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Anthropogenic Drivers of Land Use and Land Cover Change in Ghana (2000–2025): A PRISMA-Based Systematic Review and Quantitative Synthesis

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Abstract
Land use and land cover (LULC) in Ghana have undergone substantial transformation over the past two decades, largely driven by the intensification of human activities. This study presents a PRISMA-guided systematic review and quantitative synthesis of peer-reviewed and grey literature published between 2000 and 2025 to examine the major anthropogenic drivers, spatial patterns, and environmental implications of LULC change in Ghana. Using a PICO-informed search strategy, 52 studies were retained for qualitative and quantitative synthesis. Evidence from the reviewed studies shows that agricultural expansion remains the dominant driver of forest loss and vegetation decline, while urbanization and population growth accelerate the conversion of agricultural land, wetlands, and peri-urban landscapes, particularly around Accra, Kumasi, and Sekondi-Takoradi. Mining, including legal and illegal small-scale mining, was identified as a localized but severe driver of land degradation, soil disturbance, and water pollution. The quantitative synthesis compared reported LULC change indicators, including forest loss, built-up expansion, agricultural conversion, wetland degradation, and mining-related land disturbance. Findings indicate that anthropogenic pressures interact with governance weaknesses, land tenure challenges, climate variability, and socio-economic vulnerability to intensify landscape transformation across Ghana's ecological zones. The study highlights the need for stronger implementation of land-use planning regulations, coordinated institutional governance, climate-adaptive agriculture, responsible mining control, and region-specific restoration strategies. These findings provide an evidence-based foundation for sustainable land management, environmental monitoring, and policy planning in Ghana.

Keywords
Land Use and Land Cover Change, Anthropogenic Drivers, Systematic Review, Quantitative Synthesis, Environmental Degradation, Ghana

1. Introduction

LULC change is one of the most significant manifestations of global environmental change, profoundly influencing biodiversity conservation, climate regulation, ecosystem services, food security, and sustainable development. Across Sub-Saharan Africa, the intensification of anthropogenic activities, including agricultural expansion, rapid urbanization, mining, infrastructure development, and population growth, has accelerated landscape transformation at unprecedented rates, often exceeding the influence of natural climatic variability (Govender et al., 2022). These changes have altered ecosystem structure and function, increased habitat fragmentation, reduced carbon sequestration capacity, and heightened the vulnerability of communities that depend directly on natural resources for their livelihoods.

Ghana exemplifies these environmental challenges. Between 2001 and 2021, the country lost approximately 1.8 million hectares of forest cover, representing nearly one-quarter of its remaining forests, with significant consequences for biodiversity conservation, watershed protection, agricultural productivity, and climate resilience (Peprah, 2025a). Agricultural expansion, particularly cocoa cultivation and food crop production, remains the principal driver of deforestation, while rapid urban growth around Accra, Kumasi, Sekondi–Takoradi, Tamale, and other metropolitan centres has accelerated the conversion of agricultural land, wetlands, and peri-urban ecosystems (Ampim et al., 2021; Ashiagbor et al., 2019). Concurrently, legal and illegal artisanal and small-scale gold mining (galamsey) has intensified land degradation through vegetation clearance, soil erosion, landscape fragmentation, and contamination of rivers and groundwater systems (Larbi et al., 2025; Peprah, 2025a). These direct drivers are further reinforced by population growth, poverty, insecure land tenure, weak institutional coordination, inadequate enforcement of environmental regulations, and increasing climate variability (Asare et al., 2024; Fuseini and Kemp, 2016; Opiyo et al., 2022).

Land use refers to the socio-economic purposes for which land is utilized, whereas land cover describes the physical and biological characteristics present on the Earth's surface (Nedd et al., 2021; de Souza et al., 2022). Monitoring changes in both land use and land cover is fundamental for understanding ecosystem dynamics, carbon cycling, soil conservation, hydrological processes, and environmental sustainability (Olorunfemi et al., 2018; Vieira et al., 2021; Jawarneh et al., 2024). Consequently, analysing anthropogenic drivers of LULC change has become a major research priority within international frameworks supporting the Sustainable Development Goals (SDGs), the Paris Agreement, Land Degradation Neutrality (LDN), and the Kunming–Montreal Global Biodiversity Framework.

Over the past two decades, numerous remote sensing and geographic information system (GIS)-based studies have examined LULC dynamics across Ghana. However, the available evidence remains fragmented and methodologically diverse. Studies differ substantially in satellite sensors, spatial resolution, classification algorithms, temporal coverage, land-cover classification schemes, and validation procedures, making direct comparison difficult and limiting the development of nationally representative conclusions. Furthermore, most investigations have focused on individual districts, municipalities, watersheds, or ecological zones, while comparatively few studies have synthesized evidence across Ghana's forest, transition, savannah, and coastal landscapes. Existing research also varies considerably in how anthropogenic drivers are identified, classified, and interpreted, making it difficult to determine their relative importance and cumulative contribution to national landscape transformation (Peprah, 2025b).

Despite the growing body of literature, there remains no comprehensive synthesis that systematically consolidates quantitative evidence on the magnitude, spatial distribution, and environmental implications of anthropogenic LULC change across Ghana. Existing reviews have primarily adopted narrative approaches and have provided limited comparison of reported land-cover changes, dominant drivers, and regional patterns. Consequently, policymakers and land management agencies continue to rely on fragmented evidence when designing interventions to address deforestation, urban expansion, mining-related degradation, and unsustainable land use.

These knowledge gaps have important implications for environmental governance. Ghana has established several legislative and institutional mechanisms to promote sustainable land management, including the Land Use and Spatial Planning Act, 2016 (Act 925), the Land Use and Spatial Planning Authority (LUSPA), the Environmental Protection Agency (EPA), the Lands Commission, the Forestry Commission, the Water Resources Commission, and the Metropolitan, Municipal and District Assemblies (MMDAs). However, fragmented institutional responsibilities, conflicting customary and statutory land tenure systems, inadequate enforcement, and limited integration of scientific evidence into planning continue to constrain effective implementation of sustainable land-use policies. A comprehensive synthesis of existing evidence is therefore essential to support evidence-based environmental governance, strengthen land-use planning, and improve policy implementation.

To address these gaps, this study conducts a PRISMA-guided systematic review with quantitative synthesis of published literature on anthropogenic drivers of land use and land cover change in Ghana between 2000 and 2025. Unlike previous narrative reviews, this study systematically compiles, compares, and synthesizes quantitative evidence reported across individual studies to identify dominant anthropogenic drivers, evaluate spatial and temporal patterns of landscape transformation, and assess their environmental and socio-economic implications. The study further integrates the Driver–Pressure–State–Impact–Response (DPSIR), Coupled Human and Natural Systems (CHANS), Proximate–Underlying Drivers, and Sustainable Livelihood Frameworks (SLF) to provide a comprehensive understanding of the interactions between anthropogenic activities, environmental change, governance, and socio-economic development.

The specific objectives of this study are to: (i) systematically identify and classify the major anthropogenic drivers of land use and land cover change in Ghana; (ii) synthesize quantitative evidence on their environmental and socio-economic impacts; (iii) examine the spatial and temporal patterns of landscape transformation across Ghana's ecological zones; and (iv) develop evidence-based recommendations to strengthen sustainable land management, environmental governance, and implementation of the Land Use and Spatial Planning Act, 2016 (Act 925). By providing the first comprehensive PRISMA-based systematic review with quantitative synthesis of anthropogenic LULC change in Ghana, this study establishes an evidence base to support future research, environmental monitoring, and informed land-use policy and planning.

2. Conceptual and Theoretical Framework

Understanding LULC change requires an integrated perspective that recognizes the dynamic interactions among human activities, environmental processes, and governance systems. Across Ghana, rapid agricultural expansion, urbanization, mining, infrastructure development, and population growth have transformed landscapes at unprecedented rates, resulting in deforestation, wetland degradation, soil erosion, biodiversity loss, declining ecosystem services, and increasing environmental vulnerability (Peprah et al., 2025b; Larbi et al., 2025; Denga et al., 2025). These complex interactions cannot be adequately explained using a single theoretical perspective because they involve multiple socio-economic, ecological, institutional, and policy processes operating simultaneously across different spatial and temporal scales. Consequently, this study adopts an integrated conceptual framework that combines the DPSIR framework, the Proximate and Underlying Drivers Model, the CHANS framework, and the SLF. Collectively, these complementary frameworks provide a robust analytical foundation for identifying, classifying, synthesizing, and interpreting anthropogenic drivers of LULC change in Ghana.

The DPSIR framework serves as the principal analytical framework underpinning this study. Developed by the European Environment Agency, DPSIR explains how socio-economic drivers generate environmental pressures that alter ecosystem conditions, produce ecological and socio-economic impacts, and subsequently require institutional and policy responses (Khemiri et al., 2022; Alemayehu et al., 2025). Within the Ghanaian context, underlying drivers such as population growth, economic development, land tenure systems, and governance weaknesses generate direct pressures through agricultural expansion, urbanization, logging, infrastructure development, and mining. These pressures alter land cover by reducing forest extent, expanding built-up areas, degrading wetlands, and modifying hydrological systems, thereby affecting biodiversity, ecosystem services, food security, climate resilience, and community livelihoods. The response component highlights the importance of institutional interventions, including implementation of the Land Use and Spatial Planning Act, 2016 (Act 925), environmental regulations, protected area management, ecosystem restoration programmes, and coordinated land-use planning undertaken by institutions such as the LUSPA, EPA, Lands Commission, Forestry Commission, Water Resources Commission, and MMDAs. The DPSIR framework, therefore, provides a suitable structure for interpreting the causal relationships identified through systematic review and quantitative synthesis.

Complementing DPSIR, the Proximate and Underlying Drivers Model (Lambin and Geist, 2006) distinguishes between the immediate human activities that directly modify land cover and the broader socio-economic, demographic, institutional, and policy factors that influence those activities. Proximate drivers include agricultural expansion, mining, logging, fuelwood extraction, and urban growth, whereas underlying drivers encompass population growth, market demand, poverty, land tenure systems, governance effectiveness, technological development, and national development policies. This distinction is particularly relevant in Ghana, where cocoa expansion, illegal artisanal and small-scale gold mining (galamsey), rapid urbanization, and infrastructure development are strongly influenced by demographic pressures, commodity markets, customary land ownership, and regulatory enforcement capacity (Opiyo et al., 2022; Asare et al., 2024). Within this study, the framework guided the classification of anthropogenic drivers extracted from the reviewed literature and facilitated the interpretation of their interactions across ecological zones.

The CHANS framework extends this perspective by recognizing that human and environmental systems continuously influence one another through reciprocal feedback mechanisms (Liu et al., 2007). Anthropogenic land conversion affects ecosystem productivity, water availability, climate regulation, biodiversity, and soil fertility, while these environmental changes subsequently influence future land-use decisions and livelihood strategies. For example, declining soil fertility resulting from forest degradation may encourage agricultural expansion into previously undisturbed areas, thereby reinforcing further landscape transformation. Such feedback processes demonstrate that LULC change is inherently dynamic and non-linear, highlighting the importance of understanding environmental change as a continuous interaction between human and natural systems rather than as isolated events.

