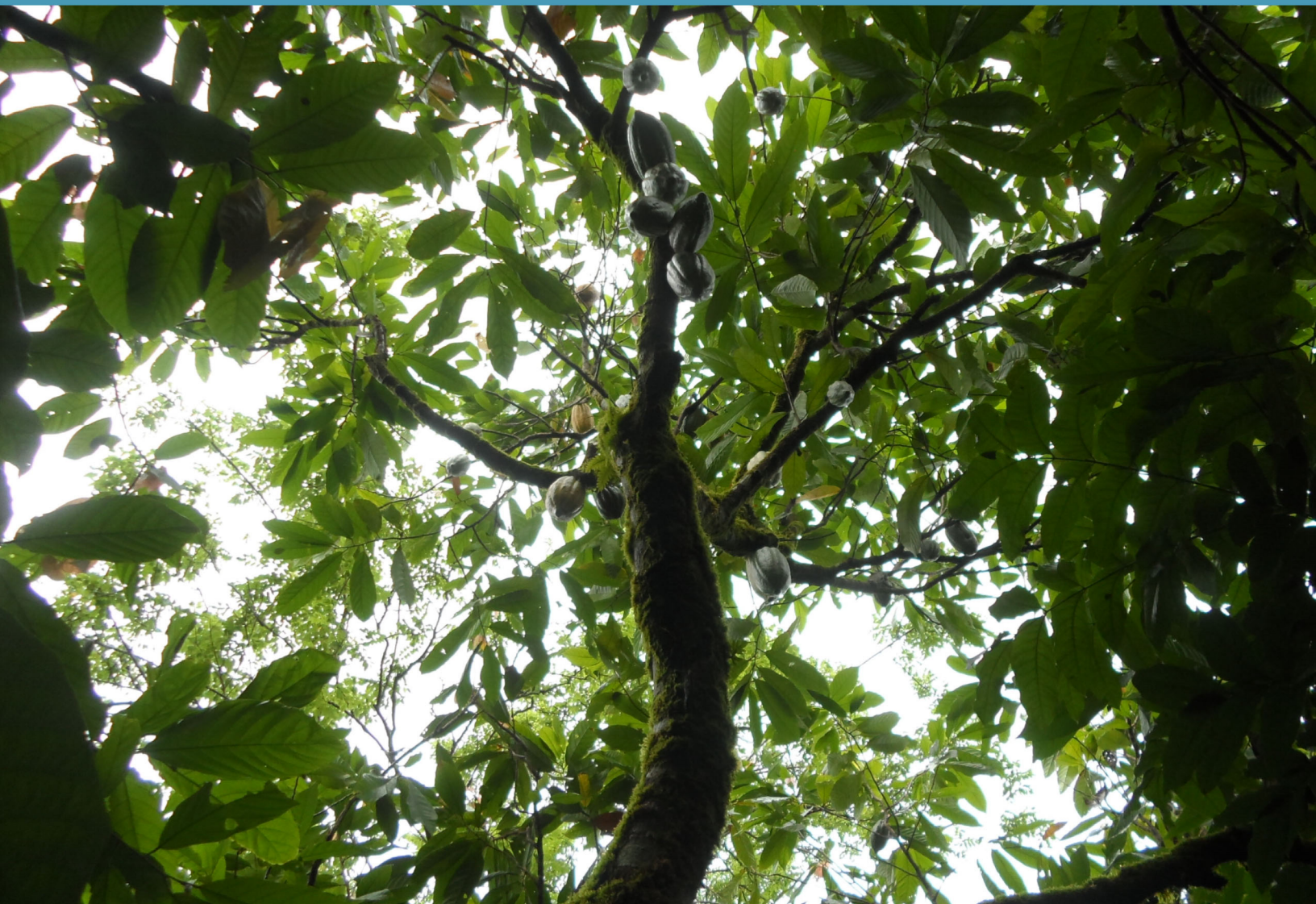


# FEED <sup>THE</sup> FUTURE

The U.S. Government's Global Hunger & Food Security Initiative



## DEVELOPING COCOA AGROFORESTY SYSTEMS IN GHANA AND CÔTE D'IVOIRE



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Developing Cocoa Agroforestry  
Systems in Ghana and Côte d'Ivoire

19 June 2020

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# 1. Introduction to cocoa agroforestry

**This guide provides an overview of recommended steps to implement cocoa agroforestry systems under the Cocoa and Forests Initiative (CFI).** Cocoa agroforestry is a prominent strategy in national implementation plans under the CFI. If designed and managed properly, cocoa agroforestry programs can contribute to each of the main pillars of the CFI: forest protection, forest restoration, sustainable production, farmer livelihoods, social inclusion, and community engagement.

**Under their CFI Action Plans, private sector actors have committed to implement nearly 400,000 hectares of cocoa agroforestry systems across West Africa.**

However, these commitments were made prior to the finalization of relevant national regulations and definitions of approved cocoa agroforestry definitions, models, and standards. Recognizing this gap, this guide provides CFI companies with the initial knowledge base and framework to understand the key elements of implementing large-scale cocoa agroforestry programs. This includes a working definition for CFI reporting purposes, which is subject to change if more stringent national regulations are passed.

## 1.1. How to read this guide

**First, this guide provides an overview of the policy and regulatory backdrop for cocoa agroforestry systems in Côte d'Ivoire and Ghana.** Each country is promoting cocoa agroforestry through a combination of sectoral strategies, laws, regulations, and ongoing REDD+ programs. This section will examine the key areas of alignment and overlap between these various strategies and highlight relevant actions and activities that frame the opportunities for collaboration moving forward.

**Second, the guide defines an assessment framework for identifying opportunities for cocoa agroforestry in landscapes.** Well-designed cocoa agroforestry programs can extend benefits beyond individual farms and affect overall landscape health. For stakeholders in shared sourcing areas, cocoa agroforestry programs are a ripe opportunity for the co-development of interventions, engagement, and implementation to collaborate pre-competitively and secure long-term sustainable cocoa production.

**Finally, the guide examines the technical needs, resource requirements, and opportunities and challenges in implementing cocoa based agroforestry systems.** The guide examines both the enabling factors for cocoa agroforestry and the available design options for systems while also illustrating how this may impact the support needs for farmers over the short- and long- term that companies must address before implementing cocoa agroforestry systems within their supply chain.

## 1.2. The benefits of cocoa agroforestry systems

**“Cocoa agroforestry” describes production systems that incorporate and maintain non-cocoa tree species on the same plot as cocoa production.**

There is no single model for how cocoa agroforestry systems can be implemented or designed, and the diversity of options enhances the potential to achieve a number of benefits. Depending on the design features of the system, cocoa agroforestry has the potential to deliver a range of benefits to the environment, climate, cocoa production, and socio-economic systems (Box 1).<sup>1</sup> In doing so, cocoa agroforestry systems may address deforestation, farmers’ livelihoods, and forest restoration.

**Achieving these benefits requires careful planning, preparation, and farmer participation.** Cocoa agroforestry systems should reflect the broader factors of the landscape and be based on the individual needs and preferences of the farmer.

To be considered “cocoa agroforestry” in the broadest sense, a system should at least maintain the production of cocoa and incorporate at least one additional species to provide shade to the farm. Other definitions, such as the Rainforest Alliance/UTZ SAN Standard, recommend at least 5 native tree species per hectare.<sup>2</sup> Species selection, and the interactions among the species, the landscape, cocoa trees, and climatic factors will determine the potential benefits that may be achieved.

**Cocoa agroforestry systems are dynamic and require ongoing support over time.**

The potential benefits of cocoa agroforestry can only be fully realized if farmers are motivated and given adequate incentives and support. Well-designed and managed cocoa agroforestry systems can produce economic, social, and ecological benefits. For instance, adding shade trees can provide a refuge for biodiversity and sustain other

*Box 1: Benefits from cocoa agroforestry*

Environmental and climate benefits	<ul style="list-style-type: none"> <li>• Carbon sequestration</li> <li>• Enrichment of soil fertility</li> <li>• Air and water quality regulation</li> <li>• Wind blockage</li> <li>• Reduced erosion</li> <li>• Biodiversity and conservation</li> </ul>
Cocoa production benefits	<ul style="list-style-type: none"> <li>• Improved farm adaptation (certain contexts)</li> <li>• Pest control and resilience to disease outbreaks</li> <li>• If well-designed, can maintain cocoa production in short-term and increase overall in long-term</li> </ul>
Socio-economic benefits	<ul style="list-style-type: none"> <li>• Supports income diversification</li> <li>• May reduce labor costs</li> <li>• Household consumption for enhanced food security, construction materials, medicinal products, fuel, etc.</li> </ul>

<sup>1</sup> For further more in-depth discussion of how cocoa agroforestry system design influences the attainment or the scale of these benefits, please see: Blaser, W.J., Oppong, J., Hart, S.P. *et al.* Climate-smart sustainable agriculture in low-to-intermediate shade agroforests. *Nat Sustain* 1, 234–239 (2018). <https://doi.org/10.1038/s41893-018-0062-8>. For more information on the potential socio-economic benefits, please see: Sonwa, D.J., Weise, S.F., Schroth, G. *et al.* Plant diversity management in cocoa agroforestry systems in West and Central Africa—effects of markets and household needs. *Agroforest Syst* 88, 1021–1034 (2014). <https://doi.org/10.1007/s10457-014-9714-5>.

<sup>2</sup> Rainforest Alliance, SAN Standard 2017. [https://www.rainforest-alliance.org/business/wp-content/uploads/2017/11/03\\_rainforest-alliance-sustainable-agriculture-standard\\_en.pdf](https://www.rainforest-alliance.org/business/wp-content/uploads/2017/11/03_rainforest-alliance-sustainable-agriculture-standard_en.pdf)

ecosystem services such as improving soil fertility, increasing resilience to climate change, and enhancing biological control of pests and diseases. It can also positively affect a farms' microclimate by mitigating high temperatures, which can also reduce the amount of water that escapes into the air increasing water availability.

**There are risks posed by poorly designed or managed cocoa agroforestry systems.** If not carefully selected, certain tree species may be competitive with cocoa production for resources or may increase the risk of certain pests and diseases. These tradeoffs can be managed by designing cocoa agroforestry systems that enhance the complementary interactions of species. Furthermore, even if a species has the potential to deliver certain benefits, it will likely require additional management practices or enabling environment factors (for example, market access or tree tenure) to deliver the benefit to the farmer. Cocoa agroforestry systems should be embedded in larger programs that can address these external factors. The CFI provides an opportunity to align industry action across these levels of intervention for successful cocoa agroforestry programs.

### 1.3. Basics of cocoa agroforestry

**Cocoa agroforestry systems encompass a range of production strategies and design options.** System design can be tailored to provide flexible, adaptive, and diverse options to meet producer' goals, such as additional sources of income, improved food security, or providing resilience to fluctuating markets and climatic conditions. In other cases, cocoa agroforestry may be designed to address environmental stressors, such as vulnerability to climate impacts or managing the spread of a disease. The chosen objective of the system should also be feasible given farmer resources and capacities, market demand, the environmental context, and the ability to support or provide the necessary materials to implement the system.

**The essential components of cocoa agroforestry systems design are:**

**1. Species selection.** This refers to the species chosen for establishment and integration into a cocoa agroforestry system. The species that are selected reflect the structural and functional goals of the producer, including their capacities to manage the system, their ability to attain the needed resources (plant materials, labor, and inputs or services), and the potential market demand for the production of that species. Additionally, the species selection should account for the previous forest composition before cocoa production, including those found in the nearest forest stands in the landscape. See Section 4.1 for further discussion on species selection.

**2. Design.** Encompasses the structural and functional goals and objectives of a cocoa agroforestry system. *Structural* refers to planting patterns between individual species, the spatial arrangement in a production system, and the number and height of the

canopy layers.<sup>34</sup> The distinct height strata include an *understory* <10m, the *subcanopy* between 10-20m, *canopy* from 20-35m, and *emergent canopy* >35m. *Functional* refers to the primary value or product of the species selected, such as household consumption, formal or informal market sale, and species interactions.<sup>5</sup>

**3. Management considerations.** These include the type, intensity, and frequency of management interventions, among other technical considerations. The design and the management components are connected and consider the producer's short-term, medium-term, and long-term goals and capacities.

**4. Plant Density.** This refers to the number of individual plants per species per hectare. The target density in a production model is dependent on the number and types of species, as the canopy width, shade distance, and other technical factors will shift depending on the design. In Côte d'Ivoire, there is a minimum requirement that all cocoa agroforestry systems retain at least 800 cocoa trees/ha.<sup>6</sup>

**5. Percentage shade** refers to the amount, degree, or quality of shade cover present in the understory of the cocoa agroforestry system. There is no simple conversion to determine the percentage shade according to the "number of trees per hectare" as there are species-specific considerations (for example, tree diameter and crown cover).<sup>7</sup> Maintaining a consistent shade cover over time may require more shade trees at a young age that are then reduced through selective pruning as the system matures.

**There is a complex relationship between shade and production.** The optimal shade percentage in a fully mature cocoa agroforestry system depends on region-specific climatic conditions, site-specific micro-climates, the age and quality of the cocoa trees, seasonality, and functional management decisions of the farmer. Companies should follow national and regional guidance:

- |                                            |              |
|--------------------------------------------|--------------|
| - Le Conseil du Café-Cacao: <sup>8</sup>   | 30 – 50%;    |
| - Cocobod: <sup>9</sup>                    | 30 – 70%;    |
| - Rainforest Alliance / SAN: <sup>10</sup> | at least 40% |

<sup>3</sup> Sonwa, Weise, Schroth, Janssens, Shapiro. 2019. Structure of cocoa farming systems in West and Central Africa: A Review. <https://link.springer.com/article/10.1007/s10457-018-0306-7>

<sup>4</sup> Sonwa, Weise, Nkongmeneck, Tchatat, Janssens (2017) Structure and composition of cocoa agroforests in the humid forest zone of Southern Cameroon. *Agrofor Syst*, 91. <https://doi.org/10.1007/s10457-016-9942-y>

<sup>5</sup> Sonwa et al. 2007. Diversity of plants in cocoa agroforests in the humid forest zone of Southern Cameroon <https://link.springer.com/article/10.1007/s10531-007-9187-1>

<sup>6</sup> Le Conseil du Café-Cacao « Orientations pour la mise en œuvre de projets dans le cadre de la promotion de techniques agroforestières en culture du cacao et du café » N. Ref. 019/2019.

<sup>7</sup> Asare, R., Markussen, B., Asare, R. A., Anim-Kwapong, G., and Ræbild, A. (2019). On-farm cocoa yields increase with canopy cover of shade trees in two agro-ecological zones in Ghana. *Clim. Dev.* 11, 435–445. Also, see: The Canopy Cover Calculator (CanOvalator), an Android App by IITA [https://play.google.com/store/apps/details?id=com.will.iita&hl=en\\_US](https://play.google.com/store/apps/details?id=com.will.iita&hl=en_US) to assess canopy cover.

<sup>8</sup> CCC, N. Ref. 019/2019.

<sup>9</sup> M.M Dohmnen, M. Noponen, R Enomoto, C. Mensah, S. Muilerman "Climate Smart Agriculture in Cocoa A Training Manuel for Field Officers," WCF and Rainforest Alliance. 2018.

<sup>10</sup> Rainforest Alliance, SAN Standard 2017.



## 2. Policy context for cocoa agroforestry

**The CFI aligns company actions for cocoa agroforestry with national and regional policies, programs, and strategies.** While cocoa agroforestry has the potential to contribute to forest protection, restoration, farmers' livelihoods, production, and community engagement goals under the CFI, the policy context determines if these opportunities are fully achievable.

**There are ongoing policy developments in each country that will likely affect cocoa agroforestry system development, design, and resources.** In Côte d'Ivoire, cocoa agroforestry is closely related to ongoing "zero-deforestation agriculture" policies. In Ghana, cocoa agroforestry is associated with "climate-smart cocoa." Both countries are collaborating on a regional cocoa standard that will incorporate elements of each countries' strategies while also reflecting developments in the International Organization for Standardization (ISO) standard for sustainable and traceable cocoa.<sup>11</sup> These standards are embedded within sectoral strategies for agriculture, forestry, and sustainable development. While these standards are still being developed, there are no clear definitions or metrics provided for cocoa agroforestry available at the time of writing this guide.

**REDD+ connects cocoa agroforestry to climate change mitigation and adaptation.** Both countries have ongoing REDD+ programs and view the mechanism as a key opportunity for public-private collaboration under the CFI. While cocoa agroforestry is featured in both countries' REDD+ strategies, the necessary arrangements to fully implement and exploit REDD+ as a cocoa agroforestry under the CFI are still under development.

**Cocoa agroforestry can also contribute to ecological restoration efforts.** The governments of Ghana and Côte d'Ivoire have restoration and biodiversity targets under the UN Convention Biological Diversity (UNCBD), the Bonn Challenge, and the AFR100 Initiative.<sup>12</sup> For example, in their National Biodiversity Strategy and Action Plans (NBSAPs) and the Bonn challenge, Ghana aims to restore 2 million ha<sup>13</sup> and Côte d'Ivoire targets 5 million ha.<sup>14</sup>

<sup>11</sup>International Organization for Standardization (2019) First international standards for sustainable and traceable cocoa just published <https://www.iso.org/news/ref2387.html>

<sup>12</sup> For a list of national restoration targets, visit : <https://infoflr.org/countries/ghana> and <https://infoflr.org/countries/cote-divoire>

<sup>13</sup> Republic of Ghana, Ministry of Environment, Science, Technology, and Innovation. National Biodiversity Strategy and Action Plan. <https://www.cbd.int/doc/world/gh/gh-nbsap-v2-en.pdf>.

<sup>14</sup> Republic of Côte d'Ivoire. Ministère de l'Environnement, de la Salubrité Urbaine et du Développement Durable, National Biodiversity Strategy and Action Plan. <https://www.cbd.int/doc/world/ci/ci-nbsap-v2-fr.pdf>

## 2.1. Côte d'Ivoire

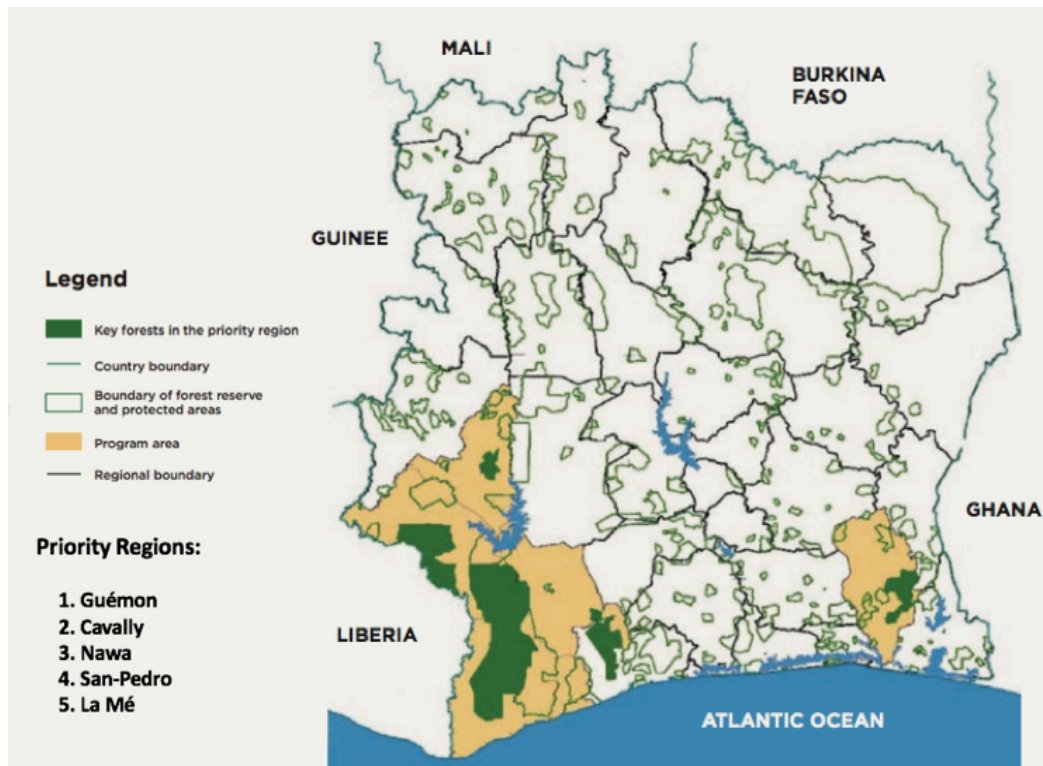
**Côte d'Ivoire is updating relevant forest laws and policies as part of its CFI commitment, with implications for agroforestry.** New regulations on commodity-based agroforestry and agricultural intensification have been created to incentivize the transition to a zero-deforestation agriculture in rural areas. Under the CFI Action Plans, Côte d'Ivoire targets the priority regions of Guémon, Cavally, Nawa, San-Pedro, and La Mé (Figure 1) for CFI implementation.

