



Situational Analysis of a Social-Ecological Landscape in the Ahafo Ano Southwest District of Ghana

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Acronyms

AASW	Ahafo Ano Southwest
AICCRA	Accelerating the Impact of CGIAR Climate Research for Africa
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consortium of International Agricultural Research Centers
CIAT	International Center for Tropical Agriculture
DCD	District Coordinating Director
DCE	District Chief Executive
DMoFA	Department of Ministry of Foods and Agriculture
DPSIR	Driver-Pressure-State-Impact-Response
ES	Ecosystem services
FGD	Focus Group Discussion
IAR4D	Integrated Agricultural Research for Development
IIAS	Impact Investment Advisory Services
IITA	International Institute of Tropical Agriculture
ILM	Integrated Landscape Management
IWMI	International Water Management Institute
LULC	land use land cover
MEA	Millennium Ecosystem Assessment
MoFA	Ministry of Foods and Agriculture
MTS	Modified Taungya System
NGOs	Non-governmental Organizations
PCC	Proportion Correctly Classified
PRM	Participatory Resource Mapping
SEL	Social-Ecological Landscape
SSEL	Sustainable Social-Ecological Landscape
TAAT II	Technologies for African Agricultural Transformation
TAFS-WCA	Transforming Agri-Food Systems in West and Central Africa
WAAPP	West Africa Agricultural Productivity Program
WP3	Work Package 3

Executive summary

A Social-Ecological Landscape (SEL) comprises a set of important resources (e.g., natural, socioeconomic, and cultural) whose flow and use are controlled by a mix of ecological and social subsystem dynamics. In developing countries, drivers of SEL changes are complex, and SEL pressures are growing. Areas endowed with natural resources (e.g., fertile soils, forests, water, minerals, etc.) tend to have high population growth rates and high poverty incidence. These tend to culminate in high demand for livelihood capitals (e.g., access to livelihood alternatives, education, food, health, water, forest resources, dwellings, roads, agriculture/aquaculture spaces, etc.). Further, multiple national and global stakeholders have continued to place a high demand on exploiting natural resources at the subnational.

Consequently, many SELs are under threat, with landscape resources being overused and misused in many places, compounded by the impacts of climate change. Due to dwindling biodiversity and ecosystem services, agricultural production systems and livelihood sustainability are being compromised. Using the Driver-Pressure-State-Impact-Response (DPSIR)-SEL framework, a mix of methods, and the Offin sub-basin in the Ahafo Ano South West district as a case, the present study is a situational analysis aimed at giving an overview of how drivers and pressures combine to delineate the SEL state and impacts, also highlighting the institutional/stakeholder responses. The study site is an excellent case considering that it is replete with natural/ecological resources, characterized by multiple competing land uses, including agriculture/aquaculture, forestry, conservation, mining, trade and industry, etc., and is currently experiencing a significant upsurge in environmental degradation.

This study emphasizes that “there is nothing more destructive than the need for necessities of life”. Based on the results, the study contends that the unsustainable exploitation of natural resources/ecosystem services in the Offin sub-basin SEL is generally underpinned by the need for “necessities of survival” rather than the quest for “opulence”. Accordingly, the driving forces behind the pressures that define the state of and impacts on the Offin sub-basin SEL are largely local, albeit a few are national and global.

The study showed that unregulated small-scale mining (i.e., galamsay, locally translated as ‘gather and sell’), large-scale wood exploitation, and the conversion of more forest ecosystems into subsistence farms and cash crop plantations all pose growing threats to the health and function of the Offin sub-basin SEL. The destructive extraction of minerals and unsustainable use of other natural resources endangers biodiversity, livelihoods, and ecosystem processes, including soil and water services. This trend is largely fueled by low equity in access to livelihood assets—i.e., limited livelihood alternatives, food, raw materials for domestic purposes, health, education, tenure insecurity (land, water and forest), etc. The issue of national and global high demand for ecological resources/services also came up strongly, with participants claiming that some multinational companies tend to use aid (promises of provision of community water and electricity) and bribes to promote the overexploitation of forest and mineral resources, citing the invasion of Chinese, South African and Brazilian companies as examples. These driving forces have led to pressures including increased inappropriate land use, increased contact use of resources and increased pollution of natural ecosystems.

The research found that the SEL state is adversely altered with the identified driving forces and pressures. The geospatial analysis showed high fragmentation within and between land use land cover (LULC) systems. The current level of alteration of the SEL has dire implications for landscape structure and composition, endangering the sustainable flow of natural resources and ecosystem services like (wild) food, water for agriculture and domestic use, fertile soils, flood control, tourism, etc. With a limited flow of ecosystem services (ES) due to an altered “state” comes increased poverty and food insecurity, limited livelihood options, entrenched inequity in

access to livelihood capitals, soil and water pollution, deforestation, forest degradation, etc. People depend on ecosystems for various services, and as a result, they judge an ecosystem's health based on how well it can fulfil those needs. According to Focus Group Discussion (FGD) participants, their farmlands can no longer provide for their household food needs. They claim they purchase more from neighbouring villages and towns in and out of the landscape. They claimed their farm households are growing food insecure, considering that it is increasingly difficult to produce 75% of their food needs. There was also a consistent claim that wild foods were gradually becoming extinct in the landscape (grasscutters, antelopes, mushrooms, snails, etc.), further deepening the food security situation in the landscape. The participants also confirmed what is widely captured in literature and media reports about pollution of water ecosystems through illegal/community mining and inappropriate use of fertilizers, pesticides, and weedicides. The impacts of intense competition between forest conservation and development are manifest in the fragmentation of the Tinte Beposo and Tano Offin forest reserves through cash crop plantations [referred to as Admitted farms or Modified Taungya System (MTS) by the Forestry Commission and locally called *Taungya*], and the removal of open vegetation through subsistence farming and illegal/community mining. Another concern is the degradation/pollution of the Mankran River (the only third-order stream in the SEL) through illegal/community mining and forest degradation.

The study also showed that most of the governance/management responses in the Ahafo Ano Southwest (AASW) district operate at multiple scales and are led by multiple actors and stakeholders. Scales of operation are largely at district, regional, and national levels, with few management platforms at the community level. Actors in this context include local people at the community level, unit committees, non-governmental organisations (NGOs), local governments (district assembly), national government agencies and departments, and international agencies. Predominant stakeholders within the AASW district (and, by extension, the Offin sub-basin SEL) were local people (resource users) represented by unit committees, local government authorities (AASW district assembly and its departments and units) and government ministries and agencies (water resources commission, forestry commission, Community water and sanitation, etc.). NGOs and international institutions/agencies were found to have a very limited presence in the area. It was also found that there is very limited coordination between/among these actors, resulting in counter-productive management initiatives. Production sectors in the district operate in isolation which inhibits integrated management of production systems and the natural resources that underpin ecosystem services needed for all the sectors. The results also showed that low institutional capacity, including inadequate human and financial capacity, limited access to information about natural resources/ecosystem services for proper planning, and the lack of tools and approaches for mapping, assessing, monitoring, and practically integrating ecosystem services (ES) to support planning, tend to hinder integrated landscape management in the AASW district.

The research proposes the following to enhance the sustainability of the Offin sub-basin SEL:

- Development of local capacities for inclusive management of natural resources and ecosystem services. The government and its development partners, through the DMOFA, Forest Commission, Minerals Commission, Water Resources Commission, etc., need to support local authorities (the district assembly, unit committees, traditional leaders, opinion leaders, etc.) to ensure sustainable development. This could be done through continued human capacity development, particularly in remote sensing and geographic information systems for spatial planning, integrated landscape management, integrated resources management, and forest reserve monitoring.

- Promotion of participatory and multi-stakeholder approaches for ecosystem conservation and livelihood improvement. One such initiative could be creating a common platform where the multiple stakeholders on the SEL (galamsayers, farmers, chainsaw operators, other water resource users, traders, traditional authorities, NGOs, district assemblies, government agencies, etc.) can meet to actively discuss impacts of the changing landscape and make binding decisions (with consequences upon noncompliance). The evidence from the literature indicates that decisions from such platforms are usually effective in dealing with undesirable outcomes of competing land uses relative to the top-down decisions emanating from officialdom.
- Spatially targeted investment in the landscape that supports sustainable development, including climate-smart goals. This may include stimulating private sector investment in sustainable social-ecological landscape (SSEL) goals, which may be done through Impact Investment Advisory Services (IIAS). In this direction, stakeholders like AASW District Assembly, MoFA, CGAIR institutions, etc., may need to invest in rice cultivation, aquaculture, vegetable farming, afforestation and reclamation of mined sites.
- Continued tracking of changes to determine if sustainable social-ecological goals are being met (e.g., sustainable land use, ILM, sustainable and inclusive livelihood enhancement, strengthened institutions, etc.). Measuring and monitoring the multiple benefits of SSEL goals is essential for tracking the effectiveness of intersectoral efforts/initiatives targeted at sustainable development.
- The District Assembly may need to coordinate appropriately and adequately with law enforcement units to protect the forest reserves and other vegetation. The current forest protection and conservation strategies need review, particularly the policy on admitted farms and settlements in forest reserves.
- The membership of the District Mining Committee may need to be reviewed to include the victims of the activities in the sector. The current membership tends to promote more illegalities. Again, strict measures should be implemented against illegal mining through by-laws emanating from participatory multi-stakeholder engagements, including law enforcement units like the police and the judiciary.

1.0 Introduction

In development research, the landscape is considered a “social ecological system (SES) that consists of natural and/or human-modified ecosystems that are influenced by distinct ecological, historical, political, economic, and socio-cultural processes and activities” (Denier et al., 2015). With their natural resources, landscapes provide opportunities for sustainable livelihoods. Accordingly, how resources are used impacts biodiversity and the global climate, among other things. Landscapes, therefore, provide opportunities for adapting to and mitigating climate change (Cole et al., 2022). However, landscape pressures are growing (Bugri, Yeboah, & Knapman, 2017). In areas with a high population growth rate, there is high demand for roads, dwellings, industry and trade, and agriculture/aquaculture. Multiple local, national, and global stakeholders also demand using natural resources (Mekuria, Haileslassie, Tengberg, & Zazu, 2021). Consequently, many landscapes are under threat, with landscape resources being overexploited and misused in many places, compounded by the impacts of climate change (Schütz, 2019). As a result, biodiversity and ecosystem services are dwindling, and agricultural production systems and livelihood sustainability are being compromised (Schütz, 2019). Against this background, research and strategies for integrated landscape assessment and management (ILAM) for Sustainable Social-Ecological Landscape (SSEL) are gaining prominence.

A social-ecological landscape (SEL) is a coherent system of natural (and/or human-modified) ecosystems and socio-economic processes and activities that regularly interact in a (non-)resilient and (un)sustained manner, at varying spatial, temporal, and organizational scales (Denier et al., 2015). A SEL is made up of a set of critical resources (e.g., natural, socioeconomic, and cultural) whose flow and use are regulated by a combination of ecological and social subsystem dynamics (e.g., the flow of ecosystem service like soil fertility may change in response to changes land use intensification for food security). Accordingly, the importance of ecosystems within an SEL to human well-being cannot be overstated. Humans extract, use, and consume units of resources from the natural environment to gain social or cultural, environmental, and economic benefits. With their natural resources, SEL provides opportunities for sustainable livelihoods for people. Using resources such as land and water opens the potential for developing disconnected regions and can improve people’s living conditions (Ellis & Allison, 2004). In addition, intact landscapes provide important ecosystem services which form the basis for the survival of all life. These include drinking water, clean air, food, energy sources, building materials, recreational opportunities, carbon storage, and climate regulation. In this context, natural resource units are synonymous with ecosystem services (ES). According to TEEB (2010), ES are ecosystems' direct and indirect contributions to human well-being. These include supporting services, provisioning services, regulating services and cultural services (see McInnes & Everard, 2017; Millennium Ecosystem Assessment [MEA], 2005).

In the last two decades, there has been a tremendous increase in concerns about ES in environment-development debates and research. Drivers of SEL changes have become more complex, and SEL pressures are growing (Bugri, Yeboah, & Knapman, 2017). In areas with a high population growth rate, there is high demand for roads, dwellings, industry and trade, and agriculture/aquaculture. Multiple local, national, and global stakeholders also demand using natural resources (Mekuria, Haileslassie, Tengberg, & Zazu, 2021). Consequently, many landscapes are under threat, with landscape resources being overused and misused in many places, compounded by the impacts of climate change (Schütz, 2019). As a result, biodiversity and

ecosystem services (ES) are dwindling, and agricultural production systems and livelihood sustainability are being compromised (Schütz, 2019).

In the context of Ghana, Pressure on the landscape resource are increasing due to human factors including growing demand for food in terms of both quantity and quality, competition for productive land for biofuel, urban expansion and other non-food uses, unsustainable land use practices that result in ongoing land degradation and which diminish soil health, indicated by lower nutrient status and organic content, and the mounting impacts of anthropogenic climate change, which is projected to exacerbate variations in year-to-year yields and income from agriculture, threatening the resilience of agroecologies and the stability of food systems. Pressures also arise from natural factors such as natural climate variability, extreme weather events and wildfire; these add to the challenge of matching management practices to environmental conditions for optimal yields and for sustainable use of the land resource. As the importance of ES is gaining wider recognition, there has been a growing need for tools that could potentially provide information to decision makers on ES supply and the effects of land use management on those services (Portman, 2013).

1.1 Context

The growth in the use of “social-ecological systems thinking” for the achievement of sustainable development (particularly SDGs 2, 6, 13, and 15 etc.) sets the stage for this present study and the entire TAFS-WCA initiative, particularly Work Package 3 (WP3). This research was commissioned by the International Water Management Institute (IWMI) as part of WP3. The study is intended for the spectrum of individuals and organizations involved in the research, planning, and implementation of WP3, particularly the Ghana Team. WP3 is about Inclusive Landscape Management and Pathways for Scaling Land and Water Innovations for Resilient Agrifood Systems. This is based on the premise that equal access to and proper use of land and water resources is a prerequisite to building a healthy, productive, One-Health-sensitive environment for resilient agrifood systems and livelihoods.

This analysis is also underpinned by the need to understand and discover synergies and trade-offs among development in a landscape and the very complex ecological resources and processes [See Ozyavuz (2013)]. The development aspect covers more intensive engagement of space and land use, organization, and arrangement. The features of the land and space with their entire natural and produced substratum are significant categories in determining future sustainable development (Ozyavuz 2013). In this context, this research becomes a primary activity, connecting current development, development possibilities/tendencies and natural resource conservation (See Pecova, 2000). Using the DPSIR-SEL framework, a mix of methods, and the Offin sub-basin in the Ahafo Ano Southwest district (Figure 1) as a case, the present study is a situational analysis aimed at giving an overview of how drivers and pressures combine to delineate the SEL state and impacts, highlighting the institutional/stakeholder responses. The study site is an excellent case considering that it is replete with natural/ecological resources, characterized by multiple competing land uses, including agriculture/aquaculture, forestry, conservation, mining, trade, and industry, etc., and is currently experiencing a significant upsurge in environmental degradation. The landscape is adopted as the principal spatial unit of analysis for this research. Consequently, this landscape assessment will be significant in decision-making for future land use, space organisation, nature protection, and sustainable use of natural resources (Ozyavuz, 2013).

