

Trend Analysis of Declining Agricultural Land Due to Illegal Mining “Galamsey” in Amansie West, Ghana (1994-2024)

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Research Article

Keywords: Illegal mining (galamsey), Agricultural land depletion, Land use change, remote sensing (RS), One Health

Posted Date: June 16th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9710728/v1>

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Additional Declarations: No competing interests reported.

Abstract

Illegal small-scale mining activities, locally known as "galamsey," pose a significant threat by depleting arable land. Despite national recognition of galamsey's impacts, there exists a gap in region-specific, quantitative analyses using advanced spatial tools in districts in Ghana. This study focused on the declining agricultural land due to illegal mining "galamsey" in Amansie West District; the current trends and implications. This study utilized RS and GIS techniques to analyze land use and land cover (LULC) changes in Amansie West over a 30-year period (1994–2024). Landsat satellite imagery for the years 1994, 2004, 2014, and 2024 was processed using radiometric correction and supervised classification to identify LULC categories. Change detection analysis quantified the extent of agricultural land conversion due to illegal mining activities and percentage changes over time were calculated. From 1994 to 2024, primary forest cover in Amansie West decreased by 88.9%, with the sharpest decline occurring between 2004 and 2014. Agricultural land exhibited fluctuating trends, with a 155.1% increase from 1994 to 2004, followed by a 73.74% decrease from 2004 to 2014, and a subsequent 160.22% increase by 2024. Secondary forests increased by 155.25% over the period, driven by natural regeneration and land abandonment. Settlements and mining sites showed the most substantial growth, expanding by 950.29% overall, reflecting the rapid proliferation of illegal mining activities. This study demonstrates significant land use changes in the Amansie West District, particularly the depletion of agricultural and forest lands due to galamsey. The findings underscore the need for robust land management strategies, enforcement of environmental regulations, and the promotion of sustainable agricultural practices. Future research should focus on addressing the socio-economic drivers of illegal mining and developing alternative livelihood options for local communities.

INTRODUCTION

Agriculture plays a pivotal role in the socio-economic development of many countries, serving as a primary source of employment, income, and food security, particularly for rural populations (Nyamekye et al., 2021). In Ghana, the agricultural sector is a cornerstone of the economy, contributing significantly to the nation's gross domestic product (GDP) and providing livelihoods for a substantial portion of the population. Despite limited mechanization, Ghana remains an agriculture-dependent country (Bawa, 2019). The sector's importance is further emphasized by its alignment with the United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty) and SDG 2 (Zero Hunger), as it ensures local food security, supports export activities, and generates employment (Antwi-Agyei & Amanor, 2023). In 2019, agriculture accounted for approximately 20% of Ghana's GDP, contributed over 40% to export earnings, and supplied more than 90% of the nation's food needs (Bawa, 2019; Nyamekye et al., 2021; Acheampong et al., 2021; FAO, 2020).

In rural areas, agriculture remains the lifeblood for about two-thirds of the population who depend on farming for income and sustenance (Acheampong et al., 2021). In regions such as Amansie West, farming not only drives the local economy but also sustains livelihoods through the cultivation of staples like maize, cassava, and plantains, as well as cash crops like cocoa (Bawa, 2019). However, a growing

threat to agriculture in Ghana is the depletion of arable land, exacerbated by global challenges such as urbanization, deforestation, climate change, and unsustainable land use practices (FAO, 2020; IPCC, 2019; UNCCD, 2017; Beuchle et al, 2021). These factors contribute to significant land degradation, threatening food security, rural economies, and environmental sustainability.

Several global trends drive the depletion of agricultural land. Rapid urbanization converts fertile farmland to non-agricultural uses; for instance, China lost nearly 9 million km² of arable land between 1997 and 2008 due to urban expansion (FAO, 2020). Similarly, soil degradation affects about one-third of the world's soil, particularly in Africa and Asia, reducing crop yields and increasing vulnerability to drought (FAO & ITPS, 2015). Deforestation, especially in the Amazon region of Brazil, has led to soil depletion and biodiversity loss as forests are cleared for agricultural expansion (World Bank, 2021).