**In early 2019, the CCC released a guidance note calling for all cocoa agroforestry systems to have:**

- A cocoa density of no less than 800 trees/ha;
- 30 – 50% shade;
- Associated tree species that are compatible with cocoa production;
- Farmers deciding which species are selected for the system.

Meanwhile, the CCC is in the process of evaluating the economic efficiency of cocoa agroforestry systems, including collecting data on existing extension tools, technologies, and agroforestry production models. More detailed guidelines for cocoa agroforestry systems are expected to be developed in the future.

*Figure 1 Priority regions for CFI implementation in Côte d'Ivoire*  
From Côte d'Ivoire's CFI National Implementation Plan.



In addition to promoting cocoa agroforestry on existing production areas, the **2019 Forest Code opened a new window to agroforestry development in the Fôret Classées**. Forests are categorized based on the level of degradation. Category 3 forests, having less than 25% shade cover,<sup>15</sup> can be developed as concessions for “agrofôrets”.<sup>16</sup> While the code outlines the rights and duties of forest owners, lists the various types of forest and use rights, and establishes the legal basis for agroforestry concessions, there must be additional guidance on how agrofôrets are to be compared to the cocoa agroforestry systems for commodity production as defined by the CCC.

**REDD+ began in Côte d'Ivoire in 2011 with the objective of reducing deforestation and forest degradation by 80% and restoring 5 million hectares by 2030.**<sup>17</sup> The Emissions Reduction Program Document (ERPD) for the country's REDD+ program includes two both types of agroforestry, defined as commodity agroforestry (including cocoa agroforestry), and the agrofôret concessions in the Fôret Classées. The current status of cocoa agroforestry systems under the REDD+ program must still be clarified and further defined in upcoming “zero-deforestation agriculture” policies and guidance. See Figure 2 for an overview of cocoa agroforestry in related laws.

*Figure 2 Relevant agroforestry provisions in select laws policies in Côte d'Ivoire*



**To date, REDD+ activity has taken place in the rural areas surrounding Tai National Park.** The ER-PD program area is focused around the Southwest of the country. Please see Figure 3 for a map of ER-PD program areas.

<sup>15</sup> Art 1. Lei. No 2019-675 du 23 juillet 2019: <http://www.droit-afrique.com/uploads/RCI-Code-2019-forestier.pdf>.

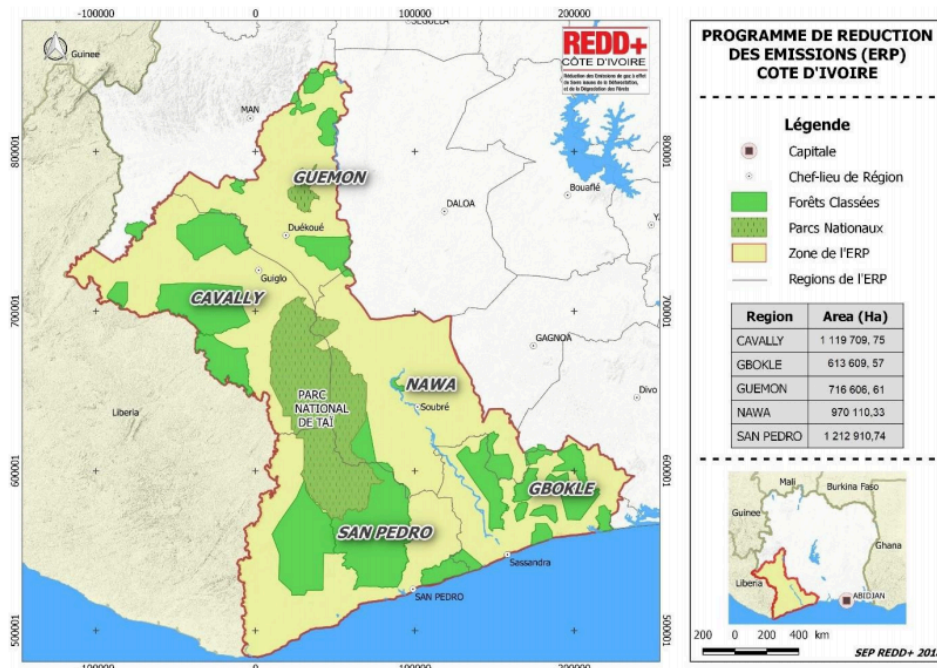
<sup>16</sup> Art 1. Lei. No 2019-675 du 23 juillet 2019: <http://www.droit-afrique.com/uploads/RCI-Code-2019-forestier.pdf>.

<sup>17</sup> REDD+ Côte d'Ivoire. National Strategy, Summary for Policy Makers, [https://www.uncclearn.org/sites/default/files/inventory/redd\\_strategy\\_document\\_-\\_anglais\\_002\\_791646.pdf](https://www.uncclearn.org/sites/default/files/inventory/redd_strategy_document_-_anglais_002_791646.pdf)

Figure 3: REDD+ / ERPD Regions in Côte d'Ivoire

Emissions Reduction Program Document (ER-PD) Emissions Reduction program document for Tai National Park, Republic of Côte d'Ivoire

Figure 2: Map of the ER Program area



**The World Bank's Forest Investment program (FIP) complements REDD+ programs.**<sup>18</sup> The FIP has two main strategies: supporting REDD+ activities in Tai National Park and investing in activities to implement zero-deforestation agriculture and cocoa agroforestry systems. FIP program areas are shown in Figure 4 below.

**Cocoa agroforestry may also be expanded in regions with existing programs or pilots.** Several of these programs led by governments, companies, and NGOs target zero-deforestation and climate smart cocoa production. The agroforestry goals of these programs seek to address the enabling environment for agroforestry, such as community capacity building, promoting agroforestry for climate change adaptation, establishing tree species nurseries, training, and working with communities to improve land management. For a list of ongoing, private sector-led projects in Côte d'Ivoire, please see Figure 5 below.

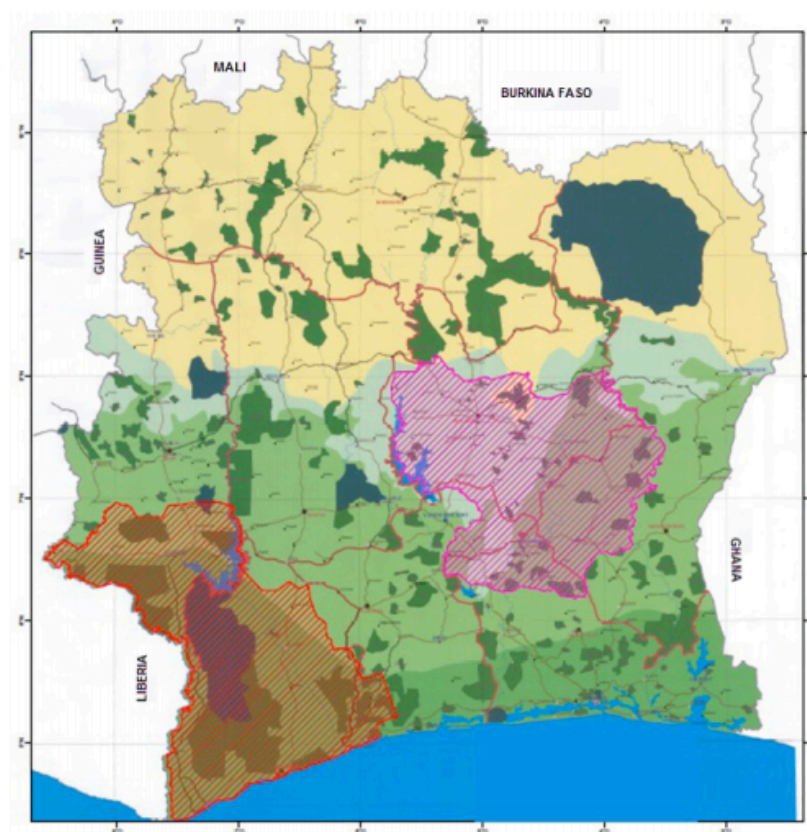
**The CFI promotes community-based natural resource mechanisms.** One area to expand this could be through REDD+ Local Committees for the Co-Management (CLCG) for Classified Forests. CLCGs are a participatory governance structure for establishing cooperatives in riparian zones for agroforestry concession agreements.

<sup>18</sup> Côte d'Ivoire, Forest Investment Plan, Final Report. 2016.

[https://www.climateinvestmentfunds.org/sites/cif\\_enc/files/fip\\_cote\\_d\\_ivoire\\_ip.pdf](https://www.climateinvestmentfunds.org/sites/cif_enc/files/fip_cote_d_ivoire_ip.pdf)



*Figure 4: FIP Regions in Côte d'Ivoire*  
Forest Investment Plan, Final Report. May 2016.



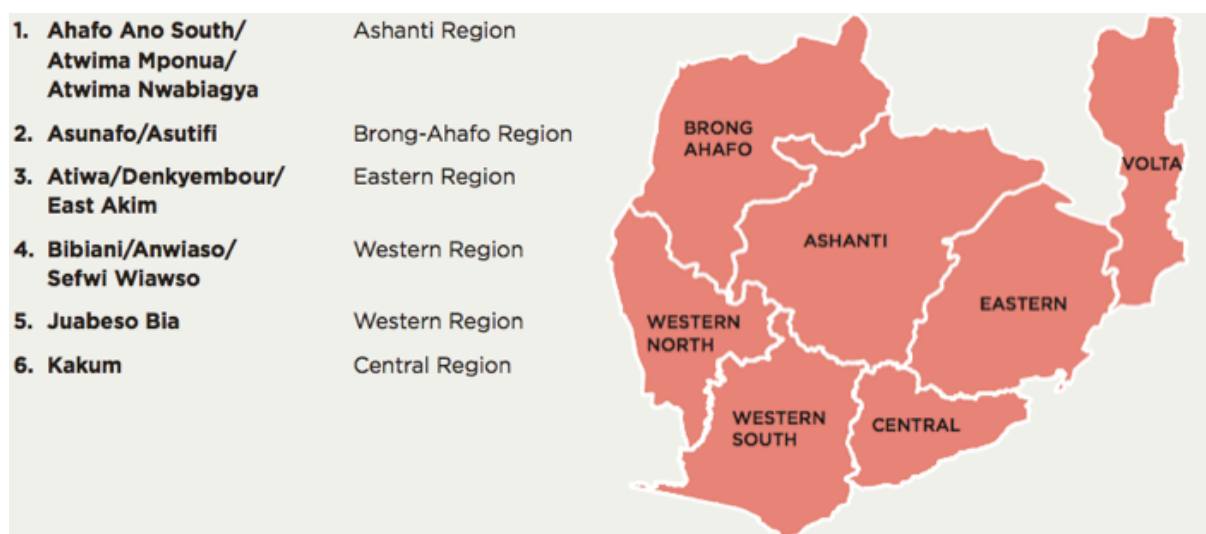
*Figure 5. Non-exhaustive list of cocoa agroforestry projects in Côte d'Ivoire*

Program	Partners	Timeline	Region	Cocoa Agroforestry Component
Vision for Change (V4C)	Mars, ICRAF, Anader	2013-2020	Soubre	Improvement of yields through cocoa agroforestry
ISLA (Initiative for sustainable land)	IDH	2016-2020	Cavally	Support the implementation of public and private sector commitments towards zero net deforestation and green field growth in the area of the Tai National Park.
Cocoa Life PES Scheme	Mondelez, Impactum,	2017-2020	Nawa	Covers 6000 hectares: 5100 ha of agroforestry, 600 ha of reforestation, 300 ha of conservation. Plant 700,000 trees from four community nurseries (target of 50,000 plants p.a. / nursery)
Forest Protection / Conservation and Integrated Rural Development	SIAT	Begin 2020	Goin Debe	Project to implement protection, production, extension, and inclusion components of sustainable cocoa production, including agroforestry based on rubber and cocoa
Transparence Cocoa	Cémoi, Ecoterra, ICRAF	2015-2021		100% traceable cocoa with sustainable livelihoods, cooperative development, and income diversification through agroforestry practices the establishment of agroforestry tree species nurseries
Unnamed sustainable cocoa project	Barry Callebaut, CCC	Begin 2020	TBD	MOU signed between Barry Callebaut and CCC to cooperate on replanting CSSV, income diversification, and forest rehabilitation
Projet CAZ	Olam, GIZ	2018	San Pedro	Engage with cooperative and producers to distribute leguminous and shade trees for the establishment of cocoa agroforestry projects
Initiative Darwin	Olam, Cefca (RA)	2017-2020	San Pedro	A holistic value chain approach including the formation of village committees, trainings and coaching for sustainable practices, income diversification, and distribution of multipurpose and shade trees.
Hana River PES and Agroforestry	Cocoanect, GIZ, ICRAF	2014	Multi-region; Tai Nat'l Park	PES scheme to protect biodiversity and conservation along the Hana river region. Included a pilot project for fruit trees and other multipurpose trees combined with PES payments.
Green Project	Cargill, Impactum		Soubre	Cocoa agroforestry with 6 cooperatives. Multi-purpose species such as fruit, wood, fuel, and training/sensitization for 700 farmers and 60 coaches. Project to be extended into 66,000 ha and additional regions

## 2.2. Ghana

**Ghana features agroforestry across its policies and strategies for forest conservation and climate change mitigation.** This includes the National Climate Change Policy to increase carbon sinks and to develop climate-resilient agriculture and food systems, and the Ghana Forest Plantation strategy which supports the incorporation of trees on farms. Ghana is also developing cocoa-specific guidance under “climate-smart cocoa.” See Figure 6 for target regions in Ghana’s CFI action plan.

*Figure 6. Map of boundaries and priority regions for CFI implementation in Ghana.*



**Ghana is developing a climate-smart cocoa standard to promote sustainable cocoa production.** The draft standard seeks to facilitate the adoption of site-specific sustainable practices that ensure higher yields, conservation, protection, management and use of cocoa landscape resources. By doing so, the standard aims for improved living standards, emissions reduction, enhanced carbon stocks and the planting of approved economic shade trees in cocoa farms and in degraded areas. For illustrative laws, please see Figure 7.

**The Ghana Cocoa and Forest REDD+ Program anchors Ghana’s National REDD+ Strategy.** Cocoa agroforestry and climate-smart cocoa are featured as key mitigation strategies to support the adoption of best practices for intensification and diversification while supporting mitigation and adaptation. Several aspects of the REDD+ program should be clarified before the benefits of REDD+ can be fully realized.<sup>19</sup> This includes tenure challenges, benefit sharing, and further defining climate-smart cocoa production practices.

<sup>19</sup> Acheampong, Dawoe, E., E., Bosu, P. and Asante, W (2014) Moving Forward with REDD+ in Ghana: Shade Systems, Crown Cover, Carbon Stocks and Socio-Economic Dynamics of Smallholder Cocoa Agroforestry Systems a Technical Report Submitted to SNV Ghana Cocoa Eco Project, <https://pdfs.semanticscholar.org/9784/b2bb3c21d68b325bc2747359408d882ec775.pdf>

*Figure 7 Select agroforestry provisions in national laws and policies in Ghana*

<b>National Climate Change Policy (2013)</b>	<ul style="list-style-type: none"> <li>• Promotes agroforestry and support agroforestry programs initiated to conserve trees in association with crops</li> </ul>
<b>The Wildlife Resources Management Bill (2014)</b>	<ul style="list-style-type: none"> <li>• Aims to ensure the community participation in the management of natural resources including forests.</li> <li>• Establishes Community Resource Management Areas</li> </ul>
<b>National Climate-Smart Agriculture and Food Security Action Plan</b>	<ul style="list-style-type: none"> <li>• Develops climate-resilient agriculture and food systems for all agroecological zones</li> </ul>
<b>Ghana Forest Plantation Strategy (GFPS)</b>	<p>Between 2016-2041:</p> <ul style="list-style-type: none"> <li>• Support for the incorporation of trees-on-farms within 3.75 million ha of agricultural landscapes and maintenance</li> <li>• Establishment and management of 625,000 ha of forest plantations in degraded forests</li> <li>• Rehabilitation of 235,000 ha of existing forest plantations</li> </ul>
<b>Cocoa Sector Development Strategy</b>	<ul style="list-style-type: none"> <li>• Enhance productivity levels from 450 kg/ha to an average of 1,000 kg/ha and promote the adoption of climate-smart cocoa production practices</li> </ul>
<b>Cooperative System Program</b>	<ul style="list-style-type: none"> <li>• Facilitates active efforts in partnership with other actors to protect and restore forests in the cocoa landscape.</li> </ul>
<b>National Cocoa Rehabilitation Program</b>	<ul style="list-style-type: none"> <li>• Develops an agroforestry approach to diversifying cocoa farmers' income.</li> </ul>

**Key provisions supported under REDD+ and relevant for cocoa agroforestry include:**

- Using improved cocoa planting material to rehabilitate over-aged cocoa farms but maintaining shade trees;
- Planting in rows at 3mx3m spacing;
- Pruning and chupon removal to promote diversification strategies (e.g. NTFPs, individual woodlots) that support alternatives livelihoods;
- Managing 18-20 matures shade trees per hectare of recommended species.

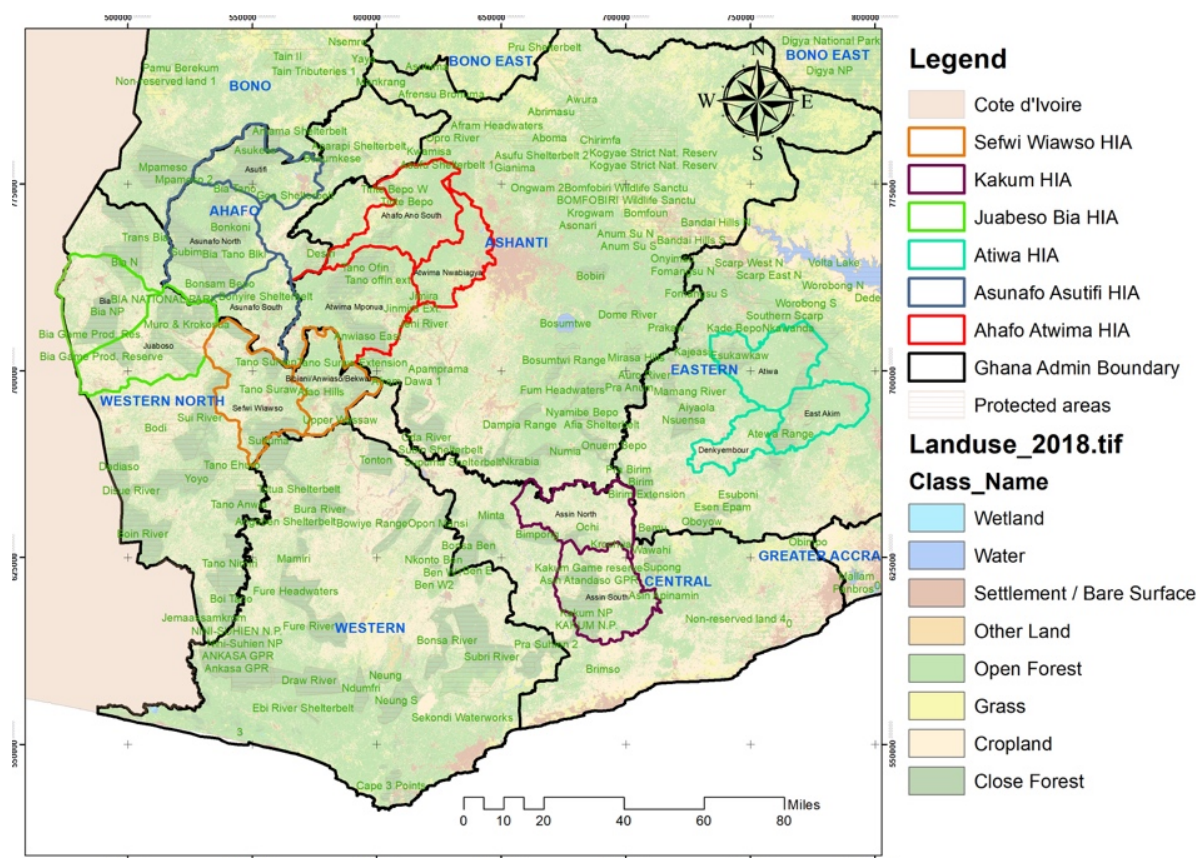
This last recommendation only slightly differs from the Cocoa Research Institute of Ghana (CRIG) 2010 recommendation of 16-18 shade trees at roughly 24 m x 24 m spacing, with about from 30 - 40% shade.<sup>20</sup>

**The emissions reduction program in Ghana has prioritized implementation in the Hotspot Intervention Areas (HIAs)** (Figure 8). These regions were based on the intensity of the drivers of deforestation and forest degradation, existing projects and interventions being implemented by private sector and state actors, and the presence of adequate capacity and implementation structures at the field level in these areas. A consortium of stakeholders who are active in these areas support the implementation of

<sup>20</sup> Asante, Winston, Dawoe, Evans; Acheampong, Emmanuel; Bosu, Paul. (2017). A new perspective on forest definition and shade regimes for REDD+ interventions in Ghana's cocoa landscape. 10.13140/RG.2.2.14758.42564.

activities. The landscape is managed by a governance body made up of farmers, landowners and traditional authorities under the Community Resource Management Areas (CREMAs) mechanism.

