Global Guide for the Implementation of Sustainable Cocoa Agroforestry

Good Practices from West Africa and Latin America Countries

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Title

Global guide for the implementation of sustainable cocoa agroforestry
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This publication is the result of a work conducted by the World Bank under the umbrella of the Forest Carbon Partnership Facility (FCPF). FCPF provides opportunity for countries like to prepare the Emission Reduction program which includes looking for private sector engagement in supporting the attainment of its objectives through strategic engagement with private companies who are supportive of the forest protections objectives. In order to fill the knowledge gaps and facilitate effective on-the-ground actions and with the aim of upscaling the private sector in sustainability business, the World Bank has conducted a global guide for the implementation of sustainable cocoa agroforestry.

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Abbreviations

AF	Agroforestry
AFS	Agroforestry System
ARS	African Regional Standards
BSP	Benefit Sharing Plan
CAR	Regional Autonomous Corporations (Corporaciones Autónomas Regionales)
CCN51	Colección castro naranjal 51 (kind of cocoa)
CFI	Cocoa and forests initiative
CHED	Cocoa Health And Extension Division of Ghana
CNRA	International Center for Agronomy Research (Centre National de Recherche Agronomique de Côte d'Ivoire)
COCOBOD	Ghana Cocoa Board
CREMA	Community Resource Management Area
CSR	Corporate social responsibility
CSSVD	Cocoa swollen shoot virus disease
CTA	Technical Center for Agriculture and Rural Cooperation (Centre technique de coopération agricole et rurale)
DBH	Diameter at breast height
ER	Emission Reduction
ER-P	Emission reduction program
ERPA	Emission Reduction Payment Agreement
ERPD	Emission Reduction Program Document
FAO	Food and Agriculture Organization of the United Nations
FCPF	Forest Carbon Partnership Facility
FIP /PIF	Forest Investment Program
FT	Fair Trade
GAP	Good Agricultural Practices
GCFRP	Ghana Cocoa-Forest REDD Program
GF	Gazetted Forests
GMO	Genetically Modified Organism
HCV	High Conservation Value
ICRAF	International Centre for Research in Agroforestry
ISO	International Organization for Standardization
LAC	Latin America and the Caribbean

Latam	Latin America
LDF	Land Degradation Fund
MFIs	Microfinance Institutes
NGO	Non-Guvernamental Organization
PNPREF	Policy for Preservation, Rehabilitation and Extension of Forests (Politique Nationale de Préservation, Réhabilitation et Extension des Forêts)
PO	Producers Organization
PPP	Private and Public Partnerships
PSE	Payments for Environmental Services
R&R	Renovation and Rehabilitation
RA	Rainforest Alliance
RCI	Republic of Côte d'Ivoire
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SAN	Sustainable Agriculture Network
SODEFOR	Forest Development Society (Société de développement des forêts)
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCC	United Nations Framework Convention on Climate Change
UTCC	Technical Unity for Coffee and Cocoa in Togo
WCF	World Cocoa Fondation

EXECUTIVE SUMMARY

Context

Cocoa sector growth resulting from deforestation has a negative impact on ecosystem services provided by forests at local, national and regional levels. Amongst other impacts, deforestation changes water cycles, increases the release of carbon dioxide into the atmosphere, and degrades biodiversity and soils. Deforestation also undermines the long-term productivity of forest landscapes and agricultural production systems. The global market demand for cocoa is expected to continue to grow and competition for agricultural land is set to increase. Consequently, the sector faces the urgent task of establishing more sustainable production practices and reducing environmental degradation, while improving returns to farmers.

Transitioning to a low-carbon, climate-resilient growth trajectory in cocoa production and processing will require significant investment and innovation. For a successful transformation, the private sector is to play a substantial role.

Agroforestry has long been identified as part of the solution to restoring degraded landscapes and improving the sustainability of cocoa production and other crops. It involves *the deliberate integration of trees in agricultural landscapes, in some form of spatial arrangement or temporal sequence, to obtain benefits from the ecological and economic interactions between these components*[1]. Agroforestry is part of the set of options to reduce the pressure on forests in a landscape approach. An agroforest does not have the same level of natural capital than a natural forest in terms of biodiversity, carbon sequestration and ecosystem services. However, it is a better alternative to traditional full sun practices as it contributes to improving the resilience of smallholder farmers and the lifespan of cocoa orchards. To avoid the associated deforestation, its development should go hand in hand with the protection of natural forests against new deforestation fronts[2], the restoration of degraded forests and the management of food security.

In a context where producing governments and private sector actors have made numerous commitments to eliminate cocoa-related deforestation and improve livelihoods, the need for a technical as well as practical guide for supporting the efforts of private and public sector to improve the adoption of agroforestry practices became evident. A study was designed and conducted in tandem with the *Cocoa & Forest Knowledge Exchange program* – a ten-month exchange program between stakeholders from six cocoa-producing countries (Brazil, Côte d'Ivoire, Colombia, Ghana, Peru, and the Dominican Republic) aimed at sharing experiences and building solutions for sustainable cocoa.

The resulting guide assesses existing agroforestry models being implemented globally. It focuses on their financial viability and the technical capacity needed for their implementation. It also considers the tension between environmental and economic costs and benefits and the actors' interest within the value chain, including the private sector. Furthermore, the guide displays viable agroforestry business models, with clear cases and descriptions as well as technical, carbon and economic simulations based on the model's key parameters.

Overall, this guide intends to provide concrete and practical tools in contributing to the transformation of cocoa production systems and their value chain across Africa, South America and beyond, considering the challenges encountered on the ground. The guide is enriched with the good practices and success levers identified by the *Cocoa & Forest Knowledge Exchange* program's participants. To accompany the guide, six films have been produced to "Bring the field online" and enable participants to interactively experience what happens on the field.

1 ICRAF et CTA, 1993.
2 Most cocoa booms are related to mass migrations, pioneer fronts and deforestation, coupled with monoculture practices. When the soils and the cocoa trees are depleted, the farmers open new forest to benefit from forest rent (Ruf F. 1995)

Recommended sustainable practices

The sustainable practices proposed in this guide aim to maintain the functionality of agroecosystems and cocoa orchards (soils fertility, carbon sequestration, water preservation, etc.). It also aims to improve crop diversification in the production systems. Some of these good agricultural practices such as zero-deforestation are obviously also applicable to full sun. Practices include:

- **Site selection**: The installation of new orchards on non-forest soils permits an increase of production without putting pressure on natural forests. This should be coupled with the replantation or rehabilitation of diseased and overaged cocoa orchards already in place through agroforestry techniques.
- **Good agricultural practices**: Shade management, soil management (compost, mulching, recycling of local waste and organic materials like pods), replacement of non-productive cocoa trees, good management of the shade trees and timber, bio-diversification of the agroforestry system, diversification of the functionalities of trees and plants associated with cocoa, nutritional inputs, flowering management, phytosanitary controls, organic treatments/fertilizers.
- **Optimization of functionality through the enhancement of biodiversity (crop diversification with timber, fruits trees, with good shade management) and soil preservation**: These practices allow higher carbon storage, soil fertility, water regulation, reduced weed growth, better control of pests and diseases, and perpetuation of good cocoa yield. Literature review shows that high shade and complex agroforestry is, in some cases, even more biodiverse than secondary forests.

Pathways toward a sustainable cocoa landscape

Given the large diversity of agroforestry systems identified by the study, they have been grouped into two categories: intercropped models and multi-strata models. In the **intercropped model**, the focus on two strata (one cocoa and one side plant) will result in simple organizations of the plot to ease the maintenance of the field. In the **multi-strata model**, the presence of more stories (four and above, which are cocoa trees, planted fruits or forest trees and natural forest trees) will result in a more complex organization of plots with a large diversity of species.

Given these good agricultural practices and these two models (intercropped and multi strata), five pathways have been identified during the study with their respective scope of application: context of rehabilitation of existing orchards and context on development of new orchards.

Context of rehabilitation or replantation of existing orchards

- Objective: increase and perpetuate the yield and improve the functionality of current agro-systems.
- Pathways: (1) Full-sun to Intercropped; (2) Full-sun to Multi-strata; (3) Intercropped to Multi-strata.

Context of the installation of new orchards:

- Objective: ensure that new cocoa installations are zero-deforestation.
- Pathways: (4) Savannah to Intercropped; (5) Savannah to Multi-strata.

A cost-benefit analysis of the transition to these new practices was carried out, taking into account:

- *Labour costs:* every operation that is made to support production was quantified in man-day.
- Inputs costs: costs of plant material, other inputs (equipment, fertilization) and the transport of these inputs to the farm were quantified in USD.
- External costs: costs borne by actors other than the producers, such as training costs to agroforestry practices and certification costs (indeed, the proposed sustainable practices can easily be certified under standards like Rainforest Alliance).

The assessment of costs followed two steps: installation and exploitation. The benefits are defined by the yield of each crop multiplied by the price that the producer could get from it. This price could be lower than the market price for crops other than cocoa as the producer is not specialized in the marketing of these products.

A cost-benefit analysis over several years allows us to conclude the following:

In Africa

The intercropped model: return on investment is reached 5-6 years after the initial investment.

The multi-strata model: return on investment is reached 6-8 years after the initial investment. The multi-strata model is more profitable in the long term than the intercropped with its margin becoming superior to the intercropped model after 15 years.

In LAC countries

Outside of *cabruca* systems, which is a forest-derived agroforestry practice where the shade trees are only occasionally exploited, there are a very small number of projects in the case studies with different strata of combined crops that are exploited at the same time and on a long-term basis. Only one cost-benefit analysis[3] has been made for Latin America: a cocoa-timber intercropped model. The return on investment is reached seven years after the initial investment. This model is more profitable than the two African models as soon as the first timber is sold. On average in this model, timber exploitation is as profitable as cocoa.

Financing the transition

Access to financing for this transition now exists in several forms:

- **Grants**, provided directly from a donor (public funds, foundations, NGOs, private companies, etc.) to a project. Subsidies are important but insufficient resources given the extent of the needs. However, these subsidies can leverage other private or innovative financing (PES, carbon) as part of the generalization of sustainable practices. It requires commitment for a long-term transition strategy.
- **Matching grant.** This mechanism consists of an offer of financing by a public fund for projects respecting given specifications; the project is proposed by companies which must also commit a minimum capital. In general, these programs finance up to 50% of a project led by companies if it notably meets sustainability requirements. The grant part is often directed towards the smallholder farmers or outgrower partnering with the private actor.
- **Private funds (including banks)**. Three mechanisms are identified: capital shareholdings (with or without outgrowers) to finance an agroforestry project; loans - carried out by a private fund dedicated to the financing of sustainable agricultural practices for example, carbon payments as some agroforestry projects are subsidized by companies or funds based on an expected carbon performance.

The following risks have been identified in term of access to finance:

- Top-down approaches: it is essential above all to start from the needs and constraints of producers and their territory. Such assessment can help to envision the format of future orchards and the content of the technical assistance needed.
- Necessary adaptation to a diversity of conditions: due to the great diversity of ecosystems in tropical countries, it is necessary to consider the agroecological factors of the areas. The goal is to carry out an adaptation of agroforestry systems in relation to the specific conditions of soil (including restoring degraded soil) and the microclimate of the place where the projects will be developed. For example, grafting is crucial to achieve expected productivity and farmers should be trained (particularly in Africa) However, to limit the spread of some diseases like the CSSV, some governments, such as in Côte d'Ivoire, may put restrictions on grafting.
- Trees and land tenure issues: The choice of farmers for full-sun cocoa cultivation to the detriment of agroforestry under shade can be explained by existing laws that make it difficult for smallholders to access land security and to the property of the timber trees.
- Poor market-access for non-cocoa products: An organizational scheme that eases the marketing of other products (fruits, timber, spices) is required. Logistics can also be an issue. For example, transporting timber under good conditions to markets can be expensive[4].

Final recommendations: holistic approach to secure the transition towards sustainable cocoa agroforestry

To accelerate the dissemination of durable cocoa agroforestry, the following recommendations have been identified:

3 However, a wider range is available in the excel simulator produced under the exchange program.
4 That is why in Central Africa, some cocoa projects intend to join forces with the certified forest companies that have logistic capacities and are committed to contribute to local development.

Table 1: Possible levers to ensure a transition towards durable cocoa agroforestry

Sector	Action	Entry point	Actor
Technical	**Develop a farmers training program based on the elements from the guide and on sustainable practices recommended by country.** Provide training to farmers: • On good practices as the site selection, crop diversification, timber management, etc. • On the introduction of additional forest species in cocoa orchards to increase biodiversity (encourage nurseries and tree plantation) based on specific purposes (medicine, wood, fuelwood, fruits), addressing local needs and promoting native species. • On self-assessment of cocoa orchards to detect pests and diseases, nun-productive trees, etc. • On identifying habitats that deserve to be preserved,	Local level	Extension services NGO
Technical	**Develop better collaboration between research, tree nurseries** (run by public services, private companies or cooperatives) and farmers in order to annually program and size the production of seedlings according to the climate zones, the soils, the economic objective of the plantation (market-based production).	Regional level (climate zones)	Public research, forestry services, extension services, private sector
Financing	**Develop PPP in producing countries.** This study showed the size of existing needs (Côte d'Ivoire, for example, intends to strongly encourage scaled agroforestry, within the framework of its PNPREF policy). Subsidies are important but insufficient resources given the scale, therefore there is a need to attract PS investment by demonstrating the profitable nature of agroforestry. Subsidies can leverage private or innovative financing (PES, carbon) as part of the generalization of sustainable practices[5]. Governments should commit to a long-term transition strategy to not rely on short term and oriented donor's funds.	National level	Governments, funds, and private sector
Organizational	**Initiate and perpetuate a community of practices on sustainable cocoa farming and agroforestry.** This work has formulated recommendations and identified existing practices in the areas studied It is essential to capitalize on the feedback provided by countries participating in the program and more broadly. Such a community will have to be connected to other existing initiatives such as living income or regenerative agriculture.	Global level	Core group members[6]
Technical	Likewise, the cost/benefit analysis could be refined by regularly recording technical and economic data from different agroforestry projects. Thus, **creating a web platform** would allow/enable an animation of the community of practices. Above all, this animation would be coupled with a resource center and free access to the Excel model via an interface and an input window.	Global level	Core group members Donors

5 It should be noted that an investment decision support tool for agroforestry project in rural domain was produced as part of this study in the form of an excel simulator.
6 To ensure a sustainable impact, the Cocoa & Forest Knowledge Exchange program has provided training to a Core Group of five to ten person from each country. They are considered as representing key actors from the cocoa value chain in each of the countries and have a comprehensive understanding of the CFI efforts in their respective countries, leadership skills and the ability to influence and advice during the decision-making processes.

Traceability	**Continue to carry on the cartography of cocoa production areas** A better knowledge of the plantations' location makes it easier to/ facilitates identify/ the identification of potential risks and negative impacts associated to cocoa supply chains. **Set up and regularly update a map with a superposition of forests and the cocoa production area (with a focus on high conservation value areas)**. This allows a closer follow up on exploitations located next to protected forests.	National level	Governments
Organizational	**Work at market level for non-cocoa products (fruits, timber, non-wood forest products)** To better orient agroforestry features, it is recommended to analyse the food industry's market needs and to make the information on available products accessible to buyers. Specifically, on timber, it is necessary to ensure income diversification as there is a strong need in Africa to organize discussions with timber companies.	Local level	Private sectors NGO

INTRODUCTION

Together, deforestation and forest degradation are the second leading causes of global warming, responsible for about 20 percent of global greenhouse gas emissions. This is particularly the case in forest-rich countries that have valuable alternative land uses. Côte d'Ivoire and Ghana are two examples of this phenomenon, where agriculture, including cocoa growing, is one of the key drivers of deforestation. Together, Côte d'Ivoire and Ghana account for more than 60 percent of cocoa beans production globally (FAOSTAT).

Cocoa sector growth resulting from deforestation negatively impacts ecosystem services provided by forests at local, national and global levels. It changes water cycles, increases the release of carbon dioxide into the atmosphere and degrades biodiversity and soils, amongst other impacts. Deforestation also undermines long-term productivity of forest landscapes and agricultural production systems. With an expectedly growing cocoa demand and competition for agricultural land also set to increase, the sector faces the urgent task of establishing more sustainable production practices. It imperially needs to improve returns to farmers and reduce environmental degradation.

Transitioning to a low-carbon, climate-resilient growth trajectory in cocoa production and processing will require significant investment and innovation. **The private sector can play a substantial role in this transformation**. In 2017, the governments of Côte d'Ivoire and Ghana, alongside 34 leading cocoa and chocolate companies, committed to working together through the Cocoa and Forest Initiative (CFI) to end deforestation and restore forest areas in West Africa, in line with the 2015 Paris Climate Agreement. The initiative has now grown to include Colombia. Building on the lessons-learned and good practices from other commodities and sectors, such as the Consumer Goods Forum, the CFI has developed a concrete, time-bound, joint action plan. It spells out the critical actions and a realistic timeframe to end deforestation. The CFI's main focus are: (i) forest protection and restoration; (ii) sustainable cocoa production and farmers' livelihoods; and (iii) community engagement and social inclusion. The next step for the CFI is the development and implementation of individual action plans from the private sector that are aligned to the regulatory, technical and financial capacities of the respective national governments.

Agroforestry (AF) has long been identified as part of the solution to restoring degraded landscapes and improving the sustainability of cocoa production and other crops (Ramachandran Nair P.K., 2007; Gebreegziabher et al., 2010). It involves the deliberate integration of trees in agricultural landscapes, in some form of spatial arrangement or temporal sequence, to obtain benefits from the ecological and economic interactions between these components. However, there are important knowledge gaps concerning the financial viability of agroforestry models in cocoa production, as well as significant barriers to widespread dissemination of successful production and processing examples.

Against this backdrop, **the World Bank – with support from the Forest Carbon Partnership Facility** – is joining the efforts of preserving forests and improving livelihoods through a global project that aims to explore public-private collaboration, opportunities with relevant networks and to develop topical deep dives and knowledge products. This will better inform private sector strategies and facilitate effective on-the-ground actions in selected jurisdictions. This global implementation guide has been prepared under this project.

CONTEXT OF THE STUDY, OBJECTIVES AND METHOD

Context of the study

The World Bank – with the Forest Carbon Partnership Facility – in its efforts to preserve forests, improve rural livelihoods and support a low-carbon and climate-resilient growth trajectory is implementing a series of activities intended to develop knowledge products. These products aim to inform private sector strategies, explore public-private collaboration opportunities, and facilitate effective on-the-ground actions in selected jurisdictions.

Recognizing that the evolution towards more sustainable agricultural practices plays a major role in the transition to a low-carbon, climate-resilient growth trajectory, the World Bank is **supporting and enhancing synergy of private and public-sector efforts. In doing so, it aims to improve the adoption of agroforestry practices in cocoa production.**

This process requires improvements in the following areas:

- Putting an end to the extension of orchards in natural, forested habitats or any other protected areas;
- Supporting the maintenance of existing plots in order to improve land fertility and yields;
- Restoring degraded areas by improving land fertility. Doing so by establishing suitable agroforestry systems for cocoa (and other crops) as well as expanding cultivation areas, without any impact on the environment.

In this context, a study was commissioned to facilitate the adoption of an economically viable and climate resilient growth trajectory for the cocoa agroforestry supply chain. By enhancing the knowledge of key stakeholders and their ability to apply it, the guide places a special emphasis on bringing together experiences from Africa and Latin-America. In that purpose, the initially planned deliverables included a global implementation guide for cocoa agroforestry. It also included a guide for the organization of knowledge exchange trips between cocoa producing countries in Latin America, the Caribbean (LAC) and West Africa regions.

Due to global uncertainties and travel restrictions brought on by the COVID-19 pandemic since early 2020, the knowledge exchange trips – which involved intercontinental travel and several field visits – were converted to a series of webinars: the *Cocoa & Forest Knowledge Exchange* program. These technical webinars on agroforestry were produced based on professional video documentaries of different case studies, that are also presented in the guide. This approach aims to "bring the field online". Along with the guide and the webinars and for participants to visualize the impact on the ground beyond mere pictures and presentations, six films were produced to showcase good practice across Africa and Latin America.

Objectives of the guide

This guide aims to close the knowledge gaps between the financial viability of agroforestry (AF) models and the various barriers to their widespread dissemination. It is therefore not a technical manual on agroforestry as there are already many, but rather a capitalization on good practices and on concrete feedback from the actors themselves. The targeted audience are technical specialists, investment officers and policymakers from public and private sectors.

The guide's development benefited from a year-long consultative process through the *Cocoa & Forest Knowledge Exchange* program and the production of good practice films. The study team gathered and analysed relevant data extracted from the following seven case studies:

- **Côte d'Ivoire**: The Camaye Vert project of the CAMAYE cooperative in Abengourou, and the experience of Mr. N'Koh's farm in Azaguiè. While these two projects were able to provide sufficient

data to conduct a cost-benefit analysis, the consultants were also able to benefit from the experience of other public (Coffee and Cocoa Council, SODEFOR) and private actors (Tranchivoire, among others).
- **Ghana**: Agroforestry projects implemented in the "Community Resource Management Areas" (CREMA) in partnership with the Ghana Cocoa Board (COCOBOD).
- **Brazil**: Ouro-verde project and Cabruca systems
- **Colombia**: Ecotierra company project.
- **Peru**: a project by Forest Finance project and a by a non-governmental organization – AIDER-Peru.

Approach and methodology

The following general approach was adopted in the development of the guide and the knowledge exchange webinars:

Figure 1. Phases of the study

The study was based on three sources:

- an extensive literature review
- an analysis of case studies based on consultation with practitioners or project promoters
- field observations.

Phases 2 and 3 were happening simultaneously to allow retro-feeding.

The writing of this guide was based on both a literature review and results from data analysis, issued from the concrete practices of countries participating in the *Cocoa & Forest Knowledge Exchange program*. The study went beyond the theoretical dimension published in certain textbooks in recent years by taking into account the value of good practices and feedback from practitioners.

The good practices were gathered in three ways: (i) interviews with project stakeholders to build the case studies; (ii) a campaign to capture six videos in Côte d'Ivoire, Colombia and the Dominican Republic; and (iii) a series of webinars organized between March and October 2021. The countries considered in the webinars were CFI signatory countries (Cote d´Ivoire, Ghana, Colombia) along with two others representing FCPF country participants and cocoa producers (Peru, Dominican Republic). Brazil was also selected, given its significant experience in agroforestry and in the perspective of conducting field visits there. A few examples were also extracted from other countries such as Togo, albeit without as many details.

The readers are highly recommended to watch the videos and to consult the case studies provided in appendix. These documents have also been cited in the relevant sections of the report.

1. OVERVIEW OF COCOA PRODUCTION SYSTEMS IN THE WORLD

1.1 Diversity of cocoa production systems

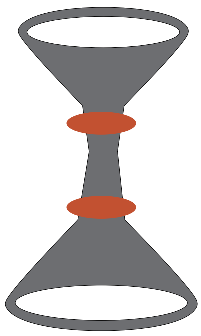
More than 90% of the world's cocoa is grown by about 5.5 million small-scale farmers, mainly in West Africa (Côte d'Ivoire and Ghana) and 14 million of rural dwellers depend directly on cocoa for their livelihoods.

Over 80% of worldwide cocoa production is done on small family farms of about five hectares or less. Farmers sell their produce to large commodity trading companies, mostly through local intermediaries who take their margin in passing. At this level, the cocoa sector conforms faithfully to a captive model in most producing countries (Le Basic, 2015).

Figure 2. Structure of the cocoa production and consumption market in the world (adapted from Alliot et al., 2016)

5.5 millions
cocoa small holders worldwide
And livelihoods for 14 million producers and workers

5 main chocolate brands
represents circa 50% of the chocolate market



3 cocoa bean processors
own circa 70% of the coating chocolate market and 50% of the cocoa paste/butter market

Billions
of consumers

The figures in *Table 2* below show some figures from cocoa producing countries that are given on an indicative basis, since they lack precision to be considered as proper reference. Indeed, the 2020 edition of the Cocoa Barometer highlights that for most of these figures, there is a lack of reliable data. For instance, the yields of Ivorian and Ghanaian producers used to be considered at 400kg/ha in older studies, based only on the estimates of the producers themselves. The data for 2020 came from companies buying cocoa and thus appeared to be higher. This can be linked to the farmers overestimating the size of their own farm, which after GPS analysis were found to be much smaller than what they declared.

Also, it is usually believed that countries in the LAC region have much higher yields than west African producing countries. This is not true at a regional level: regional yields are higher in Western Africa, however the yields in LAC are significantly increasing (Chen Y., 2016). Brazil, Peru and Ecuador have higher yields. In the case of the Dominican Republic, the average yields remain low except for a few farms that have access to more technology and plant material with high yield potential, hence better performances (Abbott et al, 2018).

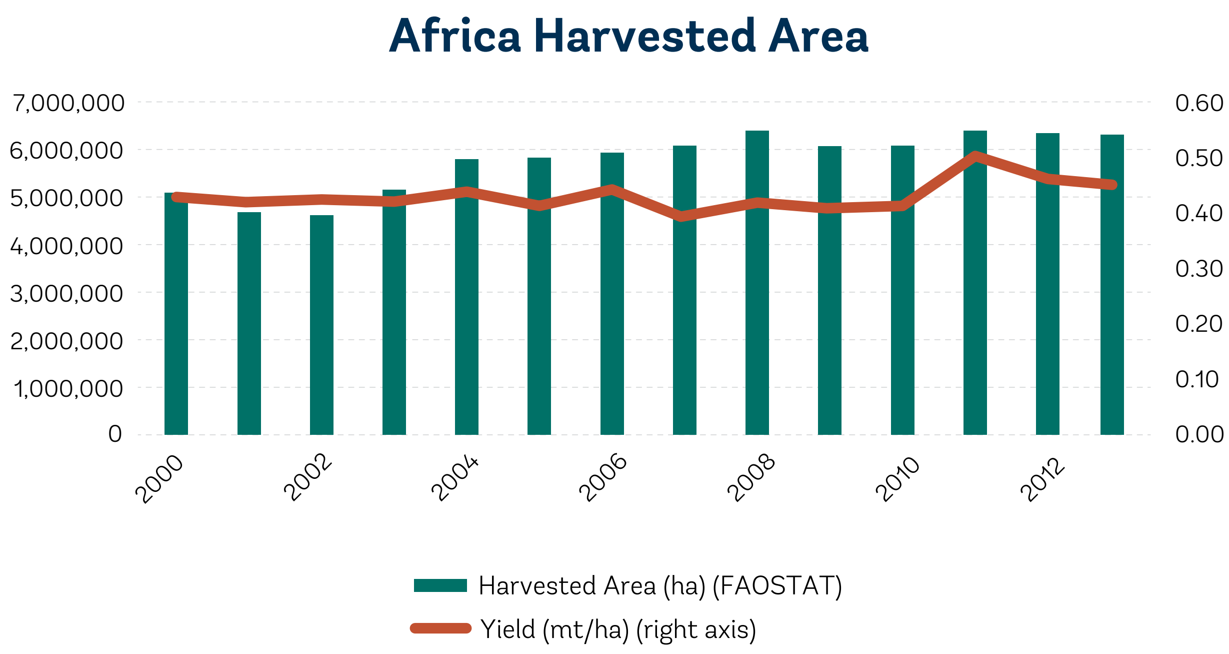
Table 2: Key figures for the producing countries of the exchange program

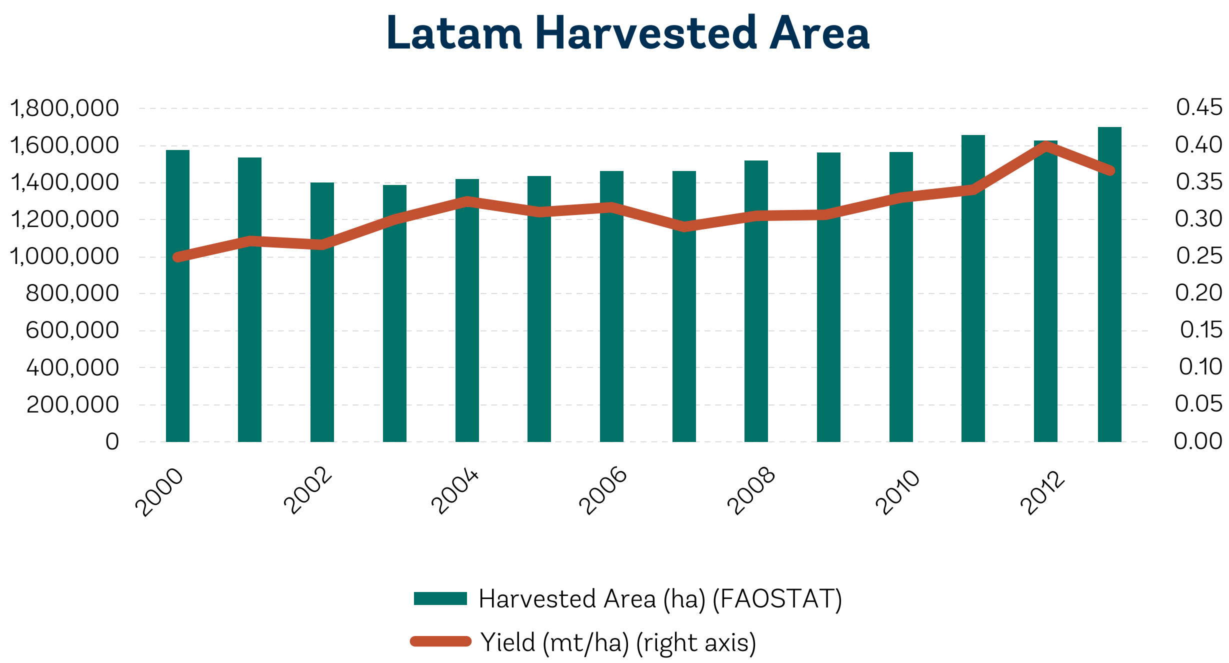
Country	Cote d'Ivoire	Ghana	Peru	Dominican Republic [6]	Colombia [8]	Brazil
Number of farmers - farms	840 000 [2]	800 000 [3]	45 000 [4]	40 000 [7]	38 000	77 600 [11]
Average yield at national level (kg/ha)	500 [1]	546 [1]	600 - 700 [5]	360	332	445 [9]
Harvested surface (ha)	3 255 000 [2]	1 910 000 [3]	156 000 (2017) [5]	152 000	165 000 (2015)	582 000 (2019) [9]
Farm size (ha)	3,4 [1]	2,1 [1]	2 [5]	3	0,5 to 1,5	8,4 ha (average area with cacao trees per farm) [10]
Labor (man days/ha)	[1] Conventional: 32 – 65 [1] With GAP: 40-211		Half of their time (rest is spent on other crops or work) [4]	Not available	Not available	Not available
Farm Gate price (USD/t)	[1] Current: 1,810 [1] Desired: 3,166	[1] Current: 1,804 [1] Desired: 3,116	2016: 2,205 2017 : 1,525 [5]	2,400 USD/t (80% of 3,000) [6]	Not available	2,254 USD/t [10]
% of certified production (Organic/FT/RFA/UTZ)	Not available	Not available	16% certified (2017) [5]	16,5% organic [7]	Not available	1% organic [10]

Note: Figures were rounded-up to facilitate lecture.

