CODEX PLANETARIUS

Data Metrics for *Codex Planetarius* on Cocoa Production in Ghana

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About *Codex Planetarius*

Codex Planetarius is a proposed system of minimum environmental performance standards for producing globally traded food. It is modeled on the *Codex Alimentarius*, a set of minimum mandatory health and safety standards for globally traded food. The goal of *Codex Planetarius* is to measure and manage the key environmental impacts of food production, acknowledging that while some resources may be renewable, they may be consumed at a faster rate than the planet can renew them.

The global production of food has had the largest impact of any human activity on the planet. Continuing increases in population and per capita income, accompanied by dietary shifts, are putting even more pressure on the planet and its ability to regenerate renewable resources. We need to reduce food production's key impacts.

The impacts of food production are not spread evenly among producers. Data across commodities suggest that the bottom 10-20% of producers account for 60-80% of the impacts associated globally with producing any commodity, even though they produce only 5-10% of the product. We need to focus on the bottom.

Once approved, *Codex Planetarius* will provide governments and trade authorities with a baseline for environmental performance in the global trade of food and soft commodities. It won't replace what governments already do. Rather, it will help build consensus about key impacts, how to measure them, and what minimum acceptable performance should be for global trade. We need a common escalator of continuous improvement.

These papers are part of a multiyear proof of concept to answer questions and explore issues, launch an informed discussion, and help create a pathway to assess the overall viability of *Codex Planetarius*. We believe *Codex Planetarius* would improve food production and reduce its environmental impact on the planet.

This proof-of-concept research and analysis is funded by the Gordon and Betty Moore Foundation and led by World Wildlife Fund in collaboration with a number of global organizations and experts.

For more information, visit www.codexplanetarius.org

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Executive Summary

This study assessed the applicability of *Codex Planetarius* environmental performance metrics within Ghana's cocoa sector, with a specific focus on data availability, measurement feasibility and institutional readiness. Using a mixed-methods approach, the assessment combined a targeted desk review, expert consultations, and field-level data collection across selected cocoa farms to test the practicality of implementing *Codex Planetarius* indicators in a smallholder-dominated production system.

The analysis confirms that all six *Codex Planetarius* environmental categories – soil health, water use, water effluent, emissions, biodiversity and land use change – can be measured within the Ghanaian cocoa context using a combination of farmer-collected field data and institutional datasets. However, the feasibility, cost, and level of technical complexity vary across categories.

Field testing demonstrated that farmers can reliably collect basic environmental data, including soil pH and temperature, water pH, electrical conductivity, total dissolved solids, salinity, shade tree counts, and GPS-based farm boundary coordinates. These data provide critical inputs for environmental performance screening and prioritisation. A key finding of the study is that existing national systems are sufficient to support *Codex Planetarius* implementation, provided they are better coordinated and harmonized. A tiered data-collection model combining farmer-led measurements and institutional validation and remote sensing was identified as the most practical and scalable approach.

The study concludes that *Codex Planetarius* is implementable within Ghana's cocoa sector and that all required data can be generated using current tools and capacities. The Ghana Cocoa Board (COCOBOD) is well positioned to serve as the lead directorate for coordination, standardisation and oversight, and working in collaboration with relevant research institutions and regulatory agencies. With clear governance arrangements, prioritized indicators and targeted capacity support, *Codex Planetarius* can be operationalized.

1 Introduction

1.1 Background

Codex Planetarius is an emerging sustainability-oriented framework that draws inspiration from the *Codex Alimentarius*, the internationally recognized collection of standards, codes of practice, guidelines, and recommendations jointly developed by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) of the United Nations (Clay, 2016). While *Codex Alimentarius* provides a global reference for food safety, quality, production, and labelling, *Codex Planetarius* seeks to extend similar principles to environmental sustainability by establishing standardized approaches for assessing the environmental performance of agricultural production systems (Docherty, 2025). Central to this framework is the concept of planetary carrying capacity and the sustainable management of renewable natural resources upon which food systems depend.

To support the future development of *Codex Planetarius*, WWF is undertaking research to test the application of *Codex* principles across 10 real-world agricultural supply chains through pilot studies. These pilots aim to generate evidence on data availability, measurement feasibility, and institutional readiness to inform the development of single-indicator environmental performance standards for agricultural production.

Ghana's cocoa sector was selected as a pilot case study due to its global significance, its predominantly smallholder-based production structure, and its considerable environmental footprint. Cocoa is a major internationally traded commodity and a critical source of income for rural livelihoods in Ghana, with over 800,000 farming households cultivating between one and two million hectares of land (Lody, 2024). Production is overwhelmingly undertaken by smallholders, with only a limited proportion of farms managed directly by the Ghana Cocoa Board (COCOBOD). Despite its socio-economic importance, cocoa production in Ghana has been strongly associated with deforestation, biodiversity loss, and land use change, particularly in the high forest zones (Ashiagbor et al., 2022; Kalischek et al., 2023).

This study was conducted in Ghana between October and December 2025 to assess the applicability of *Codex Planetarius* principles to cocoa production in Ghana. The research examined the availability, quality and coverage of farm-level data and sustainability practices. It also reviewed existing environmental regulations, standards, and monitoring systems relevant to agricultural production across the six *Codex Planetarius* environmental performance categories: soil health, water use, water effluent, emissions, biodiversity and land use change.

Beyond baseline establishment, the study collected and analyzed pilot field data across a representative sample of cocoa farms to assess the relevance, measurability and practicality of each *Codex* category within a smallholder-dominated production system, including constraints related to data availability, cost, and frequency of collection.

The findings of this assessment provide an evidence base to inform the future development of *Codex Planetarius* environmental performance standards for cocoa production. Specifically, the study offers insights into appropriate data collection requirements, capacity constraints, standard-setting approaches, and regulatory implications.

1.2 Study Objectives

The overall objective of this study was to assess the applicability and feasibility of the *Codex Planetarius* framework within Ghana's smallholder cocoa production system. Specifically, the study sought to evaluate the relevance, measurability, and practicality of *Codex Planetarius* environmental performance categories in the context of existing production structures, data systems, and institutional capacities.

The specific objectives of the study were to:

1. Establish a baseline of environmental performance indicators across Ghana's cocoa sector in relation to the six *Codex Planetarius* categories
2. Assess the availability of farm-level and institutional data relevant to *Codex Planetarius* implementation
3. Identify data gaps, methodological constraints and capacity limitations affecting consistent environmental performance measurement
4. Examine the alignment of *Codex Planetarius* metrics with existing national monitoring frameworks, policies and regulatory instruments.

1.3 Overall Approach

The study adopted a mixed-methods approach combining desk-based research, expert consultation, and targeted field data collection to assess the applicability of *Codex Planetarius* principles to cocoa production in Ghana. The approach was iterative and adaptive, allowing findings from the desk study and expert consultations to inform field data collection and analysis.

2 Desk Study and Literature Review

A comprehensive desk study was conducted to review existing literature, policies, standards, and datasets relevant to cocoa production and environmental performance in Ghana. This included an assessment of Codex Planetarius principles and metrics, national environmental and agricultural regulations, and sustainability standards for cocoa production. The review focused on identifying existing indicators, measurement methodologies, data sources and known limitations across the six *Codex* categories: soil health, water use, water effluent, emissions, biodiversity and land use change.

2.1 Summary of Major Literature Review Findings

The literature review confirmed that all six *Codex Planetarius* environmental performance metrics are directly relevant to cocoa production in Ghana. However, the evidence indicates notable differences in their criticality, measurability, cost, and practicality, particularly within a smallholder-dominated production system.

Soil health emerges as one of the most important and useful metrics for cocoa sustainability. (Amponsah-Doku et al., 2022). Due to nutrient mining, low organic matter inputs, and ongoing cultivation on naturally nutrient-poor Acrisols and Ferralsols, studies regularly show deteriorating soil fertility throughout cocoa-growing countries (Woomer, 2012). Soil Organic Carbon (SOC) is the most-used indicator. Soil pH, bulk density, macronutrients (N, P, and K), and soil texture are additional typical indications.

Given Ghana's cocoa belt's rising rainfall variability, frequency of droughts, and soil moisture stress, **water use** is also an extremely important parameter. The most useful indicators are considered to be seasonal rainfall, soil moisture, and water productivity. Research indicates that during drought years, cocoa yields might drop by as much as 40%, underscoring the necessity of efficient water stress monitoring (Attiogbé et al ., 2024). Rainfall data is widely accessible and reasonably priced, especially through national meteorological stations and satellite products like CHIRPS (Atiah et al., 2020). However, direct measuring of photosynthesis, stomatal conductance, and evapotranspiration necessitates specific tools and knowledge, making them inappropriate for regular farm-level monitoring.

Water effluent is recognized as an important, yet highly technical, metric. According to Affum et al. (2018), surface water in cocoa landscapes has been found to be contaminated by pesticides and nutrients, sometimes above international safety standards. Turbidity, pH, nitrate and phosphate concentrations, and pesticide residues are important markers. According to the literature, laboratory requirements, safety concerns, and expenses (approximately USD $20–40 per sample, excluding logistics) make it impossible for farmers to actually gather this data.

The main causes of **emissions** in cocoa systems are changes in land use, biomass loss, and soil carbon depletion (Supriadi et al., 2022). Because absolute emissions assessment is expensive and technically difficult, smallholders cannot afford it. Rather, the research endorses the use of carbon stock change and emissions intensity (kg CO_2e per kilogramme of cocoa) as practical indices. Model-based tools, such the Cool Farm Tool and FAO's EX-ACT, are frequently mentioned as economical methods that integrate emission parameters with farm activity data (Colomb et al., 2012). While institutions handle models and validation, farmers can give crucial input data, such as fertilizer use, shade tree density, and management techniques. Accuracy, scalability, and cost management are all balanced in this method.

At a national and landscape level, institutions such as the Forestry Commission, the Environmental Protection Agency (EPA), and the Ministry of Environment, Science, Technology and Innovation (MESTI) maintain emissions-related datasets through REDD+ Measurement, Reporting and Verification (MRV) systems, national greenhouse gas inventories, and forest carbon-stock assessments. At the farm level, COCOBOD maintains production, management and spatial data through the Cocoa Management System (CMS), providing essential activity data for emissions modelling, including farm size, cocoa yields, shade tree presence, and fertiliser distribution records.