Figure 8 Map of HIA boundaries in Ghana



**Ghana has a number of existing REDD+ programs and pilots in implementation.** Companies have been active in the HIA and REDD+ areas for several years. Below, Figure 9 lists ongoing or planned private sector led interventions in REDD+ areas in Ghana, and Figure 10 shows an example of existing REDD+ projects.

**CREMAs are a framework for inclusive natural resources governance and planning.** They allow for communities to manage their natural resources for economic and livelihood benefits and have evolved from focusing on wildlife management and habitat protection to supporting REDD+ project implementation. They enable communities to manage forest and tree resources in the off-reserve landscape for climate mitigation and livelihood objectives. While there are over 30 CREMAs throughout Ghana, the passage of the Wildlife Resources Management Bill could help strengthen the legal basis of their governance structure.

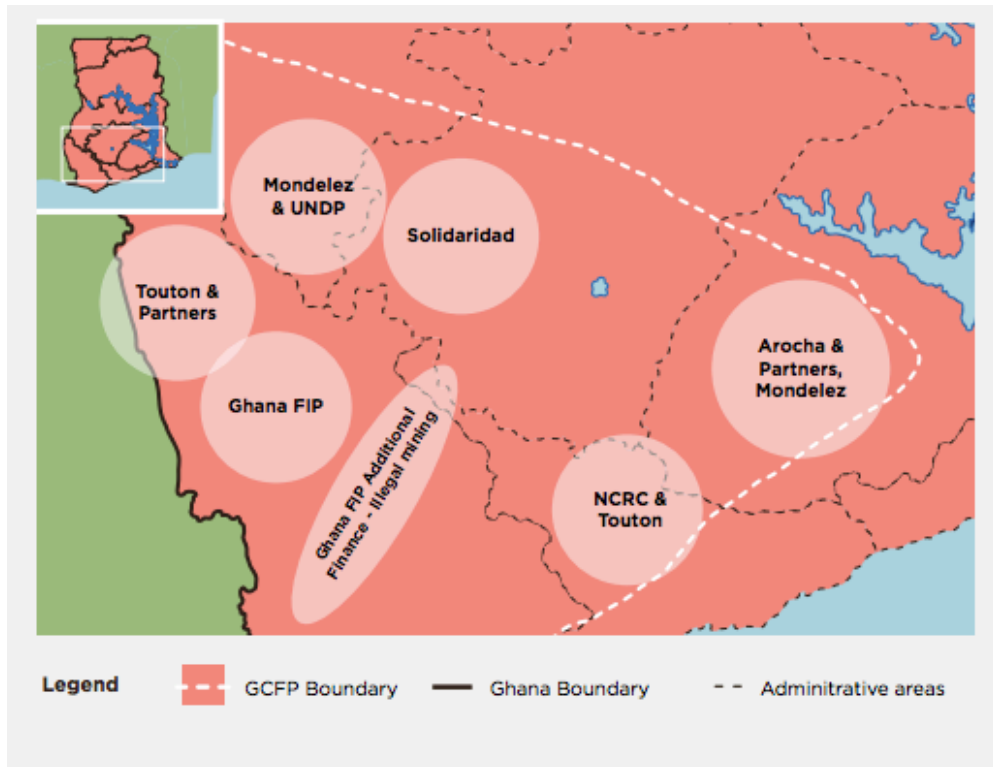


Figure 9. Non-exhaustive list of cocoa agroforestry projects in Ghana

Project Title	Lead Institutions	Project Duration	Region	Description
3PRCL: Partnership for Productivity Protection and Resilience in Cocoa Landscapes	Touton, NCRC	2017-2020	Bia-Juaboso	Develop a landscape-wide governance framework to achieve a deforestation-free cocoa landscape, support climate-smart cocoa, and unlock investment for forest protection
Partnership for Livelihoods and Forest Landscape	Olam, Rainforest Alliance	2019-2022	Sefwi Wiawso, Bodi, and the Akontombra districts	Improve livelihoods of cocoa forest landscape to conserve biodiversity, boost climate resilience, and establish Landscape Management Boards
Kakum Cocoa Agroforestry Landscape Program	Hershey and Ecom	2017-2018	Kakum	Strengthen farmers' livelihoods and improve resilience to climate change
Environmental Sustainability Project (ESP II)	Mondelez, UNDP, Olam	2016-2020	Multi-region	Develop training modules on sustainability practices and train Community Extension Agents and other Implementation Partners enabling them to also train farmers on the selected practices
Unnamed sustainable cocoa project	Barry Callebaut, Cocobod	Begin 2020	TBD	MOU signed between Barry Callebaut and Cocobod to cooperate on farmer living incomes and address deforestation
Dynamic Agroforestry	Chocolats Halba, Kuapa Kokoo, Southpole, WWF	2016-2023	Ahafo Ano, Antwima Mponua, Antwima Nwabiagya	The high-quality agroforestry project reduces the effects of climate change, contributes to biodiversity and increases the productivity of cocoa plantation and helps cocoa farming families to spread their income over several pillars.

Figure 10. Map of REDD+ projects in Ghana<sup>21</sup>

<sup>21</sup> From Ghana's CFI National Implementation Plan, [https://www.idhsustainabletrade.com/uploaded/2018/08/Implementation\\_Plan\\_CFI\\_Ghana\\_070818\\_printversion\\_final2.pdf](https://www.idhsustainabletrade.com/uploaded/2018/08/Implementation_Plan_CFI_Ghana_070818_printversion_final2.pdf)



# 3. Assessment Framework

**The design of cocoa agroforestry systems should reflect the broader landscape and enabling environment as well as the farmer preferences and capacities.** Both An initial assessment and engagement process is necessary to design and implement effective and sustainable programs responsive to the needs of communities and landscapes.

**Cocoa agroforestry systems are particularly complex from a design and management perspective; there is no one-size-fits-all solution.** A participatory approach will seek to first assess the needs, resources, capacities, and preferences of farmers to ultimately design and determine the cocoa agroforestry models to be pursued.

**Through a landscape approach, collective action can support cocoa agroforestry implementation through joint landscape management plans.** Collective action between companies can reduce costs in every phase to secure long-term success. “Landscape” may be understood as the areas where social and environmental systems interact according to a context set by physical, biological, social, and economic systems.<sup>22</sup> A landscape approach incorporates a participatory design with communities to address these broader systemic factors. A landscape management plan then defines the goals, planned interventions, and partner roles and responsibilities.

**The following steps will help identify the opportunity for collective action** (Figure 11) and guide program design under a participatory landscape approach. This chapter addresses 1 – 3, and chapter 4 looks at system design.

*Figure 11: Assessment Design Framework for Agroforestry*



<sup>22</sup> Adapted from the definition presented in Sayer, J.A., Sunderland, T.C.H., Ghazoul, J., Pfund, J.L., Sheil, D., Meijaard, E., Venter, M. et al. (2013). ‘Ten Principles for a Landscape Approach to Reconciling Agriculture, Conservation, and Other Competing Land Uses.’ *Proceedings of the National Academy of Science* 110(21):8349–56. <https://doi.org/10.1073/pnas.1210595110>. For further information on the Landscape Approach, please see: Gignoux J, Davies I, Flint S, Zucker J-D(2011) The ecosystem in practice: Interest and problems of an old definition for constructing ecological models. *Ecosystems* 14(7):1039–1054 and Farina A (2000) The cultural landscape as a model for the integration of ecology and economics. *Bioscience* 50(4):313–320. However, this definition as used in this guidance incorporates economic and market systems.

### 3.1. Landscape Prioritization

**There are widespread opportunities for collective action in cocoa landscapes; the challenge is to develop a framework to identify and prioritize the best options for cocoa agroforestry.** As an absolute minimum criterion, companies should only pursue cocoa agroforestry systems in areas that are legally defined as open to cocoa production and to agroforestry systems. This should be discovered through obtaining up-to-date land use and administrative boundaries from the relevant government authorities.

**Beyond this minimum criterion, cocoa agroforestry opportunities are recommended to take place in:**

- Landscapes where a company is operating (or plans to operate in the future);
- Landscapes with a long-term suitability for cocoa;
- Areas defined as priorities by national or local governments;
- Areas with high risk for future deforestation;

Please see Table 1 for a list of potential tools and/or approaches for identifying landscape opportunities.

**Table 1: Prioritizing and identifying landscape opportunities**

<i>Criteria</i>	<i>Tools / Approaches to Identification</i>
Overlap with company operations	<ul style="list-style-type: none"> <li>• Internal sourcing/supply chain information;</li> <li>• Using own- or supplier farm mapping;</li> <li>• 100% traceability systems;</li> <li>• Existing sustainability program boundaries;</li> <li>• Coordinating with upstream supply partners</li> </ul>
Climate suitability for cocoa-agroforestry systems	<ul style="list-style-type: none"> <li>• Relying on high-level academic research;</li> <li>• CIATs Cocoa Climate Risk Assessment tool;</li> <li>• Working with specialized service providers for climate-suitability forecasts;</li> <li>• Working with government agencies;</li> </ul>
National priority areas	<ul style="list-style-type: none"> <li>• National or sub-national structures have identified an area as high priority for restoration (e.g., REDD+, priority areas in CFI implementation, etc.)</li> <li>• Working with government agencies or other regulatory bodies (e.g. CCC or Cocobod)</li> <li>• Working with international donor community (e.g., the World Bank's Forest Investment Program, etc.)</li> </ul>
High deforestation risk	<ul style="list-style-type: none"> <li>• Deforestation-risk assessments and scoring;</li> <li>• National or global monitoring frameworks;</li> </ul>



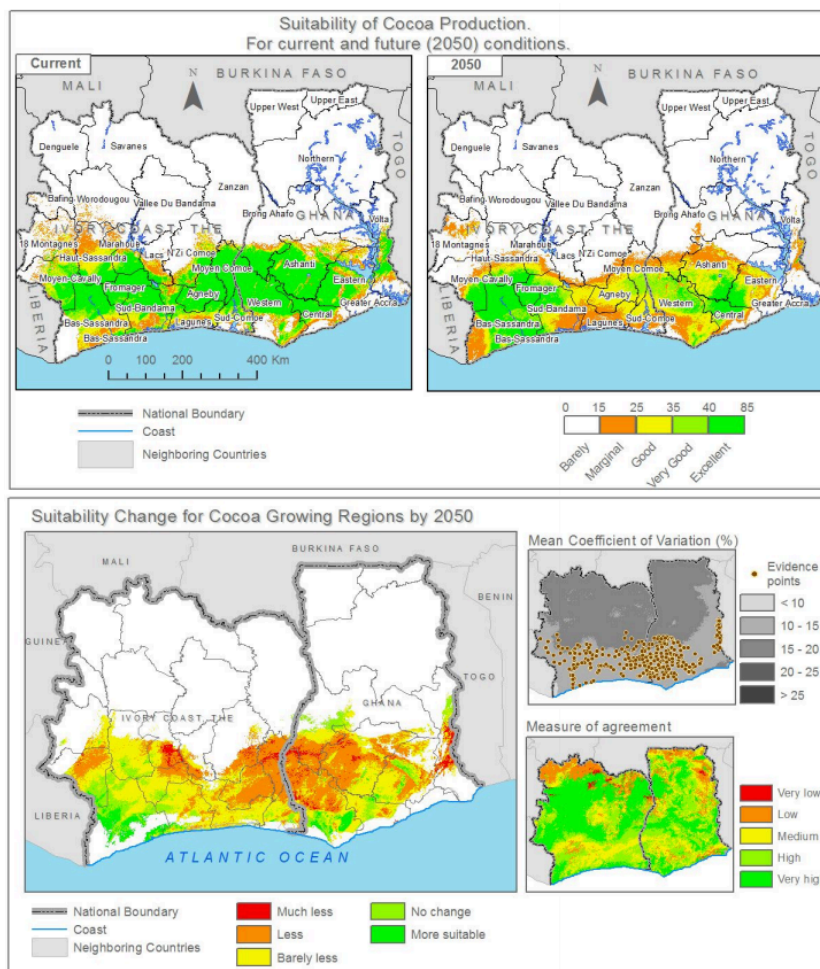
## Overlap with company operations

Companies should invest in landscapes in which they have a pre-existing or planned sourcing relationship. This can be identified through supply chain mapping, traceability systems, and working with suppliers to work through 100% supply chain mapping. In addition, it is recommended that companies examine where existing sustainability programs are operating, even if they are not explicitly based on cocoa agroforestry.

## Long-term suitability for cocoa

The impacts of climate change include shifting agroecological zones due to changing patterns in rainfall and temperature. As such, it is likely that current cocoa production regions – including those in a company's supply chain – may not be able to produce cocoa in the future.<sup>23</sup> These predictions are based on global climate models, and more exact forecasts depend on investment in regional models.<sup>24</sup> WCF and partners in Ghana have developed a Climate-smart Agriculture in Cocoa training manual,<sup>25</sup> with a similar guide is underway in Côte d'Ivoire, to further explain how companies can consider climate-proofing their supply. See Figure 12 for an example of one such analysis of long-term cocoa suitability.

**Figure 12: Current and future climate suitability for cocoa production by 2050**  
Laderach, 2011



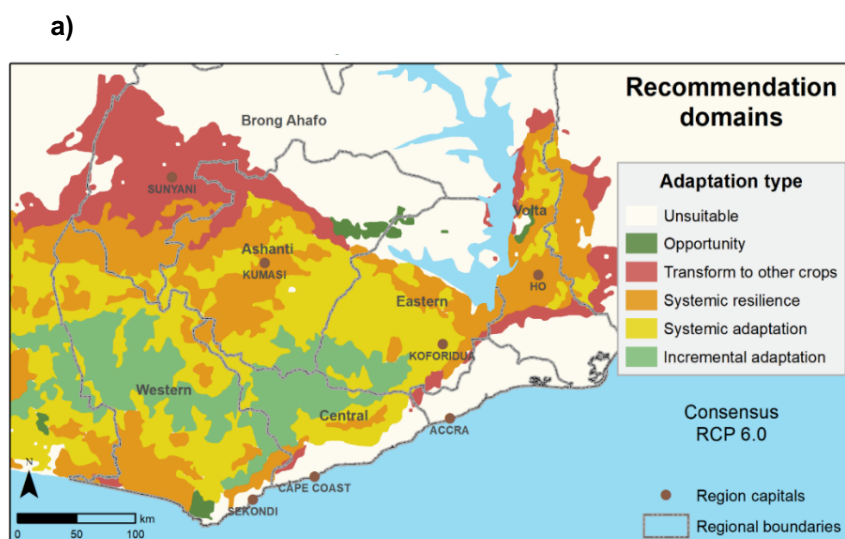
<sup>23</sup> See: Läderach, P., Martinez-Valle, A., Schroth, G. et al. Climatic Change (2013) 119: 841.

<sup>24</sup> Läderach, P., Eitzinger A, Martinez A, Castro. (2011). Predicting the Impact of Climate Change on the Cocoa Growing Regions in Ghana and Cote d'Ivoire. Final Report. p 35.  
[http://www.ciat.cgiar.org/Newsroom/Documents/ghana\\_ivory\\_coast\\_climate\\_change\\_and\\_cocoa.pdf](http://www.ciat.cgiar.org/Newsroom/Documents/ghana_ivory_coast_climate_change_and_cocoa.pdf)

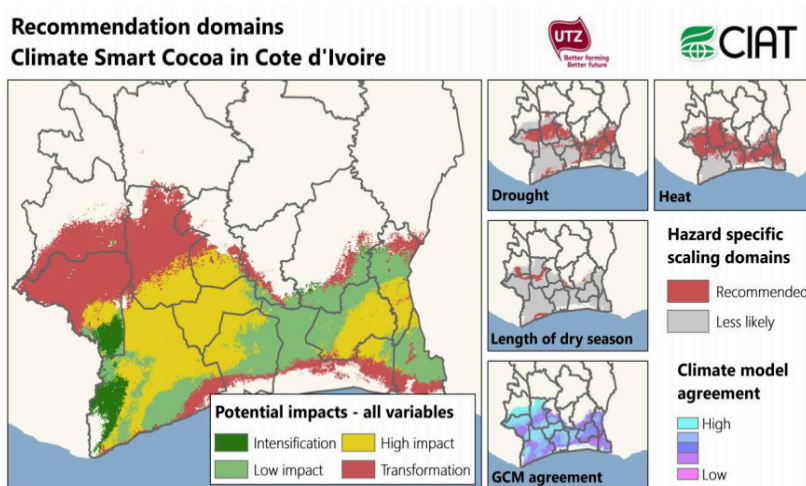
<sup>25</sup> Available here: Dohmen MM, Nojonen M, Enomoto R, Mensah C, Muilerman S. 2018. Climate-Smart Agriculture in Cocoa: A Training Manual for Field Officers. Accra, Ghana: World Cocoa Foundation and The Rainforest Alliance. <https://hdl.handle.net/10568/93360>

**Other sourcing areas may maintain their suitability to produce cocoa but may require additional support for adaptation.** One tool – the Cocoa Climate Risk Assessment Tool by CIAT, UTZ, and other partners<sup>26</sup> – combines climate suitability with the level of adaptation needed for further cocoa production. These are categorized into regions with incremental, systemic, and transformational needs (as illustrated in CIATs illustrations in Figure 13.) Depending on the specific climate impact, such as drought or heat, cocoa agroforestry may be identified as the best adaptation strategy to reduce vulnerability.

*Figure 13: Cocoa suitability and adaptation zones for (a) Ghana and (b) Côte d'Ivoire by CIAT, CCAFS Info notes for Côte d'Ivoire and Ghana*



b)



### National priority areas

**One approach to prioritization includes basing programs in target or priority areas as defined by national, regional, or global strategies.** These areas may include national strategies by assessing strategies published by the cocoa regulatory body, sector-specific strategies, or program-specific strategies such as the CFI or REDD+ programs. Given that landscape programs require significant resources, partnering with a government agency can help to improve program targeting, policy support, and engagement with communities.

### Areas with high risk for future deforestation

**The CFI seeks to end cocoa-driven deforestation.** By conducting a deforestation-risk assessment<sup>27</sup> across a supply chain, companies may prioritize interventions in high-risk landscapes for deforestation. Cocoa agroforestry is one of several strategies to lower

<sup>26</sup> CIAT, UTZ, and other partners in the Research Program on Climate Change, agriculture, and Food Security (CCAFS) and USAID, “Cocoa Climate Risk Assessment Tool,” <https://climatesmartcocoa.guide/risk-assessment-tool/>

<sup>27</sup> Please see the World Cocoa Foundation’s forthcoming *Guide to Deforestation-risk assessments*

this risk. Focusing on these areas may help fulfill CFI commitments and protect a company from the reputational risk of being connected to further deforestation.

## 3.2. Landscape Assessment

**Once a landscape has been chosen, companies can perform deeper landscape assessments.** Agroforestry programs should be designed according to the baseline conditions as well as to fit the producers' and communities' goals. These assessments should yield information that directly feeds into the design of cocoa agroforestry programs. Therefore, it is advised for companies to use the assessment period to define the environmental context of the landscape, identify the key stakeholders, analyze market conditions, and assess farmer capacities.

**The integrated High Conservation Value (HCV) and High Carbon Stock (HCS) approach<sup>28</sup> recommends several phases of assessment.** First, it recommends a pre-assessment phase for information gathering and due diligence. Then, a scoping study takes place that includes desk research, field visits, and initial consultations. A full assessment follows with fieldwork, conducting the social and environmental assessments, and a more thorough stakeholder consultation. At this stage, communities must consent to programming. Once secured, landscape management plans can be negotiated and further resources, partners, and potential co-financing can be finalized.

**Before embarking on a new or expanded program, companies need to conduct Free, Prior, and Informed Consent (FPIC) with the targeted communities.** Once the community has approved the proposed plan, the company can engage and work with local governance authorities for sensitization and awareness-raising events. As per the CFI agreements, these events should be gender and youth sensitive. Programs can leverage local governance structures to promote participatory decision making and inclusive design by using existing decision-making structures, such as the REDD+ mechanisms, community governance processes, or cooperatives to empower communities to shape the cocoa agroforestry system design.

**A thorough landscape assessment can be costly.** It is unlikely that a single company will pursue a landscape assessment on their own; however, it can be a viable opportunity for collective investment to explore collective action partnerships.