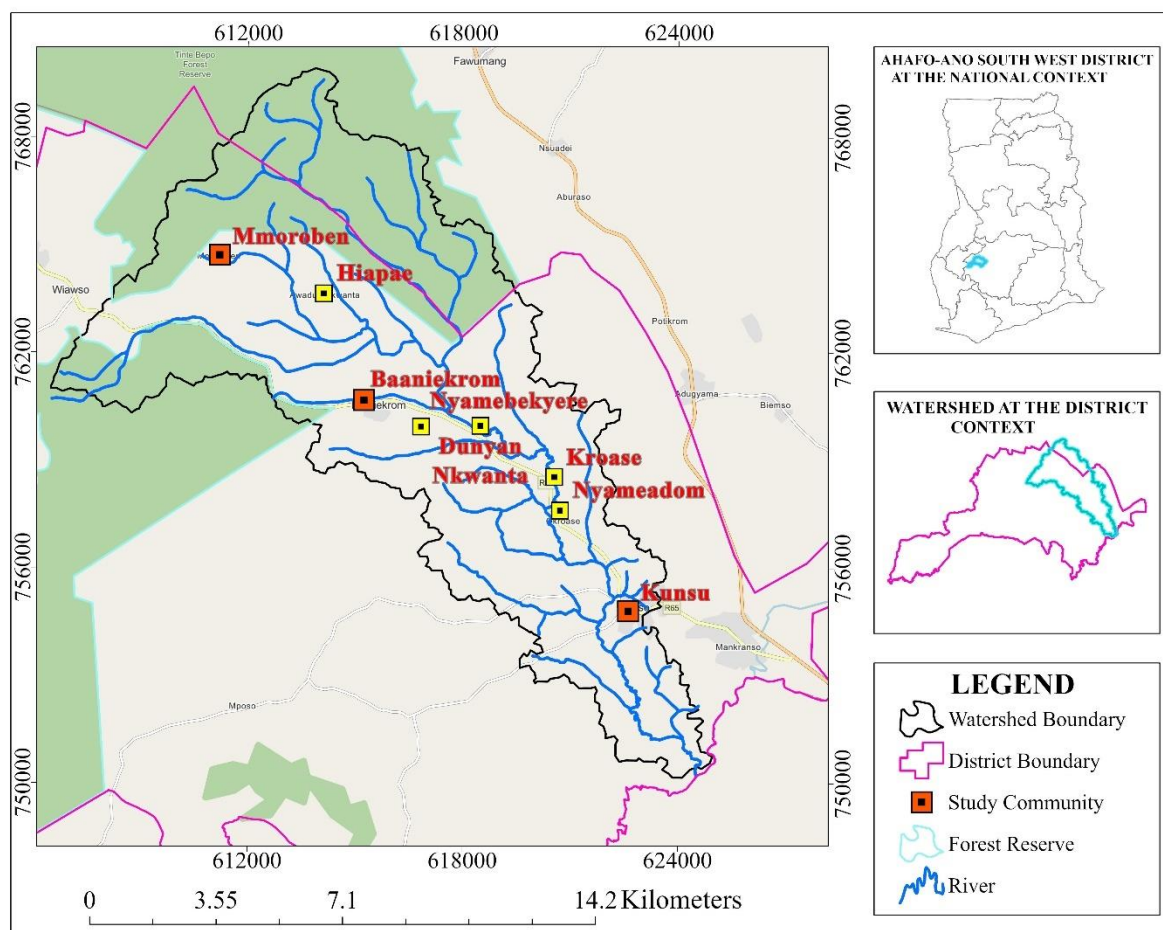


Figure 1: Map of the study landscape and district

1.2 Objectives

The main objective of this study is to assess the status and trends of natural resources and ecosystem services, considering the possible impacts on human well-being and the institutional responses. Specifically, the study seeks to:

- Assess drivers and pressures underpinning landscape change in the Offin sub-basin
- Examine the dynamics of the state of the Social Ecological Landscape;
- Explore the impacts of landscape transitions on human wellbeing, biodiversity, and ecosystem services;
- Examine the existing institutional/policy responses to landscape drivers, pressures, dynamic state, and impacts.

2.0 Methods and materials

The protocol for the fieldwork (See Supplementary Information) was followed and sometimes adjusted per field exigencies. The first point of contact for the research was the District Assembly through the District Coordinating Director (DCD) and District Chief Executive (DCE) to inform them of the researchers' presence in the district, the purpose of the study and why the district was selected. During this introduction, an introductory letter from IWMI was handed to the DCE, who, upon reading and listening to the research team, granted permission and pledged the district's support for the research. The DCD attached a cover letter to the introductory letter and circulated it among the various institutions in the AASW district. At the institutional level, the researchers visited all the offices to officially announce their presence and inquire about the

appropriate time for the engagement. Concerning community engagement, the head of social welfare and community development was assigned as a liaison to facilitate the community entries.

The research used qualitative and geospatial techniques (mixed research method) for site selection, data collection, sampling, and data analysis. These include stakeholder workshops, focused group discussions, key informant interviews, participatory resource mapping (PRM) and observations, ground truthing and image capturing using a drone, geoprocessing, land use land cover mapping, content analysis and documentary research.

2.1 Site selection criteria

The criteria below are informed by two expert workshops held in Ghana by IWMI (i.e. the WP3 team) and in Ivory Coast by the TAFS-WCA partner institutions. During these engagements, several themes/items were outlined for the selection of case landscapes for the initiative:

- Location of case landscape: For Ghana, the site must be located in the forest transition zone.
- Significant competing land uses and related degradation (e.g., Agriculture, Forestry, Mining, settlement expansion, Chain-saw operations, etc.).
- Types of crops: vegetables, sweet potato, rice, cassava, plantain, cowpea, cocoa, Yam, maize, cocoyam.
- Fishing and aquaculture
- Watersheds and related issues: quantity and quality water and productive water use.
- Existing landscape management initiatives/Low-hanging-fruits (preferably CGIAR institutions and related projects- e.g., IITA, CIAT, **AfricaRice**, TAAT II, AICCRA, CCAFS, WAAPP, IAR4D, etc.).
- Existing Multi-stakeholder platforms/forums

2.2 Conceptual framework

Frequently measuring many landscape elements can be very expensive and time-consuming. SEL systems are complex. As a result, assessment approaches cannot realistically measure all system components (Sayer, 2015). Consequently, several questions may need clarification: At what scale or scales should assessments be conducted? To what extent should assessments combine more accurate direct measures with cost-efficient proxy measures? Should assessments be tied to specific conservation and rural development projects or independent? Additionally, ecosystems are subject to a certain degree of natural variability and human interferences, making it difficult to separate human effects from natural ones (Hooper, et al., 2005). As alluded to earlier, most literature (scientists) tend to specialize and as a result, integrating frameworks for a comprehensive SEL assessment and monitoring requires a paradigm shift towards more multidisciplinary approaches/conceptions.

The purpose here is not to present an entirely new conceptual framework for analysing social-ecological landscapes (SEL). The intended aim is to draw insights from the works of Sayer et al. (2016), Maes et al. (2016), Scherr et al. (2014), Buck et al. (2006), DFID (1999), MEA (2005) and the case studies of the Satoyama Initiative to develop a relatively comprehensive framework to understand the driving forces and pressures that are underpinning changes in the state of SELs as well as their implications for human wellbeing, ecosystems services and sustainable landscape management in general. The DPSIR-SEL assessment framework (Figure 5) is a coupled social-ecological framework informed by systems thinking. It is a tool that can be used to inform the assessment of landscape-level phenomena. Essential aspects of the DPSIR-SEL include the

recognition of five key components which interact at the landscape level and have a significant influence on the benefits derived from the landscape:

Driving Forces: These factors motivate human activities and fulfill basic human needs, which have been consistently identified as the necessary conditions and materials for a good life, good health, good social relations, security, and freedom. *Driving Forces* describe “the social, demographic, and economic developments in societies”. Social determinants also have a strong influence on SEL dynamics. Therefore, for this framework, *Driving Forces* have been broadened to include socio-cultural and political factors.

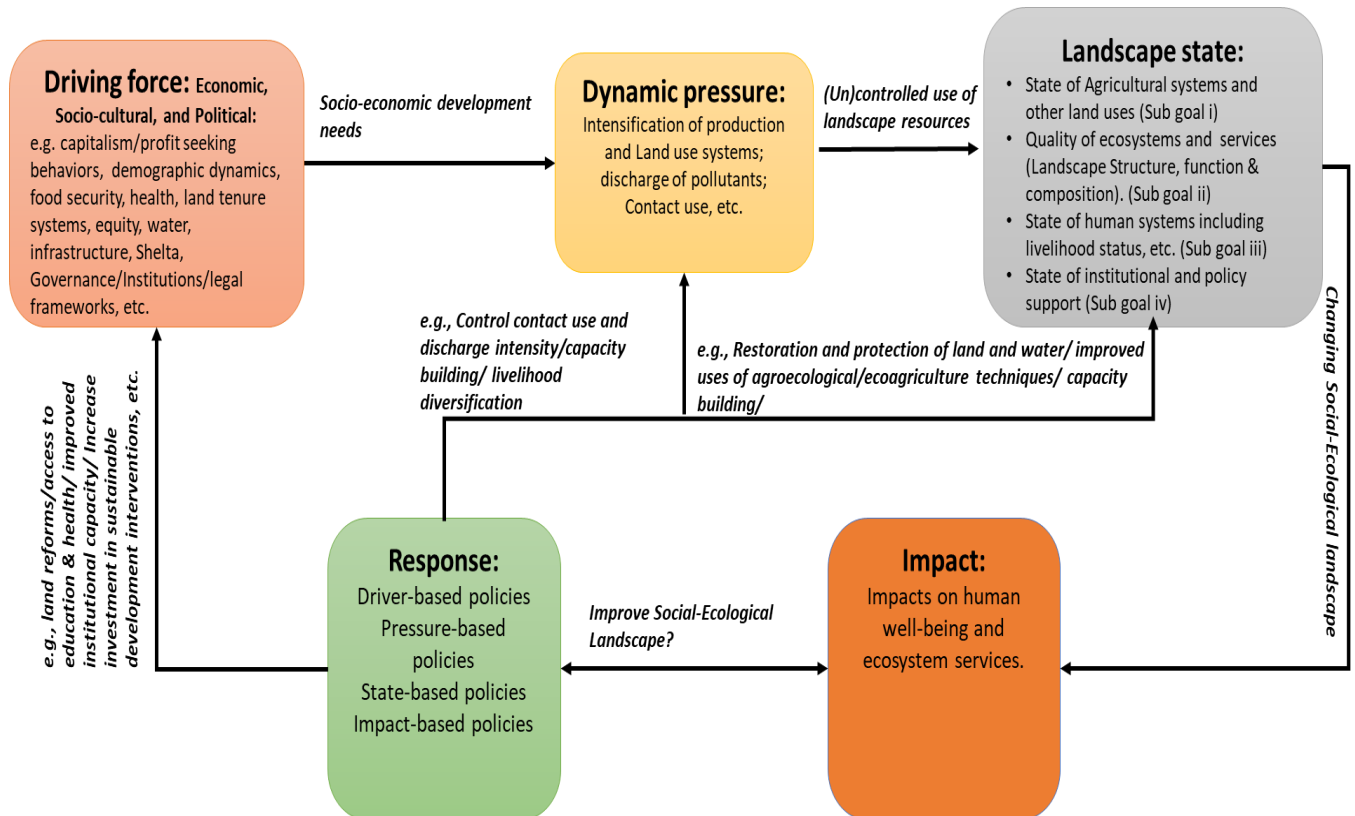


Figure 2: DPSIR-SEL framework

Pressures: These are defined as human activities derived from the functioning of social and economic driving forces that induce changes in the environment or human systems. Pressures are not stressors. Stressors are the components of the state that are changed by pressures (e.g., land development [the pressure] - increases sediment [the stressor] in urban watersheds, which then may stress the ecological components of the reef). Examples of pressures:

- Land use changes resulting from alterations of the natural landscape;
- Discharges of pollutants as may result from the operation of industries or vehicles, or the diffused distribution of contaminants from agricultural lands, roads, or lawns through ground-water or storm-water run-off, etc.
- Contact uses are human activities that lead to a direct alteration or manipulation of the environment and include:

- Physical damage – direct degradation through mining, dredging and filling, deforestation;
- Biological addition – ballast discharge, the release of non-natives, feeding, creation of artificial habitat;
- Biological harvest – harvesting, fishing, accidental by-catch, clear-cutting

State refers to the state of the natural and built environment. It provides information on the quantity and quality of the following components of the landscape;

- physical,
- chemical,
- biological,
- And human systems

Impacts on ecosystems and human wellbeing: Changes in the structure, functioning and composition of the ecosystem will impact the production of ecosystem goods and services and, ultimately, human well-being.

- **Impacts on ecosystem goods and services** have been variously defined as ecosystem processes or the products of those processes that directly or indirectly benefit humans
 - i. *Provisioning services*
 - ii. *Regulating services*
 - iii. *Cultural services*
 - iv. *Supporting processes*
- **Impacts on human wellbeing** is an abstract concept that captures a mixture of people's life circumstances and quantifies the degree of fulfilment of basic human needs for food, water, health, security, culture, and shelter. Human wellbeing reflects a positive physical, mental and social state. Human wellbeing can be quantified by metrics reflecting how well human needs are being met, including needs for basic materials, social relations, good health, security, and freedom. Human wellbeing includes: *Economic prosperity (e.g., productivity, ability to work, income)*, *Health and safety (e.g., life span, medical or insurance costs, sick days, pain and suffering)*, *Cultural and social well-being (e.g., "happiness", sense of belonging, community vibrancy, spiritual fulfilment)*

Responses: A key benefit of using the DPSIR framework is that it explicitly includes an Action or Response component that can be taken at any level of the causal network. In the DPSIR-SEL assessment framework, responses are actions taken by groups or individuals in society and government to:

- prevent
- compensate
- ameliorate
- adapt to changes in the state of the environment
- modify human behaviors that contribute to health risks
- directly modify health through medical treatments or to compensate for social or economic impacts of the human condition on human well-being.

Responses may be directed at driving forces, pressures, landscape state, or impacts. In response to driving force may be agricultural reforms, education reforms, technological innovations, equity policies, and decision support tools. If responses target pressures, strategies may include land use planning and management, strategies targeting human behavior modifications, discharge limitations, resource use management, outreach and education, etc. State-based responses may include revitalization, remediation, landscape and community planning, restoration, evaluation, etc. These impact-based responses may include adaptation strategies, livelihood diversification, mitigation, indexing of well-being, ecosystem service evaluation and monitoring, etc.

2.3 Data collection

The study used both primary data and secondary data. The primary data was largely qualitative while the secondary data were mainly geospatial, socio-demographic, and economic (See Table 1). The need for validation results underpinned the use of multiple data sources for this study.

Table 1: Secondary data used in the study

Available Data	Source	Purpose	Year
Socio-demographic and economic data	Ghana Statistical Service	Profile of study districts/communities	2021 Population Census
Satellite images	European Space Agency, NASA	Land cover/ Land use mapping	1986 - 2022
Digital elevation models	NASA	Watershed and Topographic mapping	2013-2017
Forest/Game Reserves	Forestry Commission	Protected area mapping	
Roads	Roads & Highways		2021
Streams and Rivers	Hydrological services Department	Drainage Density, watershed delineation, water quantity and quality assessment	2021

For primary data collection, focus group discussions (FGDs), In-depth interviews (IDIs) and participatory resource assessment (PRA) were used. (Plate 3). The fieldwork was conducted in 3 communities within the Offin sub-basin in the Ahafo Ano Southwest district (Kunso, Baniekrom, and Mmrobem). The FGDs were categorized in two; one with the heads (unit committee members, assembly members, chiefs, and elders) held in the District Assembly's Hall in Mankranso (Plate 1) and the other with the community members in each community under study. FGDs with community members were also into two separate groups (male and female) and included traders, farmers, and those in *galamsay* (which means gather and sell) and have been residents of the community for over ten years and could give information on the research themes. After each FGD, participatory resource mapping activities followed. Issues discussed during the focused group discussions/participatory mapping included: Agricultural production and other competing land use systems; conservation, maintenance, and restoration of wild biodiversity and ecosystem services; sustained/enhanced livelihoods and well-being for all social groups in the landscape; establishment and maintenance of institutions for inclusive governance/management,

ongoing planning, negotiation, implementation, resource mobilization, and capacity-building in support of social-ecological landscape sustainability.