Sources of the figures: [1] Cocoa Barometer, 2020, [2] REEA (Recensement des exploitants et exploitations agricoles 2015-2016, [3] Ghana Cocobod, [4] Technoserve, 2015, [5] INIA (Instituto de Innovación Agraria), 2019, [6] Berlan and Bergés, 2013) (a study made for Cocoalife), [7] Etudio Bi-nacional cocoa DR/Haiti, [8] Abbott et al. 2018, USAID, [9] FAOSTAT, [10] IBGE/PAM, 2020, [11] Ceplac, 2020

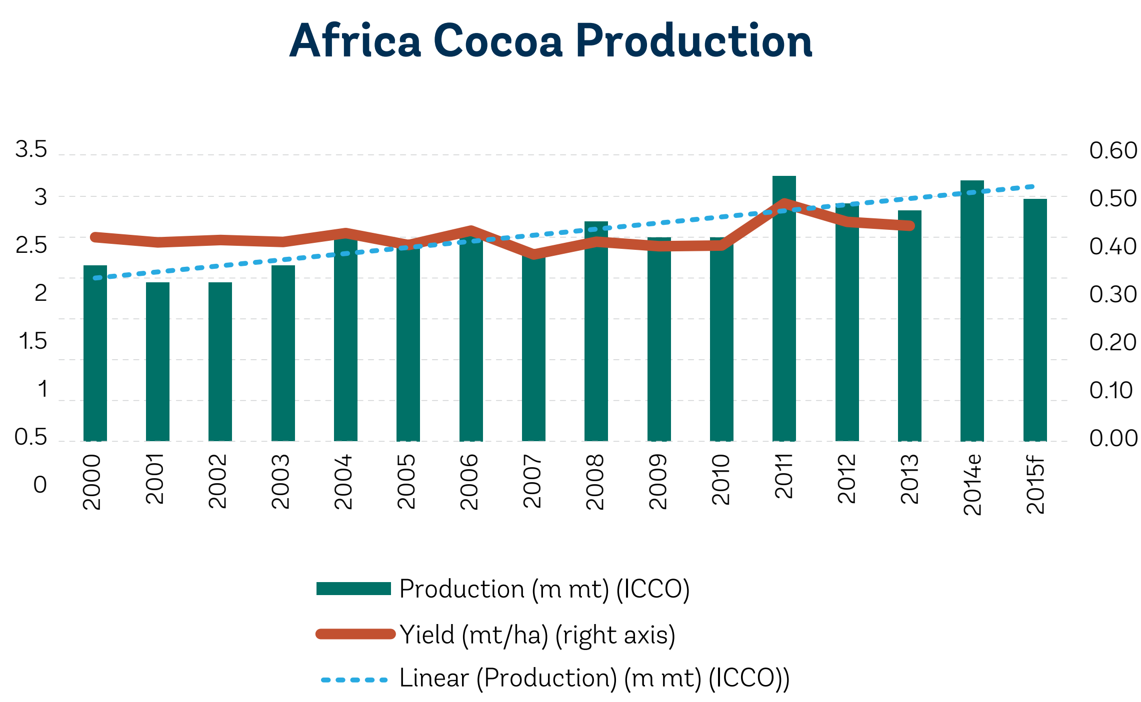
Figure 3. Evolution of yields and harvested area in Africa and Latin America (Source: Chen Y., 2016)

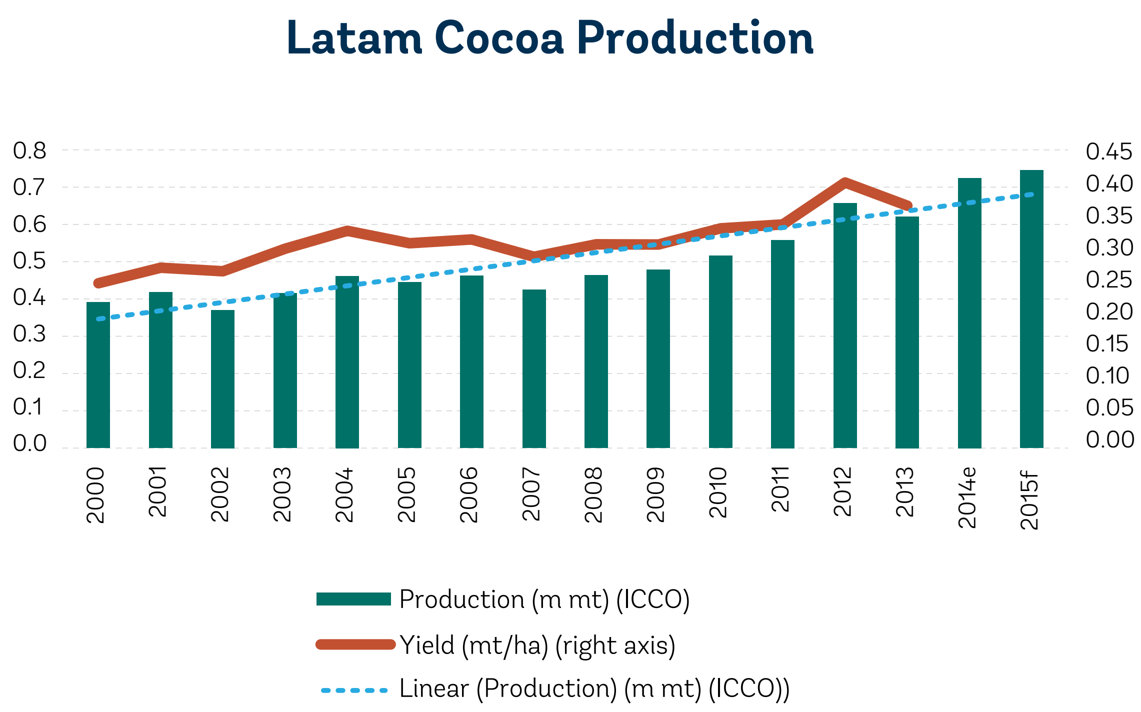




A study by Hardman agribusiness identified some differences between Africa, Latin America and Asia in terms of cocoa production and yield dynamics (Chen Y., 2016). In Africa, production increased along with the amount of harvested area, which can be directly related to the encroachment on forests. The yields, however, tended to remain stable, if not slightly decreasing (Figure 3 and Figure 4). This illustrates the slow decrease in West African orchard productivity, as there is a constant demand from farmers to expand their farms. On the other hand, Latin America also experienced a tremendous increase in production for a few years (84.2% between 2000 and 2014, against 48% for Africa). This productivity continued to improve thereafter, proving that the yields grew better over the years – a trend also linked to the expansion of the harvested area.

Figure 4. Production and cocoa yield in Africa and Latin America (Source: Chen Y., 2016)



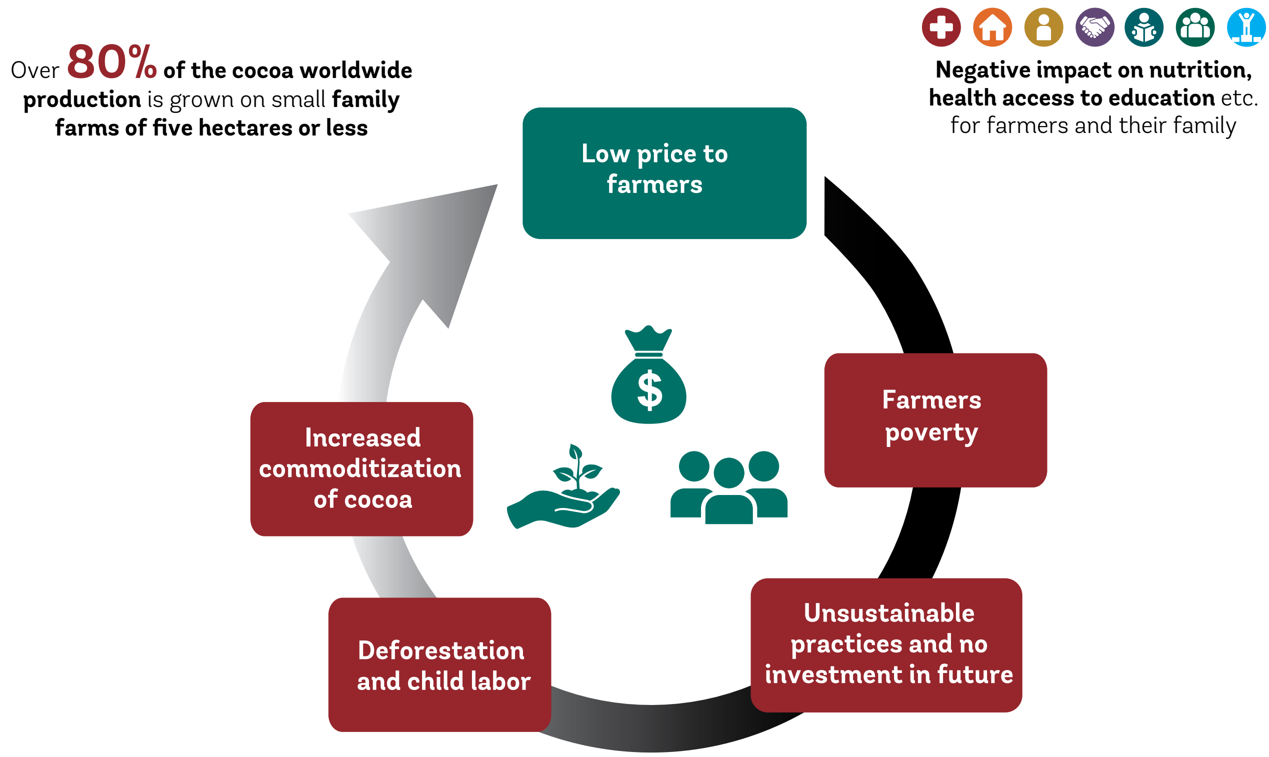


1.2 Land use dynamics and threats to the environment

Full-sun cocoa farming is the method of cultivation most prominent in West Africa: to maximize the yield in a shorter amount of time, cocoa trees are grown in full-sunlight with no shade; over time, the orchards become less productive and are abandoned (Angoran E.J., 2018, Ruf F. 1995, Tondoh et al. 2015).

The observed decrease in yields in West Africa lies in the significant proportion of over-aged orchards, while the spread of cocoa swollen shoot virus disease (CSSVD) drives the decrease in production capacities in other affected regions. The cocoa producing surface of Côte d'Ivoire and Ghana is composed of a multitude of orchards with different age classes. Young orchards have high yields while the yield of over-aged orchards tends to decrease. The productivity from CSSVD infested plots decreases rapidly and within few years the orchard dies. Farmers often cannot escape the vicious cycle of low productivity and low incomes, resulting in the lack of investment in their farms and eventually persisting low yields (The consequence of the loss of yield at farm level or production at regional level consists of a displacement of the orchard into new area, and generally, the creation of new orchards is related to deforestation (Ruf F. 1995 ; Gockowski et Sonwa, 2011 ; Amiel F, 2019b).

Figure 5. The spiral of non-sustainable cocoa



- Up to 95% of Cocoa beans are sold on global commodities markets **dependence on international price fluctuations**
- Farmers are mostly **unorganized** and depend on **middlemen selling far below prevailing market prices**

- **Child labor** in cocoa production in cote d'Ivoire and Ghana **has increased in the past 10 years**
- A lot have been done but **root causes have not been addressed**
- **Key players reputation at risk**

- **Low access to inputs and trainings**
- **Aging/sick trees**
- **Low yields**
- **Aging famers'** communities

Thus, cocoa growing has been identified as a driver of deforestation and forest degradation in the countries where it is practiced. In 2017, the NGO Mighty Earth exposed the large-scale destruction of protected areas in Cote d'Ivoire and Ghana due to cocoa production. This sounded the alarm amongst cocoa buyers, who have since responded by partnering with governments and civil society through a framework agreement with the two major cocoa producing countries (Côte d'Ivoire and Ghana), the Cocoa and Forest Initiative. They have pledged to ensure that no further conversion of land for cocoa growing would occur from January 1, 2018 onward.

1.3 Cocoa agroforestry around the world, background, and interests

Agroforestry systems are land management practices in which trees are grown on the same area as agricultural crops or livestock. The cocoa tree is commonly found in agroforestry systems around the world. In Latin America, for example, cocoa is grown in traditional agroforestry systems, as observed in the video presented from Santander, Colombia during the exchange program. In Brazil, *cabruca*[7] has been used for more than 200 years[8]. In Indonesia, cocoa agroforestry

7 The "cabruca" system, very common in Bahia, is represented only in the Atlantic Forest biome; in the Amazon Rainforest Biome the arrangements in the agroforestry systems are very different. Note that among the seven case studies used by the Guide work team, the one referring to Brazil cannot be generalized as cabruca is very common in Atlantic area.
8 In Southern Bahia, Brazil, "cabrucas are the traditional agroforests in which cacao trees are planted under thinned-out native forests" From *Biodiversity and Conservation* Volume 21, pages1055–1077 (2012). The cocoa trees grow in the shade of other trees native to the ecosystem and co-exist with a variety of other plant and animal species.

systems in Central Sulawesi are characterized by the cocoa plants young age (3 to 27 years old). These plants are grown on plots presenting a diversity of trees: native forest trees, fruits, coconut and even coffee trees (Juhrbandt et al. 2010).). Yet, despite the success of this approach in some regions, it is difficult to estimate the global share of cocoa grown in agroforestry systems. The lack of monitoring, which makes progress hard to track, is one of the elements explaining this absence of data.

In West Africa, before full sun cocoa cultivation became dominant, there were other cropping systems. Cocoa was first grown under tropical forest canopy, which came with some disadvantages such as low yield, fungi infestation, rodent attacks, black pod disease because of the excess of shade. This practice progressively shifted to cocoa being grown under slashed forest, artificial shade and finally under full sun promoted by extension services. This was mainly due to the higher yield of varieties produced under full sun conditions – as a result of the research published in the 1970-80's (Ahenkorah Y., 1974). Today, Côte d'Ivoire and Ghana have rare cocoa agroforests where cocoa is cultivated under the shade of native forest trees and other food crops. In the year 2000s in Côte d'Ivoire, 70 to 90% of plantations were characterized by conditions of light shade or full sun (Assiri A. A. et al, 2009).

However, with the scarcity of forests and commitments made to stop deforestation, Côte d'Ivoire and Ghana are entering a "post forest" cocoa era that introduces new challenges for the farmers. In aiming to solve increased disease and pest as well as decreasing soil fertility problems, they will increasingly need to restore or replant overaged and/or diseased plantations, instead of cutting down new forests (Sanial E., 2018).

To regenerate cocoa cropping and promote climate change resilience, agroforestry systems are emerging as a viable option. Indeed, shade cultivation provides benefits for biodiversity and can increase soil fertility and carbon absorption. The shade trees can help keep harmful organisms in check. Also, establishing a canopy with shade trees helps to regulate the crops temperature and humidity. Certain spatial arrangements in strips or hedges provide a windbreak effect. Under certain conditions, agroforestry systems can be an effective solution to diseases such as the cocoa swollen shoot virus[9] (known as CSSVD) that ravages many plantations. Cocoa agroforestry practices can also extend orchard lifespan with more stable yields over time (Blaser W.J. et al, 2018).

Regarding CSSVD, if some tree species are natural barriers to swollen shoot, others can host the virus and are not recommended to be mixed with cocoa. Therefore, special care needs to be taken regarding the selection of the species combined with cocoa. Integrating the right tree species to cocoa plantations is critical and context specific. This calls for better collaboration between research, tree nurseries (run by public services, private companies, or cooperatives) and farmers in order to program and size the production of seedlings according to the microclimate, the soils, the economic objective of the plantation. Several other projects promoting cocoa agroforestry have been implemented in the past but without achieving meaningful results. This points out the increased importance of analysing the factors of successes and failures and how the adoption of those systems could be facilitated. In Cote d'Ivoire, there is an official list of species that are not recommended or incompatible with cocoa plantations (CNRA, 2016).

9 The Cocoa Swollen Shoot Disease, transmitted by infectious mealybugs and infected budwood, is a serious constraint to the production in West Africa, especially Ghana where it was discovered. The most severe form of the virus can kill a tree within two to three years.

2. GOOD AGRICULTURAL PRACTICES IDENTIFIED

2.1 Ecology and agricultural practices of Theobroma cacao

Theobroma cacao L., of the family Sterculiaceae and better known as the cocoa tree, is native to tropical rainforests of Central and South America. Out of the ten main subspecies groups, three are predominantly cultivated (Memento, 2012): Criollo, Forastero and Trinitario (hybrids of Criollo x Forastero). Native to the Amazon rainforest, the tree can tolerate a significant level of shade, low light and high humidity. However, under these conditions, some varieties can be more sensitive to the brown rot of pods (*Phytophthora* spp).

During its first three years of growth, the young cocoa plant needs to be protected from too much light. After about 18 months of orthotropic growth, the stem gives birth to a crown of five plagiotropic branches. The cocoa tree reaches its full development between six and eight years of age, at which time it is between 4 to 6 metres high. Production generally begins three years after the planting (for selected varieties) for a phase that generally lasts for 25 to 30 years. Maximum production takes place eight to ten years after planting.

It was demonstrated that the production of pods can increase with light exposure if nutrient supplies are sufficiently offset - especially by soil fertilisation – if rainfall is sufficient and if here is a good crop protection. This cultivation practice of optimizing light exposure of cocoa is generally engaged in monoculture fields, where both light exposure and cocoa density are optimized. It is called **full sun cocoa cultivation**. However, under strong sunlight exposure conditions, cocoa trees are more exposed to insects such as mirids (*Sahlbergella singularis* and *Distantiella theobroma*) and diseases such as CCSVD, as previously mentioned in Section 2.3. Thus, full sun plantations are potentially the most productive. However, depending on the varieties, the yields can quickly decrease after 20 or 30 years because of tree and/or soil exhaustion.

The complex planting formats that combine multiple strata of crops and trees that are complementary to the cocoa stratum have a higher level of shading. and optimize cocoa trees lifetime (Jagoret P., 2020). If the shading is too strong, the cocoa remains exposed to diseases, mainly fungi. In agroforestry, cocoa yields will also go down 20 or 30 years after the plantation establishment, but slower than in full sun. In such models, it is possible to see cocoa orchards with a significant production 50 years after plantation establishment (Jagoret P., 2020).

To summarize:

- The cocoa tree is a small tree (4 to 6 meters) that grows in the undergrowth. It can be grown with a certain level of shade but will produce fewer pods.
- When the cacao tree is exposed to sunlight, it may produce more pods if soil fertility is sufficient, but there is a risk of quick decline in yield after 20 to 30 years.
- Under shade, the cocoa tree is exposed to fungi and under full sunlight, it can be invaded by mirids.
- There are intermediary cropping systems (see in the next parts) which combine acceptable and sustainable production of pods and access to many other products and services.

2.2 Analysis of current practices and innovations to be promoted

The two cultivation practices described in Section 2.3.3 (intercropped and multi strata models) are already existing today. The full-sun practices are mainly observed in Africa (Cote d'Ivoire and Ghana) while the agroforestry practices are mainly observed in Latin America (Brazil, Colombia, Dominican Republic...) and in some parts of Africa (Cameroon). In Ecuador, Americas' first produce, both systems are combined. Traditionally oriented towards agroforestry systems with fine cocoa varieties, the country is developing monocultures, betting on the high productivity of clones like CCN-51.

The analysis on current practices (Table 3) highlights the impacts of cocoa production on functionality (services given by biodiversity) when it is linked to deforestation. It results from the replacement of old non-productive orchards by new ones, obtained through cutting down natural forest, which is more fertile. This habit is mainly present with full-sun practices where sharp yield decrease occurs, hence pushing producers into leaving their fields to establish new ones.

Furthermore, full sun practices are less resilient to climate change and, if current practices are maintained, many cocoa producing regions could be strongly impacted by 2050 (Ladërach et al., 2013).

Finally, average cocoa production is low in many countries, with values around 500 kg/ha (Faostat, 2021). This is mainly since there are many old cocoa orchards in the main producing countries (Cote d'Ivoire, Ghana, Brazil) that need rehabilitations.

This analysis on huge functionality loss and low production is combined with complex situations for producers and high poverty, mainly in Africa (see part 4.1). It highlights the need to promote new sustainable practices that could answer these challenges. These practices are defined based on three pillars:

- **Environment: Engaging practices in a land-use pathway that avoid deforestation,** diminish the effect of climate change, and preserve biodiversity and its ecosystem services.
- **Social: Ensuring a stable, diversified, long-term income** and food supply to producing households. More generally, allow all actors in the value chain to be guaranteed human rights and a decent standard of living
- **Economic**: A significant and lasting income to finance the ambitions of the previous two pillars and **meet the world cocoa demand** with a stable, reliable, and sustainable supply.

To meet these three conditions, this guide focuses on agroforestry practices and their capacity to maximize the functionality of the plot. Mainly these practices ensure long term yields and preserve land fertility. Moreover, these practices incorporate other crops than cocoa, which allows for diversification of the producers' income. The main features of the current systems (full sun and agroforestry) and the durable agroforestry recommended by the guide are given in Table 3.

Table 3: Key features of current cropping systems and the recommended durable agroforestry

		Current systems		Sustainable cocoa agroforestry
		Full-sun	**Traditional agroforests**	
Investment features		High investment with focus on cocoa trees.	Investment on cocoa and shade tree. Lack of shade tree use planning. Lack of tree replacements (overaged cocoa trees rarely replaced).	Investment on cocoa and shade tree Every shade tree has several selected functionalities. Cocoa tree monitoring driving to decisions of replacement. **Higher initial investment** than in current practices
Inputs		Use of pesticides and non-organic fertilizers.	Low or zero inputs (the farmers rarely use fertilizers and pesticides)	Inputs are used but as low as possible or based on organic sources (compost, recycling pods, etc.)
Cocoa production		**High yields** but **for a limited time** which is important for producers. Since they have high discount rate, they need investment that can give them rapid return.	**Medium to low** yields depending on the cultivation choices.	**Medium** and **perpetuated yields,** thanks to shade management.
General state of the production LAC Rare		West Africa 70-90% of the national orchard in Côte d'Ivoire; Ghana probably has similar figure. These areas have replaced natural forests.	West Africa Estimated to 10-30% in West Africa. Old orchards with low productivity in average.	West Africa Pilot scale. New orchards in pilot projects to replace full sun cultivation or to be installed in new lands.
		LAC Dominant in some areas (Bahia in Brazil, Santander in Colombia, Dominican Republic)	LAC Increasing	
Functionality (other than cocoa production)	**Gain**		Biodiversity and soil preservation providing: shade, carbon storage, fertilization, water regulation, reduced weed growth, control of pests and diseases.	**Optimization of functionality**: Every gain of traditional agroforests plus other crops production and income diversification. Better spatial arrangement facilitates maintenance, wood harvesting and the windbreak effect.
	Loss	Linked to deforestation. Fertility losses due to erosion. Source of carbon. No protection against disease or climate change.	Could be linked to deforestation (installation of cocoa in natural forests). Disease (fungi) can appear with poor shade management.	No loss because this system is supposed to diversify the existing landscape.

2.3 Typology of cocoa agroforestry systems

This section is a technical analysis of the composition of a cocoa agroforestry system. The objective is to give an overview of the main components and tools inside these systems that enable sustainable cocoa production. This guide includes several bibliographical references to more technical guides on cocoa-based agroforestry systems, intended for readers seeking technical advice.

Definitions of agroforestry

According to ICRAF and CTA (1993), agroforestry is the voluntary integration of trees into agricultural landscapes, in some spatial arrangement or temporal sequence, to obtain benefits from ecological and economic interactions between these different components. Countries specifically have been able to provide more precise definitions, including for cocoa agroforestry. For example

- **In Côte d'Ivoire:**

According to the Agricultural Orientation Law (2015-537 of July 20, 2015), agroforestry is the reasoned integration, in space and time, of trees into agricultural and/or livestock systems. This integration is developed with the intensification of the agropastoral system and linked to the emergence of a finite space, where intensive practices no longer permit sufficient production to satisfy the populations needs. During the workshops for the presentation of this guide, the Conseil du café et du cacao specified that cocoa-based agroforestry includes at least 800 cocoa plants/ha associated with 25 shade trees. It should be noted that in Côte d'Ivoire there is a particular experiment called "complantation". Implemented by SODEFOR in classified forests, it consists of adding trees to existing cocoa plots. A specific framework presents this experience.

- **In Ghana:**

Agroforestry models in Ghana have been classified according to the number of stems and species in the cocoa growing system and the estimated canopy cover they generate. For instance, in a study, the UNDP describes three agroforestry models practiced in Ghana (UNDP, 2011) including 1) The low-shade cocoa agroforestry system with low density of shade tree layers with between 1 to 9 shade trees/ha providing a shade level between 36 to 65%. 2). The medium-shade system is shaded by diverse spectrum of planted shade trees, mostly natural growing trees ranging between 10 to 15 trees/ha and provides a shade level of 66-85%. 3). The heavy-shade system provides a high degree of shading with a natural forest setting with over 15 trees/ha and provides a shade level over 85%.

However, in their recommendations on shade cover in agroforestry systems, work done at the Cocoa Research Institute of Ghana (CRIG) recommends 16-18 mature trees/ha planted at 24 x 24 m providing an estimated shade cover of about 30-40% (Asante et al., 2017). The official COCOBOD Cocoa Health and Extension Division manual indicates a density of 1,111 cocoa trees/ha under such shade.

- **In Colombia:**

The Colombian National Chocolate Company defines agroforestry by quoting the FAO: "Agroforestry can be defined as a dynamic and ecological natural resource management system, which through the integration of trees in farms and agricultural landscapes, diversifies and provides important economic, social and environmental benefits".

Typology according to the level of shading

To have the panel of functionality wished in a cocoa agroforest, a key aspect that should be monitored is the level of shade. As mentioned in Section 3.1, this parameter is central in the definition of cocoa agricultural practices. It influences both yields and longevity of a cocoa plots and is correlated with the level of functionality of the plot. Indeed, more side plants could be planted and harvested if a farmer decides to use a high level of shade in his or her cocoa plot.

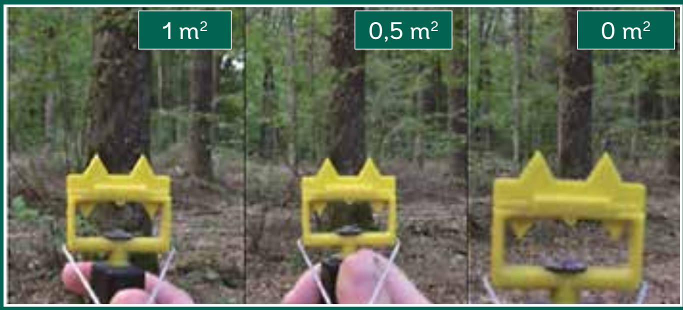
This level of shade depends on the soil canopy cover. It defines the amount of sunlight that can penetrate through the canopy to directly reach the cocoa tree. To measure it, different methods can be used. The main one is direct light measurement through a camera (Silva et al., 2020). Another easier method, currently reported in studies (Jagoret P., 2020) and adopted in field project (Nitidae, 2019) is the basal area measurement (see Box 1).

