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The business case for timber in agroforestry systems in Ivory Coast

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This is the third in a series of brief reports produced with support from the government of Luxembourg, which analyse the economics of commodity production practices in tropical regions. The purpose is to help develop the business case for sustainable land use models that can address drivers of deforestation and land degradation, while being economically viable for producers. To date, analyses have been published for sustainable robusta production in the Central Highlands of Viet Nam as well as beef cultivation in Costa Rica.



01

Introduction

*The Business Case for Sustainable Timber
in agroforestry systems in Ivory Coast*



With a total surface area of 322,463 km², Republic of Côte d'Ivoire is a country of West Africa bordered by Ghana to the east, the second largest cacao producer. The country is split in two, where the south, along the coastline of 550kms there is a huge humid forest cover while the north is dryer and dominated by savannah. The forest encompasses about 48.2 percent of the surface area and about 51.8 percent is covered by savannah. Côte d'Ivoire knows a rapid growth of population, with 6.7 million in 1975 and up to 23.8 million in 2016 (WorldBank, 2018). Population remains young and rural, mainly living in degraded forest areas in the south. Besides, population relies on agriculture and more specifically on cocoa culture. Thanks to the agricultural sector where more than two thirds of the active population is employed, the GDP was estimated at 8.8 percent in 2016 (WorldBank, 2018).

High level of insecurity still seems to prevail in some parts of the country, particularly in its most forested areas (western and southwestern ZAEs), where the application of laws and regulations by state services seems to be fundamentally difficult, according to the following press articles and publications:

"The effects of the crisis persist and are manifested by the presence of urkinabés settled in the classified forest of Mount Péko (a forest that has been 100% destroyed since 2008 and considered a war zone after the Ouagadougou Political Agreement), and self-defense militias that are still active in the Duékoué and Guiglo regions" (SOFRECO, 2009).

"Today, 80% of those in the classified forests of oin-Débé and Cavally are armed with Kalashnikovs and rifles" (Le Monde Diplomatique, 2012);

"Ivorian President Alassane Ouattara promised in oubré a "relentless" fight against the uncontrolled armed gangs that plague the country's roads. In his view, the southwest region is a rich cocoa-producing area and is the scene of regular attacks by armed individuals" (News Abidjan, 2015).

Eventually, the huge demographic growth allies with agricultural expansion and insecurity to bring pressure on natural resources. Pressure on natural resources, in the form of huge deforestation, aggravated by the rising effects of climate change, threaten the local rural population. Based on the last INS study (2015), the poverty rate was estimated at 46%.



Map 1: Forest cover in Côte d'Ivoire in 2000, where highest density of forest cover is grey and lowest forest cover density is in white.

In the above map is represented forest cover dataset ("High-resolution global maps of 21st-century forest cover change.", 2013). We can roughly distinguish three main areas based on landscapes : the south with tropical humid forest cover, the intermediate area with medium forest cover density and the north with savannah cover. One third landscapes can be distinguish : the intermediate area being at the transition of both north and south areas.

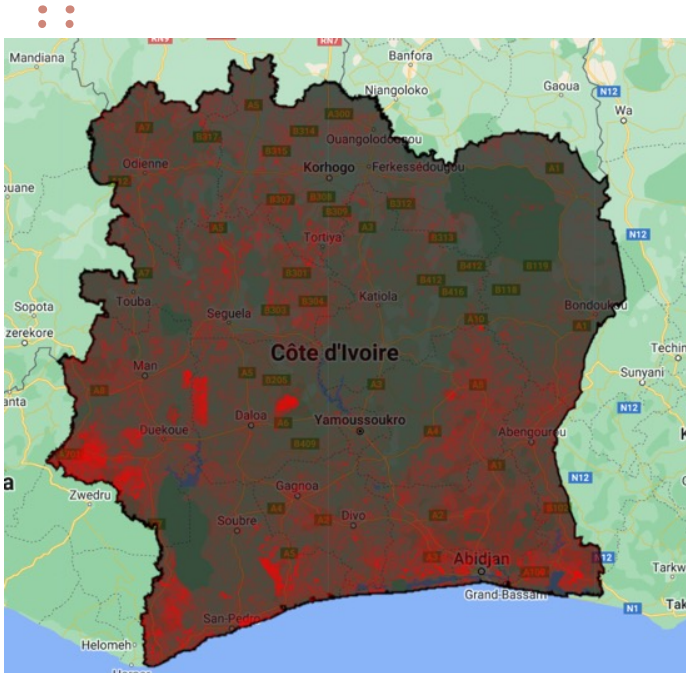
In the southern and western zone, we can find fallow lands and secondary forest forest cover encompassing few patches primary tree species such as *Musanga cecropioides* (Moraceae), *Nesogordonia papaverifera* (Sterculiaceae), *Diospyros* spp. (Ebenaceae), *Turraeanthus*

africana (Meliaceae) and *Tarrietia utilis* (Sterculiaceae).

On the intermediate landscape, we find both mesophilic forest and savannah. It encompasses several plant species such as *Khaya grandifoliola* (Meliaceae), *Khaya ivorensis* (Meliaceae), *Celtis* spp. (Ulmaceae), *Triplochiton scleroxylon* (Sterculiaceae) and *Nesogordonia papaverifera*.

Eventually, the last landscape at the north of the Côte d'Ivoire is composed of cleared forests and savannah with few patches of tree species as *Daniella oliveri* (Caesalpiniaceae), *Isoblerlinia doka* (Caesalpiniaceae) and *Azelia africana* (Caesalpiniaceae)