Plate 1: Workshop, FGD and PRM with community leaders in Mankranso



Plate 2: PRM with community members in Mmroberm in the AASW district



Plate 3: FGD with female participants in Barniekrom in the AASW district



Key informant interviews with institutions were done based on the preferred time and day within the research period. This was arranged with the institutional heads who formed part of the research. The themes that guided the interviews were: What is the state of natural resources and ecosystems? How are the institutions helping to solve the problems surrounding resource use? What are the challenges related to natural resource management in the district? What are the institution's working conditions in relation to (most prevailing issues, performance, challenges, relationships with other institutions, etc.)? After each interview, researchers requested data/reports on the discussed issues from institutions.

In all, nine FGDs/PRM sessions were held with both community heads and members in all the communities. There were also twelve institutional interviews which comprised the Agricultural Department, Forestry Division Services, Education directorate, Health Directorate, Ambulance Services, Social Welfare and Community Development, Environmental Health and Sanitation, Judiciary (Registrar), National Commission for Civic Education (NCCE), Commission for Human Rights and Administrative Justice (CHRAJ), and the Police. Consent forms were made available to seek participants' consent before the engagements. Pseudo-identification anonymized the identity of participants. To prevent social desirability response sets, the participants were informed of the purpose of the study (Leedy & Ormrod 2005). All interviews and focus discussions were recorded with permission sought from the participants.

2.4 Data analysis

The obtained data were analysed using geospatial techniques and content analysis.

2.4.1 Geospatial analysis

After selecting the target district, geospatial techniques were used to facilitate the selection of the target landscape/watershed/catchment. Here pour points located at the southernmost confluence of the Mankranso river were identified and used to delineate the watershed after a hydrologically conditioned DEM was created. Extraction of flow characteristics (flow direction, flow accumulation, stream order, flow length, stream link and stream feature) was carried out. The

resultant watershed was the Offin sub-basin. The selection of this watershed was informed by the fact that the research required a watershed with boundary transcending both Ahafo Ano South West and East Districts to scale innovations (as contained in TAFS-WCA WP3). The Offin sub-basin contains parts of the Tinte Bepo and Tano-Offin forest reserves. The major competing land uses include agriculture, mining, chainsaw operations/lumbering, forestry and infrastructure development due to urbanization. An informed opinion (relative number of 1st to 4th order streams, relative prevalence of agricultural activities, relative prominence of forest and biodiversity degradation), the Offin sub-basin presents a good social-ecological landscape (SEL) for the activities of WP3.

Historical images of the Offin sub-basin were obtained from Google Earth for 2008, 2015, 2018 and 2021, with 2008 being the base year. All the images obtained were for January except for the 2021 image, which was for December. The images were georeferenced within the ArcGIS Pro version 3.0 software, using a network of latitude and longitude lines. A modified version of the Food and Agricultural Organizations' land cover classification system was adopted to identify land cover and land use types in the watershed. The original eight dichotomous classes were expanded to 11, as shown in Table 1. The field data collection, such as participatory resources assessment (PRA), gave insight into the land cover/land use classification. During the field data collection, community members and some leaders were engaged to map the land cover/land use in the study area.

Table 2: Land use / Land cover classification systems adapted for the study

FAO LAND COVER CLASSIFICATION SYSTEM	ADAPTED LAND USE/ LAND COVER CLASSES
Cultivated and Managed Terrestrial Vegetation	Cash Crop Subsistence Farming
Natural - Semi-Natural Terrestrial Vegetation	Dense Natural Vegetation Sparse Natural Vegetation Road
Artificial Surface	Built-Up Degraded Areas
Bare Surface	Recovering Mining Sites Clear Natural Water Body
Natural - Semi-Natural Aquatic Vegetation	Natural Aquatic Vegetation
Artificial Aquatic Vegetation	Rice
Artificial Waterbody	Artificial Water Body (Irrigation)

Using unmanned aerial imaging systems, a ground-based survey and the PRM of the landscape by community members, 178 training samples covering all 11-land use land cover classes were purposefully collected from the watershed to aid the interpretation. Segmented images were created from the object-based classification process. The derived image and 110 stratified and randomly selected training samples were used to identify and classify land use/land cover types. Specifically, object-based image classification with the Support Vector Machine algorithm was used. Unlike pixel-based classification, which considers only spectral information at the individual pixel level, object-based classification considers spatial and spectral characteristics of features of interest. It can produce results comparable to visually interpreted images. Object-based

classification suits high-resolution images with spectrally heterogeneous features (Lillesand et al. 2014). Other biophysical parameters specific to biophysical parameters, such as land cover, land use, soils, surface water and elevation, have been sourced from various institutions.

The quality of the classified image was checked using the image using the remaining 68 field samples. In measuring the accuracy of classification, the proportion correctly classified (PCC) index and the Kappa statistic, derived from an error matrix, were used. The PCC index was 78%, while the Kappa index was 74.6%. Post-classification change detection techniques were employed to account for land use/land cover transfers between the period in question (i.e., January 2008 – December 2021). This involved an overlay of independently classified images. It is the most commonly used qualitative method of change detection (Macleod & Congalton, 1998). It operates on two or more independently classified images as inputs, resulting in a change map and a change matrix. The classified thematic map of 2008, 2015, 2018 and 2021 was loaded and analysed using tools in ArcGIS Pro 3.0 to indicate changes between the images in the form of a change map and change matrix, which was then used for the analysis.

2.4.2 Qualitative data analysis

Content analysis was used to analyze the reports and transcripts from key informant interviews and FGDs. According to Elo and Kyngas (2007), qualitative content analysis is a mixed methods approach that assigns categories to text through qualitative steps, working through many text passages. Content analysis is considered a systematic approach for analyzing and making inferences from text and other qualitative forms of data. It is a research method for making replicable and valid inferences from data to their context, with the purpose of providing knowledge, new insights, a representation of facts and a practical guide to action (Krippendorff 1980). However, the method is criticized for being a simplistic technique that does not lend itself to detailed statistical analysis, while others like Morgan (1993) argue that it was not sufficiently qualitative in nature. Despite the various criticisms, content analysis as a method has gained roots in social science research. The reason for its increasing relevance, as argued in literature, is that it is a content-sensitive method and flexible in terms of research design (Harwood & Garry 2003; Krippendorff 1980). The study uses content analysis for the analysis of focus group discussion (FGD) and key informant transcripts. Vaismoradi et al. (2013: pp 399) and Mayring (2014) highlight that CA is both inductive and deductive, which has predominantly been applied to recordings from FGDs and in-depth interviews.

Mayring (2014) has put together seven (7) transcription protocols but considering the amount of information this research sought to preserve and time constraint with regards to data analysis, the study used two of these protocols. These are the protocol with the comment column, and the smooth verbatim transcript protocols. The protocol with the comment column allows the researcher, who may also be the transcriber, to use a special column for all special observations besides the audio recording. These observations were aggregated with the text during transcription. The smooth verbatim transcript protocol was used for the transcription of the audio recordings. Here, the transcription was done word for word, but all decorating words like, right, you know, yeah, were left out. In doing this, a coherent text, simple to understand, but representing the original wording and grammatical structure was produced.

3.0 Results

Generally, low institutional capacity, non-existent stakeholder platforms, unregulated small-scale mining, large-scale wood exploitation for wood, and the conversion of more natural ecosystems into cash crop systems all pose ongoing threats to the health and function of the social-ecological landscape (SEL). Within the Offin sub-basin SEL, the extraction of abiotic resources through mining and unsustainable use of natural resources endangers biodiversity, livelihoods, and ecosystem processes, including soil services (Figure 3). This research assessed the status and trends of natural resources and ecosystem services, considering the possible impacts on human well-being and the institutional responses.

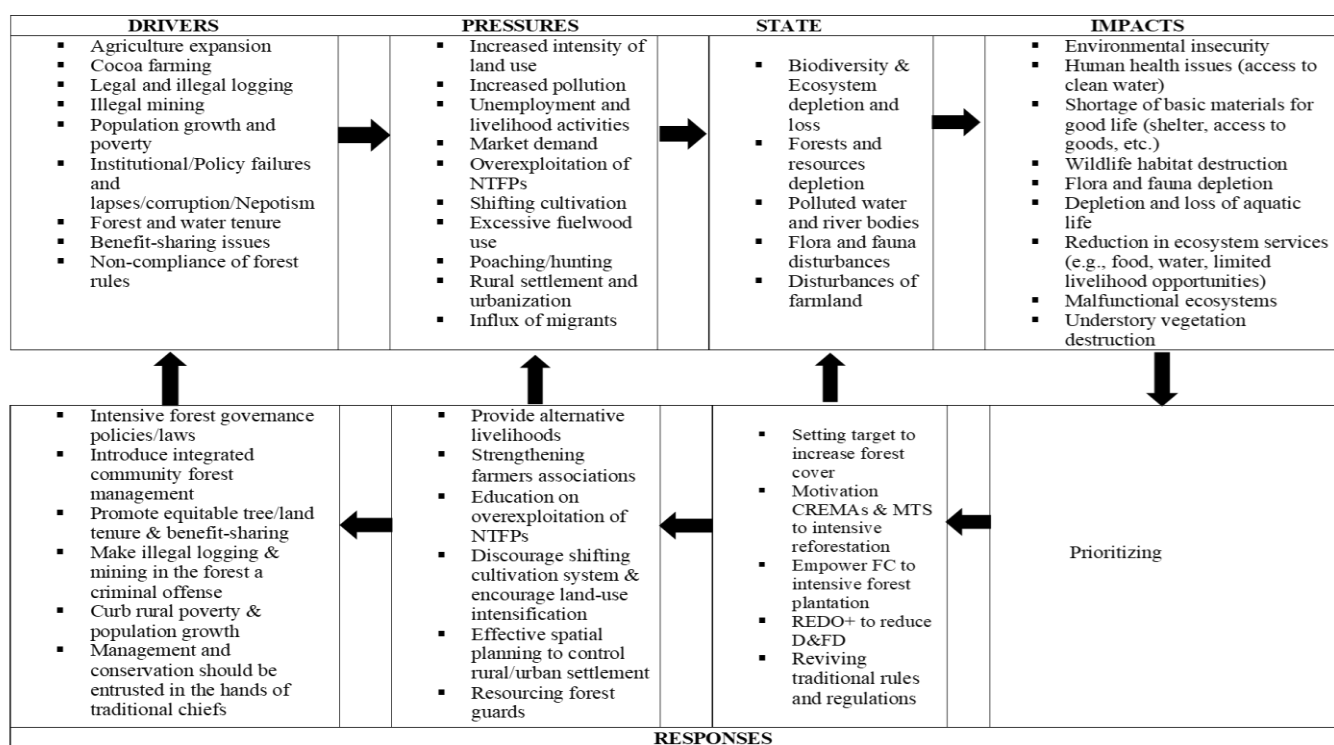


Figure 3: Summary of research results

3.1 Drivers of change in the Offin sub-basin SEL

This study emphasizes the notion that “there is nothing more destructive than the need for “necessities of life”. Based on the socio-economic characteristics of the AASW district, this study contends that the unsustainable exploitation of natural resources/ecosystem services in the Offin sub-basin SEL is generally underpinned by the need for “necessities of survival” rather than the quest for “opulence”. Accordingly, the driving forces behind the pressures that delineate the state of and impacts within the Offin sub-basin SEL are largely local, albeit a few are national and global. The issue of national and global high demand for ecological resources also came up strongly, with key informants claiming that some foreign companies tend to use aid, loan conditionalities, and bribes to promote the legalization of the forestry and mining sector activities, citing the invasion of Chinese, South Africans and Brazilians as examples. Specifically, drivers included agriculture expansion, galamsey and unregulated community mining, legal and illegal logging, population growth and poverty, policy/institutional failures/lapses, forest and water tenure, benefit-sharing issues, and climate change-related drivers.

3.1.1 Agricultural expansion

Agriculture continues to be the main stay of the district's micro-economy. The Ahafo Ano Southwest (AASW) district lies in the forest transition zone and has vast arable land and favorable rainfall patterns. The district depends predominantly on agriculture as its major source of income, employment, and food supply. Therefore, any meaningful development effort must necessarily be based on improved performance in the sector. However, agricultural development is a major contributing factor to widespread deforestation and vegetation degradation in the AASW district. The district is currently experiencing a massive expansion in trees/cash crop plantations (e.g., cocoa, palm oil, teak trees, Cinderella trees, etc.) and some food crop production (e.g., cocoyam, plantain, yam, maize). This trend has been identified by PRM/FGD participants as a major direct driving force underpinning forest degradation and deforestation, particularly in the Offin sub-basin landscape. The expansion mainly occurs around Barniekrom, Dunyakrom, and Mmroberm communities. The expansion in agriculture, particularly the *Taungya* system (admitted farming in reserves), non-admitted farming (illegal farming in forest reserves) and non-admitted farming settlements in the Tinte Beposo and the Tano Offin forest reserves, was found to be directly associated with vegetation cover degradation in the study landscape (Plates 4 and 5). With admitted farms, individuals are legally given portions of the reserve forest with defined boundaries to do plantations, subsistence farming or both. Due to limited capacity, the problem with this arrangement is that the Forest Division has been unable to monitor and manage the expansion of these farms beyond approved boundaries, which culminated in deforestation and forest degradation. The non-admitted settlements and farms in these reserves are purely issues of illegality (impunity) and could be attributed to a lack of monitoring and law enforcement.

Plate 4: Taungya farm (admitted farm) in the Tinte Beposo Forest reserve



Plate 5: Taungya farm around Mmroberm in the Offin sub-basin SEL



In the AASW district, particularly the Offin sub-basin landscape, expansion in shifting cultivation, slashing and burning, and the use of inorganic pesticides, including weedicides and insecticides, is another driving force underpinning the growing SEL pressures and state changes. The dominant narrative recited by policy experts, non-governmental organizations and many scientists is that shifting cultivation is a major cause of deforestation and forest degradation in tropical Africa. This practice is the most common type of farming in the study area, particularly among 37% of migrants. With shifting cultivation, farmlands are used for two or three years for producing food crops like vegetables and grain and abandoned for another cleared plot. The land

is often cleared by slash-and-burn method, that is, trees, bushes and forests are cleared by slashing, and the remaining vegetation is burnt. The study landscape is experiencing accelerated slashing and burning, which often spreads into other forestlands causing massive fires that tend to destroy forest trees and vegetation. The chemicals, pesticides, and weedicides applied to control crop insects, pests, diseases, and weeds are powerful substances that eventually kill many useful bacteria and insects that contribute to natural soil restoration. These ultimately render farmlands degraded and incapable of producing higher crop yields leading to the annual clearing of virgin forests, including the destruction of naturally occurring economic forests trees, including Mahogany.

Generally, Ghana's forest transition landscape zones have been experiencing pervasive forest degradation/deforestation partly due to massive expansion in the production of cocoa and economic trees (Asibey et al. 2020). According to Benefoh et al. 2018, cocoa production is responsible for converting 54.6% of the closed and 77.8% of the open forests. As alluded to earlier, the AASW district is a major cash/tree crop-producing area in Ghana, particularly cocoa, palm, and teak trees, contributing significantly to the country's GDP. However, according to the Forest Division, corroborated by the District Agriculture Development Unit (or DMOFA), cocoa production in the forest usually involves cutting the shade trees by farmers to enable the cocoa to attract much sunlight to aid increased yields. Cutting shade trees is a major driver of forest degradation and deforestation in the AASW district. This practice is detrimental to biodiversity, productivity and carbon stocks (Asibey et al., 2020).

