

# Farmer Field Book (FFB): A Standard Tool for Monitoring Agronomic and Water Management Practices and Productivity in Cocoa Farming Systems

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## Summary

This report presents the development and prospective institutionalization of an integrated data collection tool, the Farmer Field Book (FFB), created to standardize agronomic monitoring across Ghana's cocoa farming systems. Among persistent challenges such as low yields, climate variability, and inconsistent data availability, these instruments address critical data gaps by enabling systematic tracking of household information, irrigation practices, rainfed farm practices, and cocoa tree-level growth. Through its structured and consistent format, the tool supports evidence-based decision-making aimed at improving productivity, sustainability, and resilience within a sector largely driven by smallholder farmers.

The FFB serves as a comprehensive record-keeping mechanism, capturing essential elements across the cocoa production cycle. It includes farmer profiles, general seasonal information, plot details like GPS coordinates and planting density, irrigation practices, fertilizer and pesticide applications, labor inputs disaggregated by gender, agronomic activities such as pruning and weeding, growth stages, stress indicators, harvest data, and sales revenues. Tailored versions for irrigated and non-irrigated systems ensure adaptability while preserving comparability. By aligning with global key performance indicators (KPIs) from previous initiatives of CGIAR's Excellence in Agronomy and current sustainable farming science program, the FFB transforms farm-level observations into measurable outcomes, including yield stability, nutrient-use efficiency, profitability, and soil health.

Ultimately, institutionalizing these tools within organizations such as COCOBOD could build a scalable agricultural data infrastructure, promoting sectoral growth and alignment with global sustainability goals. Their adoption promises not only immediate gains in farm-level decision-making but also broader contributions to resilient cocoa value chains, urging stakeholders to prioritize training, digital integration, and cross-institutional collaboration for widespread implementation.

This report complements the CocoaSoils Core Trial and Satellite Trial Implementation Protocols (2020). While those manuals guide the experimental design and field procedures, the Farmer Field Book (FFB) serves as a standardized monitoring and data integration framework. It focuses on the collection, management, and analysis of agronomic and socio-economic indicators, transforming raw field data into performance metrics aligned with CGIAR's Excellence in Agronomy and sustainable farming program KPIs.

## 1. Introduction

The generation of reliable and standardized agricultural data is essential for advancing research, guiding policy decisions, and improving farm management practices. In Ghana's cocoa sector, dominated by smallholder farmers, yields and livelihoods are influenced by the complex interaction of agronomic practices, ecological conditions, and socio-economic factors. However, the lack of systematic and comparable data collection frameworks has long limited the capacity of institutions to monitor performance, assess interventions, and design evidence-based strategies for sector-wide improvement. Establishing and institutionalizing robust tools for farm-level data collection is therefore critical to addressing the productivity, sustainability, and resilience challenges facing cocoa farming systems. To meet this need, the Farmer Field Book (FFB) has been developed as a comprehensive instrument that provides an integrated framework for documenting household, farm, and tree-level dynamics across the cocoa production cycle.

The Farmer Field Book (FFB) provides a structured approach to recording general household information, land use, input application, labor allocation, agronomic practices, crop growth stages, stress indicators, yields, and marketing outcomes (Table 1). Versions tailored for both irrigated and non-irrigated cocoa systems ensure contextual relevance while maintaining a consistent structure that enables comparability across environments and seasons. By requiring continuous entries throughout the production cycle, the FFB generates longitudinal data that reflect both processes and outputs. Importantly, its design aligns with internationally recognized agronomic key performance indicators (KPIs), including yield, yield stability, profitability, labor productivity, nutrient-use efficiency, and water-use efficiency, as well as soil health, allowing its outputs to be integrated into broader monitoring, evaluation, and research frameworks.


The CocoaSoils Core Trial (CT) and Satellite Trial (ST) protocols provide detailed operational guidance on fertilizer formulation, plot establishment, and agronomic management (Rusinamhodzi et al., 2020a; Rusinamhodzi et al., 2020b). In contrast, the Farmer Field Book (FFB) complements these efforts by ensuring that data generated from these trials and from farmer-managed plots are systematically recorded, verified, and transformed into standardized indicators. It bridges the gap between field implementation and institutional data use, enabling consistent KPI tracking, cross-site comparisons, and integration into national monitoring systems such as COCOBOD's Monitoring and Evaluation framework.

## 2. Data collection framework

The data collection framework integrates farm-level record-keeping with internationally recognized agronomic key performance indicators (KPIs) to create a robust system for measuring agronomic gains in cocoa farming systems. By systematically documenting both household- and farm-level processes, the framework ensures that local data can be translated into standardized performance metrics that are relevant at national, regional, and global levels. The FFB aligns with and draws data inputs from the CocoaSoils Core Trial and Satellite Trial Protocols. These define how variables such as fertilizer rates, canopy size, tree density, and shade management are measured (Table 1). The FFB's purpose is to harmonize data reporting not to replace or redefine measurement methods.

A central feature of the framework is the alignment of cocoa-specific variables with the KPI framework established by the CGIAR (Consultative Group for International Agricultural Research) Excellence in Agronomy initiative (Saito et al., 2023). These KPIs capture multiple dimensions of agricultural performance, including yield and yield stability, profitability, labor productivity, nutrient- and water-use efficiency, and soil health (Table 1). For example, pod counts and bean weights recorded from rainfed and irrigated plots in the FFB can be converted into yield and yield stability measures, fertilizer and pesticide use can be linked to nutrient-use efficiency and environmental impact, while canopy expansion data from young cocoa trees serve as early predictors of yield potential. This approach allows farm-level observations to be transformed into indicators that are comparable across geographies and production systems, thereby embedding Ghana's cocoa monitoring efforts within a globally harmonized framework of agronomic gain.

