The adaptation of Ivorian cocoa production to climate change: Agroecology as a potential solution

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The international context

Côte d'Ivoire is the world's largest producer and exporter of cocoa beans, accounting for nearly a third of total production. Cocoa represents more than 30% of all export earnings and over 15% of GDP. However, average cocoa yields are among the lowest on the planet, at less than 500 kg of beans per hectare per year.

These low yields are often attributed to the country's "ageing plantations", which are facing prolonged and acute droughts on an increasingly frequent basis. Some farmers even began replacing cocoa with rubber trees when rubber prices were still relatively high. Unfortunately for them, rubber prices have since collapsed due to international overproduction, while cocoa prices are rising as a result of increased demand for chocolate in some emerging countries. All indicators point to this trend continuing in the medium term (unless China is hit by an economic crisis). Nevertheless, the incomes of Ivorian farmers are usually insufficient to allow them to invest in replanting existing cocoa plants.

Many farmers, unable to increase hectare yields, are tempted to extend their cocoa plantations at the expense of the country's remaining covered forests. To date, more than 80% of Côte d'Ivoire's primary forests have been sacrificed for agricultural purposes, and those remaining are mostly protected areas. The Ivorian Forest Development Society (SODEFOR) is attempting to remove illegal farmers in forests. Clearly, the country's cocoa industry can no longer benefit from "forest rents". The future therefore depends on rehabilitating cocoa plantations, ensuring agroecosystems have similar fertility levels to forests. This requires sufficient humus content in soil to retain water in the arable layer, low parasite pressure, enough shade to prevent weed growth, etc.

The government currently requires multinational chocolate firms based in Côte d'Ivoire to purchase cocoa beans at a minimum price of 1,000 CFA francs per kilogramme (60% of the CIF price). There are no deductions for poor quality. As oligopolies in the Ivorian market, these companies attempt to guarantee supply by encouraging supplier loyalty. To do so, they employ methods such as bonuses for producer cooperatives that respect certified agricultural practices meeting sustainable development requirements (like those developed by Rainforest Alliance and Utz) or fair trade requirements (like those developed by Fairtrade).

The issue is whether good practices adopted to protect the environment (by stopping deforestation, maintaining biodiversity, etc.) and ethical standards (by preventing child labour, supporting the fair treatment and health of producers, etc.) are capable of ensuring the current and future viability of cocoa production in Côte d'Ivoire, given the country's damaged agroecosystems and higher probability of longer and more frequent droughts. Many farmers are aware that "the soil is worn out" and that their plantations are increasingly vulnerable to

pests (mirids, caterpillars, bugs, termites, etc.), disease (brown root rot, white root rot, etc.), weeds (*Chromolaena odorata*, *Panicum maximum*, etc.) and viruses (swollen-shoot virus), leading them to use insecticides, fungicides, herbicides and synthetic fertilizers when they can afford them.

Given the growing threat of climate change, as announced by the IPCC,[1] will fair trade standards be capable of ensuring a decent ("fair") living for Ivorian cocoa producers by supporting the development of "sustainable" production systems? By sustainable, we mean economically viable, non-polluting, non-harmful to agroecosystems' productive potential (their "fertility") and compatible with the well-being of future generations. This is the question this text attempts to shed light on.

Crop systems currently recommended by Côte d'Ivoire's National Centre for Agronomic Research (CNRA) and promoted by the National Rural Development Agency (ANADER)

The CNRA regularly publishes recommendations for improving cocoa yields in a pamphlet entitled "*Bien cultiver le cacaoyer en Côte d'ivoire*" (the best ways to grow cocoa plants in Côte d'Ivoire). The August 2015 edition of this pamphlet recommends the following techniques as "good agricultural practices" to be implemented by farmers:

- Planting hybrid cocoa varieties selected by the CNRA, including a Mercedes variety that produces crops within two years, because "unsorted cocoa pods have low productivity"
- Planting seeds in plastic bags in nurseries where shade is reduced during the month prior to transplantation in order to "accustom plants to light"
- Clearing ground for transplantation by "cutting down large trees" in forests and "leaving shrubs for two to three years to provide shade to young plants", or leaving land "fallow" and "planting banana trees to provide shade to young plants"
- Creating rectangular plantations of 3 x 2 metres (1,333 plants per hectare)
- Using mineral fertilizers, especially phosphorus, potassium and magnesium
- Removing weeds by alternately chopping back with machetes and using chemical herbicides, including Gramoxone and glyphosate (Roundup)
- Shaping and maintaining trees, which involves pruning, encouraging self-shading canopies and regularly removing suckers
- Using chemicals to fight harmful insects and fungi
- Harvesting mature cocoa pods, deshelling them by beating them with a stick, fermenting beans in wooden boxes or under banana leaves, drying them on trays and storing them in dry areas.

Environmental and international solidarity organisations supporting more "sustainable" forms of agricultural development (including Rainforest Alliance, Utz and Fairtrade Africa) have established alternatives to these recommendations. These include planting shade trees, composting agricultural waste, harvesting cocoa pods every two weeks, etc. However, the

[1] Intergovernmental Panel on Climate Change

new “agricultural good practices”, which can lead to bonus payments for producer cooperatives, do not always appear to take into account local agroecological conditions or the socioeconomic situations of different farming groups. Some recommendations seem more tailored to the needs of multinational chocolate firms, which seek increased yields per hectare and better cocoa bean quality (Ruf et al. 2013).

Given this context, are the agricultural practices that producers must meet to respect fair trade standards and obtain the required certifications well founded? Are there other agricultural production systems that could help cocoa producers earn decent livings without creating high levels of pollution or harm for future generations?

Shade

Unlike plantations in Latin American countries, where cocoa originated, most Ivorian plantations do not have shade. Cocoa plants are therefore directly exposed to the sun, after being planted in primary forest or forest fringe areas cleared using slash and burn techniques.

The most common reasons given for this lack of shade are the following: shade trees expose cocoa plants to brown root rot which thrives in moist conditions; shade trees and cocoa plants compete for soil moisture; shade trees harbour insects that are harmful to cocoa plants; and cocoa plants sheltered by shade trees can be damaged by forestry companies surreptitiously cutting down forests. However, given low rainfall levels in recent years and the damage caused by increasingly intense droughts, questions arise as to whether these recommendations are well founded.

There are many arguments in favour of providing shade for cocoa plants:

- Shade trees help maintain hygroscopic moisture, preventing the desiccation of cocoa leaves due to heat or wind. When rainfall levels are low, as is currently the case for Côte d’Ivoire, this does not lead to brown root rot.
- Shade discourages mirids.
- Some shade trees attract and harbour red ants, which prey on mirids, bugs and other insects that damage cocoa plants (including the mealybugs that carry the swollen-shoot virus? To check). According to many farmers, cola trees are “friendly” towards cocoa plants, despite the fact that the CNRA recommends cutting them down before planting. Other trees considered by farmers to be “friendly” include coffee trees, cashew trees, orange trees and soursop trees.
- Some shade trees help fertilize cocoa plants, by taking up minerals from the soil and depositing them on the ground when shedding leaves. The roots of some forest species (fraké, framiré, iroko, akpi, aboudikro, etc.) are colonised by mycorrhizal fungi, allowing them to take up phosphates in laterite soil, store these phosphates in leaves and restore them to the arable layer in organic form when shedding leaves, where they help fertilize cocoa plants (Bidzanga et al. 2009). Some leguminous plants (*Gliricidia*, *Acacia*, etc.) supply nitrogen, which may be more useful than previously thought; however, planting campaigns have failed miserably (Ruf et al. 2013).

- Shade also limits the growth of some weeds, such as *Chromolaena odorata* and *Panicum maximum*.
- Fruit trees (citrus trees, soursop trees, etc.) can be planted alongside cocoa plants. This fruit can then be sold at markets, producing additional revenues for farmers and stabilising household income, especially between harvests. Mango trees, however, are to be avoided, as they support the growth of an epiphyte (loranthus) and their roots compete with those of cocoa plants.