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<sup>28</sup> Please see the following for more in-depth guidance on the HCV, HCS, and integrated approaches: "HCV Screening: Guidance for identifying and prioritizing action for HCVs as part of Jurisdictional and Landscape Approaches, [https://hcvnetwork.org/wp-content/uploads/2019/07/HCV-Screening-Guidance\\_Final.pdf](https://hcvnetwork.org/wp-content/uploads/2019/07/HCV-Screening-Guidance_Final.pdf) and "The High-Carbon Stock Approach Toolkit, Module 3. Putting No Deforestation into Practice: Integration of HCV, HCS, and FPIC. [http://highcarbonstock.org/wp-content/uploads/2018/06/Def-HCSA-Module-3-21\\_06\\_2018\\_Web.pdf](http://highcarbonstock.org/wp-content/uploads/2018/06/Def-HCSA-Module-3-21_06_2018_Web.pdf)

**Table 2: Landscape Assessment – high-level**

	Resources	Goals
Socio-economic Assessment	<p>Approaches:</p> <ul style="list-style-type: none"> <li>• Sustainable Livelihood Framework (SLF)</li> <li>• Living Income</li> <li>• HCSA/HCV approach</li> <li>• Needs assessments</li> </ul> <p>Sources for data (non-exhaustive):</p> <ul style="list-style-type: none"> <li>• Supply chain or farmer data (e.g., Olam's Farmer Information System)</li> <li>• Farmer surveys;</li> <li>• Digital management tools for supply chains</li> </ul>	<ul style="list-style-type: none"> <li>• Identification of farmer communities in target area;</li> <li>• Identify local governance structures, including cooperatives</li> <li>• Farmer knowledge / training;</li> <li>• Presence of nurseries for cocoa and shade trees;</li> <li>• Extension and support services;</li> <li>• Labor and labor-related infrastructure (e.g., CLMRS)</li> <li>• Financial services;</li> <li>• Farmer distance-to-market;</li> <li>• Other, non-cocoa industry activity</li> </ul>
Ecological assessment	<p>Approaches:</p> <ul style="list-style-type: none"> <li>• HCSA/HCV approach</li> <li>• Restoration Opportunities Assessment Methodology</li> </ul> <p>Sources for data (non-exhaustive)</p> <ul style="list-style-type: none"> <li>• Geospatial data;</li> <li>• Field visits / primary collection</li> <li>• Biodiversity assessments (flora and fauna)</li> <li>• Vegetation assessments;</li> <li>• geology</li> <li>• Soil fertility;</li> <li>• Hydrology;</li> </ul>	<ul style="list-style-type: none"> <li>• Identify HCV/HCS areas for protection;</li> <li>• Identify opportunities for restoration of recently deforested areas;</li> <li>• Presence / spread of pests and diseases, including CSSVD</li> <li>• Narrow down species that are beneficial in ecosystem (for example, native species to a region)</li> </ul>

**The landscape assessment is a key step for identifying priority and necessary elements for both the collective action elements and the programmatic aspects of cocoa agroforestry.** There is no single approach for a Landscape Assessment, but generally it includes an ecological assessment of the landscape and a socio-economic baseline assessment that incorporates farmer preferences. Versions of this process are commonly practiced, but may be further tailored to the cocoa agroforestry context.

#### Socio-economic assessment

**Cocoa agroforestry must be a viable livelihood option for individual farmers.** Transitioning from a full-sun cocoa system, or one with a few diverse species, to cocoa



agroforestry requires an investment in time, effort, and resources. Not all farmers will want or be able to pursue cocoa agroforestry systems – for example, older farmers may be less willing to pursue timber systems that require 20+ years for income to accrue.

**Socio-economic assessments examine the relevant social and economic characteristics of target communities to develop a baseline and inform the design of programs.** Companies and target communities can work together to ensure that the farmers that pursue cocoa agroforestry have the *motivation, capacity, incentives*, and *support* to manage effective and sustainable cocoa agroforestry systems.

- **Farmer motivation** is crucial to the design and implementation of cocoa agroforestry systems. They are the ultimate owners of their systems and must be able to make the necessary investment in time, effort, and money.
- **Farmer Capacity** indicates that if a farmer pursues cocoa agroforestry, they will reasonably be able to adopt the skills and techniques necessary for managing the new system. Farmer knowledge following training, for example, is positively associated with adoption of new or improved farming practices.<sup>29</sup>
- **Farmer incentives** indicate that a farmer is able to achieve positive livelihood outcomes, as demonstrated through income or more holistic indicators, by pursuing cocoa agroforestry.
- **Farmer support** refers to the ability of a farmer to receive the necessary inputs, planting materials, resources, guidance, market entry points, and other levels of support to successfully implement the system.

**The Sustainable Livelihood Framework (SLF)<sup>30</sup> is based on understanding the livelihoods of targeted communities in order to design and implement programs that contribute to better livelihood outcomes.** The approach, developed by DFID, supports project developers across a range of sectors in understanding the livelihoods and conditions of communities. The framework looks at “Livelihood Assets” of communities across five dimensions: human capital, natural capital, financial capital, physical capital, and social capital.<sup>31</sup> See Table 3 for illustrative indicators that may arise after applying the SLF framework to cocoa agroforestry.

**Combining indicators across the SLF dimensions may lead to a farmer segmentation framework.** Farmers identified as having high-motivation and high-capacity, for example, could be prioritized for cocoa agroforestry programs in the short-term. Meanwhile, farmers with lower capacity can be supported to access the needed resources to successfully manage a system in future programming.

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<sup>29</sup> This was demonstrated in the case of integrated crop and pest management practices in Ghana by: David, S. and Asamoah, C. 2011, “Farmer Knowledge as an Early Indicator of IPM Adoption: A Case Study from Cocoa Farmer Field Schools in Ghana”, *Journal of Sustainable Development in Africa*, vol. 14, no. 4, pp. 213–224. [https://www.worldcocoaoundation.org/wp-content/uploads/files\\_mf/david2011.pdf](https://www.worldcocoaoundation.org/wp-content/uploads/files_mf/david2011.pdf)

<sup>30</sup> DFID. Sustainable Livelihoods Guidance Sheets <https://www.enonline.net/dfidsustainableliving>

<sup>31</sup> DFID, Sustainable Livelihoods Guidance Sheets, Section 2.3



**Table 3: Illustrative indicators relevant for cocoa agroforestry systems**

SLF Dimensions	Illustrative indicators / data for cocoa agroforestry systems
Human capital	<ul style="list-style-type: none"> <li>- Household characteristics (such as age, gender, education, number of household members, number of dependents)</li> <li>- Access to trainings for cocoa agroforestry, cocoa productivity, GAPs, and/or climate-smart cocoa</li> <li>- # of completed trainings in cocoa agroforestry, cocoa productivity, GAPs, and/or climate-smart cocoa;</li> <li>- Farmers applying crop diversification</li> <li>- Education level;</li> <li>- Farmers implementing farm management planning</li> </ul>
Financial capital	<ul style="list-style-type: none"> <li>- Household finance including savings;</li> <li>- Household income;</li> <li>- Income diversification between cocoa-and non-cocoa income;</li> <li>- Alternate income-generating activities;</li> <li>- Access to finance (credit, microloans, lending, VSLAs, etc.);</li> <li>- Farmer has taken a loan in past 12 months from a financial institution;</li> <li>- Average costs of maintenance / ha</li> </ul>
Physical capital	<ul style="list-style-type: none"> <li>- Size of cocoa farm (# of hectares);</li> <li>- # of hectares devoted to cocoa;</li> <li>- Access to planting material distribution points;</li> <li>- Access to infrastructure, technology, roads, etc.;</li> <li>- Tenure status;</li> <li>- # of trees registered on cocoa farms</li> </ul>
Social capital	<ul style="list-style-type: none"> <li>- Cooperative membership;</li> <li>- Certification status, and which certifications;</li> <li>- Access to extension and support services;</li> <li>- Presence of CLMRS systems in communities;</li> <li>- Access to labor capacity (household and hired labor days/year)</li> </ul>
Natural capital	<ul style="list-style-type: none"> <li>- Farm management practices, including the current state of the farm, and the presence of some adaptive management practices to respond to climate change impacts;</li> <li>- GAPs adoption rate;</li> <li>- Additional species on-farm;</li> <li>- Average cocoa productivity / ha</li> <li>- Presence of cocoa diseases and/or pests;</li> <li>- Presence of CSSVD barrier crops around cocoa production areas;</li> <li>- Farms and/or hectares in need of rehabilitation;</li> </ul>

**Stakeholder mapping and resource assessments can provide information regarding farmer support, including accessibility to various resources.** This includes identifying where farmers receive their services and can also identify potential partners such as technical service providers, delivery agents, implementation partners, and the synergies between these actors.

**Living income<sup>32</sup> measurements can also provide context for farmer incentives.** Cocoa agroforestry systems can be costly, and companies should work to identify solutions for raising farmers' incomes from cocoa and non-cocoa sources. Cocoa agroforestry programs can be an important aspect of the ongoing work surrounding income diversification and strategies to achieve a living income.

**Market access impacts potential future income from cocoa and non-cocoa products.** The potential demand and market entry-points for cocoa agroforestry products should be assessed to determine the viable species to promote for a given cocoa agroforestry system. Likewise, the assessment should examine the ability for existing markets to absorb the potential increased in production volumes that would occur after implementation to manage the risk of over-supply. The outcomes of this assessment would impact farmers' incentives to pursue cocoa agroforestry, the species choice for the cocoa agroforestry systems, and program design.

## Ecological Assessments

**The ecological assessment will provide a snapshot of the current state of the landscape and will inform the design of cocoa agroforestry systems.** These assessments identify, assess, and develop strategies to protect and maintain the environmental values including but not limited to biological species diversity, landscape-level ecosystems, ecosystem mosaics, intact forest landscapes, habitats, and ecosystem services. HCS assessments, for example, differentiate between various land and forest-types to offer a framework to understand which areas can be developed and which should be conserved and protected. Under a landscape approach, parts of the landscape could be maintained as primary or secondary forest, while other land uses or degraded areas may be converted to a mosaic of land uses including cocoa production, fallow, secondary forest, food crops, and other needs.

**A combination of geo-spatial mapping and fieldwork can collect ecological data relevant to cocoa agroforestry systems.** This could include:

- **Land-use trends**, including recent trends for deforestation and degradation (including pests and disease) and habitat change or threat, and water availability.
- **Vegetation assessments**, including floristic assessments and/or ethnobotany to identify species of interest, rare or important species, and to document plant and

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<sup>32</sup> There are many resources available for developing methodologies and data collection for Living Income. Please see the Living Income Community of Practice; <https://www.living-income.com/> and the position papers for the upcoming 2020 Cocoa Barometer: <https://www.voicenetwork.eu/cocoa-barometer/> for additional information on methodologies, target levels, and specific data for cocoa farming households in Ghana and Côte d'Ivoire.

species availability and local community or farmer preferences. This may also identify extinct species that the community may re-introduce and assessments of potential ecological, social, and economic benefits.

- **Faunal studies**, including biodiversity, bird species, wildlife, or endangered species;
- **Topography or slope** studies to discover elevation information and also shade and/or light studies;
- **Soil assessments**, including soil fertility, soil type, quantity and quality of soil organic matter;
- **Hydrology** assessments, including quantity and quality of water resources.

**This information impacts various aspects of cocoa agroforestry systems.** The initial decision of how suitable a given farm landscape is for cocoa agroforestry may be impacted by recent trends for deforestation and landscape degradation, such as a presence of pests and disease. The outcomes of these assessments may also impact the management interventions for establishing a cocoa agroforestry system.

**Species selection should be informed by ecological suitability as well as farmer preferences.** As per the CCC guidance note on cocoa agroforestry systems, selected species must be compatible with cocoa. In addition, Rainforest Alliance and other certifications focus on integrating native species for on-farm trees. Furthermore, species survival should account for biodiversity, water availability and quality, soil quality, elevation, and sunlight and shade quality.

### 3.3. Opportunities for Collective Action

**The landscape assessment can reveal the opportunities for cocoa agroforestry interventions that are suitable for collective action.** Companies can rely on a combination of their Action Plan commitments and the results of the landscape assessments to map out which interventions they are willing to undertake and which can be feasibly and technically implemented in a given landscape. Cocoa agroforestry interventions can take place across the CFI's core areas: forest protection, forest restoration, sustainable production, farmers' livelihoods, community engagement, and social inclusion.

**Collective action for cocoa agroforestry systems include the direct implementation and management of these systems but may also address enabling conditions.** Interventions may target the planning/design phase; data collection and analysis; farmer engagement, segmentation, and training; supporting enabling environment infrastructure and related communities; the disbursement of planting materials, inputs, and extension services; developing end-market infrastructure for end-products; monitoring, evaluation, and reporting; or connecting cocoa agroforestry programs to forest protection and restoration.

Examples of collective action for cocoa agroforestry are illustrated in Table 4.

**Table 4: Examples of collective action in cocoa agroforestry**

Program Phase	Collective Action Opportunities
Planning / design	<ul style="list-style-type: none"> <li>- Co-investment for in-depth landscape assessments, such as HCV/HCSA or ROAM assessments;</li> <li>- Collaboration on multi-stakeholder consortia at the national and regional level;</li> </ul>
Farmer engagement, segmentation, and training	<ul style="list-style-type: none"> <li>- Sensitization for surrounding communities on the benefits of agroforestry, or, as per CFI commitments, on awareness-raising events for the benefits of forest and restoration;</li> <li>- Integrating cocoa-agroforestry practices and techniques into existing farmer training curriculums or training lead farmers to cover cocoa agroforestry techniques;</li> <li>- Expanding farm management planning to include models and costs for chosen cocoa agroforestry models (as determined by the species chosen, the number of species richness, the presence of additional markets for products, etc.)</li> <li>- Joint training programs for producers on agroforestry;</li> <li>- Farmer engagement to discover shade tree preferences in on-farm integration;</li> </ul>
Enabling environment	<ul style="list-style-type: none"> <li>- Collaboration on seed network systems and nursery establishment to provide shade and productive species to be integrated onto cocoa farms;</li> <li>- Leveraging local community governance structures for landscape management and land-use planning;</li> <li>- Joint pre-competitive support and action for producers to receive formal tenure rights for land and trees;</li> <li>- Capacity-building for cooperatives in target landscapes for trainings, extension, or financial on-lending to producers;</li> <li>- Shared investment into research on farmer shade tree preferences;</li> <li>- Joint management</li> </ul>
Management and extension services	<ul style="list-style-type: none"> <li>- The distribution of farmers' preferred shade trees for planting;</li> <li>- Technical extension services for cocoa agroforestry, including the formalization and expansion of technical service providers, such as pruning, weeding, or spraying teams;</li> <li>- Expand one-on-one farmer coaching for farm development plans;</li> </ul>
Monitoring, evaluation, reporting	<ul style="list-style-type: none"> <li>- Collaborating in deforestation-risk assessment technologies, methodologies, and processes;</li> <li>- Working with local and national authorities to share maps and data on farmers and interventions;</li> <li>- Investing in technologies and process development for national traceability systems and farm mapping;</li> </ul>
Market Support	<ul style="list-style-type: none"> <li>- Joint marketing research on local and regional market capacity to intake new production of cocoa agroforestry products;</li> </ul>

<i>Market support, cont.</i>	<ul style="list-style-type: none"> <li>- Participating in multi-commodity consortiums and forums to engage stakeholders across the landscape;</li> <li>- Value-chain development for preferred shade tree species and related products;</li> <li>- Collaboration with related industries (i.e., timber) for offtake agreements)</li> <li>- Farmer trainings on business management, financial management, or marketing support;</li> <li>- Farmer and community training on alternative-income generating activities;</li> <li>- Certification support;</li> <li>- Investment for compliance on ongoing standard development (e.g., climate smart cocoa standard in Ghana, zero-deforestation in Côte d'Ivoire, ISO Sustainable and Traceable cocoa standard, etc.)</li> </ul>
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**Initial costs will vary depending on the scale of implementation chosen.** Many of the above interventions can be expanded or scaled back depending on the target area. A pilot program involving a few farm plots will require significantly fewer resources than a program covering several communities or a district. Cocoa agroforestry systems can be costly in terms of required investment and time for implementation. The process can be made more efficient by taking advantage of pre-competitive complementarities to reduce costs and transaction costs. These existing complementarities will partially arise from the intervention mapping stage as well as from the landscape assessments. Companies will work together to identify alignment in priorities, strengths, existing capacities, and remaining gaps.

**Landscape programs offer the opportunity to benefit producers in a companies' indirect supply chain, or producers who would otherwise be excluded from sustainability programming.** Investments in cooperative capacities, enabling environments, or other types of collective action interventions detailed above may be pursued to reach a greater number of producers. These types of collective action at the intervention level will also be beneficial for programs seeking to utilize landscape-scale agroforestry forest restoration and protection. In terms of funding or co-investment from public, multilateral, or impact-oriented donors or investors, it is crucial to demonstrate a public value generation beyond any single companies' interests or supply chain.

**After a landscape is chosen and partners are identified, the benefits of cocoa agroforestry can be validated through a pilot project.** Cocoa agroforestry systems seek to integrate trees on farm by producing economic benefits to farmers, adding shade to cocoa agroforestry, and enhancing carbon sequestration. By validating the approach in landscape and demonstrating that these benefits can be attained, interest can be generated and potential investment catalyzed.



## 4. Designing cocoa agroforestry systems

**This chapter provides an overview of the main decisions that companies need to take in order to design cocoa agroforestry systems and plan for their implementation.** There are a number of questions that a company should be able to answer in regard to their agroforestry production systems, and this chapter begins to discuss the considerations for each.

**The structure and function for agroforestry system determines the specific transition that will have to be managed when moving away from full-sun cocoa.** The choice of structure and function is very much dependent on the results of the landscape assessment including farmers preferences, capacities, and markets. *Intercropping* and *multi-strata* systems have been identified as the main design structures to manage existing full-sun systems to attain.

*Figure 14: Advantages and disadvantages to different cocoa models: monoculture, inter-cropping, and multi-strata agroforestry. This table is for illustrative purposes only. Any benefits that may be potentially accrued are a result of design, management, and unique circumstances.*

	Advantages	Disadvantages
<b>Monoculture</b>	<ul style="list-style-type: none"> <li>- High short-term cocoa yields</li> <li>- Comparatively simple production model and technological package</li> <li>- Low training needs for farmers</li> <li>- Known production costs</li> </ul>	<ul style="list-style-type: none"> <li>- May jeopardize long-term sustainability</li> <li>- Lower adaptive capacity to climate impacts</li> <li>- Higher vulnerability to pest and disease</li> <li>- High inputs costs for fertilizers and pest control</li> <li>- Detrimental to biodiversity</li> <li>- Higher emissions and limited carbon sequestration</li> </ul>
<b>Inter-Cropping</b>	<ul style="list-style-type: none"> <li>- Can improve farmer food security and income diversification</li> <li>- Moderately improves resilience to climate change, pest and disease</li> <li>- Moderately improves biodiversity</li> <li>- Moderate carbon sequestration</li> <li>- Entry point to more diverse systems</li> </ul>	<ul style="list-style-type: none"> <li>- May decrease short-term cocoa productivity</li> <li>- May require new markets for non-cocoa crops</li> <li>- Requires additional inputs, training, and finance</li> <li>- Lower biodiversity value, carbon sequestration, and resilience compared to multi-strata systems</li> </ul>
<b>Multi-strata</b>	<ul style="list-style-type: none"> <li>- Secures long-term cocoa production</li> <li>- Maximizes long-term resilience to climate change, pests and disease, and carbon sequestration</li> <li>- May serve forest restoration goals</li> <li>- Can improve farmer food security and income diversification</li> <li>- Reduced cost for fertilizers and pest control</li> </ul>	<ul style="list-style-type: none"> <li>- May decrease cocoa productivity</li> <li>- May require new markets for non-cocoa crops</li> <li>- Requires sophisticated design and training</li> <li>- Requires more complex inputs incl. seedlings</li> <li>- Higher implementation cost and financing needs</li> <li>- Higher labor costs during planting and ongoing management</li> </ul>

**The information gathered from the assessment phase can shape the design of a plot-level cocoa agroforestry models.** In particular, the landscape assessment can yield important information about the farmers' preferred species, the adaptation and management needs to successfully implement the systems, and the defining starting and ending states for implementation.

## 4.1. Species selection for cocoa agroforestry systems

**Species selection is the first building block to determining the overall structure, function, and design of cocoa agroforestry systems.** The species selection is based on a number of factors, and at a minimum, it must follow the guidelines set out by the CCC:

- The species should be compatible with cocoa production;
- The selected species should be based on farmer preferences.

**There are important structural, functional, design, and management distinctions that depend on species selection.** In West Africa, it is likely that cocoa agroforestry systems will include a combination of fruit, non-timber forest products (NTFP), and/or timber species. It is possible to have a cocoa agroforestry system with cocoa, timber, NTFP, and fruit species all present on a given plot. The goal of presenting these systems according to these categories is to discuss the particular structural, functional, and management considerations for those types of species.