Land Use and Land Cover (LULC) changes, driven by deforestation, agricultural intensification, and urbanization, further contribute to environmental degradation, impacting food security and climate regulation (Obeng et al., 2023; Larbi, 2023). Remote Sensing (RS) and Geographical Information Systems (GIS) have proven effective tools in monitoring LULC changes, offering valuable insights for sustainable land management and policy development (Amoako et al., 2023; Goyal et al 2020). These technologies are critical for addressing the challenges posed by agricultural land depletion and ensuring responsible land use practices.

It is worth mentioning that environmental degradation poses a serious threat to agriculture globally. Tan et al. (2022) emphasized how biodiversity loss and deforestation harm ecosystems upon which agriculture depends, particularly forests that play critical roles in carbon sequestration, water regulation, and soil protection. Forests support approximately 80% of terrestrial biodiversity and offer essential ecosystem services (Tan et al., 2022). The loss of these forests significantly undermines global efforts to mitigate climate change and protect agricultural sustainability. Given the increasing global demand for food and the finite availability of arable land, addressing agricultural land depletion is urgent. Effective land management is necessary to mitigate land degradation and ensure the sustainability of agricultural practices. Additionally, the One Health approach advocated by Emikpe et al. (2024) calls for sustainable agricultural practices that ensure the health of both humans and ecosystems.

In Ghana, illegal small-scale mining activities, locally known as “galamsey”, have become a major contributor to the depletion of agricultural land. These unregulated mining operations clear large areas of land, leading to habitat destruction and significant ecosystem degradation (Emikpe et al., 2024). In Amansie West, where fertile land has historically supported agriculture, the spread of galamsey threatens both agricultural productivity and the region's economic stability (Gyasi, 1997). Despite the recognized impacts of illegal small-scale mining (galamsey) on agricultural land in Ghana (Hilson, 2002; Aryee et al., 2003; Bansah et al., 2016), there is a significant research gap concerning region-specific, quantitative analyses in districts like Amansie West where illegal mining activities had been on for over thirty years. Existing studies often focus on broader national trends (Hilson, 2002; Aryee et al., 2003) or other regions such as Western Ghana (Schueler et al., 2011) and lack the integration of advanced spatial

analysis tools like remote sensing (RS) and geographical information systems (GIS) to assess the extent of agricultural land depletion over time. Furthermore, while some research examines the environmental and socio-economic impacts of galamsey (Tschakert & Singha, 2007; Owusu & Dwomoh, 2012; Boampong & Adam, 2013), these studies do not utilize spatially explicit methods or predictive modelling to forecast future land use changes and their implications for local agriculture and food security. Nevertheless, there have been significant changes in land usage in recent times which have yet not been reported in literature. This study therefore aimed at analyzing the decline of agricultural land in Amansie West, Ghana, using remote sensing and GIS techniques. It investigated historical land use changes, projected future trends, and proposed sustainable land management practices to address land loss and enhance food security in the region.

MATERIALS AND METHODS

Study Area

The research focused on the Amansie West District in the Ashanti Region of Ghana, specifically encompassing areas within the Amansie West District. This area includes settlements such as Suntreso, Brofoyedu, Bontefufuo, Moseaso, Esuowin, and Akrokoso, as well as Manso Esumanya and Manso Nkwanta. Amansie West is renowned for its rich agricultural heritage, benefiting from fertile soils and a favourable climate that support diverse crop production (FAO, 2017). Geographically, Amansie West as shown in Fig. 1 below, is situated in the southwestern part of the Ashanti Region. The district covers an area of approximately 1,364 square kilometres and lies between latitudes 6°00'N and 6°30'N and longitudes 1°30'W and 2°15'W (Ghana Statistical Service, 2014). The topography is generally undulating, with elevations ranging from 150 to 300 meters above sea level. The area is intersected by several rivers and streams, including the Offin and Oda rivers, which provide essential water resources for agriculture and domestic use.