BOX 1. The basal area, a key indicator (Nitidae, 2019)

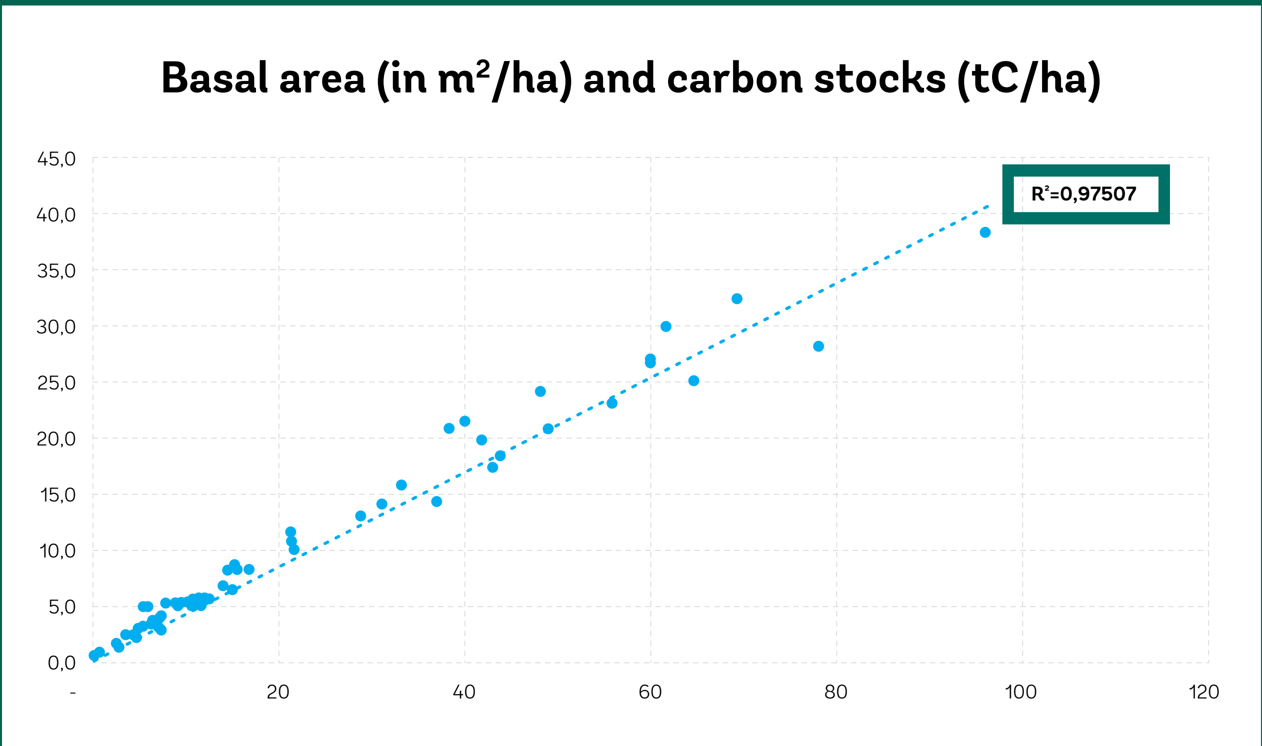
The basal area of a tree (g) is the area of the section of the trunk at breast height of 1.3 m. It is expressed in m^2.

The basal area of a stand (G) corresponds to the sum of the basal areas of trees reduced to the hectare and is expressed in m^2 / ha.

Current studies are showing a correlation between basal area and the level of shade (Jadan et al., 2015, Silva et al., 2020).



In addition to the level of shade, a study conducted by the NGO Nitidae in Eastern Côte d'Ivoire has shown that there is a strong relationship between basal area and carbon storage. Based on evidences from the field, the NGO recommended the amount of 5m²/ha (which correspond to 10 tC/ha) to trigger payment for ecosystem service of approximately 180 USD/metric ton of cocoa bean.

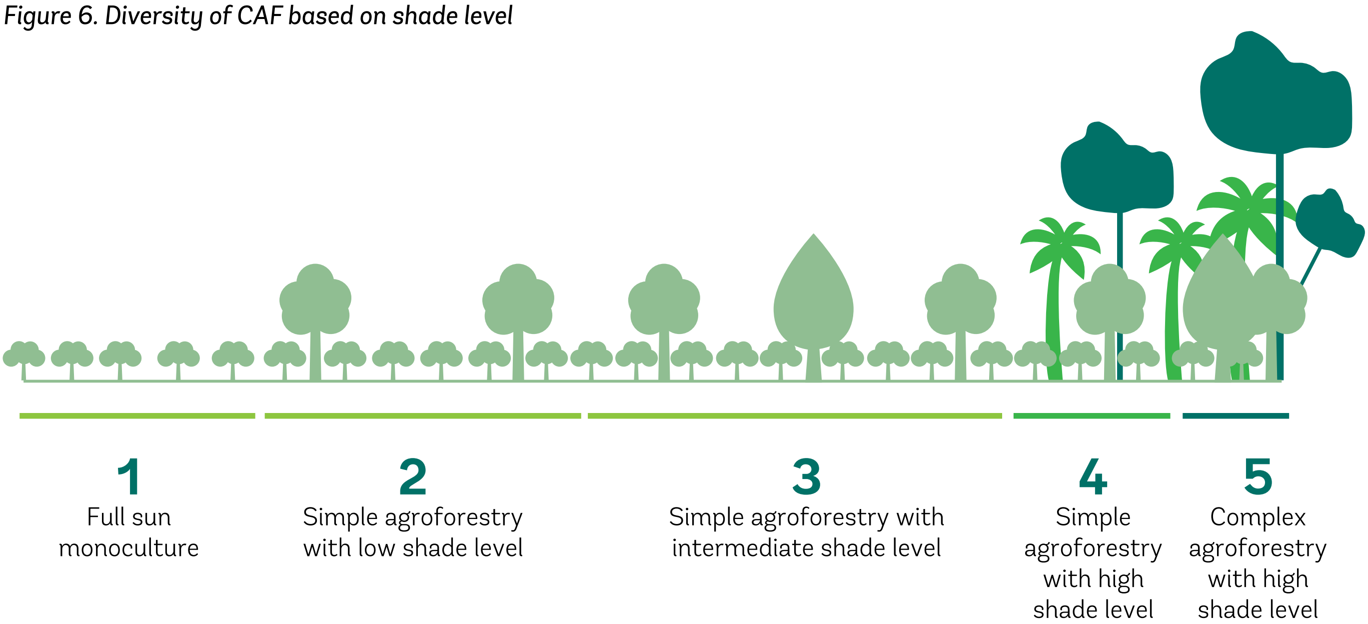


The level of shade is a good parameter to define the complexity of a cocoa agroforestry system, and some classifications of these systems based on it have been made in the literature (given in Table 4 and illustrated in Figure 6). In this table, the level of shade is calculated with amount of shade tree in the plot.

Table 4: Diversity of agroforestry systems based on shade level

Cocoa system	Description – origin of the trees	Side plants strata represented	Shade tree of the cocoa tree /ha
1 – Cocoa monoculture	Full sun cocoa. Culture in farmland.	None	0
2 – Simple shade simple agroforestry system.	Few planted fruit trees in the cocoa plot.	Strata 2	<10
3 – Medium shade simple agroforestry system	Planted shade trees or trees kept from highly fragmented forest.	Usually, trees in strata 1 and 2	>10 ; <15
4 – High shade simple agroforestry system	Planted shade trees or trees kept from fragmented forest. No work to organize vegetation strata.	Usually, trees in strata 1 and 2	>15
5 – High shade complex agroforestry system	Planted shade trees or trees kept from fragmented forest. Important work to organize the vegetation strata.	All vegetation strata represented	>50

Figure 6. Diversity of CAF based on shade level



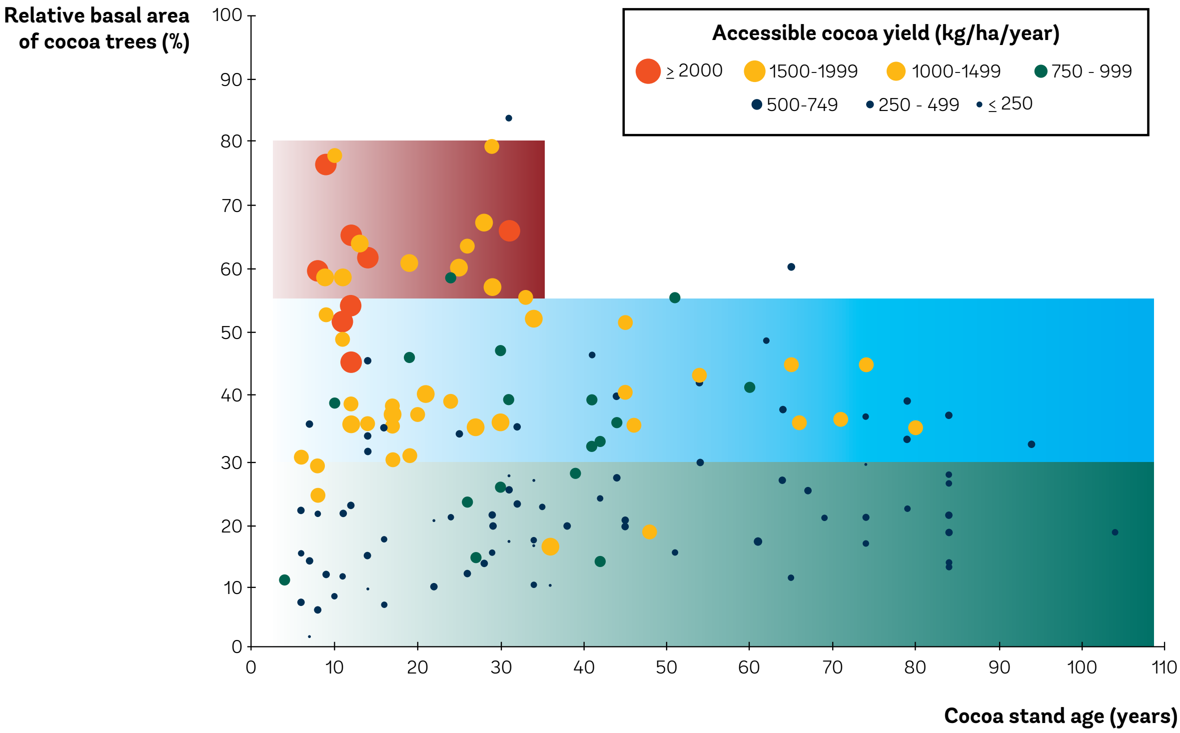
Source: *Amiel, 2018*

The question of the level of shade raises a trade-off between three parameters: cocoa yields, cocoa longevity, other crops harvested, pest and disease control through the management of shade and air circulation. To answer the trade-off between average cocoa yield and cocoa longevity, an optimum has been measured in Cameroon proposing a basal area between 40 and 55% as an optimum level (see Box 2).

Box 2. Trade-off between cocoa longevity and cocoa yields by varying the level of shade in Cameroon (measured with the basal area of cocoa trees)

A 40-55% relative basal area of cocoa stands - pledge of a good trade-off between cocoa yield and cocoa stand longevity

In this study carried out in Cameroon (Central region), each dot in the figure represents a cocoa agroforestry stand and its size is proportional to its commercial cocoa yield, with yields ranging from less than 50/kg/ha to more than 2 t/ha.



In the centre of the figure **(blue)**. Cocoa agroforestry stands have optimal characteristics. Yields are close to or above 1 t/ha of cocoa, and this performance lasted well over 40 years. These stands have per-hectare mean of 137 associated tress. The relative basal are of cocoa trees ranges from 30-50% – cocoa tress represent on average 9.3m² and associated tress 11.4m².

In the upper part of the figure **(brown)**, cocoas tree cropping is not sustainable. The stands are simple with a per-hectare means of 70 associated tress. The relative basal area of the cocoas tress is over 55% – that of cocoas tress is 8.6m² on average, while that of associated trees is 3.9m². Yields can reach over 2 t/ha, but these cocoa tress do not last more than 30 to 40 years as they are hard to maintain, even with chemical inputs such as fertilizers.

Conversely, in the lower part of the figure **(orange)**, cocoa tress cropping is sustainable but low yielding. The stands are complex, with 176 associated trees per hectare. The relative basal area of cocoas tress is less than 30% – cocoa trees represent 5.1m² and associated trees 24.4m². Yields range from less than 50 kg/ha to 750 kg/ha..

Source: *Saj et al., 2017 et Jagoret et al., 2020*

Definition According To Shade Stratification And Nature Of Secondary Crops

First, in agroforestry systems, other plants are cultivated next to the cocoa trees in the fields. These plants (mainly trees) are distributed in different strata according to their size. They are planted next to cocoa trees in agroforests due to the different functions they offer. These functions can be ecological services given to the cocoa trees, thus improving their health or yield (utility plant), or produce commodities other than cocoa, thus diversifying the farmers' income (associated crops). A list of the main functions of secondary crops is shown in Table 5. A more exhaustive analysis of the notion of functions in a cocoa plot is given in section 4.2.2.

Table 5: Typology of functions offered by crops associated with cocoa

Type of functions	Function
Ecological services to cocoa trees (utility plant)	**Shading, fertilization, water availability, refuge for fauna (pollinators)**
Products other than cocoa (associated crops)	**Wood, medicine, subsistence crops, cash crops, honey**

Once the functions of the secondary crops were defined, the different strata that could exist in an agroforestry system were characterized (Table 6), giving each one the name of the type of tree or crop that is most represented. For each stratum, the general function observed was indicated as well as some important trees observed in Africa and Latin America. A more comprehensive analysis of potential shade trees is available in Climate Focus (2020) for Africa (Côte d'Ivoire and Ghana) and in Suárez Salazar et al., (2018) for Latin America (Colombia).

Table 6: Characterization of the different strata of a complex agroforestry plot according to regions (Source: *Rivain S., 2018* and case studies)

Stratum	Analysis	General function (in order of relevance)	Important species in Africa	Important species in Latin America
1-Forest trees >20 meters	Endogenous forest species: Legumes, spice trees, timber trees	**Shade, wood, fertilization, water availability, refuge, medicinal plants, honey**	Fraké, Akpi (CDI), Muscadier du Gabon (Cameroon), Albizzia	Hévéa, Capirone, Bolaina (Peru), Erythrina (DR), *Cariniana pyriformis* (Colombia)
2- Fruit trees between 7 and 20 meters	Mainly fruit trees or leguminous plants	**Crops, fertilization, shading**	*Citrus*, *Garcinia kola*	Citrus, Avocado
3- Cocoa tree size <7 meters	Vegetable products, shade trees for young cocoa trees and legumes or herbaceous plants	**Fertilization, shading (first years), crops (first years)**	Banana trees, *Gliricidia sepium*	Banana trees
4- Soil levels	Subsistence crops during the first years of installation	**Crops (first years), fertilization**	Yam	Pigeon pea, yuka, bean

System definition through the agricultural practices

There is a large diversity of cocoa agroforestry production systems over the world, in terms of the levels of shade and of the side plants selected (with a huge panel of shade trees associated with cocoa growing). Other parameters, such as the structural complexity shown in Table 7, reinforce the diversity of these agricultural systems. To visualize this diversity, the cocoa agroforestry technical definition is summarized into six indicators, as presented in Table 7 below.

Table 7: Six main parameters defining an CAFS that characterize an agroforestry cropping system in terms of practices

Installation	
Land use pathway	Origin of the plot that will influence the nature of shade trees (natural or planted).
Location	This point will define endemism and local climate (sunlight, rainfall…)
Structuration	
Associations	Side plants chosen and functionalities prioritized
Management	Cultural choices throughout the years (shade management, inputs…)
Density	Chosen density of cocoa and shade trees. This parameter will define the level of shade in the plot
Spatial organization	Pattern of installation of cocoa and side plants

There is a very large diversity of agroforestry systems. However, the literature review made during the study and the interaction with the groups under the *Cocoa and Forest Knowledge Exchange program* suggest that the spatial organization of the orchard can define the agroforestry systems. Thus, it was decided to use a simple categorization already given in a recent report issued by the World Cocoa Foundation (WCF). In this report, two agroforestry systems models were defined: one model where the construction of the plot is focused on cocoa and one other stratum (intercropped model); and another model where every stratum is represented (Climate Focus, 2020):

- In the **intercropped model**, the focus on 2 strata (1 cocoa and 1 side plant) will result in simple organizations of the plot to ease the maintenance of the field. The level of shade can be highly variable, depending on the side plant stratum density. Hence, this system corresponds to systems 1 to 4 in Table 11. In that system, the side plant can have both ecological and cropping function but they have generally one main purpose. Hence it can either be:
    - An **utilitarian plant**. In that case, the ecological service targeted will be focusing on optimization of cocoa production (shade and fertilization). A producer in such agroforest will mainly try to optimize both the longevity of cocoa and cocoa yields in the trade-off raised in 3.3.2. He will therefore seek to adapt his level of shade to be in the optimum level of shade computed in Box 2.
    - **A combined crop**. In that case, the producer will try to optimize the income coming from both crops.
- In the **multi-strata model**, the presence of all the strata will result in a more complex organization of plots with a large diversity of species. The level of shade will generally be really high, corresponding to the system 5 defined in Table 11. The construction of the model will strongly depend on the origin of the side plants:
    - If the side plants are **natural forest trees** under which cocoa has been planted, the focus will be on cocoa exploitation. In that case, the producer will once again try to optimize both the longevity of cocoa and cocoa yields. The other trees present in the plot will be regularly maintained and could be occasionally exploited.
    - If the side plants are **planted**, these models are characterized by a great diversity of combined crops and the enhancement A producer in this multi-stratum model will try to optimize the 3 parameters of the trade-off raised in 3.3.2. He or she will balance the level of shade to find an optimum between cocoa longevity and yields while optimizing the other selected crops' production. The result of this trade-off will highly depend on the synergies between crops, the productivity of other crops and need of products other than cocoa for the producers (food crops, medicine, wood…). This system is much more complex than in the case of the intercrop but is resilient to shocks thanks to the high level of functionality and the high crop diversity.

The detailed definition of these two models following the four structuration parameters is given in Table 8. An illustration of these models and their spatial organization is given in Appendix 3.

Table 8: Structuration parameters of the 2 systems analysed in this report

System	Origin and main purpose of side plants	Associations	Management	Densities	Spatial organization (see Appendix 3)
Inter-cropped: 2 strata	**Purpose**: utilitarian plant **Origin**: could be either planted or natural plants	**Main functions**: shade and fertilization	Focused on cocoa	High cocoa densities 1,300 cocoa tree/ha or more <30 utilitarian trees in Africa.	Trees within the lines of cocoa Alternating strips cocoa/ trees
	Purpose: combined crop **Origin**: planted plants	**Main crops**: timber or fruits.	Focused on both cocoa and 1 other crop	1,000 cocoa tree or more Up to 300 combined trees (Latin America)	Alternating strips cocoa/trees Trees around cocoa fields
Multi-strata: 4 strata	**Purpose**: mainly utilitarian plants **Origin**: natural plants	**Main function**: shade	Focused on cocoa	1,000 cocoa tree or less. More than 200 natural shade trees.	Trees within the lines of cocoa
	Purpose: both utilitarian plants and combined crops **Origin**: planted plants	**Optimization** of functionalities Crop diversification	Labour intensive: cocoa; combined crops and maintenance	1,000 cocoa tree/ ha or more in pilot projects More than 200 planted shade trees (high diversity)	Alternating strips cocoa/ tree planted in staggered rows.

2.4 Field analysis and recommended practices

Before detailing the recommended practices, this section begins with an overview of the context of the cocoa practices studied during the exchange program in Africa and Latin America. These practices have been grouped into the two installation variables given in Table 8 above.

Field analysis from the case studies

The Two tables below provide the general framework for the implementation of cocoa agroforestry studied in Africa (Table 9) and Latin America (Table 10).

The main tendency observed is that there is an important traditional use of cocoa agroforestry in South America with high density of shade trees. The existing agroforests in Africa are sparser due to historic incentives to move towards a low shade cover in these countries.

Many projects exist for the rehabilitation of orchards or landscapes through agroforestry or plantation in savannah. This will be the kind of transition that will be the most recommended. given its benefits on several levels (carbon, biodiversity, income).

Table 9: Characterization of cocoa-based agroforestry systems studied in Africa

System	Implementation framework	Specificities	Origin and main purpose of side plants	Projects studied
Inter-cropped	Traditional installation in sub-optimal areas	**Main existing agroforests**. Low shade tree densities (<20 trees/ha) due to historic incentives to have a low shade cover	Natural utilitarian plants	North of cocoa producing regions in Ghana (Abdulai et al., 2018). Sonwa et al. (2019)
	State rehabilitations projects	Incentives to plant endemic shade trees in existing cocoa orchards	Planted utilitarian plants	CREMA[10] and COCOBOD projects in Ghana
Multi-strata	Traditional installation due to restriction in forest uses	Low cocoa yields. Very high cocoa densities (Cameroon). Very low cocoa densities (Cote d'Ivoire).	Natural or planted utilitarian plants	- Cameroun (Jagoret et al., 2014) - Agroforests in Beki region (Cote d'Ivoire). - General analysis: Sonwa et al. (2019)
	Long term agroforestry experiments	High agroforest complexity and cocoa yield	Planted utilitarian plants and combined crops	Champion Project (Cote d'Ivoire)
	Pilot projects to demonstrate the efficiency of agroforestry	Highly supervised projects with significant technical support	Planted utilitarian plants and combined crops	Camayé vert project (Cote d'Ivoire)

Table 10: Characterization of cocoa-based agroforestry systems studied in Latin America

System	Implementation framework	Specificities	Origin and main purpose of side plants	Field analysis
Inter-cropped	Plantation projects in savannahs	Models with 2 crops (cocoa-timber; cocoa-*Hevea brasilensis*) and a high density for the combined crop (>250 tree/ha).	Planted combined crops	- Ecotierra project (Columbia) - Oura Verde cooperative (Brazil)
Multi-strata	Traditional installation in degraded forests	**Main existing agroforests**. High shade tree density (~250 tree/ha), little exploitation of the shade trees (legal constraints)	Natural utilitarian plants	Cabruca systems in Brazil Agroforests in Columbia (see Santander and Caqueta videos) Dominican Republic (Notary et al., 2020)
	Plantation projects in savannah	Very near of an intercropped project, the strata used other than 2 prioritized are generally few planted food crops.	Planted combined crops	- Forest Finance project (Peru)

10 In Ghana, the Community Resource Management Area (CREMA) is a mechanism for community governance and management of natural resources. This model aims to encourage the constituent communities of CREMA to integrate natural resource management into their traditional livelihood strategies in areas outside forest reserves and protected areas.

Box 3. SODEFOR's "complantation" model, a temporary agroforestry system for the rehabilitation of classified forests

Definition: Complantation is the introduction of low-density forest trees into a perennial crop in production. The complantation is aimed at a farmer or a group of farmers illegally installed in classified forest. A protocol of agreement is signed between SODEFOR and the farmer or group of farmers.

History of complantation in Côte d'Ivoire:

Phase 1: The Taungya system

This system was used for the installation of large reforestation during the first two years of the plantation, with the advantages of reducing maintenance, boosting the growth of the stands and guaranteeing the success of reforestation.

Phase 2: Conversion of agricultural occupations from 1993 to 2006

Since 1992, manager of 231 classified forests totalling a cumulative area of 4.196 million ha. Implementation of a new type of reforestation within the framework of the management of classified forests, called: the conversion of agricultural occupations by introducing 340 feet/ha with local species such as fraké, framiré, niangon, etc.

Phase 3: Planting of agricultural occupations from 2007

Following the assessment of the reconversion in 2006, it was recommended to adopt a definitive density of reforestation to promote the cohabitation of trees and agricultural culture. It is done through an agreement between SODEFOR and the farmer defining the modalities of cohabitation of the farms with the forestry activities. It includes:

- The signing of a contract between the farm manager and SODEFOR;
- The introduction and protection of forest trees in perennial crops in production (100 feet/ha);
- Stop new clearings;
- The installation of dwellings outside the forest;
- The continuation of farming in production by the farmer for a predefined period.

Implementation strategy:

The implementation of this agroforestry system results from the conclusion of an agreement between SODEFOR and the peasant illegally installed in classified forest. The reforestation is done at low density (around 100 trees per hectare), with local species of slow revolution.

The work of creating the forest plantation is carried out in advance by the farmer himself.

This system allows the cohabitation of forest plants and agricultural crops over a certain period.

Implementation technique:

- Sacked seedlings are recommended for planting.
- In order to conserve biodiversity, local and/or exotic species are recommended:
  - Local species: Mahogany, Tiama, Koto, Bahia, Badi, Niangon, etc.
  - Exotic species: Teak, Cedrela, Gmelina, etc.
- The density adopted is 100 stems per hectare at a maximum of 10 meters between the lines and on the plantation lines. The spacing on the plantation line is adjustable according to the chosen density.
- Schedule :
  - Information and awareness: from July to December
  - Survey and plot transfer: from January to February
  - Field preparation: from March to April
  - Planting: May to June.

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Possible transition scenarios leading to sustainable cocoa agroforestry depending on the situation

Principles

The previous field analysis, show that there is a multitude of agroforestry systems already practiced going from the plantation of cocoa trees in Savannah or degraded forests areas to installation, under forest (Brazilian cabruca)

The durable agroforestry practices to be recommended will depend on several factors:

- The agroforestry installation pathways. This installation must not be associated with deforestation. For example, the abandonment of old cocoa farms in degraded forests may be recommended for biodiversity conservation purposes.
- The maximization of the functionality and resilience to climate change of new agroforestry cocoa farms. The study shows that complex, multi-strata agroforests can meet both these needs.
- An optimization of the trade-off between shade level, yield and longevity of the cocoa tree presented in Box 2 according to the choices of combined crops made.

Pathways

The good agricultural practices defined in Section 3 and the environmental analysis in the current section underline the contributions of cocoa agroforestry for sustainable cocoa production. To achieve the adoption of agroforestry at scale, both the multi-strata and intercropped models are necessary depending on needs and capacity of the farmer and in the framework of gradual transition. Even if the multi-strata system is preferable (more biodiverse and functional), it is complicated and expensive to set up. It needs a high investment by producers in the cocoa plot, and practical knowledge in culture associations and management, which are difficult to access for the numerous smallholders who produce cocoa.

In this context, five different pathways were defined as necessary to obtain a systemic change towards agroforestry with its respective scope of application illustrated in Table 11.

Table 11: Possible transition paths to cocoa agroforestry

Context 1: Rehabilitation and Renovation of existing orchards **Objective:** Perpetuate and improve functionality of current systems		**Context 1:** Installation of new orchards **Objective:** ensure that new cocoa installations are zero-deforestation	
Pathway	**Scope of application**	**Pathway**	**Scope of application**
1) Full-sun to Intercropped	- Systemic practices shift - Low farmer monitoring (investment costs help)	**4) Savannah to Intercropped**	- Systemic practices shift - Low farmer monitoring (investment costs help)
2) Full-sun to Multi-strata	- Local/targeted practices shift (ex: creation of biodiversity corridors, see 4.2.2) - High farmer monitoring (investment costs help, training, long term monitoring)	**5) Savannah to Multi-strata**	- Local/targeted practices shift (ex: creation of biodiversity corridor) - High farmer monitoring (investment costs help, training, long term monitoring) It should be noted that this pathway could allow a good storage of significant carbon. We detail this in section 3.2.1 Analysis of carbon sequestration in cocoa agroforestry
3) Intercropped to Multi-strata	Medium farmer monitoring (farmers with skills in agroforestry)		

In light of the carbon sequestration analysis carried out in part 5.2.1, the pathways starting from savannah and full-sun cultivation to multistrata agroforestry could allow a good carbon storage (140TC/ha for mature plantation with 140 shade trees/ha).

Focus points on the technical pathway

As explained in the introduction, this guide is not a technical manual on agroforestry. It focuses on highlighting good practices identified in the framework of the exchange program. This section summarizes some of the technical aspects to take into account t in sustainable agroforestry practice. For this purpose, three main phases must be distinguished: 1) The establishment phase of the agroforestry plantation; 2) The plot initiation phase; 3) The maintenance phase of a mature plot.

Settlement phase

Step / activity	Good practices
Vision Co-construction	• Ensure the farmer's production goals are taken into account, and the short-term income/deferred income balance • Then deduce the costs of the long-term planning and design of the plantation • In addition to economic considerations, several scenarios guiding the choice of associated species are identified (CCC, 2015): • Improved "fallow" (plot planted with fast-growing legume and used a few years later to cultivate cocoa), • Selected trees (trees left by the producer at the creation of the plantation for their utility) • Complemented trees (trees planted in the cocoa farm at the moment of its creation), • Preservation of local species (trees that appeared spontaneously and were maintained for specific needs) • Boundary planting (trees planted along the contours or boundaries of a plantation), • Protective strips (fence or barrier with trees or shrubs planted to serve as a protection or health barrier)
Planting site selection (new orchards)	• The location must be zero deforestation. • Ecosystem protection: establish plantations away from wildlife refuges, do not cut down trees in the forest to establish new plantations, create protected areas by planting trees and other vegetation along the riverbanks, maintain ground cover, use diverse and native trees, do not burn to prepare new land for agriculture (CHED, 2016) • Integrated water resource management: keep distance between planting and water sources, prevent water contamination from chemical runoff, avoid dumping waste into water, handle and store manure/fertilizer/agrochemicals to avoid contamination (CHED, 2016) • Select relatively flat land. • Vegetation: where possible, maintain local tree species instead of removing them all and then planting exotic trees for shade. If there are well-known adverse effects (such as diseases or pests), then the farmer should avoid certain species.
	• Be sure to take into account the classical characteristics expected of cocoa soils (water retention properties and good drainage, clay-loam, organic matter rate, pH: 5.0-7.5) and of the environment (annual precipitation between 1,500 mm and 2,000 mm; periods where precipitation is less than 100 mm per month, which should not exceed 3 months)
Preparation (new orchards)	• Cleaning: No fire. • Erosion prevention: If high slope => dig trenches perpendicular to water flow. Plant fast growing herbaceous species in trenches. • Weed control: integrated management, associations, no herbicides (agroforestry practice should reduce weed pressure). • Staking: Respect spacing (3mx3m or 3mx2.5m).

