickson, 2011). In all, 27 wells were drilled in the Tano, Keta, Saltpond, Accra, and Cape Three Points basins between 1985 and 2000 by various operators (Boateng 2008).

Ghana's oil exploration activities are currently in its fourth and final phase, which started in 2000. According to Hagan (2014), the GNPC cooperated with companies like Kosmos Energy, Anadarko Petroleum Company, and Tullow Oil to pursue oil exploration activities after receiving multiple promising signs about commercial oil prospects from earlier operations.

Ghanaians hold the year 2007 in high esteem because, at least in terms of modern history, it marked a significant turning point for the country. On June 18, nearly four months after a glamorous celebration of the nation's golden jubilee of independence from colonial authority, it appeared that the course of the country's destiny had taken a remarkable turn. In a press statement, Kosmos Energy, a small Texas-based exploration company, said that it had found oil in Ghana's rich Cape Three Points Block in the country's western area (Dickson, 2011; Hagan, 2014; Manu, 2011; Yeboah, 2011).

According to the finding, the Deep-water Tano Block and the West Cape Three Points Block are the two locations where oil reserves are most concentrated. The West Cape Three Points block was given the name Jubilee Fields to honor the nation's golden jubilee celebration (Manu, 2011; Planitz and Kuzu, 2015). Other significant discoveries were found later, leading to the production of oil in the Tano Enyire Ntomme (TEN). According to Hagan (2014), the oil discovery in Ghana is estimated to contain 5 billion barrels of oil. Ghana's oil reserves are expected to span between 20 and 30 years, which is a rather limited time span (Manu, 2011).

After the initial excitement of the nation's oil discovery more than ten years ago, a sober reflection followed that sparked discussions on both national and international levels. Political scientists, economists, and oil historians, among others, have contributed to this discourse with a fine balance of optimism and pessimism. Some have argued that being a relatively stable country, Ghana has a greater chance of using its oil revenues to raise the standard of living for the ordinary citizens. The former president of Ghana, John A. Kufuor, has said that the nation's new "black gold" will give Ghana the push it needs to become an "African tiger." President Kufuor stated in the jubilant days of June 2007, when the oil finding was announced; "Oil is money, and we need money to build the schools, the roads, and the hospitals. We are already doing so well without oil. Now with oil as a shot in the arm, we are going to fly" (Gary, 2009). Some, on the other hand, see the oil discovery as an emerging paradox in which the discovery of what is thought to be significant wealth leads to increased corruption and does little to help the poor. They use the plight of mining communities in Ghana and oil-rich but impoverished communities in neighboring Nigeria as examples.

Ghana's oil discovery, like Nigeria, is surrounded by very poor local communities whose primary sources of income are farming and fishing. Local communities in the Niger Delta have faced numerous challenges as a result of oil drilling operations, as their reliance on ecosystem services for survival has been completely destroyed (Adeola, 2001; Jike, 2004). Because the livelihoods of communities in the Western Region are heavily reliant on small-scale agriculture and fishing, some Ghanaian researchers have expressed concern about similar issues occurring. These communities may eventually face the same fate as the people of the Niger Delta (Adusah-Karikari, 2005; Aryeh-Adjei, Abdul-Fatahi, & Mohammed, 2015). A scenario in which the government takes a pro-agricultural stance to consolidate and protect the assets that underpin smallholder farmers' and fishermen's livelihoods, on the other hand, would ensure a thriving oil industry and agitation-free growth for the country.

Oil and Urbanisation

Unlike the urbanisation development nexus, which is unsettled at both the empirical and theoretical levels, the oil-urbanisation nexus is without dispute (Obeng-Odoom 2009). Natural and mineral resource extraction, such as oil, has long been related to urbanisation. This is due to the fact that resource exploitation usually entails the construction of infrastructure, the transportation of equipment and supplies, and the requirement for labor. According to Ebeke and Etoundi (2017), most members of the Organisation of Petroleum Exporting Countries (OPEC) became wealthy as a result of oil revenues and thus became more urbanised as a result of the oil resource. Scholars such as (Kezeiri, 1983; Grill, 1984; Basha, 1988; Al-Mubarak, 1999; Adham, 2008; Jäger, 2014; Obeng-Odoom, 2014; Abou-Korin & Al-shihri, 2015; Adjei-Mensah, Eshun, Asamoah, & Ofori, 2019) discovered that rapid urbanisation was linked to the discovery of oil in their study areas.

As stated by Burt (2014), population centers in the Arabian Peninsula have grown from small fishing and trading villages to globally networked megacities in the last half-century. According to Grill (1984), oil is the driving force for much of the Arabian Peninsula's fast urbanisation. Grill explained that historical concentrations of development projects in urban areas, trade patterns, and the Arab-Israeli wars of 1948 and 1967 all contribute to the urbanisation of the Arabian Peninsula. However, he stated that the role of its oil industry expansion is critical in this process. According to him, the vast oil wealth invested in the development of their cities resulted in well-paying job opportunities, education, and healthcare facilities, all of which attracted a large number of people to the cities. Grill's investigation of these factors reveals that improved healthcare facilities and other investments that contributed to the Arabian Peninsula's urbanisation were funded by oil wealth.

Grill claims that the urbanisation of the Arabian Peninsula was induced by both migration and natural increase (due to greater healthcare facilities). Overall, Grill demonstrates that the Arabian Peninsula's urbanisation is a result of both demographic and economic factors. However, he was careful to point out that, while there are other factors that contribute to urbanisation, oil income plays a significant role (meaning that oil facilitated other factors).

Also, he noted in his analysis of Saudi Arabia's urban population growth that Dammam and Al-Khobar are two cities that have expanded directly due to the oil industry, with approximately 85 percent migrants. Furthermore, studies conducted on several cities in Saudi Arabia using different approaches suggest that the country's rapid urbanisation is primarily due to its oil wealth (Al-Mubarak, 1999; Abou-Korin, 2015; Albassam, 2015; Alqurashi, Kumar, & Sinha, 2016). According to these scholars, Saudi Arabia was largely rural until the discovery of oil. The cities' development investments drew both skilled and unskilled labor, transforming the place from predominantly rural to predominantly urban society (Albassam, 2015).

Also in Libya, as early as 1983, Attir (1983) argued that the rapid urbanisation of Libya was caused by the discovery of oil. Despite its vast size, the majority of Libya's land is desert or semi-arid. As a result, the proportion of suitable land for human habitation does not exceed 10% of the total area, which consists of a thin coastline length and dozens of scattered desert oasis. Prior to the discovery of oil, over 70% of the people lived in rural areas and relied on agricultural activities either directly or indirectly (Attir, 1983). Following the discovery and extraction of its oil reserves, it experienced a dramatic transformation into rapid urbanisation.

Alsharif, & Pradhan, (2014), wrote extensively on the urbanisation of Libya. They stated that, the search for oil began in Libya in the mid-1950s. Libya had become one of the major oil exporting countries by the early 1960s. According to them, every year, thousands of new employments became available as the economy was stimulated. The government initiated a number of socioeconomic measures as money began to build from oil exports. Hundreds of billions of dollars are invested annually on education, health, housing, communication, power, agricultural, and industry development. Recent studies on urbanisation (Pereira, 2007; Alsharif, Pradhan, Mansor, & Shafri, 2015; Gollin, Jedwab, & Vollrath, 2016) affirm that Libya would not have developed and expanded so rapidly without oil wealth.

Another factor to consider is the increasing urbanisation of several oil-rich African countries, such as Nigeria. Though oil and gas exploration in Nigeria began in 1908, crude oil was discovered in 1956 in Oloibiri, in the Niger Delta region (Ariweriokuma, 2008). According to Numbere (2018), Nigeria experienced rapid urbanisation prior to and following independence in

1960, with the urban population increasing from 3.9 million in 1950 to 7.4 million in 1960 and 16.2 million in 1975. By 1990, there were 34.4 million city dwellers. Based on these statistics, Olalekan, Afees, and Ayodele (2016) argued that the vast income generated by the oil resource aided in the urbanisation of Nigeria.

Uzonwanne (2015) clearly stated that the commercial discovery of oil in Nigeria led to the abandonment of agriculture, and that this negligence resulted in the unemployment of many farmers. Secondly, the oil resource supplied the Nigerian government with enormous revenue (huge oil wealth), which was regularly invested in urban centers in various development projects, resulting in employment opportunities in these cities. Third, these job opportunities prompted a large-scale migration to these cities; upon arrival, some migrants found work in the oil sector, while others found work in non-oil-related occupations, with the majority of migrants underemployed or jobless. As a result, the majority of these migrants resorted to informal settlements, where they can at least acquire affordable housing and manage themselves while they wait for their oil employment. These are the mechanisms through which Nigeria's oil resources contributed to the country's rapid urbanisation.

Further to this, Obeng-Odoom (2009), anticipated that oil will accelerate Ghana's urban expansion both within and outside the oil cities when he wrote about oil and urban development in Ghana before the country's oil extraction began. He went on to say that once oil extraction begins in Ghana, migrants from other cities, rural areas, other countries, and a mix of all of these types of migrants will flood the country's cities (Obeng-Odoom, 2009).

This high rate of migration will result in rapid urbanisation, which he refers to as "oil-induced urbanisation." In fact, this was confirmed by recent studies in Sekondi-Takoradi, the immediate city closer to the oil fields (Obeng-Odoom, 2014; Adjei-Mensah et al, 2019; Chalfin, 2019; Nguyen, 2019; Ovadia, & Graham, 2022). According to a report published by the Sekondi Takoradi Metropolitan Assembly (2011), the city is presently experiencing a significant expansion in socioeconomic activities, with various infrastructure projects underway in the hospitality, health, commercial, industrial, and educational sectors. For example, the Sekondi-Takoradi Metropolis' 2010–2013 spatial development plan highlighted the changing physical landscape as a result of land demands for various development projects.

From the literature review above, the scholars made it clear that apart from oil, there are other factors of urbanisation in these oil rich countries, however, oil wealth plays a significant role. According to the literature review, most of these oil-rich countries were predominantly rural and agricultural prior to the discovery of oil. Scholars also pointed out that these countries used their vast oil resources to invest in urban areas, undertaking various developmental projects and construction activities. These massive investments drew individuals from all over the world to seek work in the oil and oil-related sectors of oil producing countries

Environmental impact of oil and gas exploration

Regardless of the economic benefits of discovering and exploring crude oil in Africa, oil exploration has unquestionably far-reaching negative consequences on air, land, and water quality, as well as all living things on the planet earth. Gas flaring (which results in a variety of gas emissions), oil spills, noise, and improper waste management (wastewaters and solid wastes) are all examples of preventable events that are frequently poorly managed in Africa (Adeola, Akingboye, Ore, Oluwajana, Adewole, Olawade, & Ogunyele, 2021). The three major sources of pollution associated with oil and gas exploration and exploitation are: (i) gaseous emissions from gas flares containing CO, NOx, SO2, hydrocarbons, and fine particulate matter; (ii) effluent water contaminated with oily effluents (oil & grease), chemicals, and solids from drilling fluid; and (iii) formation water produced alongside crude oil.

According to Jiang, Chen, Xia, Norgbey, Koomson, & Darkwah (2020), citizens have expressed concern about the quality of air due to air emissions from wellheads, pipelines, drilling sites, compressor stations, and other oil and gas field infrastructure, as well as the relative effect of production and drilling activities on the contamination of surface waters, soils surrounding well sites, and water wells. Several processes used in the production of crude oil, such as extraction, refining, transportation, and gas flaring, emit greenhouse gases into the atmosphere, causing global warming and posing serious environmental issues (Kweku, Bismark, Maxwell, Desmond, Danso, Oti-Mensah, & Adormaa, 2018; Jiang et al. 2020).

Research indicates that soil acidification occurs near locations where gas flaring and spills take place, which over time causes loss of soil infertility and decrease in agricultural productivity (Zhao, Chen, & Wen, 2020). In a study carried out in Ondo state, Nigeria, it was shown that oil and gas exploration activities resulted in land degradation (Olujimi & Emmanuel, 2011). Salts absorbed by the soil from drilling fluids during disposal can change its physical characteristics, adversely affecting plant growth and making the soil unsafe for cultivation (Adeola et al., 2021). According to Ordinioha and Brisibe (2013), oil spills can reduce household food security by 60%, reduce the ascorbic acid content of vegetables by 36%, and increase the crude protein content of cassava by 40%, resulting in a 24% increase in the prevalence of childhood malnutrition (Ordinioha & Brisibe, 2013).

Thus, the entire process of extracting oil has a detrimental impact on the environment, often leading to pollution and health issues. The Ghanaian government fined KOSMOS Energy US$35 million in 2010 for dumping 706 barrels of poisonous substance into the sea and creating environmental damage (Obeng-Odoom, 2014). According to Ozumba (1997), this spill might lead to the extinction of aquatic life, which would have a negative impact on individuals whose livelihoods depend on such marine organisms.

The environmental consequences of oil exploration may have a negative impact on the health of those who live nearby (O'Callaghan-Gordo, Orta-Martnez, & Manolis Kogevinas, 2016). This effect is significantly worse in Low and Middle Income Countries (LMICs), where 638 million people are expected to suffer from oil exploration-related health problems, primarily in rural areas (O'Callaghan-Gordo et al. 2016). They have health problems as a result of factors such as longer stays at drilling sites and the consumption of contaminated food and water. These effects are so diverse that they have an impact on people who aren't involved in oil-related activities, such as pregnant women, children, infants, and the elderly.

Control over environmental legislation is limited in LMICs. Furthermore, governing bodies may be lacking. Communities located closer to exploration sites are thus more vulnerable to oil-related environmental problems. The lack of technical regulations on the management of drilling muds, gas flaring, and water production techniques in the Peruvian Amazon resulted in the contamination of air, water, and soil in residential areas near oil fields (O'Callaghan-Gordo et al. 2016). Oil-related pollution destroys local communities' livelihoods, making it difficult for current and future generations to make a living from their land. With the exploration of oil and gas, the backbone of these economies (farming and fishing) usually come to a halt.

Communities in Nigeria's Niger delta region watched helplessly as their lands were washed away as a result of oil company activities such as soil dredging. Furthermore, the traditional activities of the people, fishing and farming, are no longer appealing and sustainable, resulting in poverty, starvation, and despair among these peoples who struggle to make a living on a daily basis (Concannon, 2004).

Effect of Oil and Gas Production on Socio-Economic Life of People

Exploration and production of oil and gas have many positive and negative socioeconomic impacts. Despite the negative socio-economic impacts associated with oil and gas production, many countries throughout the world would still cherish to discover oil and gas in their territory. This is because the presence of such natural resources is viewed as a point of economic transformation as such discoveries tend to determine a country's development fortunes. While many people see natural resources as a blessing, others warn that if they are not properly managed, they may become a curse. Moss & Young (2009) give a broad summary of the resource curse's possible negative consequences, emphasizing the ways in which natural resources might jeopardize peace, stability, and development.

Positive Impacts

Among the numerous positive impacts of oil and gas exploitation is infrastructural development. According to Broni-Bediako & Addei (2010), people have always expected the development of social amenities and economic growth, particularly in locations where natural resources are being discovered and produced. The local people believe that the discovery, development, and production of oil and gas in their communities will be a blessing in the form of infrastructure; improvements in their road network, health facilities, drinking water, electricity, and education, similar to what has happened in other natural resource endowed communities. According to a consortium conference conducted in 2011, the Sekondi-Takoradi metropolis has undergone a facelift in infrastructure since the commercial production of oil in Ghana. For instance, new roads have been built and various contemporary structures have been erected, giving the twin city a worldwide reputation. Asagunla & Agbede (2018), also noted that the presence and operations of oil firms in Nigeria have provided the government with significant revenue, which has been spent regularly in urban areas in various infrastructure projects.

The creation of jobs is another benefit of oil and gas operations. According to proponents of natural resources as a lure for socioeconomic growth (Rosser, 2006), oil and gas discoveries have spurred the industrialization of several oil-rich nations, which has resulted in the creation of jobs for the populace. According to Broni-Bediako & Addei (2010), there is no concrete or specific measure in place other than the expectation that indigenous people will take advantage of any additional short to medium term job opportunities that may arise. Therefore, the local population will anticipate working in any skilled or menial jobs that may be established in affected communities as a result of the oil and gas operations. Oteng-Adjei (2010) asserts that Ghanaians and locals in oil-host areas anticipate that the growth of the oil and gas sector would lead to the creation of jobs for them. Thus, the discovery of oil and gas is viewed as a way to improve the state of unemployment in the resource-rich jurisdictions. Furthermore, the oil and gas firms have used local labor in their exploration efforts as a kind of corporate social responsibility. This has given unemployed youth in the catchment regions, both skilled and unskilled, the chance to gain employment. In Nigeria, Odularu (2008) posited that due to the advent of oil and gas discovery and development, allied industries and small businesses have emerged, offering job prospects to the majority of prospective locals. The scenario has improved the quality of life and standard of living of the locals.

The social life of the host towns is positively impacted by oil and gas activities since they attract more tourists and individuals from diverse backgrounds. According to Gyan & Asante (2017), since 2010, when Ghana began conducting commercial oil and gas exploration, people from various locations have moved to the Sekondi-Takoradi metropolis to work in various sectors like education, construction, catering, and other services. This movement began as a result of Ghana's oil discovery in the Western region of the country. According to the Coastal Resource Centre Report (2010), the tourism industry is transforming quickly in Western Region's coastal areas.

The report reaffirmed that both governmental and nongovernmental organizations, including the Coastal Resource Centre (CRC), the Italian NGO Ricerca e Cooperazione (RC), and the Dutch Technical Cooperation Service (SNV), are supporting community tourism initiatives in the oil and gas operating zones in a variety of ways.