### **Box 2. Recommended resources for tree species guidance:**

- <http://www.shadetreeadvice.org/>
- Asare, R. 2006. **Learning about neighbour trees in cocoa growing systems - a manual for farmer trainers.** Forest & Landscape Development and Environment Series 4-2006.
- Asare R. and Asare A.R. 2008. **A Participatory Approach for Tree Diversification in Cocoa Farms: Ghanaian Farmers' Experience.** STCP Working Paper Series 9 (Version September 2008). International Institute of Tropical Agriculture, Accra, Ghana.
- Dohmen MM, Noponen M, Enomoto R, Mensah C, Muilerman S. 2018. **Climate-Smart Agriculture in Cocoa: A Training Manual for Field Officers.** Accra, Ghana: World Cocoa Foundation and The Rainforest Alliance. <https://hdl.handle.net/10568/93360>
- Ghana Cocoa Board. 2018. **Manual for cocoa extension in Ghana.** CCAFS manual. Ghana Cocoa Board (COCOBOD). <https://hdl.handle.net/10568/93355> (see Table 2.1, pg. 23 for list of desirable / undesirable shade species)
- Asare, R., David, S. and Sonwa, D. (eds.) 2009. **Conservation and biodiversity in and around cocoa farms. Learning about Sustainable Cocoa Production: A Guide for Participatory Farmer Training.** Development and Environment Series 12-2009. Forest & Landscape Denmark. <https://pdfs.semanticscholar.org/bf06/d587d494997a9f609874bb534af4f6b7dea0.pdf>
- UTZ, (2017). **UTZ and shade trees, Findings from a literature review.** <https://utz.org/wp-content/uploads/2018/01/Key-findings-on-shade-trees.pdf>

### 4.1.1. Categories of species

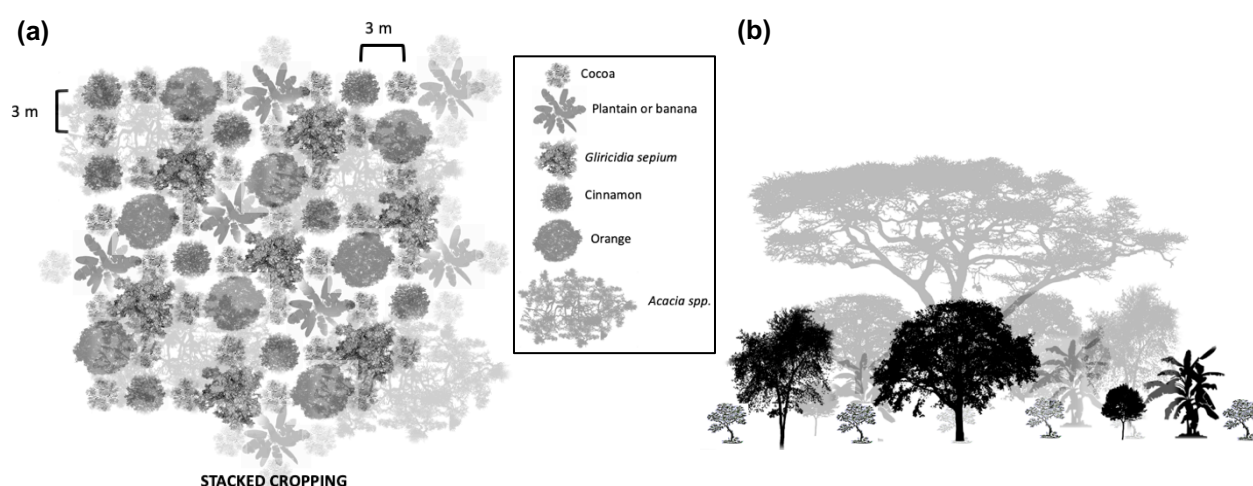
#### Fruit and edible species

Fruit species are commonly part of cocoa agroforestry systems. In smallholder producer plots, cocoa is often inter-planted with fruit-bearing species for home consumption, as well as for informal and formal market sale. Commonly grown fruit and edible species associated with cocoa agroforestry are included in Table 5.

**Table 5: Common and scientific name of fruit/edible species**

Common Name	Scientific name
Mango	<i>Mangifera indica</i>
Avocado	<i>Persea Americana</i>
Mandarin orange tree	<i>Citrus reticulata</i>
Orange tree	<i>Citrus sinensis</i>
Safoutier (eng: African pear bush)	<i>Dacryodes edulis</i>
Small lemon tree	<i>Citrus limon</i>
Coconut palm	<i>Cocos nucifera</i>
Guava tree	<i>Psidium guajava</i>
Papaya	<i>Carica papaya</i>
Cola nut	<i>Cola acuminata</i>
Coconut palm	<i>Cocos nucifera</i>

Other species that are largely not domesticated but are instead harvested in certain West Africa forests include: *Monodora myristica* (W. African nutmeg), *Cinnamomum verata* (cinnamon), *Elettaria cardamomum* (cardamom), and *Aframomum spp.* (African ginger). See Figure 15 for an illustrative example of fruit and edible species incorporated into an existing cocoa system.



**Figure 15. (a) Top-view and (b) profile of cocoa agroforestry system with fruit / edible species.** Cocoa and commercial spices (such as, cinnamon, or clove) are interplanted in the understory in a regular planting arrangement. Fruit trees such as sweet orange (*Citrus reticula*) occupy the subcanopy, shared with a soil-enriching leguminous species, such as *Gliricidia sepium*. Some legacy banana or plantain (*Musa spp.*) may remain, as space allows. Canopy layer is occupied by shade-producing and soil-enriching species, such as *Acacia mangium* or *A. auriculiformis*, providing ~30-50% shade.

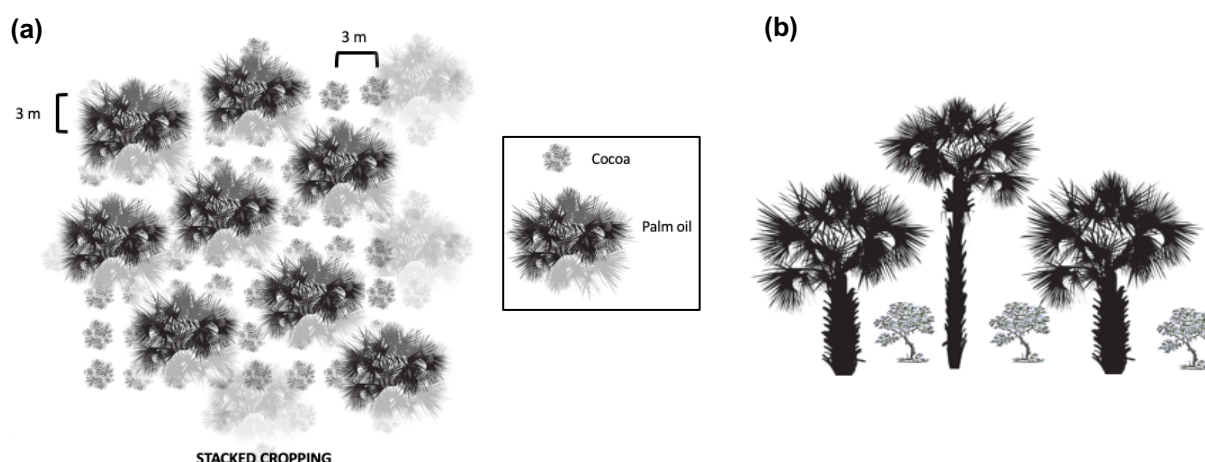
## Non-timber forest products (NTFPs) species

Incorporating species of non-timber forest products is a common strategy for smallholder cocoa agroforestry to meet household needs and for informal markets. Entry into formal markets has also been practiced and studied in commercial production systems with favorable outcomes for combined production.

NTFP species could be readily integrated with a fruit / edible based system due to fewer domestication techniques for these species and a lower availability of seedlings. In other cases, cocoa agroforestry models may focus on only two high-valued species, such as cocoa-palm oil, cocoa-rubber, or in select regions, cocoa-coffee. However, pursuing these systems should still adhere to the minimum recommendations under the CFI for species diversity and with national guidance on shade. See Figure 16 for an example of an NTFP system. Commonly grown NTFP and associated with cocoa agroforestry are in Table 6.

**Table 6: Common and scientific name of NTFP species**

Common Name / Uses	Scientific name
Palm oil – local / export market	<i>Elaeis guineenses</i>
latex, oils, fuelwood	<i>Funtumia elastica</i>
Rubber	<i>hevea brasiliensis</i>
oil, medicinal, resin, dye, fuelwood	<i>Dacryodes edulis</i>
Akpi – fiber, dye, oil, medicinal, cultural, spiritual	<i>Ricinodendron heudelotii</i>
Medicinal	<i>Alstonia boonei</i>
African nutmeg	<i>Pycanthus angolensis</i>
African tulip tree	<i>Spathodea campanulata</i>
False iroko	<i>Antiaris toxicaria</i>
Djingo	<i>Ginkgo biloba</i>
Accatiawèssè	<i>Cola pachycarpa</i>
Raffia	<i>Raphia sp</i>



**Figure 16. (a) Top-view and (b) profile of cocoa agroforestry with NTFPs.** Cocoa is interplanted with at least two NTFP species (fast-growing and slow-growing). Here *Elaeis guineenses* (slow-growing) has been interplanted with cocoa. The fast-growing, soil-enriching NTFP species (*Albizia adianthifolia*) has been harvested from the system.

## Timber species

There is increasing interest in planting timber species in cocoa agroforestry systems to provide shade and generate additional income, particularly at times of low cocoa prices or underperformance of cocoa from pest or disease pressures. Timber species are commonly either remnants of the original forest or are a result of natural regeneration.<sup>33</sup>

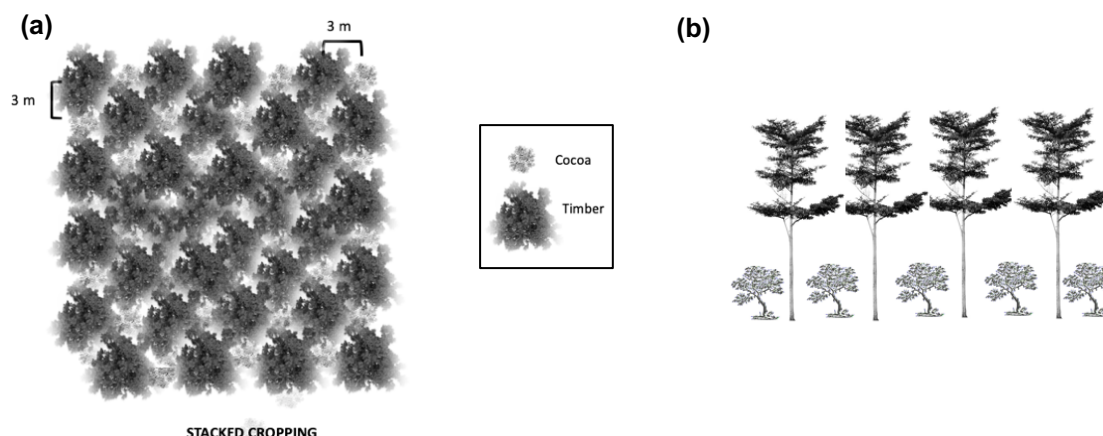
Table 7 shows commonly grown NTFPs associated with cocoa agroforestry, and Figure 17 shows an example of a timber-cocoa agroforestry system.

**Table 7: Common and scientific name of timber species**

Common Name / Uses	Scientific name
Fraké	<i>Terminalia superba</i>
Framiré	<i>Terminalia ivorensis</i>
Iroko/ Teak	<i>Milicia excelsa</i>
Ouochi, Bangbaye	<i>Albizia spp.</i>
Sipo	<i>Entandrophragma utile</i>
Syco	<i>Acer pseudoplatanus</i>
Breadfruit	<i>Artocarpus altilis</i>
Badi	<i>Nauclea diderrichii</i>
Poro	<i>Ficus sur</i>
Asan	<i>Celtis zenkeri</i>
Kpamgban	<i>Delonix regia</i>
African ash, kyereye	<i>Pterygota macrocarpa</i>
Albizia	<i>Albizia ferruginea</i>
Ijebu/tiama mahogany	<i>Entandrophragma Angolense</i>
Ivory Coast almond	<i>Terminalia ivorensis</i>
Lati	<i>Lannea welwitschii</i>
Kumbi	<i>Lannea welwitschii</i>
Mahogany	<i>Kyaha anotheca, Khaya ivorensis, Kyaha grandifoliola</i>
Niagon	<i>Heritiera utilis</i>
Ofram	<i>Tieghemella superba</i>
Red Sterculia	<i>Steculia rhinopetela</i>
Spaele	<i>Entandrophragma cylindricum</i>
Sinuro	<i>Alstonia boonei</i>
Triangle tops	<i>Blighia unijugata</i>
Utile	<i>Entandrophragma utile</i>
Ilomba	<i>Pycnanthus angolensis</i>
Emien *	<i>Alstonia boonei</i>
Sandpaper tree	<i>Ficus exasperata</i>

<sup>33</sup> Somarriba and Beer, 2010





**Figure 17. (a) Top-view and (b) profile of TIMBER Intercropped Production System (Stacked cropping).** Cocoa is interplanted with at least two timber species (fast-growing and slow-growing). Here *Terminalia ivorensis* has been interplanted with cocoa. A fast-growing, soil-enriching timber species (*Acacia mangium*) has already been thinned from the system.

Like NTFP systems, cocoa agroforestry models should adhere to the minimum recommendations under the CFI for species diversity and conform with national guidance on shade percentage.

#### 4.1.2. Opportunities and challenges

Section 3.2 argues that smallholders must have the *motivation, capacity, incentives, and support* to manage effective and sustainable cocoa agroforestry systems. This applies to the species chosen for integration or establishment of cocoa agroforestry systems, with different species presenting their own opportunities and challenges for adoptions by smallholders. While there are many opportunities and benefits to be gained from cocoa agroforestry systems, the achievement of these benefits must often be carefully managed and may need to overcome challenges.

##### Opportunities for species selection

**Cocoa agroforestry species can provide benefits to the environment.** Cocoa agroforestry systems, when compared to full-sun monoculture, can create habitats that are more favorable for wildlife or biodiversity (but not as favorable as natural forest habitats).<sup>34</sup> Cocoa agroforestry can be designed to create buffer zones around protected areas, reconnect fragmented landscapes, and retain high biomass and

<sup>34</sup> Please see: Asare, Richard. (2006). A review on cocoa agroforestry as a means for biodiversity conservation. Paper presented at world cocoa foundation partnership conference. Brussels and Jezeer, Rosalien & Verweij, P.A. & Santos, Maria & Boot, Rene. (2017). Shaded Coffee and Cocoa – Double Dividend for Biodiversity and Small-scale Farmers. Ecological Economics. 140.

carbon storage.<sup>35</sup> These benefits largely accrue to systems with higher richness and diversity of species.

**Some species can also provide non-income benefits to farmers.** Growing fruit and/or other edible species can be used for household consumption for improved food security. Certain mixes of species may allow producers to manage harvest periods so they do not overlap with cocoa, reducing labor needs. Additionally, a survey of farmers in Soubré found that *Ricinodendron heudelotii* was valued for its benefits to cocoa (shade, soil fertility, and positive soil humidity) as well as for its nutrition, income, and cultural value.<sup>36</sup>

**Certain species may provide additional benefits to cocoa production and, by extension, farmer income.** There are benefits and complementarities to cocoa production, for example improving soil fertility, requiring no additional chemical fertilizers nor mulches, and improving adaptation to climate impacts. One survey of farmers in Soubré found that farmers valued *Terminalia superba* for shade quality, increases in soil moisture, and improvement in soil fertility.<sup>37</sup> Another study found that a variety of shade tree species caused localized and positive effects on soil fertility and vulnerability to erosion, but these were not necessarily translated to the entire plot.<sup>38</sup>

**Integrating shade on farms is one aspect of achieving certification.** Certification schemes such as Rainforest Alliance / UTZ have farm-level diversification criteria for using native tree species. Companies may choose to promote these approved native species at the requisite levels to support farmer achievement of certification.

### Challenges for species selection

**Cocoa agroforestry does not guarantee a higher income for farmers.** The ability of integrated trees to produce a predictable income is highly dependent on the chosen species, the available markets, and the ability to maintain productivity of the system over time.

**Overall, there is a need for additional research on species-specific interactions.** This includes research on species impacts on cocoa and also species-to-species interactions when there is higher species richness. For example, additional research could improve understanding on compatibility and resources needs for sunlight/shade, water, soil nutrients, etc. between specific timber species and cocoa agroforestry designs and stand densities. Interactions between species should be further studied,

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<sup>35</sup> Wade, Amy SI, et al. "Management strategies for maximizing carbon storage and tree species diversity in cocoa-growing landscapes." *Agriculture, ecosystems & environment* 138.3-4 (2010): 324-334.

<sup>36</sup> Dumont, Gnahoua, Ohouo, Sinclair, Vaast (2014) Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services, *Agroforestry Systems* (2014) 88: 1047-1066.  
<https://link.springer.com/content/pdf/10.1007%2Fs10457-014-9679-4.pdf>

<sup>37</sup> Dumont, et al., 2014

<sup>38</sup> Blaser WJ, Oppong J, Yeboah E, Six J (2017) Shade trees have limited benefits for soil fertility in cocoa agroforests. *Agric Ecosyst Environ* 243:83–91. <https://doi.org/10.1016/j.agee.2017.04.007>

especially to further knowledge on negative interactions that would impact landscape health or substantially affect cocoa yields.

**Additionally, technical information regarding species choices and the potential needs, risks, and opportunities need to be communicated to smallholders.** For instance, certain fruit or NTFP species may require 3 to 7 years from first planting for a smallholder to see any returns on their production. Initial yields (year 3 or 4) are often low, with subpar weight and quality. Therefore, a producer may not truly benefit until multiple harvest years occur. The current level of a farmers' knowledge and training should be addressed during the landscape and socio-economic assessment to ensure that farmers have the necessary motivation and incentive to pursue certain species.

**There are factors in the enabling environment which may impact species choice.** Forest policies surrounding tenure must continue to be clarified to stipulate who will receive the benefits. Additionally, there may be challenges regarding the lack of improved varieties or domestication techniques for certain species, and others may suffer from a lack of access to the chosen species due to underdeveloped or under-resourced seed system networks and nurseries. It is important to ensure that there is an existing market for any species chosen for their potential to provide producers' additional income, whether that is a formal export market or local informal markets.

## 4.2. Structure and design over time

**After choosing the preferred species, companies and producers must determine the structural and functional characteristics to implement.** Cocoa agroforestry can cover a range of designs with increasing complexity. There are many categories of cocoa agroforestry system designs available, ranging from simple boundary planting (like living fences and hedgerows), to intercropping under varying shade levels, and more sophisticated multi-strata systems that mimic the structure and ecological functions of natural forests. The structure of the system can also provide insight into the particular management interventions that may take place,<sup>39</sup> as explored in Section 4.2.3.

### 4.2.1. Structure and planting design options

**Intercropping** tends to be planted in regular or irregular spatial arrangements. Irregular arrangements are common with multi-purpose trees in order to benefit the greatest number of species below. Arrangements include:

- *Relay cropping*: common agricultural crops are interplanted with short-rotation woody species, harvested before the following rainy season, and the wood is chipped and incorporated into the soil;

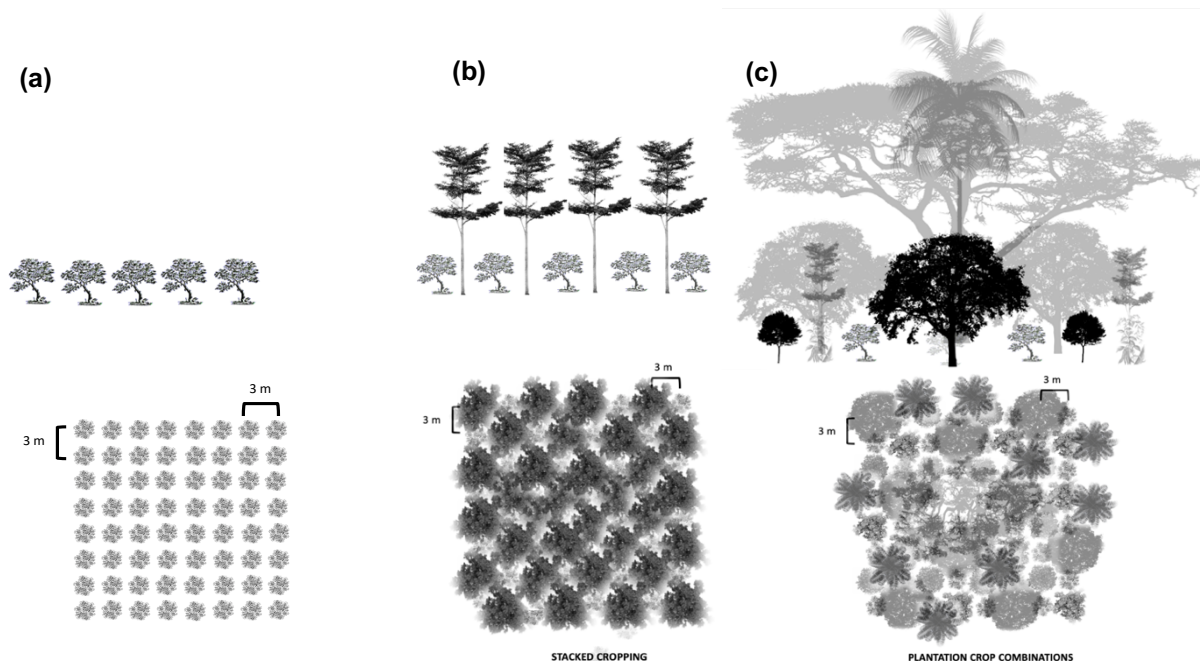
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<sup>39</sup> Sonwa et al. 2019. Structure of cocoa farming systems in West and Central Africa: A Review. <https://link.springer.com/article/10.1007/s10457-018-0306-7>

- *Stacked cropping*: shorter tree crops are interplanted below taller tree crops;
- *Alternate rows*: tree crops are planted in alternate rows with another crop planted in the micro-climate between those rows; and
- *Alternate strips or alley cropping*: agricultural species are planted in the “alley” between the clustered rows of tree crops.