Biodiversity – According to research, cocoa agroforestry systems may sustain a substantial amount of biodiversity, including native tree species, birds, and pollinators, especially in areas with more than 30% canopy cover (Nair et al., 2022). On the other hand, species richness and habitat connectivity are greatly diminished by intensification and conversion to full-sun cocoa. With remote sensing offering scalable and affordable measurement techniques, canopy cover and shade-tree density appear as useful proxy indicators for biodiversity monitoring.

Land Use Change – The most significant environmental impact of cocoa production in Ghana has regularly been found to be land use change, particularly deforestation caused by cocoa (Ashiagbor et al., 2022). Remote sensing is commonly used to monitor well-established indicators such as yearly forest loss, changes in canopy cover, and growth into wooded regions. Land use change monitoring is very economical and operationally advanced when compared to other indicators, and satellite data is readily accessible and scalable at the national level. Furthermore, Ghana's Cocoa & Forests Initiative, and new international laws like the EU Deforestation Regulation, are all highly aligned, making this metric useful and pertinent to policy.

The literature review revealed that Ghana has strong technical competence across all six metrics due to organizations like COCOBOD, CSIR, the Forestry Commission, the Environmental Protection Agency (EPA), and academic institutions. However, monitoring methods continue to be dispersed, project-based, and inconsistently implemented.

3 Expert Consultation

Expert consultations formed a central component of the study methodology and were undertaken to validate the relevance, feasibility and practicality of *Codex Planetarius* metrics for cocoa production in Ghana. The consultations brought together experts from research institutions and academia with technical expertise across soil science, hydrology, climate science, biodiversity conservation, land-use monitoring, and agricultural sustainability. The workshop was conducted on the 4th of December 2025 at the Angehill hotel in Ghana.

The consultations focused on three core issues:

- **(i)** identifying appropriate indicators and measurement methods for each *Codex* category;
- **(ii)** clarifying institutional roles and responsibilities for data collection; and
- **(iii)** assessing the feasibility of farmer-led versus institution-led data collection, including associated costs and capacity requirements.

Figure 1: Experts consultation workshop on *Codex Planetarius*

Figure 2: Mr. Alexander Owusu Ansah presenting on soil health metrics

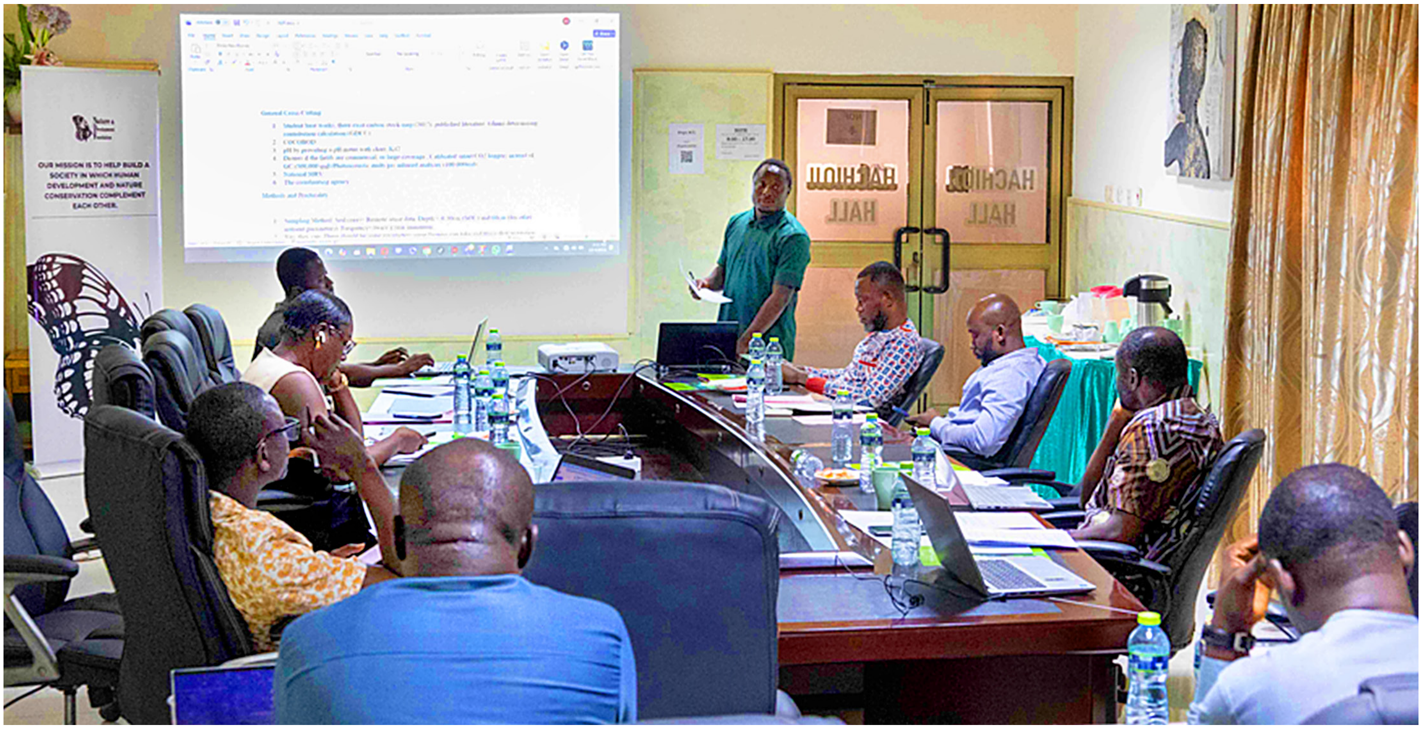
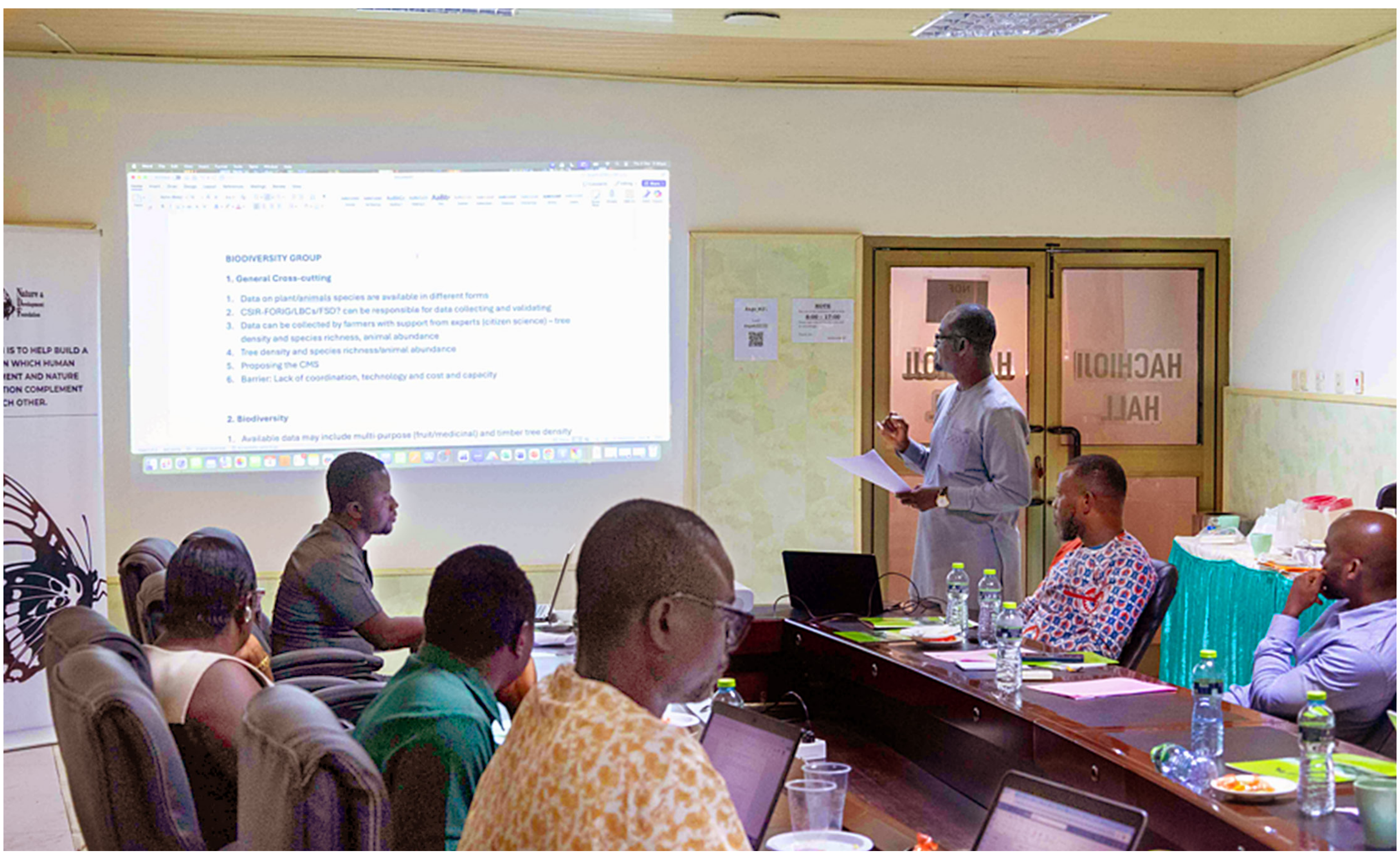


Figure 3: Dr. Shalom from CSIR FORIG presenting on metrics for biodiversity and land use change



3.1 Major Findings from Expert Discussions

Soil Health

Experts identified Soil Organic Carbon (SOC) as the most suitable indicator for testing soil health. Experts recommended SOC measurements at 0–30 cm depth, complemented by deeper nutrient profiling (up to 60 cm) to capture long-term fertility trends.

Consultations suggested that thorough soil analysis necessitates institutional support while farmers may practically gather fundamental soil health data – such as soil pH, visual soil structure assessments, and organic matter estimates using basic field instruments. It was determined that advanced metrics such as bulk density, nutrient concentrations, heavy metals, and biological indicators (microbial biomass, fungi, and nematodes) were too complex for farmers to handle and needed to be handled by recognized laboratories. One of the main obstacles identified was the high cost of a complete soil laboratory examination.