Africa's crude oil discovery and production has a direct impact on socioeconomic growth. Africa was said to be the fastest-growing source of energy at the end of 2007, with 117.481 billion barrels of crude oil, or 9.49 percent of the world's reserves (Nyemah 2011). Most of the time, oil exploration is advantageous to both the national economy and the global economy. For instance, the African nations that produce the majority of the world's oil depend on their oil revenues, which are also invested in other industries to promote growth (Olujimi & Emmanuel 2011; Mensah & Casadevall 2019). According to a US Geologic Survey Fact Sheet published in February 2010, more than 275 new oil discoveries have been identified in West Africa since 2000. Proper resource management, as well as income from trade and investment in petrochemicals and related goods, may be used to stimulate economic development, reduce unemployment, build infrastructure, and alleviate poverty and hunger on the African continent (Nyemah 2011; Faria 2022).

Oil and gas exploration also has a link with livelihood empowerment. The livelihoods of oil and gas affected communities may improve since they will have access to alternative sources of income. According to Obeng-Odoom (2014), oil corporations have chosen 26 villages from the six oil-producing districts in Ghana's Western Region to receive assistance in improving their standard of living. The 26 communities are divided into four groups: four from the Shama district, three from the Sekondi-Takoradi Metropolis (STM), five from Jomoro District, six from Ahanta West District, and four from each of the Nzema East and Ellembelle District. In total, 740 people benefited from the program. Residents of these communities were taught how to manage their finances wisely (financial literacy), how to develop new technologies (such as new ovens and fish raising), and how to diversify from their current source of revenue, such as soap production. The firms hire community liaison officers to connect with the trainers who also work for the oil companies in order to stay in touch with the local communities (Andrews, 2013).

Negative Impacts

There is evidence particularly in developing countries that the discovery and development of very valuable natural resources, notably oil, have thrown oil-producing countries into conflict, disorder and violence. For instance, the results of a study by Collier and Hoeffler's (2002), which supports the resource-curse concept and further supported by a study by the United Nations Environmental Programme (2009). Darkwah (2010) made the case that between 1990 and 2010 there were at least 18 violent conflicts caused by the exploration of natural resources, including oil, in places like Angola, Cambodia, the Democratic Republic of Congo, Darfur in the Sudan, and the Middle East, using data from the 2009 report of the United Nations Environmental Program. Inequalities in the distribution of oil income have an impact on these intra-state violent conflicts, especially when the local populations close to the oil deposits suffer, as is the situation in Nigeria's Niger Delta.

Many researchers (Ozumba, 1997; Pessoa, 2008; Boonstra, Burke, & Youngs 2008) link the oil discovery to the war in the Delta area of Nigeria. The locals believe that they have been taken advantage of, their environment has been destroyed, and their source of livelihood has been taken from them, which has caused the conflict between them and oil producing firms. According to Boonstra et al. (2008), insurgency is growing in Nigeria, as are regular attacks on oil sites and an increase in the kidnapping of foreign employees (over 100 between 2006 and 2007). Furthermore, with an increase in kidnappings and regular bloodshed, the Niger Delta has become a chaotic haven for armed gangs, according to Bloomfield (2006). For instance, Le Billon (2001) provides an accurate assessment of the extent to which oil profits were used to fund the Angolan conflict.

The corruption issue is another drawback of oil exploration. Large expenditures and contract allocations related to the oil industry might encourage corruption in countries, according to a World Bank (2006) paper. According to Palley (2003), nations that rely on oil earnings not only have poor Human Development Index scores, but also have greater rates of corruption since the funds are frequently plundered by dishonest leaders and bureaucrats. Nigeria, for example, is regarded as Africa's top crude oil producer, the world's seventh-largest crude oil exporter, and the country with the tenth-largest processed gas reserve (Amnesty International 2006; Donwa, Mgbame, & Julius, 2015). Despite massive oil revenues, Nigeria is one of the world's poorest and most indebted countries (Agbiboa, 2013; Kalu & Ott, 2019). According to the Consumer Price Index (CPI), more than 70% of its 200 million estimated citizens live on less than $2 US per day as a result of corruption and poor resource and income management (Hope, 2017). Additionally, Boonstra, Burke, & Youngs (2008) reported that Azerbaijan's corruption has grown along with the country's oil revenues.

Similarly, Appel (2012) revealed that despite a significant increase in Gross Domestic Product (GDP) per capita, the majority of Equatorial Guineans' living conditions have declined. People in Equatorial Guinea are not affected by the oil boom; compared to many other African nations, Equatorial Guinea spends far less on health and education. Oil wealth is unlikely to trickle down to the local people as a result of corrupt state actions.

In addition to these effects, oil and gas operations also undermine traditional means of livelihood. Land is required for oil production but communities' livelihoods depend on their ability to access and use that land. Without access to land for farming, grazing animals, hunting, gathering fruits and firewood, etc., most residents cannot make a living. People's means of subsistence are threatened by the taking of land for oil extraction. Additionally, the loss of resources during oil extraction has an adverse impact on people's livelihood. Water pollution, water shortages and water accessibility issues affect people’s means of livelihood in many locations across the affected regions.

According to Nour (2011), pastoralism and agro-pastoralism were the most significant sources of subsistence before the start of oil activities in the Upper Nile and Unity states (in South Sudan). Oil pollution has destroyed biodiversity, rendered South Sudan's agricultural industry, which employs the majority of workers, unsustainable, and sparked conflicts amongst the local populations. The local economy is no longer dependent on farming, fishing, and cattle rearing, hence, the majority of the youth are now jobless.

Again, the ban on fishing in the oil-producing areas in Ghana, the livelihood structure of the residents has been altered, impacting their level of living (Nguah & Mensah 2016; Akakpo Ewedji, Atta-Mensah, & Tsatsu 2018). According to Panford (2017), as a result of Ghana's oil discovery, a five-kilometer square of the sea has been designated as a "no go area" for fishing, negatively impacting the lives of local fishermen and causing hardships for them. Oil rigs attract fish due to the light they emit, and they also serve as a place for fish to lay their eggs, which protect them from predatory threats that reduce fish harvest (Fabi, Grati, & Puletti, 2004). Nevertheless, oil spills on the surface of water could have a wide range of complex effects on aquatic organisms. The hydrocarbon components in crude oil reduce oxygen levels, affecting the growth and development of aquatic organisms such as fish that generally results in low fish catch in affected marine ecosystems where oil rigs are located (Ozumba, 1997).

Also, Oil exploration and production causes change of residence. Displacement and resettlement are two possible outcomes of an oil induced change of residence. Displacement happens when petroleum plays a significant role in civil wars, ethnic conflict, violence, and excessive environmental problems. Resettlement on the other hand is when there are agreements on public infrastructure, long-term consultations, resettlement plans, and mechanisms for compensating lost property. Oil extraction is a far more complex process, and therefore the related negative consequences of the violent displacement of affected populations are often borne by the state.

According to Kuch & Bavumiragira (2019), the extraction and transportation of oil has contributed to the widespread displacement of the Nubian inhabitants from Sudan. Crude oil my lead to uncontrolled environmental issues. The contamination of drinking water, loss of soil fertility leading to low agricultural productivity, loss of fish, chemical contamination, and risk of disease are some of the factors that compel people to leave their existing residence. According to Amnesty International, oil pollution in the Niger Delta is damaging other crucial resource on which people depend.

Further, the growth and development of the extractive industry is also connected to resettlement. For instance, the Sudan Tribune's April 3, 2009, issue stated that thousands of people in Sudan were forcefully relocated in order to make room for a low-sulfur crude oil project in south-central Sudan. The community's residents lost cherished ancestral homes as a result of this forced eviction, perished from pollution, and had their livelihoods jeopardized.

One of the most significant effects of oil exploration on communities near oil reserves is the impact on cultural practices, particularly how previously benign cultural practices may become problematic in the face of changes caused by the discovery of oil. According to Takyiwa (2014)'s research in Sekondi-Takoradi, migration significantly increased community pollution and gave rise to new lifestyles, which always have an impact on the host communities. Okoli (2006) asserted in a study that the discovery and production of oil and gas, as well as related operations, have resulted in increased social vices, a high rate of school dropout, sexually transmitted diseases, teen pregnancies, and marriage breakdowns in oil and gas host communities.

Furthermore, the presence of foreign oil workers, who are usually paid well as expatriates, makes commercial sex activity potentially more lucrative in such places. A Nigerian female activist explained "See, in our (Ogoni) town, we have girls, young girls from Lagos, Enugu, Warri, Imo, Benin City, Osun, and other areas of Nigeria here every day and night going after the white men and employees of Chevron, they are performing prostitution,". (Turner and Brownhill 2005).

Another negative effect of the discovery of oil and gas is an increase rather than a decrease in the cost of goods and services (Pessoa, 2008). This is due to high inflation and currency appreciation, an increase in labor costs and input prices, as well as the growth of non-traded products and services. One of the main factors contributing to the rise in the cost of goods and services is the reallocation of resources (both financial and human) from less appealing sectors such as agriculture and manufacturing to the thriving OG and mining industries. As a result, non-oil industries usually experience a general economic downturn and a loss of competitiveness.

Furthermore, the discovery of oil and gas draws immigrants to nearby communities in search of work (Gyan & Asante 2017; Obeng-Odoom, 2014). The influx of people from various locations to communities near drilling sites puts pressure on goods and services, causing their prices to rise (Osei-Tutu, 2012). Some residents of the Sekondi-Takoradi metropolis have been forced to relocate due to significant increases in housing costs. According to Osei-Tutu, the Sekondi-Takoradi metropolitan area is experiencing a high cost of living as a result of the oil discovery (2012).

Oil and gas extraction and related landscape alteration

All mining activities requires land and often result in a reduction in the ecological and economic productive potential of the land (UNEP, 2015). Practically, an oil extraction project enters the development stage when a crude oil deposit is discovered. During oil and gas development, a complex network of well pads, roads, pipelines, and other infrastructure, such as processing plants and offices, is built across the landscape. Land impacts following the development stage can occur directly as a result of extraction and production activities, or indirectly as a result of community development around resource sites. As oil and gas activity grows, more land is converted to oil and gas well pads, such as forest or agricultural land. This land disturbance has the potential to fragment the land cover, resulting in the loss of productive forests and agricultural lands, as well as a negative impact on other resources such as water resources and wildlife habitats. It is widely feared that OG development could seriously reduce ecosystem services provided to society and threaten long-term sustainability.

Another direct effect of oil and gas extraction on landscape alteration is gas flaring associated with oil production. Gas flaring is unfriendly to natural ecosystems and biodiversity. According to Omorede (2014), soil degradation has resulted from a combination of the effects of the oil spill and acid rain caused by gas flaring, affecting crop yield and harvest. According to Omorede (2014), oil pollution from gas flaring has destroyed biodiversity and rendered the agricultural sector, the largest employer of labor in the Ogoni community unprofitable. According to her, residents believe that gas flaring is hazardous to their health, the environment, and the general well-being of the oil-producing host communities.

Apart from the direct effects of oil and gas production, oil and gas activities in developing countries frequently cause land alteration and degradation, posing social challenges. The rapid increase in population in oil and gas regions is a major challenge (UNECA, 2011; Lindahl, 2014). People tend to migrate to the host communities and surrounding areas because oil and gas operations provide employment, expand business centers, and create entrepreneurial opportunities. As the population in these areas grows, social issues such as land tenure security and access, road construction, river diversion, and migration from mining areas can all contribute to landscape alteration and land degradation (UNECA, 2011).

The most visible effects of population growth on the land are increased use of natural resources, deforestation, and domestic waste production (Lindahl, 2014; Mususa, 2014). Increased land and other natural resource pressures are associated with additional environmental stresses such as biodiversity loss and air and water pollution, all of which have a negative impact on arable land (UNEP, 2015). According to UNEP (2015), in African countries there is a direct link between population growth and land cover change because land use tends to intensify without accompanying conservation measures.

Beine, Bos, and Coulombe (2012) discovered that areas with resource booms had higher population growth, primarily due to migration, at least in the short term, a situation they explained was necessary in adjusting the local economy to the boom. To support their findings, they cited the situation in

Alberta, where total immigration increased from 1.7 percent of total labor per year to 3.1 percent after oil extraction began. This finding is supported by Jacobsen and Parker (2016), who state that communities near oil and gas reserves in the United States are "at the epicenter of a new kind of gold rush." According to them, a common feature of the early stages of the oil boom is corporations offering higher wages to attract drilling labor. An influx of migrant labor from outside the community is usually attracted due to the specialized labor requirements and the associated high wages. Despite increased employment and wages, agricultural activities, which were typically the primary source of livelihood in the pre-boom period, suffer, resulting in lower farm proprietor income, according to the study.

Definitions and rational for LULC studies

Land cover and land use are frequently used interchangeably, but there is a significant difference between the two. The observed (bio)physical cover on the earth's surface is referred to as land cover. It refers to the earth's surface cover, such as vegetation, bare soil, and built-up (settlement), without regard to how that cover is used. Land use, on the other hand, is defined by the arrangements, activities, and inputs that people make in a specific land cover type in order to produce, change, or maintain it. Briassoulis (2009) defines land use as the intended use of and management strategy applied to the land cover by human agents, or land managers, in order to exploit the land cover, and it reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging, and mining. This definition of land use establishes a direct relationship between land cover and human actions in their surroundings. The following examples further demonstrate the two main definitions discussed in the preceding section

(I) "Recreation area"; it is a land use term that can refer to a variety of land cover types, such as sandy surfaces like a beach, and built-up areas like a pleasure park.

(II) Grassland; it is a type of land cover that is commonly associated with livestock grazing as a land use. The term "grassland" refers to a grass cover, whereas "rangeland" or "tennis court" refer to the use of a grass cover.

Generally, remote sensing data provides land cover images only. The use type of the cover in the imagery is known by field observation or checking with the imagery. This is known as 'ground truthing'.

In this study, Land use land cover change is defined as any change in the physical, biological, or chemical properties of the land surface caused by natural occurrences or human activities. Land use and land cover changes are classified into two broad categories: conversion and modification. Conversion is the process of changing from one cover or use type to another, whereas modification is the process of keeping the broad cover or use type in the face of changes in its attributes (Baulies and Szejwach, 1998).

LULC is an important component of landscape and sustainable management research. Why is this such an important and expanding field of science? Land is, after all, a natural resource and a scarce resouce. To ensure that humans continue to develop and support growing populations, we must effectively manage the limited amount of usable land that remains. Although humans have been modifying land for thousands of years in order to obtain livelihoods and other necessities, the extent, intensity, and rate of LULCC are far greater now than in the past.

According to Lambin (2005), sustainable resource use is the use of environmental resources to produce goods and services in such a way that the natural resource base is not harmed in the long run, allowing future human needs to be met. Managing the transformation of the earth's surface caused by changes in land use and land cover is one of the most significant global challenges of the twenty-first century (Mustard et al., 2004, cited in Daniels et al., 2008).

Undeveloped (or wilderness) areas are estimated to account for 46 percent of the earth's land surface. Approximately half of the earth's land area was covered by forests 8000 years ago, compared to 30% today. To meet the demand for food and fiber, agriculture has spread throughout the world into forests, savannas, and steppes (Lambin et al., 2003). The Global Forest Resources Assessment 2000 estimated that the world's natural forests decreased by 16.1 million hectares per year on average during the 1990s, representing a loss of 4.2 percent of the natural forest that existed in 1990, based on data from various sources (Lambin et al., 2003).

As a result, land cover classification has recently emerged as a popular research topic with numerous applications (Liang et al., 2002). A significant amount of research has been conducted all over the world in an attempt to comprehend major shifts in land use and land cover and to link them to changing environmental conditions. Land-use dynamics, according to Baulies and Szejwach (1998), will play a significant role in driving global environmental changes in the coming decades. As a result, global mapping that reflects the dynamics of irrigated and dry land agriculture, semi-natural areas, and forest cover can aid in assessing the biophysical implications of land use and land cover change within the earth's system.

Generally, agriculture has been identified as the primary driver of land cover change in tropical regions (Lambin et al., 2001 cited in Daniels et al., 2008). As a result, LULCC research must address the identification, qualitative description, and parameterisation of factors that drive changes in land use and land cover, as well as the incorporation of their consequences and feedbacks (Baulies & Szejwach, 1998). However, one of the major challenges in LULCC analysis is linking human behaviour to biophysical data at appropriate spatial and temporal scales (Codjoe, 2007). It is argued, however, that if the unit of analysis is at the national, regional, district, or municipal level, land use and land cover change trends can be easily assessed and linked to population data.

A variety of natural and human factors in social, economic, and political contexts cause changes in land use and land cover. As a result, by measuring the rates and types of changes and analyzing other relevant data sources such as demographic profiles, household characteristics, and land resource administration policies, the local human activities expressing the drivers can be determined.

The aim of LULCC research is to gain a better understanding of the human and biophysical forces that influence land use and land cover change. Thus, linking human behavior and social structures to biophysical characteristics of the land is a key component of LULCC research (Baulies & Szejwach, 1998). Land use and land cover have a significant impact on global environmental change and sustainability, including climate change response, effects on ecosystem structure and function, species and genetic diversity, water and energy balance, and agro-ecological potential (Codjoe, 2007).

In conclusion, land use land cover change studies provide planners and policymakers with answers to some critical questions:

I. What type of land is under the most severe threat?
II. Where do forests need to be protected?
III. In which direction is an urban center expanding, and is this endangering the natural environment?
IV. What impact does changing land use have on the atmosphere and nearby water resources?
V. Where do we have the best chance of exploiting land as a natural resource?

Driving forces of land use land cover change

LULCC are complex phenomena that are influenced both directly and indirectly at various scales by a variety of socioeconomic and biophysical driving forces. The drivers do not act alone, rather they interact to produce outcomes that are generally harmful to human survival. However, it has been observed that human activity, rather than natural change, is now driving the majority of land cover modification and conversion (IGBP 1993). Natural causes of LCC include storms, landslides, diseases and pests of existing vegetation, and fire, which is the most common in most areas. Land use/cover change is the result of increased use of nature to meet a wide range of human survival and development needs. Meyer and Turner II (1992) identified the primary drivers of land cover change as technological capacity, socioeconomic organization, level of development, and culture. According to Basommi et al. (2015), one of the leading causes of global land use change is population growth.