The framework also reflects a systems perspective on cocoa farming. Complex interactions between ecological conditions, agronomic management practices, and household-level decision-making shape cocoa production (Gutiérrez-García et al., 2024). By integrating structural, socio-economic,



phenological, and biophysical data within a single platform, the Farmer Field Book (FFB) enables multi-scalar analysis of cocoa farming systems. This comprehensive approach allows researchers and policymakers to explore how micro-level processes, such as irrigation practices, canopy development, pest and disease stress, or nutrient uptake, translate into macro-level outcomes like household income, sector-wide productivity, and resilience to climate shocks. In doing so, the FFB recognizes the socio-ecological complexity of cocoa production and provides a unified framework for systematically analyzing it.

The framework is also designed to facilitate knowledge flows across multiple levels of the cocoa sector. At the farm level, the FFB can serve as a management tool, enabling farmers to track input use, yields, and profitability. Extension agents can use standardized data to target recommendations more effectively and monitor adoption of best practices. Researchers benefit from high-quality longitudinal datasets that support impact assessments and crop modelling, while policymakers in institutions such as COCOBOD and the Ministry of Food and Agriculture can rely on aggregated indicators to inform subsidy programs, resilience strategies, and sustainability standards. Beyond the national level, global stakeholders such as the World Cocoa Foundation can draw on harmonized datasets to support cross-country comparisons and sector-wide learning.

Conceptually, the framework thus represents a flow from data inputs to decision-making outcomes. Household, farm, and cocoa tree-level data are collected and transformed into agronomic KPIs, which in turn provide an evidence base for analysis. These indicators inform decision-support systems that provide management advice, extension strategies, and policy dashboards, ultimately contributing to improved productivity, profitability, resilience, and environmental sustainability. In this way, the Farmer Field Book serve as a bridge between local farming realities and global standards, ensuring that Ghana's cocoa sector has the empirical foundation necessary to address productivity challenges, climate variability, and sustainability imperatives



**Table 1. Summary of variables, indicators, and methods in the Farmer Field Book (FFB).**

Section	Variable(s)	Detailed Indicator Description	Unit of Measurement	Method of Data Collection	Linked Impact Area(s)	Responsible Role(s)
<b>Farmer Profile</b>	Farmer Name, Household ID, Community/Village, District, Phone Number	Identifies the farmer and household for traceability; enables linking socioeconomic data with farm performance	Text / Number / Code	Farmer self-report	Social Inclusion / Data Traceability	Farmer (recording); Enumerator (verification); Supervisor (quality check)
<b>General Information</b>	Year, Cropping Season	Provides a temporal reference for comparing seasonal production data and intervention outcomes	Year / Text	Farmer self-report	M&E / Resilience	Farmer; Enumerator; Supervisor
<b>Farm &amp; Plot Details</b>	Plot ID, GPS Coordinates, Total Farm Size, Size of Young Cocoa Area, Tree Age, Variety Planted, Year Planted, Spacing, Shade Trees Present	Captures structural characteristics of the farm; informs land use efficiency, planting density, and varietal performance	Acres / Years / Text / Meters (m × m)	GPS device; Farmer self-report	Productivity / Land-Use Efficiency / Resilience	Farmer (info); Enumerator (GPS, measurements); Supervisor (validation)
<b>Irrigation Data</b>	Water Source, Flow Rate, Soil Moisture Status	Measures irrigation practices, water use, and soil condition to evaluate water-use efficiency and drought resilience	Text / Liters per minute / Categorical	Observation, flow meter, farmer self-report	Resource-Use Efficiency / Resilience / Environmental Sustainability	Farmer (reporting); Enumerator (measurement); Supervisor (verification)
<b>Fertilizer Application</b>	Fertilizer Type, Quantity, Cost	Tracks nutrient input use and costs, enabling analysis of	Kg or Liters / GHS	Farmer self-report; record verification	Productivity / Nutrient-Use Efficiency / Profitability	Farmer (reporting); Enumerator (verification); Supervisor (validation)

		soil fertility management and profitability				
<b>Pesticide Application</b>	Pesticide Type, Quantity, Cost	Measures crop protection practices and associated costs, with implications for yield and environmental impact	Kg, g, or Liters / GHS	Farmer self-report; record verification	Yield Stability / Profitability / Environmental Sustainability	Farmer (reporting); Enumerator (verification); Supervisor (validation)
<b>Labor Data</b>	Family Labor, Hired Labor, Labor Cost	Records labor contributions (by gender, family, or hired) and associated costs, key to assessing labor productivity and gender inclusion	Count / GHS	Farmer self-report	Labor Productivity / Profitability / Gender Inclusion	Farmer (reporting); Enumerator (verification); Supervisor (cross-check)
<b>Agronomic Practices</b>	Practice Type, Method	Captures adoption of recommended practices (e.g., pruning, weeding, harvesting) and whether mechanized or manual	Text	Farmer self-report; field observation	Resource-Use Efficiency / Productivity	Farmer; Enumerator; Supervisor
<b>Young Cocoa Monitoring</b>	Canopy Diameter, Canopy Condition, Phenological Stages, Stress Indicators	Provides detailed growth data (canopy expansion, leaf health, flowering, pod formation) for modelling early productivity & resilience	Meters / Categorical / Dates	Field measurement (tape), observation	Productivity / Yield Potential / Resilience / Plant Health	Enumerator (measurement & observation); Supervisor (validation); Data Manager (entry)

