Adaptation Benefit Mechanism Methodology

ABM-NM003: Sustainable Agroforestry for enhancing the resilience of smallholder cocoa farmers against drought, rising temperature and heat waves (ABM Methodology Cocoa Resilience)

Version 1.0

This methodology has been prepared by

The Center for International Forestry Research
and World Agroforestry (CIFOR-ICRAF)

Methodology

Contents

1. Summary of the methodology

Summary of the methodology	
Title	Sustainable agroforestry for enhancing the resilience of smallholder cocoa farmers against drought, rising temperature and heat waves (ABM Methodology Cocoa Resilience)
Typical activities	Application of a package of sustainable agroforestry measures in new or replanted smallholder cocoa plantations, encompassing the following measures: 1. Shade tree planting 2. Rescue irrigation 3. Intercropping These typical activities fall under the concept of nature-based solutions for adaptation. A new cocoa plantation is a plantation where the cocoa trees are not older than 3 years.
Adaptation benefits (ABs)[1]	Option 1: • Cocoa plantation under sustainable and climate-resilient practices (ha) OR Option 2 – Option 1 in combination with the following additional ABs: • Improved survival rate of cocoa saplings at the end of the establishment period (%) • Enhanced productivity of cocoa farms (kg of cocoa beans/ha) • Complementary farm output (USD/ha)
ABs to be quantified as Certified Adaptation Benefits	Option 1: 1 AB = 1 ha of Cocoa plantation under sustainable and climate-resilient practices Option 2: 1 AB = the combined benefits of 1 ha of cocoa plantation under sustainable and climate-resilient practices, expressed in improved survival rate of cocoa saplings at the end of the establishment period (%); AND enhanced productivity of cocoa farm (kg of cocoa beans/ha) AND complementary farm output (USD/ha)

[1] This methodology proposes approaches for quantifying and monitoring these ABs, with the view to issuing them as Certified Adaptation Benefits (CABs)

Adaptation co-benefits[2] (optional)	• Improved rural employment (number of farmers) • Cocoa income uncertainty reduction (USD) • Biodiversity improvement (ha) • Avoided land use change (ha) • Carbon sequestered (tCO_2/ha)
Other possible co-benefits[3]	• Reduction of pests and diseases • Farmers' labor reduction • Reduction of soil runoff and erosion • Soil fertility improvement
Associated SDG benefits	• SDGs 1 (mandatory), 2 (mandatory), 3, 5, 8, 13 (mandatory) and 15 (mandatory)
Sector/sub-sector/type	Agriculture/Agroforestry/Cocoa production
Climate risk occurrence	Sudden extreme events and slow onset events
Climate change parameters	Precipitation and temperature
Climate change hazards	Heat waves, temperature variability, drought, and desiccation, leading to exceedance of tolerance thresholds of cocoa trees
Geographic applicability	Local, sub-national, national, or regional in West and Central Africa.

[2] This methodology does not propose approaches for quantifying and monitoring these co-benefits of the adaptation activity.

[3] This methodology does not propose approaches for measuring these co-benefits, but they could be reasonably expected to occur from the activity.

2. Introduction

Cocoa is cultivated in many tropical regions globally. At least, 70% of the global production comes from four West and Central African countries: Côte d'Ivoire (42.5%), Ghana (11.7%), Nigeria (5.2%) and Cameroon (5.2%) [1]. Smallholder farmers are responsible for the majority of the production. Many of them belong to the poorest segment of the society and rely on the sale of cocoa as a single source of income for all their needs [2].

Cocoa trees are very sensitive to climatic changes [3,4]. Studies indicate that temperature levels of 34ºC and not more than three consecutive months with rainfall lower than 100 mm are the highest tolerable temperature and drought resistance for cocoa saplings and trees [3,5,6]. Exceeding those limits makes an area unsuitable for cocoa growing. Hence, temperature and rainfall are the two most critical climatic factors to be considered by cocoa growers. However, due to climate change, heat waves above 34ºC, longer periods of drought and increasing precipitation variability are being observed more frequently in the relatively stable until recently climates of the largest cocoa producing countries in West and Central Africa, especially during the dry season. Hence, the dry season is becoming a challenge for all cocoa growers.

Currently, most of the cocoa orchards are established in the full sun or with insufficient shade and are exposed to more climate risks. Productivity of such farms is decreasing; the life span of the cocoa trees is decreasing to less than half and it is becoming more and more challenging to establish new cocoa plantations by following this approach. In the face of these critical climate-related challenges, resilient and sustainable cocoa agroforestry is needed by farmers to adapt to the climate hazards and improve the resilience and productivity of cocoa plantations. Agroforestry practices are easiest to apply when the cocoa trees are still young, for example in new cocoa plantations and in plantations where damaged mature cocoa trees are being replaced with new ones, which are not older than 3 years, because young cocoa trees are most vulnerable to climate change and cocoa trees older than 3 years that have not been protected properly are likely to be already damaged.

This methodology provides a modular approach for calculating the adaptation benefits and other benefits of a package of three sustainable agroforestry practices for enhanced resilience. While certain aspects of this methodology are mandatory, ABM activity developers can opt to monitor also co-benefits and contributions to the implementation of SDGs.

The methodology provides two options to evaluate the delivery of adaptation benefits: at three years after planting (Option 1) and at seven years after planting (Option 2). The first option focuses on measuring the key short-term output of the project as a whole —the area of cocoa plantations established under sustainable and climate-resilient practices. So, for option 1, the primary output to be reported is the area of cocoa plantations under sustainable and climate-resilient practices (in hectares), where one Adaptation Benefit is equal to one hectare of such plantations.

Achieving the above output is made possible by the following effect of the applied adaptation measures: improved survival rate of young cocoa seedlings delivered by the project activity. Moreover, a plantation under sustainable and climate-resilient practices ensures that at least some mid- and long-term adaptation outcomes will be achieved. In particular, the establishment of companion agroforestry species guarantees that, as the cocoa trees mature, they will receive appropriate shade to enhance their lifespan, productivity, and overall climate resilience. Thus, the second option (Option 2) focuses on assessing the detailed effects of the adaptation practices, including both outputs and outcomes. Option 2 can only be applied in combination with Option 1, since the application of the sustainable agroforestry package is a prerequisite to get these effects on the plantations. Option 2 is appropriate when a more comprehensive

assessment of the specific effects of the adaptation measures is demanded by stakeholders. In that case, the project's budget should be tailored accordingly.

The procedures for both measurement levels are outlined in sections 8 and 9 on a baseline and monitoring methodology, respectively. When reviewing this section, readers are encouraged to concentrate on the adaptation benefits and co-benefits of interest. For a comprehensive understanding of the intended methodology, the definition section and the Appendix, can be helpful. Table 1 below summarizes the minimum key elements of the methodology.

Table 1. Key elements of the methodology

Typical activities	Application of a package of sustainable agroforestry measures in new or replanted smallholder cocoa plantations, encompassing the following measures: 1. Shade tree planting; 2. Rescue irrigation; 3. Intercropping. These typical activities fall under the concept of nature-based solutions for adaptation. A new cocoa plantation is a plantation where the cocoa trees are not older than 3 years. For the measures to be effective in replanted cocoa plantations, the cocoa trees must also be not older than 3 years.
Associated Adaptation Benefits	**Option 1:** • Cocoa plantation under sustainable and climate-resilient practices (ha) OR **Option 2** (Option 1 in combination with the following additional ABs): • Improved survival rate of cocoa saplings at cocoa farm establishment (%) (mandatory) • Enhanced productivity of cocoa farming (kg of cocoa beans/ha) (mandatory) • Complementary farm output (USD/ha) (Mandatory)
Associated SDG Benefits	• SDGs 1 (mandatory), 2 (mandatory), 3, 5, 8, 13 (mandatory) and 15 (mandatory). See official respective SDG indicators that can be monitored in Annex 1.