The climate of the district is classified as tropical rainforest, characterized by a bimodal rainfall pattern. The major rainy season occurs from March to July, and the minor season from September to November. Annual rainfall ranges between 1,500 mm and 1,700 mm, providing adequate moisture for crop cultivation (Meteorological Service Department, 2015). Temperatures are relatively uniform throughout the year, averaging between 26°C and 30°C, which is conducive to agricultural activities.

Soil types in Amansie West are predominantly forest ochrosols, known for their fertility and suitability for a wide range of crops. These soils, combined with the favourable climatic conditions, support the cultivation of staple crops such as maize, cassava, and plantains. Additionally, cash crops like cocoa, which is a significant contributor to Ghana's export earnings, thrive in this environment (FAO, 2017). The district is one of the notable cocoa-producing areas in the country, contributing to both local and national economies.

Demographically, the district is predominantly rural, with communities relying heavily on agriculture as their primary source of livelihood. According to the Ghana Statistical Service (2014), the population of Amansie West was approximately 134,331, with a majority engaged in farming and related activities. The agricultural sector not only provides employment but also ensures food security and supports other sectors through the supply of raw materials. Despite its agricultural potential, Amansie West faces significant challenges due to the encroachment of illegal small-scale mining activities, locally known as *galamsey* since the 1980s. These unregulated mining operations have led to the degradation of fertile agricultural lands, deforestation, and pollution of water bodies (Boateng et al., 2019). The fertile lands that once supported robust agricultural activities are now threatened, impacting food security and socio-economic stability in the region.

Study Design

The study adopted a quantitative analysis of satellite imagery to evaluate the decline of agricultural land due to illegal mining (*galamsey*) in the Amansie West District of Ghana. This approach allowed for spatial-temporal analysis of land use changes. The study employed remotely sensed satellite imagery to assess the effects of land use changes in the Amansie West District over 30 years. Landsat images were utilized to analyze changes in land cover for the years 1994, 2004, 2014, and 2024, providing decadal intervals that allowed for a comprehensive examination of temporal land dynamics.

Data Collection Process

Data Source

Landsat images of the study area were acquired from the Geological Survey (USGS) archives. The selected years included 1994, 2004, 2014, and 2024, providing consistent 10-year intervals, resulting in four epochs for analysis. These images were chosen based on their availability, minimal cloud cover, and suitability for detecting land cover changes over the specified periods. The study area was categorized into secondary forest, Primary forests, Agricultural lands, and settlements /mining sites.

Image Preprocessing

To ensure the accuracy and reliability of the satellite data, radiometric correction was applied to all images. Radiometric correction adjusted the satellite and aerial images to accurately represent true surface conditions by correcting for sensor biases and atmospheric effects. This process standardized the data, making it comparable over time and suitable for precise quantitative analysis.

Study Area Extraction

The geographical boundaries of the Amansie West District were used to clip the study area from the larger Landsat images. This focused the analysis on the area of interest and reduced computational requirements. The clipping process isolated the relevant portion of the imagery for detailed examination.

Land Use and Land Cover Mapping

Land Use and Land Cover (LULC) maps were generated from the pre-processed images. A supervised classification approach was employed to categorize the land cover types within the study area. Training samples for each land cover class such as agricultural land, forest, built-up areas, water bodies, and mining areas were selected based on field data and existing land cover information. The Maximum Likelihood Algorithm was used for the classification process, utilizing GIS software tools.

Change Detection Analysis

The classified LULC maps for each epoch were analyzed to detect changes in land cover over time. By comparing the maps from different years, transitions between land cover types were identified, with particular attention to the conversion of agricultural land to mining areas and other non-agricultural uses. Area statistics were calculated to quantify the extent of change for each land cover category as well as the percentage changes over the years.

Data Analysis

The temporal land cover data were subjected to statistical analysis to assess patterns and rates of land use change in the study area. The analysis provided insights into the extent of agricultural land depletion and the impact of factors such as illegal mining activities (galamsey). Trends over the study period were identified, and the results were used to understand the spatial dynamics of land cover changes.