<b>Harvest Data</b>	Pods Harvested, Harvest Date, Harvest Time	Quantifies production levels and timing of harvests, essential for yield measurement and seasonal labor planning	Count / dd-mm-yyyy / HH:MM	Farmer self-report; observation	Productivity / Yield Stability	Farmer (reporting); Enumerator (verification); Supervisor (validation)
<b>Above Ground Biomass (AGB)</b>	Estimates of total dry matter produced by cocoa tree using tree diameter, height, and wood density	Used with yield to calculate Harvest Index (yield:AGB); helps diagnose whether management drives vegetative growth vs. pod production	Kg/tree	Non-destructive allometric models	Productivity / Harvest Index / Resource-Use Efficiency / Carbon Sequestration	Enumerator (measurement); Supervisor (validation); Data Manager (entry)
<b>Sales &amp; Revenue</b>	Yield Sold, Market Price, Transport Cost, Market Name	Captures marketing performance and financial returns, including costs and market access constraints	Kg / GHS/kg / GHS / Text	Farmer self-report; market verification	Profitability / Market Access / Livelihoods	Farmer (reporting); Enumerator (verification); Supervisor (quality check); Data Manager

**Table 2. Tools and materials required.**

<b>Role</b>	<b>Tools and Materials</b>
Farmer	Farmer Field Book (printed or digital), pen/pencil or mobile device, farm activity calendar, basic measuring tools.
Enumerator	GPS-enabled device (tablet/smartphone), KoboCollect or similar app, measuring tape, field forms, protective gear, optional camera.
Supervisor	Quality control checklist, access to enumerator data, laptop/tablet, transport means for farm visits, communication tools.
Data Manager	Computer with Excel/R/STATA, secure database platform, internet connectivity, and backup storage devices.

Project Manager

SOP manuals, training guides, monitoring dashboards, meeting/training materials, communication tools, budget oversight checklists.

**Table 3. Procedures (Step-by-Step Workflows).**

Step	Responsible Role(s)	Activities
Step 1: Data Recording	Farmer	Record weekly activities (fertilizer, irrigation, pesticide use, labor, harvest, sales). Maintain accuracy and timing.
Step 2: Data Verification	Enumerator	Visit farms, verify farmer records, take GPS, measure canopy, and check completeness before submission.
Step 3: Quality Check	Supervisor	Review data weekly, cross-check inconsistencies, and resolve discrepancies with farmers/enumerators.
Step 4: Data Management	Data Manager	Upload datasets, clean and validate entries, and store securely with backups.
Step 5: Oversight & Reporting	Project Manager	Oversee SOP compliance, conduct training, and generate reports on data quality, KPIs, and compliance status.

### 3. Detailed variable description

Each variable in the FFB corresponds to a dataset or measurement defined in CocoaSoils protocols. Enumerators and technicians should refer to the relevant protocol for the measurement method, while ensuring accurate data entry in the FFB template for consistency across sites.

#### 3.1. Farmer profile

The farmer profile captures key identifiers such as household ID, farmer name, community, district, and contact details (Table 1). These variables ensure data traceability and allow socio-economic characteristics to be linked with farm performance. Data completeness can be monitored to guarantee the quality of household records. This approach follows international best practice in agricultural household surveys and supports income and productivity monitoring frameworks (World Cocoa Foundation, 2024).

#### 3.2. General information

General information captures the temporal framework of data collection, including the production year and cropping season (e.g., major and minor cocoa seasons in Ghana) (Table 1). Recording this information is essential for aligning agronomic practices with seasonal cycles and climate variability.

To estimate cocoa yield from each plot, farmers should select a representative sample of trees, with 3–10 trees tagged per plot, depending on size, variability, and available resources. Smaller plots may use three trees, while larger or more heterogeneous plots should use up to ten to ensure robust estimates. Yield measurements must be taken during the same peak harvest round to maintain consistency across the sampling unit.

Additionally, farmers must record the plot area (in hectares) or the total number of trees. These data are crucial for converting harvested yields into standardized per-hectare estimates, which enable meaningful comparisons across plots, farms, and seasons.

**Measurement:** Farmers report the year and season of their activities, while enumerators cross-check this information with local cropping calendars and meteorological data.

**Why it matters:** Agricultural productivity and input responses vary significantly across seasons; thus, seasonality must be factored into impact assessments.

### 3.3. Farm and plot details

Farm and plot details provide the structural and biophysical context for all other data in the Farmer Field Book. The information collected includes plot ID, GPS coordinates, plot area, cocoa tree age and year planted, variety, spacing, and the presence of shade trees (Table 1). GPS locations and polygons can be reliably captured using KoboCollect, which allows for accurate area estimation, geo-tagging, and integration with remote-sensing datasets. These variables enable the calculation of key indicators such as planting density and land-use efficiency:

$$\text{Planting Density (trees/ha)} = \frac{\text{Number of cocoa trees}}{\text{Plot area (ha)}}$$

$$\text{Yield (kg/ha)} = \frac{\text{Total yield (kg)}}{\text{Plot area (ha)}}$$

Shade tree presence and canopy cover are also recorded, as studies in Ghana have shown that moderate shade regimes and proper spacing significantly influence cocoa yields, soil carbon, and resilience (Asare et al., 2014; Dawoe et al., 2016). By capturing these details systematically, the tool ensures that productivity, sustainability, and ecological interactions can be properly assessed across farms.

