Cocoa agroforestry systems in Africa – the art of reconciling sustainable production and ecological services

Patrick Jagoret, Stéphane Saj, Aurélie Carimentrand

perspective
the CIRAD policy brief

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT

Through *Perspective*, CIRAD provides an opportunity to explore new avenues for discussion and action based on research.

Cocoa agroforestry systems in Africa – the art of reconciling sustainable production and ecological services

54

Patrick Jagoret - Stéphane Saj - Aurélie Carimentrand

Combining mixed trees with cocoa trees in so-called cocoa agroforestry systems is emerging as a viable option for regenerating cocoa cropping in Africa. Pure cocoa crop stands currently prevail in these areas but are running out of steam. Technical solutions are therefore urgently needed to stabilize cocoa-growing areas, reduce pressure on forests and adapt to climate change. A balance can be struck in stands by combining cocoa trees with diverse trees chosen by farmers for their different uses, while maintaining a suitable and sustainable cocoa yield. Ecological services such as carbon storage and crop protection are co-benefits of this balance. Recent research in Cameroon highlights that cocoa agroforestry stands can be managed using a straightforward indicator—measurement of the basal area of cocoa trees and associated trees. This indicator could be adopted for sustainable cocoa production certification purposes, while the observed convergence between local know-how and scientific results could facilitate joint drawing up of technical recommendations.

Cocoa production has been booming in Africa over the past 60 years and the cocoa cropping area has doubled in size from 3.3 million ha to 6.5 million ha. The African continent—with its 3 million t of cocoa produced yearly (865,000 t in 1961)—has become the world's leading cocoa producing region. The main producing countries are Côte d'Ivoire and Ghana, which alone account for 70% of global supply.

The average yield of the African cocoa orchard also roughly doubled from 254 to 484 kg/ha between 1961 and 1996, after which it levelled off and has remained virtually unchanged. Note therefore that, since the cost of rehabilitating a degraded cocoa farm is higher than that of setting up a new cocoa farm after forest clearing, increased global cocoa production has always been inseperable from the expansion of cultivated areas.

In Côte d'Ivoire and Ghana, the expansion of cocoa cropping has led to massive deforestation, with the concomitant loss of many ecological services—biodiversity conservation, carbon storage and soil fertility maintenance. Pure cocoa tree cropping (monocropping, with few or no associated trees) has historically prevailed, but this strategy is unsustainable and currently deadlocked. Old cocoa orchards—due to a lack of adequate inputs—barely produce after 20-30 years and proposed rehabilitation techniques (replanting, pruning) are seldom applied. Forest areas available for setting up new orchards are also dwindling, prompting many farmers to encroach on classified forests. Moreover, climate change will further reduce areas suitable for cocoa production in West Africa. In response to the threat of seeing their last forests disappear, Côte d'Ivoire and Ghana, alongside major companies in the cocoa industry, therefore pledged at the Bonn Climate Conference in 2017 (COP23) to protect these forests and promote agroforestry.

Sound technical solutions are now urgently needed to enable this region to address two major challenges—stabilize existing cocoa-growing areas while reducing the growing pressure on residual forests and, secondly, adapt to climate change.

Moreover, alternatives to cocoa monocultures should be considered in countries that still have abundant forests, especially in Central Africa. These countries could legitimately diversify their economy by developing cocoa farming, thereby reducing the strain on West Africa where the peak production capacity could soon be reached.

Agroforestry – a viable option for enhancing cocoa cropping in Africa

Cocoa farmers have been advised against adopting agroforestry—i.e. combining fruit and forest trees with cocoa trees—since the 1960s. This traditional practice is still being denounced today for delivering lower yields than cocoa monocropping, despite the fact that it is implemented in many cocoa-producing countries elsewhere. According to its detractors, associated trees of varying numbers compete for light, water and minerals to the detriment of cocoa trees.