**A multi-strata system** is most often arranged in alternate or other regular arrangements similar to alley or row cropping. Plantation crop combinations have a greater stand density than intercrops.

Figure 18. Examples of Cocoa-fruit agroforestry, (a) full sun, (b) inter-cropped and (c) multi-strata



#### 4.2.2. Starting state of the plot

**Structural and functional aspects of the system should be designed to reflect the starting state of the given plot.** The specifics regarding the starting state of the plot should initially be identified during the landscape assessment phase, and later on in the farmer selection and segmentation phase. Depending on the starting state, companies may offer a different set of species and adopt a varied management plan approach. Common starting states may include:

- A full-sun cocoa system;
- A degraded forest-area, such as a *Fôret Classée*;
- New cocoa farm, previously undeveloped, non-forested land;
- A cocoa system in need of rehabilitation and/or renovation;
- A cocoa system with some diversification (such as some inter-cropping).

**The starting state of the plot should be compared to the desired “end” state in order to develop implementation plans.** This allows companies to understand the types of transitions that are necessary for their interventions. For example, three potential transitions, which are further discussed in Annex 1, are:

- Full-sun to *intercropped cocoa agroforestry*
- Full-sun to *multi-strata cocoa agroforestry*
- *Intercropped* to *multi-strata agroforestry*

#### 4.2.3. Management phases of agroforestry development

**This section describes the phases of stand development in the lifecycle of any cocoa agroforestry system.** It then highlights the corresponding key adaptive management interventions and activities in each of those phases to assist the transition of a full-sun cocoa system to a cocoa agroforestry system (Figure 19).

The phases of cocoa agroforestry stand development are categorized here as: **Early Establishment, Fully Established, and Maturity.**

*Figure 19: Phases of stand development and key objectives*



**Each phase of cocoa agroforestry development corresponds to a set of adaptive management interventions and activities** that support the health and productive capacity of the cocoa agroforestry system.

##### Early-establishment agroforestry

**This phase takes places during Years 0 - 4 and is characterized by the installation and initial survival of newly planted species in the cocoa system.** It is analogous to the “Stand Initiation” phase of secondary forest stand dynamics. It is guided by long-term planning and design as well as by the production goals. It is constrained by technical feasibility and capacity, and relative access to quality seeds/plant genetic material.

**This is the most labor-intensive phase.** Labor is key to implementing design goals and management plans to ensure an optimal species mix, spacing, density, and



productivity is reached in later phases. This will also protect the investments against climate risks and vulnerabilities inherent in exposed and/or degraded sites.

**This phase may include the following management techniques:**

- Rehabilitation or renovation management interventions for existing cocoa plants, such as grafting improved genetic material on established rootstock.
- Installation of fast-growing leguminous species (stakes, seedlings, and seeds) for shade, nutrient cycling, and biomass production (mulch);
- Establishing groundcover (e.g. leguminous herbaceous plants or grasses for forage) to reduce soil exposure, erosion, and increase moisture retention;
- Installation of complimentary tree crops (fruits, nuts, timber, and NTFPs) in appropriate spacing for future shade and density goals;
- Active management of soil and water sources (e.g. pollarding leguminous trees for mulch/soil organic matter accumulation, slowing/diverting/directing water flow patterns to optimal locations, etc.); and
- Pruning for desired architecture (ease in harvesting/management) and to stimulate/intensify fruit production.

### Established agroforestry

**This phase, from Years 4 – 16, is characterized by the establishment of strong, resilient root systems below ground, reflected by overall plant growth, health, and vigor above ground.** The regular felling of trees and non-replacement of dead cocoa or associated trees results in gaps that are filled by young seedlings which are naturally established through existing forest seed banks or introduced through seedlings.<sup>40</sup> This phase is when a producer can expect to see initial yields and subsequent returns.

**The management focus in this phase is the adaptive management for rehabilitating established species, including:**

- Gradual replanting through the removal or rehabilitation of weak, malformed, diseased or underperforming plants;
- Selective thinning (branches, whole trees) for seasonal airflow or shade reduction;
- Pruning to stimulate or intensify fruit production; ongoing mulching/assisted accumulation of soil organic matter;
- Targeted nutrient amendments, foliar sprays, pest deterrents;
- Harvesting and post-harvest processing; and
- Improving storage and logistical efficiencies, etc.

**This phase also involves adaptively renovating or refining the system design of density, spacing, or other techniques by installing new seedlings in canopy gaps**

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<sup>40</sup> Sonwa et al. 2017

created by thinning and removal. These gaps may be filled by species at any canopy, such as fruit trees, nuts, palm and/or timber, and can be used to:

- Diversify age classes amongst established species; and/or
- Add or integrate species or varieties to diversify the production portfolio.

### Mature agroforestry

**From Year 16 on, this phase reflects the efficient management and maintenance of a matured agroforestry system.** Shade-crop systems are rehabilitated or renovated and stand replacement should be planned for gaps that emerge through selective harvesting of canopy and emergent canopy trees. In this stage, producers should see annual returns from their production.

**During this phase, the producer begins to selectively harvest timber and may cash in on long-term investments.** The producer may initiate the stand replacement plan, removing dying or underperforming individuals, and plant replacement seedlings in the gaps.

## 4.3. Estimating implementation costs

**The exact cost of establishing agroforestry systems is highly context dependent.** Generally speaking, two main cost types should be considered by companies:

### 1. Start-up and Implementation costs:

- a. Assessments on land and plots for baseline and program design
- b. Supporting land and tree tenure efforts for farmers
- c. Monitoring infrastructure
- d. Certification costs
- e. Stakeholder engagement
- f. Capacity

### 2. Per hectare costs:

- a. Acquisition of planting materials:
  - i. Seedlings ( $\# \text{ trees per hectare} * \text{unit cost of seedling by species}$ )
- b. Costs of inputs:
  - i. Organic fertilizers ( $\text{kg application per tree} * \# \text{ trees /ha} * \text{unit cost per kg}$ )
  - ii. Herbicides ( $\text{kg application per tree} * \# \text{ trees /ha} * \text{unit cost per kg}$ )
- c. Labor costs for transportation and system establishment
- d. Management costs

### 3. Per farm costs:

- a. Tools for planting, pruning and harvesting
- b. Training per farmer
- c. Marketing, storage or processing costs for non-cocoa product starting around Year 5

**It is important to consider – as described in Chapter 4.3 and Annex 1 – that the process of establishing and maintaining agroforestry systems is a long-term commitment.** Therefore, costs must be estimate not only for initial establishment or specific component such as seedlings but the entire package over a period of at least 10 years. Once the desired agroforestry systems, resulting transition models, potential implementation partners, and local providers have been identified, companies are advised to carry out a detailed costing exercise for their intended program.

**This is fundamental for understanding the financial implications for companies and farmers and provides a basis for considered financing strategies.** Companies have a series of options to finance implementation. Beyond their own resources that have been pledged, companies may explore financing arrangements with specialized investors, recognizing that a solid investment case needs to be made. For this purpose, the development of markets for non-cocoa products, potentially through partnerships with non-cocoa value chain companies, is a key opportunity. Companies may also leverage donor funds, taking into account that most donors prefer to fund scalable and ultimately self-financing activities that crowd in private sector funds.

**Some of the key determining factors of cocoa agroforestry programs include but are not limited to:**

1. **Characteristics of the chosen cocoa agroforestry systems** including species, density, fertilization requirements, harvesting regimes, and labor intensity.
2. **Scale of the cocoa agroforestry program.** Large scale programs and partnership approaches might promise reduced per hectare costs, as program costs may be spread over a larger area but may require the establishment of additional nursery infrastructure which can be associated with significant capital expenditures.
3. **Training needs of farmers** depending on existing skills and the complexity of the targeted agroforestry systems.
4. **Ability to cost-share** and leverage strategic partnerships both in and outside of the cocoa value chain.

## Annex

**This annex includes the structural and functional components as well as management consideration of previously identified transitions by management phase:**

1. Full-sun to Intercropped agroforestry
2. Full-sun to Multi-strata agroforestry
3. Intercropped to Multi-strata agroforestry

## Transition 1: Full-sun to Intercropped agroforestry

### Phase 1: Early-Establishment

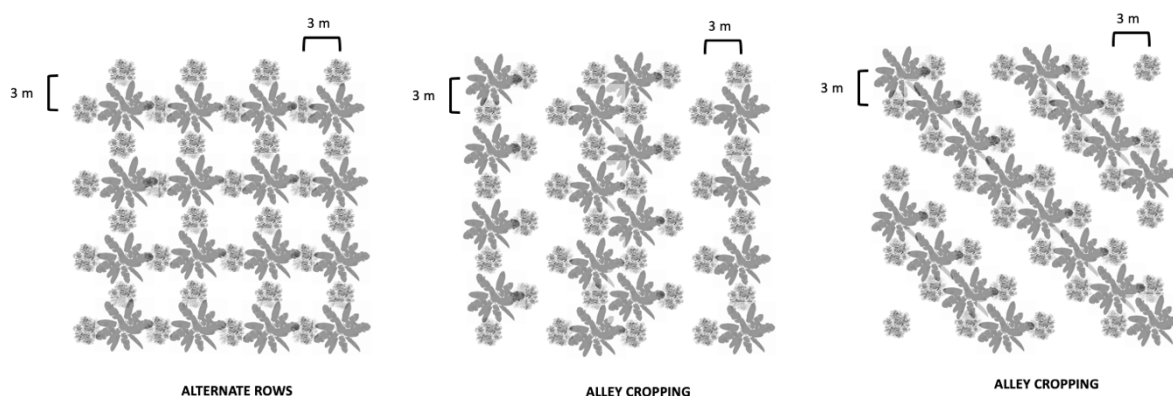
Years 0 – 4: Installation and Survival

#### **Adaptive Management Interventions & Activities:**

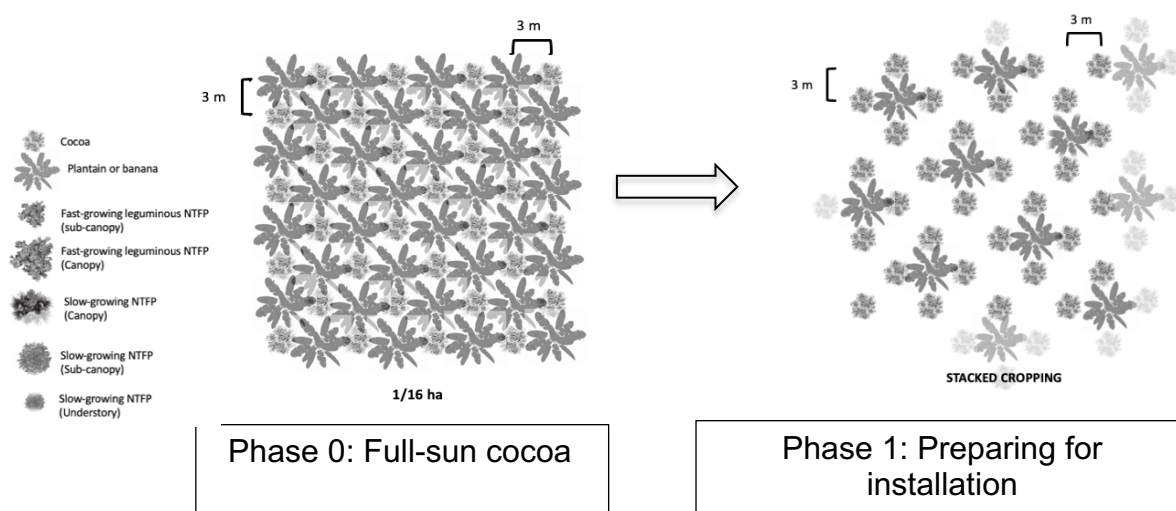
##### **Preparation:**

The rehabilitation of existing cocoa plants or renovation occurs often, but not is always done in preparation of new planting material. This may open up gaps where new cocoa or other species can be planted in its place.

Thinning/selectively removing *Musa spp.* (banana) will determine the overall structural design, so it is important to consider what design one seeks. For example, removing every other *Banana* can open up alternate rows or alley cropping spatial arrangements:



For a stacked intercropping design, a farmer will **selectively remove banana only**, so that four cocoa plants encircle one *banana* at a time. This provides flexibility in ideal placement of new plants in microclimate niches:



Areas where banana or dead, diseased, or underperforming cocoa have been removed and where new plants will be planted are to be weeded and cleared to the ground. Clean plant material that has been cleared is chopped into smaller pieces and mulched around outer root-zones of existing cocoa – careful to leave a plenty of space away from the trunk to reduce conditions favorable to fungal diseases. Diseased plant material should be carefully removed and disposed of away from productive areas to prevent cross-contamination and spread of fungal spores.

The plot has been staked to flag placements of new species -- careful to space following recommended *height x spread*, growth rate, and initial vs. final density, following contour lines to slow water runoff and counter erosion appropriately in drought-prone areas. Often initial species density will be 3x the final species density desired to allow for the producer to select the healthiest and strongest seedling and thin/remove the others. For example, initial count may be 90 for the eventual result of 30. Spacing and species placement should account for this, which is often easier done in the field using stakes to visualize and adjust as needed.

In some instances of high slope inclination, digging trenches and mounding swales perpendicular to water flow may be necessary to slow/divert/direct water to more optimal locations, etc. It is important to plant fast-growing herbaceous species on the swales so that the disturbed soil does not get swept away in the rain.

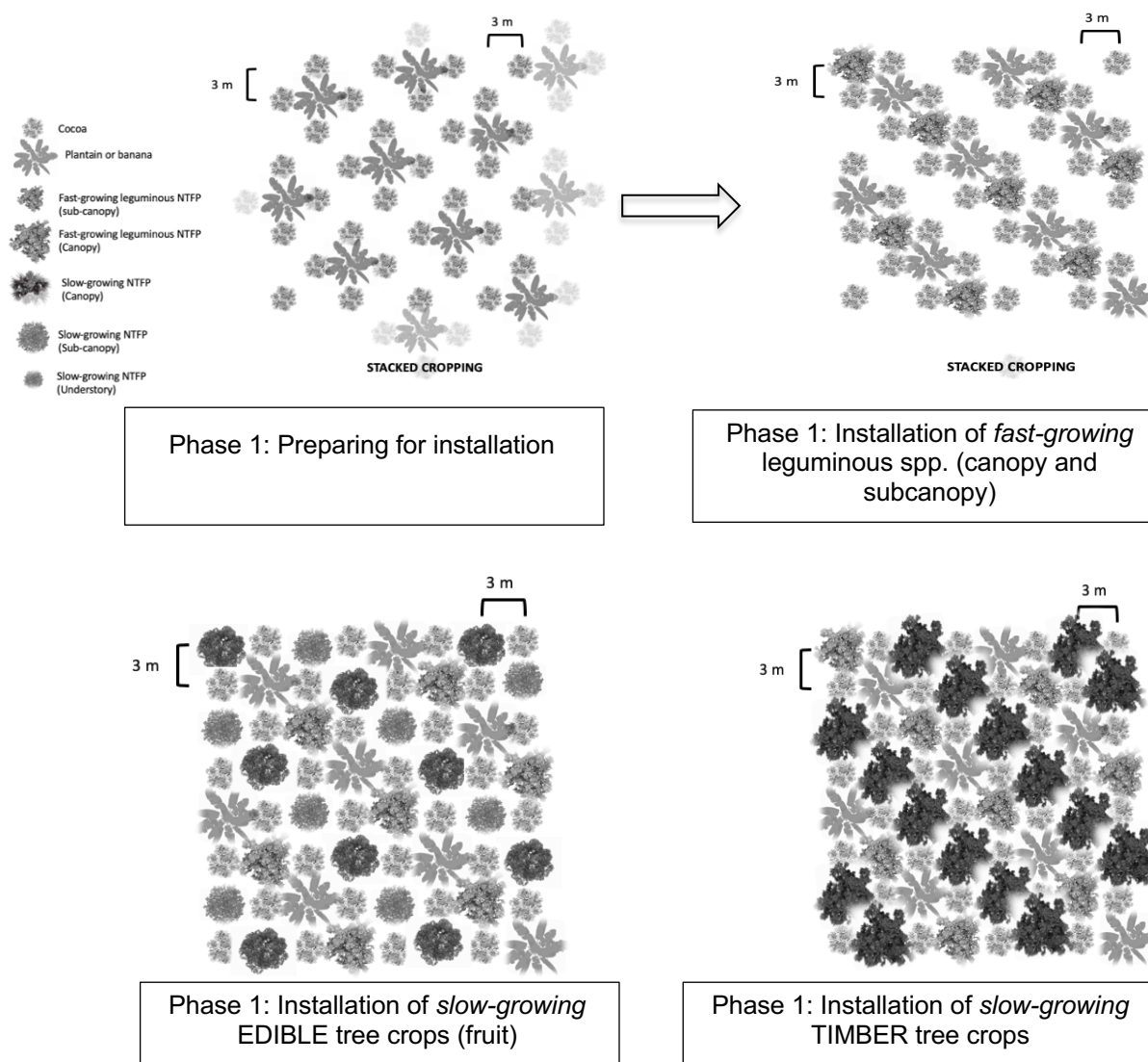
Holes have been dug at least twice as wide and deep as the seedling being planted. Ideally worm castings (vermicompost) are generously mixed into the native soil to give seedlings a natural boost in nutrients and soil quality.

### **Installation:**

First, plant fast-growing leguminous species (with live stakes, seedlings, and/or direct-seeding) for shade, nutrient cycling, and biomass production (mulch), and establish groundcover (e.g. direct-seeding leguminous herbaceous plants or grasses for forage) to reduce soil exposure, erosion, and increase moisture retention. Any existing leguminous trees may be pollarded (cut back, at head height) and the leaves/branches cut into smaller pieces for mulch around priority species to support survival rates.

Slower-growing tree crops may be planted in the same installation period, but the exposure to the elements may cause undue stress and will likely require much more labor to ensure their survival (irrigation, mulch, fertilizer, weed and pest control, etc.). It is better to plant fast-growing leguminous species first to allow a couple years of growth for their crowns to provide adequate shade (reduce sunlight intensity and water evapotranspiration) and modify soil environments (soil fertility), after which the conditions are more favorable for slower-growing trees. This approach is more cost-effective, as it is less labor- and input- intensive.





### Survival:

Once plants have been installed, the first 1 to 2 years are critical to their survival. Young seedlings are vulnerable to the elements, disease, and predation. Depending on the availability of inputs (particularly fertilizer), on-site resources, and the labor capacity of the producer, the approach to care for newly installed plants will differ from farm to farm.