Challenges reducing the impact of measures



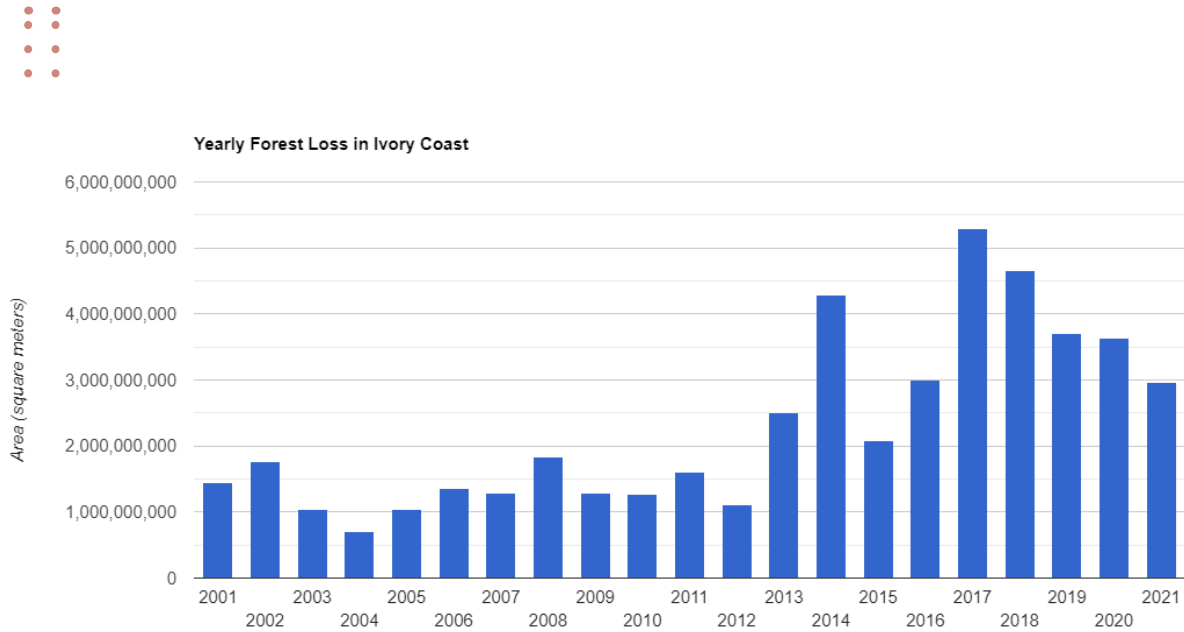
Map 2 : Deforestation over 2001-2020 in Côte d'Ivoire

Source : Author's calculation based on ("High-resolution global maps of 21st-century forest cover change.", 2013)

The Côte d'Ivoire has known a huge loss of its primary forest cover (during the period 1960 to 2017) with more than 3 million hectares of forest loss . Based on deforestation dataset ("High-resolution global maps of 21st-century forest cover change.", 2013), we can observe that trends of deforested areas increase with

a peak of deforestation in 2017 and about 500,000 hectares of forest loss. Also, in the map 2, and due to geographical features describe previously, we see that deforestation is more intense in the southern and northwest of the country.

¹ <https://euredd.efi.int/countries/cote-ivoire/>



Map 3 : Cumulative deforestation trends over 2001-2021 in Côte d'Ivoire

Source : Author's calculation based on ("High-resolution global maps of 21st-century forest cover change.", 2013)

As a result of the significant land deforestation and degradation highlighted before, which has caused important tree scarcity, timber production has been steadily declining in recent years. While more than 5 million m³ were logged in 1970, timber exploitation dropped to 1.2 million m³ in 2020 (MINEF, 2019 ; (Richard, 2021)). Nevertheless, « the forestry sector represents the fourth largest source of export revenue by value and remains a major provider of employment with approximately 50,000 direct jobs » (Richard, 2021) (ITTO, 2008; (Finif-

ter, 2010)). The main products of forestry exploitation are wood energy, namely charcoal and firewood and timber and service wood. However there exists no official data on timber production while fuelwood and charcoal consumption is difficult to assess. Besides, the growing population faces a lack of timber production due to its constantly increasing demand for firewood (about 80% depends on firewood to cook ((Cerutti P.O, 2015) ; Cerutti et al. 2017)) and a reduced timber production due to advanced forest loss.

According to ATBIT, in 1995 « fuelwood production was estimated at 14 million m³ » (Richard, 2021). Regarding deforestation, the main driver of deforestation remains agriculture expansion, through cash crops such as cocoa. Agriculture represented 27% of GDP and accounted for about 60% of employment in 2010 (PNIA, 2011). Besides, cash crops represent 73% of land crop area while others food crops account for less than 23% (RNA, 2001). Cocoa cash crop remains the main driver of deforestation with more than 1.7 millions tons of exports, making Côte d'Ivoire the world's largest producer with about 40% of global production.

Sawmilling units also face difficulties related to scarcity of some tree species such as Mahogany (*Khaya ivorensis*), Bete, Niangon (*Tarrietia utilis*), Makore (*Tieghemella heckelii*), Aboudikro (*Entandophragma cylindricum*) or Sipo (*Entandophragma utile*), Iroko (*Milicia regia*). Côte d'Ivoire is experiencing a huge lack of resources affecting all the supply and demand value chain. As for example, in 2004, only the ten biggest sawmills were able to transform timber (CIB, Inprobois, Sitrans-Bois, Thanry, Tropical Bois, SNTRA, SCAT, Trabex, Covalma et FIP). And in 2010, two sawmills (CIB and Covalma) closed while the remaining sawmills only manage to transform 40% of the national wood production. Eventually,

this lack of resources brings with it a lack of primary processing of timber transformation capacities for sawmills. Indeed, the current industries do not have technical means to saw wood with small diameter. Ultimately, the lack of technical means combined with the lack of primary resources exacerbates the wood crisis in Côte d'Ivoire.

Foresters' Actors:

In Côte d'Ivoire, we can find four main actors dealing with timber harvest. The first group encompasses actors primarily concerned by the exploitation of wood, the sustainable management of forest perimeters and wood processing units. These are loggers and wood manufacturers. The second group represents actors with the integration of the wood resource into the consumption circuit, with the marketing of wood and the manufacture of furniture and other finished products made from wood. This group is made up of merchants and wood craftsmen. The last group is comprised of actors that participate in the organization of the actors by structuring their professions and taking into account their various concerns for a better profitability of their activities.

The first three groups structure timber industries at each timber processing steps - going from timber harvesters, to timber processors