Land conversion is a direct driver of changes in land use and land cover. Humans alter land use in order to change the mix of ecosystem services provided by that land. Land conversion can be intentional, such as plowing grasslands to grow crops or cutting down forests to make way for farming. In other cases, land conversion is the result of another human induced activity.

Biological invasions are a global phenomenon that affects the majority of biomes' ecosystems (Mack et al. 2000). Invasion-induced ecosystem changes can have both short-term and long-term ecological and evolutionary consequences. In some ecosystems, invasive alien organisms and diseases cause the extinction of native species or a significant loss of ecosystem services. The invasion of black pod disease, for example, causes cocoa farm closures (Stow et al, 2013).

In the case of demographic and urbanisation which is an indirect driver of LULCC, population growth is determined by demographic factors such as fertility, mortality, and migration. As the population grows, so will the demand for food and shelter (e.g. Kuusaana and Eledi, 2015; Kleeman et al., 2017). The demands will have an impact on land use. More land, for example, will be required for housing. More land under cultivation or intensification is required to meet rising food demand. This is about land conversion. In terms of physical development, population growth causes urbanisation, infill, and sprawl (Cobbinah et al., 2017).

A study in Sekondi Takoradi Metropolis by Adjei Mensah et al. (2021) shows a phenomenal expansion of the city's built-up lands over time due to population growth, with such expansion taking place on farmlands, forests (especially closed forest), barren lands, and water bodies.

To understand culture as a driver of ecosystem change, it may be best to focus on the values, beliefs, and norms that a group of people share and that have the most influence on environmental decision making. According to Kusimi (2008), despite the fact that these forces are critical in shaping an area's land use changes, little attention has been paid to land use and land cover changes when it comes to the political structure, political economy, and cultural values of the people. In this sense, culture shapes a person's perceptions of the world, influences what he or she values, and suggests appropriate and inappropriate courses of action (Kumi-Boateng et al, 2012). Land use culture could refer to crops grown, building types and forms, areas where land conversion is permitted. This contributes to the transformation of a society's land use and land cover (Koranteng et al, 2017).

Theoretical Perspective

The Growth Pole Theory

The Growth Pole Theory (GPT) has long been developed to describe how the activities of firms and industries contribute to, and spread growth and development of towns and cities. The establishment of industry leads to growth and development in the source region and spread spatially from its point of location to neighboring areas and the strength of the spread depends on the strength of the industry. When this occurs, it is said that the industry is serving as a growth pole and the town where it is situated is the growth center. According to Musa and Kpanache (2014), a growth pole can be identified based on infrastructural development, resource frontier, industrial development, and high political and administrative status.

The GPT was formulated in the 17th century by British economist Sir William Petty (1623-1687). He was fascinated by London's rapid economic growth and proposed that strong urban economies serve as the backbone and engine of national wealth (Petty, 1984). However, it was the French geographer and economist Francois Perroux (1903-1987) who expanded on the theory in 1949, adding that industrial development is concentrated in one or two major cities, and that growth begins in the central cities and spreads to the periphery (Perroux, 1949; cited in Darwent, 1969). His wok centered on the economic aspect of the growth pole. However, there is a lack of agreement among experts in this subject about the growth pole, particularly when taking the authors' areas of expertise into consideration. As a result, there are many perspectives on the growth pole coming from economists and geography experts. According to the common understanding of growth pole, a growth pole is an industry or possibly a cluster of companies within an industry. For instance, a growth pole can be a single firm or a cluster of industries at their most extreme.

The growth pole's basic tenet is that economic development or growth does not occur uniformly across an entire region but rather revolves around a particular pole. This pole is frequently represented by a dominant industry around which linked industry develop, primarily as a result of direct and indirect effects. The expansion of this key industry of the economy entails growth in output, employment, related investments, new technologies, and new industrial sectors.

The role of mineral exploitation to develop growth poles cannot be underestimated. Sharaky (2014) explains the role of mineral exploitation in providing a source of livelihood for millions of the rural and semi-urban African communities, transforming these communities into towns and cities. According to him, "the gold rush resources of the Wit-waterstand's were discovered in 1886 and were responsible for the quick rise of Johannesburg, which remains the economic hub of South Africa".

Bukari, Aabeyir, & Basommi (2014) investigated the development of growth poles in Ghana's three major ecological belts under the influence of natural resources. They stated that in Ghana's coastal region, the first European traders who arrived at the country's shores and the subsequent construction of castles and forts at Cape Coast and Elmina in the Central Region, Accra in the Greater Accra Region, Sekondi-Takoradi in the Western Region, and Keta in the Volta Region, among other places, to become growth poles. Later, these developments had immediate effects on neighboring villages and towns in terms of trade, education, and (especially Cape Coast in the latter two aspects).

They attribute Tema and Takoradi's rapid development to the establishment of Takoradi and Tema Ports in 1928 and 1962, respectively. Some of the ports were built in response to the exploitation of natural resources. For example, the Takoradi Port in the Western Region, which facilitate the export of most mineral and other natural resource wealth of Ghana, was built to encourage the export of gold from the Tarkwa Gold Mine. While Takoradi port specialises in timber, minerals, and now oil exports, Tema port is well known for its contribution to cocoa exports. Furthermore, the Tema oil refinery and the discovery of crude oil at Cape Three Point in Ghana's Western Region are ways for Ghana's coastline to contribute to national growth and development (Moss & Young, 2009).

All of these factors increased the centrality of coastal cities, reflecting the characteristics of the Growth Pole Theory in this and other belts of Ghana, with Accra serving as the country's capital, Takoradi serving as the Western Regional Capital, Cape Coast serving as the Central Regional Capital, and Tema serving as one of the country's most significant habour city.

According to this theory as it relates to this study, the establishment of the oil and gas industry in the study area (Ellembelle district) has resulted in the emergence of other businesses and economic activities, which have in turn aided in economic growth and urbanisation, changing the landscape of the area. The presence of growth poles in oil and gas regions attracts a significant workforce, leading to rapid urbanization as people migrate to these areas in search of employment opportunities. This influx of population necessitates the construction of residential, commercial, and institutional infrastructure to accommodate the growing urban population. Consequently, rural land is converted into urban areas, resulting in changes in land cover from agricultural or natural to built-up environments.

Growth poles require robust infrastructure to support the transportation, extraction, processing, and distribution of oil and gas resources. This infrastructure includes roads, pipelines, storage facilities, and housing for workers. The development of such infrastructure often involves land acquisition and land use changes. For example, the construction of pipelines may require clearing of vegetation and alteration of natural habitats, while the expansion of road networks may lead to fragmentation of ecosystems.

Overall, the Growth Pole Theory provides a framework for understanding how the concentration of economic activity in specific regions, such as those driven by the oil and gas industry, can influence land use and land cover changes. These changes have implications for environmental sustainability, economic development, and social well-being in both urban and rural areas surrounding growth poles.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This chapter presents the study area and methodology. Basically, it discusses the materials and methods of the study as well as the logic and justification for the choice of these methods. Also, the chapter provides details regarding the quantitative methods used including the GIS approach as well as the household survey conducted. The methods in both the data collection and analysis of qualitative data sections are also presented in this chapter. The chapter is organised under the following themes: research design, study area, target population, data collection, sampling procedure, data processing and analysis, and ethical issues.

Research design

Research design according to Creswell (2007), is the logic or master plan of a study that explains how the study will be carried out. A research design's primary function is to ensure that sufficient evidence has been gathered to allow one to approach the research problem rationally, logically, and as unambiguously as possible (Labaree, 2013). Also, according to Creswell (2007), the type of research design used for a study is determined by the aim and objectives of the research. The explanatory sequential design was the most appropriate research methodology for this study given the nature of the research problem and the objectives of the study.

Explanatory sequential research is a type of research design in which the researcher first conducts quantitative research, analyses the results, and then expands on the findings with qualitative research to provide an in-dept explanations for the results obtained from the quantitative analysis aspect of the study. It is regarded as explanatory because the initial quantitative data results are further explained using qualitative data. The quantitative phase is referred to as sequential because it is followed by the qualitative phase. This research design is common in fields that have a strong quantitative foundation, so the project starts with quantitative research (Creswell, 2007).

The research aims to assess the impact of oil and gas extraction on land use land cover change in Ellembelle district. In this research, data from satellite images were first analysed to determine the changes that have occurred overtime. Based on the results from the satellite images, a household survey was conducted to further obtain information that helped the study achieved its objectives. Interviews were later conducted after the image analysis and household survey to explain the triggers or drivers of the changes and also the impact of the change on the livelihoods of the people.

The research design adopted implies the use of the mixed method research approach. In practice, the mixed method research approach involves the application of both the quantitative and qualitative methods in a particular research. Qualitative methods provide a comprehensive view of human experiences by providing detailed information about participants' realities and social contexts (Holloway, 2005). Rich and detailed information about participants is extremely useful in investigating and comprehending their experiences and vulnerability to changes in land use land cover in the study area. Furthermore, the use of qualitative methods allowed for greater flexibility in data collection because reports from community members and key respondents were captured verbatim. The qualitative research strategy involved participant observation, interviews and in-dept interviews.

The use of geographic information systems using the ArcGIS software tools complemented by other software such as Statistical Product and Service Solutions (SPSS), Microsoft Excel and Stata constituted the quantitative methods and techniques that were employed in the study. This ensured positivist and bias free outcomes, which reduces the likelihood of interpretation errors.

According to Creswell (2003), one of the major challenges of using both qualitative and quantitative methods is that, it is time consuming. Nonetheless, it is still one of the greatest techniques to adopt because it examines a situation from multiple perspectives rather than just one (Neuman, 2003).

Study Area

The study was carried out in the southern part of Ellembelle district in Southwestern Ghana. The area forms part of the Greater Amanzule Landscape in the Nzema traditional area, an important wetland ecosystem in Ghana (Figure 2).

posing a threat to wildlife and and the local community's means of livelihood (Kankam et al., 2021).

Geology, relief and soil

The topography of the area is generally undulating, with the highest point about 18 meters above sea level. The underlying rock is mostly Cambrian Birimian and Tarkwaian Sandstone-Association of Quartzite and Phylites types (GSS, 2010). This area is rich in minerals such as kaolin, silica, and gold, as well as sandstone deposits. The district's soil is mostly ferric acrisols. The ferric acrisols soil type accounts for approximately 98 percent of total land area and allows for the cultivation of a wide range of crops including cocoa, coffee, coconut, oil palm, plantain, and cassava (GSS, 2010).

Climate

The climate zone is West African sub-semi-equatorial. The area receives rain all year, with May and June having the highest or maximum monthly mean rainfall. The annual rainfall averages 26.8mm to 46.6mm. The District's average daily temperature is around 29.40°C, with monthly mean temperatures ranging from 40°C to 50°C all year.

Vegetation

The vegetation of the study was originally moist semi-deciduous rain forest, but it was transformed into secondary forest due to human activities such as tree felling and farming. The vegetation along the coast is mostly savanna (GSS, 2010). The area contains small timber species as well as non-timber forest products such as rattan and bamboo.

State of the Natural Environment

The Ellembelle district is faced with many challenges. Prominent amongst these challenges are deforestation, bushfire, soil erosion and mining and quarrying. These factors are disturbing as their effect could lead to food insecurity and aggravation of poverty in the district.

Amongst their tracts of forest is the mangrove forest. However, the forests in this area are reported to record high occurrence of deforestation. This can be attributed to the exploitation of timber for logs and lumber by legal and illegal chainsaw operators. Also, mangroves are reported to be deforested for firewood and for construction purposes. Further, they are reported to be cleared to make way for fish farming and wood fuel.

Target Population

The target population refers to the entire set of residents/inhabitants from which the study sample was drawn to obtain the needed information and data that were analysed to provide useful study conclusions. The household heads were the study's target population. The Ellembelle district has 85,338 households, according to the 2010 Population and Housing Census. The household heads were chosen because they are the breadwinners in their respective households. As a result, their social and economic well-being has a huge impact on the members of their households. A selected household head must have stayed in the district for not less than 25 years. This facilitates the identification of significant changes in the nature of land cover in the study area (Paintsil, 2014).

Sampling size estimation

The sample size for the study was determined using the number of households in the Ellembelle district from the 2010 National Population and Housing Census, which was estimated to be approximately 85,338. (2010 Population and Housing Census). Specifically, the sample size for the study was determined using the Fisher et al, (1998) formula for determining sample size of finite population when the sample size is greater than 10000 (see Nashiru, 2019; Manu, 2011; Kaku, 2018). The formula is as follows:

$$n = \frac{z^2 pq}{d^2}$$

Where:

n = the desired sample size when the population is more than 10000

z = standard normal deviate, which is usually set at 1.96 which corresponds to 95 % confidence level;

p = the proportion in the target population estimated to have particular characteristics

q = 1.0-p. (with 1.0 as constant)

d = the degree of accuracy desired, this is usually set at 0.05

With the (z) statistic being 1.96, degree of accuracy (d) set at 0.05 % and the proportion of the study population with similar characteristics (p) at 80% which is equivalent to 0.8, then the sample size generated was:

$$n = \frac{1.96^2 \text{ x } 0.8\ [1-0.8]}{0.5^2}$$

n = 246

Approximately, a calculated sample size of 246 respondent was obtained for the study.

Sampling Technique

Different sampling procedures were used to arrive at a number that reflects true representation of the total population. First of all, a purposive sampling technique was used to select five communities in the district. These communities were Atuabo, Sanzule, Esiama, Aiyinase and Kikam. These communities were selected purposefully because they have pipelines running through them and majority of the people have lost their farmlands and other properties due to the construction of the gas processing plants.

The proportional sampling technique was used in the second stage of sampling. The proportional sample technique was used to determine how many respondents should be assigned to each community. Based on the number of households in each community, Esiama had 78 respondents, Aiyinase had 98, Kikam had 45, Atuabo had 15 and Sanzule had 10 respondents (Table 1).

Table 1: Sample size distribution

Communities	No. of Households	Proportion	Sample
Ainyinase	2177	0.3986449368	98
Esiama	1734	0.317524263	78
Kikam	991	0.1814685955	45
Atuabo	325	0.0595129097	15
Sanzule	234	0.042849295	10
TOTAL	**5461**	**1**	**246**

Source: Blay (2021).

The ArcGIS 10.8 software was then used to randomly select the houses, which were then imported into a computer assisted personal survey tool. The researcher and field assistants used this as a guide to identify the randomly selected houses and household heads that they interviewed

Data collection instruments and procedure

This study gathered data from two major sources; primary and secondary. Consequently, the study objectives were addressed using both primary and secondary data. In terms of data sources, two types were used: quantitative data sources and qualitative data sources.

Quantitative data

The quantitative data for this study involved both primary and secondary data. Primary data were collected using interview schedule, and a handheld GPS. The interview schedule was used to solicit for data about the general factors accounting for the changes in land use and land cover within Ellembelle district. Data about occupational changes and effects of the changes of land use on their local communities were also solicited. The interview schedule had both open ended and closed ended questions. The interview schedule was divided into five parts. The first part (Part A) constituted the socio-economic demographic characteristics of the respondents such as age, sex, marital status, educational level, occupation, monthly income, years of stay in the community and household size. Part B captured issues relating to the drivers of LULCC in the district which entails likert scale questions (1-5). Part C tackled issues relating to the effect of LULCC on livelihoods of the citizens of Ellembelle district. Part D consisted of likert scale questions (1-5) measuring the Socio-economic impacts of land use land cover change on livelihoods. The final part (Part E) measured the state of some basic infrastructure in the district. The instrument was administered to the household heads in their respective houses by the researcher and field assistants to collect the quantitative data.

Also, a field survey was also conducted to collect GPS location (coordinates) for accuracy assessment and for training sites during the classification of the acquired satellite data using a handheld GPS.

Additionally, secondary quantitative data generated by government agencies and other institutions that were useful for the study were consulted. The secondary data was collected mainly via internet download. For instance, Landsat images of the study area were obtained from the Earth-Explorer website, which is one of several data repositories for USGS satellite images. The study made use of Landsat data from three different years: 2000, 2010, and 2021. Table 3.1 provides a summary of the data obtained, which includes one Landsat 4 Thematic Mapper (TM) data, one Landsat 7 Enhanced Thematic Mapper Plus (L7 ETM+) data, and one Landsat 8 OLI TIRS data. To improve the accuracy of the results, the data were carefully selected with a cloud cover of less than 10%. The data for 2000, 2010, and 2021 were all obtained in January.

Table 2: Details of Landsat data

No.	Date of acquisition	Satellite specification	Spatial resolution
1	01/01/2000	Landsat 4 Thematic Mapper	30
2	15/01/2010	Landsat 7 Enhanced Thematic Mapper	30
3	06/01/2021	Landsat 8 Operational Land Imager/Thermal Infrared Sensor	30

Blay (2021).

Qualitative data

In accordance with the study's research design, qualitative data were collected second in the sequence to help explain or elaborate on the quantitative results obtained in the first phase. The rational behind this approach is that qualitative data analysis refine and explain statistical results by delving deeper into participants' perspectives. In-depth interviews, informal interviews, and observations were used to gather qualitative data. Respondents' knowledge about the nature of the land cover, land management, and the potential effects of land use change were gathered through in-depth interviews. Opinion leaders, assemblymen, and farmers were among those who took part in the in-depth interview.

Data Processing and Analysis

Image processing

Individual bands of the various images were staked to create a composite image using the ERDAS IMAGINE image analysis software. To delineate the study area from the images, a subset via Region of Interest (ROI) was performed using Ellembelle polygon shapefile. The study images were then subjected to a number of pre-processing procedures. First, radiometric calibration was performed. The goal of this calibration was to eliminate distortion in the data capturing process caused by factors such as sun angle, curvature, earth rotation, and instrument effect. Second, atmospheric calibration (correction) was performed to improve image reflectance. Finally, the ERDAS IMAGINE haze and noise reduction module was applied to all of the images to provide better and enhanced images for classification. The imported image was geocoded using the WGS 84 UTM Zone 30 coordinate.