SOC data are available and may be accessed through research institutions and universities, typically at no cost or for a minimal fee. These data are primarily generated through externally funded research projects and academic studies. Institutions such as the Council for Scientific and Industrial Research (CSIR), universities, and the Environmental Protection Agency (EPA) have generated SOC datasets through soil surveys, long-term trials and landscape assessments, including applications of the Land Degradation Surveillance Framework (LDSF) (Diwediga et al., 2022). These datasets provide reliable baseline information and are suitable for regional assessments and trend analysis, but they are not collected systematically or frequently enough to support continuous SOC monitoring at individual smallholder farms.

Emissions

Direct measurement of CO_2, N_2O, and CH_4 fluxes was deemed technically difficult and expensive, according to experts, making it unfeasible for regular farm-level monitoring. Rather, consultations suggested using model-based methods that combine remote sensing and proven emission parameters with agricultural practice data (such as fertiliser inputs and shade-tree density).

A more practical entry point for *Codex Planetarius* was determined to be carbon stock change, namely above-ground biomass and canopy cover. Experts underscored that while institutions would be in charge of biomass modelling, calibration, and validation utilising remote sensing, plot inventories, and national forest information, farmers may contribute basic data like shade tree counts.

Monitoring changes in carbon stocks on farms is carried out by institutions with expertise in remote sensing, forest inventories, and modelling. The Forestry Commission (FC) of Ghana, through its technical arm, the Resource Management Support Centre (RMSC) collects spatial data, maps forest cover changes, and supports biomass estimation. The Forest Research Institute of Ghana (FORIG) undertakes allometric modelling and conducts research on carbon stocks. The Centre for Remote Sensing and Geographic Information Services (CERSGIS) at the University of Ghana performs remote sensing processing and GIS analyses, which are essential for carbon mapping and detecting changes over time. Additionally, universities such as the Kwame Nkrumah University of Science and Technology (KNUST) conduct studies on land use, biomass modelling, and environmental monitoring. The Ghana Cocoa Board (COCOBOD) also contributes cocoa farm management and tree cover data relevant to carbon accounting in agricultural landscapes.

The costs of a remote sensing–assisted carbon stock monitoring system can include several components. Monitoring system costs, field inventory costs, which vary depending on sample size, travel logistics, and labor requirements (Forestry Commission, 2015). While some data may be free or low-cost, there are additional implicit costs related to computing infrastructure, analytical software, and expert labor needed to process and model the data. Certain globally available remote sensing datasets, such as Sentinel-2 and Landsat imagery, are free of charge and can be supplemented with targeted field inventory data and, if necessary, UAV or other advanced remote sensing data.

Water Effluent

There was broad agreement that, given the technological demands and health hazards involved, water effluent monitoring should continue to be institution-led. Experts emphasized that farmers are unable to accurately evaluate nutritional quantities, pesticide residues, or heavy metals. In high-risk cocoa zones, it was advised to sample surface water seasonally or quarterly and have accredited institutions perform laboratory examination.

Additionally, experts recommended that *Codex Planetarius* prioritise high-input cocoa landscapes and regions with direct hydrological links to streams by implementing a risk-based monitoring strategy. Instead of concentrating on chemical measurement per se, farmer engagement should emphasise compliance-oriented behaviors including safe pesticide handling, riparian buffer maintenance, and integrated pest management.

Water Use

Consultations confirmed that cocoa production in Ghana is highly sensitive to rainfall variability and soil moisture deficits. Experts agreed that basic water-use data collection can be partially farmer-led, particularly rainfall measurements using manual rain gauges and simple water-level observations where appropriate.

However, advanced indicators such as evapotranspiration, water-use efficiency, plant water stress and derived indices (e.g. NDVI, SPI) were deemed institution-dependent due to the cost and technical complexity of required instruments. Experts recommended combining farmer-collected rainfall data with institutional datasets from the Ghana Meteorological Agency and satellite-based products to reduce costs and improve spatial coverage.

The Ghana Meteorological Agency (GMA) maintains a national network of synoptic and agro-meteorological stations that collect rainfall, temperature, humidity and other climate variables across the country (Gbangou, 2021). These stations provide the most accurate ground-based rainfall measurements available in Ghana, as they follow internationally standardised measurement protocols under the World Meteorological Organization framework (Ghana Meteorological Agency, 2024). However, spatial coverage remains uneven, particularly in remote cocoa-growing areas, and station density is not sufficient to capture micro-climatic variability at the farm scale.

To complement ground observations, satellite-derived Earth Observation (EO) rainfall datasets such as CHIRPS, TAMSAT and other gridded precipitation products are increasingly used in Ghana (Atiah et al., 2020). These datasets provide near-complete spatial coverage and are particularly useful in areas without weather stations. While EO rainfall estimates are generally reliable for seasonal and regional trend analysis, their accuracy can vary depending on topography, cloud dynamics and calibration with ground stations. Studies in West Africa indicate that EO rainfall products perform reasonably well when validated against station data but may under- or over-estimate rainfall at very local scales. Therefore, the most robust approach involves blending GMA station data with satellite products to improve spatial resolution and reliability (Mekonnen et al., 2023; Balogun et al., 2018).

Regarding farmer-level rainfall data, systematic collection is not yet widespread. Some development projects and sustainability certification schemes have distributed manual rain gauges to selected farmer groups, but there is no nationally coordinated program for routine farmer-recorded rainfall data across cocoa landscapes. Where farmers do record rainfall, data consistency and standardization can vary due to differences in measurement practices and record-keeping capacity. Consequently, farmer-collected rainfall data remain supplementary rather than central to national climate-monitoring systems.

Biodiversity

Biodiversity is one category where farmer participation is both possible and beneficial, according to experts. With the right training, farmers can consistently gather fundamental data like shade tree counts, GPS coordinates of farm boundaries, and photos of habitats. For institutional evaluations of canopy cover, species richness, and habitat connectivity, these data are essential inputs.

It was determined that advanced biodiversity evaluations, such as species identification, soil macrofauna analysis, and bird surveys needed institutional supervision and qualified staff. For routine *Codex* monitoring, experts advised using proxy indicators like canopy cover percentage and shade tree density, backed by recurring in-depth inspections at sentinel sites.

Land Use Change

With established monitoring systems currently in place, land use change was found to be the most technically advanced *Codex* category. Experts attested to the fact that satellite-based remote sensing, when paired with GIS analysis, provides scalable and affordable detection of changes in canopy cover, deforestation, and farm expansion.

Using GPS coordinates and photographic data, farmer participation was deemed crucial for ground-truthing and border verification. Land-use classification, mapping forest decline, and integration with national datasets such as those kept up to date by the Forestry Commission as well as international platforms, are among the institutional duties.

Cross-Cutting Insights

Across all six *Codex* categories, experts highlighted that Ghana possesses strong technical capacity within research institutions and government agencies, but data collection systems remain fragmented and unevenly applied. The consultations underscored the importance of tiered data collection approaches that clearly distinguish farmer-collectable indicators from institution-led measurements. Cost, laboratory capacity and long-term sustainability of monitoring systems were identified as key considerations for *Codex Planetarius* implementation.

Overall, expert consultations confirmed that *Codex Planetarius* is technically feasible in the Ghanaian cocoa context, provided that indicators are prioritized, proxy measures are adopted where appropriate, and institutional roles are clearly defined to support smallholder participation.

Table 1: Summary of findings from the experts consultation (soil health, emmissions, water effluent, water use, biodiversity, land use change)

Soil Health

Codex Metric	Measurement Indicators	Methods for Data Collection	Who Collects the Data	Farmer-Collectable Data	Research-Institution Data	Instruments Used	Cost (Approx.)	Relevant Research / Gov Institutions
Soil Organic Carbon (SOC) & Soil Health	SOC (0–30 cm), Nutrients (0–60 cm), pH, EC, OM, NPK, Ca, Mg, Na, Acidity, Bulk Density, Texture, Biological indicators (earthworms, fungi, bacteria)	Soil cores, auger sampling; Lab analysis; Remote sensing	Farmer (basic), Institution (full)	pH (using meter + chart), Organic matter (simple color chart), Visual soil assessment	Texture, Bulk density, NPK, heavy metals, biological assays (bacteria, fungi, nematodes)	Auger, soil core, earth chisel, knife, pH meter, K12 kit	GHS 2,220 per full soil sample (lab-based)	CSIR-SRI, CSIR-FORIG, COCOBOD, Universities (UG, KNUST), EPA
Soil Physical Properties	Texture, Structure, Bulk Density pH, EC, NPK, cations, heavy metals	Field sampling + lab analysis Field pH; lab chemical assays	Institution Farmer (pH only), Institution	None pH	All parameters All chemical tests	Auger, bulk density cylinder pH meter, lab reagents	Included above Included above	Research institutions & certified labs CSIR, COCOBOD
Soil Chemical Properties	pH, EC, NPK, cations, heavy metals	Field pH; lab chemical assays	Farmer (pH only), Institution	pH	All chemical tests	pH meter, lab reagents	Included above	CSIR, COCOBOD
Soil Biological Health	Earthworm density, microbial biomass	Field counts; lab assays	Institution	Earthworm count	Microbial analysis	Trowel, lab equipment	Included above	CSIR-FORIG, Universities

Emmissions

Metric	Measurement Indicators	Methods	Who Collects	Farmer Data	Institution Data	Instruments	Cost	Relevant Institutions
GHG Emissions (Soil & Farm-level)	CO_2, N_2O, CH_4 fluxes; Emission factors	Carbon inventory; Remote sensing; Sample-based modelling	COCOBOD, Research Institutions Institutions	Fertilizer inputs, shade trees, farm practices	Carbon flux modelling, soil emissions factors, calibration	CO_2 smart loggers, remote sensing tools	High; depends on sensors	COCOBOD, EPA, Universities, CSIR
Carbon Stock Changes	Biomass estimates, shade cover	Remote sensing, plot surveys	Institutions	Shade tree counts	Biomass modelling	Drones, GPS	Variable	FC/RMSC, FORIG

Water Effluent

Metric	Indicators	Methods	Who Collects	Farmer Data	Institution Data	Instruments	Cost	Relevant Institutions
Water Quality	Heavy metals (Pb, As, Hg, Cd, Cr, Ni), pesticide residues, pH, EC, turbidity	Seasonal/ quarterly sampling; lab analysis	Institution only	None (farmers cannot measure)	All chemical/ microbial parameters	Water sampling bottles; lab instruments	GHS 400–600 per sample	CSIR-WRI, EPA, GMet, HYDRO
Effluent & Stream Health	Streamflow, sediment load	Streamflow monitoring	Institutions	Water level (with training)	Hydrology measurements	Water level gauge	Varies	HYDRO, CSIR-WRI