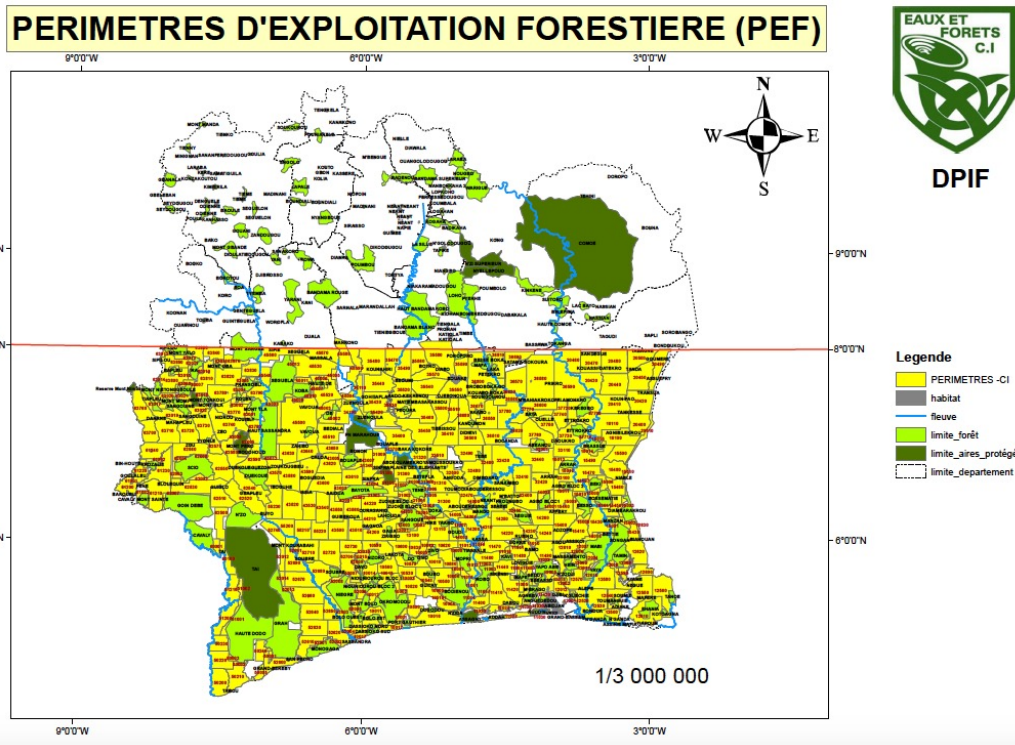
(sawmills), to timber commercials. Eventually they deal with legal deforestation and construction woods value chain. The last category of actors relies on illegal deforestation and fuelwood value chain. This supply chain is often unregulated where fuelwood is directly collected by local consumers (UNEP, 2019).

Legal forestry context and recent evolution:

The former Forestry Code of 1965, stipulated that the government of the Côte d'Ivoire owns trees. To harvest timber in Côte d'Ivoire logging companies have to get a licence (PEF : perimeter d'exploitation forestière). Those licences are handed out and managed by SO-DEFOR, which handles the technical monitoring of the forestry sector. Those PEF, where

timber harvest is legally allowed, are located under the 8th parallel (see map 3). Consequently, every timber harvest occurring above it, is considered illegal.

Illegal deforestation remains important in Côte d'Ivoire, even within PEFs. Illegal deforestation occurs mainly through fuelwood channels processing. Even if sanctions or other fiscal sanctions exist, illegal deforestation is still highly profitable. To face the current challenges of reduction of forest cover, Côte d'Ivoire has initiated the development of a new national strategy for the preservation and rehabilitation of forests. In 2019, a new Forest Code was published (Law No. 2019-675 of 23 July 2019). This new code includes a new forest category of "agro-forêt", where agriculture and reforestation will be carried out and where logging will be authorized under restriction.



Map 3: Périmètres d'Exploitation Forestière (Finifter, 2010).

Reference of Independent Monitoring as part of the governance has also been included in this new code. Publication of the associated implementing regulations is anticipated in 2020, following a multi-stakeholder consultation process (Gibson, 2007) . After a first revision

of the forestry code in 2014, a new forest code has been applied in 2019. In decree no. 2019-980 of 27 November 2019, a new area of PEF has been established. This area, called the agro-forest area, allows for forestry activities within agricultural areas.

Legislation and taxation scheme of 2019 forest code

The conditions for logging within Agro-Forests and Classified Forests in the State's private domain and in territorial Communities. The Agro-forests and classified forests of the State and local communities' private domain can be logged as part of managed concessions. In Agro-forests and classified forests of the State and local communities' private domain, logging is carried out in accordance with the management plan, the specifications and the technical standards defined by the forest administration. Logging quotas are established by the forest administration on the basis of, among other things: a forest inventory that is less than two years old; The minimum density threshold to be reached to ensure the regeneration of the ligneous resource, calculated based on the results of the forest inventory; The minimum harvestable diameter. The conditions for logging in forests belonging to private legal entities and individuals Logging in forests belonging to legal entities governed by private law and individuals shall be carried out in accordance with the simplified management plan or the management plan and the technical standards established by the forest administration. The harvesting of timber for domestic use in forests belonging to legal entities governed by private law and individuals or in community forests shall be carried out freely by the owner, in keeping with sustainable forest management and any provisions pertaining to protected species. The 2019 Forestry Code requires that forests be registered in the name of their owners (legal entities under public law, private law and natural persons). The registration of forests will make it possible to identify the owners of forests and thus avoid possible conflicts related to the ownership of the tree and the forest, and also to settle problems pertaining to responsibility. In the long term, and in the rural domain, PEFs (in their current format) will disappear, to be replaced by individual or collective forest properties, which will be subject to negotiations between loggers and the forest owners. Logging is subject to the obtaining of a logging permit, depending on the forest area. Since management concessions are specific, several types of logging permits will be generated. Every logging company is required to obtain an approval issued by the Ministry in charge of forests, and this approval is granted for a fee. The conditions and cost of this approval are determined by regulation.

Tax and fees:

In the rural sector, the Ministry in charge of Water and Forests continues to grant the management of forest logging areas (PEFs) to logging companies that have met the demands outlined in regulations. The payment of various specific taxes is a precondition in order to obtain a provisional authorisation to harvest within the area, namely:

- Usage Fees for General Interest Works – (TIG - Travaux d'Intérêts Général);
- Attribution and Area Taxes – (TAS - Taxe d'Attribution et Superficie), and;
- Taxes on the sale of logs.

It should be noted that other conditions are mandatory, such as, for example, having met one's obligations in terms of compensatory reforestation, not being subject to litigation related to logging misconduct, and producing a debt clearance certificate in relation to the forest administration.

Within the framework of partnership agreements related to classified forest area, a distinction is made between:

- Payment of an annual land usage fee based on the forest area under agreement
- Payment for stalks that will be harvested in accordance with the management plan.

In sum, this new Forest code helps ensuring the Zero Deforestation SDG goal to be achieved by promoting restoration of forest cover. However, other administrative issues remain regarding the ownership of tree. Indeed, based on the Article 27 paragraph 2 of

the Forest Code: “Ownership of a newly established forest or a planted tree lies with the landowner or the person who established or planted it under an agreement with the landowner”.