Image classification

The supervised maximum likelihood classification was used to classify the preprocessed images. The maximum likelihood algorithm is a statistical decision rule that examines a pixel's probability function for each class and assigns it to the class with the highest probability (Firdaus, 2014). The maximum likelihood classification was performed to derive five classes of land use land cover identified in the study area. The classification scheme used for the study is detailed in the Table 3.

Table 3: Classification Scheme

Classes	Description
Water	All water bodies in Ellembelle district including swamps and marshes (wetlands) around water bodies
Dense vegetation	Forest, mangroves, tall trees and dense vegetation
Sparse vegetation	Farmlands, all forms of grasses and sparsely distributes vegetation
Bare land	Recently cleared farmlands, untarred roads, mining sites and barren lands
Built up	Dense infrastructural developed areas such as residential, commercial and roads

Blay (2021).

Using the time series function in Google Earth Explorer, high resolution images corresponding to the dates of the satellite images were downloaded and superimposed on the satellite images. Training samples were then picked from the superimposed images to give accurate classification.

In ArcGIS 10.8, the LULC were created and LULC class statistics were generated in square kilometers. The percentage of each LULC category was then calculated in Microsoft Excel version 19 by dividing the area of each LULC category by the total land area multiplied by hundred. The ArcGIS 10.8 software's intersection function tool was used to find changes in important LULC categories. This aided in the creation of the transition matrix.

The classified images were validated by calculating and analysing the overal Kappa and accuracy using the accuracy assessment formula below.

Overall Accuracy = Total number of correctly classified pixels x 100
Total number of reference pixels

Kapa coefficient = (Total*sum of correct)-sum of all the(Row Total*Column Total)
Total Squared-Sum of all the (Row Toal*Column Total

Two hundred and fifty (250) points were randomly selected on the images of each year using ArcGIS 10.8 software for the accuracy assessment of the classified images. Traditionally, image accuracy assessment measures the likelihood in percentage that the classifier correctly classified an image pixel. Also, it measures the likelihood that a reference pixel will be accurately categorized (Yan et al., 2006).

Socio-economic survey data analysis

The data gathered from the administered questionnaires were coded and analyzed. In this phase of the data analysis, the questions in the survey questionnaires were assigned numerical values based on the responses provided or supplied by the respondents using the Statistical Product for Service Solution software (SPSS). This classification method reduced the data to meaningful information that could be analyzed. Socioeconomic demographic variables were coded as gender (Male=1, Female=2); age (young adult: <35 years, middle-aged adult: 35-55 years. and old- aged adult: >55 years; see Armah et al., 2019); residence status (Native=1, Migrant=2); years spent in community (<31 years = 1, 31-35 years =2, and more than 35 years =3); level of education (no formal education=1, basic=2, secondary=3, post secondary=4); marital status (Single=1, Married=2, Divorced=3, Separated=4); religious affiliation (Christian=1, Muslim=2, Traditional=3, Do not belong=4). Respondents' occupations were later grouped and coded in to Fishing=1, Farming=2, Formal government work=3 Formal Private work=4, Informal work=5, Unemployed=6. Using the median of GHC600, income class as part of the economic characteristics was grouped into three: low class (<GHC600). middle class (GHC600-999), and high class (GHC999) (see Adzido, Dzogbede, Ahiave, & Dorkpah, 2016). Nature of income after oil and gas coded as Decreased=1, Unchanged=2, Improved=3. Socioeconomic impact of LULCC on livelihoods was coded using likert scale (SD=Strongly Disagree, D= Disagree, N= Neutral, A= Agree, SA= Strongly Agree. Lastly, Conditions of basic infrastructures was coded as Worsened=1, Unchanged=2, Don't know=3, Slightly Improved=4, Greatly Improved=5.

SPSS, STATA, and Microsoft Excel aided the statistical data analysis aspect of the study by representing results of the analysis in tables, graphs, charts, and frequency distributions. In addition to the nominal values, percentages were calculated to better understand the variable distribution. These estimates were created to aid in the interpretation of the study results and to provide answers to various research questions. A non-parametric test (Pearson Chi-square) was also used to determine the relationship between income, occupation, and level of education.

The ranking index used by Musa, Peters, and Ahmed (2006) and Solomon, Birhane, Tadesse, and Meles (2017) was used to compute the ranking of the drivers of LULC changes perceived by respondents (household surveys).

$$\text{Index} = \frac{R_nC_1+R_{n-1}C_2\ldots\ldots+R_1C_n}{\sum R_nC_1+R_{n-1}C_2\ldots\ldots+R_1C_n}$$

Where R_n = Value given for the least ranked level (for example, if the least rank is 5^{th}, then R_n=5, R_{n-1} = 4, R_1=1; C_n= counts of the least ranked level (in the above example, C_n is the count of the 5^{th} rank, and C_1 is the count of the 1^{st} rank)

Ethical Issues

The study placed emphasis on ethical issues because human subjects were involved. As a result, before administering the questionnaire, the researcher first introduced himself and briefed the respondents about the study's aims and objectives, as well as obtaining their consent to participate in the study. The participants exercised their rights voluntarily by accepting or refusing to participate in the study. Also, study respondents were informed that they could withdraw from the study at any time if they did not wish to continue.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The main aim of the study was to assess the impact of oil and gas extraction on LULCC in Ellembelle district. This chapter, therefore, seeks to provide answers to the research questions outlined in the first chapter of this thesis. The results of the analysis of the study data are presented and interpreted in this chapter. Generally, the chapter is structured to follow the study objectives outlined in chapter one of this report. Specifically, the chapter covers the following major themes: Spatial and temporal changes of the LULC in Ellembelle district; Drivers of LULCC in Ellembelle district; Socioeconomic impact of LULCC on livelihoods; and Impact of LULCC on basic spatial infrastructure in the study district.

Spatial and Temporal Changes of the LULC in Ellembelle District

LULC in Ellembelle district for 2000, 2010 and 2021

Figure 3 shows a spatial representation of the classification results obtained in the multi-temporal satellite images. The study used maximum likelihood supervised classification scheme to identify 5 land use classes. Table 1 shows the statistics of the area extent in square kilometres (km^2) for the LULC classes across 2000, 2010 and 2021.

The data shows that in 2000, Dense vegetation was the most dominant LULC class in Ellembelle district with a total land surface area of 120.667km^2. It represented 40% of the surface area of Ellembelle district. This was followed by Sparse Vegetation covering 91.932km^2, representing 30% of the total land surface area. The Bare Land occupied 44.156km^2 (15%) of the area while the rest of the district was occupied by the Water (28.251km^2, 9%) and built-up classes (16.604km^2, 6%).

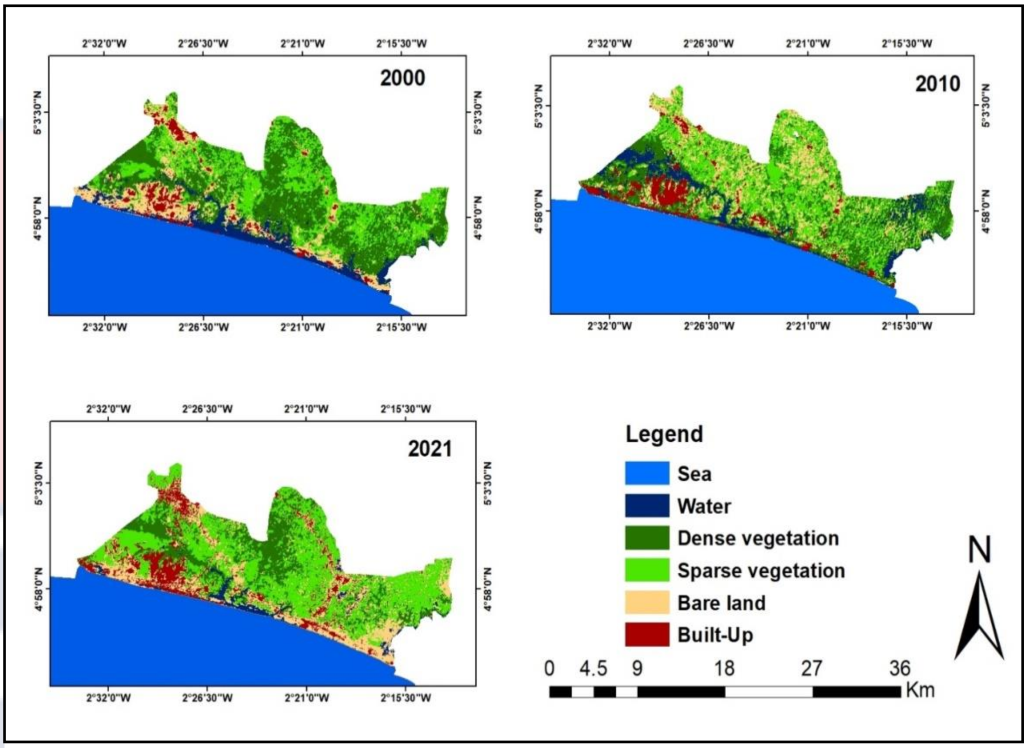


Figure 3: LULC Maps of Ellembelle District for 2000, 2010 and 2021.
Source: Blay (2022).

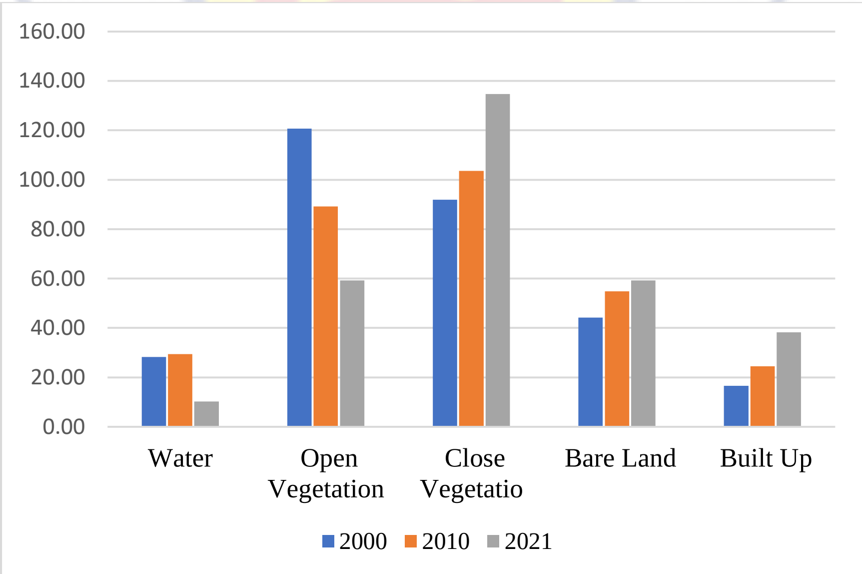


Figure 12: LULC Trends for 2000, 2010 and 2021
Source: Blay (2022).

Table 4: LULC in km² for 2000, 2010 and 2021

	2000		2010		2022	
LULC classes	Area (km)	Percent (%)	Area (km)	Percent (%)	Area (km)	Percent (%)
Water	28.251	9%	29.393	10%	10.206	3%
Dense vegetation	120.667	40%	89.189	30%	59.252	20%
Sparse vegetation	91.932	30%	103.623	34%	134.715	45%
Bare land	44.156	15%	54.858	18%	59.261	20%
Built-Up	16.604	6%	24.548	8%	38.176	13%
Total	**301.610**	**100%**	**301.610**	**100%**	**301.610**	**100%**

Source: Blay (2022) based on image analysis

In 2010, Sparse Vegetation became the most dominant LULC class in the area. It recorded an increase in surface area, covering 103.623km^2 and representing 34% of the total landmass of Ellembelle district. Dense Vegetation loss surface area (decreased in spatial extent) and became the second dominant LULC class in the area. It covered a total surface area of 89.189km^2 (30%). Bare Land increased to 54.858km^2 (18%) followed by water (29.393km^2, 10%). In all, the Built-up class remained the least dominant LULC class, however, it recorded an increase in surface area (24.548^2, 8%).

The classification of the 2021 satellite image revealed that Sparse Vegetation remained the most dominant LULC class, covering 134.715km^2, (45%). Built-up which was the least class in 2000 and 2010 increases to 13% in 2021. Water became the least LULC class (10.206km^2, 3%) in the Ellembelle district.

Accuracy assessment

Table 5: Error matrix classification

2021 Classified	W	DV	SV	BL	BU	Total	U.A
W	**34**	0	3	1	0	38	89.47
DV	0	**46**	6	0	0	52	88.46
SV	3	4	**54**	0	0	61	88.52
BL	0	0	0	**48**	0	48	100
BU	0	0	0	0	**51**	51	100
Total	37	50	63	49	51	250	
P.A	91.89	92.00	85.71	97.96	100		
2010 Classified	W	DV	SV	BL	BU	Total	U.A
W	**29**	1	5	2	0	37	78.38
DV	0	**42**	9	0	2	53	79.25
SV	1	6	**58**	0	0	65	89.23
BL	2	0	0	**40**	6	48	83.33
BU	0	0	0	5	**42**	47	89.36
Total	32	49	72	47	50	250	
P.A	90.63	85.71	80.56	85.11	84		
2000 Classified	W	DV	SV	BL	BU	Total	U.A
W	**30**	0	4	1	0	35	85.71
DV	0	**46**	4	3	3	56	82.14
SV	1	6	**54**	5	0	66	81.82
BL	0	0	2	**40**	4	46	86.96
BU	0	0	0	4	**43**	47	91.49
Total	31	52	64	53	50	250	
P.A	96.77	88.46	84.38	75.47	86.00		

P.A= Producer Accuracy, U.A=User Accuracy
Source: Blay (2022) based on image analysis

Overall Accuracy (2021) = $\frac{34+46+54+48+51}{250} * 100$

Overall Accuracy = 93.2%

Kapa Coefficient = $\frac{(Total * sum\ of\ correct) - sum\ of\ all\ the (Row\ Total * Column\ Total)}{Total\ Squared - Sum\ of\ all\ the\ (Row\ Toal * Column\ Total}$

Total = 250

Sum of correct = 233

Row Total*Column Total = 12802

Total squared = 62500

Kapa coefficient (2021) = $\frac{(250*233)-12802}{62500-12802}$

Kapa coefficient (2021) = 0.91

Based on Table 5, the overall accuracy for the 2021 image anslysis is 93.2% while the Kapa coefficient gave 0.91. Following the same procedure, the overall accuracy and kapa coefficient for 2010 were 84.4 and 0.80 respectively while in 2000, the overall accuracy was 85.2 and kapa coefficient was 0.81. These show that the classification performed on the images were largely accurate and reliable given the overall accuracies and kapa coefficients of the accuracy assessment.

LULCC Analysis (Spatial Pattern) of Ellembelle District 2000 to 2010

The supervised LULC classification maps were used as imputes to quantify the LULC conversions, which have been taking place from 2000 to 2010 within the study area. In practice, the conversions as shown in Table 6 and Figure 4 quantify the changes between the two dates. The diagonal bolden figures in Table 6 shows areas of the LULC proportions that are not affected by the conversion or remain unchanged. In all, a total of 134.94km^2 representing 44.74% of the study area remained unchanged. In 2010, it is observed that the highest loss incurred by Water was to Dense Vegetation with a surface cover of 11.16km^2.

Similarly, Bare Land lost to Dense Vegetation more than any other LULC type with a surface cover of 10.26km^2. Dense Vegetation made the highest conversion of 46.94km^2 representing 15.56% of the study area to Sparse Vegetation. This is followed by Sparse Vegetation to Bare Land surface conversion of 25.32km^2 representing 8.39%. The least conversion among the LULC types was the change from Built-up to the Water class with a surface area of 0.12km^2 representing 0.04% of the total land surface area. In all, Built-up showed the least land cover conversion (from 2000 to 2010. Gross gain/loss of LULC categories were estimated for 2000 to 2010 (Table 6). From the Table 6, only Dense Vegetation has gross loss greater than the gross gain. The gross loss (69.82km^2) of Dense Vegetation was higher than the gross gain (38.23km^2) recorded during 2000 to 2010. Sparse Vegetation recorded a gross gain of 59.27km^2 and gross loss of 47.47km^2 indicating an increase in this LULC category. Also, Bulit-up showed an increase in land cover with a gross gain of 11.82km^2 and a gross loss 3.89km^2

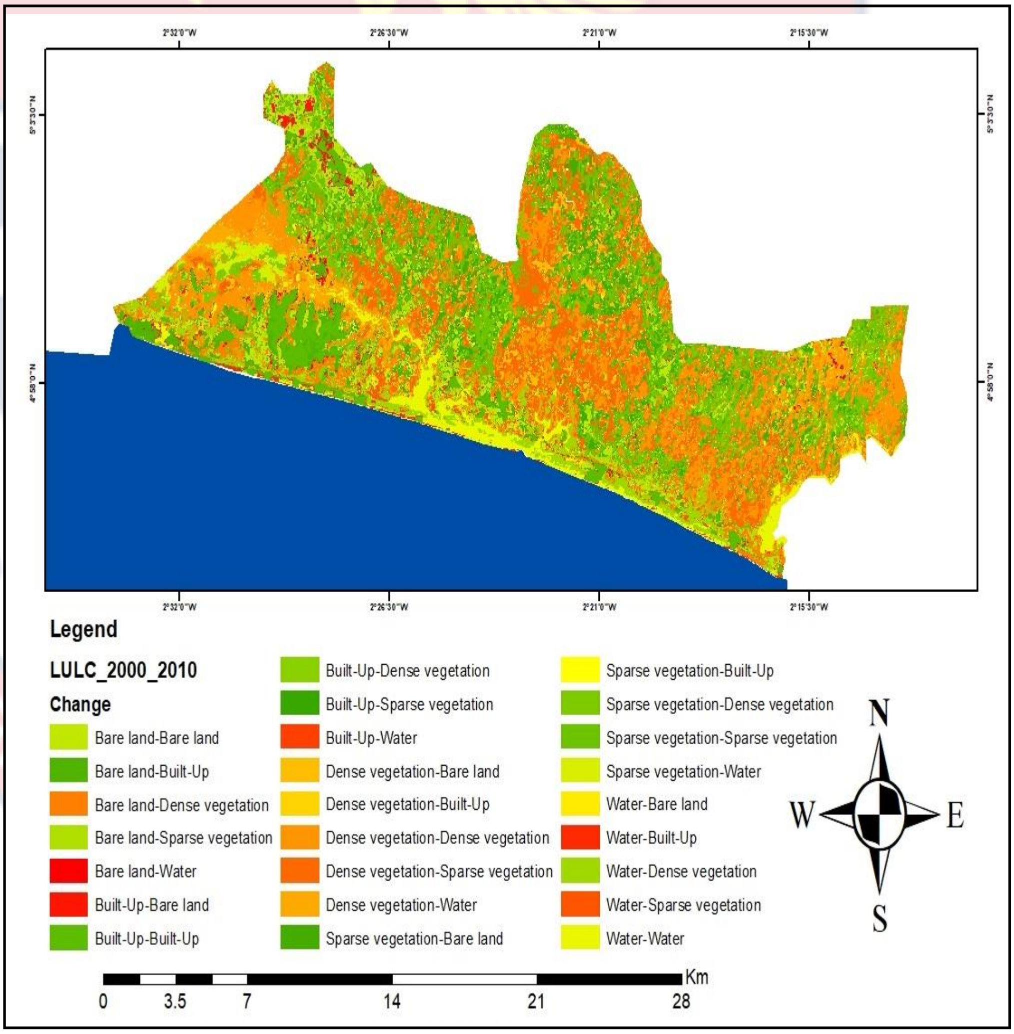


Figure 4: LULCC map of Ellembele district (2000 to 2010)
Source: Blay (2022), based on image analysis