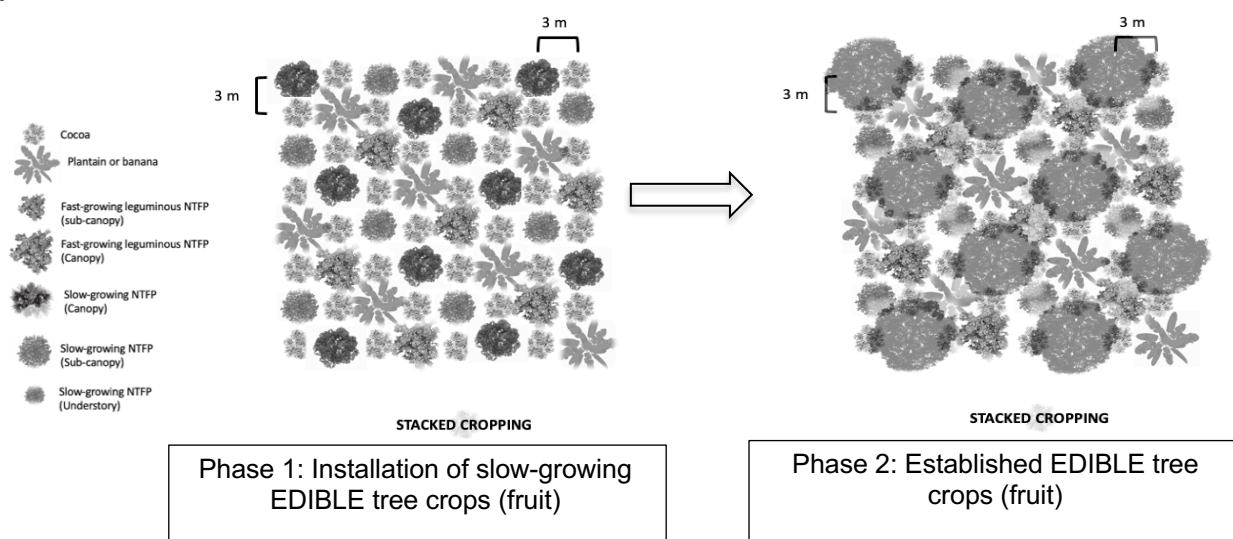
In general, it is recommended to ensure the new plants have adequate root access to rich organic matter – ideally compost, vermicompost for the addition of important organic matter to the soil, or at minimum, slow-release fertilizer. The soil surrounding and adjacent to new seedlings should be covered with leguminous groundcover or cover crops (such as peanut or groundnuts), and/or a thick layer of mulched organic matter. This will protect the vulnerable roots from heating up and drying out from sun exposure, prevent the soil from erosion, maintain soil moisture, and suppress weeds from growing below. It will also provide the important soil micro-organisms with material to breakdown into soil organic matter, making nutrients available to the seedlings.

Priority materials for mulching include banana stalks/leaves, leguminous leaves and branches (less than 50mm in diameter, chopped into pieces half the length of the forearm of the producer), and leaf litter from healthy, un-diseased trees and shrubs. Unwanted herbaceous weed species that primarily establish themselves through seed dispersal or via rooting cuttings should be avoided in mulch material, lest they strangle the new seedlings and compete for limited available resources. Mulch layers should be no higher than the lowest leaf of the seedling and no lower than the diameter of the producer's thigh. Mulch should never touch the seedling stem/trunk and, to mitigate conditions favorable to gnawing rodents or fungal disease, should be no closer to the stem/trunk than the mid-length of the average branch to ensure proper airflow.

## Phase 2: Established Intercropped Agroforestry

### Year 4 – 16: Growth and Productivity

The management focus in this phase shifts from “rehabilitation” and “renovation” to emphasizing adaptive management focused on “refining” the overall system design (density, spacing, etc.) to optimize productive capacity on a per plant/per ha basis. By Year 4, the previously installed system will have established itself above and below ground, filling in the space they have been planted. Any unforeseen errors in planning/spacing will reveal themselves now. Newly installed cocoa plants will have begun to produce first yields, indicating potential and expected yields in the years to come. Other fruit trees will also begin to flower and fruit, with nut trees producing first yields in Years 5 to 7.



## Adaptive Management Interventions & Activities:

### Pruning, thinning, or removal:

Managers will thin or remove weak, malformed, diseased or underperforming plants, or species with a shorter productive lifetime that are no longer desired in the system, such as *Musa* spp. Managers will also selectively thin (remove branches or whole trees) to

increase seasonal airflow and to reduce percentage shade, and prune to stimulate or intensify fruit production.

#### **Re-installation:**

The regular thinning and removal of trees may create large enough gaps that can be filled by young seedlings without detriment to the sun/nutrient demands of established species. Re-installation in the gaps is done to either: 1) diversify age classes amongst established species (such as cocoa or another priority species) to ensure continuous production over the long-term, and/or 2) add or integrate new species or varieties to diversify the production portfolio.

#### **Managing soil and plant health:**

As the system matures in Years 4 to 16, root systems and nutrient cycling processes start to establish themselves, labor requirements and costs associated with applying inputs (such as fertilizers) may reduce--depending on the species selected and its nutrient needs, the starting soil conditions, and the soil management approach implemented. Other labor requirements include ongoing mulching (assisting in the accumulation of leaf litter and therefore, soil organic matter), targeted applications of nutrient amendments, foliar sprays, and pest deterrents, used as necessary. Rather than intensive management, this phase allows the producer to observe changes and make subtle refinements for sustainability as they walk their land. The cost of managing soil fertility and pest/diseases will be far less than that of a full-sun cocoa system.

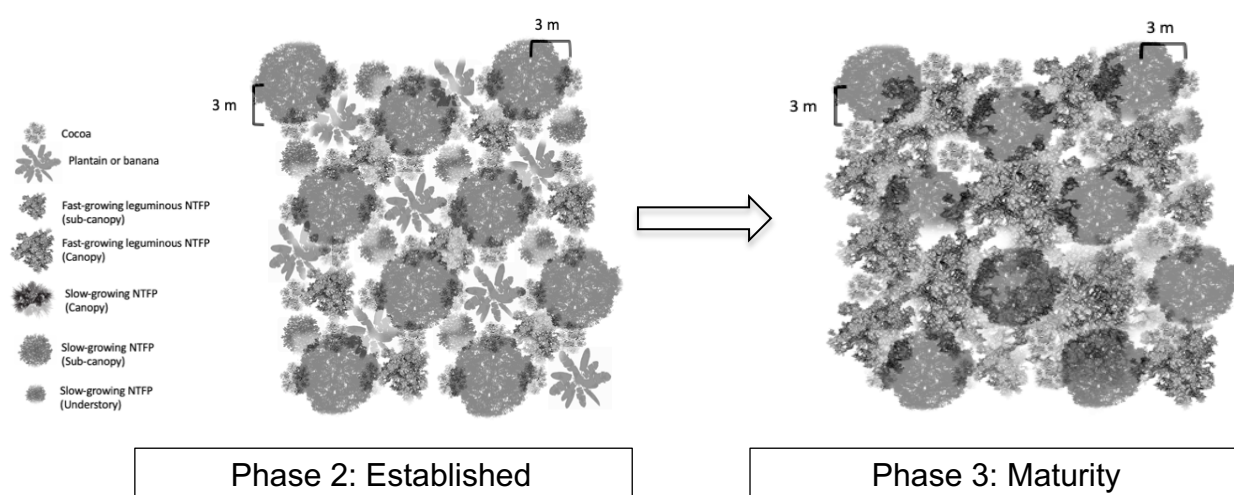
#### **Harvest and post-harvest activities:**

This phase marks the beginning of when a producer can expect to see results of design plans and management decisions and initial yields/returns from their labor/material investment over the previous years. Harvesting and post-harvest processing processes become critical, as do improving storage and logistical efficiencies, etc.

### **Phase 3: Mature Intercropped Agroforestry**

#### **Year 16+: Maturity and Maintenance**

This is the phase in which earlier design, planning, and management decisions are reflected in the overall health and efficiency of a matured agroforestry system. Harvesting and post-harvest processing processes are the central focus, improving storage and logistical efficiencies, etc.



### **Adaptive Management Interventions & Activities:**

#### **Harvest and post-harvest activities:**

Mature agroforestry stands mark the time when labor/management shifts from exclusively focusing on soil and agronomic conditions to improving harvesting/post-harvest infrastructure. The producer is beginning to cash in on long-term investments.

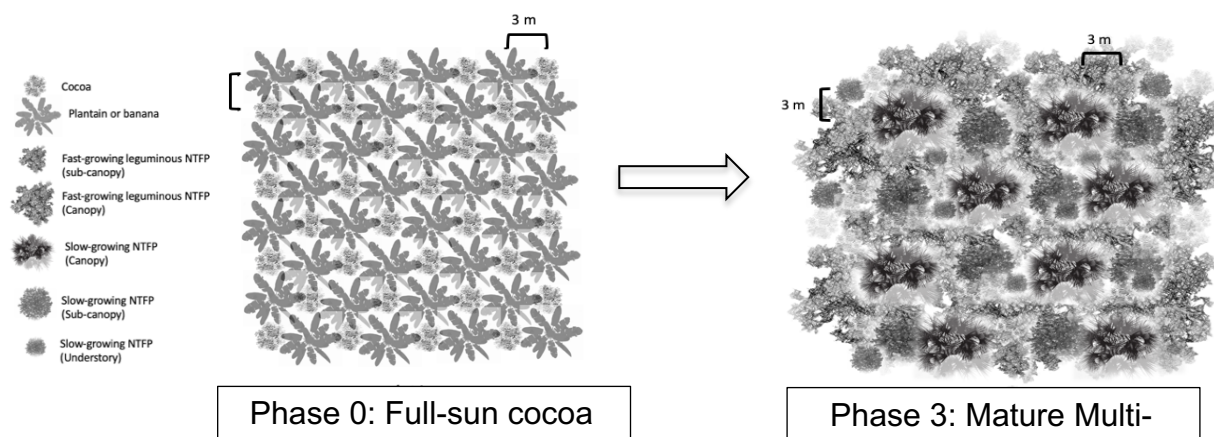
#### **Rehabilitation or renovation:**

In this phase, crop quality and/or productivity may be waning as nutrients critical to flowering/fruiting (such as phosphorous, calcium, and potassium) are not sufficiently available to meet the species' needs, and/or the species stands develop past productive age. In the case of the former, rehabilitation through targeted pruning regimes and/or applications of mineral fertilizers may be necessary to improve consistent quality of fruit. If nutrients are not the limiting factor to productivity, shade-crop systems may be renovated and replaced with younger seedlings. Renovation is generally recommended to be incremental or gradual (rather than complete) to reduce micro-economic shocks to the farmer.

Renovation consists of initiating the stand replacement plan, removing dying or underperforming individuals, and planting replacement seedlings in the gaps that emerge through selective harvesting of canopy and emergent canopy trees.

### **Transition 2: Full-sun to Multi-strata Agroforestry**

The additional vertical space available in multi-strata cocoa agroforestry provides even greater opportunities than intercropped cocoa agroforestry for production diversification and/or sustainable intensification on a per hectare basis. However, the diversification of species and their respective management requirements adds complexity to the system. The following sections present how the transition approaches will differ from intercropped agroforestry and outline management implications at each step.



## Phase 1: Early-Establishment

Years 0 – 3: Installation and Survival

### Advanced Planning: *Structural design*

In transitioning from a full-sun to multi-strata cocoa agroforestry, the desired system design must be forefront in mind to successfully guide the stand development into productive age. The labor requirements for preparing the physical site for multi-strata agroforestry is the same as for intercropped agroforestry, with a crucial difference in **advanced planning** and **phased installation**. Greater importance is placed on the *timing* of the species installation, based upon their respective growth rates and expected height and spread, to ensure growth patterns and resource requirements complement rather than interfere with existing or introduced species. It is strongly recommended to have a planting plan to refer back to regularly during the preparation and installation process.

### Advanced Planning: *Harvest and post-harvest logistics*

An increase in species richness in multi-strata systems results in an increase of potential returns from a single plot of land due to the introduction of staggered harvest periods throughout the year. However, higher species richness also results in lower species density on a per ha basis, making aggregation through farmer cooperatives a critical entry point to formal markets.

The opportunity for diversified production portfolio also brings with it the challenge to manage harvest and post-harvest activities and logistics. Some producers may be able to account for the increase in labor required for harvesting activities at different parts of the year by investing a portion of their income received from additional products, particularly if the products are directly sold into informal local markets. Other producers simply won't have the labor capacity to handle the multitude of harvest activities in multi-strata systems and making intercropped agroforestry a better fit.



There will be a steep learning curve for farmers transitioning directly from full-sun to multi-strata systems. Producers will need to plan ahead for how the species selected in their multi-strata systems will change labor demands and logistical considerations for harvesting, transporting, aggregating, and processing new products. Reaching economies of scale through the aggregation of products with other farmers is critical for accessing formal market value chains. Support and information on how to enter new value chains may be needed by smallholder producers to access aggregation centers and processing facilities equipped to handle a diversification of products throughout the year. Access to technical and micro-business capacity-building trainings and support from extension services will be necessary.

### **Adaptive Management Interventions & Activities:**

#### **Preparation:**

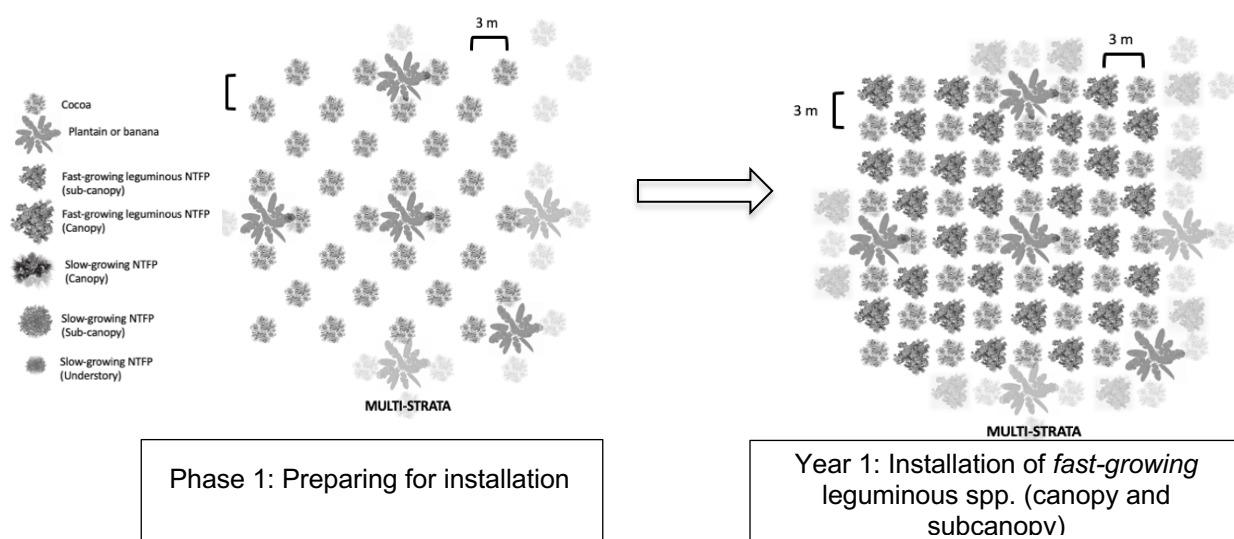
Once desired species are selected and the feasibility of post-harvest activities are accounted for, producers are ready to prepare their plot for the transition period. Of critical importance is identifying and planning spatial arrangements around rehabilitated or renovated cocoa plants, according to the expected height, eventual spread, and growth rate of each new species desired. In multi-strata agroforestry, it is critical to first plant drought-tolerant, fast-growing species before slower-growing tree crops to mitigate consequences of resource competition from newly planted root systems establishing at the same soil depth, vying for the limited availability of (initial) water and nutrient resources. Staking out the placement of all species at the onset will keep the installation process clear and reduce confusion in the field. Coding stakes (using color-coded fabric strips or plastic tape) is a helpful way for producers to distinguish between *fast-growing subcanopy*, *fast-growing canopy*, *slow-growing subcanopy*, *slow-growing canopy*, and *slow-growing emergent canopy* species. Once the stakes are placed and the plan is clear, installation can begin.

#### **Installation: Year 1**

Because stand density in multi-strata agroforestry will likely be greater than intercropped systems (dispersed more evenly across *understory*, *subcanopy*, *canopy*, and *emergent canopy* strata), planting a diversity of species at once will place a greater burden on available nutrient stocks and water sources, with new roots competing at the same relative soil depth for the same resources. Therefore, it is recommended to remove 2-3x the quantity of banana as you would have in the intercropped system to create more space. Then plant drought-tolerant, fast-growing species (with live stakes, seedlings, and/or direct-seeding) in Year 1, with the plan to install slow-growing species in Year 2 and onward. These fast-growing species provide important functions to prepare and modify the soil and microclimate environment of the multi-strata system: initial shade, soil enrichment/nutrient cycling, and biomass production (coppice materials from fast-growing legumes are used for rapid accumulation of mulch material). It is strongly recommended to establish drought-tolerant groundcover (e.g. direct-seeding herbaceous legumes or forage grasses) to reduce soil exposure, erosion, and increase moisture retention and nutrient cycling. This approach is cost-effective, as it is

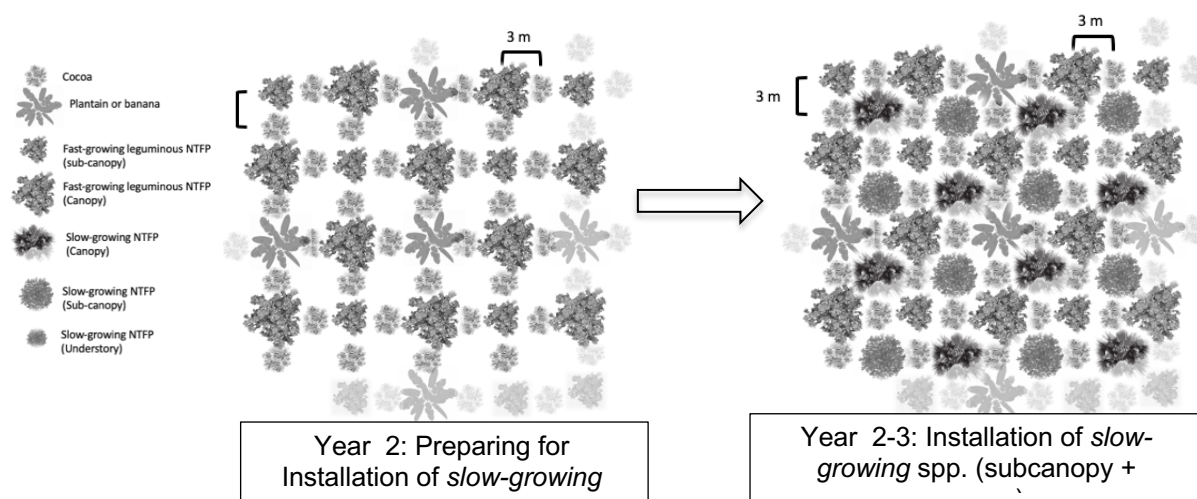
less input intensive overall, and labor requirements reduce after soil-enriching species are established.

Fast-growing, leguminous *subcanopy* and *canopy* species can be planted densely at the same time. For every stake of one fast-growing species (staked at desired placement), 3-5 replicates of the same species can be planted closely around it. This approach mimics seed dispersal patterns in natural regeneration processes and accelerates natural selection of the strongest and most vigorous individual plant. During the rainy season, these fast-growing species will shoot up and stretch for the sun, competing with its' replicates for space and establishing dominance amongst the stems. This encourages fast, vertical growth, below which ample space becomes available for the next installation of seedlings. The land manager should select the strongest, most erect stem to keep in the system, and thin out the remaining 3 to 5 replicates. Because all replicates will have been planted close to the original stake placement, the system design will remain intact. The removed stems should be chopped into smaller pieces and dispersed around the adjacent cocoa plants to build soil organic matter *in situ*.



### Installation: Years 2 to 3

Fast-growing species replicates, demonstrated in the graphic of Y1, are removed in favor of the strongest species, conveyed in the graphic of Y2. Depending on the species-specific growth rate from Y1 installation, and crown development post-selective thinning, it is advisable to wait a year or two before the fast-growing species of Y1 have developed crowns substantial enough to provide adequate shade/protection for vulnerable seedlings, and deep enough root systems to modify soil environments without competing for resources. From Year 2 onwards, slow-growing trees can be nursed in the shade of Y1 installment's early-establishment crown. It is recommended to plant the slow-growing canopy and subcanopy trees first to give them a head-start in development, before planting slow-growing understory species.



Understory species can be planted as conditions evolve and are commonly planted during Phase 2 (Established), when more niches become available in the understory.

### Survival:

Adaptive management approaches for ensuring the survival in early-establishment multi-strata agroforestry are similar to those in intercropped agroforestry. Each year, the area around each stem should be chopped back and left as mulch around priority species (excluding unwanted weedy species that disperse by seed or rooted cuttings from the mulch). Special attention should be paid to protecting the slow-growing species from drought, predation, and disease, as they are also slow at recuperating from shocks and stressors. Any weak or dying seedlings should be replaced, with careful attention to the conditions and soil quality to which replacements are being re-introduced. Pest predation and disease pressures are lower in diverse multi-strata agroforestry than in intercropped species due to the diversity of natural predator habitats and lower abundance of single species (source of food) for opportunistic pests. Nevertheless, shock from overexposure to the sun and drought are the leading cause of mortality in early-establishment multi-strata systems.