The SLF complements these ecological and systems-based perspectives by emphasizing that household land-use decisions are strongly influenced by livelihood assets, institutional support, vulnerability, and socio-economic opportunities (Chambers and Conway, 1992). In many rural communities throughout Ghana, dependence on agriculture, forest resources, fuelwood, and artisanal mining reflects broader livelihood constraints rather than purely environmental preferences. Consequently, sustainable land management cannot be achieved solely through environmental regulation but must also address poverty reduction, livelihood diversification, institutional capacity building, and equitable access to natural resources. Incorporating the SLF, therefore, enables interpretation of anthropogenic LULC drivers within their wider socio-economic and development context.

Rather than applying these frameworks independently, this study integrates them into a single conceptual model that guided the systematic review, evidence synthesis, and interpretation of findings. The integrated framework informed the formulation of the research objectives, categorisation of anthropogenic drivers, organisation of evidence according to proximate and underlying causes, interpretation of interactions among socio-economic and environmental processes, and development of evidence-based policy recommendations. Specifically, the Proximate and Underlying Drivers Model informed the classification of direct and indirect drivers; DPSIR structured the causal pathways linking drivers to environmental impacts and policy responses; CHANS explained dynamic feedback mechanisms between anthropogenic activities and ecological change; and the Sustainable Livelihoods Framework provided a socio-economic perspective for interpreting livelihood-related land-use decisions. This integrated approach enables a more comprehensive understanding of LULC change than any single theoretical framework alone.

Although each framework has recognised limitations, including simplified causal assumptions within DPSIR, limited representation of complex feedback mechanisms within the Proximate and Underlying Drivers Model, substantial data requirements for CHANS, and the socio-economic information required by the Sustainable Livelihoods Framework, their integration considerably strengthens the analytical robustness of this study by combining complementary perspectives. Furthermore, the use of a PRISMA-guided systematic review and quantitative synthesis provides a transparent and reproducible approach for consolidating evidence from studies employing diverse methodologies, geographical contexts, and temporal scales.

Fig. 1 presents the integrated conceptual framework developed for this study. The framework illustrates how underlying demographic, socio-economic, institutional, and policy drivers influence proximate anthropogenic activities, including agriculture, mining, logging, infrastructure development, and urban expansion. These activities generate environmental pressures that modify land use and land cover, resulting in deforestation, wetland degradation, land degradation, biodiversity loss, declining ecosystem services, and altered hydrological processes. The framework further illustrates the feedback relationships through which environmental degradation influences socio-economic vulnerability and future land-use decisions, while institutional responses, including land-use planning, environmental governance, ecosystem restoration, and implementation of the Land Use and Spatial Planning Act, 2016 (Act 925), seek to mitigate anthropogenic impacts and promote sustainable land management.

Consequently, this integrated conceptual framework provides the theoretical foundation for interpreting the findings of this systematic review and quantitative synthesis and for developing evidence-based recommendations to support sustainable land governance in Ghana.

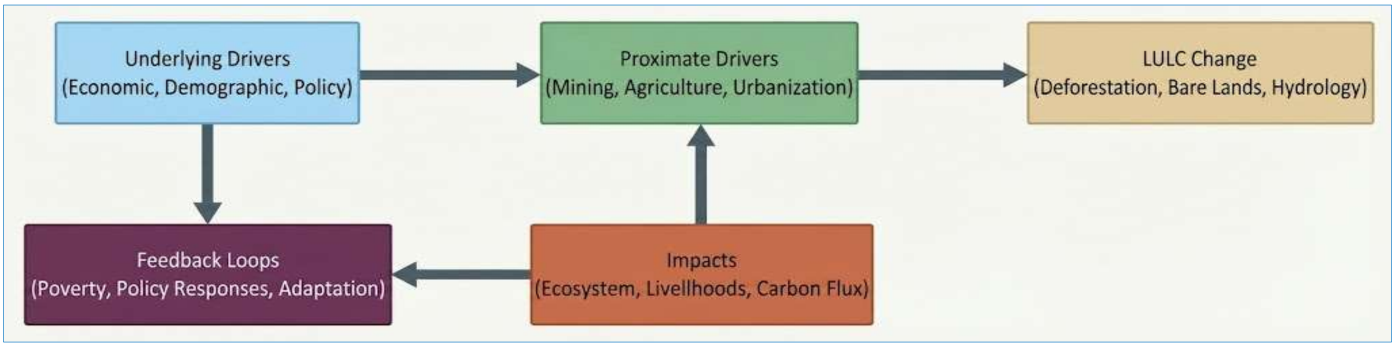

Fig. 1. Flowchart Depicting the Conceptual Framework of the Study

3. Materials and Methods

3.1. Study Area

This study focuses on the Republic of Ghana (Fig. 2), a coastal country in West Africa located between latitudes 4°44′N and 11°11′N and longitudes 3°15′W and 1°12′E, with an area of approximately 238,533 km². Ghana shares international boundaries with Côte d'Ivoire to the west, Burkina Faso to the north, Togo to the east, and the Gulf of Guinea to the south. Its geographical location, ecological diversity, and rapidly changing socio-economic conditions make it an important setting for investigating anthropogenic LULC change (Mohammed et al., 2023). Ghana comprises three major ecological zones: the Coastal Zone, Forest Zone, and Savannah Zone. The Coastal Zone is characterized by dense urban settlements, industrial development, expanding transportation infrastructure, and ecologically important coastal wetlands.

The Forest Zone, extending across southern and central Ghana, contains tropical forests that support cocoa production, commercial agriculture, timber harvesting, and large-scale mineral extraction. In contrast, the northern Savannah Zone is dominated by Guinea and Sudan savannah vegetation and is characterized primarily by rain-fed agriculture, livestock production, and increasing climate variability (Johnson and Madise, 2011; Kambala, 2023). These ecological differences provide an appropriate basis for examining how anthropogenic drivers of LULC change vary across environmental and socio-economic settings.

Climatic conditions also differ considerably across the country. Southern Ghana experiences a humid tropical climate with bimodal rainfall ranging between approximately 1,200 and 1,500 mm annually, whereas northern Ghana receives between 600 and 1,100 mm of unimodal rainfall. Mean annual temperatures have increased during recent decades, while rainfall variability has become increasingly pronounced, contributing to droughts, flooding, shortened growing seasons, and changing agricultural practices (Antwi-Agyei et al., 2018; Awuni et al., 2023). These climatic conditions increasingly interact with anthropogenic land-use decisions, influencing agricultural expansion, settlement patterns, mining activities, and environmental degradation. During the past three decades, accelerated agricultural expansion, rapid urbanization, infrastructure development, timber harvesting, and legal and illegal artisanal small-scale mining (galamsey) have significantly transformed Ghana's landscapes. These pressures have contributed to deforestation, wetland degradation, biodiversity loss, soil erosion, declining water quality, and increasing greenhouse gas emissions (Aboagye et al., 2020; Armah et al., 2010; Peprah, 2025a). Consequently, Ghana provides an appropriate socio-ecological setting for synthesizing evidence on anthropogenic drivers of LULC change and evaluating their environmental and policy implications.

3.2. Study Design and Review Protocol

This study employed a PRISMA-guided systematic review with quantitative synthesis to examine the anthropogenic drivers of LULC change in Ghana. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency, reproducibility, and comprehensive reporting throughout the review process. A review protocol was developed before commencement of the literature search to minimise selection bias and ensure consistency during study identification, screening, eligibility assessment, quality appraisal, data extraction, and evidence synthesis. The protocol specified the review objectives, search strategy, eligibility criteria, study selection procedures, data extraction variables, quality assessment framework, and methods for qualitative and quantitative synthesis.

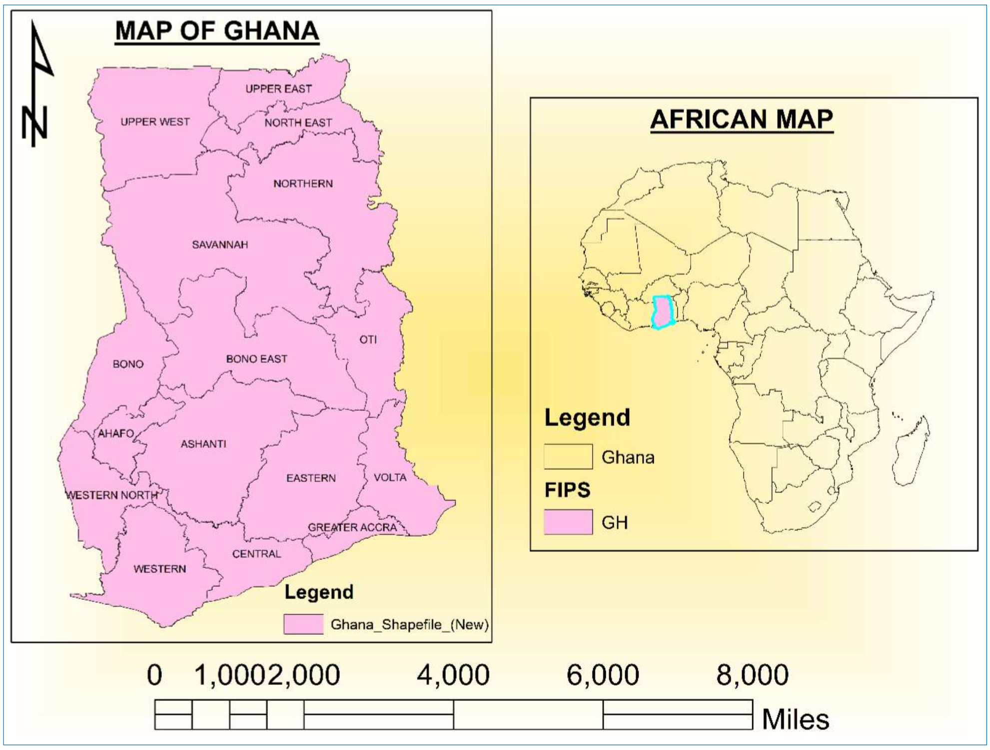

Fig. 2. Geospatial Examination of the Study Region

The review was guided by the Population–Exposure–Comparator–Outcome (PECO) framework, which is widely recommended for environmental systematic reviews. The population comprised terrestrial ecosystems and land-use systems within Ghana, including forest, savannah, coastal, agricultural, mining, and urban landscapes. The exposure consisted of anthropogenic activities driving LULC change, including agricultural expansion, urbanization, mining, logging, infrastructure development, fuelwood harvesting, and population growth. The comparator represented historical land-cover conditions or earlier observation periods used to identify changes attributable to these anthropogenic activities. The outcomes included quantitative indicators of LULC change, such as forest loss, agricultural expansion, urban growth, wetland conversion, land degradation, transition matrices, annual rates of change, and the associated environmental and socio-economic impacts reported in the reviewed studies.