Step / activity	Good practices
Planting (for new orchards)	• Respecting the dimensions of the planting holes. This is a key element for the good rooting and growth of cocoa trees and associated trees. Recommended dimensions: 60cmx60cmx60cm (minimum 40 cm) • The quality of the filling soil is also important to feed the young plants properly. It is recommended to return the surface soil to the bottom. • Do not pack too much then.
	• In addition to banana trees, install leguminous species such as fast-growing gliricidia to provide shade, utilize nutrients, and produce biomass
	Focus on mulching from leaf fall.
	• Installing supplemental trees (fruit, nuts, wood, etc.) in adequate spacing for future shade and density goals
Mulching	• Spread dry plant material around the base of the cocoa plant in the late rainy season. In termite-infested areas, mulch material should be treated with a termicidal solution (CHED, 2016).
Planting (rehabilitation case)	• Locating and replacing old or diseased cocoa trees to reach at least 800 cocoa trees/ha. • Open spaces (areas already empty or soon to be left by old cocoa trees to be pulled out) offer the opportunity to install other species (fruit trees and timber). Also, it is necessary to identify the light holes while respecting the spacing of the species in order to eventually achieve the optimal shade sought (Climate Focus, 2020). • Weeding and clearing areas where plantains are dead or diseased and where low-yielding cocoa has been removed • Planting on plot boundaries.

Box 4. SODEFOR's "complantation" model, a temporary agroforestry system for the rehabilitation of classified forests

In many cocoa manuals, attention is not given to the age and stage of the cocoa trees nor the shade trees. In his definition of a cocoa agroforestry, Asare (2006) placed emphasis on time and space as the key indicators for species selection and incorporation in cocoa system. Asare and Ræbild (2016) also argued that shade provision should not only be on stem numbers but should also consider species type and diameter at breast height (DBH) for appropriate shade at a particular time based on the special arrangement. Based on these, a cocoa agroforestry model can be developed as 1) Establishing cocoa with food crops; 2) Integrating fruit trees in cocoa; 3) Integrating timber and nitrogen fixing tree species in cocoa; 4) A mixture of two or all the above (Asare and David, 2011).

The model on establishing cocoa with food crops starts at the establishment stage where cocoa is between 1-3 years. This involves the cultivation of cassava, plantain, maize together with cocoa. Over the years the farmer harvests food crops for home consumption and sales to make extra income while waiting for the cocoa to mature. The model on Integrating fruit trees in cocoa involves cultivating economical fruits such as avocado, mango, orange, oil palm in cocoa farms. These trees are also planted between 1-3 years. The model on Integrating timber and nitrogen fixing tree species in cocoa involves planting permanent shade trees such as Terminalia ivorensis, Alstonia boonei and Khaya ivorensis, in cocoa in addition to nitrogen fixing plant like gliricidia sepium. It also includes addition of timber species for shade when the cocoa is at the mature stage. The fourth model presents a blend of either two of the earlier models or all at the same time.

Initiation phase

Step / activity	Good practices
Temporary shade control	Thin or remove weak, malformed, diseased or low-yielding banana trees that are no longer desired in the system.
Gap filling	If thinning and regular felling of trees to control shade creates large gaps, take the opportunity to fill in with young shoots to: • Diversify age classes (cocoa or other priority species) • Ensure long-term continuous production, and/or incorporate new species or varieties to diversify production (Climate Focus, 2020)
Soil cover	Cover crops in early years. Use of cover crops: cover crops such as *Mucuna puriens*, tropical kudzu (*Pueraria phaseoloides*), *Stylosanthes* sp. can normally be planted between rows of cocoa seedlings to manage weeds on the farm (CHED, 2016).
Pruning	Pruning is important to facilitate cohabitation between species. For the training pruning of the cocoa tree, regularly remove with pruning shears or a sharp knife the poorly formed greedy and stems in order to have a single stem with a 5-branch crown. If the crown is low, leave 1 to 2 greedy stems on the crown; if the crown is well formed, the greedy stems must be regularly removed at the level of the trunk. Pruning is done in years 3 and 4 (CCC, 2015; CHED, 2016).
Weed control	Give preference to ground cover and manual weeding (3 to 4 times per year to limit herbicide treatments. Progressive closure of the canopy will also help control weeds.
Pest control	Adopt good cultural practices (weeding, shade adjustment, pruning of branches...) to avoid the development of insects (caterpillars, psyllids, leafhoppers, bark beetles, termites) and make a chemical treatment every two months (CHED, 2016)

Maintenance and maturity phase

Step / Activity	Good practices
Temporary shade control	• At maturity, shading will be around 30%; trees should be handled appropriately. • Wood harvesting and continued regeneration of shade and diversity: in this phase, the producer begins to selectively harvest wood and can benefit from long-term investments. Replacement of the individuals and filling of gaps that emerge as a result of selective harvesting must be planned. • The producer can initiate the stand replacement plan, removing dying or poorly performing trees and planting replacement seedlings in gaps.
Maintenance pruning and grooming	• Clear the cocoa trees of greedy and parasitic plants and epiphytes as well as dead or diseased branches and twigs regularly. • Pruning: with a pruning knife or a machete for the greedy ones accessible and with a lopper or pruner for the taller greedy ones, cut regularly low on the trunk • Pruning of parasitic plants: red flowers and berries / yellow flowers and blue fruits): cut or pull regularly with a pruner, a lopper or a machete until their total elimination from the plantation by cutting the parasitized branch just below the loranthus (3 to 5 cm) in order to avoid leaving a snag that could vegetate again

3. PATHWAY TO SUSTAINABLE COCOA AGROFORESTRY AND SUSTAINABLE LANDSCAPE

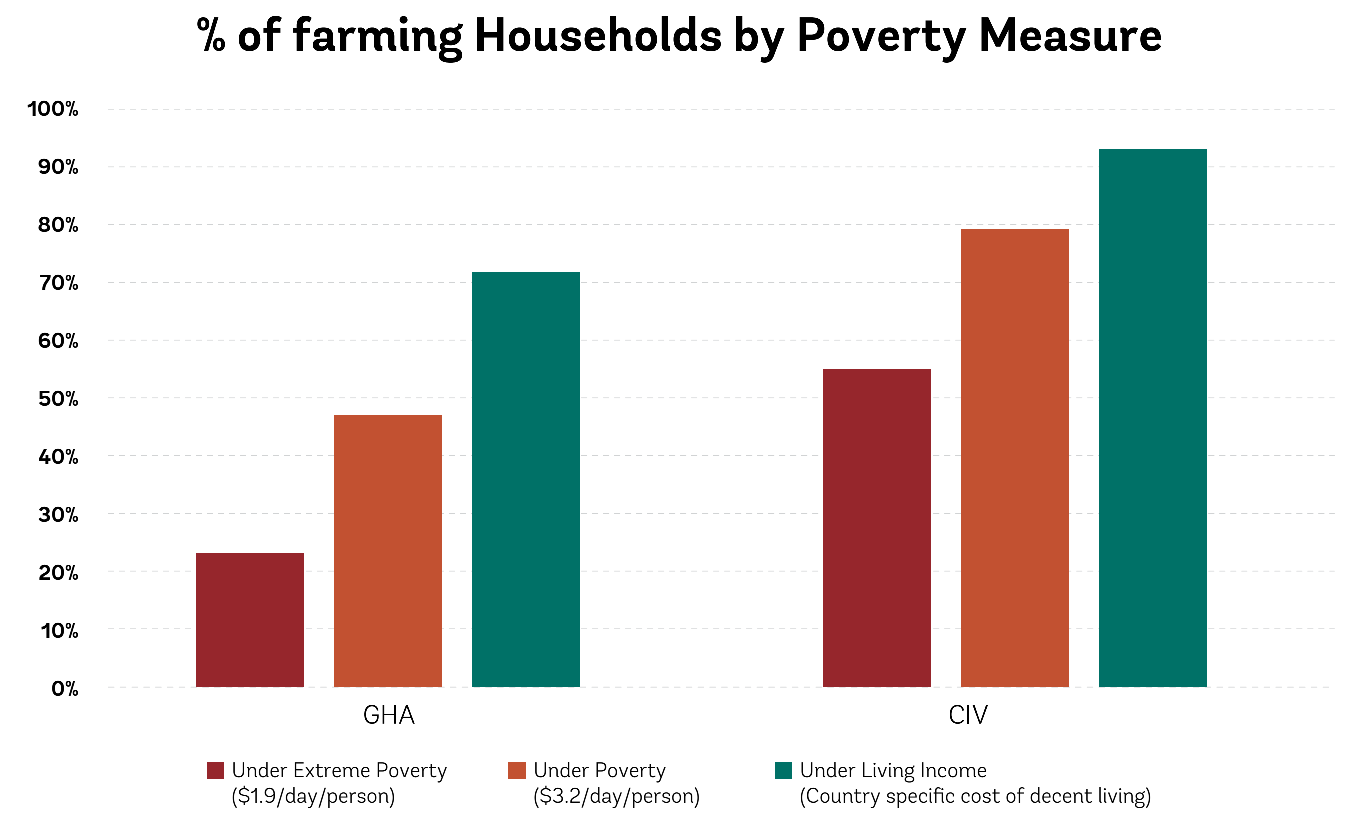
3.1 Socio-cultural analysis

Socio-Economic Situation of Cocoa Producers

The cocoa producing population is mainly composed of smallholders both in Africa (Werner and Husain, 2016) and Latin America (Hernandez et al., 2014; Carr M. K. V., 2012). Cocoa production is generally the main source of cash income for them.

In Africa, the cocoa producing population is very poor. A recent study (see Figure7) showed that the majority of the producing households in the main producing countries (Côte d'Ivoire and Ghana) were low-income earners. This poverty is coupled with another problem of child labor (Thorsen D., 2021).

Figure 7. Poverty of cocoa producing population in Ghana and Côte d'Ivoire



Study made by Mars on a panel of producers in its supply chain in 2018, shared with us in the 4th webinar.

In Latin America, the living conditions of the cocoa producers are better than in Africa. Indeed, the value chain is organized in a way that farmers can get a higher share of the cocoa revenue because of, for example, lower taxes (Ecuador) (FAO and Basic, 2020), more direct supply chains or better quality management.

Status of cocoa agroforestry

In West Africa

As stated before, in the main producing countries in Africa (Côte Ivoire and Ghana), monoculture was historically favored. Culturally, we can still observe today that producers are generally convinced that full-sun cultivation is the best way to produce cocoa (see video on Camayé Vert project – Côte d'Ivoire). Hence, cocoa producers do not master cocoa agroforestry practices and must be convinced that they are the best way to grow cocoa.

However, agroforestry is now encouraged for producers. This is done through provision of incentives and training to shift practices through projects carried by public funds (For example, the: Camayé Vert Project, shown in Appendix 5), government agencies (For example: the project implemented by CREMA and COCOBOD and FIP ,presented in Appendix 4) or by companies (For example, the project: Cémoi – Transparence cacao, 2018). In the case of Camaye Vert for example, the donor provides: training, support to tree and cocoa planting (in-kind by providing seedlings, for example, or in the form of cash to pay the field workers), and monitoring support.

Finally, the use of shade trees is impacted by the deforestation history of the countries: the timber shade trees are considered as an economic reserve that could be sold when cash is needed. There is also a complexity linked to the shade trees exploitation: the ownership by a cocoa producer of a planted forest tree has only recently been guaranteed by countries' regulations (see 5.2) and old practices and permits of logging company are still existing in the case of Cote d'Ivoire.

In Latin America

In Latin America, agroforestry is cultural. Having shade trees in the cultivation plot is considered a normal way to produce cocoa. In some countries such as Brazil, the cocoa producing farmers resisted changing their practices toward monoculture despite the incentives from the government to do so in the 1990s (Johns, 1999).

3.2 Environmental analysis

The environmental analysis of cocoa agroforestry practices was based on the measurement of natural capital. Natural capital is defined as the resources made available to humans by biodiversity. These resources can be global, thereby impacting the human population (climate regulation, carbon storage), or local, via ecosystem services rendered to nearby populations (agricultural assistance, provision of equipment). This analysis is based on existing literature

The study first focuses on carbon sequestration, a central global ecosystem service, before proposing a general analysis of this capital.

Analysis of carbon sequestration in cocoa agroforestry

Carbon can be stored in above-ground biomass (stems), below-ground biomass (roots), soil and necro mass. The first is measured by diameter at breast height (DHT) measurements while the latter are estimated via soil analyses.

The carbon storage values were analyzed along a land-use gradient ranging from natural forests to cocoa monocultures to agroforests.

Non-biomass carbon

In the different studies that could be carried out, the non-biomass carbon storage value, especially in the soil, is quite similar for natural forests, cocoa agroforest or full sun cocoa exploitations (Jadan et al., 2015; Saj et al. 2017; Sauvadet et al., 2020).

Biomass carbon

Regarding Biomass carbon, the difference between the three land use types is clear. On average:

- Carbon stored in **natural forests is above 150 TC / ha**, it can reach 250 TC/H (Jadan et al., 2015, Saj et al., 2017).
- In **agroforestry systems**, stored values can range between **60 TC/ha and 150 TC/ha** depending on the age and density of agroforests (Jadan et al., 2015; Pocomucha et al., 2016; Saj et al., 2017).
- In monocultures, stored carbon values are less than 10 TC/ha (Jadan et al., 2015).

In these studies, there is three times or more carbon stored in aerial biomass than in soil biomass.

The value of carbon stored obviously depends on the age of the cocoa exploitation analyzed. In a dynamic way, the cocoa trees could generally store 10 TC/ha (cocoa of more than 40 years old, Saj et al., 2017). The amount of CO_2 that can be sequestered by the shade trees depends on the densities of shade trees and the age of the exploitation. For instance, in dense agroforest sampled by Saj et al. (2017) in Cameroon (140 shade trees), approximately 65 TC/ha were stored in young agroforests (<20 years), 95 TC/ha for ages between 20 and 40 years and 140 TC/ha for old agroforests (>40 years old).

General natural capital assessment methods for agroforestry systems

Two parameters were used to analyse the natural capital: biodiversity and functionality.

Biodiversity capital of cocoa agricultural systems.

Methodology: Existing literature describing how to measure the biodiversity of the cocoa agricultural systems includes two sort of studies, as detailed in Table 12. The studies analysing biodiversity are focused on worldwide biodiversity.

Table 12: Levels of study usually found in cocoa natural capital studies

Analysis	Description	Way of measurement
Vegetation analysis	Census of plants satisfying a given criterion: • *Tree*: diameter at breast height (DBH) above 2.5cm or height above 1m to 2.5 m. • *Understory plants*: vascular plants of less than 1.3 m height. ⇨ Main kind of cocoa biodiversity studies in the literature.	Inventories (Bobo et al., 2006 ; Jagoret et al., 2014)
Multi-taxa analysis	• Global analysis of biodiversity within cocoa agroforestry systems (vegetation, mammals, amphibians, reptiles, invertebrate...). This analysis can be summarized with the definition of a global parameter aggregating the different species' biodiversity (Blaser W.J. et al, 2018) • Complete analysis seldomly performed (Deheuvels et al., 2014).	Inventories, trapping, capture. (Deheuvels et al., 2014 ; Blaser W.J. et al, 2018).

Globally, it is clear that **agroforestry systems are more biodiverse than cocoa monoculture** (full-sun). The agroforestry systems is shown in a number of studies to be around **five times more biodiverse** than full-sun systems in terms of vegetation biodiversity (in Ecuador: Jadan et al., 2015 and in Ghana: Asase et al., 2008 and 2010) and **twice for containing other taxa** (bird, butterflies: Asase et al., 2008).

Furthermore, the **biodiversity rises with respect to the complexity of the agroforests**. The study defined the augmentation of complexity through the extent of the shade cover (see Table 11). There is no absolute value of the biodiversity variation but two kinds of studies can be analyzed to illustrate this point:

- Aggregated studies such as Blaser W.J. et al, 2018, see Figure 8.
- Studies comparing two distinct levels of shade (Jagoret et al., 2014; Tetteh et al., 2018) or measuring a rise in biodiversity with the ageing of the agroforestry systems, and associated shade augmentation (Jagoret et al., 2014).

In a **biodiversity conservation** interest, the high shade complex agroforestry system (Agroforestry systems model number 5, Table 11) can be highly biodiverse and contain up to 70% of the biodiversity of primary forest (Zapfack et al. 2002). It is even in some cases more biodiverse than secondary forests (Vebrova et al., 2014). However, it is impossible to obtain comparable biodiversity conservation in agroforestry systems with respect to primary forests (Vebrova et al., 2014).

Hence, CAF are usually seen as an opportunity in terms of biodiversity conservation to (Vebrova et al., 2014):

- create natural corridor between forests,
- create buffer zones around protected areas,
- reduce edge effects between forest and agricultural land.

Functionality measurement of cocoa systems.

Methodology: The methods used to measure ecosystem services brought by cocoa systems globally, to communities and directly to cocoa production are listed in Table 13.

Table 13: Functionality analysis approach in cocoa natural capital studies

Variables	Description	Way of measurement
Natural produce provisioning	Produces for on farm consumption (food, material, medicine...) and marketable consumption (wood, food...)	Farmer assessments of use and value of shade tree species (Jagoret et al., 2014).
Supporting services	Services facilitating cocoa production: shade, water regulation, nutrients availability, pest control... (Mortimer, 2017).	Soil analyses (Savaudet et al., 2020) and inventories (Babin et al., 2010).

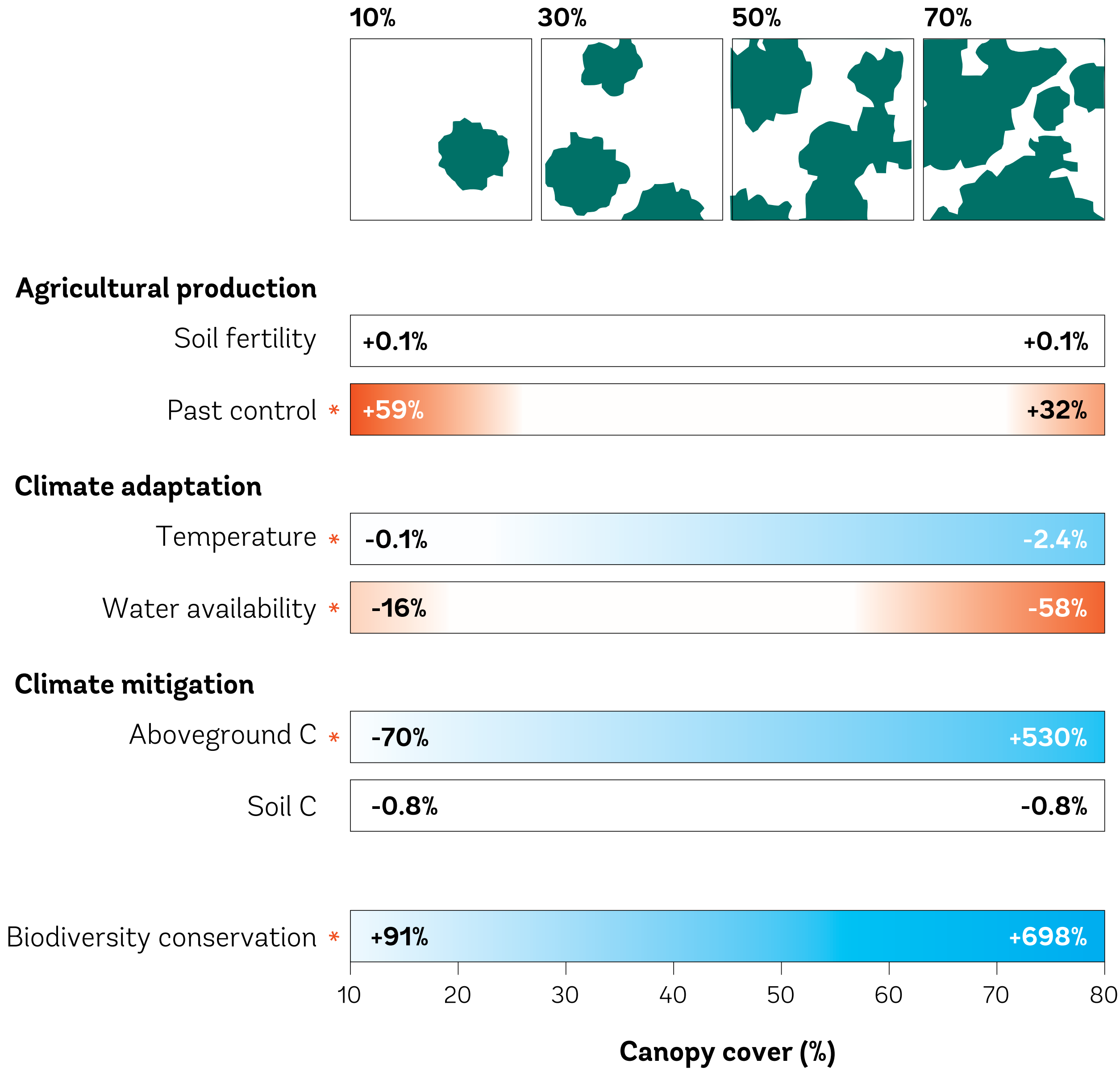
For **natural produce provisioning**, the services provided depend on the choice of the tree installed by the farmers in the agroforest system. Many studies exist to analyze the choices of the farmers and the different functionalities of the trees that could be used in association with cocoa (Jagoret et al, 2014), the summary of the main functionalities have already been given in Table 5. These services provided by cocoa agroforests could replace the services offered by natural forest (such as charcoal needs) and could also lower the pressure on primary forests (Vebrova et al., 2014).

Supporting services is a key issue in the analysis of a cocoa system's functionality. These services vary in function of the shade in the analyzed agroforest, some could rise continuously with shade (such as temperature control) whereas others could be optimum for a medium level of shade (such as pest control, see Figure 8.). It is these services that influence the longevity of cocoa production.

One should keep in mind that the level of the services provided is highly variable and dependent on the region of analysis, the age of the cocoa trees or the shade tree present: see for instance the analysis of nutrients availability depending on the shade tree selected (Savaudet et al., 2020).

A meta-analysis (Mortimer et al., 2017) recently listed the state-of-the-art knowledge on the different supporting functions provided by agroforestry systems.

Figure 8. Agricultural production, functionalities (climate adaptation and mitigation) and biodiversity conservation (multi-taxa analysis) compared to cocoa monoculture along a gradient of shade-tree cover (10–80%) for cocoa trees between 15 and 25 years ([Blaser W.J. et al, 2018](#)).



Natural capital of the systems proposed in the study

Assessing exact biodiversity and functionality values of the systems defined in this study is complex as these systems are not defined following the level of shade or the plant diversity in the orchard. The definition of these systems let the association parameter free, however, a few conclusions can be made:

- They are both more biodiverse and functional than cocoa monoculture.
- In each model, the cocoa agroforest with the denser shade tree cover will have the highest global natural capital (more biodiverse, highest carbon storage…).
- The more diverse shade trees are on a plot, the higher the overall biodiversity.
- Multi-strata models should generally be more biodiverse and functional than intercropped systems because there is more investment in this model in the establishment of the shade tree layers.

Cocoa agroforestry and climate smart agriculture

Amid the current climate variability, cocoa agroforestry has proven to be an adaptation strategy by farmers to improve farm resilience for agronomic and economic gains. In their attempt to quantify the possible trade-offs in cocoa agroforests, Blaser et al., (2018), analysed the impact of various levels of shade on agricultural production, climate adaptation, climate mitigation and biodiversity conservation. They argue that different levels of costs and benefits are realised across the shade gradient with improved cocoa yield at lower shade levels and high biodiversity gains at higher shade levels (Figure 8).

Asare (2006) defines cocoa agroforests as the strategic integration in time (at various stages in the establishment and management of cocoa farms) and space (the three-dimensional arrangement of trees on the ground and into the canopy) of suitable and valuable non-cocoa tree species and other plants. Species may include indigenous forest species, fruit trees, food crops, shrubs etc. in the context of climate change, the design should be adapter and the species carefully selected.

Box 5. A case for the different climatic impact zones of Ghana (Kofituo K. R. and Asare R., 2022)

The Ghanaian cocoa landscape is currently divided into three cocoa suitability impact zones in terms of climate change namely: Transform zone (suitability of cocoa production in this area is projected to be highly unpredictable), Adjust zone (suitability requires systemic adaptation to ensure productivity at current levels) and Cope zone (suitability is relatively stable or relatively favourable for cocoa production compared to the other zones) (Bunn *et al.*, 2016).

The Transform zone dominates the deciduous and semi-deciduous ecological zones of Ghana; the Adjust zone dominates the moist evergreen ecological zone of Ghana, and the Cope zone dominates the wet evergreen ecological zone of Ghana. The economic impact on farmers without adaptation strategy is projected at 60%-100% reduction in cocoa income in the Transform zone, 30%-50% reduction in cocoa income in the Adjust zone and 10%-20% reduction in cocoa income in the Cope zone (Bunn et al 2018).

The difference in the impact of climate change on various ecological zones in Ghana can be reduced depending on the cocoa agroforestry model practised. This is because the intensity of the impact of climate change informs the extent of shade recommendation needed. The following interventions are proposed for the various climatic/ecological impact zones for cocoa agroforestry to strive; 1). Coping zone: 15–25 trees/ha that will provide 30–40% shade cover. 2). Adjustment zone: 20–45 trees/ha that will provide 40–50% shade cover. 3). Transform zone: 25–50 trees/ha which would provide 50–70% shade cover. Considering the varying shade species across various climatic impact zones in Ghana. Annex 1 provides some shade trees to be considered in the various impact zones. The Canopy cover calculator (CanOvaLator) https://play.google.com/store/apps/details?id=com.will.iita which is an offline free mobile based app serves as a handy tool in calculating the percentage shade cover in cocoa farms. The CanOvaLator uses the measured DBH of shade trees in calculating percentage shade cover on farms.

3.3 Costs-benefits analysis

This section presents a cost-benefit analysis that was carried out on the implementation of the intercropped and multi-strata models, starting with the planting of every tree in the plot. This analysis can either be applied to the two savannah pathways or to the two pathways from full-sun to agroforestry (see Table 14) in cases where all the cocoa trees are replaced (diseased orchards, for instance).

The purpose of this analysis is to give a general idea of the timeline and the costs required to implement an agroforestry system today in Africa and Latin America. It follows the constraints and cocoa uses of each region. It has been generated by gathering exploitation data of the different projects listed in Appendix 4 and Appendix 5 and completing the missing data (mainly long-term data) through discussions with experts and assessment of other models such as Rivain S. et al., 2018, Adden and Kokou, 2017, Cémoi – Transparence cacao, 2018. The objective of this process was to simulate possible problems encountered in the field. As these problems are very different between Africa and Latin America, a separated model was generated for each region.

All calculations are given for one ha of cocoa agroforestry cultivation.

3.3.1 Variables used for the analysis

The different variables used in the analysis were defined as follows:

Variable for costs

To assess costs, three main categories were considered important:

- *Labour costs:* every operation that is made on the plot to support production, should be quantified in man-day (MD).
- *Inputs costs:* costs of plant material, other inputs (equipment, fertilization) and the transport of these inputs to the farm, quantified in USD.
- *External costs:* costs borne by other actors other than the producers such as formation costs to agroforestry practices and certification costs (indeed, the proposed sustainable practices can obtain organic or RFA labels).

The assessment of costs follows has been done for installation phase and exploitation phase.

The **installation costs** are the investment that should be made to set up the new exploitation in the first year called year zero i.e:

- Plantation input costs (plant material and equipment),
- Site preparation labour costs (thinning, plantation preparation),
- Planting labour costs (plantation and weeding after the plantation).
- The so-called External costs (traceability, training)

The **exploitation costs** are the cost that should be paid every year to maintain the production, i.e:

- The maintenance costs (inputs and labour), it is a unit price that should be invested every year (both labour and inputs),
- The costs related to the harvest (for each kind of crops in the plot), these costs depend on the number of crops that should be harvested and conditioned every year.

Variables for benefits

The benefits are defined by the yield of each crop multiplied by the price that it could get the producer. This price could be lower than the market price for crops other than cocoa as the producer is not specialized in the marketing of these products.

An unrecorded benefit is represented by the self-consumption of the food crops and pruning wood by the producing household.

3.3.2 Cost-benefits analysis in Africa

Field observations

As explained in 3.1, cocoa agroforestry is not a natural practice for producers throughout most of Africa. Even if we can observe some implementation, it is often in pilot projects where the cocoa producers received incentives and trainings to switch to agroforestry. There are few models with significant hindsight on their effectiveness. Thus, a broad diversity of agroforestry projects with various experiments of side culture choices is observable.

However, African agroforestry practices have some points in common:

- the cocoa varieties used are grown from seed and hence composed of a mix of cocoa varieties and hybrids. This diversity implies a high variety of cocoa yield within the orchards (Wibaux et al., 2018).
- the use of fertilizer and other input is generally included in broad state or company fertilization's financing projects and generally, the same amount of fertilizer is provided to every cocoa tree.

The practices are also impacted by the poor implementation of agroforestry practices by producers: for instance, the producers generally do not utilize their timber trees, reducing a lot the benefits coming from this source.

The different cultivation choices observed in Africa can be summarized stratum by stratum as follows:

- **1- Forest trees**: Generally, the exploitation choices use little densities of stratum 1 shade trees (between 10 and 50). The selected forest trees have above all a utilitarian purpose (shade and water regulation). Beyond this purpose, the main use of these shade tree is timber but others could be used as spices, gum, fiber or for medicinal purposes. The choice of the forest trees has different motivations: it could be selected for its endemism (CREMA/COCOBOD projects), for provision of desired material to the producing household (Camayé Vert project: fraké/akpi) or because there is a market for it (ex: teck). The selected timber trees are generally slow growing with a cut of half of the trees after 25 years of exploitation and the other half after 50 years. The plantation of forest trees can also preserve the functionality (soil fertilization, carbons storage, biodiversity habitats)
- **2- Fruits trees**: Fruit trees are often used, mainly citrus and mango, they are grown to have an outlet in the local market. African plum tree (safoutier) has also good potential and is a good source of income; avocado tree, rambuttan, cocoa nut and palm tree are also well appreciated
- **3- Cocoa level:** High cocoa density (1,320 tree/ha and more), common use to plant banana tree in the first years to shade the young cocoa (could be replaced in an RRI by the old cocoa tree). It is often seen in projects that gliricidiae is used for improving fertility.
- **4- Land level:** Existing use in some pilot models of food crops in self consumption and peanut, chili pepper, African eggplant and yam also work for commercialization.