These arguments may be partly relevant, yet recent research in Cameroon illustrates that the presence of service trees in cocoa stands does not preclude decent crop yields. Actually, cocoa agroforestry systems predominate in this country. The average cocoa yield, estimated on the basis of pod counts, is 740 kg/ha of commercial cocoa in plots with an average of 1,500 cocoa trees—similar to densities in monocropped cocoa plantations—and 190 fruit and forest trees. Yields as high as 1 t may be obtained, even without chemical fertiliser applications. Moreover, depending on the complexity of these cocoa stands (number and types of associated trees), their average carbon sequestration capacity can reach 75 t/ha or even more, which often represents 50% of that of secondary forests in the areas where they have been planted. Otherwise the carbon sequestration capacity of monocropped cocoa plantations is around 10 t/ha.

In some plots, this trade-off between cocoa production and carbon sequestration coincides with another crucial ecological service for farmers, i.e. controlling two major pests: black pod rot caused by a fungus, and mirids, i.e. biting and sucking insects whose repeated damage gradually leads to cocoa tree death. Farmers modulate the shade provided by associated trees to curtail fungal dissemination (favoured by dense shade) and infestation by mirids (which swarm when there is little or no shade). This enables them to reduce pesticide treatments and therefore save up to 70% of the crop protection budget in intensively managed plots.

Basal area – an operational indicator for cocoa agroforestry system management

Studies on cocoa agroforestry stands in Cameroon have shown that the basal area per cocoa tree, which reflects the extent of competition between cocoa trees and associated trees, is a good indicator to help farmers decide on trade-offs between cocoa production and ecological services. The basal area is determined by measuring the trunk circumference at a given height and then calculating the cross-sectional area, or so-called 'basal area'. This measure—which is conventionally used by foresters—can be readily applied by technicians and even farmers.

The target indicator here is the relative basal area of cocoa trees (see box p. 3), i.e. the ratio between the sum of the basal area of all cocoa trees in the stand and that of all trees in the stand (cocoa trees + associated trees). In Cameroon, the mean value of this indicator is 40% in adult cocoa agroforestry stands that produce 1 t/ha of commercial cocoa, whereas it is 36% in cocoa farms with the best trade-offs between cocoa yield, carbon storage and pest control.

This indicator may also be used to assess another trade-off that reconciles a good cocoa production level with the cocoa farm longevity. In Cameroon, the fact that the relative basal area of cocoa trees ranges from 40% to 55% means that cocoa yields of up to 1 t/ha can be achieved while at the same time maintaining cocoa tree stands beyond 40 years—the threshold above which it is generally considered that stands need to be rehabilitated.

Cameroonian farmers achieve this balance by gradually reducing the associated tree density over time, while retaining only 120-140 trees/ha in the oldest cocoa farms. The basal area of these trees levels off at around 16 m^2/ ha, to the benefit of cocoa trees whose basal area increases from 2.4 m^2/ha in young stands to 9 m^2/ha in the oldest. These long-term associated tree management practices are accompanied—particularly in the senescent stands—by the gradual rehabilitation of cocoa stands. The latter involves replacing dead trees and pruning old cocoa trees to promote new shoot growth from the trunks (rejuvenation pruning). The presence of associated trees in degraded cocoa stands enables farmers to sidestep stand rehabilitation measures to restore both shade, which is already present, and soil fertility fostered by plant debris decomposition.

Farmers' choice of tree species mixtures depends on their uses (fruit for self-consumption or sale, timber, medicinal bark, etc.) and the services they may provide (soil fertility maintenance, shade, etc.). Farmers select associated tree species according to their positive or negative effects on cocoa trees. They deliberately make trade-offs between cocoa production and other uses and services according to their production strategy and economic capacity. The cocoa yield variability noted in Cameroon suggests that many farmers would need to better select and manage their associated species mixtures, yet their empirical knowledge seems to be in line with the scientific knowledge overall. This convergence between local know-how and scientific results could serve as a legitimate basis for dialogue between farmers and researchers so as to be able to co-construct technical advice tailored to farmers' needs.