Unlike conventional narrative reviews, this study systematically synthesized both qualitative descriptions and quantitative evidence reported across the included studies. Considerable heterogeneity existed among the selected studies with respect to study design, geographical coverage, temporal extent, remote sensing datasets, image classification techniques, and reporting formats. Consequently, quantitative synthesis was undertaken by systematically comparing reported patterns of land-cover change, anthropogenic drivers, and their associated environmental impacts rather than statistically pooling effect sizes. This approach provided a robust synthesis of the available evidence, enabling the identification of consistent national trends while preserving methodological rigour and avoiding inappropriate statistical aggregation of heterogeneous data.

3.3. Literature Search Strategy

A comprehensive and reproducible literature search was conducted to identify studies investigating the anthropogenic drivers of LULC change in Ghana published between 2000 and 2025. This period was selected because it coincides with the widespread availability and application of medium- and high-resolution satellite imagery, including Landsat ETM+, Landsat OLI, Sentinel-2, and MODIS datasets, together with the increasing adoption of geospatial technologies for environmental monitoring and LULC assessment in Ghana.

The literature search was performed across five major electronic databases, namely Scopus, ScienceDirect, Google Scholar, ResearchGate, and Academia.edu, to ensure comprehensive coverage of both peer-reviewed and scholarly publications. To maximise the retrieval of relevant studies, the electronic database search was supplemented with backward and forward citation tracking, manual screening of reference lists from eligible articles, and targeted searches of grey literature, including government technical reports, postgraduate theses, institutional publications, and conference proceedings. This multi-source search strategy was adopted to minimise publication bias and capture relevant evidence that may not have been indexed in conventional bibliographic databases.

The search strategy combined controlled vocabulary and free-text keywords using Boolean operators (AND and OR) to improve search sensitivity and specificity. Search terms were organised into four thematic groups covering the geographical context, land use and land cover terminology, anthropogenic drivers, and geospatial methodologies. The geographical terms included Ghana, West Africa, Ashanti, Greater Accra, Northern Ghana, Pra Basin, Ankobra Basin, Offin Basin, and Volta Basin. Land use and land cover terms comprise land use, land cover, LULC, land use change, land cover change, landscape dynamics, land transformation, and land conversion. Anthropogenic driver terms included anthropogenic drivers, human activities, agricultural expansion, urbanization, mining, illegal mining, galamsey, logging, deforestation, infrastructure development, population growth, and bushfires. Geospatial methodology terms included remote sensing, Geographic Information Systems (GIS), satellite imagery, Landsat, Sentinel, MODIS, change detection, time-series analysis, and machine learning.

A representative search string applied in the Scopus database was: ("Ghana" OR "West Africa") AND ("Land use" OR "Land cover" OR "LULC" OR "Land use change") AND ("Anthropogenic" OR "Agricultural expansion" OR "Mining" OR "Urbanization" OR "Deforestation") AND ("Remote sensing" OR "GIS" OR "Landsat" OR "Sentinel"). Equivalent search strings were adapted for each database according to its indexing structure and search syntax while maintaining conceptual consistency across all searches. All retrieved records were imported into Mendeley Reference Manager, where duplicate records were identified and removed before title, abstract, and full-text screening. The complete search strategy, including database-specific search strings and syntax, is presented in Table 1 to enhance the transparency, reproducibility, and methodological rigour of the review.

Table 1. Search Strings by Database

No	Database	Search String
1	Scopus	(Ghana OR "West Africa") AND ("land use" OR "land cover" OR LULC) AND (anthropogenic OR urbanisation OR deforestation OR "agricultural expansion" OR mining) AND ("remote sensing" OR GIS OR satellite)
2	Google Scholar	Ghana "land use land cover" anthropogenic impacts urbanisation deforestation "remote sensing"
3	ScienceDirect	"Ghana" AND "LULC" AND ("anthropogenic drivers" OR "human activities") AND ("change detection" OR "temporal analysis")
4	ResearchGate	Ghana LULC anthropogenic impacts urbanisation deforestation remote sensing
5	Academia.edu	"Ghana land use change" anthropogenic drivers deforestation mining

3.4. Eligibility Criteria

Eligibility criteria were established before commencement of the literature search to ensure methodological consistency and transparency throughout the review process. The criteria were developed using the PECO framework and were designed to identify studies that explicitly investigated anthropogenic drivers of LULC change in Ghana while providing sufficient quantitative information for evidence synthesis. Studies were included if they satisfied all of the following criteria: (i) were conducted wholly or partly within Ghana; (ii) were published between January and March; (iii) investigated anthropogenic drivers of LULC change using spatially explicit datasets; (iv) analysed LULC dynamics using at least two temporal observations; (v) reported quantitative indicators such as forest loss, agricultural expansion, built-up area growth, wetland conversion, land degradation, transition matrices, or annual rates of land-cover change; (vi) employed recognised geospatial techniques including remote sensing, GIS, aerial photography, unmanned aerial vehicles (UAVs), or high-resolution satellite imagery; and (vii) provided sufficient methodological information to permit quality appraisal.

Eligible publication types included peer-reviewed journal articles, conference papers containing original empirical findings, government technical reports, institutional publications, postgraduate theses, and other grey literature reporting original research. Inclusion of grey literature helped minimise publication bias and improve the comprehensiveness of the evidence base.

Studies were excluded if they: (i) focused exclusively on natural drivers of environmental change without evaluating anthropogenic influences; (ii) lacked temporal analysis of LULC dynamics; (iii) presented only qualitative descriptions without quantitative land-cover information; (iv) were editorials, opinion articles, book reviews, or narrative commentaries without original empirical evidence; (v) did not provide sufficient methodological information to support critical appraisal; or (vi) were published in languages other than English.

The eligibility criteria ensured that all included studies contributed directly to understanding anthropogenic LULC change in Ghana while maintaining consistency across the qualitative and quantitative components of the review.

3.5. Study Selection and Screening

The study selection process followed the PRISMA framework and comprised four sequential stages: identification, screening, eligibility assessment, and final inclusion (Fig. 3). The database search identified 8,337 records. Following importation into Mendeley Reference Manager, 587 duplicate records were removed through automated and manual verification procedures, leaving 7,750 unique publications for title and abstract screening. Title and abstract screening were undertaken independently by two reviewers using the predefined eligibility criteria. Studies were excluded where they were unrelated to Ghana, did not investigate anthropogenic drivers of LULC change, lacked temporal analysis, represented review articles without original empirical evidence, or did not provide sufficient methodological information. Following the initial screening stage, 1,672 publications underwent full-text assessment. Full-text articles were evaluated independently according to study design, geographical relevance, methodological transparency, temporal coverage, availability of quantitative LULC indicators, and overall relevance to the review objectives. Disagreements between reviewers were resolved through discussion until consensus was achieved. Ultimately, 52 studies satisfied the eligibility criteria and were included in the systematic review and quantitative synthesis. The PRISMA flow diagram summarises the identification, screening, eligibility assessment, and inclusion process and provides reasons for exclusion at each stage, thereby ensuring transparency and reproducibility.

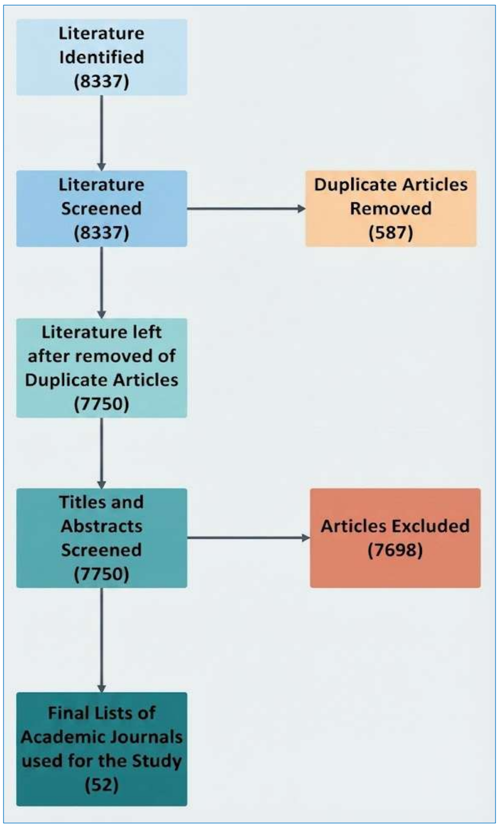

Fig. 3. PRISMA Flow Diagram for the Study Selection Process

3.6. Data Extraction

A standardized data extraction form was developed and pilot-tested before full data collection to ensure consistency throughout the review. Two reviewers independently extracted information from each eligible study, after which the extracted datasets were compared and reconciled through discussion to minimise transcription errors and reviewer bias. Information extracted from each study was organised into six categories. The first category comprised general study characteristics, including author(s), publication year, study location, ecological zone, geographical extent, study period, and publication type. The second category captured geospatial and remote sensing information, including satellite platforms (e.g., Landsat, Sentinel, MODIS, SPOT), spatial resolution, temporal resolution, image preprocessing procedures, atmospheric correction techniques, cloud masking methods, and field validation approaches. The third category documented LULC mapping methodology, including classification algorithms, software environment (e.g., ArcGIS, ENVI, ERDAS Imagine, Google Earth Engine, or QGIS), land-cover classification scheme, overall classification accuracy, producer's accuracy, user's accuracy, and Kappa coefficient, where reported. The fourth category recorded anthropogenic drivers of LULC change, including agricultural expansion, cocoa cultivation, urbanization, mining (including artisanal and small-scale mining), logging, fuelwood harvesting, infrastructure development, bushfires, population growth, and other human-induced activities. The fifth category comprised quantitative indicators of land-use and land-cover change, including forest loss, agricultural expansion, built-up area growth, wetland conversion, land degradation, transition matrices, annual rates of change, and other reported measures of landscape transformation. The sixth category documented environmental and socio-economic impacts, including biodiversity loss, ecosystem degradation, soil erosion, water quality deterioration, carbon dynamics, livelihood impacts, policy implications, and recommended management interventions. The extracted information formed the primary database for both qualitative interpretation and quantitative synthesis undertaken in this review.

3.7. Quality Assessment

The methodological quality of the included studies was independently evaluated by two reviewers using a modified critical appraisal framework adapted from the Critical Appraisal Skills Programme (CASP), together with published quality assessment criteria commonly applied in remote sensing and environmental monitoring research. The appraisal focused on methodological transparency, the reliability of geospatial analyses, and the overall relevance of each study to the review objectives. The quality assessment considered four key methodological domains. The first domain examined study design and reporting, including the clarity of research objectives, adequacy of study area description, justification of the temporal scope, and transparency of the methodological procedures. The second domain evaluated the quality of remote sensing and geospatial data, including the suitability of satellite imagery, image preprocessing techniques, atmospheric correction, cloud masking procedures, spatial resolution, and the use of field validation.

The third domain assessed the reliability of land-cover classification by examining the appropriateness of the classification algorithms, reported overall accuracy, Kappa coefficient, validation procedures, and consistency of the land-cover classification scheme. The fourth domain evaluated the interpretation of anthropogenic drivers by assessing the clarity with which human-induced drivers were identified, the strength of the linkage between anthropogenic activities and observed land use and land cover changes, and the discussion of environmental and policy implications.

