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> SUSTAINABLE COCOA PRODUCTION

Learning from agroforestry

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In order to meet growing demand for chocolate products, numerous initiatives have been launched over the last 10 years with a view to increasing cocoa production. These initiatives continue to promote the input-intensive model advocated since the 1960s, even though this model has reached its agronomic, socio-economic, and environmental limits. Hence the proposal to learn from agroforestry in order to develop the current model: introducing fruit and forest tree species into cocoa plantations contributes to the agro-ecological intensification of cocoa production, while improving flexibility and resilience, which are essential to smallholder farmers, who grow 95% of the world's cocoa.

One of the consequences of improved standards of living in the emerging countries, such as India, China, Brazil and Russia, will be a 3% annual increase in demand for cocoa by 2020, according to the International Cocoa Organization (ICCO). At the same time, global production, which stands at around 4 million tonnes per year, will grow less quickly, creating a gap between supply and demand. Experts predict that by 2020-2025, 1 million additional tonnes of cocoa will be required to meet demand. There is therefore a high risk of a shortage by 2030 and of a 500 or 600% increase in cocoa prices. To prevent this, there is an urgent need to increase production in the long term.

Increasing production presents challenges to the main actors in the sector, in other words chocolate manufacturers, producer countries and farmers. Manufacturers must both secure their supplies in the long term and meet consumer demand at an acceptable price. The producer countries in which cocoa production plays a major macroeconomic role (contribution to the state budget, provision of foreign currency) must increase the income generated by this activity by exporting more cocoa, while limiting environmental damage. Finally, farmers, who cultivate small areas (2 to 5 hectares on average) and depend on the sale of cocoa, must increase their production in an unstable context, in terms of both the economy (fluctuating global prices, a lack of state support) and the climate (shifting seasons, global warming).

To meet these challenges, the chocolate industry has launched a number of different initiatives, but these initiatives continue to promote the input-intensive model proposed since the 1960s. Yet this model, which has admittedly generated a 180% increase in production between 1964 and 2014, has reached its limits for the smallholder farmers who produce almost 95% of the world's cocoa. These limits are agronomic, socio-economic and environmental.

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Limits of the intensive model

> Moving on from the intensive model, which has reached its limits.

The intensive model is based on the monoculture of selected, robust varieties, grown from hybrids seeds, in totally cleared forest areas or under light shade. For the first 20 years or so, yields remain high, often exceeding 1 tonne of cocoa per hectare, thanks to good soil fertility and low pest pressure following clearing. Then soil depletion occurs and pest pressure increases. In order to avoid a decline in yields, the intensive model advocates chemical fertilisation and phytosanitary treatments. However, the farmers rarely apply this model, because they either lack the financial means to acquire it (low capital, limited investment capacity, especially in the event of falling world prices), they do not fully understand it or they adopt another strategy. Cocoa plantations then become degraded, leading to the collapse of production, and the farmers abandon them (or replace them with different crops such as oil palms or rubber trees) and clear other areas to set up new cocoa plantations.

> Introducing trees into cocoa plantations.

In addition to its limited lifespan, this intensive model implies the constant expansion of cultivated areas and is also limited by a lack of land. Indeed, in the main producer countries (Côte d'Ivoire, Ghana), forests are becoming scarce, and in the other countries, access to available land is limited by pressure on land and the growing number of protected forest areas.

The advantages of cocoa agroforestry systems

> Obtaining high yields.

There are, however, cocoa production systems capable of steering the current model towards more diversified and resilient models that can help to increase and secure production in the long term: agroforestry systems. These systems have been developed and used for centuries by farmers in Central America (from Mexico to Panama) and South America (Colombia, Ecuador, Peru and Brazil), and also in Asia (Indonesia) and Africa (Côte d'Ivoire, Nigeria, Ghana and Cameroon). They can provide satisfactory yields – contrary to what is often reported –, while reducing the consumption of chemical inputs: key assets for the ecological intensification of cocoa production.

In Cameroon, for example, the yield of cocoa agroforestry plantations may exceed 900 kg per hectare after 20 years. This yearly output is similar to or even greater than the output obtained in many monoculture cocoa plantations where the farmers are struggling to apply the recommended model. It has been achieved in where cocoa trees are planted at a density of 1 000 plants per hectare, in association with around 100 trees (70% fruit trees and 30% forest trees). This performance has been confirmed in Central America. The assessment of cocoa plantations in a complex agroforestry system reveals yields which, despite their variability, may reach 1 100 kg of cocoa per hectare, a result that is all the more satisfactory given that it is achieved without any fertiliser application. In addition, the lifespan of cocoa agroforestry plantations often exceeds 50 years, which is far greater than the 20 to 30 years for monoculture systems when the intensive model is not adopted.