Adaptation Benefit quantified for issuance of Adaptation benefits (ABs)	**Option 1:** 1 AB = 1 ha of cocoa plantation under sustainable and climate-resilient practices **Option 2:** 1 AB = the combined benefits of 1 ha of cocoa plantation under sustainable and climate-resilient practices, improved survival rate of cocoa saplings at farm establishment (USD/ha); AND enhanced productivity of cocoa farming (kg of cocoa beans/ha) AND complementary farm output (USD/ha)

3. Scope and applicability

3.1. Scope

The methodology covers a package of sustainable agroforestry interventions, including shade management, rescue irrigation, and crop diversification. Different technologies or plant mixes are eligible for each of the three measures. An example provided by ICRAF in Box 1 Summarizes the package for the broader audience. Cocoa trees must not be exposed for long time to temperatures above 34ºC. Young cocoa trees exposed to higher temperatures may die, while for mature cocoa trees their productivity and lifespan will decrease. Young cocoa plants grow best at about 30%-70% light [7]. For shade management, it should be considered that in order to secure shading for young cocoa trees on the shorter term, temporary quick-growing shade plants should be used, while allowing the shade trees with a longer growth period to develop in parallel with the temporary ones. Suitable shade trees, include for instance *Spathodea campanulate, Terminalia superba, Terminalia ivorensis, Khaya ivorensis and Milicia excelsa.*

BOX 1: The proposed sustainable agroforestry package.
The cocoa saplings encounter significant challenges in surviving the harsh conditions of the dry season in West and Central Africa. Adult cocoa trees, when exposed to full sun, exhibit reduced lifespans.

Introducing shade from fast-growing species like plantain bananas, along with a small amount of irrigation (rescue irrigation), significantly improves the survival rate of cocoa saplings during the first three-years after planting. Rescue irrigation is applied only during this first three-years period using bamboo or PVC pipes vertically buried close to the saplings.

Beyond seven years after planting, providing shade cover from companion trees not only extends cocoa trees' lifespan but also enhances overall productivity over time.

While these measures have proven effective, there is no universal solution for extreme heatwaves and dry seasons, such as those induced by El Niño episodes. To address these extremes, ICRAF scientists integrate both practices with intercropping of crops that can grow well together with cocoa trees for income diversification as a backup plan for securing livelihoods of smallholder cocoa farmers. Most of them are now dependent on the incomes from a single crop – cocoa.

The combined implementation of these three practices is proposed as a single package for the sustainable management of cocoa farms against climate change in West and Central Africa. In this methodology, this package is referred to as the sustainable agroforestry package.

Cocoa trees must not receive less than 100 mm water for more than three consecutive months. If the total rain amount of three consecutive months appears to be less than 100 mm, young cocoa trees will die while mature cocoa trees exhibit decrease in their productivity and lifespan [8]. If rainfall levels are insufficient, supplementary affordable micro irrigation can be applied through PVC or bamboo pipes (Fig. 1). This micro-irrigation method, referred to as rescue irrigation, has been proven effective in rescuing young cocoa trees (aged 0-3 years) from potentially lethal drought conditions. It requires only a minimal amount of water (up to 2 liters per sapling).

Project developers shall consider any risk of water-related maladaptation. In certain geographical contexts, such as cocoa-producing areas of West Africa, the small amounts of water used generally do not pose a maladaptation problem. However, in cases of uncertainty, developers should verify that the local context has not changed or, if necessary, take appropriate measures to mitigate risks of water competition. Such measures may include collecting and storing water on farms during the rainy season. Water can be collected from nearby villages, or from ponds, streams, or rivers—**but only during the rainy season**. This requires providing farmers with suitable containers as part of the irrigation equipment, along with a calendar for water collection based on local climate patterns. When water is sourced from ponds, streams, or rivers rather than rainfall, its quality may be tested to ensure it is safe for irrigation and does not pose any risk of plant toxicity. This quality check is strongly recommended when nearby activities include mining, industrial operations, waste disposal, as these may cause contamination by heavy metals, chemicals, or other pollutants. In such contexts, the analysis should include tests for parameters such as pH, EC, and heavy metals (e.g., mercury, arsenic, cadmium, lead). If contaminants exceed acceptable limits, project developers should identify alternative water sources or apply appropriate treatment measures before irrigation.

Fig. 1: Micro irrigation description and application to cocoa

Crop diversification is needed to reduce the dependence of cocoa farmers on a single source of income, which is being threatened by climate change and cannot be protected entirely from extreme events. Diversified earnings will improve the resilience of cocoa farmers and their livelihoods by reducing income uncertainty. Crop diversification can also ensure sufficient incomes for the cocoa farmers in the first 7-10 years upon establishment of the plantation, when

the cocoa trees are still young and are not delivering yield or later - in the periods between cocoa harvest. Moreover, crop diversification can improve the situation of women, if plants are used that can be maintained, harvested, and sold by women. They can improve the food variation and food security of the local community. Some crops like rubber may also reduce the spread of Cocoa Swollen Shoot Disease (CSSD) in cocoa farms.

The ABM activity using this methodology should cover the whole area of cocoa farmland where the sustainable agroforestry measures are being applied. This methodology is suitable for application at local, sub-national, national, or regional scale in West and Central Africa. Further testing is needed to determine its applicability in other regions.

3.2. Applicability

The methodology is applicable under the following conditions:

- Sector: Agriculture - crop production.
- Sub-sector: Agroforestry
- Crop type: Cocoa production
- Vulnerability to climate change hazards: heat waves, drought, precipitation variability
- Farm size: up to 10 ha size farms, which represent a typical smallholder cocoa farmer in West and Central Africa.
- Farming system: the project activity concerns the introduction of a sustainable agroforestry practices or a package of practices to enhance the resilience to the climate hazards of cocoa production systems that are new or in the stage of replanting and for which the business-as-usual scenario is either full-sun cocoa monocultures or systems that already include shade trees but are not sufficiently effective against the climate hazards.
- The impact of climate change on cocoa farms is homogeneous in the project geographic area. Note: in agroforestry, it is possible that one project covers an area with more than one climatic zone. As the baseline depends on the local impact of climate change, the baseline can be unique for each agroclimatic zone. In such cases, it is necessary to define each homogenous agroclimatic zone geographically and apply this methodology to each such zone.
- Only on-farm activities are covered by this methodology.
- Smallholder cocoa farmers have access to high quality seeds and saplings for shading and intercropping, materials for rescue irrigation, trainings of smallholder cocoa farmers on climate change, and use of rescue irrigation.
- Smallholder cocoa farmers have access to high-quality seeds and saplings for shading and intercropping, as well as materials for the implementation of rescue irrigation. Additionally, they receive training on utilization of the micro irrigation techniques.
- Local stakeholder consultations on the package of measures and expected benefits and co-benefits is conducted, including with women and women organizations.

The methodology is not applicable under the following conditions:

- Farming systems result in deforestation including plantations installed in protected areas.

- Off-farm management practices, including cocoa processing, transportation, marketing, etc. are not covered by this methodology.

4. Normative references

This methodology is based on the following documents and tools that may be indispensable for applying or modifying the methodology:

(a) Document ABM EC/2021/10/5 "Glossary of terms for the Adaptation Benefits

(b) Document ABM EC/2022/14/4 "Guidelines on the Adaptation Benefits Mechanism Activity Cycle procedure for developers of Adaptation Benefits Mechanism activities".

(c) Document ABM EC/2022/15/15 "Guidelines on the development of an Adaptation Benefits Mechanism Methodology", Version 2.

(d) Document ABM EC/2022/15/14 "Guidelines on ABM Environmental and Social Safeguards", Version 2.

(e) Document ABM EC/2022/15/13 "Guidelines on demonstration that an Adaptation Benefits Mechanism activity is new and not Business as Usual".

(f) Document ABM EC/2022/15/12 "Guidelines on activity types under the Adaptation Benefits Mechanism", including the Annex on "ABM adaptation activities typology".

(g) Document ABM EC/2022/14/6 "Guidelines on principles, criteria, and indicators regarding the determination of adaptation benefits"

(h) Cocoa livelihood resilience methodological tools in Appendix 1.

5. Definitions

In addition to the definitions contained in the ABM Glossary of terms, the following definitions shall apply:

Agroforestry: the purposely integration of trees and shrubs on farms and landscapes, involving a multitude of planting design, structures, and management practices for ecological, social and economic benefits.

Cocoa agroforestry system: managed farming systems associating cocoa with other trees and crops on the farm/ landscape, to optimize cocoa production, provide food and environmental benefits, and diversify and increase farmer income.

Sustainable agroforestry package: A package of adaptation measures to enhance resilience, including rescue irrigation, intercropping, and shade trees planting. Shade trees are planted in a regular pattern to ensure even shade covers across the plantation. In Côte d'Ivoire, ICRAF recommends a density of 40 shade trees per hectare. The spacing between a shade tree and the nearest cocoa trees is 3 m × 2.5 m.