Analysis

Costs assessment

The study found that rural wages are highly variable in Africa and are poorly monitored, for example, an analysis of the rural costs of one man-day in Côte d'Ivoire showed variations between 1,000 XOF and 2,000 XOF (RONGEAD, 2016). A unit price of 2,000 XOF for one man-day was selected for this study, corresponding to USD 3.6.

The cost for the shade tree seedling or fruit tree seedling is usually low due to the practice of raising planting material directly from seed in nurseries nearby. It is usually under USD 0.5 per seedling.

Intercropped

Based on available field observations (case studies from Togo and from Ghana), a West-African inter-cropped model has been documented and a cost-benefit analysis has been developed. The cropping system is made of a cocoa layer and one stratum shading cocoa with a low shade tree density. The case concerns a new plantation developed in a savannah landscape. The shade is provided by a timber species, which is the fraké (*Terminalia superba*). However, fraké is not the unique species adopted in West Africa. In Côte d'Ivoire for example, there is an increasing trend of intercropped cocoa-rubber, cocoa-palm oil, cocoa-cashew. Indeed, this tree is endemic to most producing regions in Africa and is highly used in cocoa orchards.

Figure 9. Cocoa-fraké intercropping (Source: Adden A., 2017)

The structure of the model is given in the Table 14.

Table 14: Composition of the intercropped model for the costs-benefits analysis in Africa

Strata	Number of trees/ha
1- Forest trees (fraké)	25-30 timber trees At start: 100 trees (10mx10m) After 4-5 years: 50 trees (quincunx) Final density : 25-30 (quincunx)
2- Fruit trees	0
3- Cocoa level	1,320 cocoa trees 1,320 banana trees planted in the first years (will last three years)
4- Food crops	0

In that case, the **installation costs** are given in Table 15. The external costs are defined as three or four days of technical trainings and training in documentation management for certification. The certification in this model is obtained at the end of the training.

Table 15: Installation costs of the intercropped model in Africa

Category		Year 1	Year 2	Year 3
Input costs (/ha)	Vegetal inputs	530 USD		
	Equipment and transport	253 USD		
Labor costs (/ha)	Preparation	622 USD		
	Plantation	325 USD		
External costs (/ha)	Certification	0 USD	0 USD	27 USD
	Training	164 USD	164 USD	164 USD
Total installation costs		2,513 USD		

Exploitations costs are given in Table 16.

Table 16 : Exploitation costs of the intercropped model in Africa

Category		Value
Maintenance of the plot[11]	Input (bio-insecticide, fertilisation)	72 USD
	Labour (Weeding, tree maintenance)	202 USD
Fix exploitation cost per year	Sub-total	274 USD
Harvest	Pruning wood	6 USD (108 USD/18 year)
	Cocoa (Harvest, breaking pods, fermentation, drying, packaging)	345 USD (annual mean value of the productive years)
	Banana	76 USD (only three years; mean value)

The exploitation costs for a full production cocoa are estimated around USD 700-720/ha/year.

The mean value of the **benefits** is given in the following table:

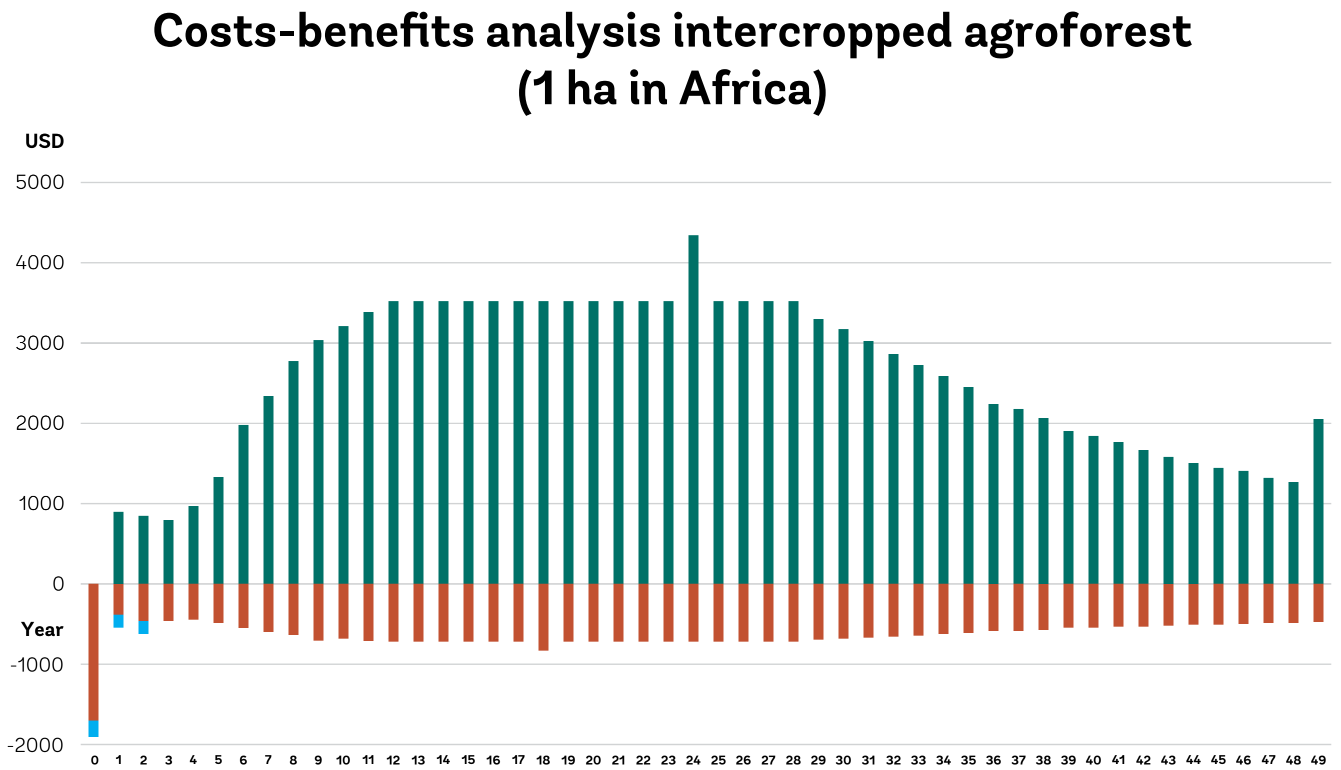
Table 17: Mean value of the benefits from intercropped system in West Africa

Category	Unit	Mean value	Remark
Cacao	kg/ha	1,009	
	USD	2,458	
Banana tree	kg/ha	84	
	USD	38	
Fruit trees / Spice trees	kg/ha	0	
	USD	0	
Pruning wood	m^3/ha	1	11 m^3 harvested at year 9 then 27 m^3 at year 18
	USD	0	
Timber	m^3/ha	2	41 m^3 harvested at year 24 and then year 49
	USD	33	
Total	USD/ha	2,529	

11 The materials like machetes, pruning tools (shears, chain saw) have not been included in the computation. They will be fine-tuned during the workshops (which cost is annual or multiyear based) and integrated in the next version. The acceptable yields and unit prices for cocoa, fruits, food crops and timber will also be discussed and validated during the workshops.

Based on these two results, the study was able to plot the cost-benefits profile in Figure 10. The detail of the annual figures is available in the excel attached to this report.

Figure 10. Analysis costs of the intercropped model in Africa (external costs labelled in blue)



In this model, the return on investment is reached five years after the initial investment if we focus just on the producer margin and six years if we take into account the external costs. The peaks of income in years 24 and 49 are related to the sales of timber trees.

Multi-strata

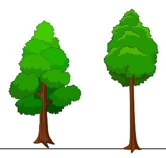
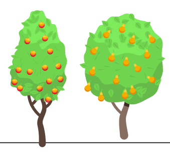
For this model, the study was mainly inspired by the models of the Camayé Vert project completed and confirmed with the analysis of the farm figures of the "Champion of agroforestry" filmed during the exchange program (see Appendix 5). A model with a focus on cocoa, timber and food production was hence selected, along with the use of gliricidiae for fertilization. This model optimizes the use of the land level to generate profits and food crops in the first years to absorb the higher investment costs.

The structure of the chosen model to make the analysis is given in Table 18 and 11.

Table 18: Composition of the in multi-strata model for the costs-benefits analysis in Africa

Strata	Number of trees/ha
1- Forest trees (fraké)	26 timber trees
2- Fruit trees (citrus – mango)	100 fruits trees
3- Cocoa, banana tree and gliricidia	1,320 cocoa 1,500 gliricidia 1,320 banana tree in the first years
4- Food crops	6,000 Yam buttes 3,000 Planted vegetables

Figure 11. Spatial organization of a multistrata system in Côte d'Ivoire (Source : Programme Equité)

Layer	1- Forest trees	2 – Fruit trees	3 – Cocoa, gliricidia and banana (first years)	4- Vegetables and Yam butte
Legend				
Density and spacing	26 trees/ha 20 m	100 trees/ha 13.5 m	Cocoa: 1,320/ha (2.5mx3m) Plantain: 1,320/ha *Gliricidia: 1,500/ha*	Vegetables: 1,500/ha *Yam: 6,000/ha*

The **installation and exploitation costs** are given in Table 19. Here, the external costs are composed of regular trainings over two years to teach the multi-strata management and training to help with the certification. Again in this model, the certification is obtained at the end of the training.

Table 19: Installation costs of the multi-strata model in Africa

Category		Year 1	Year 2
Input costs	Vegetal inputs	1,483 USD	
	Equipment and transport	401 USD	
Labor costs	Site preparation	1,190 USD	
	Plantation	391 USD	
External costs	Certification	0 USD	27 USD
	Training	1,266 USD	1,266 USD
Total installation costs		6,024 USD	

The exploitation costs are the same as in Table 16. With cocoa and fruit trees in full production, the exploitation costs are around USD 1,080/ha/year.

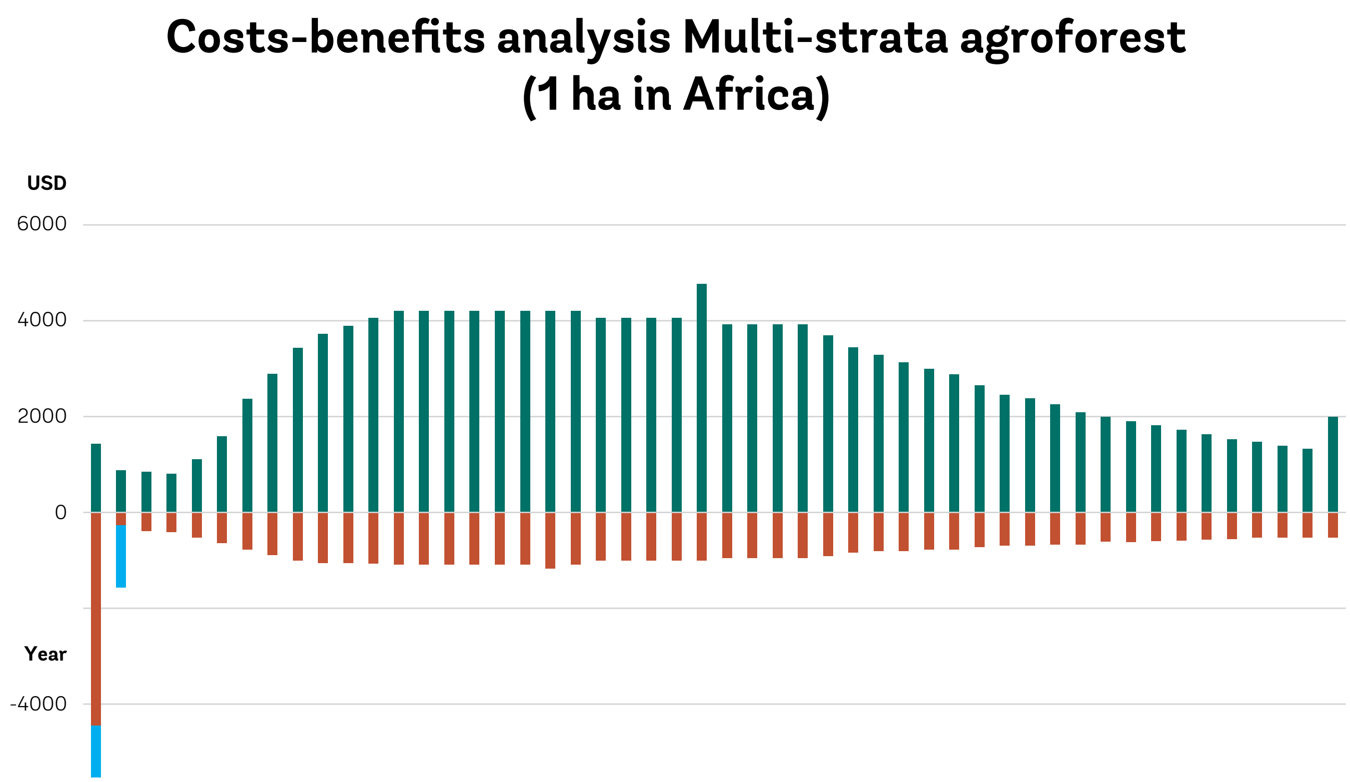
The mean value of the **benefits** is given in the following table:

Table 20: Mean benefits from multistrata system in West Africa

Category	Unit	Mean value	Remark
Cacao	kg	1,009	
	USD	2,458	
Banana tree	kg	84	
	USD	38	
Fruit trees / Spice trees	kg	2,600	
	USD	353	
Pruning wood	m^3	1	10 m^3 harvested at year 9 then 26 m^3 at year 18
	USD	0	
Timber	m^3	2	40 m^3 in year 24 and 40 in year 50
	USD	28	
Total	USD	2,877	

Based on these two results, the study was able to plot the cost-benefits profile in Figure 12. The details of the annual figures are given in the excel attached to this report.

Figure 12. Cost-benefits analysis costs of the multi-strata model in Africa (external costs labelled in blue)



In this model, the return on investment is reached six years after the initial investment if we focus on the producer margin and eight years if we take into account the external costs.

The multi-strata model is more profitable in the long term than the intercropped one, with its margin becoming superior relative to the intercropped model after 15 years.

Table 21: Profitability of intercropped and multistrata models in Africa

Category	Unit	Intercropped	Multistrata
Cacao	USD	2,458	2,458
Banana tree	USD	38	38
Fruit trees / Spice trees	USD	0	353
Pruning wood	USD	0	0
Timber	USD	33	28
Total	USD	2,529	2,877

3.3.3 Cost-benefits analysis in LAC

Field observations to be modeled

In contrast with Africa, agroforestry is traditional in Latin America (see 3.1. 4.1). The producers master agroforestry practices and do not usually require specific training. There is also more experience weaved into the definition of the most effective agroforestry systems and it is easier to categorize the existing agroforest systems, which derive from three main models:

- The *forest-derived model* (Cabruca model, see Appendix 4): the most common and historical model. In this case, the targeted functionality is the shade and biodiversity conservation, and there is little exploitation other than cocoa. It is mostly seen in Bahia area of Brazil, Costa Rica and Dominican Republic.
- The *cocoa-timber model*: the specificity of this model involves a focus on valuable timber among the shade trees (in Cabruca, there is no specific care for timber species). In this case, the wood exploitation is nearly as profitable as cocoa. It is mostly seen in Andean America: Peru (Cocoa - Capirona – Bolaina model), Colombia (Cocoa – Abarco), Ecuador.
- New *cocoa-crop* models such as cocoa-rubber (see Ouro Verde case study), cocoa-avocado or cocoa-coconut. In these models again, the other crop is as profitable as cocoa, which is one of the key discoveries of the study.

It can be observed that, following the recommended pathways of this analysis, the two main models in Latin America are intercropped models (cocoa-timber and cocoa-crop). Indeed, the interviews during the study highlighted that in LAC, outside of Cabruca where the shade trees are little exploited, there are few tree diversities in the agroforestry system. Essentially, there are very few projects where different strata of combined crops are exploited at the same time on a long-term basis (the only example being the Forest Finance project but the fruit trees are sparse – see Appendix 5). Given these parameters, only one cost-benefit analysis was made for Latin America. The study selected a cocoa-timber intercropped model because it was comparable with African agroforests and because it is the most proven model in the study's defined pathways.

In practical terms, different features of Latin American practices can be underlined. The agroforestry practices are defined in a dynamic way: trees are replanted every time other trees are cut. There is a tendency to strongly fertilize cocoa in the first years of exploitations because of a cultural belief by the producers that vigorous cocoa will be more productive. The fertilization after these first years depends on the choices of producers to use fertilizing shade trees or not. There is finally a common practice which is to prepare the ground before cocoa plantation with a vegetation cover (gliricidiae, banana), twelve to eighteen months before cocoa plantation.

To summarize the observation in this part, the study analyzed the general American practices stratum per stratum in projects according to the land-use , considering the impact of this traditional management on agroforestry practices:

- **1- Forest trees**: Generally, the exploitation choices use high densities of stratum 1 of combined crop (between 100 and 300). The main crop used is timber. The choice of the combined crops is market oriented. For instance, the timber trees selected must have a potential outlet and facilities of exploitation in the country where it is planted. The timber tree cultivation is following a model where half of the timber trees are regularly cut: after 5 years of exploitation (for gmelina), 10 years (abarco: see the Ecotierra project) and up to 15 years. Every time a cut is done, the trees are replaced following the current state of the market.
- **2- Fruits trees**: Observing fruit trees in cocoa plots in Latin America is rare, the only project analyzed using it was the Forest Finance project (see Appendix 4). However, some new intercropped models are observed where cocoa is associated with just one fruit tree such as the cocoa-avocado agroforests.
- **3- Cocoa density level:** Lower cocoa density than in Africa (<1100 tree/ha), common use to plant banana tree in the first years to shade the young cocoa (could be replaced in a RRI model by the old cocoa tree). The cocoa trees are usually selected clones that could bring higher yields than in Africa (not considered in this analysis).
- **4- Soil level:** Generally, not used but there are existing uses in pilot models of food crops (pigeon pea, yuka) in Peru (AIDER and Forest Finance model: Appendix 4 and 5).

Analysis

Cost assessment

Generally, the different costs in Latin America are higher than in Africa due to two factors:

- Manpower is much more expensive,
- The plant material is more controlled and comes, for instance, from nurseries where clones are selected.

The analysis followed this tendency by using a value of USD 12.5 for one man-day, which is the minimum salary in Brazil. Furthermore, the plant material cost is between USD 1-2.

Intercropped analysis

Based on the field observations, an intercropped model for Latin America was analyzed with one stratum shading cocoa with a high shade tree density. The focus was applied on the use of timber trees, and a model was created on the abarco exploitation results. The chosen intercropped model to make the analysis is given in Table 22.

Table 22: Composition of the intercropped model for the costs-benefits analysis in Latin America

Strata	Number of trees/ha
1- Timber trees (Abarco)	250-300 timber trees (6 meters of spacing)
2- Fruit trees	0
3- Cocoa, banana tree and gliricidia	1,100 cocoa 1,100 banana tree in the first years
4- Food crops	0

Figure 13. Spatial organization of an intercropped system in Latin America

The estimated installation and exploitation costs are given in Table 23 and Table 24.

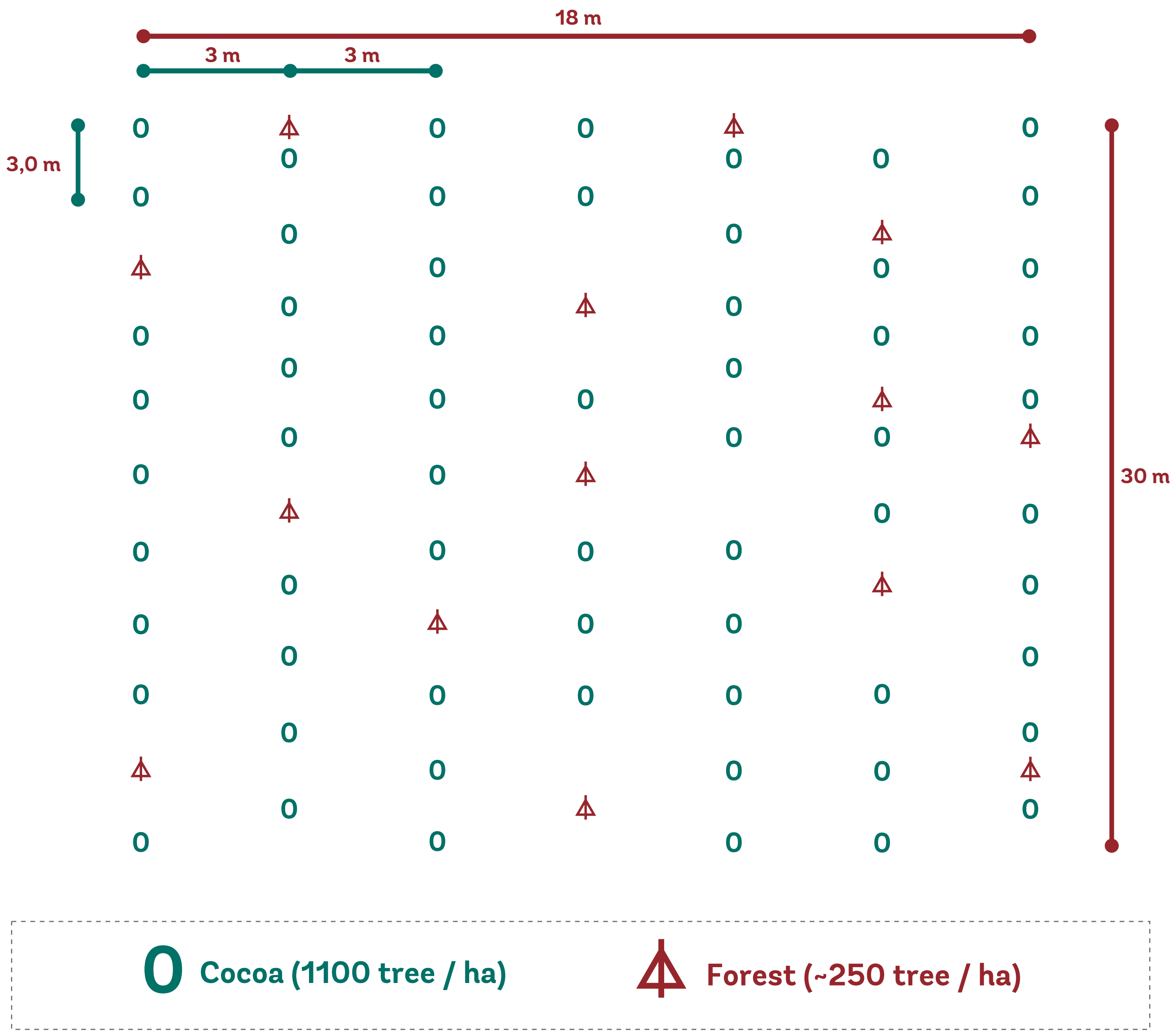


Table 23: Installation costs of the intercropped model in Latin America

Category		Year 1	Year 2	Year 3
Input costs	Vegetal inputs	1880 USD		
	Equipment and transport	100 USD		
	Fertilisation inputs	530 USD	530 USD	530 USD
Labor costs	Setting up (thinning, weeding)	80 MD	30 MD	30 MD
	Plantation	40 MD		
	Fertilisation	11 MD	11 MD	11 MD
External costs	Certification			30 USD
Total installation costs		6400 USD		

Table 24: Exploitation costs of the intercropped model in Latin America

Category		Value
Maintenance of the plot	Weeding	62 USD
	Tree maintenance	438 MD
	Sub-total	500 USD
Harvest	Timber	1,969 USD
	Fruit trees	0
	Cocoa (Harvest, breaking pods, fermentation, drying, packaging)	688 USD
	Banana	125 USD
Replantation of timber		625 USD

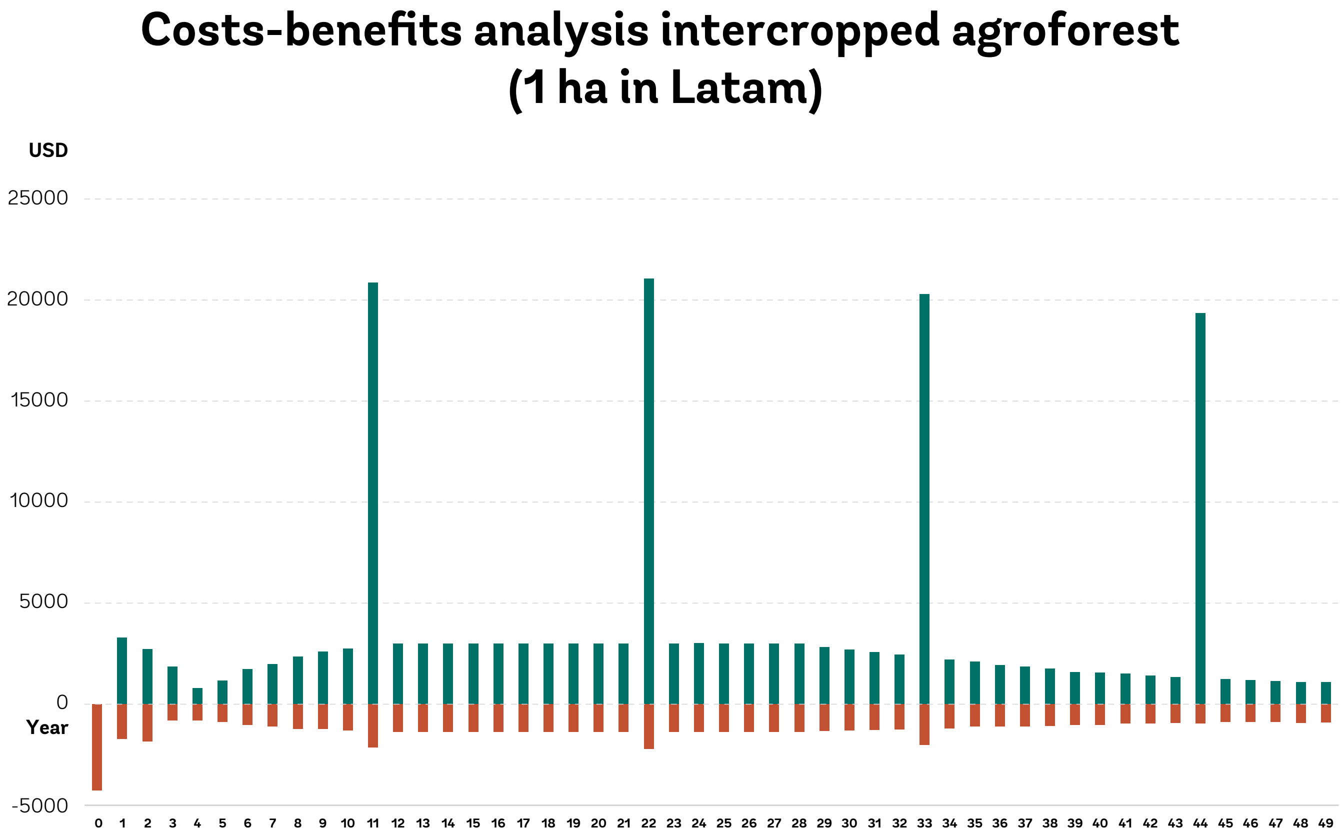
The exploitation costs with a cocoa in full production, are estimated around USD 1,100/ha/year. The mean value of the benefits is given in the following table:

Table 25: Mean benefits from intercropped system in Latin America

Category	Unit	Mean value
Cacao	kg	841
	USD	2102
Banana tree	kg	70
	USD	141
Timber	m^3	36
	USD	1440
Total	USD	3683

Thanks to these 2 results we were able to plot the cost-benefits profile in Figure 14.

Figure 14. Cost-benefits analysis costs of the intercropped model in Latin America



In this model, **the return on investment is reached seven years after the initial investment.** This model is more profitable than the two African models as soon as the first timber is sold. On average in this model, timber exploitation is more profitable than in Africa (1,440 USD/year in average in LAC versus 30 USD/year in Africa) because of the unit price of the timber and also the volume harvested.

3.3.4 Conclusion on the costs-benefits analysis

Key differences between Africa and Latin America

From a factual point of view, there are key differences between Africa and Latin America.

First, beyond the differences for unit costs between the two continents, the total labour units invested is lower in Latin America than in Africa because it their model is less labour intensive. However, the budget invested in salaries is lower in Africa as man-day is cheaper.

Secondly, the very low wages offered in Africa are unattractive. In addition, the relationship with work on cocoa farms is very different. In Africa, work is culturally defined by the task to be accomplished (quantity of pods to be harvested or trees to be cared for) so there are no clear linkages between the labour cost and the level of effort (the task requested by the landowner may sometimes require a high level of effort without any impact on the salary). Furthermore, since each task may require the recruitment of a specific farm worker in Africa, there are many different workers that can alternate in a plot. This can generate inefficiencies because every new worker needs extra time to appraise the individual characteristics of the orchard. It also generates a specific organization of work where a cocoa producer may be required to work in a neighboring producer's cocoa farm for some tasks. On the contrary, in Latin America, work is defined on a daily basis. Workers are thus recruited to provide complete care and are usually associated with specific cocoa farms. This gives them more responsibility for monitoring the cocoa farms under their care.