### 3.4. Irrigation data

Although cocoa production in Ghana is predominantly rainfed, recording irrigation practices where applicable strengthens resilience monitoring and helps understand how supplementary water use supports yield improvement. Key data include the water source, flow rate, irrigation date, start and end time of irrigation, type of irrigation technology employed (such as drip, sprinkler, or manual methods), frequency of irrigation, and total irrigated area and soil moisture condition (Table 4). These variables also help assess irrigation scheduling and management practices that influence cocoa productivity.

While the focus of irrigation data collection is on scheduling and the effective application of water to boost yield, water productivity (WP) can be optionally computed where detailed water-use data are available. This provides additional insight into the efficiency of water use but is not the primary objective of irrigation monitoring (Saito et al., 2025).

Note: Where complete irrigation and yield data are available, Water Productivity (WP) may be additionally calculated as:

$$\text{Water productivity (kg/m}^3\text{)} = \frac{\text{Yield (kg/ha)}}{\text{Total water applied (m}^3\text{/ha)}}$$

to provide supplementary insight into the efficiency of water use.

In addition, the start and end times of each irrigation event were recorded to determine the total irrigation duration per day. This information is crucial for accurately estimating the total volume of water applied during irrigation. The volume of water used (V) was computed based on the relationship between flow rate and irrigation duration, expressed as:

$$\text{Volume (V)} = \text{Flow rate} \left( \frac{V}{t} \right) \times \text{Period of Irrigation (T)}$$

where:

- Flow rate ( $V/t$ ) represents the volume of water discharged per unit time (e.g., liters per minute), and
- $T$  represents the total irrigation period in a day (calculated as the difference between irrigation start and end times).

Including these time variables allows for a more precise estimation of daily irrigation volumes, which is essential for evaluating water-use efficiency and understanding irrigation management practices among farmers.

**Table 4. Variables to be recorded.**

Variable	Description	Unit of Measurement	Method of Data Collection	Purpose / Use
<b>Water Source</b>	Identify the origin of irrigation water (river, boreholes, wells, ponds, rainwater harvesting, etc.)	Text	Direct observation; Farmer self-report	To assess the reliability, sustainability, and accessibility of irrigation water.
<b>Timing of Application</b>	Date and time irrigation are applied.	dd-mm-yyyy / HH:MM	Farmer self-report; Enumerator verification	To understand irrigation frequency and scheduling relative to rainfall and crop water needs.
<b>Flow Rate</b>	Volume of water applied per unit of time.	Liters per minute	Measured using containers of known volume or a flow meter	To calculate the total irrigation volume applied when combined with irrigation duration.
<b>Irrigation Duration</b>	Length of time irrigation is applied per event.	Minutes	Farmer self-report; Enumerator verification	Used with flow rate to estimate total volume of water applied per irrigation event.
<b>Soil Moisture Status</b>	Soil condition before and after irrigation (Dry, Moist, Wet).	Categorical	Farmer observation; Enumerator cross-check with soil probe	To determine whether irrigation is applied appropriately and assess scheduling effectiveness.
<b>Labor Data</b>	Number, gender, and type of labor (family vs hired) involved, plus costs.	Count / GHS	Farmer self-report; Record verification by Enumerator	To capture labor requirements and economic aspects of irrigation practices.
<b>(Optional) Water Productivity</b>	Ratio yields to total water applied.	kg/m <sup>3</sup>	Derived from yield and total water data	Provides additional insight into the efficiency of water use, where data allows.

### 3.5. Fertilizer application

Fertilizer applications and related labor must be recorded by each farmer for every plot on a biweekly basis. For fertilizer use, farmers should document the date of application, the size of the land treated, and the type of fertilizer used (Table 5). If a solid fertilizer is applied, they must record the weight (25 kg

or 50 kg), the number of bags used, and the price per bag (GHS) (Table 5). If liquid fertilizer is applied, the record should include the volume (1 L, 5 L, or 20 L), number of bottles, cost per bottle (in GHS), and the amount of water used for dilution (in liters) (Table 5). Labor inputs should also be captured by indicating the date, the number of male and female family workers, and the number of hired male and female workers. Farmers must also record the labor cost in kind or cash (GHS) (Table 5). Supervisors review these entries every two weeks to ensure accuracy and monitor both fertilizer use and labor practices. Research in Ghana and Côte d'Ivoire shows that balanced nutrient application significantly improves cocoa yields and income (Aneani and Ofori-Frimpong, 2013; World Cocoa Foundation, 2024). Conversely, poor or unbalanced fertilizer use can reduce profitability and harm the environment. By systematically documenting fertilizer data, the FFB enables robust cost–benefit analysis and supports the design of site-specific nutrient management strategies.