6. Results chain for adaptation benefits (theory of change)

6.1. Results chain

A typical results chain for an ABM activity using this methodology is illustrated in Figure 1.

The long-term impact pursued through typical ABM activities using this methodology is that smallholder cocoa farmers are resilient to the already occurring climate induced drought, heat waves, desiccation, and temperature variability, leading to exceedance of the tolerance thresholds of cocoa trees. This methodology concerns an intervention at the level of direct impacts, which are the observed reduced productivity of mature cocoa trees, the high mortality of young cocoa trees and hence, the high costs of establishment/replanting of cocoa orchards in the full sun, which is the predominant common practice in West and Central Africa. The intervention is application of a package of sustainable agroforestry measures (shade trees, rescue irrigation, and intercropping), which has proven to be an effective measure against the identified climate hazards in West and Central Africa. Hence, it can be expected that the resilience of the cocoa farmers will already be significantly improved once the sustainable agroforestry package of measures has been applied (output) and this has started to deliver tangible adaptation benefits and co-benefits (outcomes & co-benefits).

The application of the package of sustainable agroforestry measures requires the provision of access to high quality seeds and saplings for shading and intercropping, materials for rescue irrigation application, trainings of smallholder cocoa farmers on climate change, installation, use of irrigation, local stakeholder consultations on the proposed measures, including with women and women organizations, which may lead to adjustments or finetuning of the measures and can give an indication of the already occurring damages and the expected benefits and co-benefits by the local community.

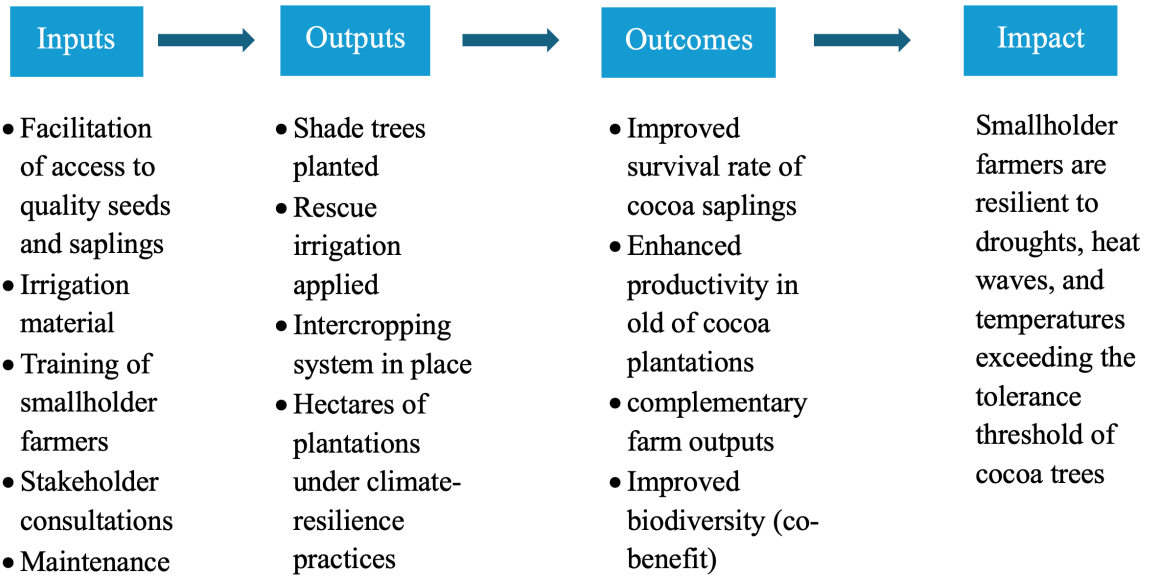


Fig. 1: Result chain for the adaptation benefits.

6.2. Definition of Adaptation Benefits

Adaptation benefits are calculated using Certified Adaptation Benefits (CABs) as a measurement unit. One AB equals to:

(a) 1 hectare of cocoa plantation under sustainable and climate-resilient practices OR

(b) The set of benefits delivered by 1 hectare of cocoa plantation under sustainable and climate-resilient practices, expressed as improved survival rate of cocoa saplings (% of planted saplings) at the end of the establishment period. (Living plants/ha), enhanced productivity in old cocoa plantations (kg of cocoa beans/ha), and complementary farm outputs (USD/ha)

There is a risk of double counting when adaptation benefits are measured using option 2. In this case, the project developer shall register benefits in terms of improved cocoa sapling survival rates (%) at the end of the establishment period (living plants/ha), enhanced productivity in mature cocoa plantations (kg of cocoa beans/ha), and complementary farm outputs (USD/ha).

Box 2: About project monitoring options 1 and 2

Option 1: Simplified Measurement of Adaptation Benefits

Measuring the area of cocoa plantations under sustainable and climate-resilient practices is a straightforward way to track the resilience improvement at field level. It takes place three years after planting when young climate-driven mortality of cocoa trees becomes zero. This option has two main advantages:

- *Check that the resilience drivers are in place:* It confirms that the essential conditions for generating adaptation benefits are met. This allows project developers to frame multiple benefits in a single, easy-to-measure output while keeping monitoring costs relatively low.
- *See results sooner through a proxy:* Benefits can be monitored just three years after planting, instead of waiting seven years for detailed measurement of outcomes. The plantation area acts as a proxy, providing an early indication of adaptation benefits such as long-term productivity, giving timely feedback to project stakeholders.

Option 2: Deeper measurement of Adaptation Benefits

Measuring in detail the effects of the adaptation practices goes beyond the plantations under resilient practices. Its conservative period starts 7 years after planting as it is at this year that cocoa trees start bearing significant pods. This measurement option breaks down the effects of the climate-resilient practices on the cocoa farms, providing a fuller picture of the project's impact. This option requires more data, monitoring resources, and technical capacity, but it offers a more comprehensive understanding of the project's benefits.

7. Demonstration that the activity is new and not business as usual

ABM activity developers should follow the ABM EC "Guidelines on demonstration that an Adaptation Benefits Mechanism activity is new and not Business as Usual". For option 4a, in the IRR analysis, it should be considered that typical activities are expected to start generating some revenues from intercropping about the 3rd year of implementation and will begin to generate revenues from cocoa production about the 7-10 year of establishment of the plantation. The costs for trainings, seeds, purchase, and preparation of irrigation materials, maintenance, stakeholder consultations, consultancy costs for preparing the ABM activity and passing it through the ABM cycle, including for the preparation of an Activity Design Document and monitoring, should be included in the analysis.

8. Baseline and monitoring methodology

8.1. ABM activity boundary

The project boundary for an ABM activity using this methodology, within which Adaptation Benefits and SDGs will be generated, comprises both a geographical component (a spatial framework) and a value chain component (a segment of the cocoa value chain).

- The spatial boundary is the geographical area within which the project activities are implemented. It shall encompass one homogenous agroclimatic zone. If the project activity covers several different homogenous climatic zones, the baseline and monitoring methodology shall be applied separately per homogeneous climatic zone. The spatial boundary shall be delineated with GPS coordinates and be reflected on a map to insert in the Activity Design Documents. Agro-climatic stratification should be based on the one hand, on differences in annual rainfall amount and distribution, and on the other hand, on the maximum temperature of the dry season (Box 3).
- The cocoa tree growing segment reflects the specific steps of the cocoa value chain (Fig 2) where the ABM activity takes place. The ABM activities using this methodology take place under first stage of the cocoa value chain [9], which is cocoa trees growing. Within this stage, the project has influence over farmers' practices in cocoa plantations and their related results.

Box 3: Multi-zone stratification

When a project covers an area with heterogeneous climate change impacts, each homogeneous sub-area should be treated separately during monitoring. Technically, sub-areas should be considered distinct if they show significant variations in parameters that most affect cocoa trees, such as the annual rainfall amount (mm) length of the dry season (days) and the maximum temperature (°C) during that period. For rainfall, an annual total of 1,300 mm with a dry season shorter than three months (90 days) can serve as a relevant criterion to distinguish suitable and marginal areas. In areas with homogeneous rainfall but varying temperatures, sub-areas within the optimum temperature range for cocoa should be distinguished from that are not.