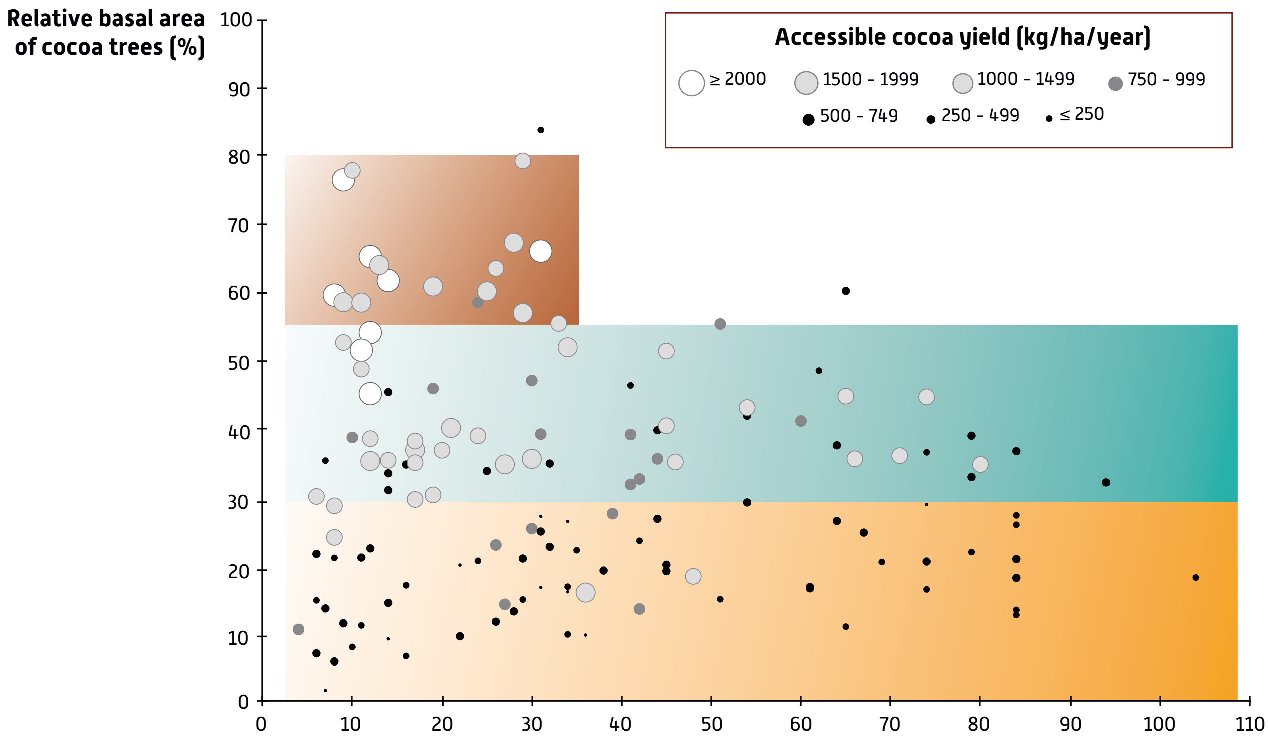
In conclusion, the relative basal area of cocoa trees appears to be a key indicator for managing cocoa agroforestry stands, their agronomic performance, longevity and trade-offs between cocoa yield and various ecological services. This type of analysis—which may be achieved via a straightforward measurement on cocoa trees and associated trees—could readily be carried out in other cocoa growing areas or environmental situations. Local values of this basal area indicator and the associated tree densities should be specified. This would enhance estimation of existing trade-offs and help identify optimal levels that could be achieved locally (cocoa yield, carbon storage, etc.). Such calibration would provide a basis for discussions with farmers on technical levers that could help them achieve their sought-after balances.