Water Use

Metric	Indicators	Methods	Who Collects	Farmer Data	Institution Data	Instruments Used	Cost	Relevant Institutions
Water Use & Stress	Rainfall, soil moisture, water level, WUE, stomatal conductance, photosynthesis, dry spells, ET, SPI, NDVI stress	Daily measurements; seasonal assessments; modelling	Farmer (basic), Institutions (advanced)	Rainfall, water level, soil moisture	Soil water potential, WUE, photosynthesis, derived indices	Tensiometer, AWS, Scholander chamber, MiniPAM, CIRAS-3	AWS: $2,000–15,000; Pressure chamber: $1,500–4,000; Tensiometer: $5,000–100,000	GMet, HYDRO, CSIR-WRI, UG
Rainfall Monitoring	Daily rainfall	Manual rain gauge; automated stations	Farmer + GMet	Daily rainfall	AWS data	Rain gauge, AWS	Variable	GMet

Biodiversity

Metric	Indicators	Methods	Who Collects	Farmer Data	Institution Data	Instruments	Cost	Relevant Institutions
Biodiversity	Tree density, species richness, soil macrofauna, birds	Tree inventory, point counts, photo evidence, GPS	Farmer (basic), Institution (full)	Shade tree counts, habitat assessment, GPS boundaries Rainfall, water level, soil moisture	Species ID, soil fauna, detailed biodiversity	GPS, mobile phone, camera	Variable (training, logistics)	CSIR-FORIG, University of Ghana, IITA, FC, LBCs

Land Use Change

Metric	Indicators	Methods	Who Collects	Farmer Data	Institution Data	Instruments	Cost	Relevant Institutions
Land Use Change	Deforestation, forest loss, canopy cover change, farm expansion	Remote sensing, GIS mapping; field verification, Satellite (Sentinel-2, GFW), drones	Institutions + farmers (for boundary verification)	GPS coordinates, photos of boundaries	LULC classification, forest loss mapping	GPS, drone, satellite imagery	Varies	FC/RMSC, CERGIS, Global Forest Watch, Universities

Farmer-Level Field Data Collection in Ghana's Smallholder Cocoa Sector

A key element of adopting *Codex Planetarius* in Ghana's smallholder cocoa sector is farmer engagement in field data collecting. Farmers can reliably gather observational and activity-based data, which, when combined with institutional datasets, provide crucial inputs for environmental performance assessments and enable a useful, scalable approach to sustainability monitoring, even though they are unable to perform intricate laboratory or highly technical measurements.

Basic soil health indicators, such as soil pH, visual evaluations of color, texture, and structure, basic assessments of organic matter content, basic measures of soil moisture, and earthworm counts, can be collected by farmers to provide early signals of soil condition and management efficacy. These are useful for monitoring trends and ranking farms for additional research, but they do not take the place of in-depth laboratory analyses. Because of their complexity and expense, full chemical studies, biological assays, and heavy metal testing are still conducted by institutions.

Farmers are unable to monitor greenhouse gas emissions directly, but they may contribute important activity data on things like fertilizer application, the usage of compost or biochar, the density of shade trees, and farm management techniques. These inputs enable accurate calculation of emissions intensity and changes in the carbon stock when combined with emission factors and remote sensing data. It is possible and essential to relate practices to spatially explicit assessments using basic farm logbooks and GPS data.

Due to technical, safety, and laboratory constraints, farmer participation in water effluent data collection is restricted and instead concentrated on compliance measures such as safe chemical usage, buffer zone maintenance, and reporting. On the other hand, farmers can gather simple indications of water usage and stress, such as measurements of rainfall, observations of water levels, measurements of soil moisture, and visual monitoring of plant stress. While sophisticated measurements are still dominated by institutions, these datasets supplement satellite and institutional climate data.

Farmers also contribute to biodiversity monitoring by counting shade trees, identifying species using local names, observing habitats, taking photos, and mapping farm boundaries. While thorough species surveys continue to be led by institutions, these inputs enhance spatial coverage and help institutional biodiversity evaluations.

Across all *Codex Planetarius* metrics, farmers can contribute meaningful data when indicators are simple, observational, and activity-based, and when proper tools and training are provided.

Table 2: Data collectable by farmers

Codex Metric	What a Farmer Can Collect	Tools Needed	Notes for Fieldwork
1. Soil (SOC & Soil Health)	- Soil pH readings - Organic matter (colour/texture observation) - Basic soil moisture - Visual soil characteristics (color, structure) - Earthworm counts (simple field count)	- pH meter + color chart - Simple organic matter chart - Soil moisture probe (if trained) - Hand trowel - Clean sample bags	Farmers can collect basic indicators. Full chemical, biological & heavy metal tests must be done by institutions.
2. Emissions (Farm-level)	- Fertilizer application records - Compost/biochar use - Shade tree density - Farm management practices (mulching, burning, pruning)	Notebook / farm logbook- GPS	Farmers provide activity data
3. Water Effluent	None	None	Water quality requires lab testing and trained scientists.
4. Water Use & Water Stress	- Daily rainfall - Water level in nearby streams/wells (if gauge installed) - Soil moisture (with training) - Visual plant stress signs (wilting, leaf scorch)	- Manual rain gauge - Simple water level ruler/gauge - Soil moisture meter - Notebook for daily logging	Farmers can measure rainfall, water level & soil moisture. Tools like pressure chambers, MiniPAM & CIRAS-3 require experts.
5. Biodiversity	- Shade tree counts - Tree species (common names) - Simple habitat condition observations - Photos of wildlife or habitat features - GPS points of farm boundary	- Mobile phone (camera + GPS) - Notebook - Field sheets	Farmers can support citizen science biodiversity monitoring with photo evidence and basic counts.
6. Land Use Change	- Farm boundary GPS points - Photos showing land cover condition - Records of any changes (new planting, clearing)	- Smartphone GPS - Camera	

4 Field Data Collection

Targeted field data collection was conducted throughout representative cocoa farms in the Eastern, Central, Ashanti, and Ahafo regions of Ghana based on the established criteria and indicators from the desk review and expert consultations. With an emphasis on identifying the practicality of farmer-led data gathering and reporting and possible expenses and constraint. The fieldwork assessed the viability of gathering farm-level data across production indicators and the six *Codex* environmental categories.

Table 3: Field data collection

Codex Metric	Data Collected	Tools Used
1. Soil (SOC & Soil Health)	- Soil pH readings, Basic soil moisture, Soil temperature	- pH meter - Hand trowel - Clean sample bags
2. Emissions (Farm-level)	- Fertilizer application records - Compost/biochar use - Shade tree density - Farm management practices (mulching, burning, pruning)	- Notebook
3. Water Use & Effluent	- Water pH. TSD, temperature, Electrical Conductivity, salinity	- Water pH meter, Notebook for daily logging
4. Biodiversity	- Shade tree counts - Tree species (common names) - Simple habitat condition observations - Photos of wildlife or habitat features - GPS points of farm boundary	- Mobile phone (camera + GPS) - Notebook - Field sheets
5. Land Use Change	- Farm boundary GPS points - Photos showing land cover condition - Records of any changes	- Smartphone GPS - Camera

4.1 Study Area

The study was conducted across representative cocoa farms in four major cocoa-producing regions of Ghana: Eastern, Central, Ahafo, and Ashanti. Targeted farm locations were selected to capture regional variation in environmental conditions, farm management practices, and smallholder characteristics. Data collection was carried out between 11th and 17th December 2025, following the indicators and criteria established through desk reviews and expert consultations. These locations are part of Ghana's humid tropical cocoa belt, which is distinguished by semi-deciduous forest landscapes and bimodal rainfall patterns that are essential to the cultivation of rain-fed cocoa. Without management interventions like organic inputs or customised fertilization techniques, cocoa soils in this agroecological zone are usually highly weathered and nutrient poor. They are primarily made up of classes like Acrisols, Lixisols, and related soil types (with Acrisols frequently making up the majority), which exhibit low pH and limited organic matter (Dawoe et al., 2014; Doe et al., 2022).

With average annual rainfall often measuring between 1,200 and 1,650 mm and mean temperatures between 24 and 29 ° C, the climate in the cocoa belt is generally humid and conducive to cocoa development (Buxton, 2018).

Collecting field-level data from these diverse agroecological and management contexts provides a comprehensive understanding of cocoa production and environmental sustainability across Ghana’s key cocoa landscapes.

Table 4: Data collection location and dates

Region	Farm Location	Date of Data Collection	Coordinates of Farm
Eastern	Koforidua	11th December 2025	N 06° 02.3228 ′ W 000° 12.7074′
Central	Odoben	12th December 2025	N 05° 38.6329′ W 000° 53.8387′
Ahafo	Dadiesoaba	15th December 2025	N 06 ° 48.2165 ′ W 002 ° 22.5598 ′
Ashanti	Abofrem	17th December 2025	N 06° 30.6151 ′ W 002° 20.3292 ′

4.1.1 Soil pH Measurement Procedure

Soil Sampling:

Using portable pH meters, the pH of the soil was directly recorded in the cocoa farms without the need for laboratory analysis.

Soil samples were taken from the top 0–20 cm layer of each cocoa farm, which is the primary root zone of cocoa trees. To capture spatial heterogeneity, several subsamples (10–15) were taken throughout each plot using a stratified random sampling technique. For each farm location, a composite sample was created by combining these subsamples to produce a representative measurement. In some cases, the pH was tested in situ in the dug hole for comparisons

Measurement Using Portable pH Meters:

Two soil pH meters were purchased for the data collection. Debris was removed from the composite soil sample. A standardised ratio of soil to distilled water was mixed to create a soil-water mixture. Once stabilised, values were recorded using portable pH meters submerged in the mixture. Using portable pH meters in situ allowed for rapid, cost-effective assessment of soil acidity across multiple farms.