**Table 5. Fertilizer Application Variables.**

Variable	Description	Unit of Measurement	Method of Data Collection
Date of Fertilization	Records the exact date (and optionally time) when fertilizer was applied.	dd-mm-yyyy / HH:MM (if applicable)	Farmer self-report; Enumerator verification
Size of Land Fertilized	Area of the plot where fertilizer was applied.	Acres / Hectares / m <sup>2</sup>	Farmer self-report; GPS measurement; Enumerator verification
Name and Type of Fertilizer	Identifies the commercial name and whether fertilizer is solid or liquid.	Text (Name) / Categorical (Type)	Farmer self-report; Enumerator cross-check with packaging
Labor	Records number, type (family vs hired), gender, and cost of labor for fertilization.	Count (persons) / GHS (cost)	Farmer self-report; Record verification by Enumerator

### 3.6. Pesticide application

Pesticide application and related labor must be recorded by each farmer for every plot on a biweekly basis. For pesticide use, farmers should document the date of application, the size of land treated, and the type and name of the pesticide (Table 6). If a liquid pesticide is applied, the following information must be recorded: the volume (100 ml, 250 ml, 500 ml, or 1 L), the number of bottles used, the price per bottle (GHS), and the amount of water used for dilution (in liters). If a powdered pesticide is applied, the record should include the weight (100 g, 250 g, 500 g, or 1 kg), the number of sachets or bags used, and the cost per unit (GHS). Labor inputs should also be captured by indicating the date, the number of male and female family workers, and the number of hired male and female workers. Farmers must also record the labor cost in kind or cash (GHS) (Table 6). Supervisors review these entries every two weeks to ensure accuracy and monitor both pesticide use and labor practices. Effective pest and disease management is crucial for maintaining cocoa yield stability, as cocoa swollen shoot virus and mirids (capsids) are significant yield-reducing factors in Ghana. However, excessive or inappropriate pesticide use increases production costs, endangers the health of farmers, and threatens biodiversity. Studies highlight the importance of integrated pest management (IPM), which combines cultural, biological, and chemical measures to reduce reliance on pesticides while maintaining yields (Angon et al., 2023; Dormon, van Huis and Leeuwis, 2007). By systematically documenting pesticide data, the FFB enables robust analysis of yield stability, profitability, and sustainability.

**Table 6. Pesticide application variables.**

Variable	Description	Unit of Measurement	Method of Data Collection
Date of Pesticide Application	Records the exact date (and optionally time) when pesticide was applied.	dd-mm-yyyy / HH:MM (if applicable)	Farmer self-report; Enumerator verification
Size of Land Applied	Area of the plot where pesticide was applied.	Acres / Hectares / m <sup>2</sup>	Farmer self-report; GPS measurement; Enumerator verification
Name and Type of Pesticide	Identifies the commercial name and whether pesticide was powdered or liquid.	Text (Name) / Categorical (Type)	Farmer self-report; Enumerator cross-check with packaging

<b>Labor</b>	Records number, type (family vs hired), gender, and cost of labor for pesticide application.	Count (persons) / GHS (cost)	Farmer self-report; Record verification by Enumerator
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### 3.7. Agronomic practices

This section records all agronomic practices carried out on cocoa plots. For every week, farmers must note the date of activity, the type of practice (e.g., pruning, weeding, pollination, fermentation, pod breaking, drying, spraying, harvesting), the size of land covered, the method used (manual or mechanized) with tools or equipment specified, and the labor inputs, disaggregated by male and female family and hired workers (Table 7). Labor costs must also be recorded in both cash and in-kind terms (GHS) (Table 7). These standardized records provide a clear account of farm activities, labor use, and their contribution to productivity and sustainability.

**Table 7. Agronomic practices variables.**

Practice Type	Details to Record	Method of Verification
<b>Pruning</b>	Date, area covered (acres/ha), method used (manual vs mechanized), number of trees pruned.	Farmer record + enumerator observation.
<b>Weeding</b>	Date, area covered, method (manual/chemical/mechanical), frequency of operation.	Field observation + farmer record.
<b>Shade Management</b>	Presence/absence of shade trees, number removed/retained, reason for removal.	Observation + farmer confirmation.
<b>Pod Sanitation</b>	Date of pod removal, number of diseased/infested pods destroyed, method used.	Observation (field check).
<b>Harvesting Methods</b>	Method (manual, pole-harvesting, mechanized), frequency of harvesting rounds.	Farmer record + spot verification.
<b>Other Practices (e.g., pollination, fermentation, drying)</b>	Activity type, date, tools used, labor inputs (family vs hired).	Farmer report + enumerator verification.

### 3.8. Stress monitoring

Farmers should systematically record the dates (dd/mm/yyyy) when stress symptoms are observed at different cocoa growth stages, pod formation, maturity, and harvesting (Table 8). Key indicators include leaf yellowing, midday wilting, leaf damage or holes, uneven ripening, rotten/moldy pods, premature pod drop, branch or tree breakage, and tree death (Table 8).

These records provide critical insights into how biotic stresses (e.g., pests, diseases) and abiotic stresses (e.g., drought, nutrient deficiency, extreme heat) affect crop performance throughout the production cycle. By linking stress events to specific growth stages, farmers and supervisors can:

- Assess their impact on yield quantity and quality.
- Identify when interventions such as irrigation, pest control, or pruning are needed.
- Develop long-term management strategies for healthier and more resilient cocoa farms.