In addition, the functioning and origin of the rents of the agroforestry systems across the two continents are very different. In Latin American agroforests, there is a dynamic and highly market-oriented management of combined crop. The rents of these crops are important and comparable to those of cocoa. In Africa, the models remain focused on cocoa, which represents the main profitability of the crops. Side plants are primarily used for a utilitarian purpose as a way to raise the natural capital of the plot before representing a resource for the producing household. In this context, with timber exploitation modes with a distant time horizon (25 years), its exploitation is not part of the business models.

Complexity of establishing an economic dynamic for the installation of agroforests in Africa

The cost-benefit analysis for Africa, compared to the one for Latin America, illustrates the economic obstacles to agroforestry installation in Africa. On the one hand, the income generated by the sale of timber is low, due to the very low selling price of timber. On the other hand, the fruit exploitation, while it generates a significant profit in the multi-strata model, delays the horizon of a return on investment. Hence, there are important implications for the uptake of cocoa agroforestry systems: develop the market for timber and other AF products like fruits, identify AF species intercropped with cocoa, that can be exploited in a short horizon for producers to have quick return on investment.

This lack of economic dynamism stems from the original objective of converting African cocoa farms to agroforestry coming from the project financing it: environmental impact by increasing natural capital and monitor climate change and social impact by providing food crops to producing households, see 5.2. Shade trees are thus added to cocoa farms as part of these projects (CREMA/COCOBOD, Camayé Vert) rather than as part of a predefined business model defined by the producer. This may imply a lack of social acceptability for producers to choose agroforestry. Indeed, positive returns in environmental terms are more difficult to perceive than returns in economic terms.

However, the progress in legal terms of the recognition of the use of timber planted by African agroforestry could change this situation. It opens the way to a more pronounced economic profitability for African agroforests, in the image of their Latin American equivalents. However, before such agroforests can be established, work must be done to define the preferred markets in which they can be sold.

Perspectives on sustainability

Agroforestry models in Latin America and Africa are very different and therefore face very different issues.

The Latin American models are established models that have proven their economic value. From a sustainable perspective, it is necessary to ensure that they have a positive impact on the environment. These systems must therefore be installed without causing deforestation (savannah pathways) and their natural capital should be monitored.

The models in Africa are new and must find a preferred mode of operation. This situation in Africa is however an opportunity, thanks to the important funds that can be attracted, to develop very innovative and diversified models. These models, such as the multi-strata model, could allow, in addition to the economic return, to maximize the environmental impact and to guarantee the most sustainable use of the land and anticipation of climate change impacts.

3.4 Alliances and innovative financing to mainstream sustainable cocoa

3.4.1. What to finance?

Two funding mechanisms can be considered to finance the transition:

- A **global mechanism** for systemic change in the cocoa sector.
- A **local mechanism**, aimed at changing the practices of cocoa producers.

Most of the mechanisms that exist today are local ones. These correspond to initiatives generally supported by partnerships between exporting cooperatives and importing companies. Sometimes the public development agencies finance the cooperatives and their partnering NGOs.

Project financing needs

The feedback from the promoters of various projects financing the implementation of good practices shows that to mitigate the risks, significant monitoring of partner farmers is necessary. The analysis of all identified financing needs is mentioned in Table 26. Their identification requires tight monitoring of producers and a holistic approach to identify all their needs to set up long-term dynamics.

Table 26: Summary of the need assessment in the context of implementation of sustainable practices

Current obstacles to changes in practices	Financial needs
Lack of technical know-how	• Training. • Monitoring. • Quality-based incentive mechanisms.
Poverty, inability to face the initial costs Farmers need more guarantees	• Direct, regular and long-term monitoring • Holistic approach: take into account the household economy as a whole and facilitate the access to some services (like health insurance, education, credits)
Cultural obstacles Lack of financial education (no long-term vision of cocoa farm nor investment approach); farmers focus more on volume than productivity.	• Financial education • Pilot projects to showcase the interest of a business approach
Access to land	• Support for producers to legalize their land situation. • Clarify when needed the regulations of land and tree tenure to secure the investments
Aging farmers and need of youth inclusion	• Showcase the interest of a business approach on cocoa and its competitiveness • Train the young farmers. • Facilitate access to land

Strategy to provide supports for producers

To implement the needs listed in Table 25, it is recommended to design funds around two components:

- A **technical transformation component** that assumes training and infrastructure needs; the structuring of the sector through the creation of cooperatives engaged in sustainable cocoa. This is generally provided directly by the exporting companies, NGOs and public services.
- A **social component** making it possible to provide broader support for households. It takes the form of a large set of initiatives: creation of savings and credit associations, health insurance, emergency aid, educational aid, capacity building among institutions, etc. These initiatives are often carried out by partner NGOs and sometimes sustainability teams of companies.
- A de-risking mechanism: farmers need support to face the waiting phase (before the return on investment), to reap the benefits during the fifth year. In practice, a package of services and support is to be provided to producers.

Packages	Funding	Farmers contribution
Training in farming techniques and agroecological practices	Subsidy in kind	
Cost of replanting, renovation of fields		
Labour requirements for cocoa	Payment	
Labour requirements for food crop	Payment	Farmer's participation up to 10%
Cost of food crop protection products	Subsidy in kind	
Cost of fertilizers	Subsidy in kind	
Equipment cost	Subsidy in kind	Farmer's participation up to 10%
Pesticide treatment	Subsidy in kind	
Plan costs for seedling	Subsidy in kind	
Compensating for shortfall	Payment	

3.4.2 Financing mechanisms for existing initiatives

Projects promoters

Most of the projects in place that aim to transform production practices are supported by a partnership

between buyers and cooperatives. These partnerships are often reinforced by associations with local businesses and NGOs. These projects are often self-financed by companies who see an interest in them both in their Corporate social responsibility (CSR) policy but also in the modification of their supply chain.

Origin of funds

Some of the projects may seek funding support through **public funds**. In this case, two mechanisms are used:

- **Grants**, provided directly from a development agency to a project. Such subsidies are important but insufficient resources given the extent of the needs. However, public funding can leverage other private financing as part of the generalization of sustainable practices.
- **Matching grant.** This mechanism consists of an offer of financing by a development bank for projects respecting given specifications; the project is proposed by companies which must also commit a minimum capital. These programs finance up to 50% of a project led by companies if it notably meets sustainability requirements.

Other projects may seek financing support through **private funds**. Three interesting mechanisms can thus be identified:

- Participation in the capital of an exporting company or an estate to finance the development of cocoa agroforestry within their proper land and/or the land of outgrowers farmers in the scheme.
- Loans: for example carried out by a private fund dedicated to the financing of sustainable agricultural practices (Table 27).
- Carbon payments: some agroforestry projects are subsidized by companies or funds based on an expected carbon performance (Box 6).

In either case, these private funds will need a financial return on investment. This can be derived from improvements in the value chain, price increases due to certification or even increases in yields due to the integration of sustainable practices. Table 27 lists existing private funds that may be interested in financing a project to transition to sustainable cocoa.

Table 27: Private funds that can be mobilized to finance cocoa agroforestry and sustainable landscapes projects

Fund	Investment scope	Form of partnership
Mirova Natural Capital / LDN Fund	Sustainable agriculture with impact on carbon sequestration on soils.	Investment in a large project
Moringa	Sustainable agroforestry	Participation info a company
12Tree	Sustainable agroforestry	Participation info a company

Box 6. The Urapi fund.

In Colombia, in the "Sierra Nevada de Santa Marta", the Private Equity Fund "URAPI" through its manager "ECOTIERRA", has acknowledged the lack of access to sustainable financial tools for the farmers of the area. In reaction, it has implemented a multi-functional strategy, based on innovative financial approaches, and offers to producers:

- **A shared governance and risks**: a dry processing mill is financed by the URAPI fund and co-owned by the PO, with a progressive buyback
- **Partnerships with cocoa private sector (work in progress)** to find high added value markets
- **An income-raising strategy:** by providing financial support for land use transition to sustainable CAF, crop diversification (coffee, cocoa, honey and timber plantations generating long-term income) and carbon credits (VCS certified)

The project is managed by ECOTIERRA, with the objective of increasing long term income, improving productivity and quality of production and mitigating climate change impacts. It should also allow 4,500 ha to be converted in sustainable agroforestry system, to reduce 1.3T CO_2 emissions and to conserve 70,000 ha of forest.

Box 7. Tambopata-Bahuaja: Transforming land use and biodiversity conservation in Peru

The Madre de Dios region of Peru is experiencing accelerated deforestation due to extensive agriculture and gold mining. These activities are often the main source of income for local populations, particularly small farmers and indigenous communities.

Within the framework of a contract established with the Peruvian government for the management of the Tambopata National Reserve and Bahuaja Sonene National Park, AIDER NGO has set up a REDD+ project that has resulted in the planting of 1,250 hectares of cocoa in agroforestry in the buffer zone, the creation of a farmer cooperative (COOPASER), as well as the conduct of surveillance and biological monitoring activities in the vicinity of the park and reserve.

To these private funds can be associated development agencies that have concerns into the change of practices. These public funds can complement and coordinate with governments.

Expansion of financing

Many cocoa agroforestry projects are local in scope. For large-scale change the coupling of public and private funds is indicated. The **matching grant** mechanism seems very promising for strengthening existing initiatives and attracting new private capital. The share provided by public funds supports investments of general interest (inclusion of cooperatives and small producers in the supply chain for example) while leveraging the capacities of the private sector.

For systemic change, a more global mechanism can be imagined to transform national sectors. This mechanism can be inspired by **Renovation and Rehabilitation** (R&R) programs (Grundmann S. & Saccucci M., 2016; Werner, K. & Hussain, U., 2016; Root Capital, 2016). These programs finance the rehabilitation of sick or aging plots in a given agricultural sector by providing financial means and training. They are generally used in sectors made up mostly of small producers such as cocoa and coffee because of the risk aversion and limited finances of small producers which prevent them from embarking on such projects. These programs are financed through major partnerships between public entities (governments, development agencies), private entities (companies in the value chain of the sector) and impact foundations. These partnerships seek in particular to bring together a maximum of private players in the given sector. They are generally coordinated by the public sector and in particular the local governments which provide a large part of the funds and ensure a part of the repayments of the transferred loans.

Table 28: Entry points of the funds that would finance systemic changes in cocoa national sector

Entry points	Objectives of the financing	Transformation mechanism
Existing projects	Enhancement of existing projects • Funding and training of staff providing daily monitoring of producers. • Financing of social nets to enable (emergency aid, health insurance, etc.)	Allow scaling up of existing projects by providing everyone with means on certain parts (compensation or service costs). The objective would be to allow each exporter to source the majority of their cocoa from producer partners in these projects. This funding could also stimulate knowledge sharing between existing projects.
Diseased or overaged farms	Donations to producers of healthy plant material in exchange for monitoring and training for its sustainable management.	Follow a renovation and rehabilitation (R&R) mechanism: offer healthy plant material. The recovery of this material by producers is also a pretext to provide them with training in sustainable practices (to accompany the renovation of farms with training)
Subsidized loans to voluntary producers	Offer training and loans to producers. The revolving fund model could be used. Loans could be partially guaranteed by the transition finance fund to lighten the burden on the producer as was done in the coffee sector R&R project in Colombia (from 2009 to 2014: Root Capital, 2016).	Large-scale transmission of practices according to an "oil spot" model: the first interested farmers demonstrating the effectiveness of their practices attracting new producers to them.

Box 8. Description of the revolving fund mechanism aimed at self-financing of producers

Revolving funds are a self-financing mechanism for producers to finance a transition towards sustainable practices, usually driven by microfinance organizations (Horus, 2018). These funds consist of the granting of credits or repayable advances to the beneficiaries (can be cash or in kind). The repayments of the loans allow the granting of new credits to other beneficiaries. This "revolving" operation encourages a strong monitoring of loans to maintain the existence of the fund. The provision of these funds could thus be accompanied by technical monitoring (offer of guides, for example) allowing self-training of producers. This micro-credit operation would thus make possible for producers to familiarize with monetary management while being able to finance investments in sustainable practices for producers (labor, certification, etc.).

3.5 Certification of the sustainable cocoa

3.5.1 Development of international and regional standards (West Africa)

In May 2019, the first international standard for sustainable and traceable cocoa was published - ISO 34 101. The standard consists of four parts:

- Requirements for cocoa sustainability management systems (based on ISO 14001 and 9001)
- Sustainability criteria (social, economic and environmental criteria)
- Traceability requirements for sustainable cocoa
- Assessment methods

As part of their partnership formalized in the Abidjan Declaration (March 26, 2018), Ghana and Côte d'Ivoire concluded to develop a regional standard (ARS 1000) for sustainable cocoa, based on ISO 34 101, while improving it to better take into account the reality of these countries. "The objective of ARS 1000 is to establish a common cocoa sustainability standard applicable to all actors in the cocoa value chain. Without excluding private sustainability standards and voluntary certification programs of independent organizations, ARS 1000 defines a minimum set of requirements to be met. Private organizations should obtain regulatory consent when setting criteria that are more stringent than ARS 1000." (Source: 2nd Cocoa Talks meeting, 2021). A summary of its contents is provided in Appendix 6.

3.5.2 Main certification actors and practices

Organic, Fairtrade and Rainforest Alliance are the most common third-party certification labels, but there are many others. The main standards in the cocoa sector (UTZ, RA / SAN and Fairtrade) covered a significant market share in 2017: 1.7 millions of metric tons (42%) of cocoa produced by more than 920,000 farmers on an area of 2.8 million hectares (28.1% of the world production area). However, some productions benefit from a double labeling, thus reducing the gross figures.

In addition, there are also a number of private certification schemes by chocolate and cacao companies which are not included in this study.

Organic agriculture

There are several existing organic labels (European organic, for the US, Japan etc...)

Organic certification focuses mainly on **producing practices**. It verifies mostly the use of phytosanitary products and GMOs. In 2014 was also introduced the notion of protecting landscapes, and in particular, forests, considering that "*farms located on land that has been obtained through the clearing of High Conservation Value (HCV) Areas within the previous 5 years should not be considered in compliance*", even though those criteria considering landscapes are quite weak compared to the attention on the plots and do not consider the ecological continuity of landscapes.

The commercial benefits from Organic certification can **compensate the costs linked to the change of production model but** the organic model is viable only if there are sufficiently remunerative opportunities. External support to accompany the conversion process for is recommended.

While organic farming offers good guarantees in terms of **protecting biodiversity** at the plot level thanks to its restrictions on the use of phytosanitary products and synthetic fertilizers, it does not offer any guarantees for forests or agroforestry (Amiel F. et al, 2019a)

In a competitive model, where conventional agriculture is still both more productive and lucrative, organic certified products should be offered to buyers **ready to pay a higher price, unless** external financing from public or private sector supports this production and reduce its cost.

Fairtrade (FT) certifications

In 2017, cocoa was the third most Fairtrade certified product, behind coffee and bananas. Several FT labels exist for cocoa: FT International (Max Havelaar), World FT Organization, Fair for Life, SPP (Peasant producers Symbol), Biopartenaire (Organic and FT), etc.

The guarantees from FT certification are:

- A **minimum price** paid to the producers
- A **premium**, usually allocated to the cooperatives, and that enables renewing material, access to trainings etc..
- A multi-year engagement producers/buyers
- Enhances traceability

The main goal is **the better remuneration of the producers' work**. However, Fairtrade tends to enhance sustainable practices in general. The extra received income should enable the transition towards agroecological practices (as opposed to producers living at just the subsistence level, or even decapitalizing).

In 2017, cocoa was the third most certified product as Fairtrade, behind coffee and banana.

Rain Forest Alliance (RFA) and UTZ certification

The new entity resulting from the merger between the Rainforest Alliance and UTZ in 2018 covers more than a third of global cocoa production through its various certifications. It is important to note that at present both certification systems (UTZ and RA/SAN) remain in force, and that an update of the standard is underway.

The World Bank's 2017 report *Eliminating Deforestation from the cocoa Value Chain* identifies RFA certification as one of the most demanding in the cocoa sector in terms of the fight against deforestation (Kroeger et al., 2017). Indeed, it is mainly due to its definition of forest, that includes all natural forests, thus protecting both primary and secondary forests. it requires compliance with HCV (High Conservation Value) but also HCS (High Carbon Stock) zones (contrary to UTZ certification that did not protect secondary forests).

Some of the main points of this certification (Rainforest Alliance, 2020) are that:

- Farms that destroyed natural ecosystems since 2014 cannot be certified
- Increasing the indigenous forest cover (in farms, AFS or conservation areas) to guarantee not only cocoa farming doesn't have a minimal negative impact, but it also creates positive impacts.
- A minimum shading level of at least 30%, with at least 5 different tree species per hectare

The approach is addressed to firms, in a social responsibility approach, and not only on a capacity building for cooperatives or producers' organizations.

The criteria of RA expectations are declined within 5 principles that are:

- An effective planning and management system;
- Biodiversity and conservation;
- Conservation of natural resources;
- Improvement of living standards and well-being;
- Sustainable livestock production

Box 9. Ambrosia in Dominican Republic: the biggest organic cocoa/coconut farm in Americas

Ambrosía is the first 12Tree project in Dominican Republic. This 30-year-old coconut farm encompassing over 2,000 Ha was purchased with aim of rehabilitating the established coconut palm plantation back to full productivity and to establish an 800-Ha fine flavor, organic cocoa plantation inter-cropped with coconut palms, which will be the largest in the Dominican Republic and among the largest in the world.

The entire Project will be organic certified and produce premium cocoa for export and a range of premium-quality coconut products, such as virgin coconut oil, coconut water and sugar, sold domestically and abroad. The plantation design encompasses:

- **Forest conservation** for ecosystem services optimization, climate change adaptation
- **Honey production**: positive impact on the environment (biodiversity, pollination services) and for business (income diversification)
- **Cocoa clones' diversity:** promotes biodiversity and genetic heritage, offers a larger choice for special buyers (e.g., bean to bar), ensuring premium prices

The farm is on its way to reach **organic certification,** which will allow an economic recognition on to the market of the efforts on the ground.

4. BARRIERS AND OPPORTUNITIES

4.1 Barriers

4.1.1 Social barriers: the process of innovation's adoption in question

The concept of innovation refers to the adoption of a different way of doing things by a significant number of producers. There are different types of innovations (technical, social, institutional) and different levels of complexity (simple or systemic innovations) (CIRAD and GRET, 2002).

The adoption of innovative agricultural models with significant socio-economic and environmental benefits, such as cocoa agroforestry under shade, may seem obvious and easily acceptable by local populations. Nevertheless, the phenomenon of adopting an agricultural innovation is a complex process that requires taking into account certain conditions linked to local environmental and institutional contexts.

While some authors consider that innovative agricultural practices have always come from external actors (for example, Mendras, 1986 suggests that "In a peasant community, innovations can only come from outside. Peasants invent small improvements but they cannot conceive of a real technical innovation."), innovations have in fact been anchored in local practices for thousands of years. This is also referred to as 'endogenous innovations'. These local innovations tend to be forgotten even though they are the most likely to be easily accepted and disseminated by a large part of the populations targeted by development actions.

An innovation is appropriate only if it meets a number of conditions (Sibelet, 1995): it must have a real benefit for its beneficiaries (e.g. produce more), it must have a cost that can be borne by producers and it must be introduced gradually, i.e. without generating brutal upheavals in the system already in place and its environment (institutional and ecological). It is therefore rare for an innovation to be suitable for everyone, as its implementation necessarily involves a certain number of changes that entail risks for producers. It is therefore essential to take an interest in the real needs of the beneficiary populations, but also in the existing local and national contexts, which can be obstacles to the dissemination of innovations.

In the case of cocoa agroforestry under shade in West Africa, several factors explain the difficulties associated with its large-scale deployment, including the functioning of national land tenure systems and legislation governing tree ownership, as well as regional migrations associated with the development of cocoa farming in full sun. Technological changes supported by government (introduction of hybrids adapted to full sun) and the low perception of the ecological benefits of this innovation by producers are also determining factors in the difficulty of adopting agroforestry under shade for cocoa in West Africa (Ruf F. 1995). To facilitate adoption of cocoa AF, performing hybrid varieties adapter to shaded condition within a relatively short period of time need to be identified as well. In addition, to make the performant seedlings more affordable and available in term of quantity, there will be a need to involve of performant private seedling providers (cocoa, fruit trees, timber trees).

There is also a need to improve the synergy between cocoa sector and timber sector. The market for the tree products (timber, fruits, etc.) is not well organized and developed, which gives little incentives to venture in this technology. Such partnership will definitely remove this bottleneck.

Also, there is the fact that these ecological benefits are not well valued, giving them little incentive for adoption of AF. However, the study demonstrated that for example in Côte d'Ivoire, the SEP REDD and NGO Nitidae have successfully tested the direct payment for ecosystem services, an experience that would need to be well disseminated.

It is therefore essential to take the risk factor into account, that is, to ask oneself what the beneficiaries' capacity is for taking risks and what the foreseeable effects of the innovation are. In most cases, it will be useful to distinguish target interest groups that will be more likely to appropriate the new practices and disseminate them to their neighbors. The selection of the target group, the coaching and the monitoring of the learning process should not be taken lightly. Target groups are rarely homogeneous, and this should be taken into account and their members fully integrated into the appropriation of the innovation through several meetings (facilitated in a participatory manner) and protocols for experimenting the new practice with the target groups.

The dissemination of the innovation from an external actor to local populations must also adopt a communication strategy in a way that the messages meet the perceptions of the farmers. It is essential to adapt one's communication to this audience. In addition to the language barrier, there is a real pedagogical task to be done, taking into account the different perceptions of the world of local producers, so that the dissemination of the innovation is optimal. Once this process of experimentation with small target groups has been completed, a phase of dissemination and multiplication of the innovation to a wider public can take place. This can be done through the media and local information networks. Demonstrations can be carried out with the help of relay farmers who have participated in preliminary experiments.

However, some innovations require the early resolution of conditions of access to natural resources in rural areas (e.g. regulatory framework for access to land and tree ownership). This is the case for agroforestry under shade in West Africa.

Box 10. Overcoming the social barriers: some experience shared by the participants to the knowledge exchange program

To overcome the social barrier around the adoption of sustainable agroforestry practices, several participants in the knowledge exchange program recommended appropriate communication that includes the concerns and needs of producers. The idea is not to want to tend at all costs towards agroforestry but to understand the role that the tree can have within the farm. How can the tree associated with the cocoa tree be a solution and not an additional problem. In concrete terms, when designing the plot, the choice of species is discussed with the farmer on his needs. Because trees have an agronomic utility (nitrogen fixation for example) and uses (source of income thanks to fruits and non-timber forest products, wood energy, timber or pharmacopoeia). These themes are approached in such a way as to professionalize the farmer in the knowledge of the different species. But communication must also adapt to the realities on the ground so as not to lose the farmer in terms that are too scientific. In the programs accompanied by a cocoa buyer in Côte d'Ivoire and Ghana, for example, the interest of the tree is explained by the image of the "umbrella that protects against extreme heat". Without being too technical, this image responds well to the concerns of producers in certain areas who have lost cocoa trees in recent years, due to significant hot and dry episodes. It is also important to provide a rational explanation for the problems observed each time. For example, the drop in yield or the development of fungi can be linked to an excess of shade. An image box on good practices can help.

Finally, the farmer needs to feel secure to be motivated to sustainably invest in trees, we discuss this in the next section.

4.1.2 At the legal and institutional level, the problems related to the tree and land ownership

The rights arising from ownership of property are the right to use the property (*usus*), to benefit from the fruits produced by the property (*fructus*) and to dispose of the property as one wishes (*abusus*). Applied to a tree, the owner will therefore have the right to use it, to receive the benefits it generates and to dispose of it. In a context of agroforestry deployment, the question of ownership of the tree arises both with regard to the status of the forest tree planted on a farm, and that of the natural tree located in a forestry area.

In Côte d'Ivoire and Ghana, numerous legal texts regulate the ownership of land, trees and forests. Nevertheless, the lack of hierarchy between the texts makes it difficult to understand the regulations on these subjects. The inadequacies of the legislation and the multiple interpretations given to the texts can lead to conflicts and influence the practices of agricultural and forestry actors (Table 29).

In addition to the technical aspects (better yield of the hybrid varieties under full sun), the decision of farmers for full-sun cocoa cultivation to the detriment of agroforestry under shade can therefore be explained by existing laws that make it difficult for smallholders to own land and any timber trees. Decades of colonial and post-colonial legislation play a key role in this regulatory deficiency.

Table 29: Tree and land tenure issues for agroforestry (FAO and ICRAF, 2019)

Key issue	Barrier associated
Tenure insecurity: Long-term land tenure security is capital for investing in sustainable agricultural practices and perennial farming systems. It is one of the three main factors influencing the adoption of agroforestry (FAO,2017).	Adopting agroforestry requires huge investments on the land for long time-scales which could only be done by farmers if they are confident in the benefit from their investment.
Social inequities: Land use reflects power relations between different groups. These relations lead to conflicts, for instance between indigenous populations and migrants.	Competition on land use leads to afforestation and expropriations, increasing insecurity and destroying agroforestry projects.
Gender inequities: Women are usually less likely to own land.	Restriction of possibilities for women-households whereas these households are more likely to undertake long term investments such as agroforestry.
Institutional issues: Agroforestry have a hybrid status between different ministry (agriculture, environment…).	Land-use restrictions coming from the different administrations (such as restriction of tree planting on agricultural land or restrictions of commercialization of timber species).
Plot size: The plot size and its position with respect to the homestead influences the culture choices.	It is more complicated for farmers to adopt agroforestry on small plots or plots far of the homestead.

Table 30: Tree and land tenure opportunities for agroforestry (FAO and ICRAF, 2019)

Area of action	Opportunity
Customary tenure (or socially legitimate tenure systems): Often a brake for agroforestry today (tree species belonging to communities, tree planting considered as a way to claim land…).	Highly flexible and legitimate in the communities. It could be modified to include agroforestry.
Land formalization: State recognition of customary laws and ownership. To be efficient it should provide information and tools to allow owner to use their rights.	Could stabilize land use and decrease land use competition thanks to land titling (see the REDD+ la Mé project example: case study 3).
Conditional tenure and long-term lease: State providing of long-term, secure rights to harvest specific tree products in exchange for the application of good natural resource management practices.	State control in the cession of its own land that could force conversion to agroforestry.
Community-based land management: Participatory process to establish land-use management rules. Could be helped by organizations as facilitators.	A way to bring actors together (such as herders and farmers) to consider agroforestry. Opportunities to consider suitability of customary rules with agroforestry.

- **The case of Côte d'Ivoire**

In 1960, the newly independent Ivorian state perpetuated a colonial principle which says that '*unused or unoccupied land was* vacant and without a landowner' (decree of 15 November 1935) in order to develop the massive exploitation of timber and the cocoa plantation economy. The state took ownership of large forest areas in the west that were still important reserves in sparsely populated regions. Populations from neighbouring countries in the north and centre of Côte d'Ivoire were encouraged to migrate in order to convert these forests into cocoa-growing areas (Sanial E., 2018). The main objectives of both migrant and indigenous cocoa farmers have been to secure their land and obtain income as quickly as possible. With the rise of the global timber industry and legal contradictions in terms of land ownership, both of these objectives have involved getting rid of natural forest trees. Cutting down trees and farming in full sunlight has proved to be a way of securing land.

Nevertheless, the 2019 Forestry Code has brought innovations by first giving the ownership of trees out of forest to the landowner:

Outside forest tree property :

"Trees located either in a village, or in its immediate environment, or in a collective or individual field, are the collective property of the village or the property of the person to whom the field belongs.

These trees can be transferred to third parties."

Propriété des arbres hors-fôret :

"Les arbres situés soit dans un village, soit dans son environnement immédiat, soit dans un champ collectif ou individuel, sont la propriété collective du village ou celle de la personne à laquelle appartient le champ."

Ces arbres peuvent faire l'objet d'une cession en faveur des tiers."

ARTICLE 21 – CODE FORESTIER

This code also clarifies several issues concerning of the ownership of the tree and the forest:

"Ownership of a natural forest or tree shall belong to the owner of the land on which it is situated. Ownership of a created forest or planted tree shall belong to the owner of the land or the person who created or planted it by virtue of an agreement with the aforesaid owner."

"La propriété d'une forêt naturelle ou d'un arbre naturel revient au propriétaire de la terre sur laquelle ils sont situés. La propriété d'une forêt créée ou d'un arbre planté revient au propriétaire du foncier ou à la personne qui l'a créée ou planté en vertu d'une convention avec ledit propriétaire."

ARTICLE 27 – CODE FORESTIER

This article clearly links land ownership to tree and forest ownership. It states that ownership of the planted tree belongs to the landowner (Client Earth, 2020). It is therefore necessary to make the producers who exploit their land more secure by making them aware of the opportunities offered by the land regulations of their country and thus give them the means to better manage their farms. By obtaining a land certificate from the administrative services, farmers can become legal owners of their land and thus develop agriculture under shade without fear of exploitation by forestry companies.

"The owner may overhead all plantations and constructions that he deems appropriate, with the exceptions established under easements or land services"

"Le propriétaire peut faire au-dessus toutes les plantations et constructions qu›il juge à propos, sauf les exceptions établies au titre des servitudes ou services fonciers."