RESULTS

Changes in land use and land cover

Table 1 shows the changes in land use and land cover (LULC) from 1994 to 2024 across four categories: Primary Forest, Agricultural Land, Secondary Forest, and Settlements/Mining Sites. In 1994, primary forests dominated the landscape, covering 89,320 km², which accounted for 66.8% of the total land area. However, by 2004, there was a dramatic reduction in primary forest area to 53,340 km², representing 39.9% of the land cover. This decline continued sharply over the following decades, with primary forests dwindling to 18,157 km² (13.6%) in 2014 and further decreasing to just 9,913 km² (7.4%) by 2024 (Table 1). Agricultural land exhibited fluctuating patterns over the study period. In 1994, agricultural activities occupied 26,387 km², constituting 19.7% of the land area. A significant expansion occurred by 2004, with agricultural land nearly tripling to 67,313 km² (50.4%). However, by 2014, agricultural land

experienced a sharp decline to 17,676 km² (13.2%). Interestingly, there was a resurgence of agricultural land by 2024, increasing to 45,997 km² (34.4%) (Table 1). Secondary forests also underwent notable changes. Initially covering 13,941 km² (10.4%) in 1994, secondary forests decreased to 4,106 km² (3.1%) by 2004. However, a remarkable increase was observed by 2014, with secondary forests expanding to 71,543 km² (53.5%). By 2024, secondary forest cover decreased to 35,584 km² (26.6%) (Table 1). Regarding the case of areas occupied by settlements and mining sites, in 1994, these areas covered 4,015 km² (3.0%), but expanded to 8,904 km² (6.7%) by 2004. The growth accelerated significantly in the following years, reaching 26,287 km² (19.7%) in 2014 and 42,169 km² (31.5%) by 2024 (Table 1).

Table 1
Changes in land use and land cover (LULC) from 1994 to 2024

Year	Land Use and Land Coverage							
	Primary Forest		Agricultural Land		Secondary Forest		Settlements/Mining Sites	
Area (km ²)	% LC	Area (km ²)	% LC	Area (km ²)	% LC	Area (km ²)	% LC	
1994	89320	66.8	26387	19.7	13941	10.4	4015	3.0
2004	53340	39.9	67313	50.4	4106	3.1	8904	6.7
2014	18157	13.6	17676	13.2	71543	53.5	26287	19.7
2024	9913	7.4	45997	34.4	35584	26.6	42169	31.5

The results displayed in Table 2 below shows that between 1994 and 2024, there was a significant decline in primary forest cover, with a total reduction of 88.9%. This decline was especially pronounced from 2004 to 2014, where primary forests saw a 65.96% reduction. Agricultural land exhibited fluctuating changes, with a substantial increase of 155.1% from 1994 to 2004, followed by a decrease of 73.74% between 2004 and 2014, and then another significant rise of 160.22% from 2014 to 2024, resulting in an overall increase of 74.32% over the 30-year period. Secondary forests experienced an overall increase of 155.25%, with the most substantial growth occurring between 2004 and 2014 (1642.4%). Settlements and mining sites saw the largest overall percentage increase, rising by 950.29%, with steady growth over each decade, peaking at 195.23% from 2004 to 2014.

Table 2
Percentage Changes in land use from 1994 to 2024

Land Use	Percentage Changes in Land Use (%)			
	1994–2004	2004–2014	2014–2024	Overall (1994–2024)
Primary Forest	-40.28	-65.96	-45.4	-88.9
Agricultural Land	155.1	-73.74	160.22	74.32
Secondary Forest	70.55	1642.4	50.26	155.25
Settlements/Mining Sites	121.77	195.23	60.42	950.29

The Landsat images showing the type of land use and land cover changes in the for 1994, 2004, 2014, and 2024 are shown in Fig. 2 below.