Figure 4: Distribution of soil pH values measured across regions. ***NB;*** *The dashed horizontal line indicates pH 6.0, representing the lower bound of the optimal range for cocoa cultivation.*

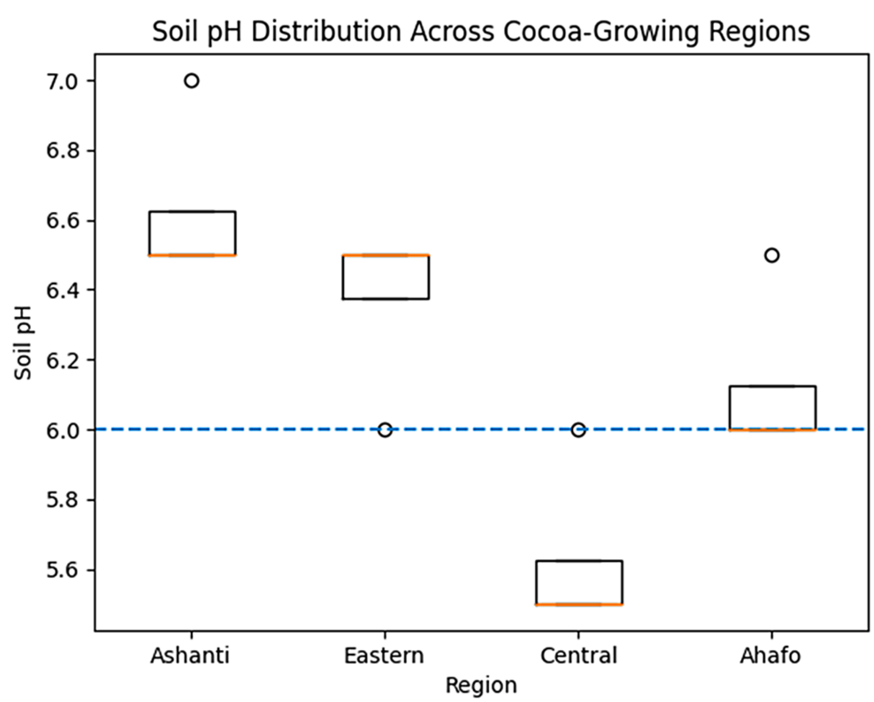


Table 5: pH and temperature readings

Region	Points	pH	Temperature (°C)
	A	6.5	22
	B	7	22
Ashanti	C	6.5	25
	D	6.5	24
Eastern	A	6.5	22
	B	6.5	24
	C	6	23
	D	6.5	23
	A	5.5	24
	B	5.5	23
Central	C	5.5	22
	D	6	24
	A	6	22
	B	6.5	23
Ahafo	C	6	22
	D	6	23

Analysis of Soil pH and Temperature Across Cocoa-Growing Regions

Across all sampled points, soil pH values ranged from 5.5 to 7.0, while soil temperatures ranged from 22 °C to 25 °C. These ranges indicate generally suitable conditions for cocoa cultivation, though notable regional differences were observed.

Regional Differences in Soil pH

With a mean pH of roughly 6.6 and values ranging from 6.5 to 7.0, the Ashanti Region had the highest soil pH readings. Given that they promote soil biological activity and increase nutrient availability, these nearly neutral conditions are ideal for cocoa growth. With pH values ranging from 6.0 to 6.5 and a mean of roughly 6.4, the Eastern Region's soils were moderately acidic, indicating stable and appropriate soil conditions throughout sample locations. The Central Region, on the other hand, regularly displayed lower pH values, with a mean of roughly 5.6 and ranging from 5.5 to 6.0. The pH values of 5.5 found in three of the four test locations, indicated extensive soil acidity that could restrict the availability of nutrients, especially phosphorus, and perhaps have an impact on long-term cocoa productivity if left unchecked. With pH readings ranging from 6.0 to 6.5 and a mean of roughly 6.1, the Ahafo Region found mildly acidic soils, indicating rather consistent soil conditions across farms.

According to studies on soil fertility in Ghana's cocoa landscapes, most cocoa soils typically have a pH between 5.6 and 7.2, which is considered to be suitable for cocoa production. However, values vary greatly depending on location and management history, with highly acidic soils being prevalent in many areas. While near-neutral soils (6.5–7.0) are typically better for cocoa cultivation and biological activity, soils below pH 6.0 can restrict nutrient uptake and microbial activity (Kongor et al. 2019). This will then agree with the results that locations, like Ahafo and Eastern, are more likely to offer stable soil conditions for cocoa than those with lower pH, like Central.

Overall, the findings suggest that the Ashanti, Eastern, and Ahafo Regions' soil pH levels are mostly within the ideal range for growing cocoa. However, the Central Region's continuously acidic conditions point to a greater risk of soil degradation and nutrient limitation. These results highlight the usefulness of regular, field-based soil pH monitoring as a useful metric for directing decisions about sustainable cocoa soil management.

Figure 5: Soil pH data collection in cocoa farms

4.1.2 Water Quality Measurement Procedure in Cocoa Farm Landscapes

Key physico-chemical parameters, such as pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, and temperature were measured directly in the cocoa farms using a portable multiparameter pH meter. Water measurements were obtained from nearby streams and available on-farm sources. Sampling locations were chosen to represent areas that might be impacted by agricultural practices including applying pesticides and fertilizers. In order to prevent chemical changes brought on by storage, transportation, or postponed analysis, measurements were carried out in situ. The pH, EC, TDS, salinity, and temperature of the water were all measured using a single portable multipurpose water quality meter.

The multiparameter meter's probe was immediately immersed in the waterbody at a short depth after being cleaned with distilled water at each sampling location. Once the numbers on the meter display stabilised, readings for pH, EC, TDS, salinity, and temperature were taken. Since the study concentrated on quick, field-based evaluation in line with realistic monitoring requirements in smallholder cocoa systems, no water samples were gathered for laboratory analysis.

Figure 6: Water parameters comparison

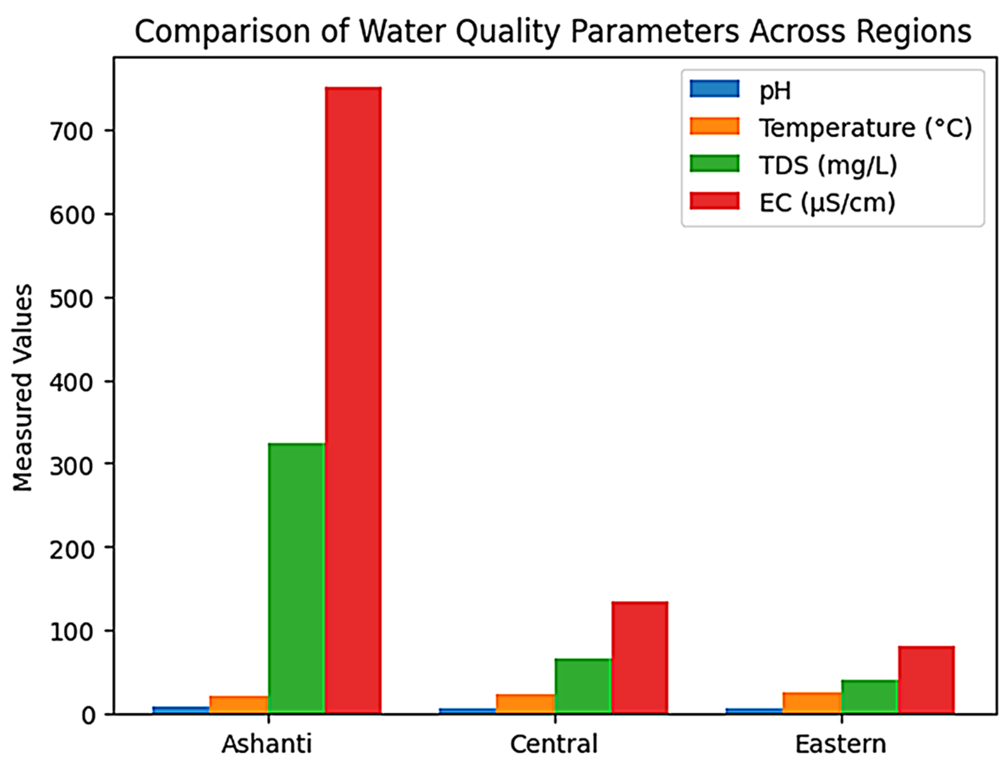


Table 6: Water quality parameters

Region	pH	Temperature	Salt Content	TDS	EC
Ashanti	8.2	22.5	0.02	325	750
CENTRAL	7.75	23.7	0	67	135
EASTERN	6	25.1	0	41	81

Different levels of mineral content and ionic composition were indicated by differences in pH, total dissolved solids (TDS), and electrical conductivity (EC) in the water quality assessment. The Ashanti Region's water has the highest pH (8.2), suggesting mildly alkaline conditions. In comparison to the other locations, this alkalinity and elevated TDS (325 mg/L) and EC (750 µS/cm) indicate a larger concentration of dissolved minerals and ions. Long-term usage of such water for supplemental irrigation or pesticide mixing could progressively raise soil alkalinity, even if it might not immediately hinder cocoa output. Increased EC levels may also lead to salt buildup over time, which could have an impact on root function and soil structure. Water quality metrics in the Central Region show generally favorable conditions. The pH of 7.75 is almost neutral to slightly alkaline, which promotes biological activity and nutrient stability. The relatively low TDS and EC values (67 mg/L and 135 µS/cm, respectively) suggested low salinity and little dissolved ionic content. These circumstances are unlikely to worsen the reduction in soil fertility and support steady nutrient dynamics and microbial activity in cocoa soils. As a result, there are less long-term concerns to soil health and water resources in the Central Region which is in good alignment with the chemical requirements of cocoa soil.

The water in the Eastern Region has the lowest TDS (41 mg/L) and EC (81 µS/cm) values among the three regions, as well as a somewhat acidic pH of 6.0. Although this water is generally excellent for producing cocoa, its acidity may exacerbate the acidity of the soil, which is typical in regions where severely weathered Acrisols and Ferralsols predominate. Continued usage of mildly acidic water could lead to additional soil acidification without sufficient organic matter inputs or liming, which could eventually impact cocoa root development and nutrient availability.

Figure 7: Testing water near cocoa farms for key physico-chemical parameters that might be impacted by agricultural practices.

4.1.3 Cocoa Farm Boundary Mapping

A handheld Garmin Global Positioning System (GPS) receiver was used to spatially map the borders of cocoa farms in order to get precise georeferenced data for land use and land use change analysis. Every cocoa farm was mapped in situ by utilizing a Garmin GPS to record geographic coordinates while traversing the whole farm's perimeter. At the beginning of the boundary walk, the "track" or "waypoint" recording feature was turned on and permitted to constantly record location points at regular intervals.

ArcGIS was used to visualize the GPS tracks and waypoints. Each cocoa farm was represented by a closed polygon feature created from the boundary points. Each polygon was associated with attribute data, such as farm identifiers and survey metadata. The spatial foundation for the ensuing land use analysis was established by these georeferenced farm boundaries.