Each assessment criterion was scored using a three-point scale, where a score of 2 indicated that the criterion was fully satisfied, 1 indicated partial satisfaction, and 0 indicated that the criterion was not satisfied. Total quality scores ranged from 0 to 24 and were subsequently classified into three categories. Studies scoring between 18 and 24 were considered to be of high methodological quality, those scoring between 12 and 17 were classified as moderate quality, while studies scoring between 0 and 11 were regarded as having low methodological quality. The quality assessment was used to evaluate the overall reliability of the evidence base and to guide the interpretation of the synthesized findings rather than to assign statistical weights to individual studies. The appraisal facilitated the identification of methodological strengths, limitations, and potential sources of bias across the included literature, with particular attention given to selection bias, reporting bias, measurement bias, and analytical bias that could influence the interpretation of anthropogenic land use and land cover change in Ghana. Overall, the assessment indicated that the majority of the included studies were of moderate to high methodological quality, providing confidence in the robustness of the synthesized evidence while acknowledging methodological variability among individual investigations.

3.8. Quantitative Evidence Synthesis

Following data extraction and quality appraisal, quantitative information reported by the included studies was synthesized to identify common patterns, trends, and magnitudes of anthropogenic LULC change across Ghana. Because the reviewed studies exhibited substantial heterogeneity in study design, geographical coverage, temporal extent, satellite imagery, spatial resolution, classification techniques, and reporting formats, statistical pooling of effect sizes was considered inappropriate. Instead, a structured quantitative synthesis was undertaken to systematically compare and integrate reported numerical findings while preserving the methodological integrity of the individual studies.

The quantitative synthesis focused on indicators that were consistently reported across the literature, including changes in forest cover, agricultural land, built-up areas, wetlands, water bodies, mining-related land disturbance, and other major LULC classes. Additional variables extracted from the studies included annual rates of land-cover change, land-cover transition matrices, percentage changes in individual land-cover categories, and the reported environmental and socio-economic impacts associated with anthropogenic activities. To facilitate meaningful comparison across studies, the extracted evidence was organized into four broad themes encompassing the principal anthropogenic drivers of LULC change, the spatial distribution of landscape transformation across Ghana's Forest, Transition, Savannah, and Coastal ecological zones, temporal trends observed between 2000 and 2025, and the environmental and socio-economic consequences of land-cover change.

The synthesis examined the influence of key anthropogenic drivers, including agricultural expansion, urbanization, mining, logging, infrastructure development, fuelwood extraction, and population growth, while comparing their relative contributions across Ghana's major ecological zones. It also evaluated temporal variations in reported LULC changes over different observation periods and assessed their implications for deforestation, biodiversity loss, wetland degradation, soil erosion, declining water quality, carbon dynamics, ecosystem services, and rural livelihoods. Where comparable quantitative indicators were available, findings were summarized descriptively using frequencies, percentages, ranges, means, and reported rates of land-cover change. Comparative tables and graphical summaries were subsequently developed to illustrate dominant trends, regional variations, and the relative importance of the major anthropogenic drivers. This synthesis approach enabled systematic comparison of quantitative evidence while acknowledging the methodological diversity of the included studies and avoiding inappropriate statistical aggregation.

3.9. Data Synthesis and Interpretation

The synthesized evidence was interpreted using a convergent approach that integrated quantitative findings with qualitative information extracted from the reviewed studies. This approach facilitated identification of recurring themes, regional similarities and differences, and interactions among anthropogenic drivers across Ghana's ecological zones. The interpretation of findings was guided by the integrated conceptual framework described in Section 2. Specifically, the DPSIR framework was used to examine causal relationships between socio-economic drivers, environmental pressures, ecological changes, and institutional responses. The Proximate and Underlying Drivers Model informed classification of direct and indirect anthropogenic drivers, while the CHANS framework supported interpretation of feedback mechanisms linking environmental degradation and future land-use decisions. The SLF provided a socio-economic perspective for understanding how livelihood strategies, poverty, institutional support, and vulnerability influence land-use practices.

Comparative analyses were undertaken across ecological zones, geographical regions, and major land-use categories to identify areas experiencing the greatest rates of landscape transformation. The review also compared reported findings among studies employing different remote sensing datasets, spatial resolutions, and classification approaches in order to identify methodological consistencies and differences within the evidence base. Rather than focusing solely on numerical changes, the synthesis examined how anthropogenic drivers interacted with governance systems, land tenure arrangements, demographic change, and climate variability to influence observed LULC dynamics. Particular emphasis was placed on identifying recurring patterns that could inform sustainable land management, environmental monitoring, and national policy implementation.

3.10. Methodological Considerations

Several methodological considerations were recognised during the synthesis of the reviewed literature. First, considerable diversity existed among the included studies regarding geographical coverage, study period, ecological setting, satellite imagery, spatial resolution, classification algorithms, and validation procedures. Although this diversity enriched the evidence base by capturing multiple environmental contexts, it also limited direct comparison of numerical estimates across studies. Second, reporting formats varied substantially. Some studies presented percentage changes in land-cover classes, whereas others reported absolute area changes, annual rates of change, transition matrices, or landscape metrics. Consequently, quantitative synthesis focuses on comparing reported trends and magnitudes rather than deriving common statistical effect measures.

Third, the geographical distribution of studies was uneven. Most investigations were concentrated within southern Ghana, particularly the Greater Accra, Ashanti, Western, and Central Regions, while relatively fewer studies examined northern savannah ecosystems and transitional landscapes. This imbalance should be considered when interpreting national patterns of anthropogenic LULC change. Fourth, although extensive efforts were made to identify grey literature and unpublished reports, some relevant studies may not have been retrieved because of limited public accessibility or publication language restrictions. Nevertheless, the inclusion of multiple bibliographic databases, institutional repositories, and manual reference searches substantially improved the comprehensiveness of the review. Despite these limitations, the systematic review followed internationally recognised PRISMA guidelines, employed transparent eligibility criteria, independent study selection, duplicate data extraction, structured quality appraisal, and a rigorous quantitative synthesis of reported evidence. These procedures enhance the transparency, reproducibility, and credibility of the findings while providing a robust evidence base for understanding anthropogenic land use and land cover change in Ghana.

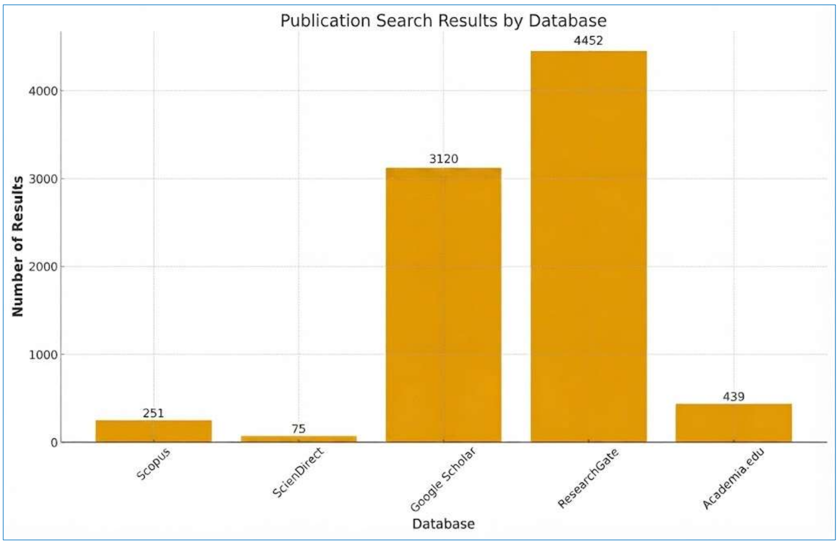

Fig 4. A Chart displaying the results obtained from the search database

3.11. Ethical Considerations

This study was based exclusively on published literature and publicly available secondary data. Consequently, no human participants, animals, or confidential datasets were involved, and ethical approval was not required. Throughout the review process, the principles of academic integrity, transparency, and responsible research conduct were maintained by accurately reporting methods, appropriately acknowledging sources, and synthesizing evidence without alteration or misrepresentation. The review was conducted in accordance with internationally recognised standards for systematic reviews, ensuring that study selection, data extraction, quality assessment, and evidence synthesis were undertaken objectively and transparently. Every effort was made to minimise reviewer bias through independent screening, duplicate data extraction, and consensus-based decision-making during the review process.

4. Results and Discussion

4.1. Results

4.1.1. Study Selection

The systematic search identified 8,337 records from five electronic databases and additional grey literature sources. After removing 587 duplicate records using Mendeley Reference Manager and manual verification, 7,750 unique publications remained for title and abstract screening. During this stage, 6,078 studies were excluded because they were unrelated to Ghana, did not investigate anthropogenic land use and land cover (LULC) change, lacked temporal analysis, or did not provide original empirical evidence. Subsequently, 1,672 full-text articles were assessed against the predefined eligibility criteria. Following detailed evaluation, 1,620 studies were excluded because they lacked quantitative LULC information, did not examine anthropogenic drivers, focused exclusively on methodological developments, or provided insufficient methodological detail to support quality assessment. Consequently, 52 studies satisfied the inclusion criteria and were retained for the systematic review and quantitative synthesis (Fig. 3). The selection process followed the PRISMA guidelines, ensuring transparency and reproducibility throughout identification, screening, eligibility assessment, and final inclusion.

Fig. 4 illustrates the distribution of retrieved records per database in descending order, emphasising the relative contribution of each source to the evidence base.

Table 2. Inclusion and Exclusion Criteria

Criteria Category	Inclusion Criteria	Justification	Exclusion Criteria	Justification
Geographic Focus	Studies conducted in Ghana, with specific regional or national coverage	Ensures relevance to the Ghanaian socio-ecological context and policy environment	Studies conducted exclusively outside Ghana without comparative Ghanaian data	Limits scope to regions with directly comparable environmental and institutional contexts
Publication Period	Studies published between 2000-2025	Captures contemporary anthropogenic pressures coinciding with rapid urbanisation, population growth, and improved remote sensing data availability	Studies published before 2000	Pre-2000 studies lack access to modern satellite data (Landsat 7+, Sentinel) and contemporary socio-economic contexts
Study Focus	Studies examining anthropogenic drivers of LULC change with quantitative temporal analysis	Directly addresses the primary research question on human-induced land transformation	Studies focused solely on natural drivers (climate, geology) without anthropogenic components	Does not provide evidence on human impacts, which is the core focus
LULC Analysis	Studies employing temporal LULC classification with at least two time periods	Enables assessment of change dynamics and rates of transformation	Single-time-point studies or purely predictive models without a historical baseline	Cannot demonstrate actual anthropogenic impacts without a temporal comparison
Anthropogenic Drivers	Studies explicitly identifying and quantifying human activities as drivers (urbanization, deforestation, agriculture, mining, logging, population growth, infrastructure)	Ensures direct relevance to anthropogenic impact assessment	Studies attributing LULC changes primarily to natural factors without examining human activities	Does not address the anthropogenic dimension of land change
Data Sources	Studies using satellite imagery (Landsat, Sentinel, MODIS, SPOT), aerial photography, or high-resolution imagery with ground truthing	Provides standardised, verifiable data for cross-study comparison	Studies relying solely on questionnaires, interviews, or anecdotal evidence without spatial data	Lacks the spatial precision and reproducibility necessary for meta-analysis
Quantitative Metrics	Studies reporting quantitative LULC change metrics (area change in hectares/km², percentage change, transition rates, classification accuracy)	Essential for meta-analysis and quantitative synthesis	Studies providing only qualitative descriptions or categorical assessments	Cannot contribute to quantitative meta-analysis
Methodological Rigor	Studies employing recognised LULC classification methods (supervised/unsupervised classification, object-based image analysis, machine learning) with accuracy assessment	Ensures methodological transparency and reliability of results	Studies with undocumented methodology or no accuracy assessment	Cannot assess reliability or weight evidence appropriately
Study Type	Peer-reviewed journal articles, conference proceedings from reputable venues, government technical reports with clear methodology, Master's/PhD theses	Prioritises quality-controlled research while acknowledging diverse knowledge sources relevant to Ghana	Opinion pieces, policy briefs without original data, news articles, unpublished working papers without peer review	Lacks the methodological rigor necessary for systematic review inclusion
Language	Studies published in English	Practical limitation based on the review team capacity and Ghana's official language	Studies in languages other than English	Resource constraints prevent translation; acknowledged as a potential limitation
Driver Specification	Studies providing specific information on types, magnitude, or spatial patterns of anthropogenic activities	Enables subgroup analysis by driver type and assessment of relative impacts	Studies mentioning "human activities" generically without specification	Insufficient detail for meaningful analysis of specific anthropogenic factors