Table 6: Change Matrix for LULC in km^2 for Ellembelle District Between 2000 and 2010

		2010						2000-2010
	LULC Classes	W	DV	SV	BL	BU	2000 Total	GL
2000	W	**12.22**	11.16	2.48	0.91	1.47	28.25	16.03
	DV	10.84	**50.96**	46.94	11.47	0.56	120.78	69.82
	SV	4.82	16.07	**44.36**	25.34	1.24	91.83	47.47
	BL	1.40	10.26	9.28	**14.67**	8.54	44.15	29.48
	BU	0.12	0.73	0.57	2.46	**12.73**	16.62	3.89
2010	Total	29.40	89.19	103.63	54.85	24.55	301.62	
2000-2010	GG	17.18	38.23	59.27	40.18	11.82		

Source: Blay (2022), based on image analysis

LULCC analysis (Spatial Pattern) of Ellembelle district 2010 to 2021

Table 7 summarizes the LULC conversions from 2010 to 2021 based on Figure 5. The diagonal bolden figures shows areas that remained unchanged. In all, 115.40km^2 of land out of 301.61km^2 surface area remained unchanged. This represents 38.26% of the total land surface area. Dense vegetation made the highest conversion of 36.16km^2 representing 11.99% of the study area to Sparse Vegetation. This is followed by Bare Land to Sparse Vegetation surface conversion of 29.61km^2 representing 9.82%. Other high conversions are Sparse Vegetation to Dense Vegetation surface conversion of 22.13km^2 representing 7.34%, Dense Vegetation to Bare Land surface 21.13km^2 (7%) and Sparse Vegetation (17.02km^2) to Bare Land representing 5.64% of the total land surface of the study area. Also, Built-up continued to make the least conversion in 2021 with its highest conversion (5.71km^2, 1.9%) to Bare Land.

At the gross change level, Dense Vegetation recorded a gross loss of 65.86km^2 and a gross gain of 59.53km^2. This shows that the gross loss of Dense Vegetation was higher than the gross gain during both the first (2000-2010) and the second (2010-2021) time intervals. Also, Water recorded a gross loss 921.72 km^2) greater than the gross gain (2.55km^2) during the second time interval (2010-2022). However, Sparse Vegetation continued to have a gross gain (77.55km^2) higher than the gross loss (46.64 km^2) in this second time interval. Again, Bare Land and Built-up class showed an increase in land cover in both the first and second time intervals with gross gain of 47.84km^2 and 22.06 km^2, and gross loss of 43.49km^2 and 8.49km^2 respectively.

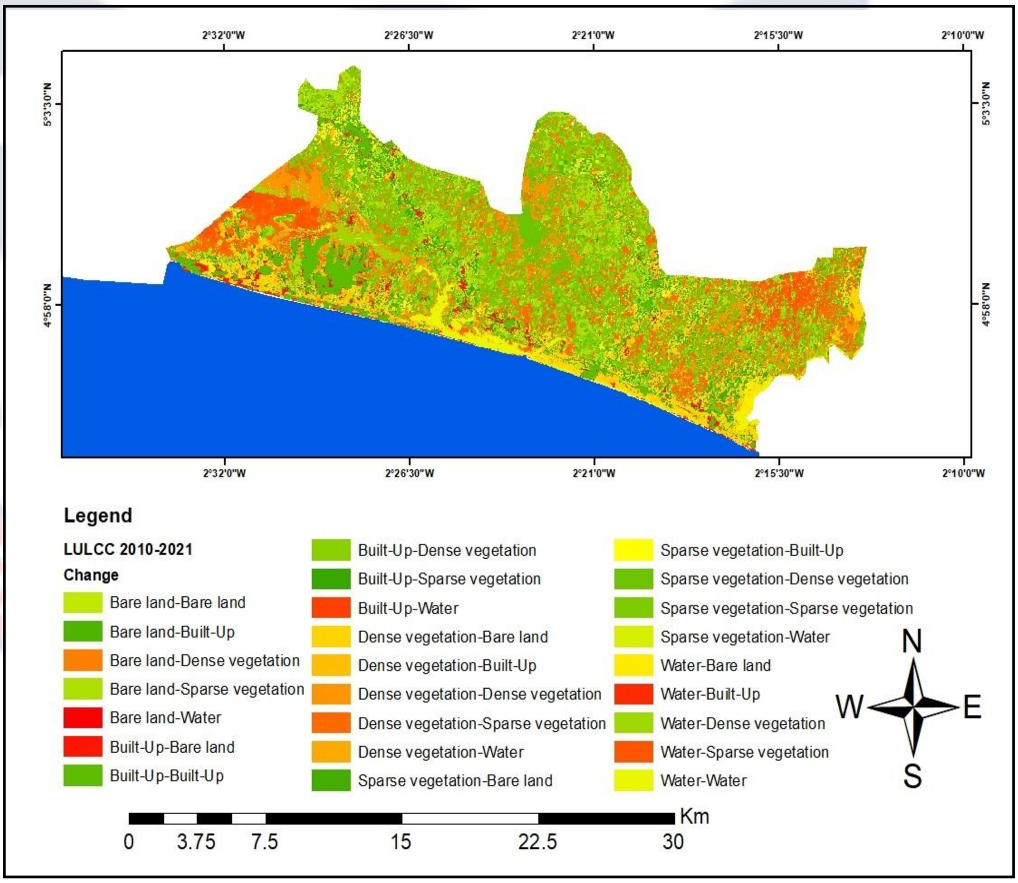


Figure 5: LULCC Map of Ellembele District for 2010 to 2021
Source: Blay (2022), based on image analysis

Table 7: Change Matrix for LULC in km2 for Ellembelle District Between 2010 and 2021

		2021						2010-2021
	LULC Classes	W	DV	SV	BL	BU	2010 Total	GL
2010	W	**7.67**	6.28	10.01	3.98	1.46	29.39	21.72
	DV	1.26	**23.33**	36.16	21.13	7.32	89.19	65.86
	SV	0.68	22.13	**56.98**	17.02	6.81	103.62	46.64
	BL	0.20	7.20	29.61	**11.37**	6.48	54.86	43.49
	BU	0.41	0.60	1.77	5.71	**16.06**	24.55	8.49
2021	Total	10.22	59.53	134.54	59.21	38.12	301.61	
2010-2021	GG	2.55	36.20	77.55	47.84	22.06		

Source: Blay (2022), based on image analysis

LULCC analysis (Spatial Pattern) of Ellembelle district (2000 to 2021)

Table 8 shows the LULC dynamics of the entire study period (2000-2022). In all, 43.9% (132.42km^2) of the land surface area remained unchanged throughout the study period (2000-2021). This shows that more than half of the land surface area has been converted from one land use category to the other. Specifically, Dense Vegetation made the overall highest conversion of 60.31km^2 representing 20% of the study area to Sparse Vegetation. This was followed by Sparse Vegetation (15.21km^2) to Dense Vegetation representing 5.01% of the total landmass of the area. Other conversions worth noticing are Sparse Vegetation to Bare Land surface 12.99km^2 representing 4.31%, Bare Land to Built-up surface 12.57km^2 (4.17%), Bare Land to Sparse Vegetation surface (12.26km^2, 4.06%), Water to Bare Land surface 10.23km^2 (3.39%) and Built-up to Bare Land surface 3.60km^2 representing 1.19% of the total land surface area across the study periods.

Finally, the spatial analysis of the images revealed that (Table 8) Dense Vegetation recorded a gross loss of 82.60km^2 between the periods 2000-2021 and a gross gain of 21.22km^2. This shows that the Dense Vegetation class consistently recorded gross loss higher than the gross gain in all the three time intervals. Additionally, the study found that the Water class recorded a gross gain higher than the gross loss in the first time interval but recorded gross gain lesser than the gross loss in the second (2010-2021) and third (2000-2021) time interval. Also, Sparse Vegetation had a gross gain (42.75km^2) higher than the gross loss in this third time interval (2000-2021). Finally, Bare Land recorded a gross gain (43.01km^2) higher than the gross loss of 27.91km^2 and Built-up (gross gain, 26.06km^2; gross loss, 4.50km^2).

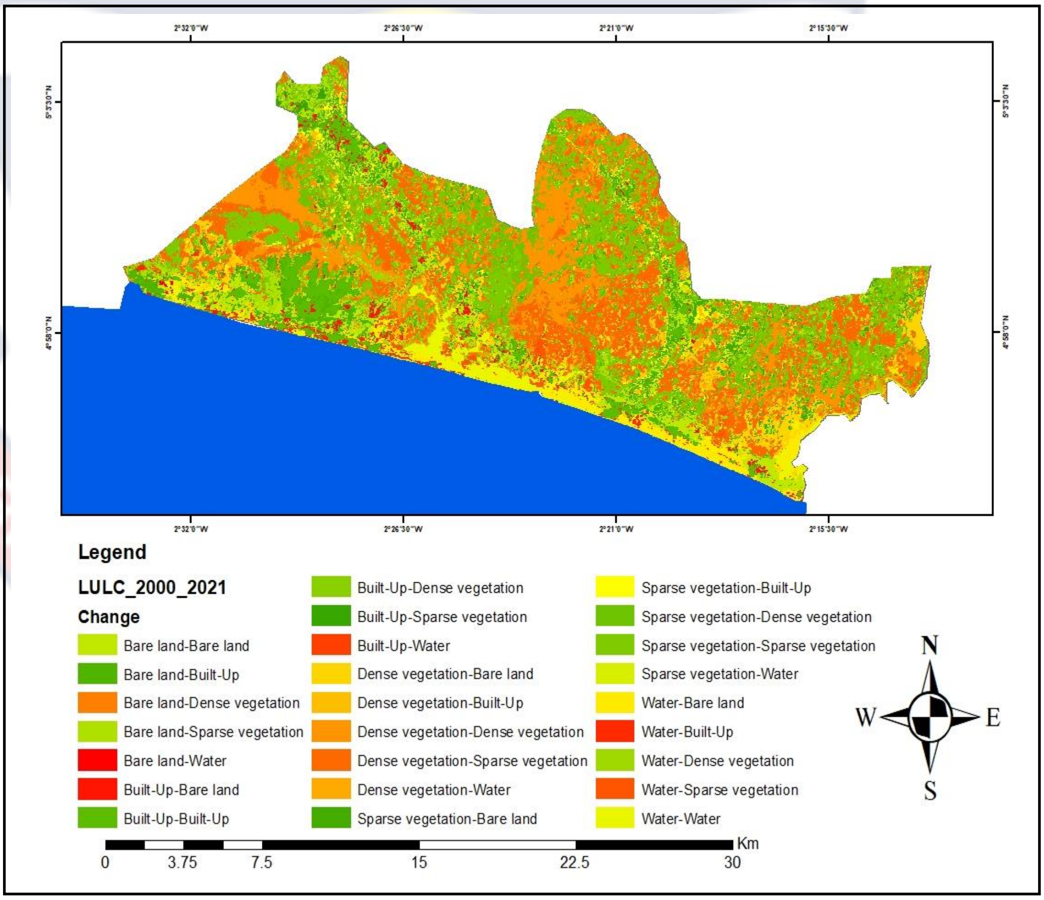


Figure 6 : LULCC Map of Ellembele District for 2000 to 2021
Source: Blay (2022), based on image analysis

Table 8: Change Matrix for LULC in km^2 for Ellembelle District Between 2000 and 2021

	LULC Classes	2021 W	DV	SV	BL	BU	2010 Total	2010-2021 GL
2000	W	**8.41**	3.19	3.72	10.23	2.70	28.25	19.84
	DV	0.84	**38.07**	60.31	16.19	5.25	120.67	82.60
	SV	0.60	15.21	**57.60**	12.99	5.54	91.93	34.34
	BL	0.31	2.77	12.26	**16.24**	12.57	44.16	27.91
	BU	0.05	0.05	0.80	3.60	**12.11**	16.60	4.50
2021	Total	10.22	59.29	134.68	59.25	38.17	301.61	
2000-2021	GG	1.81	21.22	77.09	43.01	26.06		

Source: Blay (2022), based on image analysis

Net gain/loss of LULC classes across 2000, 2010 and 2021

The study proceeded further to detect the changes in LULC categories by computing the net loss/gain in order to better understand and appreciate the pattern of changes in the major LULC categories of the landscape of Ellembelle district. The net gain/loss statistics were estimated for the periods 2000-2010, 2010-2021, and 2000-2021 (Table 9).

Net gain or loss is the area of cover of a LULC category in the present year minus the area of cover for a LULC category in the previous year. Therefore, positive statistics (figures) show a gain while negative statistics (Figures) show a loss in LULC extent. From 2000-2010 (first time interval), Water recorded a gain of 1.15km^2 indicating an increase in landmass coverage. However, it recorded a net loss of 19.17km^2 during the second time interval (2010-2021).

Overall, Water recorded a net loss of 18.03km^2 (2000-2021) indicating a loss in total landmass coverage in the entire study period. Dense Vegetation continued to decrease in landmass coverage throughout the study period with net loss of 31.59 km^2, 29.66 km^2, and 61.38 km^2 in 2000-2010, 2010-2021, and 2000-2021 respectively. The net gain (42.75 km^2) of Sparse Vegetation over the entire study period was higher than the net gain in the first and second time interval though it consistently showed an increase in total surface area in all the three time interval. Built-up areas showed an increasing rate in landmass in throughout the study period with net gain of 7.93 km^2 in 2000-2010, 13.57 km^2 in 2010-2021, and 21.56 km^2 in 2000-2021.

Table 9: Net Gain and Loss of LULC Categories During 200-2010, 2010-2021 and 2000-2021

LULC Classes	2000-2010	2010-2021	2000-2021
W	1.15	-19.17	-18.03
DV	-31.59	-29.66	-61.38
SV	11.80	30.91	42.75
BL	10.71	4.35	15.09
BU	7.93	13.57	21.56

NB: Negative (-) sign shows a net loss in the area extent of LULC category while positive (+) sign shows net gain
Source: Blay (2022), based on image analysis

Demographic Characteristics of Respondents

This section presents statistics on the background information (socio-demographic and economic characteristics) of respondents. The study sampled 246 household heads within 5 communities in Ellembelle district. In all, the study recorded a hundred percent response rate. Basically, frequencies and percentages were used in describing the demographic data.

Socio-demographic characteristics of respondents

Table 10 indicates that the study sample was male dominated as females represented only 28.9% and males represented 71.1% of the total number of respondents that were interviewed. In terms of age, most (50.4%)

of the respondent were middle-aged adult with only 33.7% being young adult and 15.9% being old-age adult. Out of the 246 respondents surveyed, 181 representing 73.6% were indigens of the study communities in Elembelle district with migrants constituting only 26.4% (Table 10). In terms of formal education, the study showed that 131 (majority; 53.2%) of the respondent had basic education comprising of primary and Junior High School (JHS) while 46 (18.7%) had no formal education. The remaining 41 (16.7) and 28 (11.4%) had secondary and post-secondary education respectively.

On religious affiliation, majority, 132 (53.7%) of the respondents mentioned that they are affiliated to the Christian religion, those who are affiliated to the Muslim religion constituted 10.6% of the respondent. Those who mentioned that they are affiliated to Traditional Religion constituted 16.3% of the respondent, while those who stated that they are not affiliated to any religion were 48 constituting 19.5% of the respondent. In respect to marriage, the study found out that more than half (168, 68.3%) of the study population were married and were living with their partners while about 30% of the respondents were unmarried (Table 10).

Table 10: Socio-demographic Characteristics of Respondents

Variable	Frequency	Percentage (%)
Gender		
Male	175	71.1
Female	71	28.9
Total	**246**	**100.0**
Age		
Young adult	83	33.7
Middle-aged adult	124	50.4
Old-aged adult	39	15.9
Total	**246**	**100.0**
Residence status		
Native	181	73.6
Migrant	65	26.4
Total	**246**	**100.0**
Years spent in		
community	67	27.2
15 – 25	69	28.1
26 – 35	110	44.7
More than 35	**246**	**100.0**
Total		
Highest Education		
No formal education	46	18.7
Basic	131	53.2
Secondary	41	16.7
Post-secondary	28	11.4
Total	**246**	**100.0**
Marital status		
Single	46	18.7
Married	168	68.3
Divorced	21	8.5
Separated	11	4.5
Total	**246**	**100.0**
Religious affiliation		
Christian	132	53.7
Muslim	26	10.6
Traditional	40	16.3
Do not belong	48	19.5
Total	**246**	**100.0**

Source: Blay (2022), based on field data.