Issues of tree ownership in Côte d’Ivoire

The agreement between the parties can therefore stipulate that ownership of the trees planted by an investor reverts either to the investor or to the owner, i.e., the land title holder. Where the parties agree, there may be a difference between ownership of the land and ownership of that which is above and below the ground. The owner of a plot of land may therefore be different from the owner of the trees planted on it. In the absence of agreement between the parties, ownership of the tree reverts to the land title holder if, for example, he or she was unaware of the project (which is implied by Article 27 of the Forest Code). In this case, the land title holder can ask the investor to remove the planted trees. However, if the land title holder wants to keep the planted trees, he or she is required to compensate the investor (Article 555 of the Civil Code). But if the land title holder was made aware of the project by the investor and allowed it to proceed, the trees will not belong to the land title holder. Ownership of the planted trees then reverts to the investor (as implied by Article 27 paragraph 2 of the Forest Code). In this case, the land title holder who wants to reclaim a plot, whether or not he or she wants to keep the planted trees, is required to compensate the investor (Article 555 of the Civil Code). The above analysis is also applied to for compensatory reforestation, which is carried out to offset the timber removed from selective logging areas. So, depending on whether an agreement exists between the parties, ownership of the trees lies either with the land title holder or with the operator who planted the trees. This type of situation will very rarely arise in the years to come, given the current very low level of land registration in the country.

https://euredd.efi.int/wp-content/uploads/2022/07/Legal-framework-for-agroforestry-in-CdI_EN.pdf

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Agroforestry system in RCI

Overview of agroforestry potential for cacao



Despite Côte d'Ivoire being the largest cocoa producer in the world, it is also the one with the lowest cocoa yield per hectare (Assiri, 2012). It is experiencing mono sun-cropped cocoa systems, Cote d'Ivoire has a cocoa yields from 0.2 to 0.5 tons/ha per year (Assiri, 2012). Also, it leads to huge land degradation on the long term which ultimately requires rotation to new land every 20-30 years (Ruf, 2001). Land degradation, intensive and

extensive deforestation, with low yields increase the risk of food insecurity, non-cash flow for farmers that mainly lean on this cash crop (Gibson, 2007).

At current rates of deforestation, the country will lose all its forest cover by 2034. Reducing deforestation and increasing cocoa production becomes paramount for Côte d'Ivoire. One solution lies on good agricultural practices: agroforestry.

Agroforestry definition:

Agroforestry is the interaction of agriculture and trees, including the agricultural use of trees. This comprises trees on farms and in agricultural landscapes, farming in forests and along forest margins and tree-crop production. Interactions between trees and other components of agriculture may be important at a range of scales: in fields (where trees and crops are grown together), on farms (where trees may provide fodder for livestock, fuel, food, shelter or income from products including timber) and landscapes (where agricultural and forest land uses combine in determining the provision of ecosystem services).



In sum, agroforestry is a type of land management relying on the association of trees (used for multiple purposes, like timber firewood or fruits) and crops. In the case of the cocoa crop, it means using a mono-cropped cocoa system combined with tree species that allow shades. Promoting cocoa agroforestry should both increase yields in cocoa and improve forest restoration. Cocoa agroforestry system should thus relies on trees that are positively associated with cocoa which means trees that do not prevent the growth of young cocoa crop and increase cocoa yields (for either young or old cocoa). In spite of the scarcity of scientific data, literature states that young cocoa needs 70% shade while older cocoa requires less shade (up to 30-40%) (David, 2011). Based on their agroforestry system that encompasses plantain, cassava and timber trees, authors stipulate that in case of young cocoa crop, 70% shade is equivalent to 69 trees per hectare. Older cocoa needs 18 trees per hectare. Eventually, increasing shade and land nutrients will increase yields in the short term and increase farmers climate resilience in the long term. Based on REDD+ context, agroforestry is defined as a dynamic and ecological natural resource management approach that, through the integration of trees into agricultural landscapes, diversifies and increases production while promoting social, economic and environmental benefits to users. "In addition to shade, associated trees provide nutrients from deeper soil strata, and

some nitrogen-fixing plants (such as legumes) also enrich crops with their leaf litter".

Theoretically and on an economic point of view, this association of forest trees with cocoa trees is also a means for farmers to secure their income. They can be a vital source of additional income in the event of a drop in prices or poor harvests. For the producer, agroforestry is often promoted as a means of : (i) diversification of income, (ii) reduction of risks (especially market and climatic fluctuations) linked to monoculture, (iii) production of timber, energy wood and other useful products for the farmers and (iv) an extension of the cocoa tree's production period.

However, the complexity of an agroforestry system added to the distrust from cocoa farmers due to the lost of planted cocoa to plant trees make a different reality of such positive output. And this distrust is accentuated given the lack of reliable data and lack of consistent definition of what would be an efficient cocoa agroforestry system regarding geographic characteristics of south Côte D'Ivoire. Most of the time, if there are willing to develop cocoa agroforestry systems, farmers develop a simple agroforestry system that allow them to reduce their fears from loss of cocoa productivity. Also, the simplest form of agroforestry does not allow to meet ecological benefits like land restoration. Ultimately ecological benefits and cocoa yields increase skepticism of farmers to implement more complex agroforestry systems.

² "To create a well-established shade level, use the following spacing regimes for the corresponding crops and trees: i) Plantain : planted at 3 x 3 m rectangular spacing, resulting in 1111 plantain suckers per hectare ii) Cassava: planted at 2 x 2 m rectangular spacing, resulting in 2500 cassava cuttings per hectare iii) Timber trees: planted at 12 x 12 m triangular spacing, resulting in 69 timber seedlings per hectare iv) Nitrogen fixing trees like.

³ Gliricidia sp. : planted at 6 x 6 m triangular spacing, resulting in 277 Gliricidia seedlings per hectare". (David, 2011)

⁴ <https://euredd.efi.int/wp-content/uploads/2022/07/FULL-REPORT-CACAO-EN-COTE-DIVOIRE-FRENCH.pdf>

Presentation of the different agroforestry models

Cocoa agroforestry systems encompass the implementation of trees within cocoa crops in order to decrease human pressure on land, increase climate resilience of farmers and lift cocoa farmers out of poverty. In the (UNEP) report, two agroforestry models have been explored and compared with business as usual cocoa crops (mono-cropped). The first cocoa-agroforestry model relies on boundary planting model, while the second model leans on full intercropping planting. Both models increase soil fertility and incorporate mix tree plantations. Mix tree plantation encompasses fruit, energy tree and timber tree. The main difference between these two models relies on the shade cocoa exposure. Efficiency of agroforestry models will depend on climate, tree species and mix tree strategy. Indeed, incorporating

agroforestry into cocoa crop has the potential to reduce risks for cocoa farmers. Either agroforestry system diversifies income for farmers, thanks to fruit tree for example, or it increases cocoa yields (through soil improvement). Ultimately, analysis emphasizes that mix tree plantations combined with full intercropping planting are the most efficient regarding profitability of cocoa agroforesters. However, it is well mentioned that the most viable agroforestry-cocoa deals with young cocoa crop and “the model suggests an important advantage in combining crops with different revenue cycles such as food, timber, fruit or energy trees. The diversification allows to compensate or crop-specific revenue gaps”. Authors also warn that results are highly dependent with environmental and social features, which in turn will affect farmers’ choice.