3.1.2 Galamsey and unregulated community mining

Despite the available laws [The Minerals and Mining Act, 2006 (Act 703) (as amended by the Minerals and Mining (Amendment) Act, 2015 (Act 900) and the Minerals Commission Act, 1993 (Act 450)] and institutions (Minerals Commission, Water Resource Commission, Forest Commission and Environmental Protection Agency), there is widespread illegal mining (Galamsey) and unregulated community mining in parts of the Offin sub-basin landscape, especially around the Kunsu township. Most FGD participants agreed that small-scale community/illegal mining and mining by foreign companies are responsible for the degradation of vegetation cover, the conversion of subsistence farmlands to mines and the degradation of the Mankran River and its tributaries. However, a few strongly argued that galamsey/community mining had improved their livelihoods. They argued that the challenge with galamsey is the difficulty associated with the reclamation of mining sites, which they claim the Assembly and the chiefs are taking steps to address. "*Galamsey must continue*", some FGD participants shouted. It was also revealed that some farmers have used the lands for galamsey or sold them to locals or foreigners for mining purposes. In the Offin sub-basin landscape, factors such as the need for increased income, unemployment, and increased market activities constituted drivers of galamsey. According to AASW District Assembly, despite the introduction of small-scale community mining, more than 50% of mining in the study zone are still under galamsey or illegal mining. Although illegal mining operations can reduce rural poverty and enhance youth employment, the operations pose adverse consequences on biodiversity and ecosystems with implications for human sustainability. For instance, illegal mining activities in Kunsu and Sikafremogya along the Mankran River have driven irreparable habitat and biodiversity loss (Plates 6 and 7), further worsening the already limited access to water for domestic and agriculture purposes.

Plate 6: Mining and farming along the Mankran River at Kunsu



Plate 7: Sites for mining, farming, and aquaculture at Sikafremoja



Notwithstanding the official processes for formalizing artisanal small-scale mining operations in the AASW district, a key informant at the District Assembly claims/projects that about 60% of small-scale miners are unregistered. If this holds, there may be implications for the sustainability of mining in the district. To a large extent, galamsey operators use mining methods that are not socially and ecologically sustainable. There is, therefore, an urgent need for a second look at the introduction of the “community mining” program the Ghana government has introduced in the AASW district.

The research also found that the less punitive sanctions meted out by the police and judiciary to small-scale miners demotivate officials to arrest the illegal miners. In contrast, government

officials are reluctant to engage the miners on the proper ways of regulating and formalizing their mining activities. The government's anti-galamsey crusade seems not to be doing much to curb the menace. The crusade included deploying a joint police-military team to arrest illegal miners on site. However, the crusade may never succeed until the political drivers that propel the galamsey operations are dealt with. This is because the network of powerful nationals and foreigners tends to engage in unapproved mining activities with the connivance of top political actors, landowners, and chiefs. The persistence of illegal mining activities in the AASW district, to some extent, is fueled by political leniency and corruption associated with law enforcement, as pointed out by a key informant:

“With the current political setting, galamsey can never be stopped. The only way to deal with the menace is a stronger political will to promote sustainable mechanisms to regularize the illegal miners’ activities and accordingly sanction offenders for non-compliance to deter others” (Key Informant, Mankrasu, 2022).

3.1.3 Legal and illegal logging

Illegal logging may be defined as the harvesting, transporting, buying, or selling of timber violating relevant national laws. (Hembery et al, 2007). Other illegal activities related to forests, such as illegal burning or non-timber-related clearance for firewood or charcoal production, opencast mining or small-scale agriculture, all constitute important drivers of forest destruction and degradation in Ghana. According to Asamoah and Acheampong (2018), Ghana's legal and illegal logging activities involve a mix of overlapping interests and a complex network that links various local and international actors. At the regional level, these actors are lumber dealers in the wood-poor neighbors of Ghana. At the national level, they are national government agencies that deal with forest management, collecting forest fees and law enforcement, regional administrations, and the sawmilling and logging industry. At the local level, the actors are district administrators, those involved directly or indirectly (e.g., chainsaw owners, chainsaw operators, carriers, and transporters); suppliers of chainsaws and spares; buyers of chainsaw lumber; sponsors of chain sawing; planer mills that dress chainsaw lumber; affected owners among others (See also Marfo, 2010).

Directly causing deforestation, forest degradation, and the associated pollution of water bodies is the extensive legal and illicit logging in the AASW district. According to results from the participatory resource mapping (PRMs) and FGDs in Barniekrom and Mmrobem, illegal logging through illegal chainsaw operations in the forest reserves was one of the major factors of deforestation and forest degradation (Plate 8). A review of forest-related policies and laws showed that all prior forest laws included forest conservation but did not make unlawful logging and the consequences of it illegal. On the other hand, the Timber Resources Management Act, 1997—Act 547 and the ensuing Timber Resources Management (Amendment) Act of 2002 forbid unlawful logging in the reserves and lay out the associated penalties. Similarly, Community Resource Management Areas (CREMAs) was tasked to stop illicit logging in Ghana's forests. These three significant initiatives in forest policy were distinct because they included clauses that make illegal logging in forests, in all of its manifestations, illegal; nonetheless, the activity continued unabated. These depict flaws and failures in the governance and management of the forests concerning logging operations, forests and reserves. A key informant revealed that some staff of the forest division aid the operations of illegal loggers by leading their loads through security check points for a fee, an allegation they refuted.

Plate 8: Illegal lumber ceased by the Forestry Division in Mankranso



It was also mentioned during FGDs in Kunsu that forest guards connived with illegal chainsaw operators to cut trees at night during public holidays and on weekends. They emphasized that despite the bylaws prohibiting illegal chainsaw operations in the district, some youth still engage in illegal logging in the middle of the reserves. The Forest Division, on the other hand, claimed the police and judiciary were not helping the fight against illegal logging. According to them, when illegalities are reported to the police, not much is done, which is very discouraging. The Division also mentioned traditional authorities as drivers of illegal logging, particularly from the Offin-Tano forest reserve. They explained that some chiefs consider mineral deposits more important than forests; as a result, they encourage the clearing of forests for mining.

Some forests and reserves, as in the Tinte Beposo and the Offin Tano reserves in the AASW district, are earmarked for large timber companies for timber production concessions. However, it is important to note that the two Acts stated above explicitly outline the Timber Utilization Contract (TUC) that authorizes legal logging in the off-reserves and the production sides of on-reserves. These give TUCs the legal power and authority to log as much as they operate within the TUC legal framework. This tends to encourage overexploitation of forest products to meet local and international demand, leading to deforestation and forest degradation, with implications for biodiversity loss and ecosystem health (Arcilla et al. 2015).

3.1.4 Population dynamics and poverty

According to Population and Housing Census 2021, out of the district's total population of 65,770, the proportion of the male population is 51.1% (33641), and that of the female population is 48.9% (32129). This gives a sex ratio of 104.7 (the third in the Ashanti Region), indicating that for every 105 males, there are 100 females. The district's male population (51.2%) is higher than the regional average of 48.4% and the national average of 48.8%. This may be explained by the presence of plantations and mining activities which attract predominantly large numbers of male workers from northern parts of Ghana. Migrants make up 37.8% of the total population, out of which 87.1% have established permanent residence. Most (70%) of migrants in the Ahafo Ano South West District are from the Northern, Upper East, Upper West and Western Regions of Ghana. One of the sources of agitations during FGDs was the fact that migrants were taking over agriculture and the small-scale mining in the district. Migrants-indigenes contentions must be taken into account by the district and/or development partners when planning initiatives.

According to the AASW District 2022 Annual Action Plan, based on demography, there are about six towns in the district with a population of more than 5000, which can be classified as urban. These are Mankranso, the district capital, Kunsu, Wioso, Hwibaa and Mpasaso No1&2. The skewness in the population distribution in favour of the urban centres has an adverse effect on the provision of a social, economic and technical infrastructure which normally needs a required threshold population to justify its provision. From the analysis, 56% of the district population lives in urban areas, and about 44% live in rural areas. This indicates that a large proportion of the district population lives in rural areas where poverty, deprivation, illiteracy and other social vices are more pronounced.

3.1.5 Forest and water tenure

Tenure is a generic term referring to various arrangements that allocate rights to land and resources and (usually) set conditions for those who hold land (FAO 2012). Tenure determines who: has access and rights to use or withdraw resources; can make decisions on use or a use change; decides who may use resources and who is prevented from using them; and determines who may transfer, sell or lease the resources. Secure tenure is critical in ensuring sustainable livelihoods, good governance, and environmental protection (FAO 2020). According to the FAO (2020), strengthening the position of individuals and communities within the political economy of natural resources governance, particularly for the rural poor whose livelihoods and food security depend on secure and equitable access to water and land/forest, is central to sustainable development. However, in the Developing South, land, water and forest tenure structures and dynamics continue to constrain access and use rights of people and communities dependent on natural resources/ecosystem services (Saeed et al., 2018; Bukari et al., 2018; Dumenu et al. 2014). Contextually, all water bodies and forests in Ghana are owned by the state for the stools/skins, and the state has the *De Jure* rights, albeit some level of recognition of the *De Facto* rights of local people and communities. A review of the constitution, land, forest and water-related laws indicates that Ghana lacks an appropriate legal definition for formal and customary rights of water and forests and land tenure arrangements, resulting in conflicts (See Kansanga & Luginaah 2019). Also, Ghana's tenure structures are complex and lack precision, which tends to engender unfair and inequitable access and use rights to natural resources (Tetteh 2015).

The AASW district is no exception to these tenure complexities and dynamics. The lack of secure tenure of and rights to land, forests and water, especially among migrants and women, poses several constraints and threats in the district, promoting unsustainable use of biodiversity and ecosystem resources. Apart from the forest reserves that are 'supposed' to be vested in the state for the people, open forests tend to be under contested tenure and user rights. In the Offin sub-basin landscape, FGD participants generally agreed that trees in open forests belong to them, considering that their fathers and forefathers bequeathed the land to them. As such, cutting these trees to make a living was their birth right. The District Assembly and the Forest Division disagree with this assertion, arguing that per the formal law, no one has the right to cut a tree without a permit, regardless of where the tree is located. The current forest policies (e.g., Ghana Forest and Wildlife Policy 2012) contain lapses regarding timber tree tenure and ownership, which leads to locals getting limited benefits from the existing forest policy. This, farmers and landowners in the AASW district claim, demotivates them from getting involved in local/community afforestation initiatives:

"Through the Modified Taungya System (MTS), we planted lots of economic trees, but the Forestry people cut and sell the trees without giving us anything. We have complained to the forest guards, but the injustice is still going on. We

in Mmroberm have decided we will not be part of the MTS again. Now, when you see any Taungya going on in the Tinte Beposo forest reserve, it is the Northerners. The forest officials now by-pass us and cut the forest reserve to the migrants who may be will not complain about the maltreatment” (FGD participants in Mmroberm, 2022).

Consequently, this has increased illegal logging and destroyed naturally occurring trees on farmlands and other lands. The formalization of forest tenure rights of Indigenous people and local communities could contribute to forest conservation and livelihood. Similar to forest and tree tenure is the contentious issue of benefit-sharing. The financial benefits that accrue from the forest intervention schemes are expected to trickle down to benefit the average farmers or communities. Nonetheless, these benefits do not reach their intended beneficiaries. There is a lack of an appropriate benefit-sharing framework and policy in the forestry sector, which hampers sustainable forest resources use

Water tenure comprises the diverse legislative and customary systems that shape how various stakeholders, whether individuals or groups relate to one another in their use of and impacts on water resources (van Koppen 2022; FAO 2020). Within water governance frameworks, water tenure systems include the rights and rules governing those rights, which determine how individuals and groups can use various freshwater resources, for how long, under what circumstances, and how they relate to other users. These rights and rules may emanate from legislation, regulations, decrees, and judicial decisions, as well as from customary and religious laws and practices. The Offin sub-basin landscape is drained by River Mankran, Abu and Aboabo and their tributaries, including Bintini, Nyaasi, and Bonhunu. The Water Resource Commission is the government institution managing these streams and all other water bodies in Ghana. It was realized that the commission had no decentralized office in the AASW district; it operates from the regional office in Kumasi. It was also realized that the customary system of water tenure is less visible in the Offin sub-basin landscape. The above has created a *De facto* water tenure system outside of both legislative and customary systems by virtue of the failure of formal and customary water governance institutions to enforce existing legislative requirements and traditional rules and norms, creating a further level of complexity that engender water resources degradation in the study landscape.

3.1.6 Policy and institutional failures and corruption

In Ghana, natural resource-related institutions, agencies and ministries are to some extent weak, lack appropriate coordination and capacity, and are characterized by lapses and failures (Akamani et al., 2019). For instance, the weak institutional lapses and coordination by forest institutions and agencies (Akamani et al., 2019; Nketiah et al., 2016) have fueled illegal logging and overexploitation of forest resources due partly to weak forest monitoring. This is evident in the AASW district, where FDG participants accuse the Forest Division of complicating the fight against illegal logging. The Ghana Forestry Commission (FC) and Ministry of Lands Natural Resources (MoLNR), expected to play a critical role in coordination and integration for monitoring, are relatively passive (Kansanga & Luginaah, 2019) and lack bottom-up inclusion at the community-level for engagement, participation and decision-making in natural resource governance (Nketiah et al., 2016). Further, most related institutions lack adequate accountability and transparency in the natural resource's governance processes (Baruah, Bobtoya & Mbile, 2016; Hirons, 2015; Agyei & Adjei, 2017), driving competing claims and conflicts (Derkyi, 2013). Policy and institutional lapses and failures are primarily the products of noncompliance

with the formal laws and rules (Ramcilovic-Suominen et al., 2013), leading to all forms of natural resources-related illegalities, including illegal logging and illegal mining, among others (Boakye, 2018).

The excessive illegal chainsaw operations occurring in both off-forest and on-forest reserves in the AASW district indicate severe lapses in the current and existing laws. Inadequate sanctions or punishment against the perpetrators of exploitation illegalities have driven massive degradation of forest and water ecosystems in the AASW district. It became evident that, in the AASW district, persons who engage in forest illegalities when arraigned before the court are fined as low as (Ghc500) a fine not deterrent enough to deter illegal chainsaw operations in forests, including the Tinte Beposo and Offin Tano forest reserves. These processes have gained social acceptance in the AASW district. Promoting active local community participation in resource governance and management, coupled with modern resource law compliance and enforcement regimes other than the traditional command and control methods, will go a long way to improve social-ecological sustainability.

Corruption in Ghana is ubiquitous, driving illegal activities that lead to water and forest resources degradation. The FGD, with the unit committee members and opinion leaders, revealed that corruption was a major factor driving illegal logging and mining in the AASW district. According to the participants, illegal chainsaw operators and miners use corrupt networks with officials from District Assembly and the Forest Division to engage in illegalities. The forest division's unfair benefit-sharing arrangement of forest resources has engendered corruption compelling the disadvantaged and marginalized local forest and farming communities to engage in illegal logging activities perceived as their share of the “forest cake”. Furthermore, the allocation of mining rights is characterized by bureaucratic and political corruption. In the AASW district, particularly Kunsu, some respondents alleged that some officials from the Assembly, Minerals Commission, MoLNR, and political party “big guns” receive payment as bribes to allow or facilitate illegal mining activities in the district. Similar to this was the assertion by some participants that illegal chainsaw operators continue their nefarious forest activities through a similar scheme. In Kunsu, influential personalities such as Traditional leaders, District Chief Executives (DCEs), and the Member of Parliament (MP) were also considered a major challenge in combating natural resources-related illegalities. These powerful individuals were accused of often interceding to quash or reduce and sometimes avoid the sanctions meted out to the illegal loggers and miners. They also support and campaign for them during constituency, parliamentary and national elections.

“The institutions are the ones destroying everything. They work together with the galamseyers and chainsaw operators. When you interact with them, some claim that the assembly gave them the operational mandate through the District Committee on Mining, while others claim that they approached the chief and that the chief is aware of their activities. What confidence can we have in these officials if their actions assist illegalities? All of our efforts may be in vain, so we might as well join them to degrade the environment in the name of improving our livelihoods (Interview with Key Informant, Kunsu, 2022)

3.2 Pressures underlying the state of Offin sub-basin SEL

The human activities and associated intensity induced by the above driving forces can be categorized into three: increased contact use of natural resources, increased discharge of waste into ecosystems, and complex land use land cover (LULC) transitions. The Offin sub-basin SEL is well noted for its tropical forest vegetation (Plate 9) and agricultural practices, which have been

prevalent in the area for many decades. As of 2008, the northern parts of the landscape were dominated by tropical forest vegetation, most of which have been demarcated as reserves. The Tinte Bepo Reserve and Tano Offin Reserve are examples of the watershed's pristine and secondary forest vegetation.