Also, if future climate projections indicate divergent impacts within an area that is currently homogeneous, these projected variations should be taken into account in the stratification process.

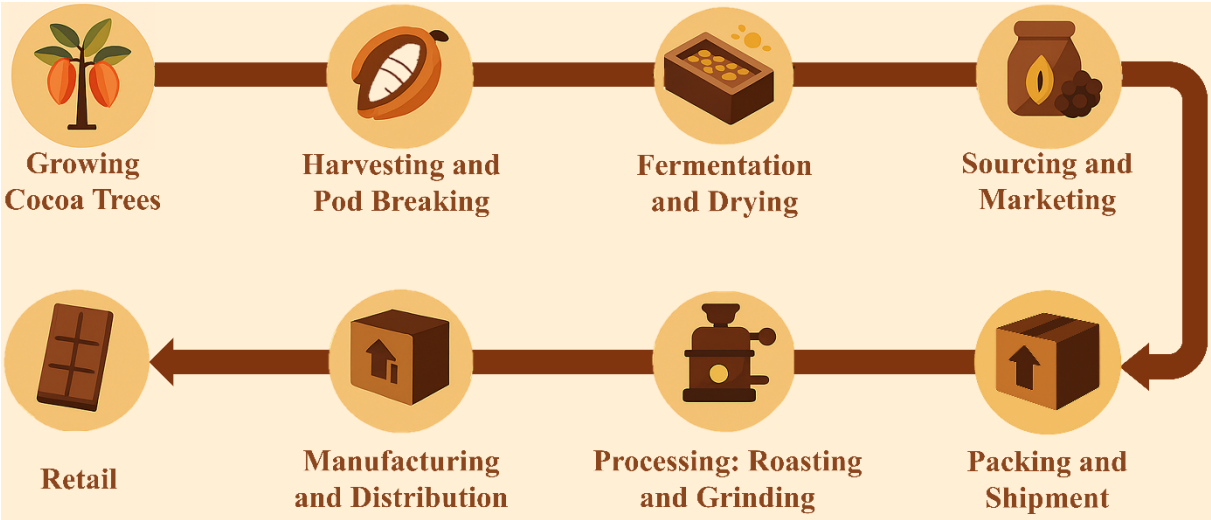


Fig. 2: The main steps of the cocoa value chain

8.2. Definition of the adaptation baseline scenario

The activity proponent shall demonstrate that in the absence of the ABM activity the cocoa farmers or communities targeted by the project would have managed cocoa orchards either in full sun or under insufficient shade, with canopy cover at or below 13 percent as indicated by a satellite-based assessments [10,11] of West African cocoa systems. Furthermore, they would have depended solely on rainfall for water provision at cocoa farm establishment and would not have practiced tree intercropping for income diversification. Relevant parameters should be used to describe the baseline including productivity of cocoa under BAU, average canopy cover, agroforestry stand density for shade tree in existing cocoa plantations, and cocoa yields.

8.3. Adaptation baseline

A baseline scenario shall be defined for each metric under each of the two options. It shall represent the situation that would happen if the proposed package of sustainable agroforestry practices was not applied.

8.3.1. Adaptation baseline for Option 1

Under the baseline scenario, the adaptation measures are not or insufficiently applied on the cocoa plantations, leaving them highly vulnerable to drought and heat. As a result, there are zero hectares of cocoa plantation under sustainable and climate resilient practices.

$$SCR_{BL} = 0\ ha \quad (1)$$

Where:

SCR_{BL} = Area of cocoa plantations under sustainable and climate-resilient practices in baseline

If for some reason, the proposed agroforestry package has been already applied by part of the farming community within the project geographic boundary, the actual surface covered by the sustainable agroforestry measures before project implementation should be accurately assessed.

8.3.2. Adaptation baseline for Option 2

The baseline is determined per hectare of cocoa farm without the proposed measures, as described in the

baseline under Option 1 for each of the following three indicators:

- Improved survival rate of cocoa saplings at farm establishment (% of planted saplings); AND
- Productivity of cocoa farming (kg of cocoa beans/ha) AND
- Complementary farm output (USD/ha)

Baseline of young cocoa tree survival rate

The method for evaluating the baseline survival rate of cocoa saplings is as follows:

$$SR_{BL} = 100 * \frac{NS_{BL}}{N_{BL,COCOA,TOT}} \quad (2)$$

Where:

SR_{BL}= Survival rate of young cocoa tree planted under baseline (% of planted saplings);

NS_{BL}= Number of surviving cocoa saplings three years after planting under baseline, saplings/hectare.

$N_{BL,COCOA,TOT}$ = Total number of cocoa seedlings (including replanted saplings) at farm establishment. It depends on the recommended number of cocoa trees, the local climate (drought and heat) and the sensitivity of the cocoa germplasm to these climate risks.

Baseline for enhanced productivity of cocoa farm

The baseline for enhanced productivity of cocoa farms, reflecting the productivity of cocoa farms without appropriate shade trees, drops to zero kilograms per hectare when cocoa trees reach between 19 and 30 years old. This decline occurs because cocoa trees planted without protective shade (or insufficient shade) [12,13] typically die between 19 and 30 years of age. Consequently, the baseline is determined as follows:

$$PROD_{BL(31-60)} = 0\ kg \quad (3)$$

Where:

$PROD_{BL(31-60)}$ = production of cocoa farm aged between 31 and 60 years old under baseline condition (kg)

Baseline for complementary farm output

In the baseline, complementary farm output shall be assessed under either of the following cases:

- Case 1: The baseline complementary farm output consists solely of a perfectly pure monoculture.
- Case 2: The baseline complementary farm output encompasses earnings from both cocoa trees and randomly spared non-cocoa plant species that produce outputs with significant economic value.

a) For case 1, the additional earnings generated by species other than cocoa are negligible in baseline. The baseline complementary farm output accounts for cocoa earnings only (USD).

b) However, if, in baseline conditions, there is a meaningful additional income due to the presence of certain species randomly spared by the farmers during the establishment of the unsustainably managed cocoa farms (this is a possibility observable in actual farms), the additional income provided by these species should be assessed annually, particularly during the harvest season of the spared species.

$$\boldsymbol{CO_{BL,t}(i) = V_{BL,t}(i) * P_{BL,t}(i)} \quad (4)$$

For:

$CO_{BL,t}(i)$ = complementary output from specific plant species i under baseline on the period t in USD;

$V_{BL,t}(i)$ = price of the output of plant i on the period t; expressed in USD/kg;

$P_{BL,t}(i)$ = production of plant i (in kg) under baseline on the period t. It strongly depends on the specific plant, climate, soil, and the farm management practices; For each plant of interest, it can be assessed by utilizing the minimum production per hectare or using the tool "Assessment of one plant production under baseline".

The baseline of complementary farm output from all plant species is assessed as follow:

$$tCO_{BL,t} = \sum_{i=1}^{n} \boldsymbol{CO_{BL,t}(i)} \quad (5)$$

Where:

$tCO_{BL,t}$ = baseline of complementary farm output from all plant species

n: total number of plant species of the farm

8.4. Adaptation activity scenario

8.4.1. Adaptation activity scenario for Option 1

The area of cocoa plantations under sustainable and climate-resilient practices is the total cocoa farm area covered by the ABM activity. One hectare of cocoa farm is under sustainable and climate-resilient practices if it has the following characteristics:

More than 50% of the cocoa farming area has co-planted shading plant species providing 30-70% shade to cocoa trees at the adult stage.

AND, if the farm is aged three or younger, more than 50% of cocoa trees were replanted thanks to the application of rescue irrigation during dry seasons.

$$SCR_{PROJ} \neq 0 \quad (6)$$

With:

SCR_{PROJ}= Cocoa plantation under sustainable and climate-resilient practices in project activity scenario

8.4.2. Adaptation activity scenario for Option 2

Adaptation activity scenario for "Improved survival rate of cocoa saplings at farm establishment. (USD/ha)

When the package of adaptation practice is applied, the impacts of drought and extreme temperatures are mitigated, improving the survival rate of cocoa saplings. The baseline survival rate is obtained using the formula below:

$$SR_{PROJ} = 100 * \frac{NS_{PROJ}}{N_{PROJ,COCOA,TOT}} \quad (7)$$

For:

SR_{PROJ} = Survival rate of young cocoa tree planted under project activity (%); USD;

NS_{PROJ}= Number of surviving cocoa saplings three years after planting under project activity

$N_{PROJ,COCOA,TOT}$ = Number of cocoa saplings (re)planting under sustainable agroforestry practices. Its ex-ante estimation can be obtained using the tool "Assessment of the number of cocoa trees (re)planted at cocoa farms establishment under sustainable agroforestry practices."