⁵ <https://euredd.efi.int/wp-content/uploads/2022/07/FULL-REPORT-CACAO-EN-COTE-DIVOIRE-FRENCH.pdf>

Cocoa based Agroforestry business model : What matter ?

1. The level of shade

The level of shade depends on the number and crown area of each tree associated with the cocoa tree. The optimal shade for cocoa tree growth has been estimated at 70% - 80% . This study assumed that up to 70% shading would not impact cocoa yield compared to full sun planting. Increasing shading beyond 70% is likely to decrease yields. When shading is total (100%), this yield loss can be as high as 70% compared to full sun.

2. Density of associated trees

In high density situations, competition between cocoa trees and with associated trees has a negative effect on cocoa productivity. Therefore, this study assumes that an increase of 50 trees/hectare in density beyond 1320 trees/hectare, whether associated trees or cocoa trees, would result in a 10% reduction in cocoa productivity.

3. The nature and fertility of the soil

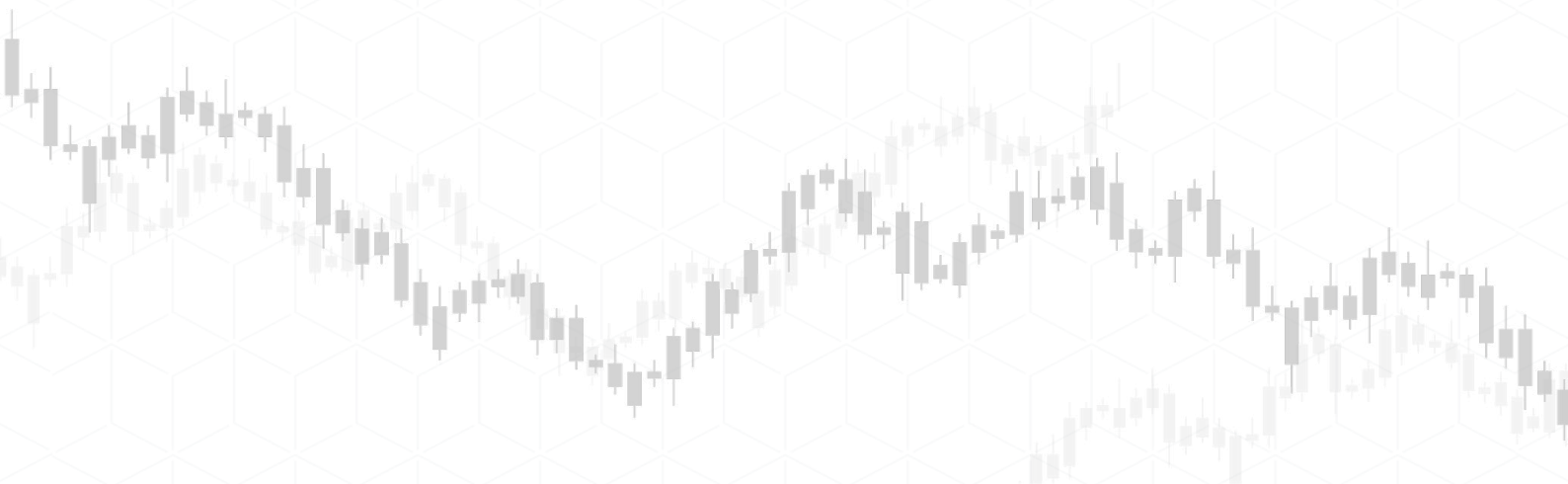
The chemical characteristics of the soil can be corrected by the use of fertilizers. In agroforestry systems, many authors argue that fertilizer application has no impact on the yield. In agroforestry systems, many authors argue that fertilizer application has no impact on yield in cocoa trees older than 25 years under optimal shade (shade compensates for fertilizer at this age). However, fertilizer applied to cocoa trees between 10 and 24 years old under shade resulted in a 40% increase in cumulative yield over the same period. This study makes the conservative assumption that the absence of fertilizer in agroforestry systems results in a reduction in cocoa yield of :

- 25% for cocoa trees less than 10 years old
- 40% for cocoa trees between 10 and 25 years old
- 10% for cocoa trees older than 25 years

These three factors are likely to have a very significant influence on the performance of an agroforestry system in terms of cocoa yields, and therefore indirectly on the profitability for the producer. A national definition of agroforestry including quantitative elements is needed to guide investments in a manner consistent with national policy objectives. This definition will have to take these factors into account in the trade-off between environmental and economic costs and benefits for the different actors in the cocoa value chain.

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Giving value to trees: the potential and importance of forest- based business models



As presented above, sustainable agricultural practices require to extend agroforestry to reduce land degradation and reduce risks for farmers. Also, based on sustainable agricultural practices, we distinguish two types of trees: one that is favorable for young cacao (more canopy density) and the other one that is favorable with old cocoa (land canopy density). Previous sections allow to highlight

the forestry context of the Côte d'Ivoire. We thus have identified three value chain through which agroforestry could deal with both better cocoa yields and reduce land degradation. The first value chain we identify deals with the development of construction woods and agroforestry. The second value chain relates to Non timber forestproducts tree species dealing both with fuelwood and fruit trees.

Long term cash flow generation: Construction woods and agroforestry

Construction tree species

Côte d'Ivoire is experiencing a huge scarcity of wood. Furthermore, due to legislation it is more advantageous for timber producers to export internationally processed timber instead of satisfying local demand MINEF (13.07.2021 - DOGUI Aboa, M. Ynsa)". In order to restore forest areas and increase timber production as well as satisfying local demand for woods, one way would be for timber producers to use agriculture lands to implement plantation. Based on qualitative data collected and literature, woods for construction has been identified as a potential value chain to develop for timber producers practicing agroforestry. Indeed, local demand is important for materials and construction woods "MINEF (13.07.2021 - DOGUI Aboa, M. Ynsa)".

Moreover, some agribusinesses identify promising tree species to develop the timber production. Timber harvesters note that Fraké and Framiré are interesting tree species to incorporate in cocoa planting. Timber sector highlights the need to develop and invest in construction trees. M. Fabien Larché, from Inprobois industry, has recently shared Inprobo-

is management plan to decrease land degradation by planting 2000 ha of construction trees within fallow agroforestry lands. Beyond that initiative, in 2014 the SODEFOR, the main forest institutional stakeholder in Côte d'Ivoire, was widely planting more than 34 tree species, where the Fraké and the Framiré represented 13% and 7% of tree species respectively.