4.1.2. Characteristics of the Included Studies

The 52 studies included in this review were published between 2003 and 2025, reflecting increasing scientific interest in anthropogenic LULC change in Ghana (Table 2). Publication output remained relatively low before 2015 but increased markedly thereafter, with almost half of the studies published between 2021 and 2025, illustrating the growing importance of geospatial technologies in environmental monitoring and sustainable land management. Most studies employed remote sensing integrated with GIS as the principal analytical approach. Landsat imagery was the most frequently used dataset owing to its long temporal archive and free accessibility, followed by Sentinel-2, MODIS, SPOT, ASTER, and high-resolution commercial imagery.

Supervised image classification was the dominant analytical technique, with Maximum Likelihood Classification, Random Forest, Support Vector Machine, object-based image analysis, and machine-learning algorithms increasingly adopted in more recent studies. The reviewed studies covered all major ecological zones of Ghana, including the High Forest Zone, Forest–Savannah Transition Zone, Coastal Zone, and Guinea and Sudan Savannah Zones. However, geographical coverage was uneven, with considerably greater research effort concentrated in southern Ghana than in the northern regions.

4.1.3. Methodological Quality Assessment

The methodological quality assessment revealed that the majority of the included studies demonstrated moderate to high quality (Tables 3a and b). Most investigations clearly described their study objectives, satellite datasets, image preprocessing procedures, classification methods, and validation techniques. Overall classification accuracies commonly exceeded 85%, while reported Kappa coefficients generally indicated substantial to almost perfect agreement between classified maps and reference datasets. Studies receiving lower methodological scores typically omitted independent validation procedures, reported limited methodological details, or failed to describe image preprocessing adequately. Nevertheless, none of the retained studies exhibited methodological weaknesses sufficiently severely to compromise the overall synthesis. The quality assessment further demonstrated considerable improvements in methodological rigour over time. Earlier studies relied predominantly on conventional pixel-based classification techniques, whereas more recent investigations increasingly incorporated cloud-computing platforms, machine-learning algorithms, higher spatial resolution imagery, and more robust validation procedures.

Note: Methodological quality was independently assessed by two reviewers using a modified Critical Appraisal Skills Programme (CASP) framework combined with quality assessment criteria commonly applied in remote sensing and environmental monitoring studies. Each criterion was scored as 2 = fully satisfied, 1 = partially satisfied, and 0 = not satisfied, yielding total quality scores ranging from 0 to 24. Quality assessment informed the interpretation of the synthesized evidence but was not used to assign statistical weights to individual studies.

Table 3a. Summary of methodological quality assessment of included studies

Quality Assessment Domain	Assessment Criteria	Studies Fully Satisfied, n (%)	Studies Partially Satisfied, n (%)	Studies Not Satisfied, n (%)
Study design and reporting	Clearly stated objectives, study area description, temporal justification, and methodological transparency	46 (88.5)	6 (11.5)	0 (0.0)
Remote sensing and geospatial data quality	Appropriate satellite imagery, preprocessing, atmospheric correction, cloud masking, spatial resolution, and field validation	42 (80.8)	10 (19.2)	0 (0.0)
Classification reliability	Appropriate classification approach, overall accuracy, Kappa coefficient, and validation procedures	40 (76.9)	12 (23.1)	0 (0.0)
Interpretation of anthropogenic drivers	Clear identification of drivers, linkage to LULC change, environmental and policy implications	45 (86.5)	7 (13.5)	0 (0.0)

Table 3b. Summary of methodological quality assessment of included studies

Overall methodological quality	Quality score (0–24)	Number of studies (n)	Percentage (%)
High quality	18–24	34	65.4
Moderate quality	12–17	18	34.6
Low quality	0–11	0	0.0

4.1.4. Temporal Trends in Research

The temporal distribution of publications reveals a progressive increase in research on anthropogenic LULC change in Ghana over the past two decades (Fig. 5). Between 2003 and 2014, publication frequency remained relatively low, averaging fewer than two studies annually. From 2015 onwards, however, research output increased substantially, reaching its highest level during the period 2021–2025. This increase coincides with the wider availability of freely accessible satellite imagery, the emergence of cloud-based geospatial platforms such as Google Earth Engine, and increasing national and international attention to climate change, land degradation neutrality, and sustainable development. Growing policy interest in environmental monitoring and implementation of the Land Use and Spatial Planning Act, 2016 (Act 925), has also stimulated greater application of remote sensing and GIS technologies in Ghana. The increasing methodological sophistication observed in recent publications further demonstrates the evolution of LULC research from descriptive mapping toward integrated environmental assessment capable of supporting evidence-based land management and policy formulation.

4.1.5. Geographical Distribution of Studies

The spatial distribution of included studies demonstrates a pronounced geographical concentration within southern Ghana (Fig. 6). Greater Accra, Ashanti, Western, Central, and Eastern Regions accounted for most published investigations, reflecting the intensity of urbanization, commercial agriculture, mining, industrial development, and associated environmental pressures within these regions. The Greater Accra Metropolitan Area represented the single most intensively studied location because of rapid urban expansion, wetland conversion, and increasing pressure on peri-urban ecosystems. Similarly, studies conducted within the Western and Ashanti Regions primarily focused on forest conversion, cocoa expansion, and mining-related land degradation, while investigations in the Central Region frequently examined coastal ecosystem change and agricultural transformation. In contrast, northern Ghana remains comparatively underrepresented despite experiencing extensive agricultural expansion, vegetation degradation, and increasing climate-related environmental stress. Only a limited number of studies investigated the Guinea and Sudan Savannah Zones, highlighting an important geographical imbalance within the current evidence base. The uneven spatial distribution of research has important implications for national environmental planning. Although southern Ghana currently experiences the greatest concentration of anthropogenic pressures, expanding agricultural frontiers and increasing climate variability suggest that greater research attention should be directed towards northern and transitional ecological zones. Future investigations should therefore prioritise these underrepresented landscapes to provide a more balanced understanding of national LULC dynamics and strengthen evidence supporting regional land-use planning

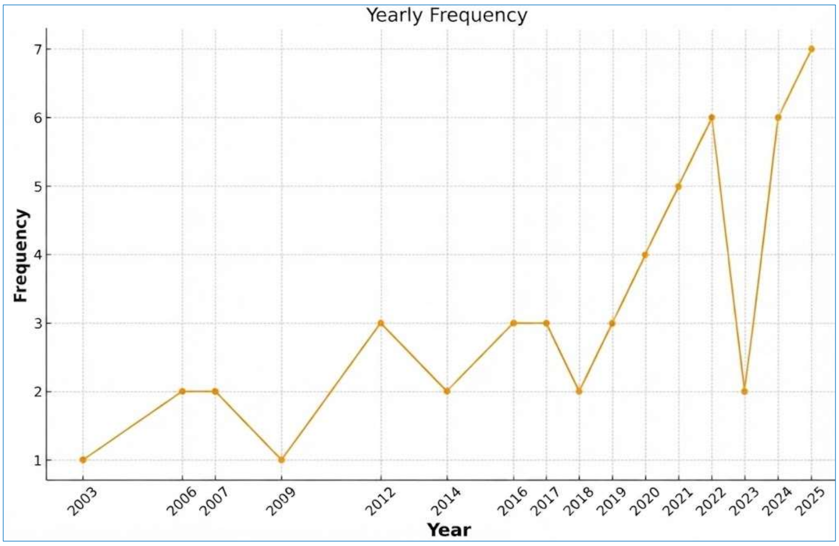

Fig. 5. Annual publication trend of studies included in the review (2003–2025)

4.1.6. Anthropogenic Drivers of LULC Change in Ghana

The synthesis of the 52 reviewed studies demonstrates that anthropogenic activities have become the principal drivers of LULC transformation across Ghana. Although the magnitude and spatial extent of reported changes varied according to ecological zone, study period, and analytical approach, there was remarkable consistency regarding the dominant drivers of landscape transformation. Agricultural expansion, urbanization, mining, infrastructure development, and population growth were the most frequently reported direct drivers, while weak governance, land tenure complexities, poverty, market demand, and climate variability acted as important underlying factors that intensified environmental change (Ampim et al., 2021; Ashiagbor et al., 2019; Asare et al., 2024; Fuseini and Kemp, 2016; Larbi et al., 2025; Opiyo et al., 2022; Peprah, 2025a). Table 4 presents their principal environmental impacts and geographical distribution. Agricultural expansion was the most consistently reported driver, followed by urbanization, mining, and population growth.

4.1.6.1. Agricultural expansion and forest conversion

Agricultural expansion emerged as the dominant driver of LULC change throughout Ghana, particularly within the High Forest Zone and Forest–Savannah Transition Zone. Most studies attributed continued forest conversion to expansion of cocoa cultivation, food crop production, commercial agriculture, and smallholder farming systems (Ampim et al., 2021; Kleemann et al., 2017; Peprah, 2025b). Quantitative evidence indicates substantial reductions in forest cover across multiple ecological zones. Kleemann et al. (2017) reported an estimated 22% decline in national forest cover between 1975 and 2000, while Weeks et al. (2017) observed a reduction in forest cover from approximately 37% to 27% across southern Ghana between 2000 and 2010. Similarly, Ashiagbor et al. (2019) documented considerable declines in both open forest and riverine forest within the Ga West Municipality as agricultural and residential land uses expanded

The reviewed studies consistently demonstrate that agricultural expansion has occurred primarily through horizontal land conversion rather than agricultural intensification. Expansion into previously forested landscapes has contributed to habitat fragmentation, declining biodiversity, reduced carbon storage, increased soil erosion, and disruption of ecosystem services. These impacts were particularly pronounced in cocoa-producing districts of the Western, Ashanti, Eastern, and Central Regions, where commercial agriculture continues to exert substantial pressure on remaining forest ecosystems (Table 5).