To evaluate land use and land use change over time, satellite imagery and historical land cover datasets were superimposed on the GPS-mapped farm polygons.

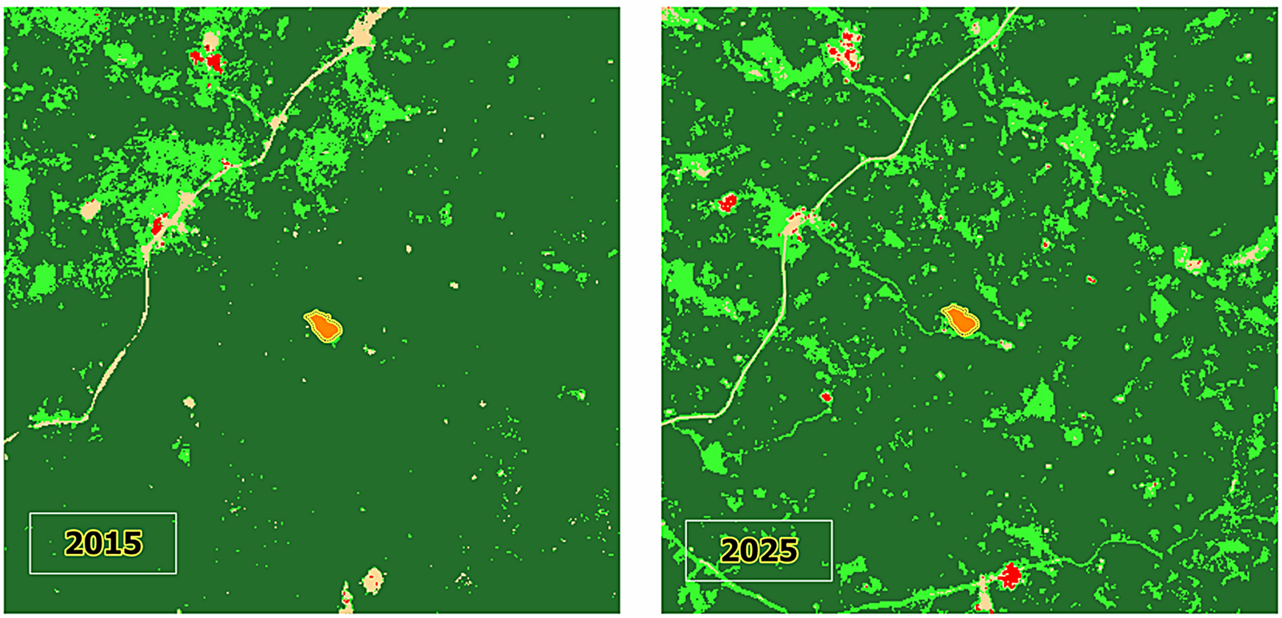
Figure 8: Using a handheld GPS receiver to spatially map the borders of cocoa farms for land use change analysis.

4.1.4 Land Use Change Analysis

With the Garmin GPS, polygons of plots were taken in all four regions and plots of interest. These polygons of both new and old cocoa farms were subjected to change analysis. Due to the relatively small plot sizes, the assessment was conducted on the wider areas rather than the specified cocoa farms as shown in Figures 9, 11, 12 and 13 below. We focused on two cocoa plots in Ahafo and Eastern Region to determine change in land use. These are presented as Figure 10 and Figure 14. In all regions, we observed change in the total dense forest areas as well as the sparse vegetation areas. There was reduction in dense vegetation in all areas except for Central Region. In all regions, the total area of sparse forests increased, probably due to conversion from dense vegetation, likely attributable to conversion to other crops including cocoa. Even though land use change analysis using remote sensing requires special expertise, it is a relatively easy means to assess and report change over cocoa production systems that can be easily reported to meet *Codex Planetarius* reporting requirements.

Figure 9: Land use change analysis for cocoa plot of interest and surrounding vegetation in the Ahafo Region

AHAFO



LEGEND
- Cocoa Farm
- Built Up
- Dense Vegetation
- Sparse Vegetation
- Bareland

LULC Class	Area 2015 (ha)	Area 2025 (ha)	Change (ha)	% Change
Built Up	8	40	+32	+400%
Dense Veg	6,873	6,369	-504	-7.3%
Sparse Veg	832	1,338	+506	+60.8%
Bareland	132	98	-34	-25.8%

N

0 0.5 1 1.5 2 2.5 km

Figure 10: Representation of change in cocoa land between 2015 to 2025

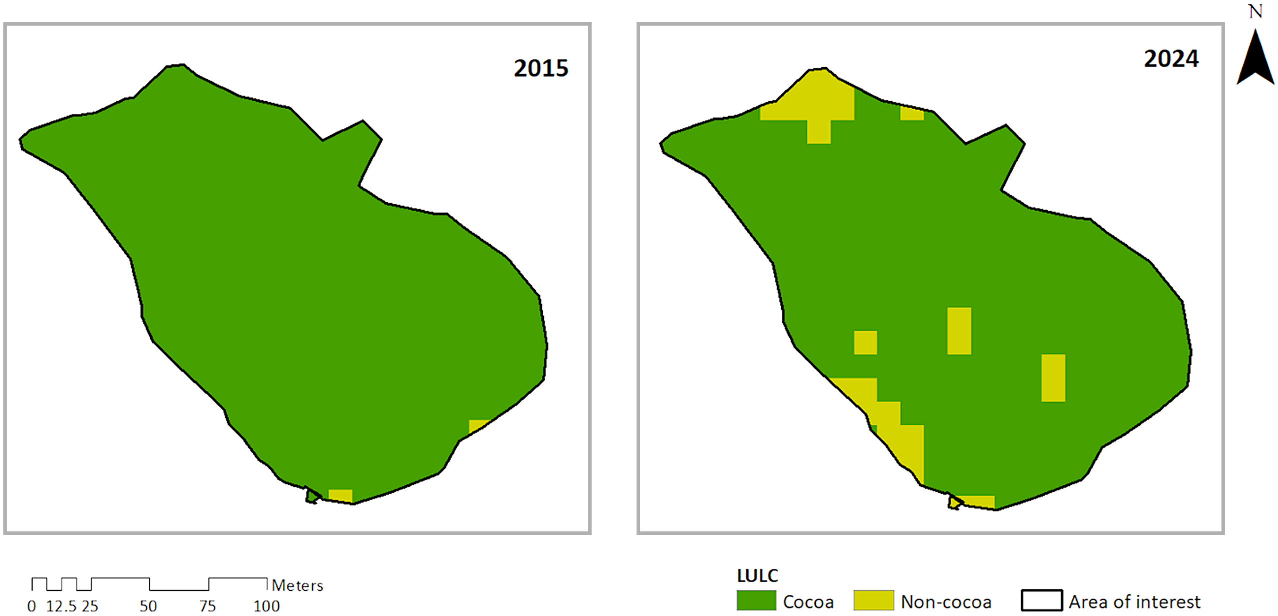
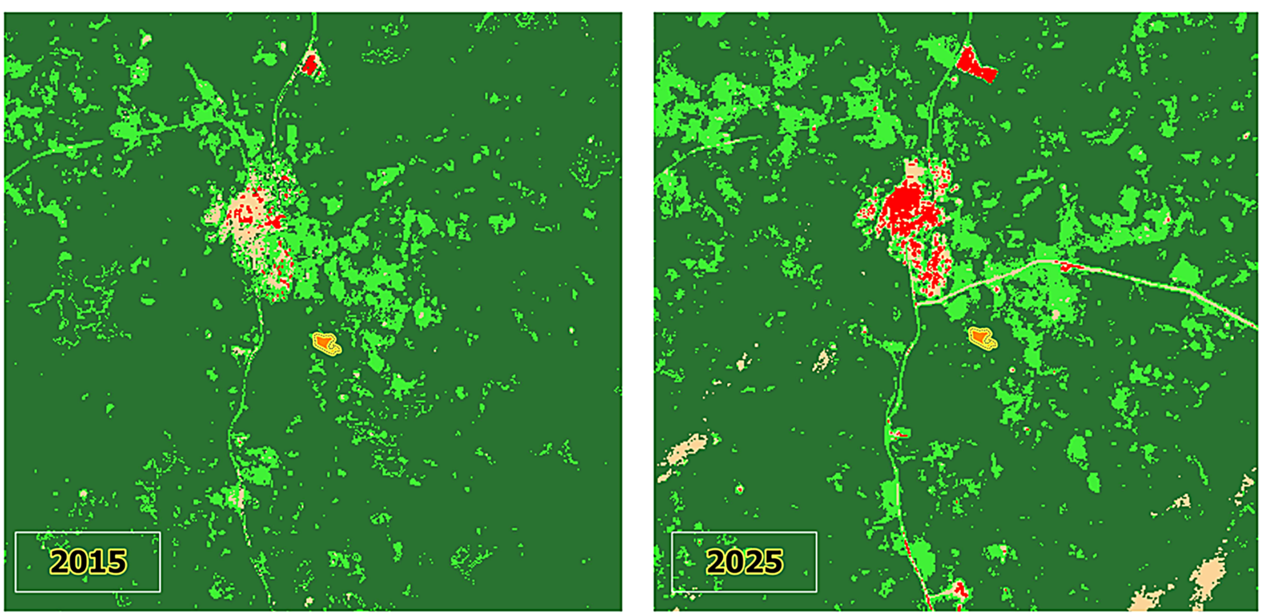


Figure 11: Land use change analysis for cocoa plot of interest and surrounding vegetation in the Ashanti Region

ASHANTI



LULC Class	Area 2015 (ha)	Area 2025 (ha)	Change (ha)	% Change
Built Up	15	246	+231	+1540.0%
Dense Veg	7,162	6,396	-766	-10.7%
Sparse Veg	631	1,009	+378	+59.9%
Bareland	138	193	+55	+39.9%