Adaptation activity scenario for enhanced productivity of cocoa farm (kg of cocoa beans/ha)

Species of the planted companion trees in the cocoa plantation should have height and density sufficient to provide 30-50% shade to mature cocoa trees. Companion tree species in cocoa plantations should have sufficient height and density to provide 30–50% shade to mature cocoa trees. These species should be locally adapted. Examples include *Garcinia kola*, *Ricinodendron heudelotii*, *Terminalia superba*, *Terminalia ivorensis*, *Irvingia wombolu*, *Triplochiton scleroxylon*, *Mansonia altissima*, *Khaya ivorensis*, *Beilschmiadia mannii*, *Tieghemella heckelii* [14]. It is worth noting that, while the choice of species can be flexible depending on the local context and circumstances, invasive species shall be avoided in the agroforestry package. This precaution helps prevent species-related maladaptation risks.

The shade provision from the appropriate species will prolong the lifespan of cocoa trees, allowing for the continuous production of cocoa beans on the same land for at least 60 years, as opposed to the 20-25 years typical of full sun monoculture [15–17].

Cocoa farm production beyond 30 years of age is determined through the application of the following formula:

$$PROD_{PROJ(31-60)} = \sum_{t=31}^{60} PROD_{PROJ,t} \quad (8)$$

Where:

$PROD_{PROJ,t}$ = annual cocoa productions under sustainable agroforestry practices at ages t between 31 and 60 years old.

Aside from the presence of protective shade, the actual long-term productivity of cocoa trees depends also on the cocoa varieties and local climate. Thus, for a given cocoa variety and a local climate, conservative values of $PROD_{PROJ,t}$ will be used based on whether protective shade (30-50%) is present.

BOX 4: Timing and conservative estimation of this benefit
This specific effect of the project activity doesn't occur before the cocoa trees reach 30 years of age. However, ex-ante monitoring can be conducted during the period 7-10 years after planting because this is when the shade provided by protective trees for cocoa trees becomes predictable. To avoid overestimation, a conservative value will be assigned to the production of a one-hectare plantation beyond 30 years of age. This assignment will only be made if the protective shade falls within the appropriate range of 30–50%. The conservative value can be estimated using the tool "*Ex-ante assessment of cocoa production under sustainable agroforestry measure at ages after 30 years old*"

Adaptation activity scenario for complementary farm output (kg/ha)

The agroforestry package promoted allows for the cocoa farm to provide diversified farm outputs that mitigate income fluctuations. Each farm output under project activity is determined using the formula below:

$$CO_{PROJ,t}(i) = V_{PROJ,t}(i) * P_{PROJ,t}(i) \quad (9)$$

For:

$CO_{PROJ,t}(i)$: farm output from specific crop i, on the period t, USD/ha;

$V_{PROJ,t}(i)$ price of crop i intercropped with cocoa on the period t, USD/kg;

$P_{PROJ,t}(i)$ = production of one crop i under project activity on the period t, Kg/ha. It strongly depends on the specific crop, climate, and the farm management practices; It can be pre-assessed using the tool "Ex-ante assessment of one crop production under sustainable agroforestry".

$$tCO_{PROJ,t} = \sum_{i=1}^{n} CO_t(i) \quad (10)$$

Where:

$tCO_{PROJ,t}$ = Complementary farm output under project activity

8.5. Quantification of the Adaptation Benefits of the activity

The adaptation benefits are calculated per Option and indicator.

8.5.1. Quantification of the Adaptation Benefits for Option 1

Adaptation benefits are calculated as hectares of sustainable managed cocoa plantation after 3 years upon establishment of the farm and application of the sustainable agroforestry package of measures. The number of hectares of sustainably managed cocoa farms due to the project is calculated by subtracting the total area of such farms under the baseline scenario from that under the project activity.

$$SCR = SCR_{PROJ} - SCR_{BL} \quad (11)$$

Where:

SCR_{BL} = Area of cocoa plantations under sustainable and climate-resilient practices in baseline conditions (in hectare).

SCR_{PROJ}= Area of cocoa plantations under sustainable and climate-resilient practices in project activity scenario (in hectare).

SCR= Sustainably Managed Cocoa plantation (in hectare).

In case:

$$SCR_{BL} = 0\ ha \quad (12)$$

The result is:

$$SCR = SCR_{PROJ} \quad (13)$$

8.5.2. Quantification of the Adaptation Benefits for Option 2

Adaptation benefits are calculated as the combined benefits per hectare of sustainably managed cocoa plantation after 7-10 years upon establishment of the farm and application of the sustainable agroforestry package of measures. The calculations are separate for each of the three indicators.

Quantification of reduced establishment costs of cocoa farm (USD/ha)

$$\text{ISR} = SR_{PROJ} - SR_{BL} \quad (14)$$

Where:

ISR = Improved survival rate of cocoa saplings three years after planting (%);

SCR_{BL} = Area of cocoa plantations under sustainable and climate-resilient practices in baseline scenario

SCR_{PROJ}= Cocoa plantation under sustainable and climate-resilient practices in project activity scenario

Quantification of enhanced productivity of cocoa farm (kg of cocoa beans/ha)

$$PROD_{(31-60)} = PROD_{PROJ(31-60)} - PROD_{BL(31-60)} \quad (15)$$

$PROD_{(31-60)}$ = Gains from enhanced productivity of cocoa farming (kg/ha)

$PROD_{PROJ,t}$ = annual cocoa productions under sustainable agroforestry practices at ages t between 31 and 60 years old.

$PROD_{BL(31-60)}$ = production of cocoa farm aged between 31 and 60 years old under baseline condition (kg)

Quantification of complementary farm output (USD/ha)

$$CO_t = tCO_{PROJ,t} - tCO_{BL,t} \quad (16)$$

$CO_{PROJ,t}(i)$: complementary output from specific crop i, on the period t, USD/ha;

$CO_{BL,t}(i)$ = complementary output from specific plant species i under baseline on the period t in USD;

8.6. Adaptation Benefit issuance period

A sustainable and climate resilient cocoa farm typically operates for about 60 years, after which cocoa trees need rejuvenation. The literature reports a lifespan of cocoa trees under shade ranging from 60 to 100 years after planting; however, the lower bound of 60 years is applied here for conservativeness [18–20]. Despite the local communities' benefiting from the project over this 60-year period, ABM project developers could aim to recover their investments within a maximum of 10 years through revenues from Certified Adaptation Benefits. Consequently, careful monitoring and reporting of Adaptation Benefits over this 10-year window becomes imperative. The monitoring can be done through two options:

- Under Option 1, the Adaptation Benefits shall be accrued upon a period of 3 years after the establishment of a sustainable cocoa farm.
- Under Option 2, the Adaptation Benefits shall be accrued upon a period of 7-10 years after the establishment of the sustainable cocoa farm.

A combination of both options is possible, where Adaptation Benefits are accrued upon 3 years under Option 1 and upon 7-10 years under Option 2. In such cases, the ABM activity developer must identify metrics for which double counting can occur, and what measures will be taken to avoid it. For instance, reporting must clarify that this first effect of the agroforestry package has already been issued. The payment scheme should then account only for the two remaining effects: enhanced productivity in mature cocoa plantations (kg of cocoa beans/ha), and (ii) complementary farm outputs (USD/ha).

9. Monitoring Methodology

A monitoring methodology is proposed per Option.

9.1. Monitoring for Option 1

- **Monitoring of the AB "Cocoa plantation under sustainable and climate-resilient practices"**

List of data and parameters monitored: $SCR_{BL,}$ $SCR_{PROJ,}$

Data / Parameter table 1.