DISCUSSION

This study analyzed land use and land cover (LULC) changes in the Amansie West District of Ghana over a 30-year period from 1994 to 2024, employing remotely sensed satellite imagery and GIS techniques. The analysis of land use and land cover (LULC) changes from 1994 to 2024 in the Amansie West District reveals significant transformations with profound environmental, socio-economic, and policy implications. The drastic decline in primary forest cover from 89,320 km² (66.8%) in 1994 to just 9,913 km² (7.4%) by 2024 highlights severe deforestation in the district. This decline is largely attributable to the conversion of forests into agricultural land and the proliferation of illegal small-scale mining activities, locally known as *galamsey*. The loss of primary forests has significant environmental implications, including biodiversity loss, disruption of ecosystems, and diminished capacity for carbon sequestration. These changes exacerbate climate change impacts and undermine the ecological integrity necessary for sustainable agriculture and community livelihoods (FAO, 2020; IPCC, 2019). The substantial loss of primary forests and the expansion of mining activities necessitate urgent policy interventions to enforce environmental regulations and curb illegal mining. Strengthening institutional capacities to monitor and regulate land use is essential to prevent further degradation (Bansah et al., 2016). Effective enforcement can mitigate the environmental impacts of deforestation and mining, preserving biodiversity and ecosystem services vital for the region's sustainability.

Agricultural land exhibited fluctuating patterns over the study period. The expansion from 26,387 km² (19.7%) in 1994 to 67,313 km² (50.4%) in 2004 suggests a period of aggressive agricultural development, possibly driven by policies aimed at boosting food production. However, the sharp decline to 17,676 km² (13.2%) by 2014 indicates challenges such as land degradation, soil fertility loss, and displacement due to mining activities. The resurgence to 45,997 km² (34.4%) by 2024 may reflect efforts in land reclamation and shifts in land use policies favouring agriculture. These fluctuations have significant

socio-economic implications, affecting food security and the livelihoods of local communities who depend on farming (Nyamekye et al., 2021).

The changes in secondary forests from an initial decrease to 4,106 km² (3.1%) in 2004, followed by an increase to 71,543 km² (53.5%) in 2014, and a subsequent decline to 35,584 km² (26.6%) by 2024 suggest cycles of deforestation and natural regeneration. The initial decrease may be due to continued deforestation for agricultural expansion and mining. The substantial increase by 2014 could result from natural regrowth on abandoned agricultural and mining lands or from reforestation initiatives. However, the decline by 2024 indicates renewed pressures from land conversion due to the expansion of settlements and mining activities. The observed change in secondary forests presents opportunities for reforestation and forest restoration initiatives. These dynamics underscore the need for effective forest management and conservation strategies to maintain ecosystem services and support sustainable land use (Obeng et al., 2023; Tan et al., 2022). Policies that encourage the rehabilitation of degraded lands and the conservation of secondary forests can contribute to ecological resilience and carbon sequestration efforts. Engaging local communities in these initiatives through participatory approaches can enhance their effectiveness and sustainability (Yomo et al., 2023). Community-based Forest management programs can empower local populations to take an active role in conservation.

The exponential growth of areas occupied by settlements and mining sites from 4,015 km² (3.0%) in 1994 to 42,169 km² (31.5%) by 2024 reflects intensified human activities and urbanization. The proliferation of *galamsey* operations has led to significant land degradation, pollution of water bodies, and health risks for local populations (Hilson, 2002; Mensah et al., 2015). This trend poses substantial policy and management challenges, highlighting deficiencies in regulatory enforcement and land use planning. The environmental implications are severe, as mining activities often destroy arable land, rendering it unsuitable for future agricultural use. The expansion of settlements underscores the need for integrated land use planning which balances development needs with environmental conservation. Policies should guide sustainable urban development, ensuring infrastructure expansion does not come at the expense of valuable agricultural and forest lands. Incorporating spatial analysis tools like remote sensing and GIS can improve land use planning and decision-making processes, enabling authorities to identify critical areas for conservation and development (Pankajakshan, 2024). Moreover, addressing the challenges posed by *galamsey* requires not only enforcement but also the provision of alternative livelihoods for those involved in illegal mining. Economic incentives, vocational training, and support for small-scale, legal mining operations adhering to environmental standards can reduce the attractiveness of illegal activities (Hilson, 2016). Such measures can alleviate poverty and reduce environmental degradation simultaneously.