Economic Characteristics of respondents

According to a world Bank report (1996), sources of employment is a strong indicator of poverty or wellbeing (World Bank, 1996). Despite the fact that poverty affects all households, it is most harmful when it affects entire communities. The host communities for oil and gas operations best exemplify this phenomenon as oil and gas operations reduce the available ‘safety net’ of affected communities. Among the listed occupations, informal sector workers were the highest (30.9%), followed by farmers (26.8%), formal private workers (16.7%), fishing (13.0%), and those who are unemployed constituted 4.5% of the total study respondents. Both farming and fishing form the core economic activities (agriculture, about 40%) in the study area. On income, most of the respondents (97, 39.4%) were found to be low income earners whereas 36.2% and 24.4% were found to be middle and high income earners respectively (Table 11).

Table 11: Socio-economic characteristics of respondents

Variables	Frequency	Percentage (%)
Occupation		
Fishing	32	13.0
Farming	66	26.8
Formal government work	20	8.1
Formal Private work	41	16.7
Informal work	76	30.9
Unemployed	11	4.5
Total	**246**	**100.0**
Income Level		
Low (>Gh¢600)	97	39.4
Middle (Gh¢600-999)	89	36.2
High (>Gh¢1000)	60	24.4
Total	**246**	**100.0**
Nature of income after oil and gas	101	41.1
Decreased	68	27.6
Unchanged	77	31.3
Improved	**246**	**100.0**
Total		

Source: Blay (2022), based on field data.

Overall, about 41% of the people surveyed indicated that their income has decreased after the discovery and production of oil and gas while 31.3% and 27.6% indicated that their income has improved and remained unchanged respectively (Table 11). Also, the study found significant associations between income and occupation (X^2 = 130.33, df = 10, p = 0.000) as well as level of education (X^2 = 166.42, df = 6, p = 0.000). Additionally, figure 7 indicates that income level increased as the level of educational attainment increased. Additionally, Figure 7 indicates that a higher proportion (71.7%) of the respondents who were formal government (public) and private workers earn a higher income whereas a higher proportion of farmers and fisherfolks earn low income (see Figure 7).

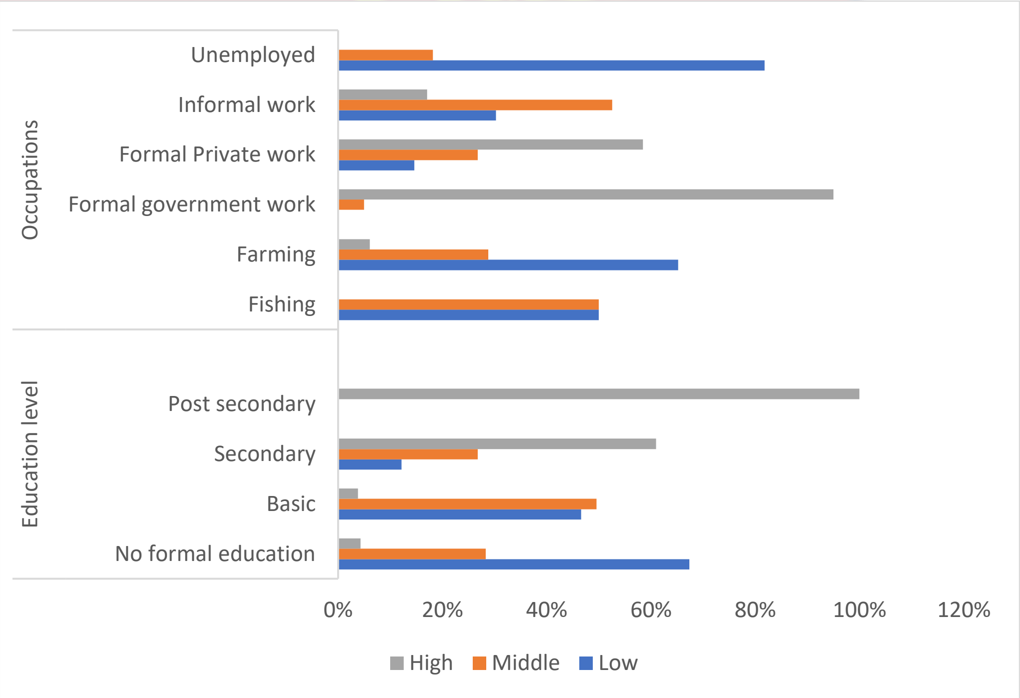


Figure 7: Income Class by Level of Education and Occupation
Source: Blay, 2022

The link between occupation and level of educational attainment

Table 12 seeks to provide information on whether ones level of education has any link with the kind of occupation that the person is engaged in. According to Table 12, the likelihood that someone without formal education will be able to find employment in the formal sector, both private and public is less, especially when some level of literacy is required. Out of the 46 respondents who have not had any formal education, 19.6% were into fishing 52.2% were farmers and only 4.3% worked in the formal private sector. Further, the table indicates that with regards to those who have had post secondary education, 85.7% were in the formal sector (53.6% were in the formal government sector and 32.1% were in the formal private sector) whereas 14.3% were in the informal sector. None of the respondents who had post secondary education is into agriculture related occupation (farming and fishing). This shows that with a higher level of education, it is easy to gain employment in the formal public and private sectors of the Ghanaian economy.

Table 12: Crosstab of Occupation and Level of Education

	Level of Education				
Occupation	No formal education	Basic	Secondary	Post secondary	Total
Fishing	9 (19.6)	22 (16.8)	1 (2.4)	0 (0.0)	32 (13.0)
Farming	24 (52.2)	39 (29.8)	3 (7.3)	0 (0.0)	66 (26.8)
Formal government	0 (0.0)	0 (0.0)	5 (12.2)	15 (53.6)	20 (8.1)
Formal private	2 (4.3)	11 (8.4)	19 (46.3)	9 (32.1)	41 (16.7)
Informal work	8 (17.4)	52 (39.7)	12 (29.3)	4 (14.3)	76 (30.9
unemployed	3 (6.5)	7 (5.3)	1 (2.4)	0 (0.0)	11 (4.5)
Total	**46 (100.0)**	**131 (100.0)**	**41 (100.0)**	**28 (100.0)**	**246 (100.0)**

Source: Blay (2021), based on field data.

The link between occupation and change in income after oil and gas discovery and production

Further, the study examined whether there was a relationship between ones profession and changes in income after the oil and gas find. This was important as it sort to provide information on whether a particular category of profession has experienced change in income level. The result as shown in Table 13 and Figure 8 show that majority (86.1%) of the respondents who engaged in agricultural activities (fishing and farming) has their income decreased, 5.9% had their income remained unchanged and 9.1% had their income increased. With regards to the formal sector (private and government), it could be seen from Figure 8 that all the respondents had their incomes increased. Out of the 76 respondents who were within the informal sector, 94.1% (majority) had their income remained unchanged, 3.0% had their income reduced and 11.7% had an increase in income.

Table 13: Crosstab of Occupation and Change in Income

	Percentage Change in income			
Occupation	Decreased	Unchanged	Increased	Total
Fishing	27.7	1.5	3.9	13.0
Farming	58.4	4.4	5.2	26.8
Formal government	0.0	0.0	26.0	8.1
Formal private	0.0	0.0	53.2	16.7
Informal work	3.0	94.1	11.7	30.9
Unemployed	10.9	0.0	0.0	4.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Blay (2022), based on field data.

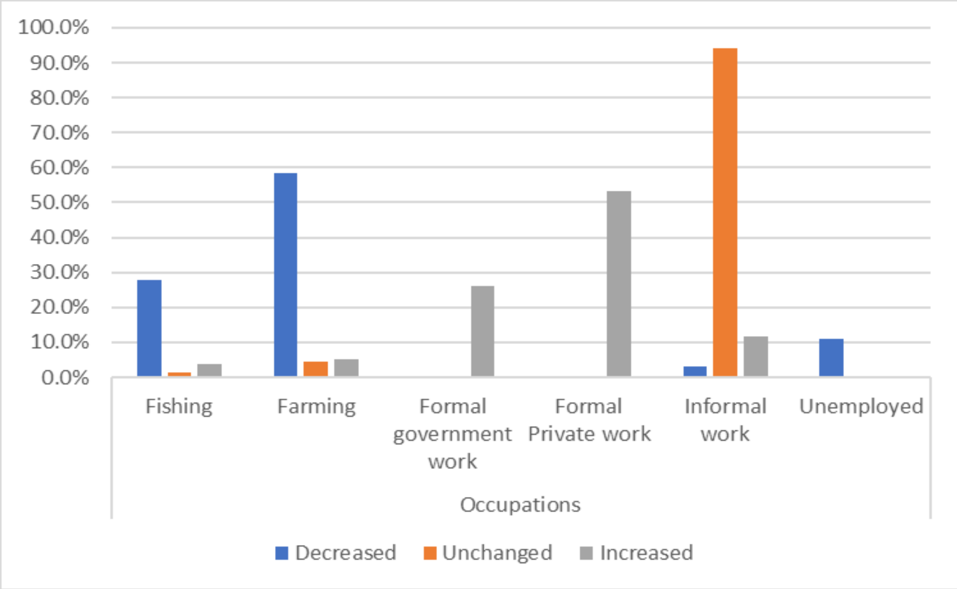


Figure 8: Relationship Between Occupation and Change in Income
Source: Blay (2022), based on field data.

Drivers of LULCC in Ellembelle District

Table 14 indicates that most of the respondents (97%) agreed that LULC in Ellembelle district is changing rapidly following the discovery of oil and gas in the district. Respondents were further asked to rank the drivers of LULCC on a scale of 1 to 5 with 5 being most important and 1 being less important. The result from the weighted average ranking index is presented in Table 14. From the table, oil and gas activities was the first ranked driver of LULCC in the district with weighted average of 1110 and an index of 0.169. Population growth followed as the second most dominant driver of LULCC with weighted average of 1042 and an index of 0.159. The third driver was urbanisation with weighted average of 1036 and an index of 0.158. Infrastructural development, farming activities firewood collection, charcoal and lumbering, climate change and bush burning were ranked 4th, 5th, 6th, 7th, and 8th with indexes of 0.138, 0.127, 0.094, 0.085 and 0.071 respectively. Similar results were also revealed during the key informant interviews in which oil and gas activities was identified as the main cause of LULCC in the study area and has positively influenced all other drivers.

Table 14: Ranks of Drivers of LULCC in the Ellembelle District

Drivers of LULC change	No. of Respondent Per Rank					Weight	Index	Rank
	1	2	3	4	5			
Oil and gas activities	1	13	11	55	166	1110	0.169	1
Population growth	1	17	30	73	125	1042	0.159	2
Urbanisation	1	22	32	60	131	1036	0.158	3
Infrastructural development	10	14	93	56	73	906	0.138	4
Farming activities	2	59	76	58	51	835	0.127	5
Firewood collection, Charcoal & Lumbering	25	100	95	23	3	617	0.094	6
Climate change	55	102	66	17	6	555	0.085	7
Bush burning	130	48	44	13	11	465	0.071	8

Source: Blay (2022), based on field data.

Comparison of the Types of Land Cover That Existed Before and After the Oil and Gas Discovery and Production in Ellembelle District by Respondents

Table 15 shows that forest cover (dense and sparse) was dominant in the study area with approximately 58.9 percent (27.6 % -open forest; 31.3% -closed forest) of land cover but had drastically decreased to a total of 26.0 percent at the time of the survey. This confirmed the results of the classified images from 2000 to 2021. In addition, the water class decreased from 5.7 percent to 1.6 percent. Settlement and bare land, on the other hand, increased from 19.1 percent and 16.3 percent to 63.0 percent and 9.3 percent, respectively.

It is important to note that these changes have occurred over time as a result of numerous socioeconomic activities such as an increase in population, farming activities, and urban growth in the district. These factors have resulted in a rapid increase in human activities, such as the construction of residential buildings to house the district's growing population and the meet housing demand, which has altered the existing LULC in the district. It is important to note that these changes have occurred over time as a result of numerous socioeconomic activities that have resulted in an increase in population, farming activities, and urban growth in the district. A number of issues have arisen as a result of the district's massive changes in LULC over time. Notably, residents face land ownership conflicts as a result of some sub-chiefs selling one parcel of land to more than one person. Other problems associated with the growth of the study area include increased social vices and the struggle to meet the high living standards.

Table 15: Respondents Perception of LULC in Ellembelle Before and After Oil and Gas Discovery and Production

LULC Classes	Before		After	
	Frequency	%	Frequency	%
Close forest	77	31.3	7	2.8
Open forest	68	27.6	57	23.2
Settlement	47	19.1	155	63.0
Bare land	40	16.3	23	9.3
Water	14	5.7	4	1.6
Total	**246**	**100**	**246**	**100**

Source: Blay (2022), based on field data.

Occupation in the District Prior to the Discovery of Oil and Gas

Ellembelle district is characterized by many rural communities whose livelihoods depend on agricultural activities. Land is an important asset in the district through which the livelihoods of many households are earned. From the result of the of the study portrayed by Figure 9, 81% of the respondents opined that before the discovery of the oil and gas in the district, majority of it's citizens were engaged in agricultural activities (farming and fishing activities) while few others (19%) indicated that citizens were engaged in other economic activities (petty trading and other economic activities such as carpentry, teaching, nursing, driving) (figure 9).

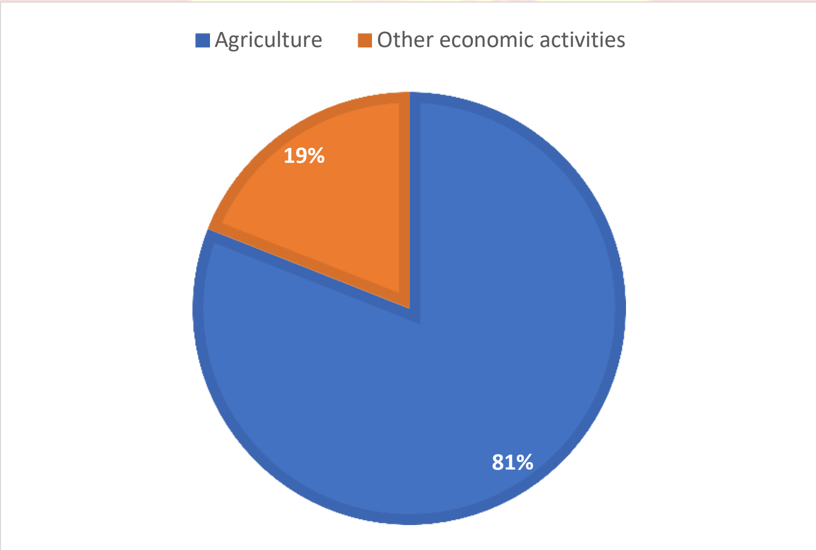


Figure 9: Occupation Before OG Discovery
Source: Blay (2022), based on field data.

Socioeconomic Impact of LULCC on Livelihoods

LULCC has also had a negative impact on livelihoods in the Ellembelle district resulting in the reduction in forest cover, high cost of living, high cost of land and high cost of accommodation due to increasing immigrantion and urbanisation. In examining the relationship between LULCC and cost of living, majority of the respondents (54.1%) strongly agreed to the fact that oil and gas activities and its related LULC change have resulted in high cost of living in Ellembelle district (Table 16). Only 0.8% disagreed that the price of goods and services has absurdly increased. Also, 65.4% of the respondents indicated they strongly agree that the prices of land have increased therefore has resulted in high cost of accommodation (44.4%). With regards to reduction in forest cover, 43.5% indicated they agree, 30.9% indicated they strongly agree, 20% were neutral and 4.1% disagreed. In terms of employment opportunities, 40.2% agreed that there has been lack of employment opportunities and only 1.6% strongly disagreed to the statement (Table 16). In all, 63.4% noted that there has been food shortage since the oil find in the district (36.6% agree; and 26.8% strongly agree).

Table 16: Socio-economic Factors of LULCC

Socioeconomic factors	SD (%)	D (%)	N (%)	A (%)	SA (%)
Reduction in agricultural land	7 (2.8)	55 (22.4)	101 (41.1)	63 (25.6)	20 (8.1)
Food shortage	15 (6.1)	24 (9.8)	51 (20.7)	90 (36.6)	66 (26.8)
High cost of living	2 (0.8)	11 (4.5)	7 (2.8)	93 (37.8)	133 (54.1)
High cost of land	13 (5.3)	6 (2.4)	12 (4.9)	54 (22.0)	161 (65.4)
High cost of accommodation	1 (0.4)	45 (18.3)	24 (9.8)	66 (26.8)	110 (44.7)
Lack of job opportunities	4 (1.6)	32 (13.0)	103 (41.9)	99 (40.2)	8 (3.3)
Reduction in soil fertility	2 (0.8)	140 (56.9)	45 (18.3)	48 (19.5)	11 (4.5)
Reduction in forest cover	3 (1.2)	10 (4.1)	50 (20.3)	107 (43.5)	76 (30.9)

Source: Blay (2022), based on field data.

Impact of LULCC on Basic Infrastructure in the District

The study went further to assess the state of some of the basic infrastructure in the district under study for the past 10 years. Details of the state of these infrastructures are presented in Table 17. The results reveal that a vast majority (90.2%) of the respondents in the district indicated that roads in their respective communities have improved (both slightly and greatly). On the other, 13 (5.3%) of the respondents indicated that Road networks have deteriorated and 3.7% indicated that road networks have remained the same since the oil and gas development in the district.

According to the results presented in Table 17, majority (52.4 percent) of the study respondents believe that the availability and quality of mobile communications, whether telephony or internet, has improved (slightly or significantly), with only 6.5 percent believing that communication has deteriorated. The results in the table show that the district's electricity and water supply have either deteriorated or remained unchanged. 9.3% of the respondents said that electricity and water have improved, while 13.8 percent said they don't know. The majority of the respondents (45.9%) noted that health-care facilities had neither improved nor deteriorated (remained unchanged). The outcomes for educational institution improvements are similar to those for road networks. A larger proportion of respondents (77.6%) mentioned that educational facilities have improved (both slightly and greatly).