Data / Parameter:	SCR_{BL}
Data unit:	*Hectare (ha)*
Description:	Baseline area of cocoa plantations under sustainable and climate-resilient practices - *Area of plantation covered by the sustainable agroforestry measures under baseline conditions*
Source of data:	
Measurement procedures (Three options):	• *Census using field survey:* - *Randomly sample a representative number of farms in the project geographical boundary* - *Record the cocoa farm locations (GPS), size, which practices are applied* - *The baseline area is calculated by summing the areas of farms that include the proposed adaptation measures* • *Farmer self-reporting in case of very large area where survey is too costly* - *Farmers report practices and areas* - *Cross-check with sub-sample collected by extension services* • *Remote sensing / satellite imagery* - *Map cocoa farm locations using high-resolution imagery.* - *Identify land-use patterns consistent with sustainable agroforestry practices* - *Validate remotely sensed data with field surveys on a subset of farms.*
Monitoring frequency:	*Once, following the third dry season after the young cocoa trees are planted*
QA/QC procedures:	
Any comment:	*It can be considered zero when the proposed adaptation practices are not already applied in the project area*

Data / Parameter table 2

Data / Parameter:	SCR_{PROJ}
Data unit:	*Hectare (ha)*
Description:	Area of cocoa plantations under sustainable and climate-resilient practices in activity scenario - *Area of plantation covered by the sustainable agroforestry measures under project activity*
Source of data:	
Measurement procedures (if any):	• *Census using field survey:* - *Randomly sample a representative number of farms in the project geographical boundary* - *Record the cocoa farm locations (GPS), size, which practices are applied* - *Sum areas of farms that are not under the proposed adaptation measures to get the baseline area.* • *Farmer self-reporting in case of very large area where survey is too costly* - *Farmers report practices and areas* - *Cross-check with sub-sample collected extension services* • *Remote sensing / satellite imagery* - *Map cocoa farm locations using high-resolution imagery.* - *Identify land-use patterns consistent with sustainable agroforestry practices* - *Validate remotely sensed data with field surveys on a subset of farms.*
Monitoring frequency:	*At the end of the third year of the cocoa farm establishment*
QA/QC procedures:	
Any comment:	

9.2. Monitoring for Option 2

- **Monitoring the AB "Improved survival rate of cocoa saplings at farm estaplishment"**

Required data and parameters: $N_{BL,\,COCOA,\,TOT}$; $N_{PROJ,\,COCOA,\,TOT}$; NS_{BL} *and* NS_{PROJ}

Data / Parameter table 3

Data / Parameter:	$N_{BL,\ COCOA,\ TOT}$
Data unit:	*Unit of planted cocoa saplings per hectare*
Description:	*Assessment of the baseline number of cocoa saplings planted per hectare in new cocoa farms within each homogeneous agro-climatic zone, including both the initial planting and any replanting carried out after the first and second dry seasons.*
Source of data:	*Field tests in each homogeneous agroclimatic zone: A conservative assessment of baseline number of cocoa saplings planted per hectare in each agro-climatic zone.* *Conservative value for the costs can be derived from:* - *agronomy research database.* - *plant growth model.* - *specialized tool in the appendix*
Measurement procedures (if any):	*Procedures for field tests:* • *Establish at least 4 plots in each homogeneous agro-climatic zone (e.g., 0.5–1 ha per plot).* • *Apply the local baseline cocoa planting practices with recommended spacing (3 m × 2.5 m)* • *At the end of the first and second dry seasons (March–April), identify dead sapling* • *replant to replace losses and record the number of replanted seedlings for each plot.* • *Calculate the total number of seedlings planted per hectare as the sum of the initial planting and all replanting after the first and second dry seasons.* *In case there are too many agroclimatic zones, application of the tool "Assessment of the number of cocoa trees (re)planted at cocoa farms establishment under baseline" may be considered to reduce monitoring cost.*
Monitoring frequency:	*3 years*
QA/QC procedures:	
Any comment:	*Conservative value can be used following local context*

Data / Parameter table 4

Data / Parameter:	$N_{PROJ, COCOA, TOT}$
Data unit:	*Unit of planted cocoa saplings per hectare*
Description:	*Assessment of the total number of cocoa saplings (re)planted at farm establishment under project activity*
Source of data:	*Field sampling using a statistically robust protocol*
Measurement procedures (if any):	*Sampling is conducted annually for each agroclimatic zone. Within the same zone, the result is the cumulative count of cocoa sapling plantings or replantings.* • *Select a representative sample of farms (depending on the number of beneficiaries) where farmers applied the adaptation measures - using random or stratified sampling in each agro-climatic zone* • *Document the adaptation measures applied by the farmer* • *Record the number of seedlings planted initially per plot by the farmer, along with the planting date and seedling source.* • *Record the number and date of replanted seedlings* • *Calculate the total number of seedlings planted per hectare as the sum of the initial planting and the replanting carried out after the first and second dry seasons.*
Monitoring frequency:	*At the end of each dry season, during the initial 3 years of cocoa farm establishment.*
QA/QC procedures:	- *Use standardized forms or mobile apps for farmer reports or enumerator verification.* - *Supervisors randomly verify 5–10% of farms by visiting plots to confirm planting counts and adaptation measures applied.* - *se GPS and photos for verification.*
Any comment:	

Data / Parameter table 5

Data / Parameter:	NS_{BL}
Data unit:	*saplings*
Description:	*Number of surviving cocoa saplings three years after planting under baseline scenario. This number depends on the cocoa variety and local climate conditions. It is expressed in number of surviving saplings per hectare*
Source of data:	*Field test in each homogeneous agroclimatic zone: A conservative assessment of surviving saplings from field test plots established in each agro-climatic zone.* *If necessary other sources may be used such as :* - *agronomy research database.* - *plant growth model.* -
Measurement procedures (if any):	*Field Test in Each Homogeneous Agro-Climatic Zone* 1. *Plot Establishment* o *Establish four test plots of 0.5-1 hectare each in every homogeneous agro-climatic zone.* o *Apply local baseline cocoa plantation practices in each plot.* o *Ensure that cocoa trees are planted according to the recommended spacing of 3 m × 2.5 m.* 2. *Monitoring During Initial Dry Seasons* o *At the end of the first and second dry seasons (March–April), record the number of cocoa saplings that died.* o *Replant all dead saplings in the optimum period after counting.* 3. *Survival Assessment* o *At the end of the third dry season (March–April), count and record the number of surviving cocoa saplingsin each plot.*
Monitoring frequency:	*During the initial three-years of the farm establishment*

QA/QC procedures:	- *Ensure homogeneity of climate in the agroclimatic zone* - *Follow standardized protocol including the same planting schedule and the same practices as BAU* - *Ensure that every planting and replanting event is accurately documented, verifiable, and traceable* - *Check and prevent double counting of surviving saplings at the end of the third year*
Any comment:	

Data / Parameter table 6

Data / Parameter:	NS_{PROJ}
Data unit:	*saplings*
Description:	*Number of surviving cocoa saplings three years after planting under activity scenario. It is expressed in number of surviving saplings per hectare*
Source of data:	Field data collection from farmers' fields
Measurement procedures (if any):	Survey: - recommend and document the same project activity in the fields for each agroclimatic zone - Define the population: e.g. all farmers participating in the project - Select a representative sample of farmers based on the number of beneficiaries - conduct surveys at the end of the dry seasons after planting to record survival data per plot or farm in standardized forms (during the first three years after planting).
Monitoring frequency:	During the initial three years of the farm establishment
QA/QC procedures:	*Survey must be done following a standardized protocol* *Follow the same schedule as baseline*
Any comment:	

- **Monitoring the AB "Enhanced productivity of cocoa farming"**

Required data and parameters: $PROD_{BL(31-60)}$; $PROD_{PROJ,t}$

Data / Parameter table 7

Data / Parameter:	$PROD_{BL\ (31-60)}$
Data unit:	*kg/ha*
Description:	$PROD_{BL\ (31-60)}$ can *be considered zero if the protective shade is less than or equal to the current level observed in cocoa farms, which is estimated at 13%. In this case, monitoring is carried out using protective shade cover as a proxy. Otherwise, it can be monitored through field survey .*
Source of data:	- *Literature review* - *Field survey and remote sensing*
Measurement procedures (if any):	*Literature* *Field survey in complement with remote sensing* - *Assess the shade cover of the farms in absence of project activity* - *If it's less or equal to the current level of shade, then the* $PROD_{BL\ (31-60)}$ is zero kg/ha. Literature has shown the current shade is below 13%; It is also know that this BAU doesn't allow cocoa tree to be productive beyond 30 years of age
Monitoring frequency:	*7-10 years (pre-assessment)*
QA/QC procedures:	
Any comment:	*The default value is zero after 31 years from planting.*