Although agriculture remains fundamental to Ghana's economy and food security, the synthesis suggests that current production systems remain environmentally unsustainable without improved land management, agroforestry adoption, conservation agriculture, and climate-smart farming practices.

4.1.6.2. Urbanization and built-up expansion

Rapid urbanization was identified as the second most significant driver of LULC change. Nearly all studies conducted within metropolitan and peri-urban areas documented continuous expansion of built-up land accompanied by substantial reductions in agricultural land, wetlands, and natural vegetation (Ashiagbor et al., 2019; Fuseini and Kemp, 2016; Songsore, 2020).

The largest reported increase occurred within the Ga West Municipal Assembly, where built-up land increased by approximately 149.12 km² between 1985 and 2015, representing an increase of nearly 1200% (Ashiagbor et al., 2019). During the same period, landscape fragmentation increased considerably, and urban development was projected to dominate almost the entire municipality by 2050 if existing trends continue. Similarly, Fuseini and Kemp (2016) reported a 78% increase in built-up land within Tamale between 2001 and 2014, corresponding to an annual urban growth rate of approximately 4.4%.

The review further indicates that urban expansion has generally exceeded population growth in several metropolitan regions, suggesting increasing land consumption through low-density peri-urban development rather than compact urban growth. Expansion of residential settlements, commercial infrastructure, transportation networks, and industrial estates has accelerated conversion of agricultural land and ecologically sensitive wetlands, particularly within Greater Accra, Kumasi, Sekondi–Takoradi, Cape Coast, and Tamale.

Collectively, these findings demonstrate that urbanization has become a major mechanism of landscape transformation within southern Ghana, contributing to increased impervious surfaces, altered hydrological processes, declining ecosystem services, and greater vulnerability to urban flooding.

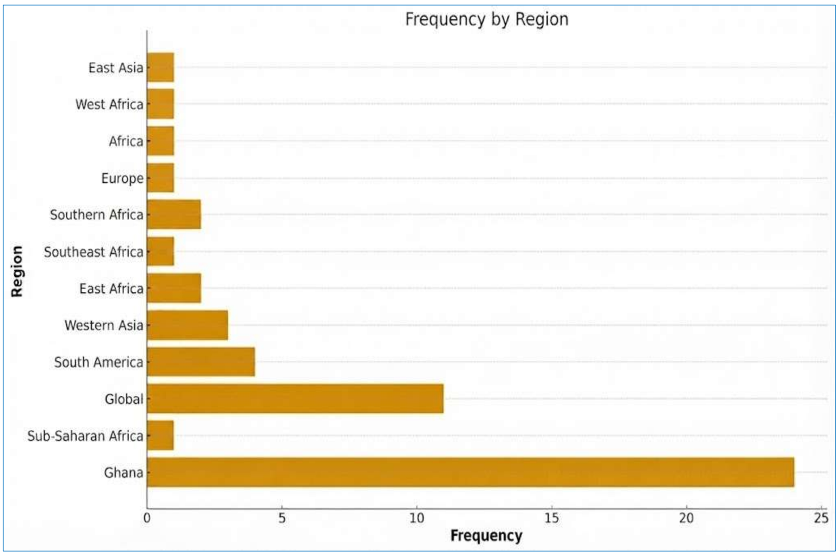

Fig. 6. Spatial distribution of studies included in the systematic review

4.1.6.3. Mining-induced landscape transformation

Mining, particularly artisanal and small-scale gold mining (galamsey), was consistently identified as one of the most environmentally destructive anthropogenic drivers despite occupying relatively smaller spatial extents than agriculture or urbanization (Larbi et al., 2025; Asare et al., 2024). The reviewed studies indicate that mining activities have contributed substantially to vegetation clearance, soil disturbance, landscape fragmentation, river sedimentation, water pollution, and abandonment of degraded land. Asare et al. (2024) estimated that approximately 4.55 million m³ of sand are extracted annually around the Accra–Gomoa corridor, degrading nearly 284 hectares of agricultural land each year, while approximately 85% of extraction occurs outside formal regulatory systems.

Mining-related landscape transformation was most pronounced within the Western, Western North, Ashanti, Eastern, and Central Regions, where both legal and illegal mining have accelerated the conversion of forest and agricultural land into barren surfaces and excavated landscapes. Beyond direct land-cover change, mining also contributed to the deterioration of water quality, increased sediment loads, heavy metal contamination, and declining agricultural productivity within surrounding communities. The synthesis therefore demonstrates that although mining affects smaller geographical areas than agriculture, its environmental consequences are disproportionately severe because of the intensity of land disturbance and long-term ecological degradation.

4.1.6.4. Wetland degradation

Coastal wetlands emerged as one of the most vulnerable ecosystems affected by anthropogenic land transformation. Studies conducted within the Greater Accra Metropolitan Area consistently documented substantial conversion of wetlands into residential, commercial, industrial, and transportation infrastructure (Danso et al., 2021). Reported wetland losses ranged from approximately 38% within the Sakumono wetland system to more than 80% within parts of the Kpeshie–Korle wetland complex over the past five decades. Residential development accounted for the largest proportion of observed wetland conversion, while industrial expansion and road construction contributed additional pressure. Loss of wetland ecosystems has reduced flood regulation capacity, biodiversity conservation, groundwater recharge, water purification, and carbon storage while simultaneously increasing urban flood risk and ecological vulnerability. These findings highlight the urgent need for stronger enforcement of wetland protection policies and integration of ecosystem conservation into urban planning.

Table 4. Major anthropogenic drivers of land use and land cover change were identified in Ghana between 2000 and 2025

Driver Category	Evidence of Dominance	Implications for LULC Change
Agricultural Expansion	Most frequently identified across national and regional studies as the principal cause of deforestation and land transformation (Peprah et al., 2025b; Acheampong et al., 2018).	Conversion of forest and savanna to farmland remains the largest-scale change, contributing to biodiversity loss and carbon emissions.
Urbanisation & Population Growth	Dominant in southern Ghana (Accra, Kumasi, Takoradi) (Kleemann et al., 2017; Ashiagbor et al., 2019).	Accelerates built-up land expansion; loss of agricultural and wetland ecosystems, driven by migration and housing demand.
Mining Activities (Legal/Illegal)	Particularly strong in Obuasi, Tarkwa, and Northern Ghana (Agyemang, 2012; Bryceson et al., 2022).	Leads to localised, high-intensity land degradation and severe soil and water pollution.
Climatic Variability	Ranked highly by experts in the Volta Basin (Kotir et al., 2017) and national reviews (Peprah et al., 2025a).	Alters rainfall and vegetation cycles; exacerbates deforestation and drought-related land degradation.
Policy and Institutional Factors	Foundational in shaping long-term trajectories (Acheampong et al., 2018; Anarfi et al., 2020).	Weak land tenure systems, market forces, and policy-driven deforestation (e.g., SAP/ERP) accelerate unsustainable land use conversion.

4.1.6.5. Population growth, governance and other underlying drivers

Beyond direct anthropogenic activities, the review identified several underlying socio-economic and institutional drivers that amplify LULC change. Population growth, rural–urban migration, poverty, land tenure arrangements, market demand for agricultural commodities, and weak environmental governance consistently emerged as important indirect drivers influencing land-use decisions (Opiyo et al., 2022; Asare et al., 2024; Fuseini and Kemp, 2016). Rapid population growth has increased demand for housing, infrastructure, food production, and natural resources, thereby intensifying pressure on forests, wetlands, and agricultural land. At the same time, fragmented institutional responsibilities, limited enforcement capacity, and the coexistence of customary and statutory land administration have facilitated unregulated land conversion in many parts of the country. These findings indicate that anthropogenic LULC change in Ghana is driven not only by individual human activities but also by broader socio-economic and governance conditions that influence how land resources are managed. Consequently, effective environmental management requires integrated institutional coordination, transparent land administration, strengthened enforcement mechanisms, and improved participation of local communities in land-use planning.

4.1.7. Environmental and Socio-economic Impacts of Anthropogenic LULC Change

The synthesized evidence demonstrates that anthropogenic LULC change has generated widespread environmental and socio-economic consequences across Ghana's ecological zones. Although the magnitude of impacts varies among regions, there was strong agreement across the reviewed studies that continued landscape transformation has reduced ecosystem resilience, degraded natural resources, and increased the vulnerability of both rural and urban communities (Ampim et al., 2021; Ashiagbor et al., 2019; Larbi et al., 2025; Peprah, 2025a).

Table 6 summarize the environmental and socio-economic consequences associated with major anthropogenic drivers of LULC change in Ghana.

4.1.7.1. Environmental impacts

Forest degradation emerged as the most consistently reported environmental consequence of anthropogenic LULC change. Conversion of forests into agricultural land, mining sites, settlements, and infrastructure has accelerated habitat fragmentation, reduced species richness, and diminished ecosystem connectivity throughout the High Forest Zone (Kleemann et al., 2017; Weeks et al., 2017). The resulting fragmentation has reduced the ecological integrity of protected areas while increasing the susceptibility of remnant forest patches to further degradation.

Land degradation was another major environmental consequence identified across the reviewed studies. Agricultural expansion, unsustainable cultivation practices, illegal mining, sand winning, and infrastructure development have accelerated soil erosion, nutrient depletion, compaction, and declining soil fertility, particularly within intensively cultivated landscapes and mining districts (Asare et al., 2024; Larbi et al., 2025). In many mining communities, removal of topsoil and vegetation has resulted in permanently degraded landscapes requiring extensive ecological restoration.

Water resources have also been substantially affected.

Mining activities were frequently associated with sedimentation, increased turbidity, heavy metal contamination, and deterioration of river water quality, while rapid urbanization contributed to wetland loss, reduced groundwater recharge, and increased flood frequency within metropolitan areas (Danso et al., 2021; Larbi et al., 2025). These changes have important implications for domestic water supply, irrigation, aquatic biodiversity, and ecosystem functioning.

The synthesis further indicates that LULC change has altered regional carbon dynamics by reducing forest biomass and increasing greenhouse gas emissions associated with deforestation and land degradation. Loss of forest ecosystems diminishes carbon sequestration capacity while simultaneously reducing ecosystem resilience to climate variability. Consequently, continued anthropogenic landscape transformation presents significant challenges for Ghana's climate-change mitigation and adaptation strategies.

Table 5. Comparative Ranking and Regional Variations

Tier	Driver Category	Key Evidence and Examples
Primary Drivers	Agricultural expansion, population growth, urbanisation, and mining	Peprah et al., 2025b; Acheampong et al., 2018; Kleemann et al., 2017; Agyemang, 2012
Secondary Drivers	Policy/governance systems, land tenure regimes, infrastructure	Acheampong et al., 2018; Anarfi et al., 2020; Ashiagbor et al., 2019
Tertiary Drivers	Climatic variability, droughts, and soil fertility decline	Kotir et al., 2017; Peprah et al., 2025a

4.1.7.2. Socio-economic impacts

Beyond ecological consequences, anthropogenic LULC change has generated important socio-economic impacts affecting livelihoods, food security, and human well-being. Agricultural expansion has contributed to increased food production and rural income generation in many regions; however, these short-term economic benefits have often been accompanied by long-term environmental costs, including declining soil fertility, reduced agricultural productivity, and increasing dependence on expansion into previously uncultivated land (Ampim et al., 2021).