Potential update of certification criteria

Since the late 1990s, voluntary sustainability and fair trade standards relating to the cocoa sector (Rainforest Alliance, UTZ, Fairtrade, etc.) have aimed at boosting the productivity and sustainability of cocoa stands. It is assumed that these standards—which benefit from certification systems—will ensure compliance with a set of sustainability criteria via different procedures, such as the development and revision of specifications, as well as compliance criteria, audit procedures, and training and accreditation of certification bodies. The specifications of these standards include a set of agricultural, social and environmental management criteria. However, criteria for agroforestry practices differ from one standard to another—they may include the number of mature trees present in the cocoa stand (e.g. 12 trees/ha), above-ground cover of shade trees (e.g. 30%) combined with a number of associated tree species (e.g. five species), or indigenous vegetation cover (e.g. 15%).

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

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



Source: Saj *et al.*, 2017. https://doi.org/10.1016/j.agsy.2017.06.002

In the centre of the figure **(blue)**, cocoa agroforestry stands have optimal characteristics. Yields are close to or above 1 t/ha of cocoa, and this performance lasted well over 40 years. These stands have a per-hectare mean of 137 associated trees. The relative basal area of cocoa trees ranges from 30 to 55%—cocoa trees represent on average 9.3 m^2 and associated trees 11.4 m^2.

In the upper part of the figure **(brown)**, cocoa tree cropping is not sustainable. The stands are simple, with a per-hectare mean of 70 associated trees. The relative basal area of cocoa trees is over 55%—that of cocoa trees is 8.6 m^2 on average, while that of associated trees is 3.8 m^2. Yields can reach over 2 t/ha, but these cocoa trees do not last more than 30 to 40 years as they are hard to maintain, even with chemical inputs such as fertilizers.

Conversely, in the lower part of the figure **(orange)**, cocoa tree cropping is sustainable but low yielding. The stands are complex, with 176 associated trees per hectare. The relative basal area of cocoa trees is less than 30%—cocoa trees represent 5.1 m^2 and associated trees 24.4 m^2. Yields range from less than 50 kg/ha to 750 kg/ha.

These standards have been widely adopted over the last decade and have led to the implementation of a virtuous chain of agroforestry practices in cocoa production systems. There are, however, serious shortcomings in their criteria with regard to ecological service provision and cocoa stand longevity—the expected benefits seem quite marginal in terms of carbon storage, biodiversity, pest control and soil fertility maintenance, etc.

Firstly, the research carried out in Cameroon shows that the expected benefit of associated trees—i.e. interesting trade-offs between cocoa production, several ecological services and cocoa tree longevity—presupposes conservation of about 100 trees/ha, which is much more than set out in the recommendations of current certification programmes.

Secondly, the above-ground shade tree cover criterion is very hard to quantify, which makes it interpretable and reduces its reliability. Shading is indeed a highly variable parameter and the various techniques geared towards estimating it have many drawbacks. This is also the case for indigenous vegetation cover, whose definition could also be questioned.

Finally, the criteria adopted—tree density, number of species, shade, vegetation cover, indigenous or not—do not enable a genuine assessment of the trade-offs between cocoa production and ecological services.

This is why the relative basal area of cocoa trees may serve as a compliance criterion that could be mainstreamed with these standards to generate a new cocoa stand management tool—a precise, easily measurable indicator that can be tailored to local conditions.

Yet to achieve the targets set by the European countries that signed the Amsterdam Declaration (2015), which pledged to stop accepting imports of uncertified cocoa while developing strategies to combat imported deforestation, the adoption of this indicator in the panel of compliance criteria for sustainable cocoa certification needs to be accompanied by funding measures for farmers. These could include upwardly revised and better distributed bonuses, financial incentives dissociated from productivity such as payments for environmental services (PES), or tax incentives (e.g. a fiscal bonus/penalty system to promote sustainable cocoa). These economic levers are essential to help cocoa farmers adapt to the production standards imposed on them and to adopt the agroforestry practices necessary for the renewal of African cocoa production. ■

Perspective n° 54 is the result of research and consultancy initiatives conducted firstly on cocoa agroforestry systems by CIRAD and the Agricultural Research Institute for Development (IRAD) in Cameroon, and secondly on cocoa certification by CIRAD for the French Development Agency (AFD, https://www.afd.fr/en).