How can these results be explained? The association and management, in both space and time, of cocoa trees and several fruit and forest species (removing surplus individuals or replacing dead trees) stabilises the biomass recycling processes (plant litter decomposition) and the nutrient cycle. These processes help to maintain or even restore soil fertility through biological activity and also reduce erosion. For example, in Cameroon, without any chemical fertiliser application, the level of organic matter in forest cocoa plantations remains constant over time, and it increases in cocoa agroforestry systems set up in grassland areas (up to 3.1% in plantations over 40 years old).

Associating different fruit and forest species with cocoa trees also provides an alternative to chemical pest control, based on ecological regulation. The incidence of certain plant pests and therefore the use of phytosanitary products are reduced thanks to the management over time of the different tree species. The shade produced by the presence of trees in cocoa plantations helps, for example, to limit infestations of mirids, sap sucking insects that are the main cocoa pests in Africa. This incidence is also reduced by certain spatial structures: in Cameroon, the random organisation of forest trees is proving effective in regulating mirid populations. In Costa Rica, this same spatial organisation helps to better control frosty pod rot, a disease caused by a fungus *(Moniliophthora roreri)* whose incidence is high in Central America.

> Limiting the use of chemical inputs.

> Meeting the needs of rural households.

Another advantage of agroforestry practices in a context of climate change is that it is possible to grow cocoa trees in areas previously considered as unsuitable or marginal. In Cameroon, cocoa plantations have been established since the 1930s in grasslands in the Mbam-et-Inoubou forest-savannah transition zone, an area that is nevertheless relatively unsuited to cocoa production. By maintaining soil humidity and limiting evapotranspiration from cocoa trees, agroforestry helps to reduce the constraints linked to the long dry season in this area that results in a high mortality of monoculture cocoa trees. Associating other tree species with cocoa trees improves soil fertility and compensates for mediocre soil quality, and also helps to control *Imperata cylindrica*, a weed that competes with cocoa trees.

Flexible and resilient systems

In addition to these favourable aspects for the ecological intensification of cocoa production, agroforestry systems also ensure flexibility and resilience, which are important to the smallholder farmers affected by sometimes highly volatile global prices and by climate change. Indeed, by associating several tree species with cocoa trees, farmers can reduce the number of technical interventions (phyto-sanitary treatments, pruning) for a period of several years, for example when world prices fall or during a problematic succession, without compromising the survival of their cocoa plantations. This is seen in the long-term management of old cocoa agroforestry plantations established in the Centre region of Cameroon in the 1920s and 1930s. In these plantations, periods of minimal cocoa tree management were followed by recovery phases during which farmers intervened to rehabilitate cocoa trees (coppicing ageing individuals and replacing missing trees). With this flexible model, cocoa plantations are more easily restored than monoculture plots, and the performance level preceding the minimal management phase is regained more rapidly (Figure 1).

Moreover, by making it possible to consume fewer chemical inputs, agroforestry systems enable farmers to reduce not only their operating costs, but also their dependence on phytosanitary products, which is especially important when income decreases further to a fall in cocoa prices.

By performing a number of functions, agroforestry systems are more suited to meeting the needs of rural households. In addition to cocoa production, they provide a range of products that can be consumed by the household or sold (fruits, medicinal products, timber, etc.), some of which constitute replacement products during the lean period or when cocoa prices fall.

Finally, agroforestry systems provide ecosystem services such as maintaining soil quality or creating a microclimate favourable to cocoa trees. In a context of rapid deforestation, they enable the circulation of numerous wild species living in forest fragments that subsist in major intensive cropland areas. Some of these services,