ARTICLE 552 ALIÉNA 2 - CODE CIVIL

The landowner who plants a tree on his land is therefore the owner of that tree. For farmers who do not own the land, agreements can be made with the owners to secure them:

> *"An agreement is made between the planter and the owner: the planter retains ownership of this tree or forest on the basis of an agreement with the landowner".*
>
> *"Un accord est passé entre le planteur et le propriétaire : le planteur conserve la propriété de cet arbre ou cette forêt sur la base d'une convention avec le propriétaire foncier."*
>
> ARTICLE 27 ALIÉNA 2 - CODE FORESTIER

- **The case of Ghana**

In Ghana, the law (notably through the Forest Resources Management Act 547 of 1997, the subsequent Forest Resources Management Act 1649, the Forest Resources Management Regulation 1998 and the Forest Resources Management (Amendment) Act 2002) is generally considered to attribute ownership of the tree to the planter. On the other hand, there is no direct link between tree ownership and land ownership as in Côte d'Ivoire:

> *"Ownership, control, management and use rights therefore lie 100% with the landowner if he was also the planter. If the trees were not planted by the landowner the agreement between him and the planter will determine who owns, controls and manages the timber resources and the use rights that lie on them."*
>
> *"The ownership of planted trees does not by default coincide with the ownership of the land they are planted on. In the same way as a farmer owns his crops even if not planted on his own land, a planter owns the trees he has planted even if it was not on his own land. "*
>
> FRAMEWORK ON TREE TENURE AND BENEFIT SHARING SCHEME, 2016

However, the reality is more ambiguous and the documentation needed to obtain property rights is expensive, the bureaucratic procedure complex, tiring and inaccessible for small farmers (Boni, 2007). It is currently clear that most farmers are not recognized as owners of their land and the trees on their plots. The majority of tree ownership is hence decided by customary rules (78% of the total land area) where planting trees is regarded as an attempt to acquire permanent ownership of land.

Moreover, Ghanaian law (unlike Côte d'Ivoire) states that farmers do not own the trees that have grown naturally on the plots they (rarely) own, and therefore cannot exploit their resources. These trees are allocated to the state, which systematically grants exploitation permits to forest concessionaires. The logical consequence is that farmers regularly cut down the trees on their plots themselves before planting cocoa, to the detriment of the development of a more sustainable agroforestry cocoa crop under shade.

The overlapping of rights (linked to timber exploitation on the one hand and agriculture on the other) has led to economic models operating in silos, making impossible to manage agriculture and timber exploitation jointly and harmoniously. Finally, this separate management has led to competition in land use, exclusion of peasants from timber revenues and a huge waste of resources.

As in Côte d'Ivoire, the most obvious solution seems to be to support farmers in the recognition of their land rights while taking into account local arrangements and customary law: only the full attribution of ownership of trees to those who planted them can guarantee the participation of farmers in cocoa agroforestry development projects in Ghana.

- **The case of Colombia**

In Colombia, if the land belongs to the nation or to natural parks, the tree also belongs to the nation. If the land is collectively owned by indigenous or Afro-American communities (34% of Colombian lands), the ownership belongs to the community. And if the land is private, the tree is private. But the exploitation of the wood requires the authorization of the environmental authority, which in Colombia are the Corporaciones Autónomas Regionales -CAR- (Regional Autonomous Corporations).

In other words, the property belongs to the owner of the land, but the use of the wood requires a license to use it, which is granted by the respective CAR

One of the main characteristics of small producers in Colombia is the high informality of land ownership. In other words, although the farmers live and cultivate on their properties, the property has not yet been formalized because they are not legalized inheritance or possession of the land with the title of ownership. Considering the above and taking into account that cocoa is a permanent crop, it is important to carry out agroforestry projects with farmers who own the land.

4.1.3 Technical barriers

Technical challenges for sustainable cocoa production. Due to the great diversity of ecosystems in tropical countries, it is necessary to consider the agroecological factors of the properties, so that an adaptation of the Agroforestry Systems -SAF- is carried out to the specific conditions of the soils and the microclimate of the place in where the projects will be developed.

Given the high-water requirements for cocoa cultivation, the need and feasibility of installing the plots with irrigation systems must be evaluated in each case. This increases installation and maintenance costs and makes the search for financing sources more demanding.

In many cases, cocoa projects in agroforestry systems have the objective of restoring degraded soils. This requires the design of special agroforestry systems arrangements and the search for funding sources.

Grafting is a crucial activity to achieve expected productivity. It is also a key variable in meeting planting schedules. For this reason, it is necessary to establish in each project, if the grafting is carried out in the field, in the nursery or in a combination of both.

Quality management. The processes of cocoa (fermentation and drying) are crucial to obtain the expected quality. For this reason, this is a key variable to take into account in the design of a cocoa project in agroforestry systems. If the decision is to make the profit on each farm, it is necessary to give personalized and intensive technical assistance to each farmer, as well as to provide them with the fermentation drawers and the drying rooms. On the other hand, if the benefit is to be done in a community manner, it is crucial to define the institutional arrangement around the processing plant, in terms of its ownership and management.

Possible restrictions such as grafting or the productivity programs. To limit the spread of certain diseases like CSSVD, some governments may impose restrictions on grafting. Similarly, to manage the risk of overproduction, Côte d'Ivoire has slowed down productivity improvement programs.

4.1.4 Financial barriers

Access to credit. Financial capacity of the producer will impact his/her ability to change his/her cocoa system. The inability to face initial costs may prevent the implementation of an excellent investment.

It is necessary to take into account the conditions of cocoa cultivation in agroforestry systems and to design credit lines with adequate financial conditions for farmers in terms of:

- Amounts of financing that include the installation of the crop and the agroforestry system,
- Amounts of financing that also includes the costs of the first three years of support,
- Amounts that include the irrigation system when necessary,
- Amounts that include the processing infrastructure (fermentation and drying),
- Terms of between 12 and 15 years,
- Grace periods of at least 3 years.

Given the financing difficulties for a crop that, like cocoa, is permanent and long-term, it is worth studying the possibilities of incentives designed in the country to support this type of activities. For example, in Colombia the Rural Capitalization Incentive (ICR) and that contributes to small producers up to 40% of the loan capital.

- Access to credit, including long-term credit
- Maturity of MFIs (being able to finance a plantation economy)

Also, it is important to take into account the Minimum Profitable Size that is between 3 and 5 hectares of cocoa in Agroforestry Systems per farmer. This Minimum Profitable Size guarantees an IRR of at least 12% and minimum income for farmers that are between 1 and 2 legal minimum wages in force. To guarantee the producer a minimum income, he will dedicate his work and family work to cultivation and will not abandon it.

Market and commercialization. To encourage improvements in quality, it is necessary to have market mechanisms that allow the recognition of quality premiums and ensure that these premiums really goes to the farmers to encourage their efforts. Also, the development of market needs also to include AF products is also key.

Before starting the execution of a cocoa project in agroforestry systems, it is advisable to select the cocoa varieties to be sown according to the destination market:

- Use varieties of fine and aroma cocoa for specialty export cocoa markets where better prices are recognized for quality. In this case, the yields are between 700 and 900 kilos / ha / year.
- Use standard varieties (e.g. CCN 51) if the market

does not recognize differential prices, since these varieties have higher yields per hectare and, therefore, generate higher income for the producer per unit area. In this case, between 1,200 and 1,500 kilos / ha / year can be obtained.

Also, research should identify hybrid varieties with high yields under shade.

4.2 Opportunities

Growing interest in zero deforestation cocoa

The cocoa sector is responsible for a part of the world's deforestation, but the majority of the world's chocolate is consumed in Europe and North America, far from the fields of West Africa and Latin America where cocoa is mainly cultivated. In this way, deforestation has been "imported" into Europe and North America. The EU has been studying, for several years, how it could reduce the impact of its consumption of agricultural products on deforestation.

In 2015, seven European countries signed the Amsterdam Declaration to end deforestation from agricultural products by 2030. On July 23, 2019, the European Commission adopted the EU Communication "Strengthening EU Action to Protect and Restore the World's Forests," in which the European Union is considering a strategy to raise consumer awareness of the need to consume products from "deforestation-free" supply chains.[12] The Commission is also exploring opportunities to provide incentives to trading partners to combat deforestation. Belgium launched a cocoa initiative, "Beyond Chocolate," on November 5, 2018, to address the issue and called for an ambitious action plan from the European Union. In France, the National Strategy to Combat Imported Deforestation (Stratégie Nationale de lutte contre la Déforestation Importée, SNDI) was adopted on November 14, 2018, to end the import of unsustainable forest or agricultural products that contribute to deforestation by 2030 (Ministry of Ecological and Solidarity Transition, 2018). Six sectors are specifically targeted, including cocoa. One of the objectives of this strategy is to raise the ambition of certifications to take into account deforestation mechanisms. The European Union has not yet determined how to concretely implement its strategy because, as the world's largest importer of cocoa, these new standards would impact the whole sector.

Governments are involved in jurisdictional emissions reduction programs (EPR) and cocoa plays an important role

REDD+ includes measures for:

- Conservation of existing forest carbon stocks through the protection of forests in countries with low rates of deforestation;
- Sustainable forest management;
- Increasing forest carbon stocks through restoration or planting of new forests.

Both Côte d'Ivoire and Ghana have identified cocoa cultivation as a major driver of deforestation and have focused their strategic actions directly on agriculture first. Cocoa is at the forefront of Ghana's REDD+ strategy, through its sub-national Ghana Cocoa-Forest REDD Program (GCFRP). Côte d'Ivoire has listed eight strategic options, the first and most important being the achievement of "zero deforestation agriculture," with a strong focus on cocoa. Both countries aim to improve yields through environmentally friendly and climate-smart agricultural practices such as promoting agroforestry, forest restoration, support for small-scale producers, and restoration of natural resources (soil and water in particular). Côte d'Ivoire's specific objective is to reduce deforestation from cocoa farming by at least 80% by 2030, a reduction of 44,000 ha/year. The country also plans to implement Payment for Environmental Services (PES) programs at the national level to encourage the implementation of agroforestry, with five one-year contracts each involving at least 30 trees per hectare.

The REDD+ strategies of the Latin American countries included in the study also focus on: first, improving the sustainable management of forest lands; and then, as a second strategic option, enhancing policies to control and limit agricultural expansion, which is also one of the main drivers of deforestation and forest degradation. However, the focus in these countries is not only on cocoa but rather on agriculture in general. Third are actions focused on protecting natural resources.

The Forest Carbon Partnership Facility (FCPF), the Biocarbon Fund, the UN REDD Program and the Forest Investment Program (FIP) (of the Climate Investment Funds) are the main initiatives for the development and improvement of REDD+ strategies.

12 Commission européenne, 2019. Renforcer l'action de l'UE en matière de protection et de restauration des forêts de la planète COM (2019) 352 final (https://eur-lex.europa.eu/legal-content/FR/TXT/?qid=1565272554103&uri=CELEX%3A52019DC0352).

Voluntary Initiatives and Commitments of the Business Sector

Most companies trading cocoa products have decided to develop internal sustainability policies that share the following issues: livelihoods, forest protection and restoration, sustainable production, community engagement and social inclusion.

The study "Eliminating Deforestation from the Cocoa Supply Chain" (Kroeger et al., 2017) proposed a method to assess the progress of companies and other stakeholders in reducing deforestation in the cocoa supply chain. This assessment is based on four criteria:

- Business engagement (supply chain implementation);
- Implementation of private sector commitments (operational plans);
- Support from actors outside the supply chain (support from environmentally invested stakeholders);
- Overall impact of deforestation (post-hoc analysis)

Of the 19 companies surveyed in this report:

- 12 (63%) have made deforestation-related commitments related to cocoa.
- Three companies (30% of global production) are implementing their commitments by training farmers and tracking their purchases to the farm level.
- Two (20% of global production) are using sourcing criteria with their suppliers to implement their commitments.
- Only one company (11% of global production) promotes land use planning.
- Two small companies (less than 1% of global production) have exemplary commitments (up to 99% of their supply certified).

Regarding collective commitments, during the 2017 United Nations Framework Convention on Climate Change Conference of the Parties (COP23), leading chocolate manufacturers engaged against deforestation, a key move to stop the conversion of forests for cocoa production. The cocoa and chocolate sector's commitment was formalized in the Cocoa and Forests Initiative's Collective Statement of Intent. Since 2018, this has translated into national implementation plans involving the participation of governments and major chocolate and cocoa companies in Côte d'Ivoire, Ghana and Colombia. They focus on conserving national parks and forest lands, as well as restoring forests that have been degraded by cocoa plantation expansion; on sustainable income intensification and diversification to increase farmers' yields and livelihoods, growing "as much cocoa on less land" and thereby reducing pressure on forests; and on engaging and empowering cocoa communities, particularly on mitigating the social impacts and risks of land use change on affected cocoa farmers and their communities.

Conclusion and recommendations

The following conclusions include lessons learned during the 10 months "Cocoa and Forest Knowledge program":

Lessons learned

Several elements, which today are sticking points, will be the levers of tomorrow to transform the value chain towards sustainable and resilient agroforestry cocoa. Cocoa is found in complex territories: it is necessary to support rural development with a territorial approach and support policies that go in this direction.

Producers need to be supported and incentivized in the design of their cocoa agroforestry. It should be customised to their needs, strategies and the markets they wish to reach. The customisation of systems must also be done according to the environment in order to manage or save natural resources. An enabling environment must be created to restore biological diversity, soil fertility and provide high yields. Producers need training and pre-financing to make a transition to sustainable cocoa which is profitable for them. Cooperatives also need to improve their governance. Moreover, it is necessary to think about how to make the chocolate makers work with the companies of the other associated crops, in order to improve not only the income of cocoa but of all the crops.

The large number of traceability tools in place and the lack of unification make it difficult to choose a tool. Furthermore, it is necessary to link cocoa traceability systems to the national forest monitoring system. This is the case in Colombia where farmers are in contact with the Forest Conservation Officers. There is also a need to link traceability systems to the different local cooperatives that produce cocoa in order to improve traceability and reduce the number of intermediaries that may currently exist.

In terms of certification, both the forestry and agroforestry components must be taken into account. One of the other central issues of this theme is the need to establish multi-year contracts with FairTarde buyers so that producers can invest in the transition of cocoa plots to agroforestry.

Governments of consuming countries are not left out. Consumers are not sufficiently aware of the damage their cocoa consumption can cause. They have too little understanding of agroforestry, its necessity and its benefits. There is a real need to raise awareness so that consumers also move towards sustainable cocoa and are prepared to pay for it. At the moment, there is an imbalance in the demand and supply of certified cocoa. Producers are making an effort to comply with restrictive specifications and this work is not being rewarded at its fair value. Indeed, a large part of the volumes produced are sold at the price of conventional cocoa.

Identified risks

The following risks have been identified:

- Instead of **top-down approaches**, it is essential to start from the needs and constraints of producers and their territory. Such assessment can help to envision the format of the future orchards and the content of the technical assistance needed.
- Due to the **great diversity of ecosystems** in tropical countries, it is necessary to consider the agroecological factors, so that an adaptation of the agroforestry systems is carried out to the specific conditions of the place in where the projects will be developed (specificity in term of soils, microclimate, available native timber or fruit species).
- Take into account restoring **degraded soils**. Many agroforestry pilots have failed because of the neglect of soils quality management.
- **Trees and land tenure issues**: The choice of farmers for full-sun cocoa cultivation to the detriment of agroforestry under shade can therefore be explained by existing laws that make it difficult for smallholders to access land and any timber trees.
- **Barriers against grafting**: grafting is a crucial activity to achieve expected productivity and farmers, particularly in Africa, should be trained. However, to limit the spread of some diseases like the CSSV, some government such as in Côte d'Ivoire may put restrictions on grafting.
- Lack of **access to market** for the non-cocoa products (fruits, timber, spices): there is a need of organizational scheme that eases the marketing of the other products.

Recommendations

The Table 31 sumps up the possible actions at the level of different actors of the sector:

Table 31: Possible actions to ensure transition towards durable cocoa agroforestry for each actor of the sector

Sector	Action	Entry point	Actor
Technical	**Develop a farmers training program based on the elements from the guide and on sustainable practices.** Provide training to farmers: • On good practices as the site selection, crop diversification, timber management, etc. • On the introduction of additional forest species in cocoa orchards to increase biodiversity (encourage nurseries and tree plantation) based on specific purposes (medicine, wood, fuelwood, fruits) addressing local needs and promoting native species. • On self-monitoring of cocoa orchards to detect pests and diseases, nun-productive trees, etc. • On identifying habitats that deserve to be preserved,	Local level	Extension services NGO
Technical	**Develop better collaboration between research, tree nurseries** (run by public services, private companies or cooperatives) and farmers in order to program and size the production of seedlings according to the climate zones, the soils, the economic objective of the plantation (market based production).	Regional level (climate zones)	Public research, forestry services, extension services, private sector
Financing Funding	**Develop PPP in producing countries.** This study made it possible to point out that the needs are huge (Côte d'Ivoire, for example, intends to strongly encourage agroforestry, in particular within the framework of its PNPREF policy). It also demonstrated the profitable nature of agroforestry practices. Subsidies are important but insufficient resources given the scale. On the other hand, they can leverage other private or innovative financing (PES, carbon) as part of the generalization of sustainable practices.	National level	Governments, funds and private sector
Organizational	**Initiate and perpetuate a community of practices on sustainable cocoa farming and agroforestry.** This work has identified practices such as they exist today in the areas studied. Recommendations were also formulated, but it seems essential to capitalize on feedback from the countries participating in the program and more generally. Such a community will have to be connected to other things such as the living income community of practices or the communities working on regenerative agriculture.	Global level	Country core group members (the group of 5 to 10 experts created during the knowledge exchange program)
Technical	Likewise, the cost-benefit analysis could continue to be refined by regularly recording technical economic data from different agroforestry projects. Thus, the **creation of a web platform** would make it possible to animate the community of practices coupled with a resource center and above all free access to the Excel model via an interface and an input window.	Global level	Core group members Donors
Traceability	**Continue to carry on the cartography of the cocoa production areas,** including a better knowledge of the plantations' location so as to identify potential risks and negative impacts associated to cocoa supply chains. **Set up and regularly update a map with superposition of the cocoa production area and the forests (with focus on high conservation value areas)**; it allows a closer follow up on exploitations located next to protected forests.	National level	Governments
Organizational	**Organize the markets of non-cocoa products at landscape level in Africa.** To accompany the income diversification there is a strong need in Africa to organize discussions with the timber companies, the food industry first to better orient the agroforestry features to market need and second to make the information on available products accessible for buyers.	Local level	Private sectors NGO

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Appendices

Appendix 1: National commitments related to climate or forests and constituting an enabling environment for agroforestry systems

Below is a short presentation of the different national laws and commitments that may create the enabling environment for cocoa agroforestry (CAF).

	Quantitative objective	Main policies or documents in place
Colombia	Restore 1 million hectares of degraded lands (initiative 20x20)	**Fondo nacional Cacao** (National cocoa fund): finances cocoa culture programs after collecting and promoting cocoa.
Peru	Reach Zero deforestation by 2030	**Estrategia nacional Cambio Climático** (National strategy for Climate Change): After an analysis of the deforestation drivers, an action plan lined promotion of agroforestry as a key activity (with prior identification of former difficulties, that are lack of finance for this kind of activities). **NDC**: objective to achieve 30% emissions reduction by 2030, mainly with Agriculture and forests being the first two prioritized sectors among the five selected.
Dominican Republic		**National action plan for sustainable cocoa (2017-2027):** aims at transforming the Dominican cocoa sector to ensure its growth, environmental sustainability and the social well-being of the producers. **NDC**: refers to agroforestry as a lever to act against deforestation and climate change Even though details and figures about agroforestry use are not mentioned, Dominican Republic is actually really engaged in this path, and the model is already in place and widely used, contrary to African countries above.
Cote d'Ivoire	Restore 20% of forest cover by 2030	**PPREF**: Policy for Preservation, Rehabilitation and Extension of Forests, adopted in 2018 **New Forestry code** (2019 edition) **NDC**: It does not specifically mention deforestation linked to cocoa, but it cites agroforestry for the development of agriculture without extension on existing forest lands. **National Plan of Investment for Agriculture** (includes REDD+ actions) **CFI** Commitments **CdI ER-Program** **Forest Investment Programme (FIP):** whose objective is to conserve and increase the forest stock, and improve access to sources of income from sustainable forest management for selected communities in target zones.
Ghana		**Forest Investment Plan** (FIP): the goal is to tackle underlying deforestation drivers by focusing on improvement of forest management practices **NDC**: aims at reducing 45% of GHG emissions due to cocoa **ER-Program** **CFI Commitments** **Ghana Forest Investment Programme:** financed by the Climate Investment Fund, among the 3 projects of the programme in Ghana, the first one aims at enhancing AF (and has most of the funding), and the two others aim at involving local communities and then private sector in REDD+.

Box 11. Overcoming the social barriers: some experience shared by the participants to the knowledge exchange program

The National Policy for the Preservation, Rehabilitation and Extension of Forests, adopted in May 2018 by the Government of Côte d'Ivoire provides, under its strategic axes 2, 3 and 4, the following categorization of protected forests:

- Category 1. Classified forests conserved at more than 75%: strictly protected and upgraded to protected areas if high biodiversity conservation value is demonstrated.

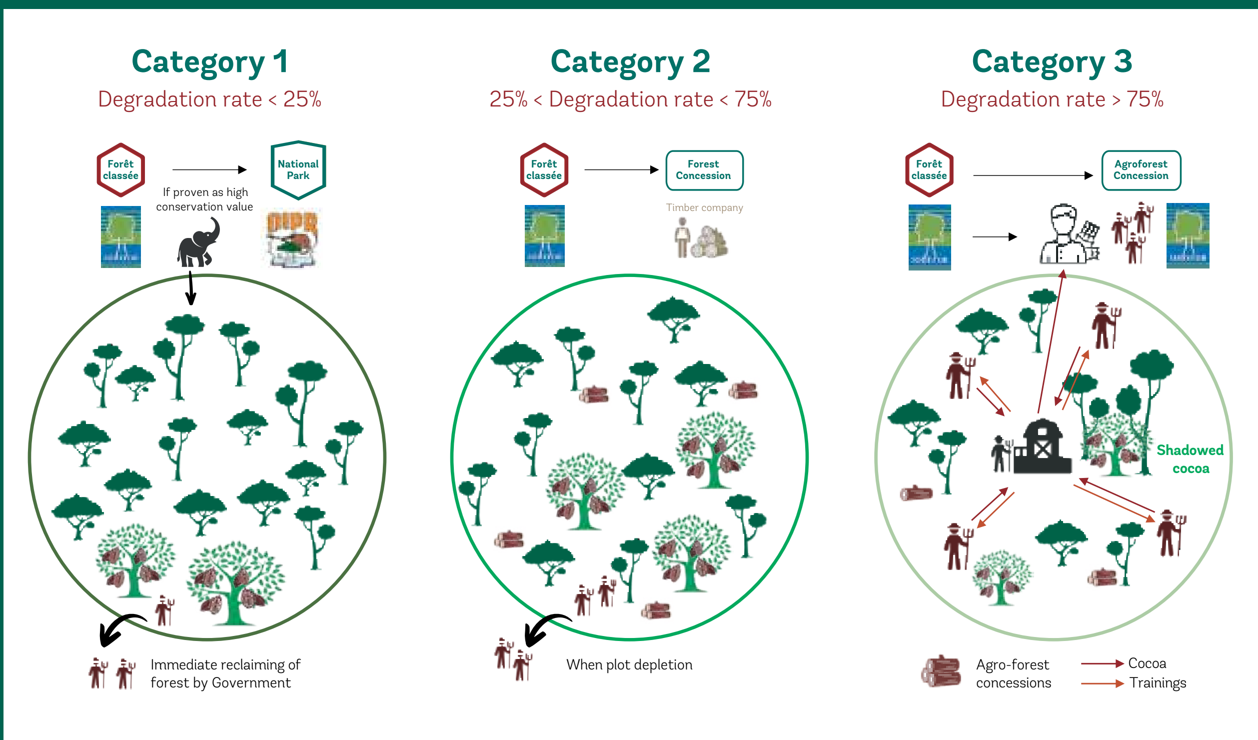
- Category 2. Between 25% and 75% conservation => phased out with permission to log sustainably under Sustainable Forest Concessions. These concessions are awarded to competent operators.

- Category 3. Less than 25% conservation, i.e., highly degraded: to be redeveloped into agroforest, supervised environmentally friendly agricultural activities (notably cocoa farming under shade), other supervised economic activities (pastoralism, ecotourism), and human settlements.

There is also official recognition of the status of agroforestry, defined as follows "Agroforests are classified spaces in which the practice of agroforestry is authorized. This concept will allow for a scale of protection that is more graduated and more adapted to the current reality of the territories, characterized by a strong mixture of land use and the presence of scattered forest areas surrounded by economic activities and human settlements, dangerous in the long term for their preservation."

To contribute to the ambitious goal of 20% forest cover in the country, the Government of Côte d'Ivoire intends to promote agroforestry as a technology that can precede landscape restoration while diversifying products and income.

Figure 15. Management scheme for "protected forests" by category, as suggested in the PNPREF of Côte d'Ivoire (Source: Authors, adapted from PNPREF)



REDD+ initiatives

REDD (for Reducing Emissions from Deforestation and forest Degradation) is a mechanism which aims at encourage developing countries to protect their forest resources, better manage them and thus contribute to climate change mitigation. The REDD principle is to give a financial value to the carbon stocked in the forests through carbon credits. By doing so, an economical incitation is created for the countries so that they invest in alternatives that emit less greenhouse gases. The incomes obtained from the issued carbon credits is used for the country's development, in particular the communities facing poorest living conditions and vulnerable concerned by the projects related to the concerned forests. The benefits should thus be superior to the ones that would have been gathered from deforestation activities by the communities.

The UN-REDD program was launched in 2008 by at the UNFCCC in order to assist the countries in elaborating and implementing their REDD+ national strategies, by developing the capacities needed to meet REDD+ requirements. It is based on the expertise of UN, FAO, UNDP, UNPE. It currently supports 49 partner countries in Africa, Latin America and Asia-Pacific.

REDD+ is an extension of the mechanism of REDD, which includes measures for:

- Conserving the existing forest carbon stocks, by protecting the forests in countries with low deforestation rates
- Sustainable management of forests
- Increasing the forest carbon stocks, by restoring or planting new forests

The FCPF (Forest Carbon Partnership Fund) as well as the UN-REDD program and the FIP (Forest Investment Program) are of the main initiatives developing and enhancing REDD+ strategies.

Regarding the progress toward their national REDD+ strategies in the frame of the Readiness fund of FCPF, all the countries of the study are not at the same stage. Some Latin American countries are not yet finished in the readiness phase and thus only have main directives for this strategy.

The role of cocoa in the REDD+ strategies

First, the two concerned West African cases both identified cocoa culture as their main deforestation driver and oriented their strategic actions directly on agriculture first. Cocoa is actually the core of Ghana REDD+ strategy, through its sub-national program named Ghana Cocoa-Forest REDD Program (GCFRP). Cote d'Ivoire listed eight strategic options, the first and most important one being reaching Zero deforestation agriculture, with a strong focus on cocoa. Both countries aim at improving yields through environmental and smart agriculture practices, promoting agroforestry and forest restoration, support to small producers and natural resources restoration (soils, and water in particular). Cote d'Ivoire's specific objective is to reduce at least 80% the deforestation generated by cocoa culture by 2030 (that is a reduction of 44,000 ha/year). The country also plans on implementing PES on a national level to foster agroforestry implementation, with 5 years-long contracts implying at least 30 trees per hectare.

Then for the Latino American countries of the study, the REDD+ strategies similarly focus first on improving forest land sustainable management, then often as a second strategic option is to strengthen policies to frame and limit agriculture expansion, which is also one of the main drivers of deforestation and forest degradation, but here not only or mainly due to cocoa, but to agriculture in general. On the third place come actions towards natural resources protection.

The Benefit Sharing schemes linked to the REDD+ programs

The Benefit Sharing Plan (BSP) is a document preceding the Emission Reductions Payment Agreement (ERPA), and that defines the modalities of benefit sharing, and always has the same structure and content. In particular, it has to define what are the benefits of the ER-P, who are the beneficiaries, and how the mechanism works (amounts, timing, scenarios etc..), the conditions for payment of the benefits (responsibilities and role of beneficiaries and stakeholders).

The similarities and differences per country consist on three main points: benefits generated by the implementation of the ER-P, beneficiaries, and mechanism of the BSP.

Benefits

The benefits are always defined as two types:

- **Carbon benefits**, which are to the results-based payments made by the CF from the sale of ERs. They correspond to benefits directly linked to climate mitigation, so related to Carbon, and thus correspond to the only monetary or non-monetary payments that will be mentioned in the ERPA.
- **Non-Carbon benefits**, which are not related to

carbon and produced by the implementation of the activities of the ER-P. These can be for example improvement in governance, land tenure rights, income increase or on the ecological side, the improvement of soil and water quality etc… **They are not included in the BSP and thus in the ERPA**.

Beneficiaries

In Cote d'Ivoire and Ghana, the beneficiaries are very similar and directly named as cocoa actors on different levels, for as seen before, the REDD+ strategies of both countries are directed mainly on cocoa. The 2 or 3 groups defined always imply field actors, such as the farmers, communities etc., **government** actors and institutions, and **private** actors. However, even though the private actors receive some benefits among the ER-P, they never receive benefits from the Carbon Fund.

The same categories of actors are defined as beneficiaries in the provisional BSP of Latam countries, but the main difference is that the beneficiaries are not directly mentioned as cocoa sector actors. Indeed, the field actors are not listed as cocoa farmers in the first place, but rather on owners of titles of rights of possession of forest, or farmers in general. In the case of Peru, there is a particular group defined for the indigenous people, because of their key role in forest conservation.