Rapid urbanization has stimulated economic growth through infrastructure development, commercial expansion, and improved access to markets and services. Nevertheless, unplanned urban growth has simultaneously increased pressure on housing, transportation, sanitation, water supply, and other public infrastructure. Expansion of informal settlements into flood-prone areas has further increased the vulnerability of urban populations to climate-related hazards and environmental health risks (Ashiagbor et al., 2019; Songsore, 2020).

Mining has generated employment opportunities and contributed significantly to national economic development; however, the reviewed studies consistently report that illegal artisanal and small-scale mining has adversely affected agricultural livelihoods, reduced access to productive land, degraded water resources, and increased conflicts over natural resource use (Larbi et al., 2025; Asare et al., 2024). These findings illustrate the complex trade-offs between economic development and environmental sustainability that characterize contemporary land-use change in Ghana.

Overall, the reviewed evidence suggests that anthropogenic LULC change has produced both economic opportunities and environmental costs. While agriculture, urbanization, and mining remain important contributors to national development, their long-term sustainability depends upon improved land governance, environmental regulation, ecosystem restoration, and integrated land-use planning.

4.1.8. Integrated Synthesis of Anthropogenic LULC Change

The overall synthesis demonstrates that anthropogenic land use and land cover change in Ghana is driven by complex interactions among demographic, economic, institutional, and environmental processes rather than by isolated human activities. Agricultural expansion, urbanization, mining, infrastructure development, and population growth represent the principal proximate drivers of landscape transformation, while governance weaknesses, customary land tenure systems, poverty, market demand, and climate variability function as underlying drivers that influence the intensity and spatial distribution of land-use change (Opiyo et al., 2022; Asare et al., 2024; Peprah, 2025b).

These findings align closely with the integrated conceptual framework adopted in this study. Consistent with the Driver–Pressure–State–Impact–Response (DPSIR) framework, socio-economic and institutional drivers generate pressures through agriculture, mining, urbanization, and infrastructure development that modify the state of natural ecosystems, resulting in deforestation, wetland degradation, biodiversity loss, declining water quality, and reduced ecosystem services. These environmental changes subsequently produce ecological and socio-economic impacts that require coordinated policy responses and sustainable land management interventions.

The review further demonstrates the dynamic feedback mechanisms proposed by the CHANS framework. Environmental degradation resulting from anthropogenic land conversion reduces ecosystem productivity, soil fertility, water availability, and livelihood opportunities, thereby encouraging further land conversion and reinforcing cycles of environmental degradation. Similarly, the SLF provides important insights into how poverty, livelihood insecurity, limited economic opportunities, and dependence on natural resources shape household land-use decisions across different ecological zones.

Collectively, the reviewed studies indicate that sustainable management of Ghana's landscapes cannot rely solely on environmental regulation. Rather, effective interventions must simultaneously address agricultural productivity, urban planning, mining governance, poverty reduction, institutional coordination, and climate adaptation. Integrating these multiple dimensions into national land-use planning will be essential for achieving Land Degradation Neutrality (LDN), enhancing climate resilience, conserving biodiversity, and supporting sustainable socio-economic development.

Table 6. Environmental and socio-economic consequences associated with major anthropogenic drivers of LULC change in Ghana

Reference/Source	Title of article	Location of study	Journal of publication	Study/Project application (Quantified changes)
Ashiagbor et al., 2019	*Landscape Transformations in Rapidly Developing Peri-Urban Areas of Accra, Ghana: Results of 30 Years*	Ga West Municipal Assembly	*Open Geosci*	Built-up area increased by 149.12 km² (1200%) between 1985 and 2015; open forest declined by 85.84 km², riverine forest by 58.05 km². Built-up LPI rose from 0.27% to 18.31%, fragmentation (ED) increased fivefold; projected 96% built-up dominance by 2050.
Weeks et al., 2017	*Demographics, Health Drivers, and Impacts on Land-Cover and Land-Use Change in Ghana*	Southern Ghana (48 districts)	*Reference Module in Earth Systems and Environmental Sciences*	Built area increased from 7% to 10% (2000–2010), agricultural land rose from 43% to 52%, while forests declined from 37% to 27%. Accuracy: 95.7% (2000) and 91.1% (2010).
Kleemann et al., 2017	*Peri-Urban Land Use Pattern and Its Relation to Land Use Planning in Ghana, West Africa*	Western & Upper East Regions	*Landscape and Urban Planning*	Built-up areas expanded 7.1% (Takoradi) and 1.1% (Bolgatanga) (2007–2013); settlement units rose by +32.4% in Bolgatanga and +89.6% in Takoradi; forest loss exceeded 22% (1975–2000) nationally.
Danso et al., 2021	*Exploring the Effects of Rapid Urbanization on Wetlands: Insights from the Greater Accra Metropolitan Area, Ghana*	Accra & Tema Metropolises	*SN Social Sciences*	Wetland loss: -38% in Tema (1960–2010), -82% in Accra (1560 ha → 285 ha). Residential land use dominated 72% (Tema) and 50% (Accra); industrial use <10%.
Doan and Oduro, 2012	*Patterns of Population Growth in Peri-Urban Accra, Ghana*	Greater Accra Metropolitan Area (GAMA)	*International Journal of Urban and Regional Research*	Built-up area increased 2.6× (1985–2002); average locality population change rose from +1,600 (1970–84) to +5,600 (1984–2000). Village magnets grew 4000% (Dome, Gbawe).
Fuseini and Kemp, 2016	*Characterising Urban Growth in Tamale, Ghana: An Analysis of Urban Governance Response in Infrastructure and Service Provision*	Northern Ghana (Tamale)	*Habitat International*	Built-up land expanded 78% (1677 ha → 2982 ha) (2001–2014), annual rate 4.4%. The doubling period ≈ is 16 years. The North-West zone grew 158%. Water access improved by 9% between 2000 and 2010.
Kotir et al., 2017	*Drivers of Change and Sustainability in Linked Social-Ecological Systems: An Analysis in the Volta River Basin of Ghana, West Africa*	Volta River Basin (Multi-country)	*Society & Natural Resources*	Population growth rate 2.7% p.a.; projected 23.8M → 56.6M (2010–2050); rainfall gradient 360–1600 mm; cereal import dependency 10–50%.
Asare et al., 2024	*Scope and Governance of Terrestrial Sand Mining Around Accra, Ghana*	Ga South & Gomoa East Districts	*Social Sciences & Humanities Open*	227,332 truckloads (~8.4M tons) sand mined yearly (~284 ha degraded); 85% miners illegal; revenue per ha = $35,200, net profit per miner $1,640.
Diao et al., 2019	*Cities and Rural Transformation: A Spatial Analysis of Rural Livelihoods in Ghana*	National (Census/GLSS data)	*World Development*	Agricultural employment share dropped from 56.9% → 41.6% (2000–2010); non-agricultural-only households up +9.1%; youth agri-only down -11.3%. Urban population share >50%.
Songsore, 2020	*The Urban Transition in Ghana: Urbanization, National Development and Poverty Reduction*	National & Metropolitan (Accra, Kumasi, Takoradi)	*Ghana Social Science Journal*	Urban population increased from 9.4% (1931) to 43.9% (2000); number of urban settlements grew 41 → 364; poverty dropped from 34.6% → 25.6% (rural) (1998–2005).
Agyemang, 2012	*Assessing the Driving Forces of Environmental Degradation in Northern Ghana: Community Truthing Approach*	Bolgatanga & Talensi-Nabdam	*African Journal of History and Culture (AJHC)*	Population rose 183,800 → 303,332 (1990–2010); density 26.1 → 231/km²; 9 of 10 residents poor (2000); mean temperature 32–40°C.

The findings presented in this section provide the empirical foundation for the subsequent discussion, where the broader scientific implications of the synthesized evidence are interpreted in relation to existing literature, theoretical frameworks, and environmental policy in Ghana.

4.2. Discussion

4.2.1. Agricultural Expansion as the Dominant Driver of Landscape Transformation

The present systematic review and quantitative synthesis identify agricultural expansion as the most pervasive anthropogenic driver of LULC change in Ghana. Across the reviewed studies, expansion of cocoa plantations, food crop cultivation, commercial farming, and shifting cultivation consistently emerged as the principal causes of forest conversion and landscape transformation, particularly within the High Forest and Forest–Savannah Transition Zones (Ampim et al., 2021; Kleemann et al., 2017; Peprah, 2025b). This finding agrees with broader evidence from Sub-Saharan Africa, where agricultural expansion continues to account for most deforestation despite increasing policy commitments to forest conservation (Govender et al., 2022; Lambin and Geist, 2006).

The predominance of agriculture reflects Ghana's continued dependence on land-based livelihoods. Approximately half of the country's labour force is directly or indirectly engaged in agriculture, making land conversion an important livelihood strategy for many rural households. However, the review indicates that increases in agricultural production have largely been achieved through horizontal expansion into forests and other natural ecosystems rather than through sustainable intensification. Consequently, agricultural growth has generated considerable environmental costs, including biodiversity loss, declining ecosystem services, fragmentation of forest habitats, and reduced carbon storage. The findings further demonstrate that agricultural expansion is influenced by broader socio-economic drivers, including population growth, commodity markets, land tenure arrangements, and limited access to improved agricultural technologies. These observations are consistent with the Proximate and Underlying Drivers Model, which distinguishes direct land-use activities from the institutional and economic conditions that shape them. They also support the Sustainable Livelihoods Framework, illustrating how livelihood insecurity and dependence on natural resources encourage continued expansion into previously undisturbed landscapes. These findings suggest that future agricultural policies should move beyond expansion-based production systems towards climate-smart agriculture, agroforestry, conservation agriculture, and sustainable land management practices that increase productivity while reducing pressure on natural ecosystems.

4.4.2. Urbanization and Peri-urban Landscape Transformation

Rapid urbanization represents the second most significant driver of LULC change identified in this review. The reviewed studies consistently demonstrate that metropolitan expansion has transformed agricultural land, wetlands, and peri-urban vegetation into residential, commercial, industrial, and transportation infrastructure, particularly within Greater Accra, Kumasi, Sekondi–Takoradi, Cape Coast, and Tamale (Ashiagbor et al., 2019; Fuseini and Kemp, 2016; Songsore, 2020). Unlike compact urban growth observed in many developed countries, Ghana's urban expansion has predominantly occurred through dispersed peri-urban development. Expansion of low-density settlements has increased land consumption, fragmented ecological landscapes, reduced agricultural land availability, and intensified flood risk through wetland encroachment and increasing impervious surfaces. Similar urbanization patterns have been reported elsewhere in West Africa, reflecting rapid demographic growth coupled with limited spatial planning capacity.

The review also highlights important governance challenges associated with urban growth. Weak enforcement of development control regulations, fragmented institutional responsibilities, speculative land markets, and conflicts between customary and statutory land administration have collectively contributed to uncontrolled land conversion. These findings underscore the need to strengthen implementation of the Land Use and Spatial Planning Act, 2016 (Act 925), through coordinated action by the LUSPA, Lands Commission, MMDAs, and other relevant institutions.