Plate 9: Densely vegetated areas around Mmrobem



As shown in Table 2, in 2008, approximately 48.6% of the landscape was dominated by dense natural vegetation. Other dominant land cover types within the watershed in 2008 were sparsely vegetated areas, most of which had been previously farmed but were fallow as of January 2008 (Table 2 and Figure 2).

Based on reports from the Ministry of Food and Agriculture, the dominant crops grown in the area include food and cash crops such as maize, plantain, yams and cassava (8.7%). Additionally, the area is known for cultivating cash crops such as Coffee and Citrus (6%). These are mainly grown on the outskirts of settlements. Rice is also grown in the valleys, mainly around waterbodies, as shown in Plate 2.

Table 3: Summary of landscape classes statistics for 2008

Name	Acreage	%
Cash Crop	1884.6	6.00
Rice	15.4	0.05
Subsistence Farming	2740.3	8.73
Dense Natural Vegetation	15258.2	48.62
Sparse Natural Vegetation	10572.1	33.69
Road	170.0	0.54
Degraded Areas	513.5	1.64
Recovering Mining Sites	0.0	0.00
Artificial Water Body (Irrigation)	2.0	0.01
Clear Natural Water Body	0.0	0.00
Natural Aquatic Vegetation	0.0	0.00
Built-Up	227.8	0.73
Total	31383.9	100.00

Based on reports from the Ministry of Food and Agriculture, the dominant crops grown in the area include food and cash crops such as maize, plantain, yams and cassava (8.8%). Additionally, the area is known for cultivating cash crops such as Coffee and Citrus (6%). These are mainly grown on the outskirts of settlements. Rice is also grown in the valleys, mainly around waterbodies, as shown in Plates 10 and 11.

Plate 10: Irrigation for rice cultivation at Dunyan Nkwanta in the Offin sub-basin SEL



Plate 11: A stream with a rice farm by the road in Barniekrom



The general distribution of these crops was ascertained with a high degree of certainty except in the case of Cocoa, where new information is required to validate the location of the farms due to the irregular pattern of planting used in Cocoa cultivation which makes it difficult to separate Cocoa from other type types of dense vegetation. Except for Cocoa, crop cultivation occupied about 14.85% of the watershed. Degradation within the watershed as of 2008 was mainly restricted to clear-cutting densely vegetated areas for cash crops and subsistence farming. In 2008,

mining was virtually non-existent within the boundaries of the watershed. Figure 3 shows the distribution of major land cover types within the watershed as of 2008.

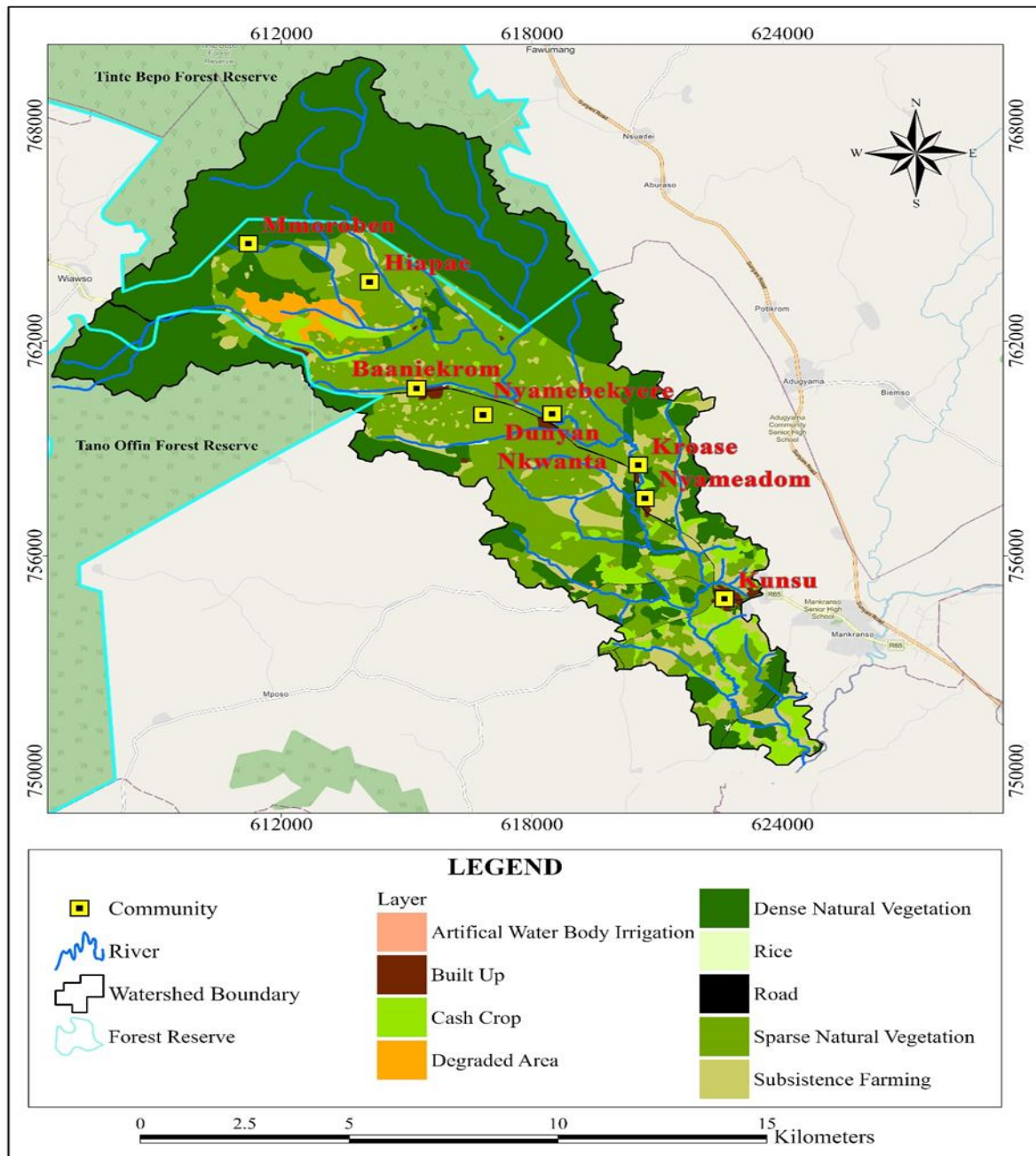


Figure 4: 2008 Land cover/ Land use map of the Offin sub-basin

By the year 2015, significant changes had occurred within the landscape. Generally, agriculture, especially cash crop farming, improved significantly. However, illegal mining activities also made incursions into the southern part of the watershed between Kunsu and Mankranso in the southern parts of the watershed. In the central and northern areas, agriculture increased by 142.4%, while Rice production increased by 300%. The improvements in agriculture brought about some significant reduction in the natural vegetation. Both densely forested areas and sparse vegetation decreased, with dense vegetation decreasing by 36.7%. In the south, this was mostly due to the intensification of mining activities in the Kunsu-Mankranso area from the 15th of January 2015. However, in the north, it was due to a gradual expansion in agricultural activities,

particularly cash crop farming and human settlement expansion, as shown in Table 3. Figure 4 shows the increased levels of degradation in both the southern and the northeastern parts of the watershed.

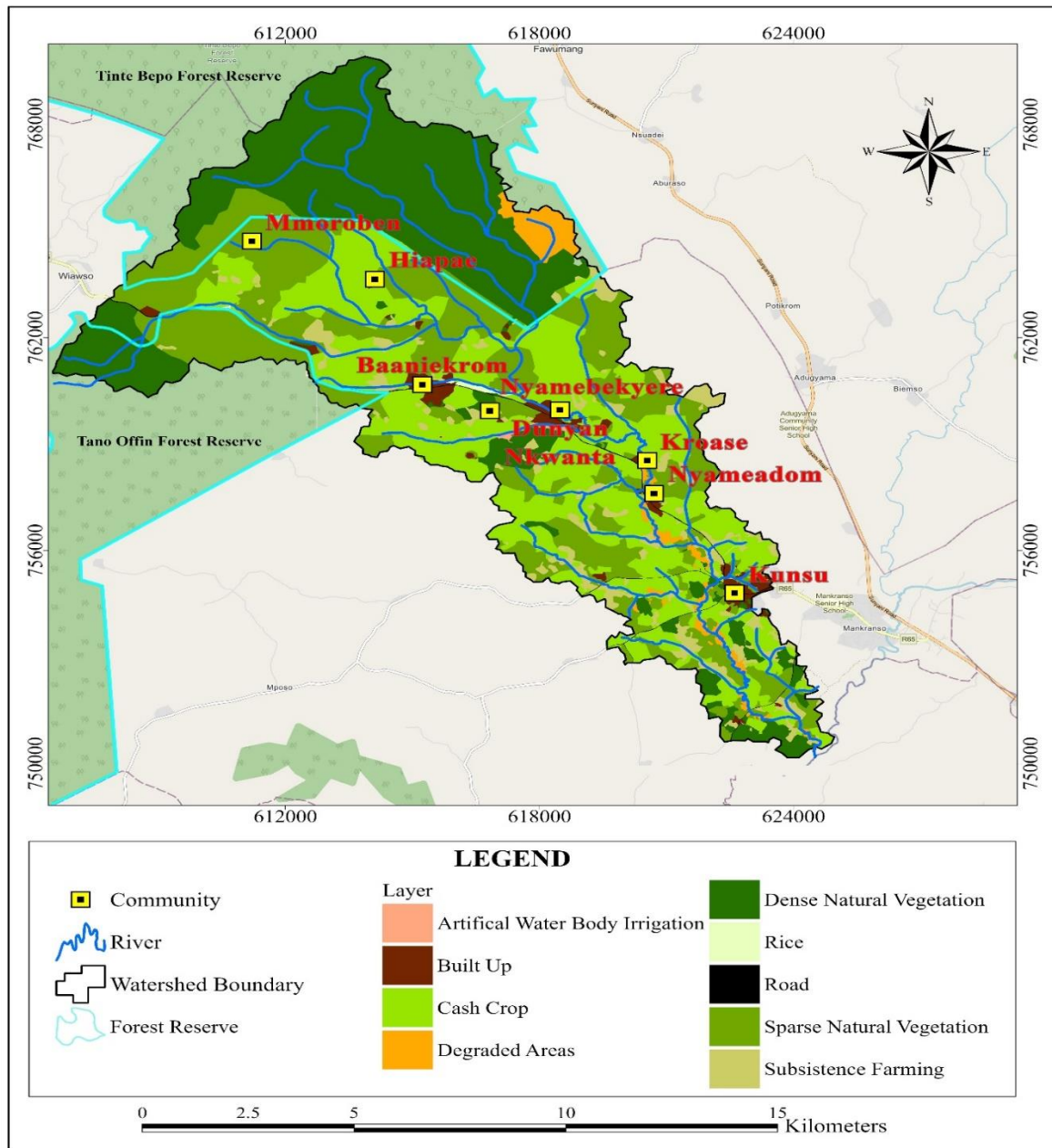


Figure 5: 2015 Land cover/ Land use map of the Offin sub-basin

Table 4: Summary of landscape classes statistics for 2015

Name	Acreage	%
Cash Crop	9540.60	30.40
Rice	54.10	0.17
Subsistence Farming	1845.80	5.88
Dense Natural Vegetation	9267.90	29.53
Sparse Natural Vegetation	9189.50	29.28
Road	196.90	0.63
Degraded Areas	874.60	2.79
Recovering Mining Sites	0.00	0.00
Artificial Water Body (Irrigation)	0.00	0.00
Clear Natural Water Body	22.50	0.07
Natural Aquatic Vegetation	0.00	0.00
Built-Up	392.00	1.25
Total	31383.90	100.00

In the year 2018, the landscape in the watershed again changed significantly, as presented in Table 4. Subsistence agriculture improved by approximately 218.5%. However, cash crop cultivation and rice farming saw drastic decreases. This was partly due to the prolonged effect of illegal mining, which directly impacted the cultivation of cash crops, as shown in Plate 12.

Plate 12: Effects of mining on cash crops within the watershed

Farmers' response to the effect of the degradation on farmlands was to increase subsistence cultivation, which is associated with lower costs and losses. In general, though, it was observed that in 2018 due to the enforcement of anti-illegal mining regulations, the landscape began to recover, as shown in Table 4. Thus, the percentage of degraded area decreased by 52%, and both sparse and dense vegetation increased, especially in previously degraded areas, as shown in Figure 5 and Table 4.

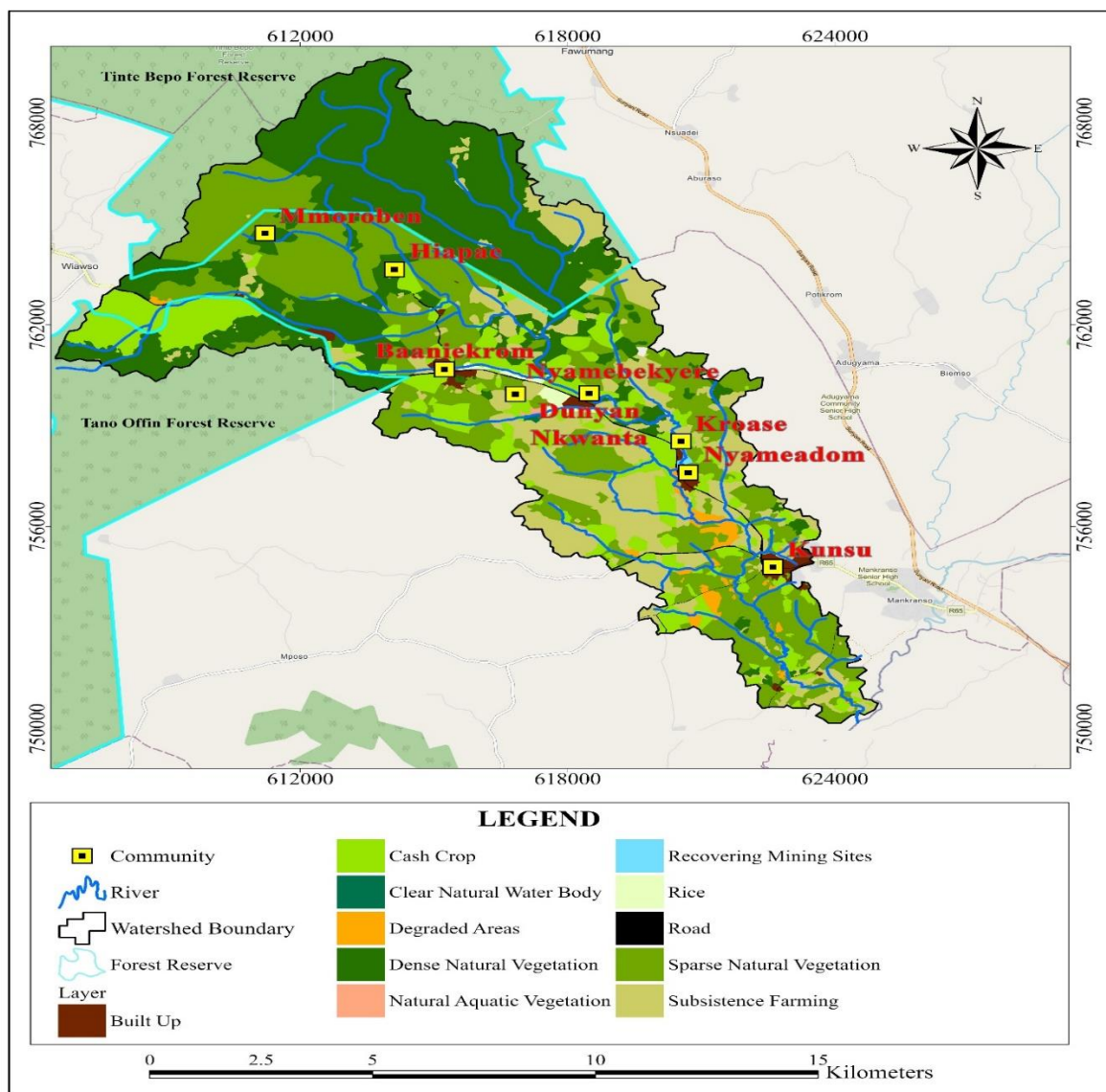


Figure 6: 2018 Land cover/ Land use map of the Mankranso watershed

Table 5: Summary of landscape classes statistics for 2018

Name	Acreage	%
Cash Crop	4546.4	14.5
Rice	187.6	0.6
Subsistence Farming	5393.4	17.2
Dense Natural Vegetation	10029.4	32.0
Sparse Natural Vegetation	10097.6	32.2
Road	209.9	0.7
Degraded Areas	391.3	1.2
Recovering Mining Sites	31.3	0.1
Artificial Water Body (Irrigation)	0.0	0.0
Clear Natural Water Body	60.5	0.2
Natural Aquatic Vegetation	17.3	0.1
Built-Up	419.2	1.3
Total	31383.9	100.00