A blanket approach to the question of shade, regardless of circumstances in different cocoa-producing regions, should be avoided. Farmers' management of shade must take into account regional agroecological conditions, establishing a balance between the potential for mirid growth and the risk of brown root rot. Ideally, trees harbouring beneficial insects should be protected when clearing closed forests or long-term forest fringe areas to plant new plantations. Fruit trees or "fertilizing" trees are options when replanting or rehabilitating older plantations. Banana trees are an almost unanimous choice when it comes to temporarily shading young cocoa plants.

Fertilization

According to many farmers, spreading the synthetic fertilizers recommended by the CNRA and ANADER has a positive and almost immediate effect on hectare yields. However, the cost of these mineral fertilizers, which contain high levels of phosphate and potassium but low levels of nitrogen, is prohibitive for some producers (a 50 kg bag costs between 22,000 and 25,000 CFA francs). This is an argument in favour of using organic materials: dead leaves from shade trees, crop waste, livestock manure, household waste from dumps, etc. These organic fertilizers would help maintain and possibly restore soil humus, leading to water retention in the arable layer. This would be excellent for cocoa plants facing the threat of climate change.

Poultry droppings have considerable potential for farmers (which is not surprising given their relatively high levels of phosphorus). An entire industry has developed around collecting, transporting and selling this form of livestock waste. Droppings appear to be very effective. Ruf and Kiendré (2016) mention the example of a producer from Doueké who managed to double his net annual income by replacing chemical fertilizers with poultry droppings, although at a relatively high cost (44 bags of droppings per hectare). The main difficulty preventing Ivorian cocoa producers from systematically using droppings is the high transport cost, as most indoor poultry farms are located far from plantations. Other problems arise when attempting to find local land that can be used to plant maize and legumes to feed egg-laying and meat chickens.

Recycling cocoa pods to fertilize plants is a cheaper option, as these pods can be collected directly from fields after deshelling. In addition to maintaining humus content in superficial soil layers, recycled pods are a source of potassium. However, spreading pods on soil is often discouraged for fear of encouraging the spread of *Phytophthora* fungi, which cause brown root rot. Recommendations therefore usually involve composting pods before spreading.

Composting cocoa pods with ashes and crop waste of varying nitrogen content is often recommended. The heat generated by oxidation during composting kills the spores of harmful fungi, weed seeds, and the eggs and larvae of harmful insects. However, windrow and trench composting are labour-intensive, as organic matter must be frequently watered and turned. This can represent a non-negligible cost for producers: they must employ labourers or postpone performing other farm tasks if the family's labour power is insufficient. Composting manuals often show how to produce excellent compost, by alternating layers of pods, green material, ashes and animal waste (Gui Bernard et al.), but techniques for producing "the best" do not always lead to "good" results, as seen in many other agronomic recommendations seeking to "maximise yields".

The Bandama fair-trade cooperative society (SCEB), which produces fair-trade and organic products and is based in Tiassalé, would no doubt benefit from applying biostimulants containing yeast strains, bacteria (*Azotobacter*, *Pseudomonas*, etc.), and mycorrhizal fungi spores (*Glomus*, *Trichoderma harzianum*, etc.) for the organic fertilization of cocoa plants, provided these products are not excessively costly. These fertilizing products do not supply nutrients, but help plants absorb those already present in soil in forms previously thought unusable.

Generally speaking, the future of Ivorian cocoa production depends on exploring different ways of stimulating microbiological activity in soil to improve the bioavailability of the minerals present (especially phosphorus, potassium and magnesium): mycorrhizal fungi growth, phosphate solubilisation, atmospheric nitrogen fixation through nitrate reductase, cocoa root reinforcement and improved soil structure for better water and mineral uptake, etc. This approach could call into question the overuse of some chemical inputs such as fungicides and herbicides.

Protection against harmful insects and fungi

Ivorian cocoa plants are grown as single crops, without shade trees. This probably explains why they are often treated with a number of broad spectrum insecticides and fungicides. These include imidacloprid and permethrin for mirids, bugs and leafhoppers; deltamethrin for caterpillars; chlorpyrifos for termites; mefenoxam and mancozeb for brown root rot; etc. The Côte d'Ivoire Coffee and Cocoa Board (CCC) actively encourages the use of these products, some of which are distributed free of charge to producer cooperatives. This has most likely led to resistant insect species and ecological imbalances in agroecosystems, as the average annual coffee bean yield per hectare is still under 500 kg.