In Cameroon, research was carried out over the 2009-2017 period as part of the Platform in partnership for research and training (dP) *Agroforestry systems in Central Africa - Agroforesterie Cameroun* (https://www.cirad.fr/en/our-research/platforms-in-partnership-for-research-and-training/list-of-platforms/agroforesterie-cameroun) via the following projects:

> STRADIV, https://stradiv.cirad.fr), 2015-2018, funded by Agropolis Fondation (https://www.agropolis-fondation.fr/?lang=en).

> SAFSÉ, Search for trade-offs between production and other ecosystem services provided by tropical agroforestry systems (https://safse.cirad.fr/en), 2012-2015, funded by CIRAD and the French National Research Institute for Sustainable Development (IRD, https://en.ird.fr).

> AFS4FOOD, Enhancing food security and well-being of rural African households through improved synergy between agroforestry systems and food-crops (https://afs4food.cirad.fr/en), 2012-2015, contracted by the African Union with financial support from the European Union (EuropeAid).

> REPARAC, Renforcement of Partnerships *in:* Agronomic Research in Cameroon, 2005-2008, funded by the French Ministry of Foreign Affairs (Pedelahore P., Onguene Neree A., Havard M., David O., 2009. Résultats et enseignements du projet REPARAC. *In* Atelier PCP-REPARAC Innover pour améliorer les revenus des exploitations familiales et la production agricole du Grand Sud Cameroun, 24-26 juin 2009, Mbalmayo, Cameroon. Communication, 21 p. http://agritrop.cirad.fr/550870/).

Publications resulting from this research include:

Andreotti F., Mao Z., Jagoret P., Speelman E. N., Gary G., Saj S., 2018. Exploring management strategies to enhance the provision of ecosystem services in complex smallholder agroforestry systems. *Ecological Indicators* 94 (Part 1): 257-265. https://doi.org/10.1016/j.ecolind.2018.06.048

Carimentrand A., 2020. Cacao : état des lieux sur la déforestation et les standards de durabilité. CIRAD Appraisal Report. Sponsor: Forest Scientific and Technical Committee of the French Development Agency (AFD). Montpellier, CIRAD, 76 p. https://agritrop.cirad.fr/596409/

Jagoret P., Michel I., Todem Ngnogué H., Lachenaud P., Snoeck D., Malézieux E., 2017. Structural characteristics determine productivity in complex cocoa agroforestry systems. *Agronomy for Sustainable Development* 37: 60. https://doi.org/10.1007/s13593-017-0468-0

Jagoret P., Ruf F., Du Castel C., Harmand J.-M., Rafflegeau S., Saj S., Snoeck D., Wibaux T., 2019. Agroforestry: diversified practices for the agroecological transition of African cacao farming. *In:* The agroecological transition of agricultural systems in the Global South. Côte F.-X., Poirier-Magona E., Perret S., Roudier P., Rapidel B., Thirion M.-C. (Eds). Versailles, Editions Quae (Collection Agricultures et défis du monde), pp. 59-73. ISBN 978-2-7592-3056-3. https://agritrop.cirad.fr/592986/

Saj S., Durot C., Mvondo Sakouma K., Tayo Gamo K., Avana-Tientcheu M.-L., 2017. Contribution of associated trees to long-term species conservation, carbon storage and sustainability: A functional analysis of tree communities in cacao plantations of Central Cameroon. *International Journal of Agricultural Sustainability* 15: 282-302. https://doi.org/10.1080/14735903.2017.1311764

Saj S., Jagoret P., Etoa L. E., Eteckji Fonkeng E., Tarla J. N., Essobo Nieboukaho J.-D., Mvondo Sakouma K., 2017. Lessons learned from the long-term analysis of cacao yield and stand structure in central Cameroonian agroforestry systems. *Agricultural Systems* 156: 95-104. https://doi.org/10.1016/j.agsy.2017.06.002

A few words about...