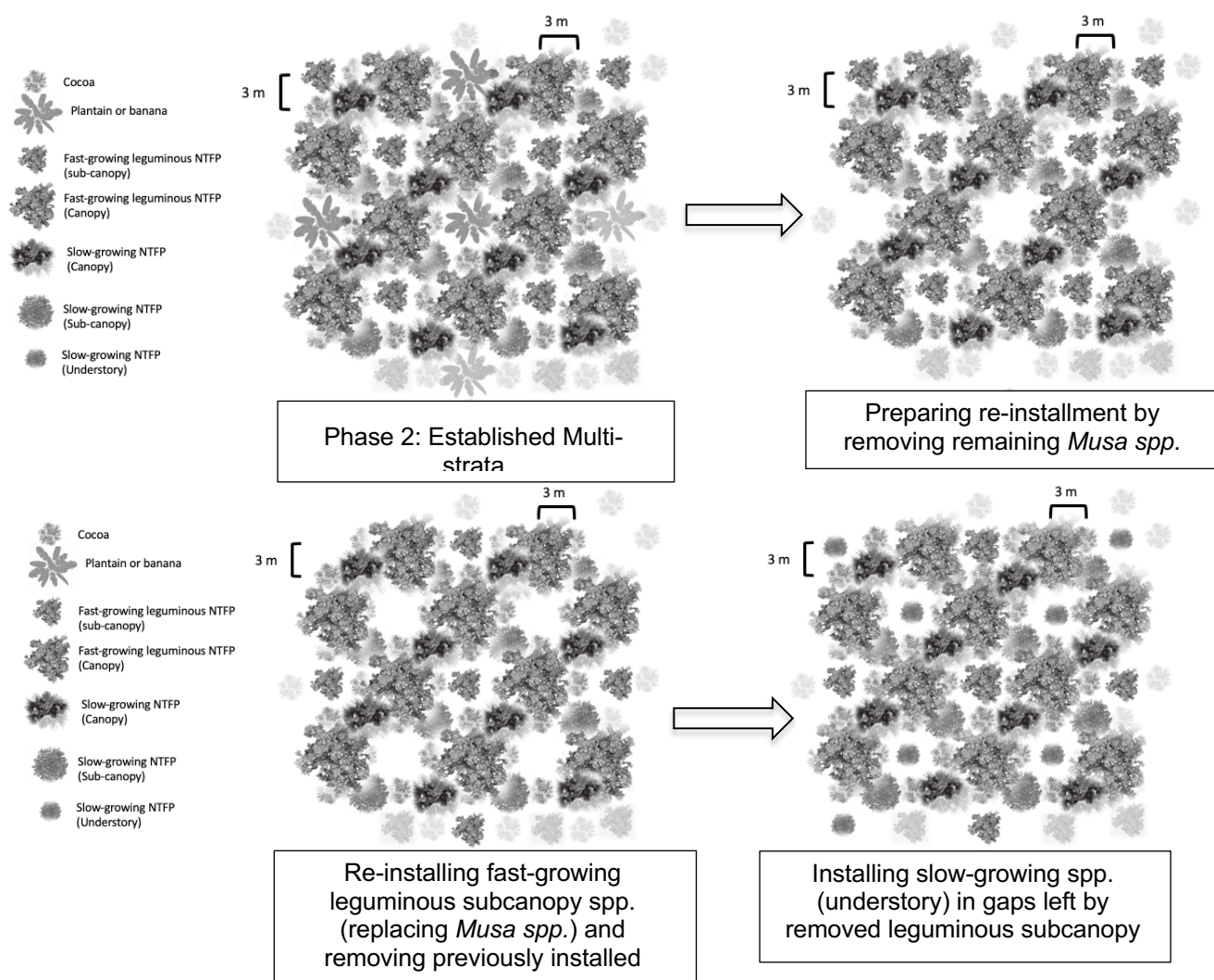
## Phase 2: Established Multi-strata Agroforestry

Years 4 – 16: Growth and Productivity

In this phase, the first installation has established, and crown differentiation becomes clearer and more stratified every year. Labor requirements are similar to that of intercropped agroforestry, but the additional layers of productive strata require ongoing adjustment to meet the needs of each species at each stratum, which requires greater attention to management practices and a clearer understanding of the implications of those practices on all vertical levels of the system.

### Re-installation:

The dynamism of multi-strata system development results in a changing structure throughout the stand development in which new seedlings may be incrementally installed into emerging structural niches. As with intercropped systems, removal of trees no longer needed in the system creates gaps that can be filled by young seedlings to diversify age classes amongst established species (such as cocoa or another priority species) and/or to integrate new species or varieties into emerging microclimate niches to diversify the production portfolio. Re-installation or “filling in” is recommended throughout the stand development of the multi-strata system to take advantage of all available vertical niches, as long as filling those gaps will not interfere with cocoa production. This is particularly relevant to emerging understory spaces as the system becomes more stratified, which can be re-installed with new cocoa or another species of value.



### Pruning, thinning, or removal:

As with intercropped systems, managers will thin or remove weak, malformed, diseased or underperforming plants, or species with a shorter productive lifetime that are no longer

desired in the system, such as any remaining *banana*. However, in multi-strata systems pruning/thinning/removal activities require a much more intentional focus, managing seasonal dynamics throughout the year to<sup>41</sup>:

- i) Increase sunlight during times of flowering and fruiting,
- ii) Increase airflow during times of heavy rain to deter fungal disease,
- iii) Stimulate nitrogen (N) fixation, and
- iv) Assist the accumulation of soil organic matter in the form of leaf litter (mulch) to depress weeds, maintain soil moisture, and bind available phosphorous in the soil, increasing N efficacy.

Added vertical structure in multi-strata systems increases the likelihood for increased shade-cover, so careful management of canopy shade will be important to ensure 30-50% shade levels are attached for sustained cocoa production, and density of subcanopy layers is controlled for adequate airflow in humid regions or in times of heavy rainfall. Any diseased plant should be immediately removed from the production area to prevent spread of disease.

### **Managing soil and plant health:**

Regular pruning provides ample vegetative material to incorporate as mulch to build soil organic matter, suppress weeds, and increase N efficiency by binding phosphorous released from decomposing material into the soil. Management in multi-strata systems should focus on increasing quality of production on a per plant basis through attentive adjustments to percentage shade, nutrient amendments, and pest/disease treatment.

### **Phase 3: Mature Intercropped Agroforestry**

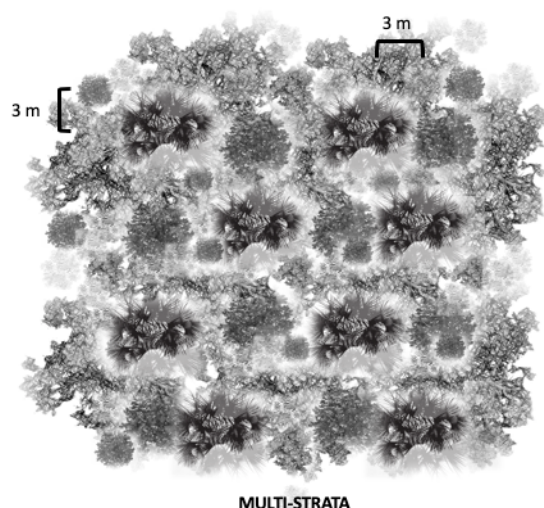
#### **Years 16+: Maturity and Maintenance**

This is the phase in which earlier design, planning, and management decisions are reflected in the overall health and efficiency of a matured multi-strata agroforestry system. Harvesting and post-harvest processing processes are the central focus, improving storage and logistical efficiencies, etc.

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<sup>41</sup> Schroth et al., 2000; Tschnartke et al., 2011; Vaast & Somarriba, 2014; Mithöfer et al., 2018.





### **Adaptive Management Interventions & Activities:**

#### **Harvest and post-harvest activities:**

Mature agroforestry stands mark the time when labor/management shifts from exclusively focusing on soil and agronomic conditions to improving harvesting/post-harvest infrastructure. The producer is beginning to cash in on long-term investments.

#### **Rehabilitation or renovation:**

In this phase, crop quality and/or productivity may be waning as nutrients critical to

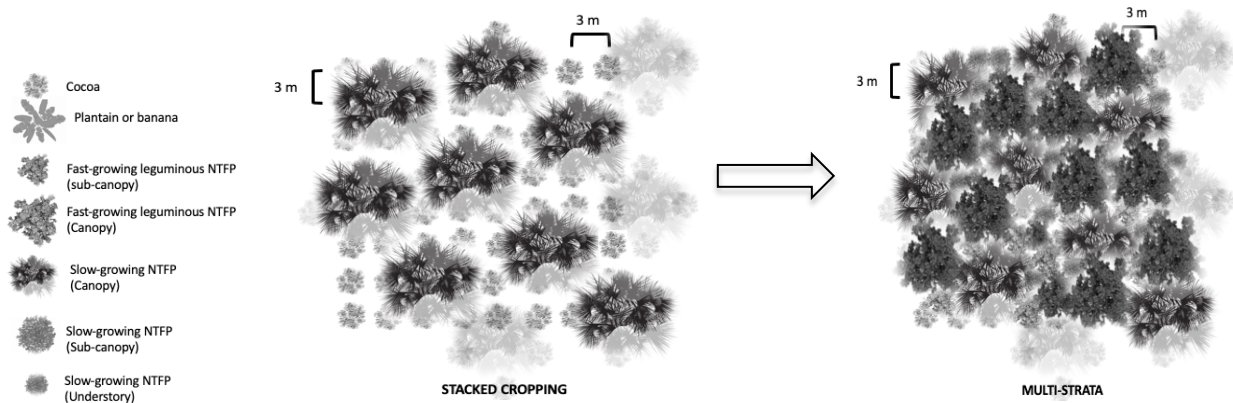
flowering/fruiting (such as phosphorous, calcium, and potassium) are not sufficiently available to meet the species' needs, and/or the species stands develop past productive age. In the case of the former, rehabilitation through targeted pruning regimes and/or applications of mineral fertilizers may be necessary to improve consistent quality of fruit. If nutrients are not the limiting factor to productivity, shade-crop systems may be renovated and replaced with younger seedlings. Renovation is generally recommended to be incremental or gradual (rather than complete) to reduce micro-economic shocks to the farmer.

Renovation consists of initiating the stand replacement plan, removing dying or underperforming individuals, and planting replacement seedlings in the gaps that emerge through selective harvesting of canopy and emergent canopy trees.

### **Transition 3: Intercropped Agroforestry to Multi-strata Agroforestry**

Some producers may already have a solid intercropped system in place but are interested in maximizing their production potential by using all vertical space available. The benefit of staging installation plans from full-sun to intercropped to multi-strata is also a cost-effective approach to spreading out upfront investments over time for costs associated with purchasing materials (seedlings, inputs, etc.) and labor.

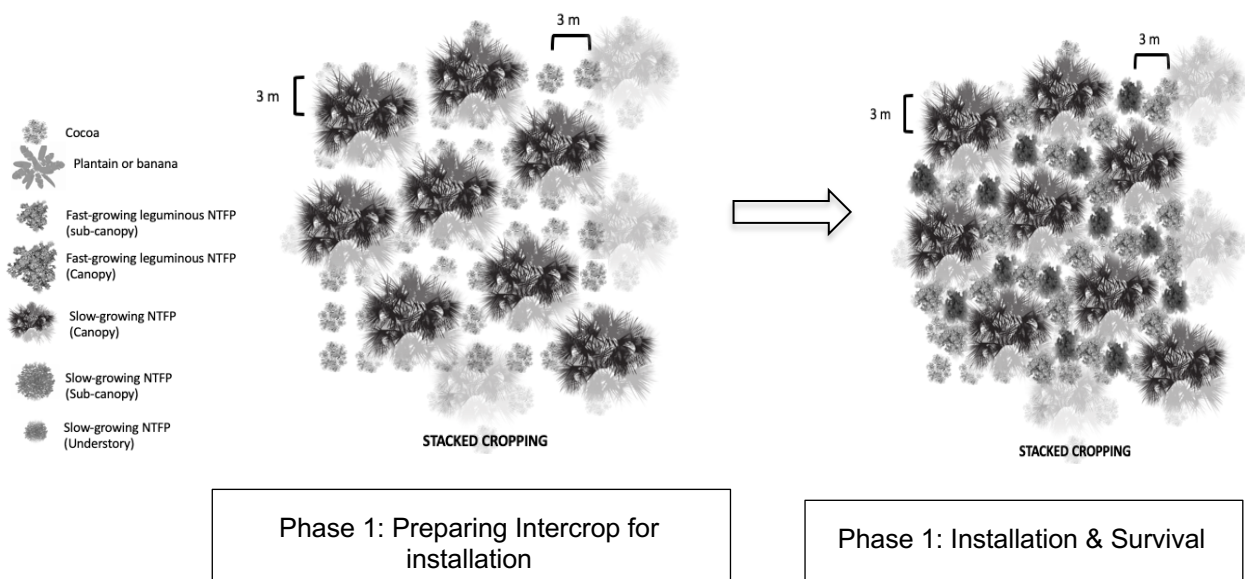
The below section illustrates how to “fill in” those gaps using an intercropped NTFP system (cocoa + palm oil) as a starting-point, and integrating both edible components (fruit, etc.) and timber into a multi-strata system. In this example, one can assume the intercropped system is mature, which is to say that the oil palms occupy the canopy stratum, with an open subcanopy, and cocoa occupying the understory. Shade levels are presumed to be ~40-50%, with adequate cocoa productivity.



## Phase 1: Early-Establishment

### Years 0 – 3: Installation and Survival

Transitioning an intercropped to multi-strata system is easiest when the intercropped system has been planned with the multi-strata goal in mind from the beginning to guarantee proper spacing for all species. However, established intercropped systems can also be transitioned by identifying the available space in each stratum, and using those gaps as spatial criteria for selecting species with appropriate height, spread, and growth rates to integrate into a multi-strata system.



### **Adaptive Management Interventions & Activities:**

### Preparation:

In this transition phase, the producer has identified what space they have available and what species they would like to integrate into the system. They have identified harvest

and post-harvest logistics and confirmed the feasibility for incorporating new species into their existing system.

The land is prepared in similar ways as one would for preparing an intercropped system, with particular attention to soil quality to ensure any additional species will not have a deleterious effect on the amounts of nutrients available to existing species. The producer has identified and staked placements for fast-growing leguminous NTFP species that will occupy the subcanopy, slow-growing timber species with narrow profiles that will eventually grow into the emergent canopy and high-value, slow-growing high-value species to integrate into the understory but that won't compete with cocoa. The producer has calculated that for every 6 cocoa plants, 1 or 2 underperforming or aged cocoa will be removed and replaced with the high-value species, without deleterious financial effect. The remaining cocoa will be managed to maximize production capacity on a per plant basis, maintaining yields on a per ha basis. These decisions reflect typical tradeoffs to consider when transitioning an intercropped system to a multi-strata system.

### **Installation:**

Just as with the other transition scenarios, priority is given to fast-growing leguminous species first so as to maximize the amount of organic matter to coppice and harvest for soil-building activities. However, in this transition scenario it would also be appropriate to plant slow-growing species (NTFPs like *Cola nitida*, or timber like *Termanalia ivorensis*) during the same installation period if soil quality is adequate to the needs of the new species and/or there is enough existing leaf litter to start to mulch and build soil organic matter at point of installation. Timber species will be placed in the triangular gap between canopy crowns, being careful to place evenly between the cocoa in the understory so as to not crowd the cocoa. Because there is an existing canopy, the density of timber does not need to be high, as the timber seedling will stretch straight up towards the light before beginning to fill out. Conversely, with timber planted in open fields, it is necessary to plant densely to encourage this vertical growth and stem exclusion before thinning out. For every 1 timber tree placement desired, it is recommended to plant 3 replicates to select out the strongest, most vigorous seedling with the best growth habit/structure.

### **Survival:**

Unlike the other two transition scenarios, the starting point (intercropped) has a canopy established, so vulnerable seedlings are already protected from the harsh elements. Survival will be much easier in this transition scenario, reducing labor requirements. Young seedlings should be watered in (or planted during the rainy season). Shade levels should be adjusted to be sure the seedlings have adequate shade to protect them but not too much to stunt their growth or encourage fungal diseases.

## **Phase 2: Established Multi-strata Agroforestry**

Year 4 – 16: Growth and Productivity

### **Pruning, thinning, or removal:**

At the earlier end of this phase, there will likely be a point at which introduced plants are all occupying the same branch space as cocoa. It may seem crowded, and doubts may emerge about whether this transition was the best choice. However, this stage usually doesn't last long, as the plants continue to grow towards their eventual height destinations. To reduce crowded cocoa plants, pruning is key. As with the pruning techniques in *Transition 2: Full-sun to Multi-strata*, pruning will not only help guide the introduced trees into their desired architecture (timber), but will also encourage fruiting (cocoa), stimulate N-fixation (leguminous), as well as modify airflow and shade levels (canopy species). Thinning of canopy (palm fronds) may be done to modify shade levels, as long as it does not have any negative effects on the production of palm oil fruits, or other subcanopy or understory species. Thinning may also be desired on the fronds closest to the timber trees to reduce any wind damage, until the timber crown has passed the palm canopy, after which fronds may be left to grow naturally. Selective removal of any individual trees is subject to the needs of the producer.

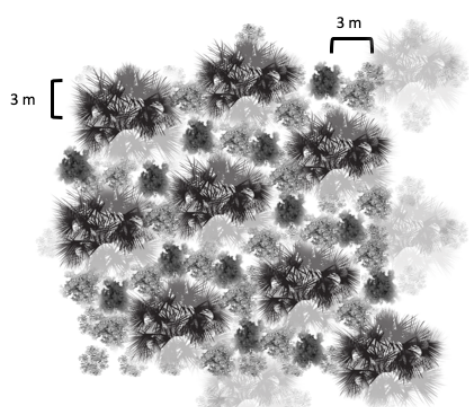
### Managing soil and plant health:

As with all agroforestry, managing soil and plant health is of utmost priority during the growth and productivity phase of stand development. The intercropped layers will have established a clear nutrient cycling pattern, which makes adjustments easier to anticipate and manage when integrating new species into a multi-strata system. As multi-strata systems mimic the conditions of a multi-tiered secondary forest, management should focus on building organic material into the soil through pruning, mulching, and targeted nutrient amendment treatments.

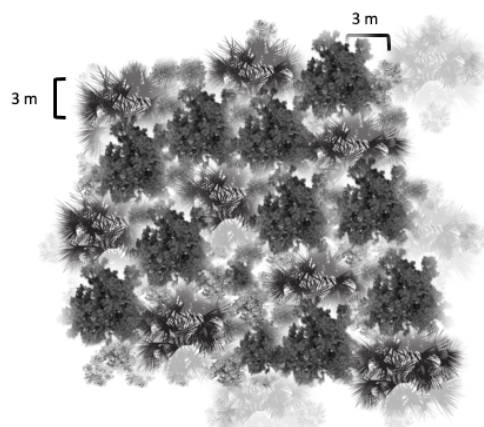
## Phase 3: Mature Multi-strata agroforestry

Year 16+: Maturity and Maintenance

After 16 years, the intercropped system will have clearly stratified into a multi-strata agroforestry system. At this phase, the overall health and efficiency of the system will have stabilized and will need to be maintained to maximize production capacity for species occupying each stratum. While soil and plant health are continuing priorities, overall labor hours shift to harvesting and post-harvest processing activities as the central focus, as well as improving storage and logistical efficiencies, etc.



Phase 2: Established Multi-strata



Phase 3: Mature Multi-strata

## **Adaptive Management Interventions & Activities:**

### **Rehabilitation or renovation:**

In this phase, original intercropped species productivity will wane as they mature past their productive age. Rehabilitation through targeted pruning regimes and/or applications of mineral fertilizers may be helpful in the short-term to improve quality of fruit and encourage productivity to its capacity. However, as species pass their productive age, the intercropped systems should be renovated and replaced with younger seedlings. Renovation is generally recommended to be targeted (individual plant), incremental (sections of the overall production plot), or gradual (selectively renovating species groups at a time), rather than complete renovation (everything at once) to reduce micro-economic shocks to the farmer. Any timber installed, survived, and of adequate girth and stem quality can be harvested for producers to cash in on their long-term investment. A plan for stand replacement should be in place and followed, removing dying or underperforming individuals and planting replacement seedlings in the gaps that emerge through felling of trees.

### **Harvest and post-harvest activities:**

As with *Transition 2: Full-sun to Multi-strata*, mature multi-strata agroforestry in this phase will have a more complex harvesting schedule and post-processing logistical requirements than intercropped agroforestry alone. The multi-strata design in this example has added an understory species for formal market sale and timber trees as long-term investments. The particular harvest and post-harvest needs will differ depending on the specific design components of each farm. Nevertheless, all mature multi-strata systems will use this phase of the stand development to improve harvesting/post-harvest infrastructure and processes to maximize earning potential from the plot.