Data / Parameter table 8

Data / Parameter:	*PROD $_{PROJ,t}$;*
Data unit:	*kg/ha*
Description:	*Annual cocoa production under sustainable agroforestry practices at ages t between 31 and 60 years old.*
Source of data:	- *Estimation of the minimum value based on the shade cover of the established agroforestry system.*
Measurement procedures (if any):	*The measurement is an ex-ante assessment. It is done in three main steps* - *Record cocoa tree density.* - *Note the name of companion tree species, heights and crown diameter of adult stage, lifespans, and planting densities.* - *estimate the future shade cover based on actual tree density and species* - *verify that the shade will be in the range of the optimum 30-50%* *Set PROD PROJ,t equal to the minimum yield of aged cocoa farms under agroforestry. This minimum yield of aged cocoa farms may be estimated through literature or through the tool " Ex-ante assessment of cocoa production under sustainable agroforestry measure at ages after 30 years old"* -
Monitoring frequency:	*7-10 years (pre-assessment)*
QA/QC procedures:	
Any comment:	*In case of actual measurement (not an ex-ante assessment), GIS and AI tools may be used to reduce monitoring cost in large project areas*

- **Monitoring of the AB "Complementary farm output"**

Required data and parameters: $P_{BL,\,t}$; $P_{PROJ,\,t}$; $V_{BL,\,t}$; and $V_{PROJ,\,t}$

Data / Parameter table 9

Data / Parameter:	$P_{BL,\,t}$
Data unit:	*kg/ha*
Description:	*Baseline production of each plant species of the farm*
Source of data:	*Data sources include field measurements, peer-reviewed agronomic datasets, national statistics, and model inputs (climate, soil, crop parameters) from recognized database.*
Measurement procedures (if any):	*1- Identify of species that are associated to cocoa by default in baseline, If baseline is pure monoculture, then* $P_{BL,\,t} = 0$ *kg/ha* *2- In case baseline isn't pure monoculture, select representative farms across the project area using stratified random sampling* *3- collect farmer-reported yields (last 3–5 years) for each non-cocoa species and triangulate with agricultural statistics* *4- Establish the conservative baseline yield as the mean of observed yields for each species.*
Monitoring frequency:	*7-10 years*
QA/QC procedures:	*- Define a clear rule for what qualifies as an "associated crop" and apply it consistently across all farms* *- Ensure sample size provides at least 95% confidence level with acceptable margin of error*
Any comment:	*It depends on the specific plant, local climate, soil and the farm management practice*

Data / Parameter table 10

Data / Parameter:	*$P_{PROJ,t}$*
Data unit:	*kg/ha*
Description:	*Production of each non-cocoa crop of the farm under project activity on the period t*
Source of data:	*Field survey, Agronomy research database, andestimation using the tool "Ex-ante assessment of one crop production under sustainable agroforestry"*

Measurement procedures (if any):	*Conservative value should be utilized, including long-term average production per hectare*
	
	Fiedl survey:
	- *Record any plant species introduced by the project in the cocoa farms that provide complementary farm output*
	- *Select representative farms using stratified random sampling by farm size, agroecological zone, and management type.*
	- *collect farmer-reported yields (last 3–5 years) and triangulate with agricultural statistics*
	- *Establish the current conservative value of $P_{PROJ,t}$ as the mean of observed yields for each crop.*
	- *Estimate future Yields:*
	  o *Option 1: Apply an agronomic or crop growth modeling tool to project yields over time under the project interventions.*
	  o *Option 2 (if modeling is not feasible): Use the minimum observed yield over past years as a conservative estimate of future yield.*

Monitoring frequency:	*Yearly, during the period 7 to 10 years after planting.* *Conservative estimate is used for the period beyond 10 years after planting*
QA/QC procedures:	*Define a clear rule for what qualifies as an "associated crop" and apply it consistently across all farms* *Ensure sample size provides at least 95% confidence level with acceptable margin of error*
Any comment:	*It strongly depends on the specific crop, weather, and the farm management practices*

Data / Parameter table 11

Data / Parameter:	$V_{BL,\,t}$
Data unit:	*USD/kg*
Description:	*Market price of each crop of the farm under baseline on the period t*
Source of data:	*Market price records / Surveys*
Measurement procedures (if any):	*- Identify all non-cocoa crops in the baseline (If any)* *- Collect Seasonal averages of price per crop* *- or use official agricultural statistics*
Monitoring frequency:	*Yearly*
QA/QC procedures:	*Ensure that statistics come from recognized, reliable institutions (government agencies, FAO, research centers).*
Any comment:	

Data / Parameter table 12

Data / Parameter:	$V_{PROJ,\,t}$
Data unit:	*USD/kg*
Description:	*Economic value of each crop of the farm under project activity on the period t*
Source of data:	*Market prices / Agricultural Surveys*
Measurement procedures (if any):	- *Identify all non-cocoa crops (e.g., plantain, cassava, maize, fruit trees, timber, etc.).* - *Collect* S*easonal averages of price per crop* - *or use official agricultural statistics*
Monitoring frequency:	*Yearly*
QA/QC procedures:	*Document price sources for transparency.*
Any comment:	

9.3. Monitoring of ABs' Supported to SDGs and NDCs

SDGs are indirectly monitored through their respective supporting ABs. Project developers should ensure there is a genuine alignment between ABs and the SDGs to which they contribute. For this purpose, project developers are expected to use the *Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development* [21].

Table 14 presents the correspondence between the monitored benefits and the relevant SDGs, based on this framework.

ANNEX:

Annex 1. Indicators for sustainable development goals and adaptation benefits

Adaptation benefits	Contribution to SDGs	SDG Sub-targets	Indicator
Cocoa plantation under sustainable and climate-resilient practices	SDG 15: Live on land	Target 15.2 by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and increase afforestation and reforestation by x% globally	15.2.1 Progress towards sustainable forest management
	SDG 2: Zero Hunger	Target 2.4 By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture (in ha)
Reduced cost of cocoa farm establishment (USD/ha)	SDG 1: No poverty	Target 1.5 By 2030 build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters	1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP). (in US$)
	SDG 2: Zero Hunger	Target 2.4 By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that	2.4.1 Proportion of agricultural area under productive and sustainable agriculture (in ha)

		progressively improve land and soil quality	
	SDG 13: Climate Action	Target 13.1 strengthen resilience and adaptive capacity to climate related hazards and natural disasters in all countries	13.1.1 **Number of** deaths, missing persons and **directly affected persons attributed to disasters** per 100,000 population (in number of persons)
		13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (*a*) national education policies; (*b*) curricula; (*c*) teacher education; and (*d*) student assessment
Extended productivity of cocoa farms	SDG 2: Zero hunger	Target 2.4 By 2030 ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture (in ha)

	SDG 13: Climate Action	Target 13.1 strengthen resilience and adaptive capacity to climate related hazards and natural disasters in all countries	13.1.1 **Number of** deaths, missing persons and **directly affected persons attributed to disasters** per 100,000 population (in number of persons)
Complementary farm output	SDG 5: Gender equality	Target 5.5 ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public	5.5.2 Proportion of women in managerial positions For this project measure also: Total number and percentage of women without incomes of their own in the activity area
	SDG 13: Climate Action	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (*a*) national education policies; (*b*) curricula; (*c*) teacher education; and (*d*) student assessment

APPENDICES:

Appendix 1: Cocoa livelihood resilience methodology tools

Tool 1: Assessment of the number of cocoa trees (re)planted at cocoa farms establishment under baseline

$$N_{BL,COCOA,TOT} = N_{COCOA,BL} * K_{REPLANT,BL}$$

$N_{BL,COCOA,TOT}$ = Cumulative number of cocoa trees planted and replanted during the first three years of farm establishment, including original saplings planted at year 1; saplings replanted at year 2 to replace dead trees; and saplings replanted at year 3 to replace dead trees

$N_{COCOA,BL}$ = Standard number of cocoa trees per hectare in baseline (1300 stands/ha)

$K_{REPLANT,BL}$ = Coefficient of replanting due to drought and heat driven mortality of young cocoa trees. It is a function of the dry season duration, cocoa genotype, and farm management practices.