With regards to cultural institutions, more than half of the respondents noted that cultural institutions have deteriorated (Table 17). Respondents also noted the increasing presence of banking institutions in the district since the production of oil in the district.

Table 17: Conditions of Basic Infrastructures in Ellebelle District

Infrastructure	Worsened (%)	Unchanged (%)	Don't Know (%)	Slightly improved (%)	Improved (%)
Road networks	13 (5.3)	9 (3.7)	2 (0.8)	79 (32.1)	143 (58.1)
Communication	16 (6.5)	60 (24.4)	41 (16.7)	115 (46.7)	14 (5.7)
Electricity and water supply	49 (19.9)	68 (27.6)	34 (13.8)	72 (29.3)	23 (9.3)
Health institutions	45 (18.3)	113 (45.9)	30 (12.2)	47 (19.1)	11 (4.5)
Educational institutions	10 (4.1)	21 (8.5)	24 (9.8)	126 (51.2)	65 (26.4)
Cultural institutions	134 (54.5)	69 (28.0)	32 (13.0)	11 (4.5)	0 (0.0)
Banking institutions	2 (0.8)	13 (5.3)	18 (7.3)	27 (11.0)	186 (75.6)

Source: Blay (2022), based on field data.

The study further looked at the relationship between investment in the study area and revenue from oil and gas production. Figure 10 shows that 87 percent of total respondents associate recent investments with the oil and gas industry, while 11 percent do not associate recent investments with the production of oil and gas in the study area. On the other hand, 2% of respondents stated that no major investments have been made in their communities since the production of oil and gas in district.

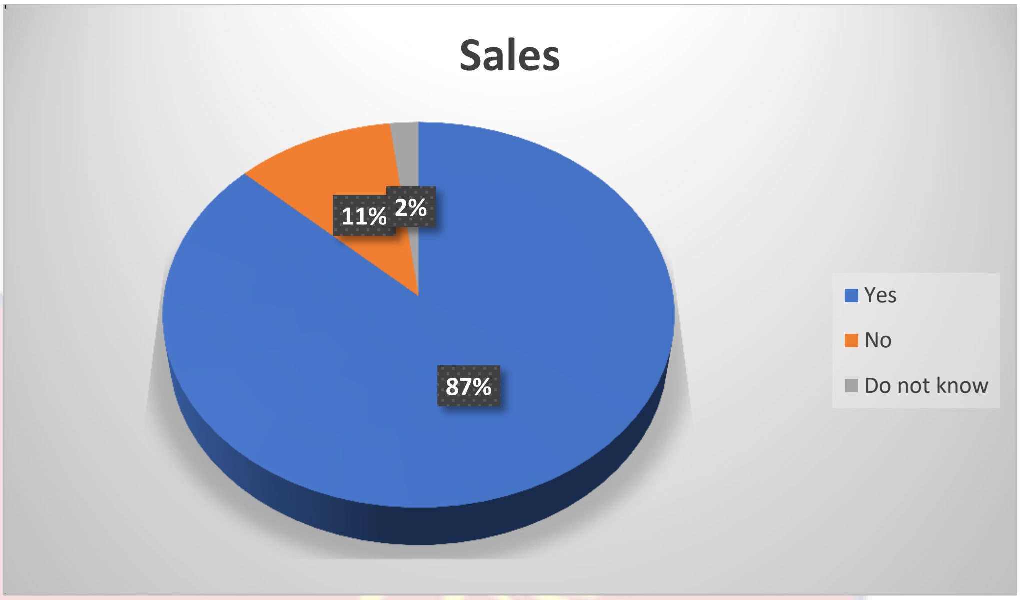


Figure 10: Do You Link Major Infrastructures in the District to the OG?
Source: Blay (2022), based on field data.

Overall impact of oil and gas on livelihood

Following the above revelations, the study sought to determine the overall impact of the oil industry on respondents' livelihoods by asking them to aggregate all perceived positive and negative effects of the oil industry on their activities. The results, as shown in Figure 11, show that the majority of respondents see the oil industry as having a positive and negative impact on their livelihood activities, with fewer respondents seeing OG production as having a negative impact on their livelihood activities.

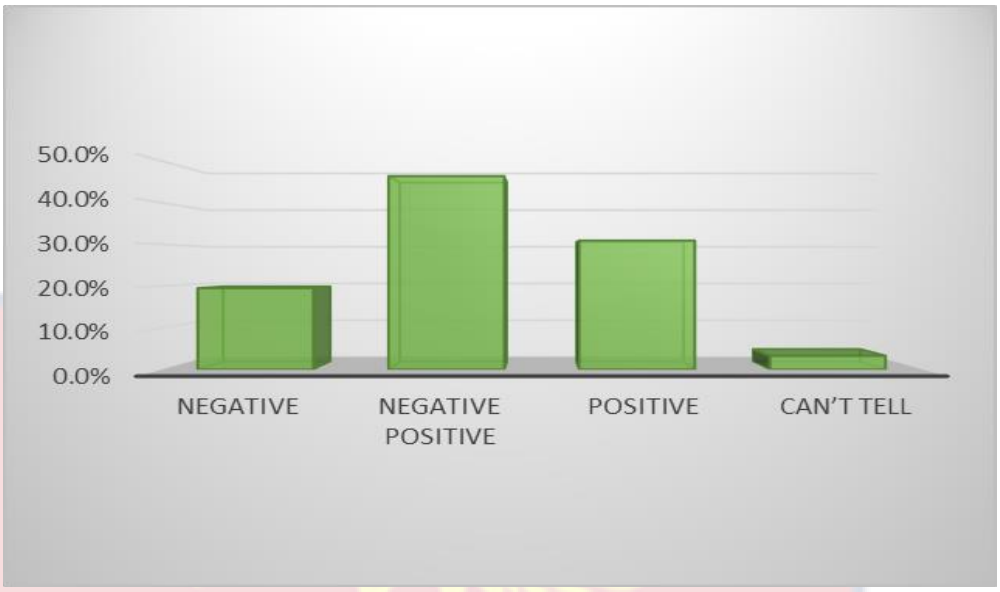


Figure 11: Respondents' View of the Impact of OG Production on Their Livelihood
Source: Blay (2022), based on field data.

Of the total number of respondents surveyed, the results in figure 11 show that 19.5% of them view that the oil industry has been detrimental to their livelihoods. Also, 46.3% view the oil industry as having both positive and negative impact on their livelihoods and 30.9% describing the impact as positive. Only 3.3% indicated that they cannot tell whether OG production in the district has had any impact on their livelihood. This result is similar to the views of a key informant.

"I can say oil and gas production in the district has helped us and has also not helped us. On a broader note, the oil industry has helped in the urbanisation of Nzema with beautiful infrastructures such as good roads, good education and beautiful buildings, which has made Nzema a site worth seeing. It has also attracted many people into the district. Now Nzema has one of the beautiful beach resorts in Ghana and has also attracted many investors. On the other hand, the oil production has destroyed our traditional

livelihoods such as fishing and farming. Our farmlands have been taken from us and you cannot also farm around certain areas, especially closer to the gas pipelines and we were not adequately compensated. Also, the locals have not been offered jobs in the industry claiming that we don't have the required skills to be employed. I personally don't believe that because we have so many unemployed graduates in this community. Apart from that, there are jobs that don't require special education such as cleaners, drivers, cooks, and many more. All that I'm saying is that on the outside oil and gas production has helped this community but it doesn't reflect in our pockets".

Discussion

LULC dynamics of Ellembelle district before and after the production of oil and gas

According to Kusimi (2015), human activity has largely replaced natural change as the primary driver of land cover modification and conversion. Since humans are at the centre of the changing environment, assessing land cover and land use changes could be regarded as the key to comprehending any complex landscape and providing experts with the best solutions for sustainable resource management (He et al, 2013).

This section discuses the trend in changing LULC patterns of Ellembelle district as affected by OG production. The results presented above reveal the land use land cover dynamics before (2000-2010) and after (2010-2021) oil and gas production in Ellembelle district and the overall changes that have occurred over the entire study period (2000-2021).

In 2000, the district was dominated by Dense Vegetation, which covered 120.67km^2 followed by Sparse Vegetation, which covered 91.93km^2 of the land surface area (Table 4). Dense Vegetation and Sparse Vegetation together covered about 70% total land area of Ellembelle district. This suggests that by 2000, the forest in the area was very high, indicating that the Ellembelle district was very green. According to Acheampong (2018), prior to the discovery of oil and gas, the western coast was naturally endowed with rich biodiversity, with timber being one of Ghana's major exports, and such forest became an important resource. Also, according to Mensah (2013), several hundreds of square kilometres of coastal ecosystems including extensive mangrove forest is found in the Ellembelle district. Near shore lagoons and estuarine environments contain mangrove forests made up of both pure and mixed stands of Laguncularia, Rhizophora, and Avicennia species.

In his studies of mangrove mapping in the Ellembelle district, Mensah (2013) found that before the oil and gas production in the district, the greater Amanzule site had 37% of the surface land area being covered by mangroves. However, as with many other mangrove forests, the vulnerability of these ecosystems keeps rising as the population increase and land use changes. His study anticipated that the west coast will become a hub of industrial activities in light of the recent oil discovery in the district, leading to social pressures and increased exploitation of mangrove forest and other coastal resources. This study confirms Mensah (2013) anticipation. During the 2010 to 2021 time interval, closed vegetation was found to have greatly reduced in size losing about 30km^2 of land. The result is also similar to a study by Kankam et al (2022), which also found out that mangroves forest is rapidly depleting in the coastal landscapes of southwestern Ghana. Mangroves are essential for conserving biological diversity by providing habitats and hatching grounds for a variety of fish and shellfish and also provide wood products. Just as many coastal communities in West Africa, people who live along the shore in the study area heavily rely on mangrove fuelwood for fish smoking. This confirms the perception of the participants and respondents that Ellembelle coast has lost a significant portion of its mangroves and other dense vegetation covers within the 21 years of oil and gas production mainly due to over-harvesting, increasing coastal development and increased farming activities. In support of this observation, an assemblyman intimated that,

> *"When we were young, we use to go to the Amanzule estuary to harvest kosolombo. We didn't struggle at all to get them. These shellfish like cold areas, especially where there are shades of mangroves. But now because of the depletion of the mangroves along the river, you need to cross the river to the other side with a canoe before you can harvest the kosolomgbo"*

As identified by Boateng (2018), the exploitation of mangroves result in the reduction of wetlands, which may lead to surface run off. From Table 6, water had a net gain of 1.5km^2 during the first time interval (2000-2010) that is before the OG development in the district. Water remained relatively stable during this period (Bar graph). However, the result of the 2010-2021 time interval shows a decrease in the land coverage area of water. Water had a net loss of 19.17km^2 implying a more than half loss in total land coverage. According to the respondents, this is primarily due to replacement conditions such as filling of water bodies for infrastructure development and construction activities. These observations show the link between the oil discovery and the expansion of the district into its designated forest and water bodies in order to meet the needs of the growing population as a result of increased oil and gas production in the Ellembelle district.

According to Boateng and Mensah (2021), the most significant land cover change in Ghana is the significant expansion of agricultural land across the entire country. The greatest increase, however, is seen in Ghana's southwestern regions, where the study area is located. At the start of the study period (2000), Sparse Vegetation was the second dominant land cover in the area. By 2010, Sparse Vegetation had become the dominant land cover. However, this increase was slow as compared to the 2010-2021 image analysis.

The findings of the study point out to increased landscape potential for food supply. Considering the food requirements of the growing population of the study area, increase in food production is inevitable. The increase in cultivated land had a considerable impact on forest as Dense Vegetation lost about 12% of land area to Sparse Vegetation during the 2010-2021 time interval. This result is consistent with a study in the study area enclave that reported a consistent expansion in cropland due to the adoption of sustainable agricultural intensification practices by farmers in the study area (Kankam et al, 2022). However, the findings of an increase in agricultural land is inconsistent with an earlier study by Acheampong (2018) and Adjei Mensah et al (2019). In their study in Ghana's oil city (Sekondi-Takoradi Metropolis), they found out that agriculture land consistently reduced throughout the study period owing to the expansion of settlement. Also, a similar study elsewhere in

Niger delta, found that the largest portion of the study area was occupied by artificial surfaces.

Similarly, the study discovered that urban expansion in the Ellembelle district was slow until 2010 following key development activities such as the Ghana Gas Processing Plant and the Sanzule Gas Plant (ENI Gas Processing Plant). This has attracted a large number of developers and speculators to the area in search of commercial housing facilities for workers. Due to improved transportation connectivity to the district's urban areas, many private residences and businesses have also sprouted up in the area. Esiama and Kikam have virtually merged to form an urban agglomeration that extends all the way to neighboring communities such as Azuleluano, Ampain, and Nkroful.

In an interview, some key informants attributed the growth of the Ellembelle district to oil and gas development, a situation that, according to one key informant, is having an impact on the forest and agriculture of the district.

> *"There was some green separation between Esiama township and Kikam community. What do you notice now? Buildings have taken up hundreds of acres of land that was previously farmland and green space."*

In his remarks, the farmer attributed the observed land cover change to the activities of Ghana Gas Company, which serves as a growth pole, resulting in an increase in human population as the cause of land cover change in the study area. While growth poles influence urban growth as well as distant some peri-urban receiving regions, Naab et al. (2013) argue that changing land use patterns affect green vegetation and lead to deforestation that forms one of the major problems associated with rapid urban growth.

The nature of the change analysis of the Ellembelle district reveals a change in the size of all the five LULC classes identified over the 21-year period of the study. The ongoing filling of water bodies for construction activities, urban expansion, and deforestation highlights the need for an integrated land use planning and management system in and around oil and gas regions like the study area.

Drivers of LULCC

The research findings, based on the household surveys and key informant interviews point to local communities perceiving OG production activities, population growth, urbanisation, infrastructural development and farming activities as the important drivers of land LULCC in Ellembelle. According to UNEP (2015), all mining activities requires land, hence causes a reduction in the land's ecological and economic productive potential. Oil and gas activities was ranked first according to the household survey owing to the fact that oil and gas production required large areas of land for its operations such as pipeline construction and storage facilities. This has led to the acquisition of land from the local communities resulting in land cover alterations and fragmentation. Also, respondents recognised that oil and gas activities has stimulated other drivers. The discovery of oil and gas has resulted in social and economic changes such as population growth, urbanisation, infrastructure development, and community displacement, all of which have contributed to LULC changes in the district.

People tend to migrate to the host communities and surrounding areas since oil and gas operations provide employment, expand business centers, and create entrepreneurial opportunities. As the population of these areas grows, social challenges such as land tenure security and access, road construction, river diversion, and displacements from mining areas all contribute to landscape alteration and increase land degradation (UNECA, 2011), all of which are common characteristics in the Ellembelle district's growth and development according to the key informants.

The link between the oil and gas production and population growth has also been observed in other parts of the world. For instance, in countries such as Saudi Arabia and the United Arab Emirates, the oil industry has attracted migrant workers, leading to population growth and urbanisation (Bashir & Ahmed, 2019). According to Emeka & AHARANWA (2016), the city of Port Harcourt, which is located in the Niger Delta region, has experienced rapid urbanisation as a result of the oil and gas industry. The city has grown from a population of about 200,000 in the 1960s to over 2 million in recent years. The industry has attracted businesses and employment opportunities, leading to the establishment of new urban centers and the expansion of existing ones leading to further land use and land cover changes (Igbokwe et al., 2019).

In Table 8, the study points out to increasing farming activities in the district, which contradict many other related studies (Abbas, 2012; Jacobsen & Parker, 2016). Farming activities being ranked as part of the most dominant causes of LULCC. This observation is not surprising taken the results of the 2010-2021 change analysis into consideration. From Table 4, Dense Vegetation lost about 41% of its land surface area to Sparse vegetation. Bare lands also lost about 54% of its surface area to Sparse vegetation. This indicates that the locals are converting other land cover types for agricultural activities. The study further reveals that there has been consistent expansion in cropland due to the adoption of sustainable agricultural intensification practices in the district.

LULC and Socio-economic Livelihood Nexus

The oil and gas production has had a significant impact on food shortage in Eleembelle as indicated by respondents in Table 16 that the industry's expansion has led to a decrease in arable land and increased food prices. Due to the expansion of the oil and gas industry, many farmers have been displaced from their land, and the land that remains available for farming is often contaminated with chemicals used in the industry. This has led to a decrease in agricultural productivity and a decrease in food supply, resulting in food shortages in the district. Though there has been expansion in cropland in the district, the study interview revealed that crop yield has decreased significantly due to soil infertility (Table 16). As noted by Banson and Yiran (2016), the oil industry has created employment opportunities, leading to an influx of people to the Western region, which has led to an increased demand for food. However, food supply in the district has not kept up with the increasing demand, leading to food shortages and increased food prices.

Another way in which oil and gas production has affected food shortage in Ellembelle district is through the destruction of fishing habitats. The production of oil and gas has caused significant damage to the marine ecosystem, leading to a decline in fish populations and a decrease in the income of fishing communities (Ahorsu et al., 2020). This has had a significant impact on food security, as fish is a major source of protein for many people in the region. The resultant effect of food shortage in the district is high cost of living as noted in Table 16 in this thesis. For instance, some respondents noted that the oil and gas industry has led to an increase in the cost of basic necessities such as food, housing, and transportation. The influx of people into the district has led to an increase in demand for these basic necessities, leading to an increase in their prices.

With regards to high cost of land, respondents massively agreed that there has been an increase in the cost of land since the production of oil and gas in the district began (Table 16). The production of oil and gas has increased demand for land, as oil and gas companies seek to acquire land for exploration and production activities, leading to a rise in land prices. Similar to Uganda’s case, the oil industry has led to an increase in the cost of renting land in Hoima district, as noted by Byakagaba, Mugagga & Nnakayima (2019).