4.2.3. Mining, Environmental Degradation, and Landscape Sustainability

Mining, particularly illegal artisanal and small-scale gold mining (galamsey), emerged as one of the most environmentally destructive anthropogenic activities despite affecting comparatively smaller geographical areas than agriculture or urbanization. The reviewed studies consistently demonstrate that mining contributes to vegetation removal, soil erosion, landscape fragmentation, river sedimentation, heavy metal contamination, and long-term ecosystem degradation (Larbi et al., 2025; Asare et al., 2024).

Unlike agricultural expansion, which often produces gradual land-cover transitions, mining generates rapid and highly localized environmental degradation. The removal of vegetation and topsoil fundamentally alters ecosystem structure and frequently leaves landscapes unsuitable for agriculture or natural regeneration without active restoration. These findings are consistent with previous research demonstrating that mining significantly reduces ecosystem resilience while increasing restoration costs. The persistence of illegal mining also reflects institutional and socio-economic challenges extending beyond environmental regulation alone. Poverty, unemployment, increasing international demand for gold, and inadequate enforcement collectively encourage the expansion of informal mining activities.

Consequently, sustainable management of mining landscapes requires integrated approaches combining stricter environmental regulation, alternative livelihood programmes, ecological restoration, and continuous geospatial monitoring.

4.2.4. Governance, Land Tenure, and Institutional Coordination

A major finding emerging from this review is that governance functions as a critical underlying determinant influencing all major anthropogenic drivers of LULC change. Weak institutional coordination limited regulatory enforcement, fragmented responsibilities among environmental agencies, and the coexistence of customary and statutory land tenure systems repeatedly emerged as barriers to sustainable land management. These governance challenges are particularly evident within peri-urban areas where rapid land conversion frequently occurs ahead of formal planning processes. Similar institutional constraints have been reported throughout Sub-Saharan Africa, suggesting that effective environmental management depends not only on technical monitoring but also on governance reforms capable of integrating environmental, economic, and social objectives. The findings therefore reinforce the importance of strengthening collaboration among the LUSPA, EPA, Lands Commission, Forestry Commission, Minerals Commission, Water Resources Commission, and MMDAs. Improved coordination among these institutions would facilitate integrated land-use planning, stronger environmental compliance, improved monitoring of illegal land conversion, and more effective implementation of national land governance policies.

4.2.5. Implications for Sustainable Land Management

The findings of this review have important implications for sustainable land management and environmental policy in Ghana. First, the predominance of agricultural expansion indicates that increasing agricultural productivity should become a national priority in order to reduce the continued conversion of forests and natural ecosystems. Climate-smart agriculture, agroforestry, conservation agriculture, and restoration of degraded lands offer practical opportunities for simultaneously improving food security and environmental sustainability. Second, urban planning should increasingly prioritize compact urban development, protection of wetlands and ecological corridors, and integration of remote sensing and GIS into routine planning practice. Strengthening enforcement of zoning regulations would substantially reduce unplanned settlement expansion and improve urban resilience to climate-related hazards.

Third, mining governance requires greater emphasis on environmental compliance, rehabilitation of degraded landscapes, and restoration of abandoned mining sites. Routine use of satellite imagery unmanned aerial vehicles (UAVs), cloud-based geospatial platforms, and machine learning can substantially improve environmental monitoring and support early detection of illegal mining activities. Finally, effective implementation of the Land Use and Spatial Planning Act, 2016 (Act 925) requires improved institutional coordination, enhanced technical capacity, transparent land administration, and greater integration of scientific evidence into planning and decision-making processes.

4.2.6. Contribution to Theory and Comparison with Sub-Saharan Africa

The findings provide empirical support for the integrated conceptual framework adopted in this study. Consistent with the DPSIR framework, socio-economic and institutional drivers generate environmental pressures through agriculture, urbanization, mining, and infrastructure development, leading to changes in ecosystem conditions that require coordinated policy responses. Similarly, the CHANS framework is reflected in the reciprocal relationships identified between environmental degradation and subsequent human responses. Forest loss, declining soil fertility, reduced water availability, and ecosystem degradation influence future livelihood strategies, thereby reinforcing continued land conversion in many regions.

Comparison with other Sub-Saharan African countries indicates that Ghana shares many regional drivers of LULC change particularly agricultural expansion, rapid urbanization, and population growth. However, the review also identifies distinctive national characteristics, including the strong influence of cocoa cultivation, widespread artisanal and small-scale mining, and the interaction between customary and statutory land tenure systems. These characteristics highlight the importance of developing policy interventions that are both evidence-based and context-specific rather than relying solely on generalized regional approaches.

Overall, this systematic review and quantitative synthesis advances understanding of anthropogenic LULC change by integrating quantitative evidence from diverse ecological settings within a coherent conceptual framework. The findings provide a stronger scientific basis for environmental monitoring, sustainable land management, and future research on landscape transformation in Ghana.

5. Conclusion and Recommendations

5.1. Conclusion

This study systematically synthesized published evidence on the anthropogenic drivers of LULC change in Ghana between 2000 and 2025 using a PRISMA-guided systematic review with quantitative synthesis. The review demonstrates that agricultural expansion, rapid urbanization, mining, and population growth are the principal drivers of landscape transformation across Ghana, while governance weaknesses, land tenure complexities, socio-economic pressures, and climate variability amplify their environmental impacts. Collectively, these interacting drivers have contributed to widespread forest loss, wetland degradation, agricultural land conversion, landscape fragmentation, declining ecosystem services, and increasing environmental vulnerability across the country's ecological zones. The synthesized evidence further reveals that although the magnitude and characteristics of LULC change differ among ecological regions, the overall trajectory of landscape transformation is consistent nationwide. Southern Ghana is characterized by rapid urban growth, industrial expansion, commercial agriculture, and intensive mining activities, whereas northern Ghana is increasingly affected by agricultural extensification, vegetation degradation, and climate-related environmental stress. These regional differences demonstrate that sustainable land management strategies should be tailored to local ecological and socio-economic conditions rather than implemented as uniform national interventions.
A major contribution of this study is the integration of systematic evidence synthesis with complementary theoretical frameworks, including the DPSIR, Proximate and Underlying Drivers, CHANS, and SLF, to provide a comprehensive understanding of the complex interactions among anthropogenic activities, environmental change, and institutional governance. By consolidating dispersed evidence from diverse ecological settings, this review provides an important scientific foundation for strengthening sustainable land management, improving environmental monitoring, and supporting implementation of the Land Use and Spatial Planning Act, 2016 (Act 925) and related national environmental policies.

Ultimately, achieving sustainable land management in Ghana will require integrated governance, strengthened institutional collaboration, climate-smart agricultural intensification, responsible mining regulation, ecosystem restoration, and wider application of geospatial technologies to support evidence-based planning and environmental decision-making. The findings provide valuable evidence base for researchers, practitioners, and policymakers seeking to balance socio-economic development with long-term environmental sustainability.

5.2. Limitations of the Study

Despite the methodological rigour adopted in this review, several limitations should be acknowledged when interpreting the findings. First, although the review followed the PRISMA 2020 guidelines to ensure transparency and reproducibility, only studies published in English were included. Consequently, relevant evidence published in other languages or inaccessible sources may not have been captured. Second, the reviewed studies exhibited considerable methodological diversity in terms of satellite sensors, spatial resolution, image preprocessing techniques, classification algorithms, temporal coverage, land-cover classification schemes, and reporting formats. This heterogeneity limited direct quantitative comparison across studies and required the adoption of a structured quantitative synthesis rather than statistical aggregation of findings.

Third, many studies reported LULC changes using different metrics, including percentage changes, absolute area changes, annual rates of change, transition matrices, and landscape metrics. The absence of standardized reporting across studies constrained direct numerical comparability and prevented the development of common quantitative indicators for all reported outcomes. Fourth, geographical representation within the available literature was uneven. Most investigations were concentrated within southern Ghana, particularly the Greater Accra, Ashanti, Western, Central, and Eastern Regions, whereas comparatively fewer studies examined northern savannah ecosystems and transitional landscapes. Consequently, the synthesized evidence may underrepresent environmental dynamics occurring within these less-studied regions.

Finally, although extensive database searches and inclusion of grey literature reduced the risk of publication bias, the review remains dependent upon the availability and quality of published research. Future investigations employing standardized national monitoring datasets, harmonized land-cover classification systems, and consistent reporting protocols would substantially improve future quantitative evidence synthesis and strengthen national assessments of anthropogenic LULC change.

5.3. Recommendations

Based on the findings of this systematic review, several recommendations are proposed to strengthen sustainable land management, environmental governance, and future research in Ghana. The Government of Ghana should enhance the implementation of the Land Use and Spatial Planning Act, 2016 (Act 925) by improving coordination among the LUSPA, Lands Commission, EPA, Forestry Commission, Minerals Commission, Water Resources Commission, and MMDAs. Stronger institutional collaboration, clearly defined mandates, and integrated land information systems would improve environmental governance and reduce unregulated land conversion. Urban planning authorities should promote compact urban development, strengthen the enforcement of land-use regulations, safeguard wetlands and ecological corridors, and incorporate remote sensing and GIS into routine land-use planning and environmental monitoring. These measures would help reduce uncontrolled urban expansion, enhance flood resilience, and conserve environmentally sensitive ecosystems.

Furthermore, environmental regulation of artisanal and small-scale mining should be reinforced through stricter licensing procedures, continuous compliance monitoring, rehabilitation of degraded mining sites, restoration of affected watersheds, and the provision of sustainable livelihood alternatives for mining-dependent communities. Agricultural policies should also prioritize climate-smart agriculture, agroforestry, conservation agriculture, sustainable land management, and landscape restoration to enhance agricultural productivity while minimizing further encroachment into forest ecosystems. In addition, national environmental monitoring programmes should expand the routine application of remote sensing, GIS, machine learning, cloud-based geospatial platforms, and unmanned aerial systems (UAS) to facilitate near-real-time monitoring of land use and land cover dynamics, illegal mining, deforestation, and wetland degradation. Greater integration of scientific evidence into national land-use planning, environmental impact assessment, and ecosystem restoration programmes is equally essential to support Ghana's commitments under the SDGs, the Paris Agreement, and the LDN framework.

Future research should prioritize ecological zones that remain underrepresented in the existing literature, particularly northern Ghana, transitional landscapes, and rapidly expanding peri-urban environments, where empirical evidence is comparatively limited. Researchers should also adopt standardized methodologies for assessing and reporting land use and land cover change, including harmonized land-cover classification systems, consistent change metrics, uncertainty estimation, and robust validation procedures. Such methodological standardization would improve the comparability of future studies and strengthen the quality of systematic reviews and quantitative evidence syntheses. Finally, greater emphasis should be placed on interdisciplinary research that integrates geospatial technologies, environmental modelling, socio-economic analysis, governance assessment, and Indigenous and Local Knowledge to provide a more comprehensive understanding of anthropogenic land transformation and to support evidence-based environmental policy and sustainable land management in Ghana.

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