Patrick Jagoret is an agronomist in the CIRAD Biodiversified Agrosystems joint research unit (UMR ABSys, https://umr-absys.cirad.fr/). Former Deputy Head of the Tropical and Mediterranean Cropping System Functioning and Management joint research unit (UMR SYSTEM), who now conducts research on cocoa agroforest stand functioning. He also coordinates the European Development Smart Initiative for Research in Agriculture (DeSIRA) *Sustainability of production systems and new dynamics in the cocoa sector* Cocoa4Future project in Côte d'Ivoire and Ghana that was launched in 2020 (https://europa.eu/capacity4dev/desira/wiki/cocoa4future).
patrick.jagoret@cirad.fr

Stéphane Saj is an agronomist in the CIRAD joint research unit UMR ABSys at Kourou in French Guinea. Head of the Tropical Agroforestry Systems (TAFS) team, he works on the functioning and design of agroforestry systems, with the following objectives: to enhance farmers' livelihoods and food security; and to develop agroforestry systems that are more resilient with respect to hazards and climate change. He studies trade-offs between ecosystem services that these complex systems may provide.
stephane.saj@cirad.fr

Aurélie Carimentrand is an economist in the Food, Innovations, Territory and Regulations (ALISTAR) team of the Innovation and Development in Agriculture and Food joint research unit (UMR INNOVATION, https://umr-innovation.cirad.fr/en). Based in Montpellier, she carries out research on certification systems regarding the social and environmental quality and origin of food commodities, on socioeconomic and territorial innovations related to these systems, as well as on their impacts.
aurelie.carimentrand@cirad.fr

A few links

Amsterdam Declaration *'Towards Eliminating Deforestation from Agricultural Commodity Chains with European Countries'*. PDF document posted online on 18-01-2017 in the web archive:
https://euandgvc.archiefweb.eu/#

Fairtrade. https://www.fairtrade.net

French Ministry of Ecological Transition (France), 2018. Stratégie nationale de lutte contre la déforestation importée 2018-2030 (SNDI).
https://www.ecologique-solidaire.gouv.fr/france-veut-mettre-fin-di-ci-2030-deforestation-causee-limportation-produits-non-durables-0

International Cocoa Organisation (ICCO). https://www.icco.org

Rainforest Alliance. https://www.rainforest-alliance.org

UTZ, Part of the Rainforest Alliance. https://utz.org

World Cocoa Foundation (WCF). https://www.worldcocoafoundation.org

23rd Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). COP23, https://cop23.com.fj

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT
42, rue Scheffer
75116 Paris • France
www.cirad.fr

Publication Director: Michel Eddi, CIRAD President Managing Director
Editors: Patrick Caron, UMR ART-Dev (Actors, Resources and Territories in Development)
Cécile Fovet-Rabot, Scientific and Technical Information Service
Étienne Hainzelin, General Management
Translation: David Manley
Graphic design: Laurence Laffont
Distribution: Christiane Mastri, Communication Service

https://revues.cirad.fr/index.php/perspective
perspective ISSN-L 2275-9190 - **Email :** perspective@cirad.fr

MUSE MONTPELLIER UNIVERSITÉ D'EXCELLENCE https://muse.edu.umontpellier.fr

To cite this document
Jagoret P., Saj S., Carimentrand A., 2020. Cocoa agroforestry systems in Africa – the art of reconciling sustainable production and ecological services. Montpellier, CIRAD, *Perspective* 54.
https://doi.org/10.19182/perspective/31916