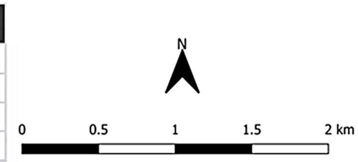
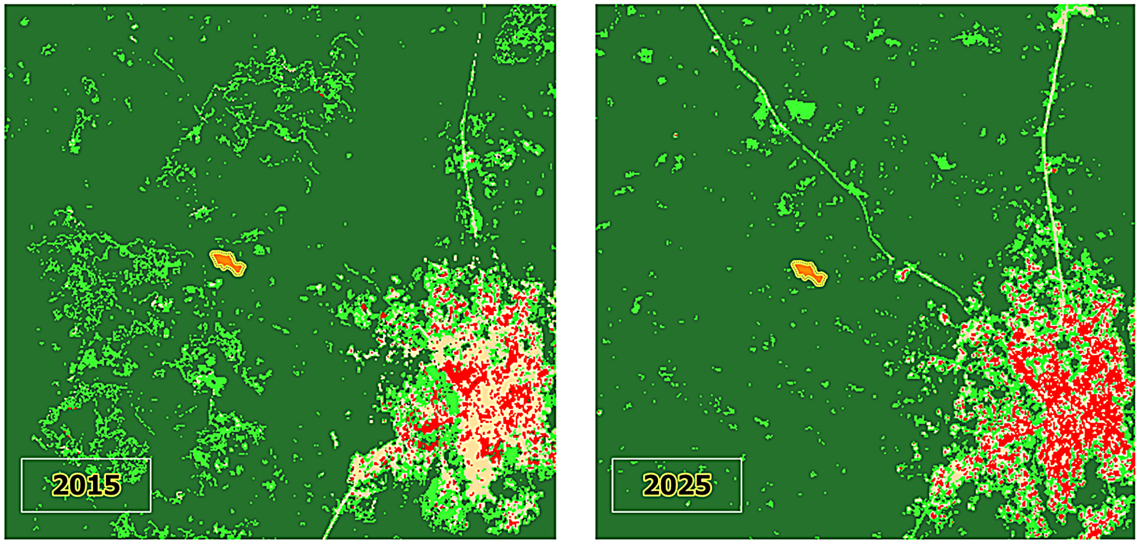


Figure 12: Land use change analysis for cocoa plot of interest and surrounding vegetation in the Central Region

CENTRAL



LEGEND
- Cocoa Farm
- Built Up
- Dense Vegetation
- Sparse Vegetation
- Bareland

LULC Class	Area 2015 (ha)	Area 2025 (ha)	Change (ha)	% Change
Built Up	61	117	+56	+91.8%
Dense Veg	7,078	7,279	+201	+2.8%
Sparse Veg	561	331	-230	-41.0%
Bareland	154	128	-26	-16.9%

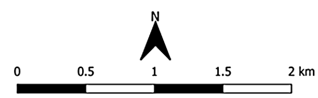
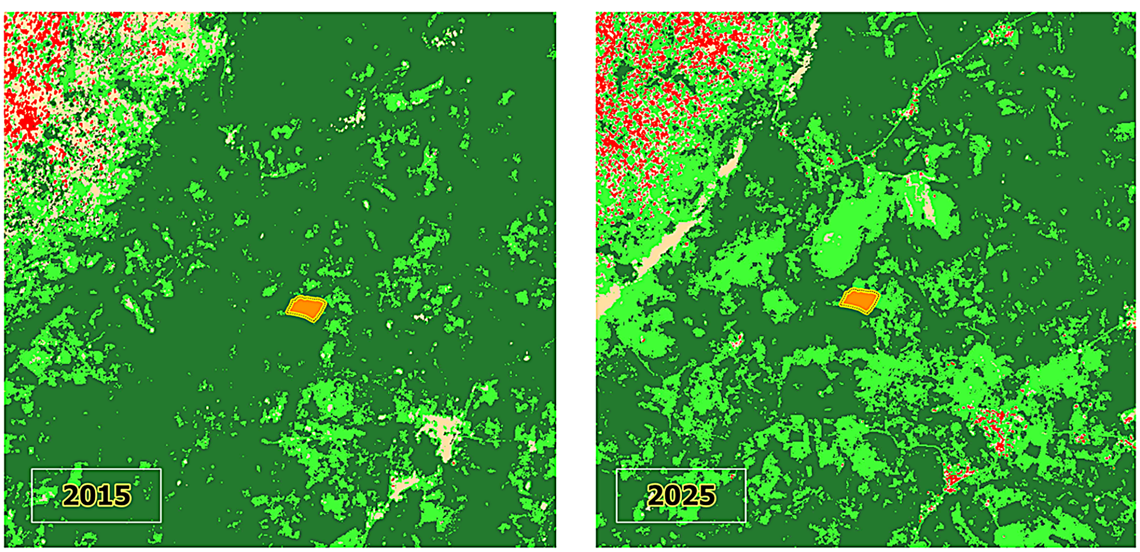


Figure 13: Land use change analysis for cocoa plot of interest and surrounding vegetation in the Eastern Region

EASTERN



LEGEND
- Cocoa Farm
- Built Up
- Dense Vegetation
- Sparse Vegetation
- Bareland

LULC Class	Area 2015 (ha)	Area 2025 (ha)	Change (ha)	% Change
Built Up	181	370	+189	+104.4%
Dense Veg	5,853	4,811	-1,042	-17.8%
Sparse Veg	1,368	2,296	+928	+67.8%
Bareland	459	384	-75	-16.3%

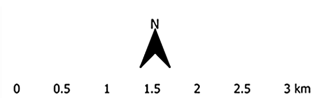
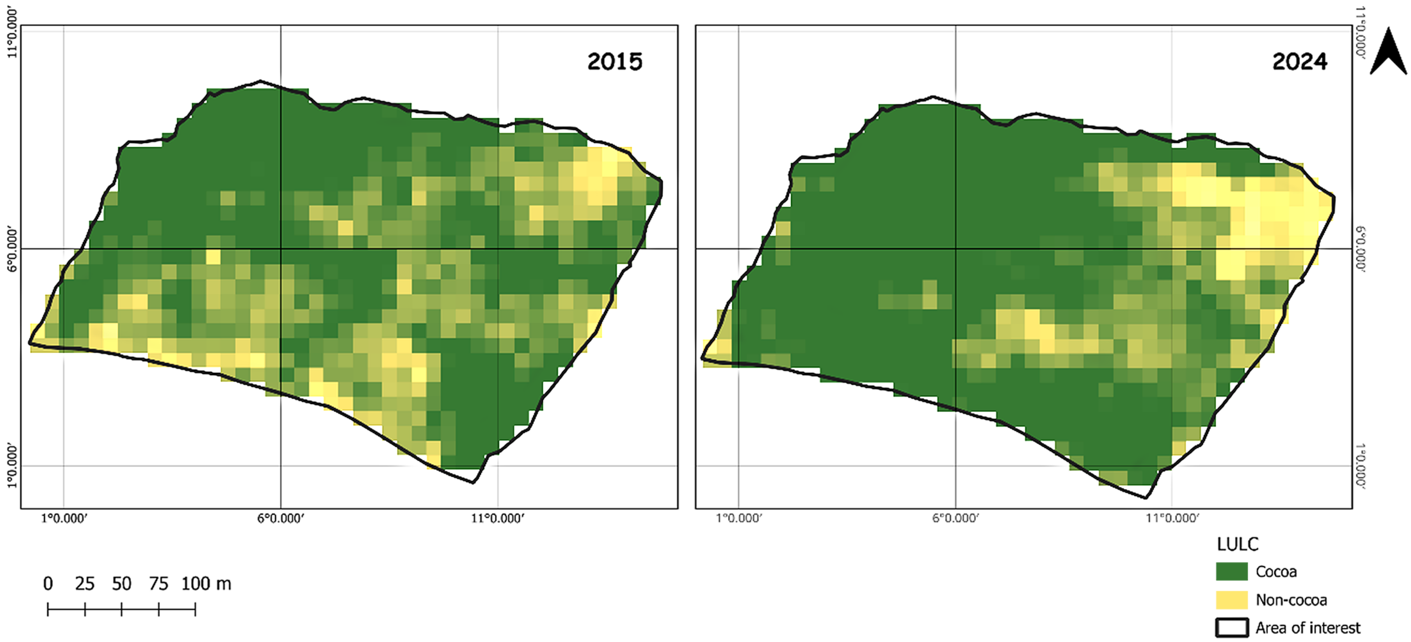


Figure 12: Land use change analysis for cocoa plot of interest and surrounding vegetation in the Central Region



4.1.5 Biodiversity Data Collection

Data on biodiversity were collected from sample cocoa plantations in the Eastern, Central, Ahafo, and Ashanti Regions using direct field observation and farmer-assisted recording. The approach focused on finding practical, farm-level biodiversity indicators that are feasible in smallholder cocoa systems and consistent with *Codex Planetarius* guidelines. The identification of shade and timber tree species, allied crops, and observable animals within cocoa farm landscapes was the focus of data gathering.

During farm visits, organized walk-throughs each cocoa plot were used to assess biodiversity. Farmers helped identify crop and tree species using common classifications and local names while guiding the data-gathering team around their properties. While non-tree crops were documented to capture on-farm species variety and intercropping techniques, shade and timber trees were identified as important structural elements of cocoa agroforestry systems. During the survey period, firsthand sightings or farmer reports were used to opportunistically record the presence of fauna.

Species were categorized into three broad groups:

- Shade/Timber Trees, which provide canopy cover, microclimate regulation and habitat structure;
- Other Plant Species, including food crops and understory vegetation commonly integrated into cocoa farms; and
- Fauna, recorded where visible or reported, recognizing that detailed fauna surveys were beyond the scope of this field-based assessment.

Table 7: Identified fauna and flora

Region	Shade / Timber trees	Others	Fauna
Eastern Region	Odum (*Milicia Excelsa*)	Maize	Earthworm
	Emire (*Terminalia Ivorensis*)	Cassava	Insects
		Cocoyam	
		Fern	
Central Region	Kusia (*Nauclea Diderrichii*)	Cocoa	Millipede
		Oil palm	Snail
		Cocoyam	Earthworm
			Insect
Ahafo Region	Onyina (*Ceiber Petandra*)	Coconut	Snails
	Odum (*Melitia Exelsa*)	Cocoa	Earthworm
	Emire (*Terminalia Ivorences*)	Pineapple	
	Wawa (*Triplochiton Scleroxylon*)	Oil palm	
		Cocoyam	
Ashanti Region	Akata (*Bombax buonopozense*)	Cocoa	Earthworm
		Avocado	
		Pineapple	
		Oil palm	
		Mango	
		Coconut	

Figure 15: Observed fauna within the sampled area in the Central Region

5 Data Collection Gaps and Methodological Constraints

1. Fragmented data systems: Environmental data are collected through multiple projects, certification schemes and institutions using different indicators, scales and reporting formats, limiting comparability and national baseline development.
2. Limited capacity for technical measurements: Smallholder farmers are unable to collect indicators requiring laboratory analysis, advanced equipment or specialized expertise, such as soil nutrient profiles, pesticide residues and greenhouse gas fluxes.
3. Capacity and training constraints: Limited technical skills, inadequate access to calibrated equipment and weak data management systems affect data quality and consistency.
4. Weak enforcement and monitoring: Environmental regulations related to agrochemical use and water protection are not routinely monitored, resulting in data gaps for water effluent indicators.