Despite the valuable insights provided by this study, several limitations must be acknowledged. The temporal resolution of the satellite imagery, using decadal intervals from 1994 to 2024, may not capture short-term fluctuations and seasonal variations in land use changes. The reliance on Landsat imagery with a spatial resolution of 30 meters could overlook small-scale land transformations, such as minor mining sites or small agricultural plots, potentially affecting the accuracy of land cover classification.

It is critical to state that if no critical measures are put in place, The depletion of primary forests and agricultural areas not only threatens food security but also undermines biodiversity and exacerbates climate change, which poses significant risks to human health through increased malnutrition, water contamination, and heightened exposure to vector-borne diseases. The destruction of animal habitats will likely lead to biodiversity loss, negatively impacting ecosystem stability and animal health. The environmental degradation caused by galamsey also has profound implications for the region's socio-economic structure, particularly in the agricultural sector, which is a major source of employment. The youth, who constitute a significant portion of the population, are at risk of unemployment and economic marginalization, further driving engagement in illegal mining.

CONCLUSION

This study revealed significant land use changes in the Amansie West District, with an 88.9% decline in primary forest cover and substantial fluctuations in agricultural land from 1994 to 2024, largely driven by illegal small-scale mining (galamsey) and deforestation. The rapid expansion of settlements and mining sites highlights the environmental and socio-economic challenges facing the region, including threats to food security, biodiversity, and sustainable agriculture.

In light of the significant depletion of agricultural land due to illegal mining activities in Amansie West, it is imperative to implement robust land management strategies that enforce environmental regulations to curb galamsey operations. Integrating continuous monitoring systems utilizing advanced remote sensing and GIS technologies can enhance the detection and management of unauthorized land use changes. Engaging local communities through educational initiatives and the provision of alternative sustainable livelihoods can address the socio-economic factors driving illegal mining practices. Additionally, prioritizing reforestation programs and promoting sustainable agricultural practices are essential to rehabilitate degraded lands, bolster food security, and strengthen the socio-economic resilience of the district. In addition, future research should focus on the broader implications of these land use changes by adopting a One Health framework that addresses the interconnections between human, animal, and environmental health. Moreover, targeted interventions for youth empowerment and employment generation are critical, with research needed to explore alternative livelihoods and vocational training opportunities in sustainable industries. Such efforts could alleviate the socio-economic drivers of illegal mining while promoting environmental conservation and long-term regional sustainability.

Declarations

All authors have read, understood, and have complied as applicable to with the “Ethical Responsibilities of Authors” as found in the instructions for authors

Ethical Approval

Not applicable.

Consent to Publish

All authors have granted their approval for the publishing of this work. Furthermore, all co-authors have examined and validated the final version of the work.

Competing Interests

All the authors of this manuscript declare the absence of financial or non-financial interests.

Consent to Participate

Not applicable

Funding

This research work did not receive any institutional funding.

Author Contribution

The authors of this study contributed to the research in the following manner: B.O.E, O.M.O., O.O.O, S.C.Y.A, A.O.E were responsible for conceptualizing the study and designing the methodology. N.A.D, H.O.J.N, D.A.A were responsible for data collection, analyzing the data, and drafting the original manuscript. N.A.D and H.O.J.N prepared the maps and the tables. B.O.E, D.A.A, P.N.T reviewed and edited the final manuscript.