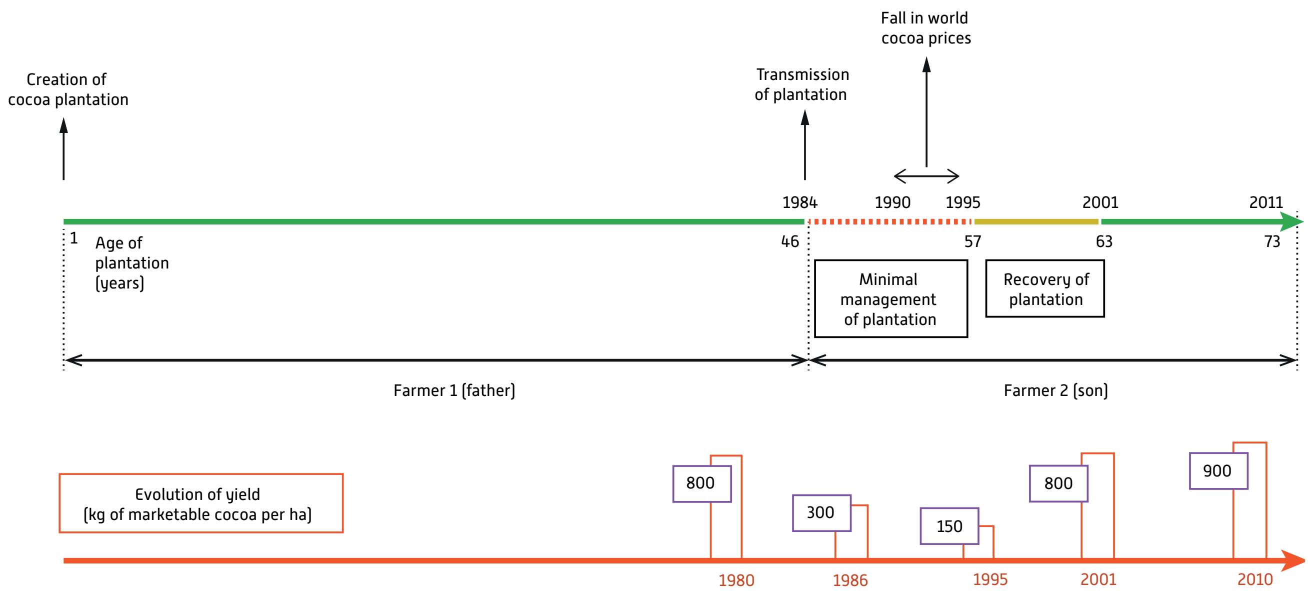

Figure 1. Resilience of a cocoa agroforestry plantation in Cameroon: the plantation regains its level of performance after a minimal management period of 11 years and a recovery phase of 6 years (Jagoret, 2011).

such as the provision of habitats for wildlife, the conservation of animal and plant biodiversity and carbon storage, could be rewarded by mechanisms that promote the ecological benefits of cocoa agroforestry plantations, as is the case in Costa Rica and Indonesia.

Understanding agroforestry systems

Developing new systems nevertheless requires a deeper understanding of the processes underway in cocoa agroforestry systems. How does a cocoa tree function within an agroforestry system? What relationships do cocoa trees have with associated species? Are these competitive relationships? Is this cohabitation mutually beneficial? What are the nutrient flow dynamics in cocoa agroforestry plantations? How do the cocoa trees benefit from this? What compromises do farmers make between cocoa production and ecosystem services? Do ecosystem services compete? Is it possible to identify optimal compromises between several ecosystem services? The answers to these questions will help to identify leverage for developing new technical and economic guidelines to help farmers to better integrate agro-environmental issues into their strategies. They will also help to improve current agroforestry systems without compromising their equilibrium.

Learning from agroforestry systems in order to steer the intensive cocoa production model – the only one currently proposed to farmers – towards models that reconcile cocoa production and the provision of ecosystem services is all the more necessary given that the key links in the global cocoa supply chain have similar objectives: producing more cocoa in the long term while minimising environmental impacts. <

This issue of *Perspective* is the result of research and appraisals carried out within cocoa agroforestry systems by CIRAD and its main partners: Institut de Recherche Agricole pour le Développement (IRAD) in Cameroon and Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica. This research was conducted from 2003 to 2012 in two research and training platforms in partnership: first, the *Agroforesterie Cameroun* platform, within which two projects financed by the French Ministry of Foreign Affairs were conducted – "Competitive and sustainable cocoa production systems in Africa" and "Strengthening agricultural research partnerships in Cameroon" (REPARAC); second the *Agroforestry Systems with Perennial Crops* platform, within which the "Central America cocoa" project was conducted (Costa Rica, Nicaragua, El Salvador, Honduras and Panama), financed by the Norwegian Ministry of Foreign Affairs.

This research has led to several publications, including:

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Quelques mots sur...

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