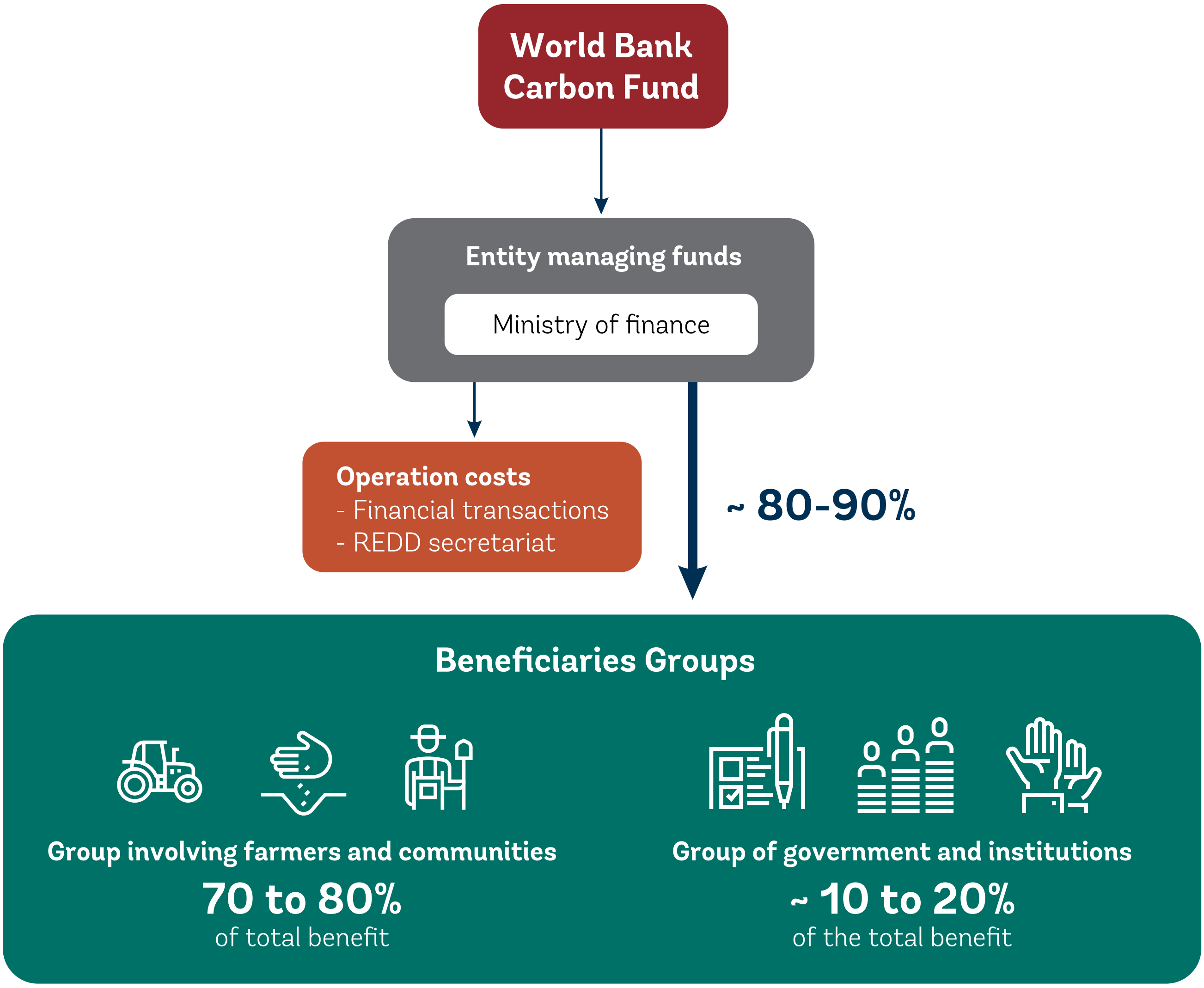
Mechanism

The main element to point out is that the producers and actors closest to the field and forest are the groups benefiting from the highest percentage of the global Carbon-benefits amount (69% in Ghana, and half of this percentage goes for farmer's groups), but this group also represent a higher number of people, in comparison with the institutions and governments groups that receive less but the amount is not divided.

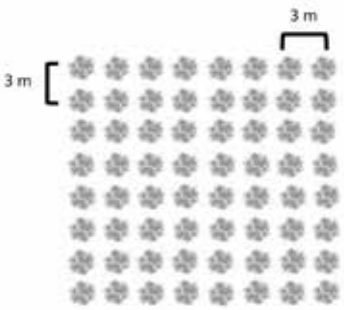
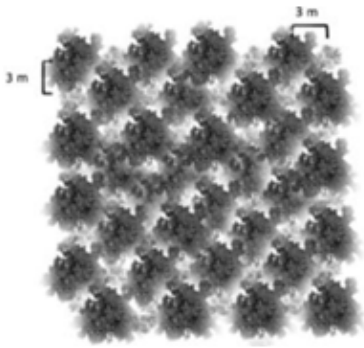
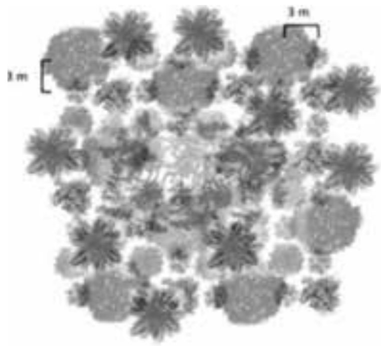
In its BSP draft, Dominican Republic decided to make the **number of hectares of land on which activities leading to ERs have been implemented** as stipulated in their respective contract the **basis criterion** for the distribution of benefits. This decision was made because the country cannot determine with precision the ER due to each beneficiary, to distribute benefits proportionally with the contribution to ER. Similarly, Peru also thinks of removing the proportional contribution to ER from basis criterion for benefit distribution, but maybe to allocate resource geographically, depending on criteria regarding the developmental needs of territories within the area of the ER-P.

It is necessary to mention that in most cases, the BSP foresees different performance scenarios of ER realization with specific benefit distribution for each. The possible scenario covers the cases form complete achievement of the ER targeted to no ER at all, with one to two intermediate scenarios. In the case of no ER (or less than 20% for Ghana), some countries will not distribute benefits, (or in Ghana a small amount for the farmers according to their performance).

Figure 16. Carbon benefit sharing general scheme for Ghana and Côte d'Ivoire (Source: Kinomé, from countries BSP)



Appendix 3: Illustration of multi-strata and intercropped models (source: Climate Focus, 2020)

	Full-sun monoculture	Intercropped model	Multi-strata model
Culture aspect			
Spatial organi-zation			

Appendix 4: Field analysis summary of intercropped models

Project and location	UTCC technical model (Togo)	CREMA and COCOBOD projects (Ghana)	Ouro-verde (Brazil)	Ecotierra project (Colombia)	AIDER (Peru)
Source or corresponding appendix	Adden et Kokou, 2017			Appendix 5	
Origin and main purpose of side plants	**Planted combined crops**	**Planted utilitarian plants**	**Planted combined crops**		
Associations	Timber trees (Fraké, Khaya)	Endemic trees (Fraké, mahogany, salsa...)	Ruber tree Banana (first years)	Abarco (permanent) Banana (first years)	Capirona, Laurel, Chaina, Pachaco Banana (first years)
Cocoa clones used	Grown from seeds: generally a mix of amelonado, trinitario and selected hybrids ([Wibaux et al., 2018](https://www.cirad.fr/)).		PS 1319, CCN 51, PH 16, CCN 10, BN 34 and CEPEC 2002	14 clones of fine and aromatic cocoa	Mainly TSH 565
Spatial organisation (see illustration below)	Tree within the cocoa lines	Tree within the cocoa lines	Trees around cocoa	Alternating strips	Alternating strips
Density per ha strata 1 (forest trees)	110 to 120 timber trees planted, 30 after pruning (year 6/7)	18 economic trees	320 rubber trees	320 abarco	12 to 50 shade permanent shade trees
Density per ha strata 3 (cocoa level)	1320 cocoa/ha 350 banana	~1300 cocoa/ha	1000 cocoa 1000 banana	920 cocoa 920 banana	1111 cocoa 1111 banana
Estimated cocoa yield in maximum production	1300 kg/ha/y	data not available	*1700 kg/ha/y*	*1900 kg/ha/y*	*900 kg/ha/y*

Appendix 5: Field analysis summary of multi-strata systems

Project and location	**Ambroise N'Koh's exploitation : Champion of agroforestry (Cote d'Ivoire)**	**Camayé Vert (Cote d'Ivoire)**	**Forest Finance (Peru)**	**Cabruca systems analysis (Brazil)**
Corresponding appendix				
Land use pathway	**Planted combined crops and utilitarian plants**	**Planted combined crops and utilitarian plants**	**Planted combined crops**	**Natural utilitarian plants**
Associations	• Food crops (*Irvingia gabonensis, Beilschmiedia mannii, akpi*), • Medicine crops (*Garcinia kola, Beilschmiedia mannii*), • Fertilization (*Albizia, Arachis hypogaea*), • Timber (not prioritized : the previous trees)	Timber (*Fraké*), spices (*Akpi*), food crops (citrus, mango, banana, vegetables, yam…) and fertilization (*gliricidiae*).	Timber (endemic trees), food crops (banana, citrus, pigeon pea), fertilization (pigeon pea)	Various forest trees
Cocoa clones used	Grown from seeds: generally a mix of amelonado, trinitario and selected hybrids (Wibaux et al., 2018).		TSH 565, clones of the Trinitario family, UF 650, UF 674	
Spatial organisation	Alternating strips cocoa/ tree	Alternating strips cocoa/tree	Alternating strips cocoa/tree	Tree within the cocoa lines)
Density per ha strata 1 (forest trees)	*36 Irvingia gabonensis* *36 Akpi*	13 fraké/ha 13 akpi/ha	280 timber trees	250 forest trees
Density per ha strata 2 (fruit trees)	*36 Garcinia kola* *36 Beilschmiedia mannii* *36 Albizia*	100 orange or avocado tree/ ha	Few citrus ~10	
Density per ha strata 3 (cocoa level)	~1300 cocoa/ha *Gliricidiae*	1320 cocoa/ha 1320 banana tree/ha 1500 *gliricidiae*	1100 cocoa 1100 banana	~1100 cocoa
Density per ha strata 4 (land level)	Arachide	6000 yam buttes 3000 vegetables (eggplants, peppers, peanut, gombo, tomato)	Pigeon pea	
Estimated cocoa yield in maximum production	*2000 to 2500 kg/ha/y*	*1200 kg/ha/y*	*1700 kg/ha/y*	*900 kg/ha*

Appendix 6: Summary of the contents of the regional standard ARS 1000-1:2

Topic	Description ARS 1000-1:2021	Reference 1000-2:2021
Management System Improvement	For the Recognized Entity: Identification of opportunities for improvement. Set and specify relevant performance objectives and implement the appropriate actions.	10
Requirements for economic aspects	Support and training for producers to build capacity in accounting, farm management and access to financial products. Skills of workers, plant materials and agrochemicals adapted and controlled to promote the agricultural performance of farms and good agricultural practices at each stage of production. The Producer Group / Producer Cooperative must inform their producers about crop diversification, adaptation to climate change of their production and support them in this diversification.	11
Requirements for social aspects	Guarantee respect for human rights. Abolish illegal child labor and forced labor. Implement the gender and youth action plan. Prevent discrimination, harassment and abuse. Ensure written or witnessed contracts for workers and regular pay. Implement an action plan on occupational health and safety. Necessary protective equipment for workers exposed to unsafe conditions provided free of charge by the Entity. The Entity provides access to social security for workers. Freedom of association and collective negotiation policy.	12
Requirements for environmental aspects	Minimize negative impact and maximize positive impact on the environment: • Preserve plant and animal wildlife areas. • Prevent deforestation and combat climate change • Protection of water bodies • Focus points for health and environmental safety related to the use of agrochemicals	13
Topic	**Description ARS 1000-2:2021**	**Reference 1000-2:2021**
Requirements for the registration of actors in the cocoa supply chain	Supply chain actors must apply to the Regulator/Legal Entity to be registered.	4
Quality requirements	The batches of cocoa beans must respect a design brief to be suitable for the manufacture of food products. A maximum limit must be respected on certain aspects (elements related to cocoa, flat beans, foreign bodies, moisture content, sifting debris, color, odor) as well as a maximum percentage of moldy, slatey, insect-affected or sprouted beans.	6
Sampling	The sampling made to check the compliance with the specifications of the design brief must be carried out in accordance with the requirements of ISO 2292.	7
Bagging/Packaging	Packaging bags must be clean, strong enough, suitable for food contact and properly sewn and sealed. Cocoa beans are shipped in new bags only.	8

Marking	Les sacs doivent afficher : le pays producteur, le nom du produit, la catégorie du produit, l'année de récolte du produit, les marques d'expédition, le cas échéant, toute autre marque d'identification applicable, y compris le type de vérification (Ex : ARS 1000) et le poids net.	9
Test report	The test report that records in an organized manner the data obtained from an evaluation of specific parameters and describes the environmental or operating conditions must meet the requirements.	10
Traceability principles	Traceability systems for sustainably produced cocoa should be able to: document the history of the cocoa or locate the cocoa in the cocoa supply chain, contribute to the identification of the cause of non-compliance, and improve the appropriate use and reliability of information, as well as the effectiveness and efficiency of the cocoa supply chain actor.	11
Traceability objectives	Traceability objectives shall be measurable, monitored, communicated to relevant internal and external stakeholders and updated as necessary. The cocoa supply chain actor shall maintain documented information on the cocoa traceability objectives.	12
Traceability requirements	The actors shall ensure that the cocoa supply chain, including all operational units, meets the requirements of this Standard. The traceability system for sustainably produced cocoa shall be verifiable, achievable, result-oriented and economically viable. It shall provide documented information on cocoa throughout the cocoa supply chain from farm to export (FOB) as well as at the local level for processors.	13
Physical traceability - Cocoa segregation	The Recognized Entity and the actors in the cocoa supply chain shall demonstrate that measures have been taken to avoid the mixing of compliant cocoa with non-compliant cocoa.	14
Monitoring and improvement	Cocoa supply chain actors shall monitor the effectiveness of the traceability system for sustainably produced cocoa. They shall conduct an internal audit at least once a year to verify compliance with the requirements of this Standard. Corrective actions shall be taken in case of non-conformities. Continuous improvement of the relevance, adequacy and effectiveness of the traceability system shall be carried out.	15
Review	A review of the traceability, monitoring, corrective action and continuous improvement system will be conducted regularly.	16
Subject	**Description ARS 1000-3:2021**	**Reference** **ARS -1000 3:2021**
Regulator/Legal Entity Requirements	Guarantee and ensure the independence, impartiality and integrity of the regulator/entity with respect to stakeholders: • Obligation to have a policy of impartiality and to ensure its effectiveness. • Requirement to have an independent and honest Supervisory Board with identified competencies	4
System Development and Management	Establish rules for the establishment and implementation of a certification system and its proper management by the Regulator/Legal Entity	5
Information Available to the Public	Ensure accessibility of information related to certification and certification organizations	6
Complaints and appeals to the Certification Bodies and the Regulator/ Legal Entity	To ensure the effectiveness of the complaint and appeal process against a client, a Certification Body or the Regulator/Legal Entity itself	7

Requirements for certification auditing organizations	To ensure the effectiveness of the complaint and appeal process against a client, a Certification Body or the Regulator/Legal Entity itself Establish rules governing the activity of Certification Bodies, including the audit cycle for sustainable cocoa; audit procedures; methods of auditing; methods of obtaining information during the audit; duration of the audit; time limits for resolving non-conformities; expiration of a certificate; requirements for auditor competence.	8
Claims and Third Party Mark of Conformity	Establish rules for the benefit of Regulators/Legal Entities governing the use of claims, marks or certificates by third parties	9 et 10
Licensing and Control	Establish rules governing the granting of a binding agreement for the use of certificates, marks of conformity or other indications of conformity.	11

Appendix 7: Summary from official technical manuals in Ghana and Côte d'Ivoire (CCC, 2015; CHED, 2016)

	Ghana	Côte d'Ivoire
Choosing a planting site	Relatively flat or gently sloping land (avoid steep slopes). Moist but draining, homogeneous soil with a pH between 5 and 8.	A soil with a good internal drainage, a rate of coarse elements lower than 50%, a sandy-clay texture, a useful depth equal to 120 cm.
Soil preparation	1. Clearing: between December and February, leaving 15 to 18 shade trees per hectare to provide permanent shade. 2. Alignment and staking: place a stake at a reference point and using a rope attached to a reference stake, draw a horizontal line approximately 100 meters from the property line. From the reference stake and along the horizontal line, mark the recommended locations (every 3 meters) for the position of the cocoa plants and place a stake at each marked point. Repeat the process vertically. 3. Spacing: 3mx3m so 1,111 trees per hectare. 4. Temporary shade: plantain and taro should be planted in a row at 3mx3m and 1mx1m respectively to provide temporary shade for cocoa seedlings. The plantain should be spaced 1.5m from the cocoa (between two plants) and the taro 1m from the cocoa. Other trees such as papaya or Gliricidia can also be planted at 3mx3m or 6mx6m. 5. Permanent shade: it is recommended to plant between 15 and 18 permanent shade trees per hectare such as Terminalia ivoriensis or Albizia coriaria.	1. Clearing is to be adapted according to the nature of the land: cutting the undergrowth, felling and bucking trees, burning or windrowing for forests, mowing vegetation for fallow land, mechanical felling of the forest, stumping and windrowing in large plantations. 2. Temporary shading with plantain or fast growing legumes. The first year the banana tree is planted and provides satisfactory shade after 6 to 9 months. The cocoa tree is then planted only in the second year. 3. Staking: draw the base line and align the stakes every 2.5 cm from the base line, draw the first perpendicular (using the 3, 4, 5 method for the right angle) to the base line and stake every 3 m, construct the other planting lines by drawing a line parallel to the base line every 3 meters and align the stakes every 2.5m. 4. Dig holes of minimum size 60cmx60cmx60cm at the locations of the stakes and fill in the hole by putting back the surface soil. 5. Plantation of banana shoots: eliminate the roots and necrosed parts of the shoot, coat the bulb with wood ash, plant the collar slightly below the ground 6. Maintenance of the banana trees: weed during the first months, remove the old hanging leaves, remove the sheaths of the old leaves at the base of the plant, remove the shoots, let two or three shoots restart so as to spread out the production in time
Planting of the cocoa tree	1. Planting: the best period to plant cocoa is from May to July (main rainy season). On the eve of planting, water the seedlings abundantly, dig holes at the place of the stakes that can contain the poly-bag and remove the bag without losing too much soil and damaging the roots and seedlings 2. Mulching: spread dry plant material around the base of the cocoa plant towards the end of the rainy season (October). In termite-infested areas, the mulching material must be treated with a termicide solution.	1. Planting arrangement: make the cocoa tree hole at the intersection of the diagonals of the rectangle formed by four banana plants. 2. Digging: at the beginning of the main rainy season (March-April), at least 15 days before the young plants are planted. Dig holes of 40cmx40cmx40cm, separate the surface soil from the deep soil, backfill immediately and tamp. 3. Plantation of cocoa trees: treat the plot with a herbicide, water the selected plants, open the hole to the dimensions of the bag, cut the base of the bag (4 cm), place the bag in the hole with the collar at ground level, remove the plastic and fill in the hole.

Conduct of a young plantation	1. Pruning: for young plants, pruning is carried out during the 3rd or 4th year by cutting the low branches, removing the excess shoots. 2. Shade management: a shade level of 30% of sunlight is necessary for young cocoa trees 3. Manual weeding: 3 to 4 times per year (March, May-June, August and November) 4. Chemical weed control: Herbicides such as glyphosate can be used to control weeds in young and mature cocoa farms. 5. Use of cover crops: Cover crops such as Mucuna puriens, tropical kudzu (Pueraria phaseoloides), Stylosanthes sp. can normally be planted between rows of young cocoa plants to manage weeds on the farm	1. Manual weeding: mow the weeds at ground level with a machete, mulch with the grass cut at the foot of the cocoa trees, clear the mulch around the collar for 10 cm 2. Replacement of dead plants: is done in September/ October of the year of planting and in May/June of the following year with vigorous plants from selected seeds 3. Training pruning: regularly eliminate with pruning shears or a sharp knife the poorly formed suckers and stems in order to have a single stem with a crown with 5 branches. If the crown is low, leave 1 to 2 suckers on the crown; if the crown is well formed, the suckers must be regularly removed at the level of the trunk 4. Pest control: adopt good cultural practices (weeding, shade adjustment, pruning of branches...) in order to avoid the development of insects (caterpillars, psyllids, leafhoppers, bark beetles, termites) and make a chemical treatment every two months. 5. Fertilization of young cocoa trees (0 to 3 years old): avoid nitrogen and prefer triple superphosphate (TSP) by using it in the following way: spread the fertilizer in the crown around the trunk following the foliage (100 in March/April and 100g in August/September) and cover the fertilizer with the grass cut during cleaning.

Conduct of a plantation in production	1. Pruning: For mature cocoa, sanitary pruning involves the removal of infected branches or epiphytes (sanitary pruning) and structural pruning allows the tree to have the desired architecture. 2. Shade management: A light level of 70% is necessary for the mature cocoa tree. 3. Manual weeding: twice a year (April-May and July-August) for mature cocoa trees. 4. Chemical weed control: Herbicides such as Glyphosate can be used to control weeds in young and mature cocoa farms. 5. Soil protection against erosion: mulching, use of cover crops, use of shade trees, terracing, runoff detour 6. Soil fertility: can be improved with fertilizers containing essential plant nutrients. The macro-nutrients are nitrogen (N), phosphorus (P) and potassium (K).and the micro-nutrients are calcium (Ca), sulfur (S) and potassium (K). (Ca), Sulfur (S), Magnesium (Mg), Iron (Fe), Zinc (Zn), Manganese (Mn), Boron (B), Molybdenum (Mo), Copper (Cu), Sodium (Na) and Silicon (Si).	1. Weed control: to avoid competition between weeds and roots in the absorption of water and nutrients and the proliferation of pests. To do this, eliminate weeds, 3 times a year, with a machete and with herbicides in alternation. 2. Maintenance pruning: clear the cocoa trees of gourmands and parasitic and epiphytic plants as well as dead or diseased branches and twigs regularly. Pruning: with a pruning shears or a machete for the gourmands within reach and with a lopper or a pruner for the gourmands higher up, cut regularly flush with the trunk Pruning of parasitic plants (red flowers and berries / yellow flowers and blue fruits): cut or pull regularly with a pruning knife, a lopper or a machete until their total elimination from the plantation by cutting the parasitized branch just below the loranthus (3 to 5 cm) in order to avoid leaving a snag which could vegetate again Elimination of epiphytic plants (green moss, lianas and lettuce): eliminate them with working tools (machete, pruning shears). For green moss, use the salt water solution Removal of dead or diseased branches and twigs: cut them off and carry them away from the plantation 3. Sanitary harvesting (picking and removing dried pods from the plantation): after the main harvest (in January/February), drop the unharvested dried fruits, remove them from the plantation, bury them or burn them. During the rainy season when the pods are actively developing: watch for the beginning of pod rot, eliminate rotten pods by cutting the peduncle as close as possible to the pod. 4. Control of insect pests and diseases: first treatment in July/August/September, second treatment in December/ January. 5. Fertilization of adult cocoa trees with a fertilizer containing phosphorus, potassium, calcium, sulfur, magnesium and boron: first application at the beginning of the main rainy season (March/April), second application at the beginning of the short rainy season (August/September) in a crown with a radius of 60 to 100 cm around the cocoa tree.

Cocoa regeneration		To make a cocoa plantation productive and profitable again by rehabilitation (application of specific technical itineraries to the trees in place) or replanting (replacing an old plantation by a new one) **1. Assessment** and decision making: target the observations on the following points: vegetative and sanitary state of the plantation, number of living and productive trees per hectare, yield of the plantation, age of the plantation... This analysis allows the decision to be taken which can be the rehabilitation (plantation of less than 30 years, 800 to 1 000 productive trees/ha, yield of 400 kg/ha), the replanting (plantation of more than 30 years, density lower than 800 productive trees/ha, yield less than 250-400 kg/ha, soil favorable to cocoa cultivation) or reconversion (rainfall less than 1,200 mm and 4 months of dry season, cuirass less than 1 meter deep, hydromorphic soil with more than 50% of coarse elements) **2. Rehabilitation** • Replantation under existing cocoa-trees • Replacement of the gaps in the plantation • Complete replantation • Gradual replantation • Coppicing and grafting • Replantation of old fallows
Agroforestry in cocoa production	Intercropping of cocoa with fruit and tree crops that serve as shade trees, timber and generate additional income. For optimal performance in a system intercropping system with cocoa, the right fruit/tree crop must be selected and planted at the appropriate spacing.	Choice of appropriate agroforestry system: Improved fallow (plot planted with fast growing legume and used a few years later for cocoa cultivation), selected trees (trees left by the producer at the creation of the plantation for their usefulness), complemented trees (trees planted in the cocoa farm at the time of its creation), preservation of local species (trees that have emerged spontaneously and are maintained for specific needs), boundary planting (trees planted along the contours or boundaries of a plantation), protective strips (fence or barrier with trees or shrubs planted for protection)
Good environmental practices	1. Water management: keep a distance between the plantation and water sources, prevent water contamination from chemical runoff, avoid dumping waste into water, handle and store manure/fertilizer/agrochemicals to avoid contamination 2. Ecosystem protection: establish plantations away from wildlife refuges, do not cut down trees in the forest to establish new plantations, create protected areas by planting trees and other vegetation on the banks, maintain vegetation cover, use diverse and native trees, do not burn to prepare new land for agriculture 3. Waste management: purchase only necessary products, empty chemical drums and use containers, ensure rinse water does not contaminate the environment, do not burn containers	

Appendix 8: Recommended and non-recommended trees according to national manuals -West Africa (source: CCC, 2015)

Recommended species

Scientific names	Common names	Specific roles
Acacia mangium	Acacia	Soil improvement, shading
Albizzia sp.	Albizzia	Soil improvement, shade
Alstonia boonei	Emian	Shade, timber
Cocos nucifera	Coconut palm	Food, diversification, shade
Dacryodes sp.	Safflower	Food, shade
Elaeis guineensis	Palm tree	Food, diversification, shade
Entadrophragma angolense	Tiama	Shade, timber
Ficus sp.		Shade
Funtumia elastica	Rubber tree	Shade
Garcinia sp.	Small cola	Food, diversification, shade
Gliricidia sepium	Gliricidia	Soil improvement, shade
Hevea brasiliensis	Rubber tree	Diversification
Irvingia sp.	Wild mango	Food, diversification
Khaya ivoriensis	Mahogany	Shade, timber
Monodora myristica		Medicinal
Musa paradisiaca	Banana tree	Shade, food
Petersianthus macrocarpa	Abalé	Lumber, shade
Psidium guayava	Guava tree	Food
Rauvolfia vomitoria		Medicinal
Ricinodendron heudelotti	Akpi	Food, diversification, shade
Terminalia ivorensis	Framiré	Lumber, Shade
Rerminalia superba	Fraké	Lumber, Shade
Tieghemella heckelii	Makore	Timber, Shade
Xylopia aethiopica	Long pepper	Medicinal

Potential host species for insects carrying the CSSV virus

Scientific names	Common names
Chlorophora excelsa	iroko
Spondias mombin	mombin or mirabelle tree or trouma
Ceiba pentandra	cheese tree
Bombax buonopozense	Kapokier
Cola gigantea var glabrescens	Great ouara
Sterculia tragacantha	Poré poré
Cola lateritia var. maclaudii	Small ouara
Adansonia digitata	Baobab
Herrania balaensis	
Bombax malabaricum	
Cola chlamydantha	
Theobroma angustifolia	
Sterculia rubiginosa	
Sterculia rubiginosa	

Coffea rupestris	
Sterculia appendiculata	
Theobroma bicolor	Mocambo
Theobroma grandiflorun	
Pterygota macrocarpa	Koto
Sterculia setigera	
Sterculia alata	
Sterculia alata	
Uvaria chamae	
Uvaria chamae	
Sterculia alata	
Sterculia alata	
Commelina erecta	
Synedrella nodifl ora	
Monodora tenuifolia	
Corchorus olitorus	Korala
Adenia lobata	
Xanthosoma maffafa	
Hilleria latifolia	
Corchorus trilocularis	
Xanthosoma sagittifolium	Elephant ear
Aerva lanata	
Commelina benghalensis	
Wissadula amplissima	
Corchorus trilocularis	
Heliocarpus popayanensis	
Corchorus tridens	Three-toothed hornet
Corchorus aestuans L	
Abroma augusta	
Cucumis sativus	

Latin America

Scientific names	Common names	Specific roles	Bioclimatic area
Cariniana pyriformis Miers	Abarco (in Spanish)	Timber	This tree is located at an altitude of about 1000 m with temperatures greater than or equal to 24°C and annual precipitation greater than 1000mm
Dipteryx oleifera	Almond tree	Oil for cosmetics and timber	Maximum altitude of 1000m. It is found in humid and tropical forests
Swietenia macrophylla King	Mahogany	Timber and medicinal properties	Altitude up to 1600m. Temperatures lower than 24°C. Precipitation between 1500 and 4200 mm per year.
Cocos nucifera	Coconut tree	Fruit, oil, water, roofing, timber	It is found in warm areas (temperatures between 22°C and 30°C). The ideal precipitation is around 1500mm per year and it is recommended not to cultivate it at more than 400 m of altitude.
Cordia alliodara	Rhodes Wood (Sam Cedar)	Timber	It is found up to an altitude of 1900m.
Cedrela odorata L	Red Cedar	Timber	Annual precipitations between 1200 and 1500 mm with temperatures varying from 23°C to 30°C. It is found at altitudes of up to 1000°C.

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