Today, very few farmers consider not using these products. Apart from the SCEB members mentioned above, cocoa producers who do not use pesticides are often too poor to do so – they are "organic by default". However, questions remain as to whether the systematic use of these products is harmful to biodiversity and farmer wellbeing in the medium and long term. Do broad spectrum insecticides harm beneficial insects (red ants, cocoa pollinators, etc.)? Are they dangerous for edible fish and snails? What impact do they have on producer and consumer health?

SCEB producers in Tiassalé use biopesticides and natural repellents (including a substance prepared using neem, garlic, peppers and oil) together with regular pruning and sucker removal to find the right balance between sun and shade, with varying degrees of success. They would like to purchase a neem grinder for this purpose. Once again, however, resistance to neem pesticide molecules may develop in the medium or long term.

The goal of sustainable organic agriculture is not so much to eradicate pests as to minimise their proliferation and the damage they cause, encouraging harmonious living conditions. But "sanitary harvesting", which involves removing pods affected by harmful fungi, insects and viruses, is insufficient. The ideal solution would be to regulate interactions between harmful and beneficial insects in crop systems that are more diverse than those existing today. Similarly, stimulators of plant defences (algae, horsetail and nettle extracts or microorganisms) should be tested to determine whether they help cocoa plants better tolerate or resist biotic stress. Perhaps, in the future, we may be able to spray plants with *Trichoderma Sp* spores, a natural antagonistic fungus from among the saprophytes living under cocoa plants that helps cocoa plantations resist *Phytophthora palmivora*. The CNRA could begin research on this subject under small-scale farming conditions.

Generally speaking, the untimely spread of pests and diseases can be prevented by avoiding single-crop farming over large surface areas and using multiple cocoa varieties with different pedigrees in the same plantations. In this respect, fields planted using "unsorted" cocoa pods with different genetic characteristics are more resilient to phytosanitary accidents than those planted with single hybrid varieties (such as the Mercedes variety) selected for their high yield potential. In the same way, farmers should avoid using too few cultivars when regenerating cocoa plantations through grafting.

Weeds

For farmers, cocoa plantations, especially those with insufficient shade, are threatened by two main types of weeds: Sékou Touré weed (*Chromolaena odorata*) and Guinea grass (*Panicum maximum*). The former is relatively easy to control by chopping back regularly with machetes. The latter is more problematic – it requires more labour due to the speed with which it grows. For this reason, producers often resort to chemical treatment, including the infamous glyphosate, a broad spectrum herbicide that the World Health Organisation (WHO) recently declared "probably carcinogenic". Only the poorest farmers and a few certified organic producers attempt to eradicate *Panicum* by manual weeding.

When plants have sufficient shade (from shade trees and self-shading canopies) and dead leaves are layered on the ground, weed regrowth and weeding requirements appear to be minimised, reducing the need for chemical products. However, fighting weeds is more difficult when replanting or rehabilitating cocoa plantations. Shade from banana trees and the weeding and hoeing of food crops are not generally sufficient to control weed growth. Weeds are therefore a major problem for farmers with young plants insufficiently shaded by shrubs or trees.

Grafting is one possible solution: not only do sowing and cutting techniques allow farmers to reap earlier harvests, grafting helps cover ground quickly with cocoa branches and foliage. However, the CCC appears to have reservations with respect to the risk of transmitting the swollen-shoot virus through contaminated grafting knives (CNRA and GFCC 2011). These concerns are questionable: indeed, the city of Soubré has authorised the Mars company and the World Agroforestry Centre (ICRAF) to use grafting to clone hybrid cocoa varieties with high yield potentials and high bean butter content.