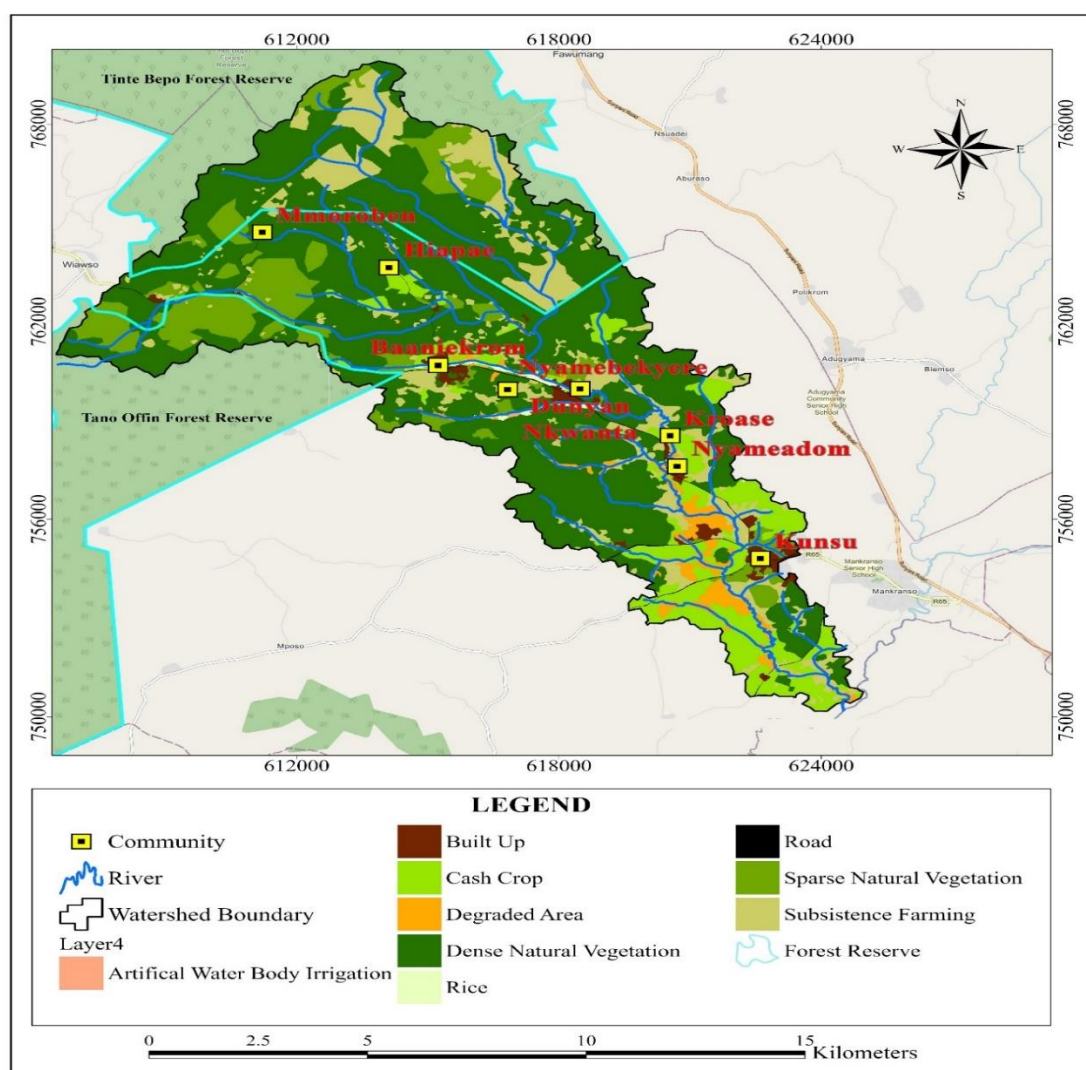


Figure 7: 2021 Land cover/Land use map of the Offin sub-basin

In 2021, generally, there was an increase in the built-up area and a resurgence of mining in the southern part of the watershed. This came in the form of community mining sites where former illegal mining sites were opened to communities to allow them to mine sustainably. However, this has negatively impacted agricultural land use, as shown in Table 5.

Table 6: Summary of landscape classes statistics for 2021

Name	Acreage	%
Cash Crop	3176.6	10.1
Rice	163.9	0.5
Subsistence Farming	4349.4	13.9
Dense Natural Vegetation	18210.0	58.0
Sparse Natural Vegetation	3879.0	12.4
Road	126.7	0.4
Degraded Areas	919.7	2.9
Recovering Mining Sites	0.0	0.0
Artificial Water Body (Irrigation)	7.0	0.0
Clear Natural Water Body	0.0	0.0
Natural Aquatic Vegetation	0.0	0.0
Built-Up	551.6	1.8
Total	31383.9	100.0

Change detection

Further analysis was conducted to assess the percentage change for the 13 years of land cover/land use change. The results for the percentage change revealed that over seven years (2008 -2015), areas covered by Cash Crop (406.24%) increased the most compared to other Cash Crop percentage coverage in 2015- 2018 and 2018 – 2021. The drastic decline in cash crops is attributed to the rise in illegal mining activities and the decline in the labour force for cash crop production. Based on secondary data and field observation, the quantity of rice production increased from 2008 to 2015 by 251.30%. and 2015 to 2018 by 246.77%, confirming that other areas have been used for rice cultivation. Also, some of the illegal mining sites have looked similar to water bodies. They could account for such an increase, but a decline for 2018 – 2021 (-12.63%) is attributed to the seizure and use of the valley by an illegal miner for mining, where rice production is suitable. Rice cultivation goes in hand with irrigation; it is not surprising to find areas covered by artificial water bodies (irrigation) to have increased to 250 times from 2008 – 2021. It is worth explaining that the water body could have increased significantly due to the dam's construction under the 1V1D initiative.

Areas with Subsistence farming decreased by -32.64% from 2008 to 2015, where illegal mining activities began at the early stage. Still, between 2015 to 2018, there was an increase in subsistence farming because the Central Government initiative to regulate the activities of mining for environmental sustainability imposed a ban on illegal mining with the popular phrase ‘operation vanguard.’ Most of the youth went back into farming activities as an alternative to mining since the district mostly engaged in farming. But in three years (2018 -2021), Subsistence farming began to decrease as illegal mining activities upsurge. The activities of illegal mining and sand winning account for the degraded area coverage of 70.32% but the Government of Ghana’s initiative to fight against galamsey in 2017 led to a decline in the percentage area cover from 2015 to 2018 (-55.26%). This led to the recovery of some land which accounts for Sparse

Natural Vegetation (8.22%) and Dense Natural Vegetation (9.88%) increase from 2015 to 2018. This threatens other land covers/land uses, especially vegetation.

Table 7: Percentage of land use land cover change

Name	2008-2015	2015-2018	2018-2021
Cash Crop	406.24	-52.35	-30.13
Rice	251.30	246.77	-12.63
Subsistence Farming	-32.64	192.20	-19.36
Dense Natural Vegetation	-39.26	8.22	81.57
Sparse Natural Vegetation	-13.08	9.88	-61.58
Road	15.82	6.60	-39.64
Degraded Areas	70.32	-55.26	135.04
Recovering Mining Sites	0.00	100.00	-100.00
Artificial Water Body (Irrigation)	-100.00	0.00	100
Clear Natural Water Body	0.00	168.89	-100.00
Natural Aquatic Vegetation	0.00	100.00	-100.00
Built-Up	72.08	6.94	31.58

Evidence from Table 6 shows that sparse natural vegetation lost the most to other land covers/land uses type within the seven years. However, its rate of decrease per year looks worrying (13.08%). This rate of decrease per year was the highest and could have similar implications on the dense natural vegetation and subsistence farming. Apart from the aforementioned effects, the other effects losing vegetation would bring about are increased soil erosion, loss of soil fertility and loss of biodiversity. Although the results show that dense natural vegetation increased (8.22), this could be the effect of the anti-galamsey enforcement. Therefore, if measures as such are put in place, there would be a little negative impact on ecological variables such as vegetation. One of the most disturbing issues with the study area is the increase in degraded areas.

3.3 State of the Offin sub-basin SEL

3.3.1 Social-economic

3.3.1.1 Settlement system

It covers an estimated area of about 645.54sq/km, about 2.6% of the land area of the Ashanti region. It has 119 settlements of varying sizes, and Mankranso is the capital, about 35km from Kumasi. One of the most serious social problems in the AASW district is the relatively high poverty level. The human settlements perhaps depict the most glaring signs of rural poverty. The incidence of low-level basic social amenities such as health, education, water, and sanitation characterizes many poverty-stricken communities in the district. It also manifests in the dilapidated buildings and general decay of the built-up environment. The district planning coordination unit (DPCU) used a population size of 50 communities to arrange settlements in descending order through a scalogram study. The analysis revealed that most of the settlements in AASW lacked the most basic functions or facilities and relied on the Mankranso, Kunsu and Wiaso settlements for their major services. The majority of roads are untarred. The district has 169.8 kilometres of feeder roads, of which 83% are graveled and 17% represent earth roads. The housing stock is estimated at around 16,154. Of this figure, 65% are built with mud/bricks and are poorly constructed. According to the DPCU, 40% of the district has no electricity, while 60percent of the communities in the district depend on rivers and streams for their domestic water

supply. It is, therefore, important to ensure equity in the distribution of necessary facilities across settlements/communities. The district's mid-to-long-term development plans present an opportunity for this to be done. It is also critical that development partners and affiliate institutions who intend to work in this district consider this information when selecting communities in which to work.

3.3.1.2 Gender, youth, and people living with a disability

At the personal level, poverty is manifested by the inability of an individual or household to meet the basic needs of life in terms of adequate food intake, clothing and shelter. Most of the poorest in the AASW district live in smaller settlements dominated by unacceptable levels of social deprivation. Smallholder subsistence farmers, among which women are the majority, form the bulk of the poor rural households. AASW district authorities claim there are ongoing programs to empower the vulnerable such as credit facilities for women farmers, sensitization of women on domestic violence bills and disability bills and encouraging women to accept public office in local government structures. The youth in the study district were also found to engage mainly in community mining (with a significant number of under-aged persons) and transport (motorbike) business. The observation of this research is that they need some training, considering that they engaged in these activities with the requisite skills and protective gear.

Persons with disabilities (PWDs) have been defined as those who are unable to or are restricted in performing specific tasks/activities due to loss of function of some part of the body due to impairment or malformation. In the AASW district, PWDs face a wide range of life challenges because of their limitation in performing certain functions to their full potential. Accordingly, the government of Ghana enacted the Disability Act, 2006 (Act 715) to address issues of high poverty among PWDs due to low levels of education and lack of employable skills; inaccessible public transport; and unfriendly environmental facilities such as the widespread absence of ramps for PWDs and uncovered drains and gutters. According to the PHC 2021, 2.6% (3,133) total population of the AASW district (121,659) have some form of disability. Between the sexes, 2.7% and 2.5% of males and females have some form of disability, indicating no marked variation in disability. Of the 3,133 PWDs, 36.4% have sight or visual impairments, the most common type of disability, followed by physical disability (29.3%). The rest are less than 20.0% (hearing impairments - 13.8%, emotion impairments - 13.4%, speech impairments - 12.0% and intellect impairments - 11.1%). Even though the male PWDs slightly dominate the females, the females were more prone to multiple disabilities than the males. For inclusive national development, there is a need for the district and development partners to consider the needs of persons with disabilities when providing programmes and projects to make them disability friendly.

3.3.1.3 Economy/Livelihoods

The major employment avenues are community mining/galamsey, subsistence farming, cash crop/tree plantations, petty trading, and chain saw operations, in order of importance. The adult population can be categorized into economically active and non-active populations. The proportion of persons 15 years and older represent 57.0% of the entire District's population (121,659). The proportion of the economically active population (75.5%) is considerably higher than the economically not active population (24.5%). For the economically active population, about 96% are employed, as against 3.6% are unemployed. However, the unemployed proportion has a majority of the (70.0%) seeking work for the first time compared with worked before and seeking work (30.0%). Moreover, out of the economically not active population, the proportion of full-time education (46.2%) dominates, followed by home duties (29.8%) and too old/young (10.0%), and the last is pensioners/retired (0.9%). In addition, it is worth mentioning that 7.1%

were economically not active population because they are disabled/sick persons. Among the economically inactive population, the proportion of males in full-time education (58.7%) is higher than females in full-time education (35.0%). Conversely, most economically not active females engaged in home duties (37.9%) are more than their male counterparts (20.8%). Similarly, the proportion of females that are disabled/sick and too old/young (7.9%) is greater than males (7.1%). This means that most females in the district are vulnerable and must be protected with safety nets.

3.3.1.4 Household income and expenditure

Studies conducted by the District Planning Coordinating Unit (DPCU) show that more than two-thirds (67.1%) of the people earn between Ten Ghana Cedis (GH¢10.00) and One Hundred Ghana Cedis (GH¢100.00) per month per household. These incomes fall outside the National and Rural Incomes, indicating that the standard of living is low, and poverty is rife in the district. It is therefore not surprising that the district's economy is regarded as agrarian as the agricultural sector contributes largely to employment generation and employs about three-quarters (74.9%) of the economically active persons 15 years and older with 81.7% of households engaged in agriculture (99.2% engaged in crop farming) on small scale levels in the district. To buttress this point, the calculated Gini coefficient was 0.65. This meant that income inequality in the district was widespread. Regarding gender, poverty was negatively skewed toward women in the district. The survey showed that agriculture was the main household income source in rural and urban communities, followed by trading, wage employment, remittances, etc.

The main household expenditure items are food, crop farming/fishing, clothing, education, transport, and health. Among the expenditures, food (33.8%) recorded the highest expenditure, followed by clothing (15.5%), crop farming (14.0%), and business/trading (5.7%) recorded the least. This suggests most household expenditure is spent on food and clothing, which form the necessities of life. However, the expenditure on education and health, which are critical for the betterment of the household in the district, is very low. Hence, there is a need to address the financial management of households in the district.

3.3.1.5. Agriculture

Despite the emergence of mining activities, agriculture remains the mainstay of the AASW district's micro-economy. Since the district lies in the forest zone and has a vast tract of arable land and favorable rainfall patterns, inhabitants depend predominantly on agriculture as a major source of income, employment, and food supply. Consequently, any meaningful development effort must necessarily be based on improved performance in the sector.