6 Alignment of *Codex Planetarius* Minimum Standards with Existing Standards and Legislation in Ghana

Soil Health

Ghana does not have a single standalone soil health legislature; however, existing agricultural and environmental policies provide a strong foundation for aligning with *Codex Planetarius* soil health standards (Fobi, 2025). Institutions such as MoFA, COCOBOD (through CRIG and its Soil Science Division), and the EPA already support soil fertility management, fertilizer regulation and sustainable land use.

COCOBOD operates a comprehensive policy and regulatory framework that aligns closely with the minimum standards of *Codex Planetarius*. Through subsidized fertiliser and approved pesticide distribution programs, Integrated Pest Management guidelines, cocoa rehabilitation schemes and agroforestry promotion, COCOBOD addresses key environmental sustainability dimensions, including soil health, water protection, biodiversity conservation, and emissions reduction (Cocobod, 2025). The Plants and Fertilizer Act further strengthen regulatory oversight of fertilizer quality and distribution.

Farmers function within this structured system, relying on COCOBOD's research-based guidance for input use and production practices. They also participate in on-farm trials, demonstration plots and contribute farm-level data through the Cocoa Management System (CMS), which supports traceability and sustainability reporting.

Given these existing instruments, *Codex Planetarius* would not require new policies but would strengthen and systematize current programmes by integrating measurable environmental performance indicators into COCOBOD's operational and monitoring systems, particularly through the CMS.

Relevant policies and frameworks

- Environmental Protection Agency (EPA) Act
- Ministry of Food and Agriculture (MoFA) soil management guidelines
- COCOBOD cocoa production recommendations

Land Use Change and Deforestation

Ghana's forest governance structure already places a high priority on land use change, especially deforestation caused by cocoa. Current regulations encourage zero-deforestation cocoa production and no cropping in protected forest areas (Forestry Commission, 2020). However, effective implementation has typically been hampered by enforcement issues and insufficient spatial traceability at the farm level. By establishing baseline requirements that provide for the spatial verification of agricultural boundaries, and the methodical tracking of land-use change over time, *Codex Planetarius* closely aligns with these current goals. This enhances the capacity to verify compliance by GPS mapping and remote sensing, methods that are increasingly acknowledged as best practices in deforestation monitoring, without changing the legal limits of allowed land use (Achard et al., 2014).

Relevant policies and frameworks

- Forest and Wildlife Policy (2012)
- Forestry Commission Act
- Cocoa & Forests Initiative (CFI)
- Ghana REDD+ Strategy
- EU Deforestation Regulation (EUDR) alignment processes

Water Use and Water Quality

Regulations on water abstraction and the use of agrochemicals are among the institutional and legislative frameworks that manage Ghana's water resources and pollution control (Water Resources Commission, 2012). However, there is limited farm-level water consumption and quality monitoring in cocoa environments, and enforcement is frequently hindered by capacity and resource constraints. By encouraging minimum requirements centred on preventive management, such as buffer-zone preservation, safe chemical usage, and basic water quality monitoring, *Codex Planetarius* can align with current water governance systems. By promoting regular, inexpensive observations that supplement institutional monitoring, a strategy that is generally endorsed in the literature on agricultural water management, these criteria enhance practical compliance rather than imposing new legal requirements (FAO, 2017). Therefore, *Codex* improves environmental management without necessitating significant adjustments to water laws.

Relevant policies and frameworks

- Water Resources Commission Act
- EPA pesticide and fertilizer regulations
- National Integrated Pest Management (IPM) guidelines

Emissions and Climate Change

Particularly through REDD+ and climate change policy frameworks, Ghana has well-established national procedures for reporting greenhouse gas emissions (Government of Ghana, 2013). Nevertheless, these systems have little connection to specific cocoa plantations and function mostly at the national or landscape levels. By establishing minimum standards that concentrate on emissions intensity and carbon stock changes related to land use and management methods, *Codex Planetarius* closes this gap. By relying on modelling and activity data instead of direct emissions measurement, these standards are in line with current climate commitments and accounting procedures and are in line with suggested practices for smallholder agricultural systems (IPCC, 2019). Therefore, without requiring new climate legislation, *Codex* improves the resolution and application of current climate data, facilitating more focused mitigation initiatives.

Relevant policies and frameworks

- National Climate Change Policy
- Ghana’s Nationally Determined Contribution (NDC)
- REDD+ Measurement, Reporting and Verification (MRV) systems

Biodiversity

Ghana's environmental policy framework places a significant emphasis on biodiversity conservation; yet, agricultural landscapes, like cocoa fields, are frequently under-represented in biodiversity monitoring systems. *Codex Planetarius* translates overarching conservation objectives into useful, farm-level indicators, such as shade tree density and canopy cover, in line with national biodiversity objectives. In comparison to full-sun cocoa systems, these indicators encourage the promotion of cocoa agroforestry systems that preserve habitat structure and ecological connectedness, which have been demonstrated to provide notable biodiversity benefits (Clough et al., 2011; Schroth et al., 2015). By making biodiversity performance visible and quantifiable inside production systems, *Codex* improves the application of biodiversity preservation duties rather than redefining them.

Relevant policies and frameworks

- Wildlife Resources Management Act
- National Biodiversity Strategy and Action Plan (NBSAP)
- COCOBOD agroforestry and rehabilitation programmes

Key Existing Systems and Legislative Implications for Implementing *Codex Planetarius* in Ghana

Implementing *Codex Planetarius* in Ghana's cocoa sector would require institutional coordination rather than major legislative reform. Ghana already has multiple systems governing cocoa production, forest monitoring, environmental protection, climate reporting and water management, but these operate in parallel and are not fully harmonized. *Codex* would function as a coordinating and standardizing framework, aligning indicators and integrating data across institutions to enable consistent environmental performance monitoring at farm, landscape and national levels.

Existing platforms such as the Forestry Commission's REDD+ and forest monitoring systems, EPA environmental regulations, national climate reporting frameworks (including NDCs), and Water Resources Commission monitoring systems already provide a strong legal and technical foundation. *Codex* would enhance these systems by introducing harmonized farm-level indicators, strengthening spatial data integration and improving attribution of environmental performance to cocoa production systems.

Most adjustments required would be procedural and technical – such as data-sharing agreements, methodological alignment and formal recognition of farm-level data—rather than new laws. Within this governance structure, COCOBOD is well positioned to serve as the central coordinating body, integrating *Codex* indicators into existing cocoa sector policies and ensuring coherence with Ghana's national sustainability and international compliance commitments.

Table 8: Key Existing Systems to be Engaged and Legislative Implications for Codex Planetarius Implementation in Ghana

Codex Area	Key Existing Systems to Engage	Primary Institutions	Legislative Change Required	Nature of Change
Land Use Change & Deforestation	National Forest Monitoring System (NFMS); REDD+ MRV platforms; Cocoa & Forests Initiative monitoring tools	Forestry Commission; COCOBOD	None to minor	Administrative recognition of farm-level GPS data for compliance and verification
Soil Health	Cocoa extension services; environmental monitoring frameworks; project-based soil monitoring systems	COCOBOD; MoFA; EPA	None	Development of technical guidelines for routine farm-level soil indicators
Water Use & Water Quality	Basin-level water monitoring systems; pesticide regulation and compliance systems	Water Resources Commission; EPA	None to minor	Update of implementation guidelines to incorporate field-based monitoring tools
Emissions & Climate Change	REDD+ accounting systems; national GHG inventory; NDC reporting platforms	Forestry Commission; EPA; Ministry of Environment	None	Methodological alignment and data integration protocols
Biodiversity	National biodiversity monitoring systems; agroforestry and shade tree inventories	Wildlife Division; Forestry Commission; COCOBOD	None	Integration of agroforestry indicators into existing biodiversity frameworks
Cross-Cutting Traceability & Reporting	Cocoa Management System (CMS); farm registry and traceability platforms	COCOBOD	None	System upgrades, indicator harmonization and inter-agency data-sharing arrangements

7 Conclusion

This study demonstrates that the principles of *Codex Planetarius* are both applicable and operationally feasible within Ghana's cocoa sector. Across the six environmental performance categories, the assessment confirms that relevant indicators can be measured using a combination of farmer-led field data collection, institutional support, and remote sensing–based approaches. While not all indicators can be directly measured at the farm level, the use of proxy indicators, modelling tools and tiered monitoring systems ensures that comprehensive, credible, and scalable data can be generated across smallholder cocoa landscapes.

The findings show that basic yet critical data such as soil pH, water quality parameters, farm management practices, shade tree density and farm boundaries – can be reliably collected in situ using simple field instruments and GPS tools. More advanced indicators requiring laboratory analysis, specialized equipment or technical modelling, including emissions estimation, detailed soil chemistry, biodiversity assessments and water effluent analysis, can be effectively managed at the institutional level. When combined, these complementary data streams provide a robust foundation for environmental performance assessment without imposing unrealistic technical or financial burdens on smallholder farmers.

Importantly, the study confirms that Ghana possesses the institutional capacity to coordinate and sustain *Codex Planetarius* implementation. The Ghana Cocoa Board (COCOBOD), with its mandate, national reach and existing extension, research and regulatory structures, is well positioned to serve as the lead directorate for *Codex Planetarius* coordination. Through collaboration with key institutions such as CSIR, the Forestry Commission, the Environmental Protection Agency, the Ghana Meteorological Agency and academic partners, COCOBOD can oversee data standardization, quality assurance, integration with national systems and alignment with international requirements, including deforestation-free supply chain regulations.

Overall, the evidence indicates that all required *Codex Planetarius* data can be collected in Ghana using existing tools, institutional frameworks and farmer engagement mechanisms. With clear indicator prioritisation, defined institutional roles and sustained capacity investment, *Codex Planetarius* offers a practical pathway to improving environmental performance measurement, supporting climate-resilient cocoa production, and strengthening Ghana's position within evolving global sustainability and trade frameworks.

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