**Table 8. Stress monitoring by growth stage.**

Stress Indicator	Pod Formation (dd/mm/yyyy)	Maturity (dd/mm/yyyy)	Harvesting (dd/mm/yyyy)
<b>Leaf Yellowing</b>			
<b>Midday Wilting</b>			
<b>Leaf Damage / Holes</b>			
<b>Uneven Ripening</b>			
<b>Rotten / Moldy Pods</b>			



**Table 10. Growth stage and canopy monitoring for mature cocoa trees (>5 years).**

Irrigation / Rain fed	Flowering (dd/mm/yyyy)	Pod Formation (dd/mm/yyyy)	Pod Maturity (dd/mm/yyyy)	Harvesting Started (dd/mm/yyyy)	Canopy Diameter N-S (m)	Canopy Diameter E-W (m)	Avg. Canopy (m)	Canopy Area (m <sup>2</sup> )	Canopy Condition	Observations (Stress, Pests, Diseases)

### 3.10. Harvest data

Harvest-related variables include the number of pods harvested, harvest dates, and timing (hours of labor required) (Table 11). Quantities are converted into standard yield measurements, typically expressed as kilograms of dry beans per hectare. Data collection involves farmer self-reports, supplemented by enumerator observation or sampling of harvested pods. Accurate yield data are the cornerstone of agricultural performance monitoring, enabling calculation of land productivity and yield stability indicators. Seasonal harvest data also inform labor planning and allow researchers to assess how climatic factors (e.g., rainfall distribution) affect harvest timing and intensity. In cocoa, yield measurement is particularly important because productivity per hectare in Ghana remains well below potential levels (Aneani and Ofori-Frimpong, 2019). The FFB’s structured harvest data provide an empirical basis for identifying yield gaps and evaluating the effectiveness of input and practice adoption. The harvest data captures information essential for measuring productivity and efficiency, while also providing the basis for calculating the Harvest Index (HI).

**Table 11. Harvest data variables.**

Variable	Description	Method of Collection
Number of Pods	Count of pods harvested per tree/plot.	Farmer record; enumerator spot-checks.
Harvest Date(s)	Specific date(s) harvest took place.	Farmer records.
Harvest Timing	Hours of labor required per harvest activity.	Farmer record, validated by enumerator.
Pod Weight	Sample pods weighed to estimate fresh pod mass.	Enumerator sampling (kg).
Dry Bean Weight	Quantity of beans after fermentation and drying.	Farmer record + market verification (kg).
Area Reference	Plot area harvested.	GPS or plot size record.

#### 3.10.1. Conversion to yield and harvest index (HI):

- Yield is calculated as kg of dry beans per hectare.
- Harvest Index (HI) is calculated as:

$$HI = \frac{\text{Drybeans}(kg)}{\text{Total above - ground dry biomass}(kg)}$$

- While full biomass measurement is often resource-intensive, pod counts, pod weights, and dry bean weights recorded in the SOP can be used as proxies for total biomass.

- Linking agronomic practices (e.g., pruning, shade management, and pod sanitation) to HI allows assessment of how management influences the efficiency of assimilate partitioning into cocoa beans.

### 3.10.2. Full biomass calculation

1. Harvest and collect: For the sampled trees, collect all harvested pods, pruned branches/green waste generated by management practices for the same period, and any other above-ground material you want to include in biomass (e.g., fallen branches linked to the harvest round). Keep these separated into categories: (a) pods; (b) pruning/branches; (c) leaves/other.
2. Weigh fresh: Weigh each category fresh (record fresh weights; useful for moisture records).
3. Prepare subsamples (for drying): Take representative subsamples of each category (e.g., 10–20% of total by weight) or dry the whole sample if feasible. Place samples in labelled bags.
4. Dry to constant weight: Use oven (standard: 65–80°C until constant weight) or solar dryer. Drying to constant weight means repeated weighing until change <0.5% between two successive weighing 24 hours apart. Record dry weights.
5. Dry beans: dry to standard commercial moisture content (or to constant weight); for comparability to record the moisture content if possible.
6. Calculate total above-ground dry biomass: If only subsamples were dried, scale dry subsample weights up to total fresh weight to obtain total dry biomass per category, then sum categories. Example: A dry sample of pods weighed 3.0 kg, but the sample represented 10% of fresh pods that weighed 30 kg → total dry pod mass = 3.0 × (30 / 3.0) = 30 kg (scaling is straightforward).
7. Compute HI:

$$HI = \frac{\text{Total dry beans (kg)}}{\text{Total above-ground dry biomass (kg)}}$$

8. Scale to per-ha if required (use plot area or tree counts).

### 3.11. Sales and revenue

The sales and revenue section captures quantities of cocoa sold, farm-gate prices received, transport costs, market name, and buyer type (e.g., cooperative, private buyer) (Table 12). Units are typically recorded as kilograms (kg) for cocoa sold and Ghana cedis (GHS) for prices and costs. These data are collected via farmer self-report and validated through market records or cooperative accounts where possible. Capturing sales and revenue allows computation of profitability (net revenue after costs) and assessment of market access. For smallholder cocoa farmers, income is directly tied to sales performance, making this variable critical for livelihood analysis. Studies by the World Cocoa Foundation (2024) emphasize that while improved agronomic practices raise yields, low and fluctuating farm-gate prices often undermine farmer incomes. Documenting both yield and revenue together therefore provides a fuller picture of livelihood outcomes and supports the design of income-enhancement strategies, including premium payment systems and cooperative marketing models.