Acknowledgement

The authors want to acknowledge the German-West African Centre for Global Health and Pandemic Prevention (G-WAC)- KNUST, Kumasi, Ghana for facilitating a 3-months Research stay at KNUST and granting access to a wide range of facilities geared to the success of this research.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

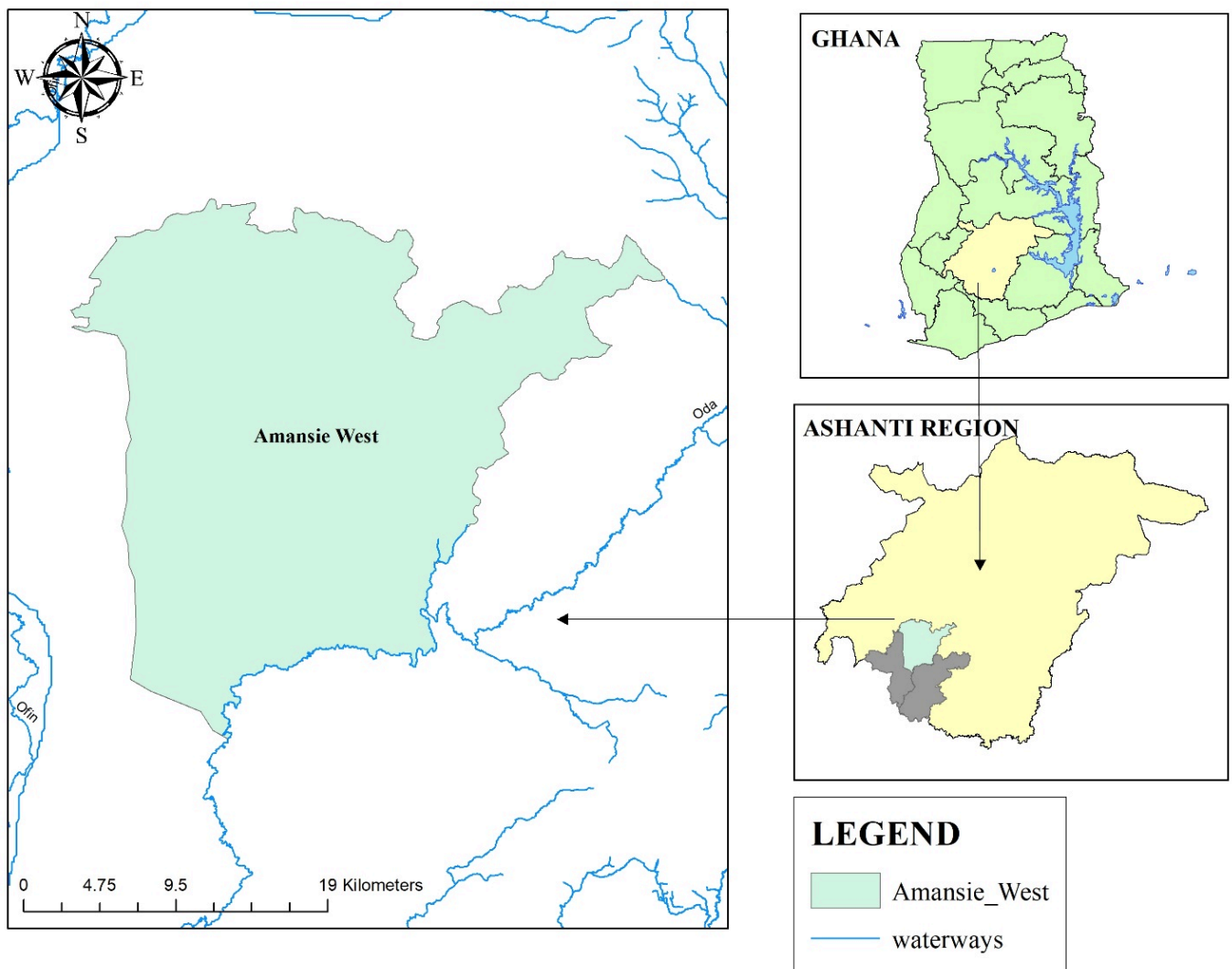


Figure 1

Administrative Map of Amansie West District

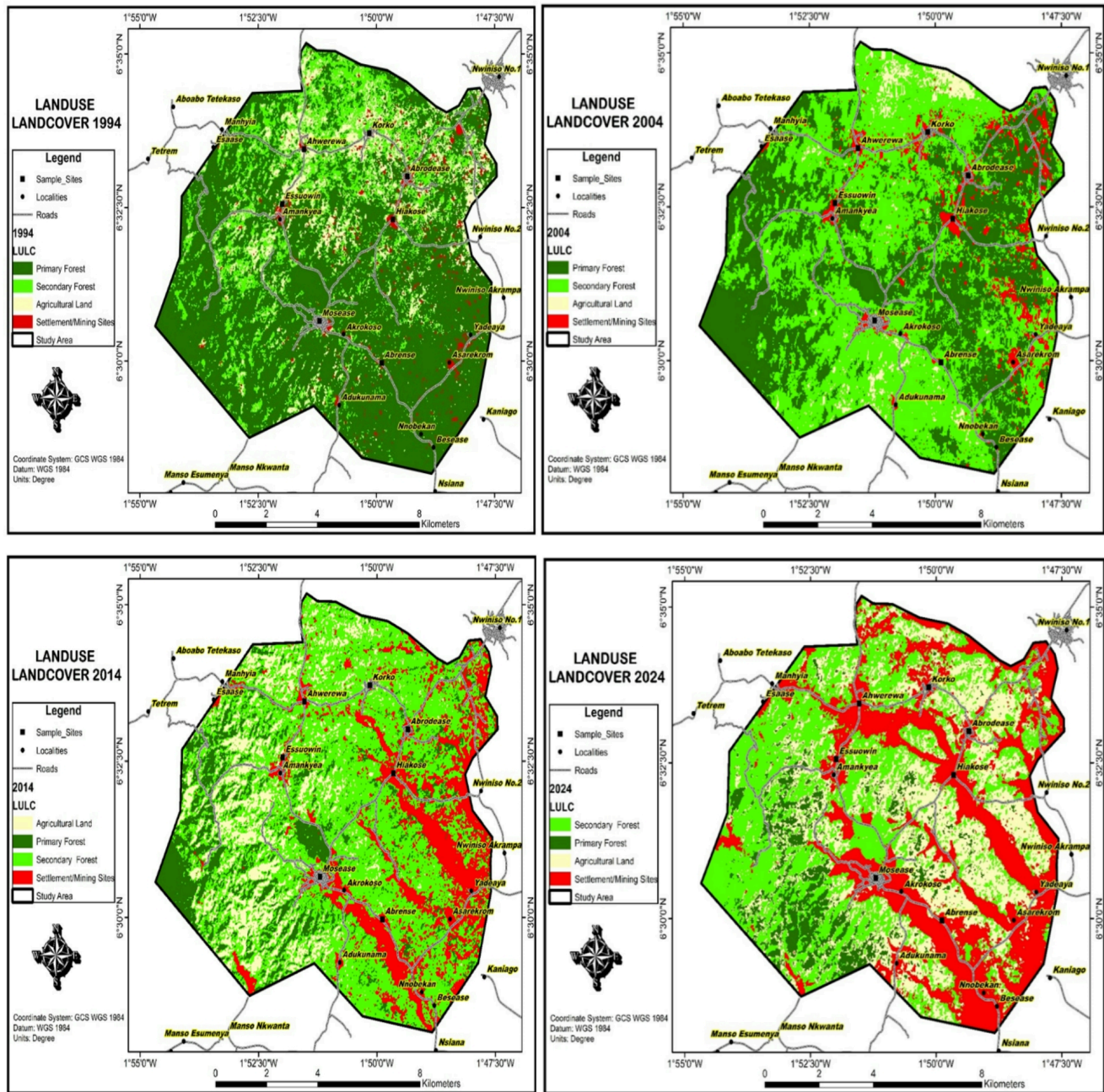


Figure 2

Landuse Landcover Map of Study area from 1994-2024