Barry Callebaut's "agroforestry" in Côte d'Ivoire uses "Mercedes" cocoa – a full sun cocoa variety – in combination with trees such as Niangon, Acajou, Cédrela, Teak, Framiré, Fraké, Samba that address timber industry needs..

Issues

In promoting construction woods, one has to think about the supply chain. Indeed, timber producers face technical issues preventing them to efficiently harvest and send their timber on the domestic market. Fraké and Framiré are two fast growth woods; however, the disability of sawmills to process woods with diameter inferior to 70cm reinforce difficul-

ties of timber harvesters MINEF (13.07.2021 - DOGUI Aboa, M. Ynsa). Moreover to technical issues, timber producers also face financial tax burden which leads them to favor international market over the domestic one MINEF FLEGT. Eventually, those two issues feeds the development of an informal timber market

and exacerbates conflicts for land use. Timber producers are even reluctant to produce construction woods due to the lack of land tenure rights and illegal deforestation. The 2019 forest code however tries to fix that by stipulating that all planters practising agroforestry own the planted wood MINEF (13.07.2021 - DOGUI Aboa, M. Ynsa).

Fuelwood trees in an agroforestry system to prioritize short-term cashflows

Another value chain that can be developed is fuelwood. Many trees in Côte d'Ivoire are used to satisfy domestic energy uses such as cooking. Moreover, the demographic growth continues to put pressure on degraded lands and the last patches of forest. To deal with domestic demand for fuelwood trees and land restauration, an effective solution would be to provide trees that can be used by local population in an agroforestry system.

However, due to informal feature of the fuelwood sector, the lack of inventory of tree species in Cote d'Ivoire, and lack of reliable scientific literature on fuelwood tree species in Côte d'Ivoire, it is complex to designate one or two specific tree species that would improve, or at least not hinder, cocoa yield. Moreover, as stipulated in the UNEP report (UNEP, 2019) "Most of fuelwood is not for sale and is collected directly by consumers", underlining the absence of a formal fuelwood value chain.

Acacia is a tree that could be used in a cocoa agroforestry system as fuelwood. By harvesting fuelwood trees that have been planted within plots instead of harvesting wild fuelwood tree, on non-agricultural lands, prevents from land degradation. Consequently, the main benefit of incorporating fuelwood

tree species is to reduce pressure of local population on lands. But it also provides short term cashflows for farmers given that fuelwood tree selectionned above have a fast growth and can be harvested after 4 years being planted. The purpose of incorporating non-timber forest products in cocoa crop is a strategy to add additional revenue, reducing their risk by either increasing their cash flow or reducing food insecurity for farmers. Based on the tree species detailed previously, this value chain guarantees an income for farmers earlier than for timber species used for construction where trees have to mature for 20 years before being harvested.

Besides, agroforestry cocoa literature posits that farmers' incentives will depend on environmental, social and expected profitability of the planting model. In that sense, successful agroforestry cocoa system should involve income diversification. Nevertheless, the lack of reliable information on tree species that are positively associated with cocoa crop leads us to provide only few fuelwood tree species. On the other hand, fuelwood are often sold following a informal supply chain in Côte d'Ivoire which may prevent the positive effect of the agroforestry system developed.

⁶ We could also think about Samba tree as fuelwood tree. However, this tree is negatively associated with cocoa growth.

Fruit trees : diversifying cash flows

In (Atangana, 2021), authors recommend to promote cocoa-based agroforestry projects in Côte d'Ivoire that "should seek to optimize the integration of trees within cocoa farms by optimizing both the number of trees and the products and services provided by different tree species in ways that maximize economically, agronomic (i.e., cocoa yield), and environmental (i.e., sustainable production) benefits".

Regarding fruit tree species, in a mix planting strategy, we favor tree species that have positive relationship with cocoa but can also benefit local population either by providing food security to the local population or by being positively associated with other cash crops. In case of the Côte d'Ivoire, rice is another cash crop that becomes important. There exist several fruit tree species that bring positive impact on cocoa plant (Kapokier, Kplé, Kakrou, Makoré, Mirabellier to cite few of them). We however focus only on tree species we consider with the highest potential :

AKPI : this tree is a fast growth tree where fruit are sold on the local market (sold between 2500 and 3500 FCFA/kg). This tree provides light shade and Prefers well-drained soils. According to "Market Analysis of Selected Agroforestry Products in the Vision for Change Project Intervention Zone, Côte d'Ivoire Kaitlyn Smoot Amos Gyau Christophe" this tree is labor intensive but is not well developed in Côte d'Ivoire while seeds have a high local demand. Eventually this tree could provide additional cash flow on the short run for farmers.

Petit Cola : This tree can be used as fruit tree. His shade is adapted for cocoa crop with low shade and it is positively associated with the cocoa as it provides soil fertility. Also its grain can be sent on the local market. As indication, in 2020 in Côte d'Ivoire, seeds were sold between 750 to 5000 FCFA the kilogram (Nitidae, 2021). However, it is relevant to note that this tree has a slow growth and the germination occurs from 7 years old.

⁷ Some may be interested in have a look at the (Nitidae, 2021) report that provides extensive tree species regarding their association with cacao crop.

From theory to practices : Presentation of Case Studies

- https://www.itto.int/sdg-details/forest_restoration_sustainable_charcoal_and_empowered_women_in_cote_d_ivoire

This project aims at restoring degraded lands by promoting fuelwood trees within an agroforestry system. In this project they provide three fuelwood tree species such as Kassod, Saba and Teak. The general objective is to reconcile the short-term subsistence needs of their families for food and woodfuel with the medium- to long-term need to rehabilitate the forest. In part, this was achieved by building local capacity in seedling production, nursery establishment, forest plantation establishment and maintenance, and agroforestry. The project has considerable potential for replication elsewhere in Côte d'Ivoire and beyond.

- <https://www.reforestaction.com/blog/cote-divoire-restaurer-les-forets-degradees-et-accompagner-les-producteurs-de-cacao>

The project aims to restore the many ecosystemic services provided by the forests and to develop the benefits of agroforestry associated with cocoa farming. Several components are being carried out in parallel:

- The creation of agroforestry systems by planting fruit and forest trees in cocoa plots;
 - The restoration of the classified forests of Séguié and Rasso by planting local and varied forest species;
 - The sensitization and training of cocoa producers in agroforestry techniques and the sustainable protection of restored forests.
- **Monitoring and maintenance of the planted trees over the long term.**

Of various forest species (Framiré, Fraké, Mahogany, Niangon, Cedrela, Teak), the 51106 trees currently being planted will allow the reconstitution of dense and perennial forest ecosystems and ensure the ecological continuity of the forests of Séguié and Rasso.