Quality

Cooperatives are encouraged to deliver high quality beans to multinational chocolate firms. Many check quality before delivering produce. This involves measuring moisture content and, in theory, removing mouldy, mite-damaged and sprouted beans, as well as those considered too flat, slaty or purple. But multinational firms generally respect the government's minimum price of 1,000 CFA francs, without making deductions for poor quality. Given the fact that these firms are mostly concerned with maintaining supply volumes, they reject very few beans for quality reasons. Consequently, it is not surprising that instructions for shelling (which must take place within five days of harvesting), fermenting (which must occur in wooden boxes), drying (which must take place on fixed or mobile trays) and storing (which must take place in dry areas) are not always strictly respected.

Cemoi is the only company that offers a quality bonus for beans used in manufacturing gourmet chocolate. This group ferments, dries and stores its own beans in centralised locations in order to control the development of desirable aromatic compounds. In addition to verifying the abovementioned criteria, the company checks beans for the residues of pesticide molecules such as organochlorine (Lindane). The company would like to promote grafting in order to clone cocoa varieties that are better suited to the manufacturing of gourmet and aromatic chocolate.

The SCEB receives 1,800 CFA francs per kilogramme of organic cocoa beans. This price would appear to be high enough to ensure organic producers earn more than those using traditional cocoa production techniques, especially given that organic cocoa yields per hectare are not significantly lower.

"Agricultural advice" in cooperatives

The good agricultural practices promoted by ANADER, certification organisations and certain multinational firms are mostly based on studies completed by the CNRA and standardised by the CCC as part of public-private partnerships (N'Goran). ANADER receives partial payment from the CCC or Cargill for some of these field operations. Good practices are spread to cooperatives using a top-down approach involving several different vectors, including "field schools" (demonstration plots), "coaches", "rural development agents", "farmer intermediaries", etc.

Cooperative directors are well informed concerning the standards taught and can "recite" them perfectly. However, this does not prevent them from being cautious with respect to their

content. This is because techniques mostly aim to increase hectare yields without taking into account implementation costs, whereas farmers are mostly concerned with maximising income. In addition, the profitability of an agricultural technique depends on the socioeconomic conditions of different producer groups. Consequently, there are no real "good agricultural practices". To spread these techniques, farmers in similar agroecological and socioeconomic situations should be encouraged to share their experiences.

For this reason, some producers consider weeding by machete cheaper than using herbicides because they have many family workers to perform agricultural tasks and relatively small farms. For producers with larger plantations, weeding by hand is more expensive than using herbicides as it involves putting off other tasks to be performed on other plots of land (in rice-growing areas, for example) or hiring labourers (on commercial farms). These observations also apply to fertilization: composting organic materials is more common for poorer farmers with sufficient numbers of family workers.

Profitability therefore means different things to different kinds of farmers. This is clearly visible in the field. Depending on cocoa producers' socioeconomic situations, they can opt to: maximise income per hectare (if they have small plantations or live in areas with high levels of unemployment), maximise income per hour worked (if they have large plantations or alternative job opportunities), maximise profit ratios with respect to capital or funds invested (if they almost exclusively use paid labour), minimise the risk of poor results by diversifying production (if they wish to avoid putting all their eggs in the same basket), pace work based on cash inflows (if they work in extremely uncertain conditions due to high levels of debt, for example), etc. In these circumstances, the cocoa farmers most likely to implement crop systems that respect the public interest appear to be small producers using their own labour. They make intensive use of family workers (for whom there is no opportunity cost) and minimise the application of costly imported chemical inputs, which present risks for the environment and the health of Ivorian citizens.

Conclusion

We therefore face a major challenge when redefining the standards farmers must comply with in order to receive fair trade labels or guarantees: the practices encouraged by these labels and corresponding bonuses must allow producers to earn a decent (and fair) living while adapting their crop systems to climate change and implementing truly sustainable forms of agriculture, without producing excessive pollution or irreversible damage to agroecosystems.

The cocoa production systems that most closely mirror these fairness and sustainability requirements are plantations under canopy, which are often called agroforestry production systems. The key issue is choosing the right tree species for the cocoa plants to grow alongside. Ideally, there should be several different species, which together present the following characteristics:

- A thin canopy, such as that provided by banana trees, during the first four years of growth following the replanting of young cocoa plants

- Shade trees that take up water from deep soil layers and maintain sufficient moisture levels around cocoa plants through transpiration
- Sufficient shade to minimise mirids and weed growth
- Fertilizing trees that take up minerals in soil and deposit them on the surface when shedding dead leaves. These leaves also help maintain humus content in soil. Tree species can be leguminous.
- Trees capable of attracting and harbouring beneficial insects: cocoa pollinators as well as red ants, which attack mirids, bugs and other harmful insects.