Cash crops such as cocoa, citrus, oil palm, and food crops like cassava, plantain, cocoyam, maize and vegetables like okra and tomatoes are the main agricultural products in the district. As a major regional cocoa producer, the district produces an average of 7500 metric tons per annum. The major producing areas are Kunsu, Wioso and Mpasaso, among others. Generally, the food crops are exported to Kumasi, Accra and beyond. However, the lack of storage and processing facilities has telling effects on the production levels. This could only be reduced if there are ready markets and/or the vegetables are processed locally. Again, the district used to produce large volumes of vegetables and was second to the Akomadan area in Ashanti Region. However, the pollution of water bodies through galamsey has rendered once lucrative venture unprofitable, drastically reducing the number of vegetable farmers. Rice, even though it has great potential in the district, is grown by peasant farmers whose capital outlay is very low, and so it is grown on a subsistence level. Areas like Mankranso, Kunsu, Dunya Nkwanta, and Dwinyama are noted for rice production.

Animal husbandry is increasingly becoming an important economic activity in the district economy. In most settlements, sheep, goats and birds (hens and cocks) are reared in the backyards to provide additional income and as a protein supplement. The field survey revealed that there is no veterinary officer in the district, so the farmers have no access to veterinary services. This negatively impacts the development of the livestock industry. Further, the forest vegetation greatly limits the number of cattle reared in the district. Fish farming has caught up with the people of Ahafo Ano South West. The district has therefore been identified among 21 districts with great potential for fish farming in the country. Suitable areas include Kunsu Sikafremogya and Dwinyama. The type of fish farming at these locations are snakehead (koboo), tilapia and chrsialithys (kontro). There are currently 25 fish ponds in the district (covering an area of 4.29 hectares). A major challenge in the fishing sector is the emergence of galamsey operations (See Plate 13). Other major agriculture development-related challenges include:

Plate 13: Aquaculture and subsistence farms were taken over by mining at Sikafremogya



Low production/productivity: Most of the operators in this sector heavily rely on traditional and obsolete farming methods. Few farmers use modern, improved farming technology due to most operators' poor attitude towards the improved farming methods. The low production is also due to the high cost of labour/inputs, the land tenure system, lack of access to information, over-dependence on the government for the supply of inputs and aging farmers.

Over-dependence on rain-fed agriculture: Agriculture activities in the district are tied to rainfall. The rainfall regime, therefore, affects the production levels. The unreliable rainfall distribution is a major cause of fluctuation in crop production. Added to this are the seasonal nature of rivers/streams and the high cost of irrigation equipment.

Limited access to credit: Almost all the farmers in the district, especially food crop farmers, have no access to credit but depend on their resources to operate. This causes the farmers to sell their crops to the market women who sometimes finance them at low prices immediately after harvest. The other sources of credit to the farmers include private moneylenders and financial institutions whose demands the farmers cannot afford.

Lack of storage facilities: Storage facilities are not available in the district to store food crops after harvest, resulting in high post-harvest losses that negatively impact the microeconomy.

An inadequate number of Agricultural Extension Agents (AEAs): The low turnout of AEAs from the agricultural institutions negatively impinges on the sector. There are only 20 AEAs in the district, meaning the extension officer–farmer ratio is 1:2,171 compared to the national standard of 1:300. The inadequate number of AEAs adds to the farmers’ unwillingness to change.

Limited market and infrastructural backup: Even though the district is close to Kumasi, the regional capital, the poor nature of the roads, the unprocessed nature of the crops and market restrictions prevent the farmers from taking advantage of proximity to the regional and metro market. There is also the issue of the ***High cost of farming inputs relative to*** the low-income levels of farmers.

3.3.1.6 Industrial, commercial and service sectors

The industrial sector is one of the most important sectors concerning employment and income. The district has small-scale cottage industries like palm oil extraction, akpeteshie distilling, soap making, gari making and kente weaving (Nsutem, Barniekrom, Nyinanufu, etc.) There are also brick and tile factories at Mankranso. There are timber industries in and around Mankranso and Nsuta. These activities have contributed to a high percentage of the industrial contribution to the district economy. The informal sector is underdeveloped. This has been identified as a major cause of youth unemployment and rural-urban migration.

The service sector constitutes 11.6% of the labor force, comprised of Public Administration and Defence, Education, Transport and Communication, Hotels and Restaurants, Health and Social work, artisans and others. The commercial sector forms 6.8% of the total labour force. It comprises the wholesale and retail trade, financial intermediaries, renting and business activities. Women are mostly engaged in petty trading, subsistence farming and marketing of food crops. Low literacy and skills do not allow women to improve their opportunities or move to the formal sector. Ahafo Ano Southwest (AASW) district has four (4) weekly markets. These are in Kunsu, Adugyama, Pokukrom and Sabronum. However, these markets do not have adequate infrastructure. Other communities also have small daily markets, such as Mankranso, Wioso, and Domiabra.

3.3.2 Physiographic

3.3.2.1 Location

The Ahafo Ano Southwest (AASW) District Assembly is one of the forty-three (43) District Assemblies in the Ashanti Region. The district is in the Northwestern part of the Ashanti region and lies between latitudes 6°42” – 7°10” North and Longitude 1°45” – 2° 20” West. The district shares boundaries with Ahafo Ano South-East District to the North, Atwima Mponua District to the South, Atwima Nwabiagya Municipal to the East and Ahafo Ano North Municipal Assembly to the West. It covers an estimated area of about 645.54sq/km, about 2.6% of the land area of the Ashanti region. It has 119 settlements of varying sizes, and Mankranso is the capital, about 35km from Kumasi. The location of the District in the Ashanti Region offers it the opportunity to interact or cooperate with other regions like Ahafo, Bono, and the Eastern Regions. The District’s location implies that the youth drift to other relatively more urban like Kumasi and Sunyani in search of better livelihood opportunities. The location of the district and its nearness to Kumasi, for instance, provide ready market avenues for petty traders, farmers, chainsaw operators, miners, etc. In addition, the proximity of the District to both Kumasi and Sunyani has made some communities enjoy relatively better basic amenities and facilities (e.g., Health and Educational facilities).

3.3.2.2 Relief and drainage

The district forms part of the Ashanti Plateau. The topography is generally undulating; the most prominent feature is the range of hills stretching west to northeast. The highest elevation of the district is about 2,500ft (763m) above sea level, including the Aya, Kwamisa and Tinte Hills. The district's main rivers are the Mankran, Offin, Abu and Aboabo and their tributaries. These rivers and streams take their source from these hills and serve as a drinking water source for the various district communities. The existence of several streams and rivers in the district enhances irrigation, promoting all year-round farming activities. In addition, these streams and rivers provide water sources for domestic use. However, recent mining and logging activities are degrading these rivers and turning the tributaries into perineal water systems (Plate 14). They have virtually become seasonal rivers, increasing the water insecurity of several communities, particularly during the dry season.

Plate 14: The current colour of the Mankran River



3.3.2.3 Climate

The district has a wet semi-equatorial climate. The major rainfall period begins from March to July, peaking in May. The mean annual temperature is about 27°C, with variations in mean monthly temperature ranging between 26°C to 28°C throughout the year. The dry season normally begins in December and ends in March, with relative humidity between 70 and 75%. The average annual rainfall for the major season is about 1,700 – 1,850 mm per year. The Double maxima rainfall supports two crop seasons, making it a continuous food supply throughout the year within and outside the district. Even though the rainfall is adequate for agriculture, its erratic and unpredictable nature and concentration have adverse implications for rain-fed agriculture. Also related to climate variability is the frequent flooding in the study landscape, worsened by river siltation. For instance, between 2018 to 2021, the climate conditions of the district did not conform to the usual trend. During this period, the district experienced erratic rainfall patterns and higher temperatures (22 - 33°C) throughout the year, causing devastating floods.

“Farmers used to be able to prepare their land for agricultural cultivation by predicting which month it would rain because rain used to fall throughout its seasonal time. However, this is no longer the case. Even though the land can be made ready for farming, it won't rain. On the other hand, it will rain when you least expect it. And this has impacted both local food production and our agricultural activities.” (FGD, Mankransu, 2022)

3.3.2.4 Vegetation and forest resources

The vegetation of the district is mainly rainforest and exhibits moist semi-deciduous characteristics. The vegetation and varying soil types jointly support the growth of big and tall trees of different kinds, such as Wawa, Ofram, Sapele and Odum. Kyenkyen, Fununtum and Mahogany. The forest reserves are rich in tropical hardwoods like Wawa, Esa, Kyenkyen, Odum, Ofram, Fununtum, Kokrodua, and others. The over-bearing vegetation is moisture-laden semideciduous. The district has two main forest reserves (Tano Offin and Tinte Bepo Forest reserve) that help preserve vegetation and biodiversity. As far as human settlements are concerned, these forest reserves are a big asset for future generations. Forest reserves are also used as a source of industrial raw materials to feed the local industries such as carving, sawmilling, and a host of others in and outside the district. The forests, in their entirety, provide a major source of energy for cooking as the people get firewood and charcoal in the forest. However, their natural vegetation cover is fast being depleted into secondary forests. Few areas outside the forest reserves have natural vegetation. The causes of deforestation include excessive and indiscriminate felling of trees, especially by illegal chain saw operators, farming systems, particularly shifting cultivation, and uncontrolled bushfires. There is an urgent need for afforestation initiatives to replenish tree stock and enhance the general ecological balance.

3.3.2.5 Geology and mineral resources

The district is underlain by the Kumasi-Offin Dwinyama-Bechemso natural resources that are rich in rocks and minerals such as granites, clay, sand, gold, bauxite, and manganese deposits. The granite rocks contain minerals such as gold and bauxite and serve as a source of building materials due to their hard nature. The gold-bearing rocks are found at Kunsu, Sabronum, Barniekrom, and other parts of the district. There are also clay deposits at Hwibaa, Wioso, Asuadei, Biemso II, and Mankranso, which have been tested by the Building and Road Research Institute (BRRI) as one of the richest clays in the country. However, this potential for sustainable development remains unexploited and, when exploited, is done unsustainably. The exploitation of these minerals legally will greatly energize the development of the district through job creation, improved household incomes, and much-needed revenue. However, illegal mining activities are very rampant in the district. These illegal miners usually use excavating machines to create large pits left uncovered, creating artificial dams and ponds. These dams pose a great danger to the lives of these communities (Plate 15).

Plate 15: Artificial ponds/gullies near Kunsu



3.3.2.6 Soils

The main type of soil in the district is the Forest Ochrosols, reddish brown and well drained. They have high humus content and are very fertile. These soils can be classified into moderately suitable soils (developed over Briminian rocks) and marginally suitable soils (developed over granite rocks). The soils in the district are generally fertile and suitable for agriculture. There is abundant arable land that is deep and can support a wide range of cash, food, and tree crops. These fertile lands produce cocoa, coffee, oil palm, maize, cassava, cocoyam, yam, rice, pear, banana, mango, plantain, sugarcane, citrus, cowpeas, cola, and vegetables, among others. However, the galamsey menace is threatening agriculture through soil degradation. Again, prolonged, inappropriate farming practices such as shifting cultivation, slash-and-burn method of farming and illegal logging is gradually depleting the forest cover and reducing soil fertility in most parts of the landscape. For enhanced production, there is a need to supplement natural fertility with organic/inorganic fertilizers, introducing smart-farming techniques.

3.5 The impacts: ecosystem services and human wellbeing

The benefits humans receive from ecosystems are known as ecosystem services. These consist of provisioning services, such as the supply of food and water. Regulating services, like the prevention of floods and the control of diseases. Cultural services, like the provision of spiritual, recreational, and cultural benefits, and support services, like the cycling of nutrients, preserve the conditions necessary for life on earth (Figure 5). The diversity of living things is referred to as biodiversity. It encompasses variation within and between species as well as variation within and between habitats. Changes in biodiversity can affect the availability of ecosystem services. The AASW district has immense natural resources: arable land, forests, clay, bauxite, and gold. The exploitation of these resources to meet the socio-economic needs of the people has adversely affected the fragile environment. The effects of direct and indirect anthropogenic driving forces have put the state of the Offin sub-basin landscape in the AASW district under severe degradation. These factors have driven biodiversity and ecosystem services into depletion and loss. With the limited flow of ES due to impacts from the “state” comes increased poverty and food insecurity, limited livelihood options, entrenched inequity in access to livelihood capitals, soil and water pollution, deforestation, forest degradation, etc. It is important to mention that people depend on

ecosystems for various services. As a result, they judge an ecosystem's health based on how well it can fulfill those needs.

According to FGD participants, their farmlands can no longer provide for their household food needs. They claim that now they purchase more from neighboring towns in and out of the landscape. This indicates that farm-households are growing food insecure, considering that it is increasingly difficult to produce 75% of their food needs. There was also a consistent claim that wild foods gradually became extinct in the landscape, further deepening the food security situation.

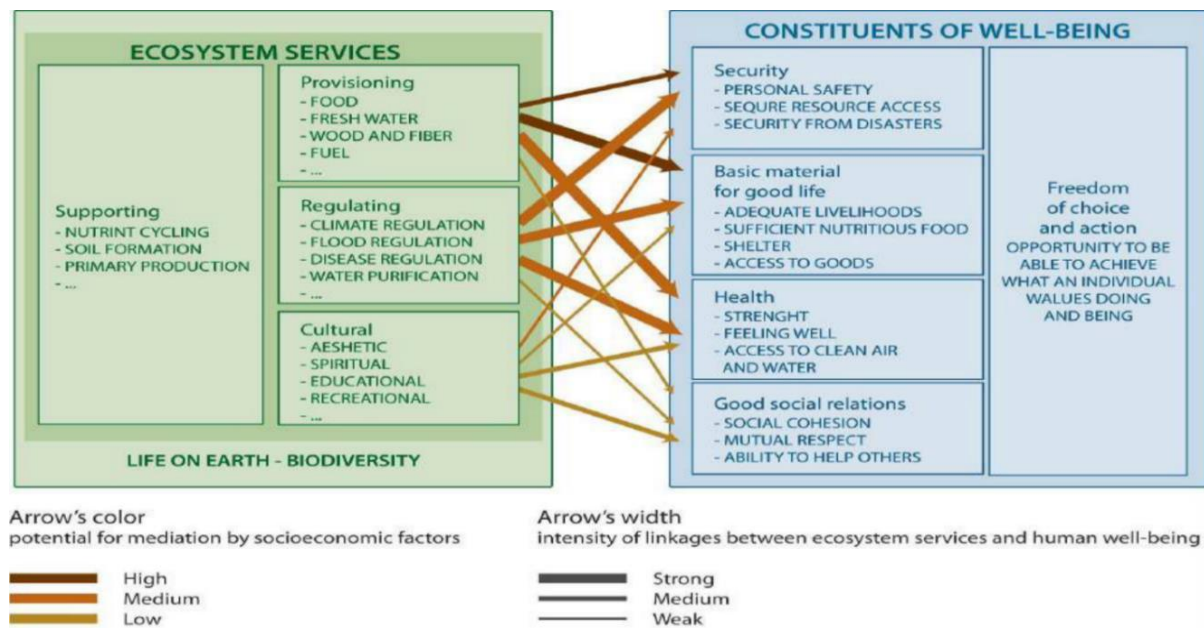


Figure 8: The links between ecosystem services and human well-being (Source: MA 2005)

The rivers and water bodies in and around the forests are being polluted and drying up due to surface mining. Illegal mining along the Mankran River has degraded vegetation and polluted the river and its tributaries. Drone images showed that illegal mining activities had caused severe habitat and biodiversity loss in open forest areas in the landscape (Plate 14), while overexploitation and illegal forest resources extraction are causing flora and fauna depletion and habitat fragmentation in the Tinte Beposo and Tano Offin reserves. Rural people living in forest areas whose only water sources are rivers, streams and other water bodies are polluted because of illegal mining. Using polluted streams and rivers for drinking and other domestic purposes has profound health implications for forest-dwelling communities.