The influx of people into the district due to employment opportunities in the oil industry has also led to an increase in demand for rental properties, including land making it more difficult for people to afford land for their own use. Relatedly, the oil and gas industry according to Babatunde (2010) has led to land grabbing and disputes in Nigeria. The acquisition of land by oil and gas companies has led to land grabbing, where local communities are forcibly displaced from their land without adequate compensation. This has led to land disputes and conflicts, which have further driven up the cost of land. This phenomenon has led to high cost of accommodation in the district as noted by the respondents (see Table 16).

Additionally, the study found out that there has been some form of employment opportunities following the discovery of oil and gas in the district but the employment has been indirect employment rather than direct employment in the oil and gas industry. The study revealed that oil and gas production has stimulated the growth of small and medium-sized enterprises (SMEs) in the district. This finding is consistent with the GPT, which state that the pole is often characterized by a key industry around which link industries develop, mainly through direct and indirect effect. The development of these businesses has created additional employment opportunities and generated income for local residents. This finding concise with the result of a study in Nigeria by Odularu (2008) that due to the advent of oil and gas discovery and development, allied industries and small businesses have emerged, offering job prospects to the majority of prospective locals. However, some respondents expressed concern about the displacement of some traditional livelihoods, such as fishing and farming, which have been the primary sources of income for many people in the Ellembelle district due to the operations of the oil and gas industry.

State of Basic Infrastructure in the District

The availability as well as the state of a country's basic infrastructure is commonly regarded as a key indicator of economic development and progress. Road construction, reliable water and electricity supply, and effective health care facilities are critical to the local communities. The Petroleum Revenue Management Act of 2011 (Act 815) requires the government to spend oil revenues on twelve priority areas. These areas include; (1) physical infrastructure and service delivery in education; science and technology; (2)

infrastructure development in telecommunications, road, rail, and port infrastructure; (3) potable water delivery and sanitation; and (4) physical infrastructure and service delivery in health (ACEP, 2012). As a result, the study focused on the state of some of the basic infrastructure in the communities under study since the oil and gas production began in the district. This study takes into account infrastructure such as roads, which are critical for accessing markets or transportation, the communication sector, which includes mobile internet and telephony, as well as electricity and water supply. Furthermore, the study evaluated the status of health care facilities, educational institutions, and cultural institutions.

In terms of roads, respondents overwhelmingly agreed that the road network in the study area has undergone massive transformations, making transportation more convenient for citizens (Table 17). Prior to the oil and gas discoveries, the road networks in Nzema were in dilapidated state, posing a significant transportation challenge for residents. For instance, a key informant (Unit Committee member) intimated that;

> *"Frankly speaking, when it comes to road construction, Ghana gas company has really done well. Now almost all the communities in Nzema have good asphalt roads"*

This observation supports the findings of a study by (Mugisa, 2016) on the socioeconomic effects of oil exploration in Hoima Municipality communities in Uganda, which also discovered that the municipality, which was previously characterized by poor road networks, saw massive transformation in the road sector, making it easier to commute to and from other parts of the district.

Roads are critical infrastructure for any developing economy, including Ghana. Because Ghana and other developing countries rely heavily on agriculture, quality road networks are essential for transporting produce from the hinterlands to market centers for exports and processing.

From Table 14, most respondent agreed that telephony and internet services have improved, for instance, a farmer commented that;

> *"I remember in 2003 I went to farm, I had to do a lot of work because I have decided not to go to the farm the following day so I kept very long. Family and loved ones were so worried I had not come home so they gathered themselves and came to look for me in the farm. I had a phone but the network then was very poor so they couldn't reach me. Now network is everywhere even in the farm. As you can see, there are a lot of network poles here. At first, we use to go to the sea side or park before we can access network".*

This observation supports a study by Iledare (2008) that oil and gas discovery in the Delta region led to improvement in telecommunication and other infrastructure development. Education and banking institutions have also seen a facelift in the district. According to the GPT, the key industry, imputes employment related investment as well as new technologies and new industrial sectors. With urbanisation, Esiama is a host to many financial institutions today. Additionally, the study observed that many of the leading financial institutions in the country have branches in the area. For instance, during the data collection exercise, it was observed that several Micro Finances were operating within Esiama and offering financial services to the people. This is due to the establishment of companies and other SMEs in Ellembelle district. Figure 4.11 shows a financial institution (Cal Bank) in the study area.

Figure 13: Financial institution

Whiles respondents hailed oil and gas production as being the backbone of infrastructural development in the district, they expressed dissatisfaction in the health institutions and cultural institutions in the study district. Majority of the respondents indicated that health institutions have either remained unchanged or have worsened (Table 17). For instance, informal interviews with respondents indicated that Ghana gas company has provided few CHPS compound to some villages but they are not enough to provide the needed health care for the growing population. Eikwe hospital is the only hospital in the district which, serve not only the citizens of the district but also citizens of neighboring districts and even some part of La Cote d'Ivoire. The hospital was there long before the production of oil in the district and there has not been any major expansion even after the influx of people into the district.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Introduction

This chapter gives the summary of the findings linking the results and findings to the general literature and its implications. This study focused on the spatial and temporal changes and livelihood nexus based on knowledge gap surrounding oil and gas regions in the context of Ghana. The analysis shows that certain key issues must be brought to the fore so that they can be addressed based on empirical evidence. The chapter therefore highlights the objectives, methodology, overview of the study and states the major findings. The chapter also provides a concluding remark based on the study objectives. The chapter finally presents recommendations that could help address some of the key issues and gaps identified in the current study.

Summary

The purpose of the study was to assess the impact of oil and gas production on land use land cover changes in Ellembelle district. Specifically, the study sought to;

I. Examine the land use land cover changes before and after the production of oil and gas in Ellembele district.

II. Assess the drivers of land use land cover change in Ellembelle district.

III. Analyse the effect of the changes in land use land cover on the livelihood of the citizens of Ellembelle district.

The study is divided into five chapters. The first chapter introduced the whole study and provided a strong justification for the study. It elaborated the problem and the objectives of the study. The second chapter reviewed previous relevant studies on the subject matter of this study. Chapter three gave directions as to how the whole study was conducted. This includes the philosophical foundation the study aligned itself to, research approach and design, how participants were selected for the field survey, and the analytical techniques employed to understand both the remote sensing and the field data. Chapter four presented the results and discussed the result in relation to the general literature and its implications. The summary of the study, conclusions and recommendations were discussed in the final chapter.

Methodological-wise, the mixed method approach was employed for the study. Qualitative data were solicited through in-dept interview whiles quantitative data were gathered trough the administration of questionnaire and the acquisition of satellite images. The study population were made up of two broad categories of people: household heads who have lived in the district for not less than 25 years selected from 246 households in Aiyinase (98), Esiama (78), Kikam (45), Atuabo (15) and Sanzule (10) for the questionnaires; and key informants: farmers (3), head of farming association (1), assembly members (2) and unit committee leaders (2) who had in-dept knowledge on the study problem were involved in the in-dept interview. Household heads were selected using the simple random sampling technique while the key informants were selected purposively. Personal observations, satellite images and ground truthing formed part of the major sources of data in addition to the in-dept interview and administration of questionnaires. The data gathered were analysed and presented using maps, frequencies, tables and graphs and the results were discussed and related to other relevant studies. Conclusion, and recommendations were also given.

Summary of major findings

Objective 1 examined the land use land cover extents before and after the production of oil and gas in Ellembelle district. The findings reveal that before the discovery of oil and gas, the district was dominated by natural vegetation (dense vegetation with enough water bodies). However, the study found significant reduction in their area extent mainly through anthropogenic activities such as overharvesting of natural vegetation as fuel wood and for construction purposes; clearing of natural vegetated areas for farming; and for building houses. These activities have expanded the human induced LULC categories like cultivated land (sparse vegetation), bare areas and built up areas. The rate of LULC change was intense in the second time interval, indicating that land transformation and associated underlying mechanisms in Ellembelle district were becoming increasingly intensive since the production of oil and gas in the district.

With regards to the second objective, the study results indicated that the important drivers of LULC change in the district are oil and gas activities, population growth, urbanisation, infrastructural development and farming activities with oil and gas activities being the major driver which has stimulated all other drivers. There has been an influx of people from divers places to Ellembelle district due to the oil and gas industry and the resultant phenomenon has been LULC fragmentation. The district has therefore experienced urbanisation with major infrastructural development at the urban centres. The study further reveals that there has been consistent expansion in farming activities due to adoption of sustainable agricultural intensification practices in the district.to meet the food demand of the growing population.

In the case of objective 3, the study found out that the oil industry has had a significant impact on food shortage in Eleembelle district. Though there has been expansion in cropland and agricultural activities in the district, the study reveals that the crop yield has decreased significantly due to soil infertility emanating from chemicals from the oil and gas industry. Additionally, the study found that food supply in the district has not kept up with the increasing demand for food, leading to food shortages and increased food prices. Also, the ban on fishing in areas closer to the oil rig and the destruction of fish habitat by the oil industry has led to a decline in fish populations and a decrease in fish catch. The study also revealed that OG production in the study area has led to an increase in the cost of basic necessities such as food, housing, and transportation.

There has been an increase in the cost of land since the production of oil and gas in the district. The industry has led to a rapid increase in human activities such as putting up residential buildings to house the rising population and also meet the demand for accommodation leading to a rise in land prices. Inhabitants are also grappling with conflicts in land ownership as a result of selling one parcel of land to more than one person by some of the sub-chiefs. These phenomena have led to high cost of accommodation in the district.

The study points out to increasing employment in the district. However, respondents posited that the type of employment generated through oil and production has been indirect employment rather than direct employment. The industry has stimulated the growth of SMEs in the district, which has been the main source of employment in the district.

The assessment of some basic infrastructures shows that road networks, communication sector comprising mobile internet and telephony, Education and banking institutions as well as electricity and water supply have seen a facelift in the district. Health institutions and cultural institutions has either remained the same or has worsened according to the respondents.

Conclusion

The impact of OG production on LULC in Ellembelle district is evident. The combination of GIS and Remote Sensing techniques in the study has provided a better understanding of the landscape (before and after the discovery and production of oil and gas) of Ellembelle district.

LULCC has impacted the livelihoods of the people in Ellembelle district in different contrasting ways. The oil and gas industry has opened up the area for people from all walks of life. There have been improvement in infrastructure and social amenities in the district.

Food shortage, high cost of living, high cost of land, and soil infertility are some of the socioeconomic challenges citizens are facing in the district. Apart from these, increased rate of conflict on land ownership and erosion of the Nzema culture and tradition, are negatively affecting the Nzema community.

Recommendations

Given the likelihood of increased urbanisation, an integrated urban planning framework for the entire district is required. This should include land zoning as well as the establishment of building codes and adherence to approved set housing standards and regulations outlined by the Ellembelle district and its relevant planning units.

When communities are properly planned in advance of their development, unplanned physical development is reduced, and communities have a solid layout and are adequately zoned. This will maximize land use and make infrastructure services such as street lighting and drainage more accessible.

The Traditional Authority should always engage the Survey Department to demarcate all plots when implementing the approved land use plans to ensure that the plan corresponds to what is on the ground.

Given the extent of vegetation destruction, oil and gas companies should identify some areas or communities for tree planting programs, as well as support farmers in crop production, to improve food security in local communities.

A continuous monitoring process should be implemented in the study area by the district assembly. This will aid in policy making and the development of more effective educational programs among indigenous people which will discourage deforestation and encouraging afforestation of mangroves.

More community training and sensitization on alternative livelihoods, particularly for women, should be organized by the district assembly and concerned NGOs.

To avoid disagreements among stakeholders, community participation in decision making should be encouraged.

Though infrastructure availability has increased and social amenities have improved, maintenance and upgrade levels have been quite poor. As a result, roads have deteriorated and health centers and primary schools have become congested. All relevant authorities and organizations should work together to ensure that infrastructure upgrades keep up with population growth.

Suggestions for Further Studies

Based on the study findings, the following suggestions are made for further studies;

I. There is a need for research to determine the impact of land degradation caused by mining activities in the district.

II. Given the influx of people in the district, it is necessary to conduct additional research into the dynamics and methods of sustainable waste management in the district.

III. There should be a comprehensive study on the state of mangroves in the western coast of Ghana.

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APPENDICES

APPENDIX A

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

QUESTIONNAIRE

Spatio-temporal analysis of the impact of oil and gas production on land use land cover in Eellembelle district.

Good morning/afternoon. My name is Macbeth Kwame Blay. I am a postgraduate student at the Department of Geography and Regional Planning, University of Cape Coast (UCC). We are conducting a research on *Spatio-temporal analysis of the impact of oil and gas production on land use land cover change in Eellembelle district.* I am asking you to take part in this study because I am trying to learn more about the land use land cover dynamics before and after the start of oil and gas production in this district. And the factors that are responsible for the changes in land use and land cover. Again, I also want to understand how the changes in land use and land cover due to oil and gas production in the district has affected the livelihoods of the people in this district. Please kindly assist by answering as many questions as you deem convenient as this study is for academic purposes. All responses would be handled with utmost confidentiality.

A. Demography

1) Age…………..

2) Sex: a. Male b. Female

3) Educational level: a. No formal education b. Primary c. JHS

d. SHS e. Tertiary f. Post graduate g. Others (specify)……..

4) Marital status: a. Single b. Married c. Divorced d. Separated

5) Religious affiliation: a. Christian b. Muslim c. Traditional

d. Not belong

6) Occupation………………………..

7) Monthly income……………….

8) Nature of income after oil and gas production a. Increase b. Decreased

c. Unchanged

9) Do you come from this community? a. Yes b. No

b) If no, where do you come from?...

c) What brought you to this community? ……………………………

10) How long have you lived here………………………

b) If less than 15 years, what was your reason for the migration …………………………

11) How many members are in your household?……………………

B. Causes (drivers) of land use land cover change

12) What do you think are the causes of land-use and land-cover changes in your area (RANK ON A SCALE OF 1 TO 5; 5 = least important and 1 = most important).

Causes or Drivers	Rank				
Economic activities (Firewood collection, Charcoal, Lumbering)	1	2	3	4	5
Infrastructural development					
Farming activities					
Bush burning					
Population growth					
Climate change					
Urbanisation					
Oil and gas activities					

C. Effects of land use land cover changes on livelihood.

13) Have you noticed any change in land use land cover in your locality since the exploration of oil and gas?

14) What type of land cover existed in your area before the extraction of oil and gas?

a) Close forest b) Open forest c) Crop land d) Settlement e) Bare land f) Water

15) What type of land cover exist now?

a) Close forest b) Open forest c) Crop land d) Settlement e) Bare land f) Water

16) Have you experienced unusual rainfall pattern off late? a. Yes [ ] b. No [ ] c) Do not know [ ]

17) How will you describe your standard of living before and during oil and gas exploration? a. improved b. remained the same c. worst of d. other……….

18) In your opinion, would you say the citing of the gas processing plants in this community is useful? Yes No

b) What is the reason for your answer? …………………………………..

19) How would you access the impact of the oil and gas activities on your household?

a. Very negative b. Negative Positive c. Very positive d. Can't tell

D. Socio-economic impacts of land use land cover change on livelihoods

20) What are the socio-economic impacts of land use land cover change on the livelihoods of your community (RANK ON A SCALE OF 1 TO 5; 1 = least important and 5 = most important).

Socio-economic impacts	**scale**				
	1	2	3	4	5
Reduction in agricultural land					
Food shortage					
High cost of living					
High cost of land					
High cost of accommodation					
Lack of job opportunities					
Reduction in soil fertility					
Reduction in forest cover					
Others					

E. Impact of land use land cover change on infrastructure

21) Do you think that improvement have been made in infrastructure in your area over the past ten (10) years?

Infrastructure	Worsened	Unchanged	Don't Know	Slightly improved	Greatly improved
Roads					
Communications					
Electricity & water supply					
Health institutions					
Educational institutions					
Cultural institutions					
Banking institutions					

APPENDIX B

UNIVERSITY OF CAPE COAST

COLLEGE OF HUMANITIES AND LEGAL STUDIES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

INTERVIEW GUIDE FOR KEY INFORMANTS

Good morning/afternoon. My name is Macbeth Kwame Blay. I am a postgraduate student at the Department of Geography and Regional Planning, University of Cape Coast (UCC). We are conducting a research on *Spatio-temporal analysis of the impact of oil and gas production on land use land cover change in Eellembelle district.* You are selected to take part in this discussion because we feel that your position in this community can contribute much to this discussion. In the interview, there will be open ended questions with the help of an interview guide for you to share your knowledge how the land use land cover has changed overtime, and how these changes have affected your community members. With regards to ethical guidelines underlying scientific research involving human participants, formal consent is required. The information which you are going to share with us will not be shared with anyone else. I humbly, want to seek your consent to participate in this study. Your participation is voluntary and you may refuse to participate in or withdraw from this study at any time. The interview will last between 30 to 40 minutes. Thank you for your willingness to take part in this study.

Brief introduction of respondent.

A brief historical background of the community

1) Kindly describe the boundaries of this community before the start oil and gas production.

2) How has the boundaries changed after oil and gas production?
3) Has there been any change in land use pattern since the start of oil and gas production?
4) If yes Explain
5) Has crop production declined or increased over the past 20 years in your community?
6) What is the trend of population growth in this community?
7) Why do people move into this community?
8) In your own opinion, what are the causes of land use land cover change in this community?
9) Does the change in land use land cover has implications on the livelihoods of the community members?
10) If yes, explain
11) What was the major economic activity in this community before the discovery of oil and gas?
12) In your view, do you think this economic activity has improved or declined as a result of the oil and gas activities in this community?
13) What was the major economic activities in this community before oil and gas production?
14) What are the major economic activities after oil and gas production?
15) Kindly describe the effects of oil and production on livelihood of your community members?
16) Would you say the discovery of oil and gas has been positive or negative to this community?

Solutions

17) The role of the community members
18) The role of the district assembly
19) The role of oil and gas companies