For 2 consecutive years of planting and replanting:

$$K_{REPLANT,BL} = 1 + Coef_{bl,lethality1} + Coef^2_{bl,lethality1} + Coef_{bl,lethality2} * \left(1 - Coef_{bl,lethality1}\right)$$

Where:

$Coef_{bl,lethality1}$ *drought lethality in cocoa seedlings aged below 1 year old in baseline. This coefficient is a function of dry season duration and the cocoa genotype.*

$Coef_{bl,lethality2}$ *drought lethality in cocoa seedlings aged between 1 and 2 years old in monoculture. This coefficient is a function of drought season duration and the cocoa genotype.*

Data description

Data	Description	Unit	Methods	Frequency	Period
$N_{COCOA,BL}$	Standard number of cocoa trees of the monoculture systems	Number of cocoa trees	Monoculture cocoa farming technical guidelines	Once	First year
$Coef_{bl,lethality1}$	Drought lethality of 0 year-aged cocoa trees in monoculture	% of mortality	Impact modelling or survey	Once	First year
$Coef_{bl,lethality2}$	Drought lethality of 1 year-aged cocoa trees in monoculture	% of mortality	impact modelling or survey	Once	Second year

Tool 3: Ex-ante assessment of cocoa production under sustainable agroforestry measure at ages after 30 years old

$P_{PROJ(31-N)} = \sum_{31}^{N} P_{PROJ}(t)$

While:

$P_{PROJ}(t) = POT_{PROJ,AGED} * (1 - \frac{RED_{PROJ,AGED}(t)}{100})$

Where:

N = age of cocoa farm 31 years after planting.

$POT_{PROJ,AGED}$ = potential production [22]

of 1ha aged cocoa farm (between 31 and 50 years old)

$RED_{PROJ,AGED}$ = The reduction percentage represents the impact of adverse climate conditions on cocoa production under sustainable agroforestry practices. Conservative values may be utilized based on factors such as shade tree species, height, and density.

This requires the collection of data listed in the table below. Data shall be collected in respect to the following descriptions, units, methods, frequencies, and periods.

Data	Description	Unit	Methods	Frequency	Period
RED_{PROJ}	Impact of sub-optimal climate conditions on potential production of cocoa	% of reduction	Impact modeling or survey	-	7-10 years after planting
$POT_{PROJ,AGED}$	Potential production of aged cocoa trees under agroforestry (it depends on the variety and sunshine)	kg/ha	Survey	-	-

Tool 4: Assessment of one plant production under baseline

For $P_{BL}(t)$ is the potential production [22] of one plant species on 1ha farm under baseline; for the year t.

$P_{BL}(t) = POT * (1 - \frac{RED_{BL}(t)}{100})$

Where:

POT = potential production of one interplanted species (including cocoa) on 1ha farm under optimal conditions (no water stress, no nutrient stress, and no damage from pests and diseases);

RED_{BL} = reduction percentage of potential production representing the impact of the actual sub-optimal conditions under baseline for year t.

Data shall be collected in respect to the following descriptions, units, methods, frequencies, and periods.

Data	Description	Unit	Methods	Frequency	Period
RED_{BL}	Impact of sub-optimal climate conditions on intercropped specie under baseline.	% of reduction	Impact modeling or survey	Annually	Project implementation period
POT	Potential production of aged trees under baseline	kg/ha	Modelling or Survey	Every 10 years	Project implementation period

Tool 5: Ex-ante assessment of one plant production under sustainable agroforestry

$P_{PROJ}(t)$ is the potential production of one plant species planted on 1ha farm under sustainable agroforestry practices; for the year t.

$$\boldsymbol{P_{PROJ}(t) = POT * \ (1 - \frac{RED_{PROJ}(t)}{100})}$$

Where:

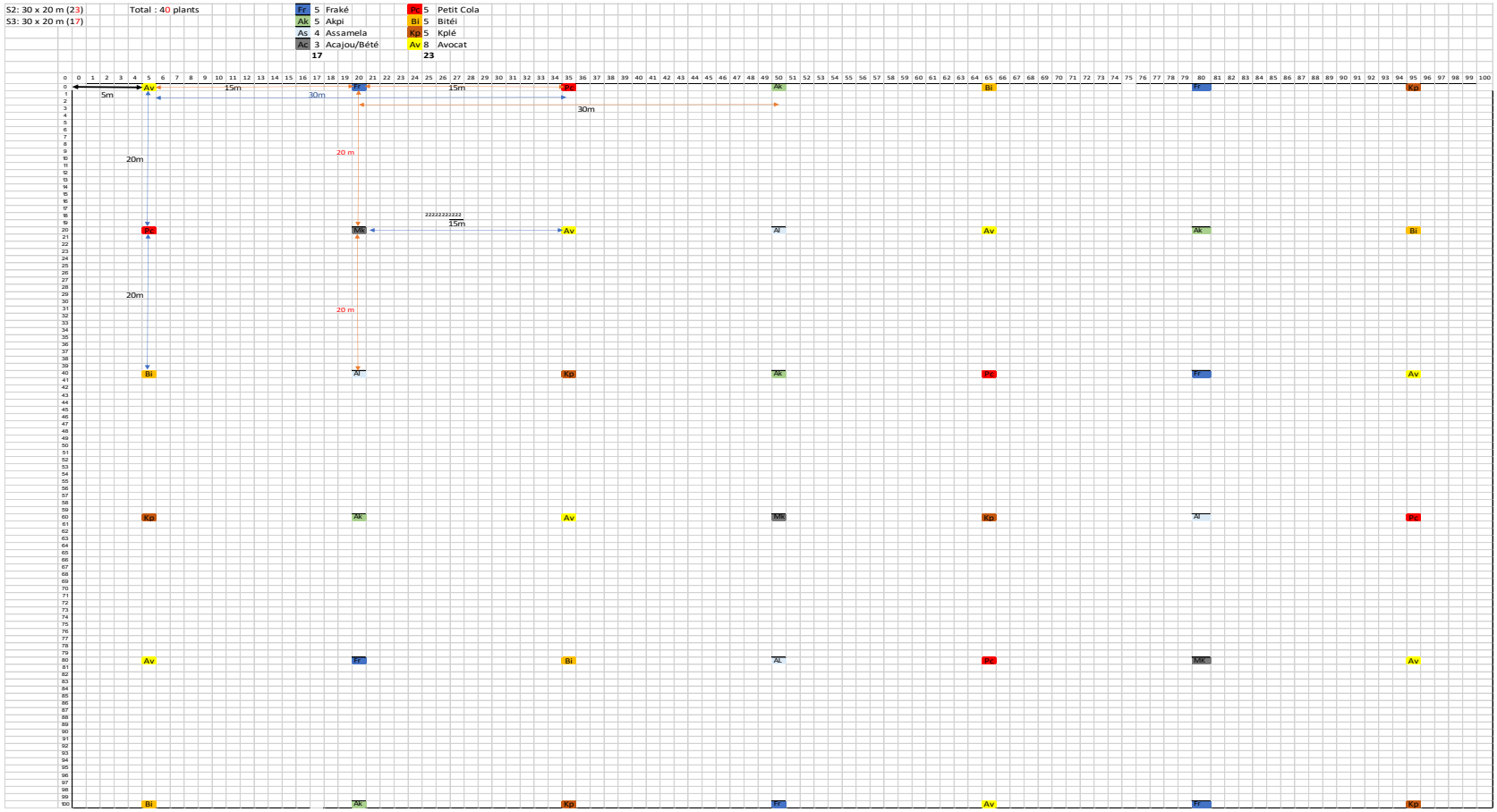
POT = potential production of one plant species on 1ha farm under optimal conditions (no water stress, no nutrient stress, and no damage from pests and diseases);

RED_{PROJ} = reduction percentage of potential production representing the impact of the actual sub-optimal conditions under agroforestry.

Data shall be collected in respect to the following descriptions, units, methods, frequencies, and periods.

Data	Description	Unit	Methods	Frequency	Period
RED_{PROJ}	Impact of sub-optimal climate conditions on intercropped specie under agroforestry.	% of reduction	Impact modeling or survey	Annually	Project implementation period
POT	Potential production of aged cocoa trees under agroforestry	kg/ha	Modelling or Survey	Every 10 years	Project implementation period

Appendix 2: Design of a prescribed cocoa agroforestry model



Appendix 3: References on cocoa agroforestry output/outcomes

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