**Table 12. Sales and Revenue Variables and Recording Procedures.**

Variable	Description	Method of Collection
Quantity Sold	Cocoa sold per transaction. If farmer reports in bags, enumerator converts to kilograms of dry beans using a standard multiplier (e.g., 1 bag = 64 kg dry beans, unless local standard differs and is documented).	Farmer self-report, validated with receipts or cooperative/market records.
Price Received	Farm-gate price per unit sold (GHS/kg).	Farmer self-report; cross-check with market price data.
Transport Cost	Cost incurred in transporting cocoa to market.	Farmer self-report; validated if receipt is available.

<b>Market Name</b>	Local market, cooperative, or buyer where sale took place.	Farmer self-report.
<b>Buyer Type</b>	Type of buyer (e.g., cooperative, licensed buying company, private buyer).	Farmer self-report.
<b>Gender of Seller</b>	Whether the cocoa was sold by a male or female household member.	Enumerator records based on farmer interviews.
<b>Gender of Transporter</b>	Whether transport was arranged by male or female household member.	Farmer self-report.

### 3.12. Why harvest index matters

The Harvest Index (HI) is a critical performance indicator because it integrates the effects of multiple agronomic practices into a single measure of efficiency. It is calculated as the ratio of economic yield (bean weight) to total aboveground biomass (ABG). In cocoa, this ratio reflects how effectively the tree converts available resources (nutrients, water, labor, and management practices) into marketable yield.

A high HI indicates that a larger proportion of the plant's resources are allocated to bean production relative to vegetative growth. This suggests that management practices, such as balanced fertilizer use, proper pruning, effective pest and disease control, and adequate shade regulation, are working together to maximize productivity.

A low HI, on the other hand, signals inefficiency: trees may be investing more in stems, branches, or leaves than in pods and beans. This often points to underlying problems such as nutrient imbalances, pest damage, excessive shading, water stress, or poor canopy management. In such cases, HI acts as a diagnostic tool, helping farmers, extension agents, and researchers identify where to adjust practices to improve yields.

#### Why it matters in the FFB:

- HI ties together multiple data streams in the Farmer Field Book (fertilizer, pesticides, labor, canopy management, and yield) and provides a clear measure of how these practices interact.
- It allows comparison across farms and seasons to identify best-performing management strategies.
- It highlights yield penalties and points to corrective actions when productivity falls below potential.
- It supports sustainability assessments, since practices that optimize HI generally improve resource-use efficiency and reduce waste.

## 4. Data management and quality assurance

Data management within the FFB framework is designed to ensure accuracy, completeness, and long-term usability of the information collected. Farmers are responsible for recording their weekly activities, while enumerators verify these entries in the field and digitize them using KoboCollect or similar platforms. Verified data are uploaded weekly into a secure database. The Data Manager then performs cleaning and validation, including checks for consistency, completeness, and logical accuracy. Supervisors contribute by conducting regular quality control, reviewing a proportion of entries through spot-checks, and field verification. Discrepancies identified at this stage must be corrected in consultation with both farmers and enumerators. Importantly, a feedback mechanism is maintained so that lessons learned from errors can improve subsequent rounds of data collection. This structured approach ensures the reliability of the FFB as a monitoring and evaluation tool.

## 5. Health, safety & ethical considerations

The FFB is designed to support institutional data alignment between CocoaSoils, COCOBOD, IWMI, and other CGIAR partners. By harmonizing the variable structure and linking field-level data with global KPIs, it enables:

1. Consistent data aggregation across countries and agroecological zones.
2. Integration into COCOBOD's farmer productivity monitoring systems.
3. Rapid conversion of field data into decision dashboards and policy briefs.

Given that the FFB records pesticide and herbicide applications, it is critical that both farmers and enumerators adhere to safety and ethical standards during handling. Personal protective equipment such as gloves, boots, masks, and protective clothing should be used at all times when mixing or applying chemicals. Pesticides must be mixed in open, well-ventilated areas and never near food, children, or animals. Storage should be locked, clearly labeled containers away from food and water sources. Empty or used pesticide containers require safe disposal, ideally through triple-rinsing, puncturing to prevent reuse, and disposing via designated collection systems or burial in pits located away from water bodies. In the event of spills, absorbent material such as soil or sawdust should be used to contain and safely dispose of contaminants. Enumerators have an ethical obligation to discourage unsafe practices and must always obtain informed consent prior to any farm-level data collection. These measures safeguard farmer health, protect the environment, and uphold ethical standards in fieldwork.

## 6. Record keeping and archiving

All FFB data must be securely stored to preserve its integrity and enable future use in monitoring, evaluation, and policy. Farmers' paper-based field books will be digitized as part of an ongoing process led by a consultant, using scanning and digital data capture methods. Once digitized, data will be integrated into the central database managed by the Data Manager. The database must be password-protected, with restricted access granted only to authorized personnel. To prevent loss, at least two forms of backup, such as cloud-based storage and external hard drives, are required. Records are to be retained for a minimum of five years, ensuring that they remain available for long-term analysis and institutional learning. Version control and audit trails should be maintained for all uploads and modifications, ensuring traceability throughout the data lifecycle.