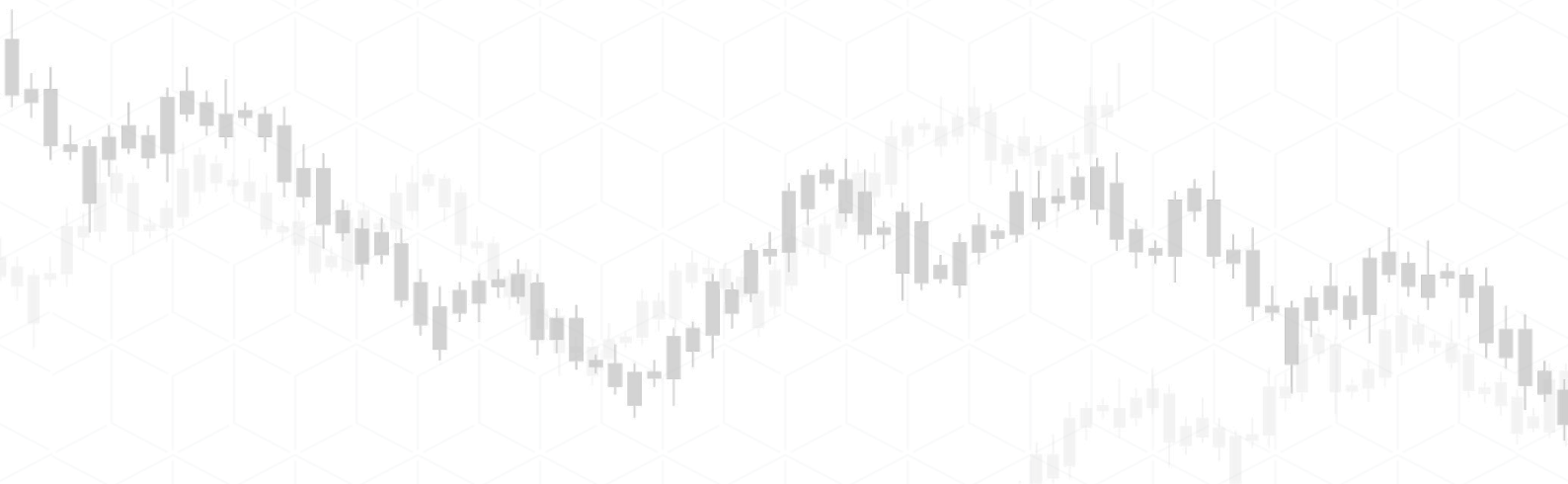
- <https://www.finnfund.fi/en/news/sustainable-teak-and-cocoa-plantation-in-nicaragua-scores-top-impact-points/>

This project took place in Nacaragua and promote cocoa based agroforestry system. The main objective of this project was to reduce pressure on forest cover by promoting fuelwood (teak mainly) in cocoa crop. They qualitatively shows positive impact in both curbing defor/ increase carbon storage and increasing cocoa yields.

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Recommendation

*The Business Case for Sustainable Timber
in agroforestry systems in Ivory Coast*



In this analysis, we saw that land degradation and deforestation in Côte d'Ivoire are mainly related to cocoa expansion and illegal deforestation (harvest of fuelwood trees). This massive deforestation has put timber producers under pressure due to scarcity of wood. The monoculture cocoa systems also put cocoa farmers under pressure. Despite being the first cocoa producer in the world, Côte d'Ivoire experiences the lowest yields per hectare.

To reduce pressure on land degradation, and improve timber producers' and farmers' livelihoods, this country initiated several legislation reforms. The most important one deals with the new 2019 Forest Code, promoting the development of agroforestry systems. Cocoa based agroforestry system should meet several sustainable development Goals. Agroforestry system should help reduce pressure on land degradation by restoring forests ecosystem. Also if well implemented, it would ensure income diversification and increase farmers resilience threatened by climate change. However several issues remain to achieve such objectives. First, farmers are expected to express reservation and hesitation regarding the implementation of agroforestry system. This hesitation is caused by a longstanding preconception that cocoa crops need to be planted in full-sun monocropped culture to perform fully. Moreover, agroforestry is seen as requiring to lose space for cocoa plants to plant trees instead. Ultimately, farmers think the lower density of cocoa plant would inevitably lead to a corresponding decrease in the cocoa yields. Second, the lack of reliable empirical analysis about the benefits of agroforestry system and tree species positively associated to cocoa prevent to sustainably promote the right agroforestry system. Based on this report, we propose several recommendations to address the aforementioned issues and reduce farmers skepticism:

1. Improve knowledge of agroforestry system and demystify myths and misconceptions about agroforestry;
2. Improve customary and formal land rights;
3. Reinforce knowledge of fast growth fuelwood trees;
4. Favor agroforestry systems that prioritize short term cashflows;
5. Improving sawmilling capacities to accommodate tree trunks of small diameters;

1. Improve knowledge of agroforestry system and demystify myths and misconceptions about agroforestry.

Adoption of agroforestry by farmers currently in cocoa monoculture systems is minimal, for several reasons. A lot of farmers express doubts about the loss of cocoa yields when agroforestry is implemented. This skepticism remains due the scarce of reliable literature showing that cocoa agroforestry systems can have similar or even better economic performance than full sun system (Jezeer et al., 2017). Beyond that many farmers think full sun system is the best performing cocoa system, another reason of such skepticism can be risen. A lot of farmers are poor and suffer from food insecurity. Ultimately, they cannot afford to lose money or wait for additional return in several years. To reverse this trend and improve farmers' behavior regarding agroforestry, it is important to reinforce first scientific knowledge of cocoa agroforestry system.

⁸ <https://euredd.efi.int/wp-content/uploads/2022/07/FULL-REPORT-CACAO-EN-COTE-DIVOIRE-FRENCH.pdf>

Scientific literature should pursue the work initiated in the UNEP report . In this report, it is well mentioned that : "In Côte d'Ivoire, there is no reliable scientific data illustrating the impact of tree association on cocoa yields. To date, there is no feedback in Côte d'Ivoire on the impact of agroforestry on cocoa yields" . Secondly, it is also important to reinforce the Farmers' trusts in the agroforestry system for their cocoa. To do so, some may think about trainings and empirical demonstration of successful cocoa agroforestry system.