Moreover, the land cover changes emanating from degradation and competing land uses affect ecosystem health and functions, reducing ecosystem services. Forest cover conversion through degradation and deforestation reduces forest carbon stocks, increasing the amount of CO₂ released into the atmosphere. It is also important to note that illegal mining and legal logging are severely destroying the understory vegetation and habits of birds and other mammals.

“Wild foods are presently less abundant than in previous years because of land clearing, tree cutting and illegal mining. Due to the activities of chainsaw operators and miners, snails, grass cutters, rats, squirrels, and other wild

animals are becoming less and less abundant. Sometimes the noise operators generate drives away these mammals” (FGD, Mmrobem, 2022).

“No river body in this contemporary Mankranso is unaffected by destruction. No matter where you are, galamsey activities are affecting every water body. In the past, as far back as I can remember, most people engaged in vegetable cultivation and relied on a nearby body of water for their agricultural needs. Many farmers have left the vegetable-producing trade because the water bodies are no longer supportive” (Key Informant, Mankranso, 2022).

The observed land cover/land use analysis showed that most vegetation is being lost to other classes such as built-up, agricultural activities, degraded activities and artificial water bodies (Irrigation). The extensive loss of vegetation has affected biodiversity conservation within the two forest reserves. From the FGD, most of the land area of the Tano-Offin forest reserves is used for agricultural activities, including the Modified Tuangya System (MTS) of farming. Thus, some flora and fauna distinct to the area were as claimed by FGD participants.

Apart from biodiversity loss, clearing vegetation has exposed the soil to surface runoff, resulting in erosion and loss of soil fertility and flood episodes. In terms of water resources, illegal mining activities pollute the water and make it unwholesome for domestic and agricultural use. From the FDGs conducted in Mankranso and confirmed through geospatial assessment, the natural water bodies are shrinking in size and being polluted due to uncontrolled mining activities and the cutting down of trees along the water bodies (Plate 16). Further, chemical fertilizer has reduced and depleted some of the ecosystem benefits and has hardened the soil surface, affecting crop yield, as revealed through the FDGs.

Plate 14: Degraded portions of the Mankran River



Changes in the observed land cover/land use impact the livelihoods of local people in the SEL. These impacts on livelihoods result from changes in the people's socio-economic circumstances. In the AASW district, the impact of land cover/ land use resulting from anthropogenic factors to some extent, constitutes a disservice to the livelihoods of the local people. The percentage increase in Dense Natural Vegetation can be attributed to the programs started by Forest Division

in the District, which are the Modified Tuangya System (MTS), Public Private Partnership, Youth in Afforestation Programs (YAP) and FarmBound (FieldWork,2022). These programs provide job creation and income generation for the district's local farmers and youthful population.

As the open/sparse vegetation is decreasing due to the increase in illegal mining logging activities, the socio-economic status of the landscape is shifting away from farming to mining. During one of the FGDs in Kunsu, participants contended that with a lesser youthful population emerging in agricultural production, the annual outputs are growing lesser and lesser, making the district's food cost relatively higher than expected. Most youthful people, both male and female, are actively engaged in illegal mining since the income generated from these activities is higher than that of a farmer's annual income. In Kunsu, the cocoa yields are declining; cocoa farms are being converted to mines, and in some cases, the labor force is moving into illegal/community mining. *"But can you blame these farmers"* a key informant exclaimed, *"what they get from the government for their produce annually is several times less than what they make from using their farmlands for mining activities"*.

Within the AASW district, the built-up area is increasing gradually, with a percentage change of 142.1% from 2008 to 2021. This increase may be attributed to the increase in population through the influx of migrants for job opportunities relative to the increase in mining activities. The district has seen an increase in the activities of degradation emerging from the sand mining activities in some of the communities like Mmoberem and Barniekrom and the illegal mining activities in Kunsu. The activities of these miners have altered the demand for goods and services since the pattern has changed from farming to mining. Fast food joints, commodities for mining activities and motorcycle-related goods are the most dominant within the commercial area of Kunsu, the core town for illegal activities. The dominant mode of transportation is the motorcycle, which is convenient for transporting goods and people to the mining site.

The increase in rice production from 2008 to 2021 by 964.3% can be attributed to the completion and renovation of the dam project at Dunya Nkwanta, which commenced in 2004. The dam was finally completed as part of the One District One Dam Project. This saw the increase in rice production in the area around the dam location despite illegal activities occurring in the valley where rice cultivation was suitable.

3.6 Responses to drivers, pressures, state and impacts in the Offin sub-basin SEL

Over the years, Ghana has embarked on several policies, laws, and regulatory mechanisms and interventions as immediate practical responses to curb the wanton deforestation and forest degradation in forests and reserves. The Forest and Wildlife Policy 1994, subsequently revised as the Ghana Forest and Wildlife Policy 2012, constitutes key forest policy and other numerous laws and regulations that guide forest governance and management strategies in Ghana. The Ghana Forestry Commission (FC), working through the REDD+ intervention, targets hotspots where degradation drives Ghana's forests into extinction by strengthening and reforming forest laws and policies to achieve sustainable forest management and governance. To address sustainable forest management challenges, including the key one of D&FD, Ghana, through the international bilateral and multilateral bodies, namely, the World Bank, FAO, IUCN, and EU, have received financial and technical support assistance to salvage Ghana's forests from further D&FD. It is envisaged that these support systems would reverse the trend and enhance ecosystem services, including carbon emissions. A local community-level intervention called the Community Resource Management Areas (CREMAs) was established to restore degraded lands and forests

and to manage lands and trees. The Modified Taungya System (MTS) was also designed to allow local farmers to grow their food and non-tree cash crops while planting and caring for trees on the farms. These interventions were expected to serve the dual purposes of enhancing participating members' livelihoods and boosting reforestation and afforestation potentials. Another response to combat the rampant forest degradation was the introduction of commercial plantation development strategies that engaged farmers to restore degraded forest reserves. Likewise, the National Forest Plantation and Development Programme (NFPDP) was also established to achieve multiple aims of lessening rural poverty, increasing food production, and job creation through agroforestry schemes to enhance local economic opportunities (e.g., Public Private Partnership for afforestation, Youth in Afforestation Programmes (YAP) and FarmBoard). The figure below presents some of the institutions who have operations/physical presence in the study landscape.

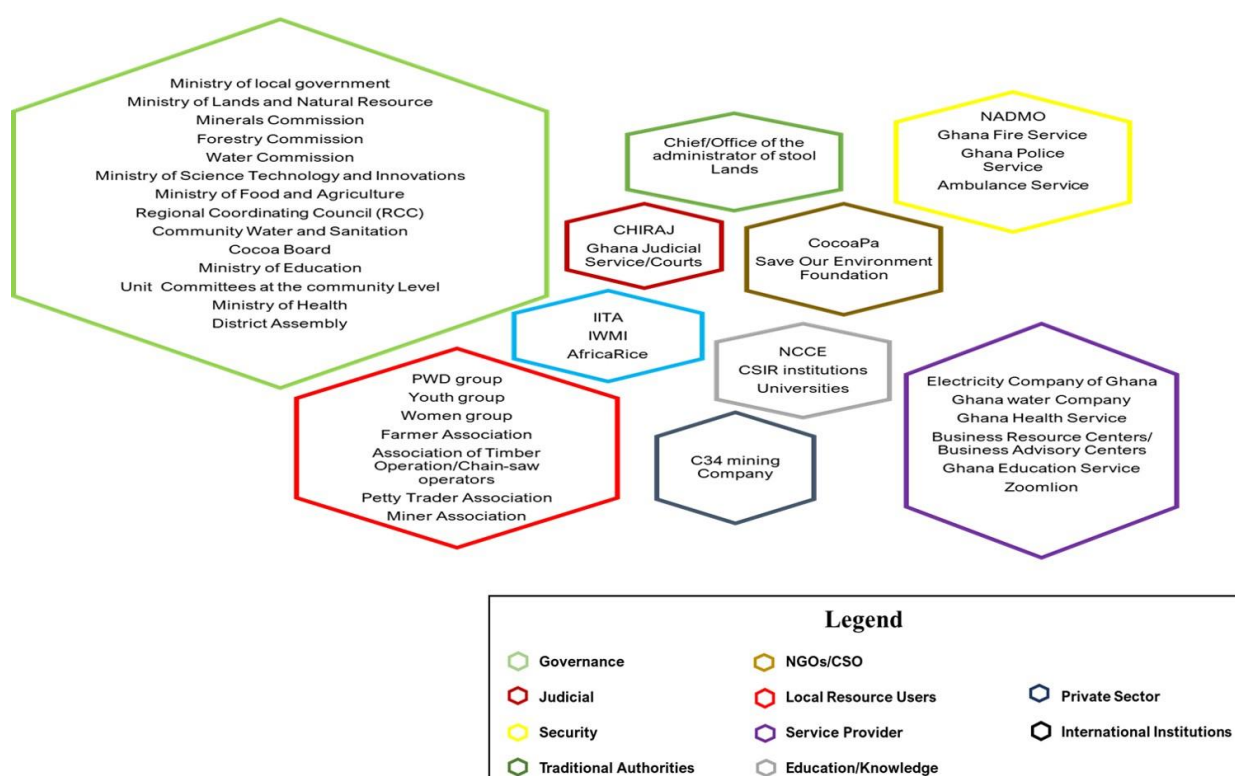


Figure 9: Institutions with operations/physical presence in Ahafo Ano Southwest District

4.0 Conclusions and recommendations

This research is a baseline landscape situational analysis (LSA) of natural resources and ecosystem services, mapping existing institutions and stakeholders that engage in Social-Ecological Landscape (SEL) exploitation and management within the Offin sub-basin in the Ahafo Ano Southwest district of Ghana. Using a DPSIR-SEL framework and a mix of methods, the study aimed at giving an overview of how drivers and pressures combine to delineate SEL state, impacts and institutional responses. The DPSIR-SEL analytical framework was applied to the situational landscape assessment of the Offin sub-Basin SEL within the Ahafo Ano Southwest (AASW) district of Ghana. The assessment showed a chain of a causal link between Drivers-Pressures-State-Impacts-Responses that affect desirable social-ecological outcomes. For instance, a chain of causal links starting with ‘driving forces’ (agricultural expansion) through ‘pressures’ (land use land cover change/shifting cultivation) to ‘states’ (biodiversity and

ecosystem depletion and loss) and ‘impacts’ (wildlife habitat destruction, increase in food insecurity) requiring prioritizing political, policy, interventions, and governance ‘responses’ to deal with the drivers, pressures, state, and impacts in a causal manner. The documentary review indicated that most formal institutional ‘responses’ were not specific, measurable, achievable, relevant, and time-bound (SMART). It is important to emphasize that identifying the precise causal chain from driving factors to impacts and responses entails a complex exercise, demanding a careful and diligent assessment of the situation holistically from the social-ecological and multidisciplinary perspective.

Based on the socio-economic characteristics of the AASW districts, this study contends that the unsustainable exploitation of natural resources/ecosystem services in the Offin sub-basin SEL is generally underpinned by the need for “necessities of survival” rather than the quest for “opulence”. Accordingly, the driving forces behind the pressures that delineate the state of and impacts within the Offin sub-basin SEL are largely local, albeit a few are national and global. The study showed that unregulated small-scale mining (galamsey translated as ‘gather and sell’), large-scale wood exploitation, and the conversion of more forest ecosystems into subsistence farms and cash crop plantations all pose ongoing threats to the health and function of the Offin sub-basin SEL. The extraction of abiotic resources through mining and the unsustainable use of natural resources endangers biodiversity, livelihoods, and ecosystem processes, including soil and water services. This trend is largely fuelled by low equity in access to livelihood assets- i.e., limited livelihood alternatives, food, raw materials for domestic purposes, health, education, tenure insecurity (land, water and forest), etc. The research found that the SEL state is adversely altered with the identified driving forces and pressures. The geospatial analysis showed high fragmentation within and between land use land cover (LULC) systems. The current level of alteration of the SEL has dire implications for landscape structure and composition, endangering the sustainable flow of natural resources and ecosystem services like (wild) food, water for agriculture and domestic use, fertile soils, flood control, tourism, etc. With the limited flow of ES due to altered “state” comes increased poverty and food insecurity, limited livelihood options, entrenched inequity in access to livelihood capitals, soil and water pollution, deforestation and forest degradation, etc. The Impacts of intense competition between forest conservation and development are manifest in the fragmentation of the Tinte Beposo and Offin Tano forest reserves through cash crop plantations [referred to as Admitted farms or Modified Taungya System (MTS) by the Forestry Commission and locally called Taungya], and the removal of open vegetation through subsistence farming and illegal/community mining. Another concern is the degradation/pollution of the Mankran River (the only third-order stream in the SEL) through illegal/community mining and forest degradation.

Scales of operation are largely at district, regional, and national levels, with few management platforms at the community level. Actors include local people at the community level, civil society organizations (CSOs), non-governmental organisations (NGOs), local governments, national government agencies and departments, and international agencies. Predominant stakeholders within the AASW district (and by extension, the Offin sub-basin SEL) were local people (resource users) represented by unit committees, local government authorities (AASW district assembly and its departments and units) as well as government ministries and agencies (water resources commission, forestry commission, Community water and sanitation, etc.). CSOs, NGOs and international institutions/agencies were found to have a very limited presence in the area. It was found that there is very limited coordination between/among these actors,

resulting in counterproductive management initiatives. Production sectors on the SEL operate in isolation, and this inhibits integrated management of production systems and the natural resources that underpin ecosystem services needed for all sectors. The results also showed that low institutional capacity, including inadequate human and finance capital, limited access to information about natural resources for proper planning, and the lack of tools and approaches for mapping, assessing, monitoring, and practically integrating ecosystem services (ES) to support planning in the Ahafo Ano Southwest district.

The research proposes the following to enhance the sustainability of the Offin sub-basin SEL:

- Development of local capacities for improved access and management of natural resources and ecosystem services. The government and its development partners through the Forest Division, Minerals Commission, and Water Resources Commission need to support local authorities (the district assembly, traditional leaders, unit committees, and opinion leaders) to ensure sustainable development. This could be done through continued human capacity development, particularly in remote sensing and geographic information systems for spatial planning, integrated landscape management, integrated resources management, and forest reserve monitoring.
- Promotion of participatory and multi-stakeholder approaches for ecosystem conservation and livelihood improvement. One such initiative could be creating a common platform where the multiple stakeholders on the SEL (*galamseyers*, farmers, chainsaw operators, other water resource users, traders, traditional authorities, NGOs, district assembly, etc.) can meet to actively discuss SEL undesirable changes and impacts and make binding decisions (with consequences upon non-compliance). The evidence from the literature indicates that decisions from such platforms are usually effective in dealing with undesirable outcomes of competing land uses relative to the top-down decisions emanating from officialdom;
- Spatially targeted investment in the landscape that supports sustainable development, including climate-smart goals. This may include stimulating private sector investment in sustainable social-ecological landscape (SSEL) goals, which may be done through Impact Investment Advisory Services (IIAS). In this direction, stakeholders like AASW District Assembly, MoFA, CGAIR institutions, etc., may need to invest in the areas of rice cultivation, aquaculture, vegetable farming, afforestation and reclamation of mined sites;
- Continues tracking changes to determine if sustainable social-ecological goals are being met (e.g., sustainable land use, ILM, sustainable and inclusive livelihood enhancement, strengthened institutions, etc.). Measuring and monitoring the multiple benefits of SSEL goals is essential for tracking the effectiveness of intersectoral/integrated efforts/initiatives targeted at sustainable development;
- The district assembly may need to coordinate appropriately and adequately with law enforcement units to ensure the forest reserves. Other vegetation and water bodies are protected. The current forest and water protection and conservation strategies need review, particularly the policy on admitted farms and admitted settlements in forest reserves and mining on the banks of rivers and streams;
- The membership of the district mining committee may need to be reviewed to include the victims of the activities in the sector. The current membership tends to promote more illegalities. Again, strict measures should be implemented against illegal mining through by-laws emanating from participatory multi-stakeholder engagements, including law enforcement units like the police and the judiciary.

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