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### 3. Fertilizer application

Date of fertilization (dd/mm/yyyy)	Size of land for fertilizer application	The Name of fertilizer applied	If Solid fertilizer			If liquid fertilizer			
			Type of fertilizer applied (in kg)	Number of bags applied	Price of 1 bag (GHS)	Volume of fertilizer if it is liquid (Liters)	Number of bottles applied	Cost of bottle (GHS)	Amount of water used for dilution (In Liters)
Please make the choices of solid and liquid fertilizer from here Solid fertilizer 1. 25kg and 2. 50 kg Liquid Fertilizer 1. 1L, 2. 5L and 3. 20 L									

### 4. Fertilizer application: labor

Date of fertilization (dd/mm/yyyy)	No Female Family workers	No Male Family workers	No. of the females hired	No. of Males hired	Labor cost (in kind) GHS	Labor cost (in cash)



### 7. Other Agronomic Practices

Date (dd/mm/yyyy)	Practice Type	Size of land for the practice	Type of method used for this practice (Mechanized/Manual)	Tool used for manual/mechanization/others	No Female Family workers	No Male Family workers	No. Of females hired	No. Of Males hired	Labor cost (in kind) GHS	Labor cost (in cash)
Types of practices: Pruning, Weeding, Pollination, Fermentation, Pod breaking, Drying, Spraying, Harvesting										

### 8. Growth Stages

Irrigation/Rainfed	Plot ID	Write the dates in the cell (dd/mm/yyyy)			
		Growth stage: flowering (eg, buds or flowers on trunk/branches)	Growth stage: Pod Formation (eg, young pods visible)	Growth stage: Pod Maturity (eg, pods ripening, changing color)	Growth stage: Harvesting started (e.g., first pod cut)

**9. Stress during various stages**

Write the dates in the cell (dd/mm/yyyy)			
	Growth stage: Pod formation (e.g., small pods development)	Growth stage: Maturity (e.g., pods ripening, leaves dropping)	Growth stage: Harvesting (e.g., ripe pod handling)
Leaf yellowing			
Wilting at midday			
Leaf damage/holes			
Uneven ripening			
Branch/tree breakage			
Pod drops before harvest			
Rotten/moldy pods			
Tree dying			

**10. Yield during harvesting**

Date (dd/mm/yyyy)	Start time	End time	Tree ID	Count the number of pods harvested.


**11. Sales and Revenue information**

Date (dd/mm/yyyy)	Market name	Travel time to the location (in Hrs or Min)	Transportation cost	Cocoa Harvest Sold (kg)	Market Price (local currency/kg)	Gender of the person who sold the product	Gender of the person who transports products to the market	Transport Vehicle (By foot/public bus/personal vehicle)

### Questionnaire for the Monitoring of Young Cocoa Trees (0-5 years)

Thank you for agreeing to participate in this important data collection activity on cocoa farming. The main aim of this data collection is to monitor the canopy development and other phenological characteristics of the young cocoa trees aged between 0 to 5 years. Specifically, the aim is to gather data on canopy development from the sapling stage to the first fruit bearing stage that will support crop modelling activities for improved decision making the information you provide will help us better understand how young cocoa trees grow. Your responses will remain confidential and will only be used for research and extension support.

I appreciate your cooperation.

#### 1. Farmer Profile

1a. Farmer Name: \_\_\_\_\_  
1b. Household ID: \_\_\_\_\_ 1c. Community/Village: \_\_\_\_\_  
1d. District: \_\_\_\_\_ 1e. Phone Number: \_\_\_\_\_

#### 2. Farm and Tree Details

2a. Plot ID: \_\_\_\_\_ 2b. GPS Coordinates: Latitudes: \_\_\_\_\_ Longitude: \_\_\_\_\_  
2c. Total Farm size: \_\_\_\_\_ acres 2d. Size of Young Cocoa Area: \_\_\_\_\_ acres  
2e. Age of Young Cocoa tree: \_\_\_\_\_ years 2f. Variety Planted: \_\_\_\_\_  
2g. Year planted: \_\_\_\_\_ 2h. Spacing Used: \_\_\_\_\_ m × \_\_\_\_\_ m 2i. Shade Trees Present? Yes/No

If the tree is 0 years old, please state:

Date of transplant: \_\_\_\_\_ Average leaf area (cm<sup>2</sup>) \_\_\_\_\_ Length of roots (cm): \_\_\_\_\_

### 3. Canopy Monitoring (Every two weeks)

For each visit, measure the canopy diameter of the same tagged cocoa tree(s) in both North-South (N-S) and East-West (E-W) directions using a tape measure. Then calculate the average. Record any visible signs of stress or health issues.

Visit No.	Date	Tree ID/Number	Canopy Diameter (D <sub>1</sub> ) N-S (m)	Canopy Diameter (D <sub>2</sub> ) E-W (m)	Average Canopy Diameter (m) $[D_1+D_2]/2$	Canopy condition (Full, Sparse, Yellowing, leaf loss, Wilting)	Observations (e.g., stress, pests, disease)
Visit 1							
Visit 2							
Visit 3							
Visit 4							
Visit 5							
Visit 6							
Visit 7							
Visit 8							

### 4. Growth Stages

Irrigation/Rainfed	Plot ID	Write the dates in the cell (dd/mm/yyyy)			
		Growth stage: Germination (Good stand)	Growth stage: Leaf development (e.g., leaves broad and healthy)	Growth stage: flowering (eg, buds or flowers on trunk/branches)	Growth stage: Pod Formation (eg, young pods visible)

**5. Stress during various stages**

Stress types	Write the dates in the cell (dd/mm/yyyy)		
	Growth stage: Germination (Good stand)	Growth stage: Leaf development (e.g., leaves broad and healthy)	Growth stage: Pod formation (e.g., small pods development)
Leaf yellowing			
Wilting at midday			
Leaf damage/holes			
Branch/tree breakage			
Tree dying			





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