The organic material deposited when trees shed leaves helps maintain humus content in soil. Spreading crop waste and animal faeces (chicken droppings, cow pats, etc.) has a similar effect.

It goes without saying that systems promoted by labels must be adapted for local agroecological conditions. Adopting a uniform set of methods ("standards") would be unrealistic. The socioeconomic situations of different producer groups must also be taken into account. Those most likely to benefit from rehabilitating cocoa plantations using the new production systems discussed here are small family-owned farms, where the opportunity cost of labour is almost zero. However, these farmers also have the fewest resources for implementing new techniques. They are therefore more deserving when it comes to enjoying the advantages of fair trade.

Two stumbling blocks must be avoided: overly specific norms that are impossible to apply in different ecological and socioeconomic situations, and overly general standards giving rise to contradictory interpretations that affect the reliability of the labelling process.

Bibliography

Adou Yao Y., Kpangui K.B., Aimé Vroh B.T. and Oattara D.: Pratiques culturales, valeurs d'usage et perception des paysans des espèces compagnes du cacaoyer dans des agroforêts traditionnelles au centre de la Côte-d'Ivoire. Revue d'ethnoécologie [online], 9 | 2016. http:ethnoecologie.revues.org/2474.

Agro Eco Louis Bolk Institute - AVSF: Guide du planteur cacao biologique et équitable au Togo. Lomé.

BASIC: Etude comparée des impacts et coûts sociétaux des filières du cacao venant d'Afrique de l'ouest et d'Amérique latine. Paris; April 2016.

Bidzanga N. et al.: Mycotrophie et connaissances paysannes des essences fertilitaires dans les agroforêts à base cacaoyers du sud Cameroun. Cameroon journal Exp. Biol. 2009.

CNRA – CTA: Bien cultiver le cacaoyer en Côte d'ivoire. Abidjan; 2015.

CNRA – CGFCC: Guide de la lutte contre la maladie du Swollen shoot du cacaoyer en Côte-d'Ivoire. August 2014.

CNRA: De nouvelles techniques pour régénérer le cacaoyer en Côte-d'Ivoire. CNRA Info n°37; October 2013.

Faessel L. and Tostivint C.: Les produits de stimulation en agriculture. Un état des connaissances sur les nouveaux intrants visant à améliorer les fonctionnalités biologiques des sols et des plantes. Notes et études socio-économiques n°40. Paris; May 2016.

Fairtrade International: Standards and pricing. Project assignment. Cocoa economic model former income. Nov 2015.

Gui Bernard B. et al.: Compostage à base de résidus d'écabossage. GiZ – PROFIAB.

Mousant D. et al.: Le rôle des mycorhizes dans la nutrition phosphatée des arbres forestiers. Rev. For. Fr XLIX - n°sp. 1997.

Mpika J. et al.: Inhibition de *Phytophtora palmivira* agent de la pourriture brune des cabosses du cacaoyer en Côte-d'Ivoire par *Trichoderma Sp*. Sciences et nature. vol. 6 2009.

N'Goran J.: Partenariat recherche agronomique et secteur privé pour une cacaoculture durable. CNRA; Abidjan.

N'Goran K.: Réflexions sur un système de production durable du cacaoyer : cas de la Côte d'Ivoire.

Ruf F., N'dao Y. and Lemeilleur S.: Certification du cacao, stratégie à hauts risques. Interéseaux; June 2013.

Ruf F. and Kiendré J.: L'innovation « fientes de poulets » dans les cacaoyères : révolution agroécologique ? CIRAD

Ruf F., Galo Kla A., Dja K. and Kiendré J.: La fiente de poulet dans les cacaoyères de côte d'ivoire. CIRAD

Voice: Baromètre du cacao. Bénéfices annuels estimés des entreprises / revenu quotidien d'un cacaoculteur. 2015.