2. Improve customary and formal land rights

" In Ivorian law, owning a piece of property means having the right to benefit from the full use and enjoyment of the property, provided that one does not use it in a way that is prohibited by laws or regulations. This means that someone who owns a tree can use it, keep it and enjoy the fruits generated by it. The tree owner can also sell the tree or give it away free of charge, in compliance with the regulations in force, which have yet to be clarified, particularly with regard to the terms of sale. There is no legal certainty regarding the ownership of trees planted on land subject to customary rights. If the investor has planted trees on land for which another person enjoys customary rights, the investor is exposed to risk. The lack of a contract leans that the investor can be evicted at any time, even if he or she is allowed to claim compensation for the plantations in question (Article 555 of the Civil Code). The conditions for transactions other than transfer (and in particular leasing) have yet to be determined by decree. This risky situation severely limits investment opportunities "

3. Reinforce knowledge of fast growth fuelwood trees

In case of fuelwood value chain, it would be necessary that the scientific literature extends research on fuelwood tree species that are positively associated with cocoa plant. Based on that report, and the precious Nitidae report, we were able to identify few fuelwood tree species that could be developed in a cocoa-based agroforestry system. However, research has to be reinforced to provide scientific evidence of the positive association between those tree species and cocoa. Indeed, due to the scarcity of information regarding fuelwood tree species and their association with cocoa crop we only provide few tree species (Acacia and Samba). Besides, those tree species are not always positively associated with cocoa yields in theoretical literature.

4. Favor agroforestry system that prioritize short term cashflows

It is worthy to note that case studies have qualitatively shown mix intercropping planting strategy brings positive outcomes for farmers. Moreover, investing in such NTFP species could prevent from future land degradation expansion but allows local population to generate short term cashflows. For example, Petit cola can be used by local population either by eating the seeds or sending them on local markets which ultimately can trigger news income channels for farmers practicing agroforestry systems. It would provide income diversification for farmers and would help promoting agroforestry system implementation. As for example, if farmers only deal with con-

⁹ <https://euredd.efi.int/wp-content/uploads/2022/07/FULL-REPORT-CACAO-EN-COTE-DIVOIRE-FRENCH.pdf>

¹⁰ <https://euredd.efi.int/wp-content/uploads/2022/07/FULL-REPORT-CACAO-EN-COTE-DIVOIRE-FRENCH.pdf>

struction woods within the agroforestry system developed, they should wait more than 20 years to generate cashflows. While implemented NTFP woods either as fuelwood or fruit tree can generate short term cashflows. Indeed, income increases through agroforestry will not alone lift the majority of these farmers out of poverty – the main factor for significantly raising farmers' income remains the cocoa revenues generated from land assets. Regarding this point, we suggest to incorporate other tree species related to fruit tree species that have positive effects on cocoa. In spite of the lack of reliable literature about it we can lean on the UNEP report that develop agroforestry business models and potential outputs. Those two business model and output are presented in the box herein after.

5. Improving sawmilling capacities to accommodate tree trunks of small diameters

In case of construction woods value chain, the main challenge remains the illegal deforestation and lack of capacities of timber producers. Based on the 2019 forest code, it would

be interesting to encourage timber producers to practice cocoa-based agroforestry by planting Fraké and Framiré. We recommend to significantly ramp up investment in sawmills equipments to increase timber extracton facilities of fast growth trees. In addition, we recommend to develop the market for the Fraké and Framiré tree species. Those trees have indeed positive impact on cocoa yields which in turn would also beneficiate to farmers.

Rubber tree is also a wood that is well developed in Côte d'Ivoire. Previously, we saw this tree specie can be used as firewood, however it also can be used as construction wood. As mentioned, the rubber does not have only positive effect on cocoa growth. However, it seems to not interfere the cacao seed quality on older cocoa plant. As agroforestry systems promote mix planting to maximize farmers' profits and as 2019 foret code reinforce protection of timber harvesters practicing agroforestry, we think that investment in rubber tree specie could be a value added. Timber harvesters could use fallow lands to plant rubber or implement a rubber mix tree boundary planting. Besides, Côte d'Ivoire already developed rubber initiative as presented in box 2 below.

11 Framework https://euredde.efi.int/wp-content/uploads/2022/07/Legal-framework-for-agroforestry-in-Cdi_EN.pdf

Issues of tree ownership in Côte d'Ivoire

Model A:

A combination of energy wood and timber with a strong preponderance of energy wood with energy wood representing 75% of the associated trees (concentration). There are no fruit trees and much more timber than in the type B pilot.

Results:

In the Type A model, Year 1 expenses related to the associated trees (purchase of seedlings and planting expenses) are significant. The results for cocoa decrease during the regeneration phase and then increase when the new Mercedes plants come into production. regeneration phase and then increase when the new Mercedes plants come into production.

The number of cocoa trees (833 trees/hectare) is 37% lower than the planting density recommended by the National Agricultural Research Center (1,320 plants/hectare). Therefore, lower cocoa revenues can be expected. In addition, the high number of associated trees per hectare affects the yield of cocoa trees.

During the period of regeneration of plant material, the planter benefits from the income from food crop. This income from the food crop compensates for the loss of income from cocoa during the first few years. There is a peak in income in year 4 due to the sale of energy wood. There is also a much more significant income peak in year 25 due to the sale of timber. It should be noted that until year 25 (except for year 4), the trees associated with cocoa (energy wood and timber) do not generate any income. and timber) only generate expenses. Compared to the reference model (a 20-year old plantation of cocoa in full the loss of income is significant and lasts a long time. For this reason, without specific assistance the financial risk associated with this type of pilot will only attract planters whose whose main source of income is not cocoa.

Model B:

A combination of energy wood-fruit trees - timber (diversification), thus all categories of trees are represented.

Results:

The density of cocoa trees is equivalent to the density recommended

The density of cocoa trees is equivalent to the density recommended by the Centre National de Recherche Agronomique (CNRA) for Mercedes cocoa, but the number of associated trees is lower than in the type A model. The optimal yield of the cocoa trees is therefore little changed. Income from food crops compensates for the loss of income from cocoa in the first few years. The small amount of fuelwood does not make its sale significant for the farmer's income. As there is less timber, the peak in income in year 25 is less significant than in the type A model. The period of loss of income compared to the reference model is very short. The farmer's income The farmer's income increases greatly. This model is therefore attractive to all farmers.

Rubber initiative

APROMAC, a private structure working in the rubber sector, has implemented its model which has made it possible to meet the demand for plants while generating jobs with new trades that could inspire the forestry sector. And OLAM has already started the production of nearly 1,000,000 seedlings with private nurseries, thus making it possible to plant more than 800,000 seedlings.

Source : Partenariat 1-20 -Compte Rendu (1-20, 2019)

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