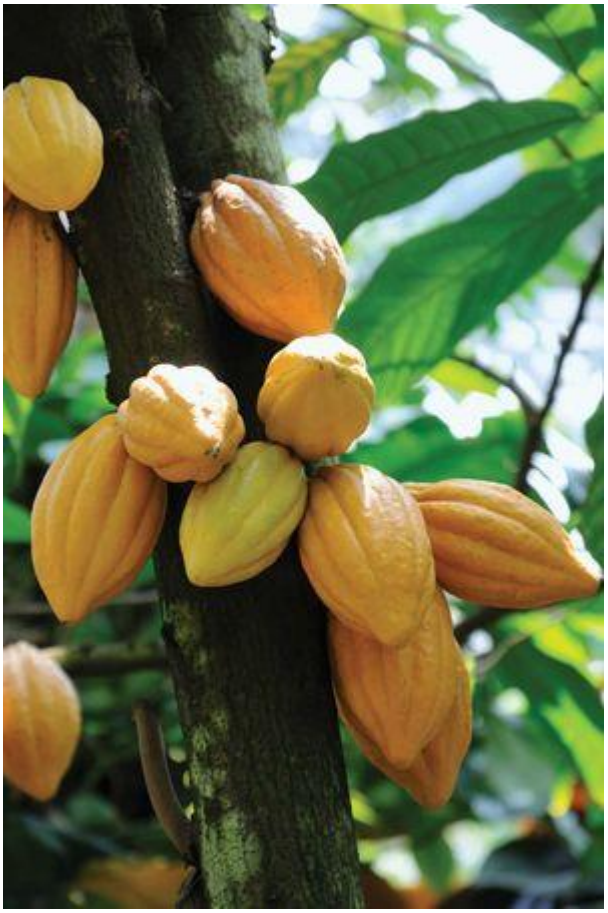
Cacao trees and farming methods



Theobroma cacao (cacao tree or cocoa tree) is a small (6–12 m (20–39 ft) tall) evergreen tree in the family Malvaceae.[1][3] Its seeds, cocoa beans, are used to make chocolate liquor, cocoa solids, cocoa butter and chocolate.[4] Native to the tropics of the Americas, the largest producer of cocoa beans in 2018 was Ivory Coast, at 2.2 million tons. Its leaves are alternate, entire, unlobed, 10–50 cm (4–20 in) long and 5–10 cm (2–4 in) broad. (Wikipedia)

Based on a literature review of cacao cultivation Life Cycle Analyses, the carbon emissions generated by cacao farming has been evaluated to be between 2 and 8.9 kg CO2 eq./ kg of dry bean. Cacao farming alone has great potential to act as a carbon sink only when carried out as part of an agroforestry system with over 25% shade trees. In this case it can sequester 30 kg CO2 eq./ kg of dry bean.

The net emissions balance for cacao monoculture is evaluated to be positive (+4 kg CO2 eq./kg of dry bean), while for agroforestry with less than 25% shade trees it is evaluated to be neutral. However, higher yielding cacao monoculture or agroforestry systems (<25% shade trees) can become competitive in terms of carbon sequestration when combined with land sparing management: combining lands dedicated to cacao farming on certain areas, with rainforest dedicated to carbon sequestration and biodiversity conservation on other areas.

To produce 10 tons of chocolate, an artisan chocolate maker would need about 7 tons of cacao. This would require 14 ha. of mature agroforestry system (>25% shade trees), sequestering the equivalent of 207 tons of CO2 per year, as

much as 30 kg of CO2 eq./ kg of dry bean. Using the same piece of land and either managing it as 50% rainforest and 50% cacao monoculture, or 40% rainforest and 60% agroforestry system (< 25% shade trees) will provide the same quantity of cacao while sequestering the same amount of CO2. It is important to keep in mind that these results based on today's literature, are subject to change since the relationship between yield and carbon storage is dynamic and highly influenced by farming techniques such as pruning, or the design of the agroforestry system such as the choice of the cacao cultivar and the companion species associated with the cacao.

Cacao monoculture or low shade (<25%) agroforestry combined with land sparing is a competitive alternative to high shade (>25%) agroforestry in terms of land use and carbon storage. However, the scientific community provides numerous reasons opposing the monoculture/land sparing model such as shorter production cycle, loss in soil fertility, systematic need for inputs, loss in biodiversity above and underground, greater threat for pest and disease, etc. Still, agroforestry systems do not represent fully preserved ecosystems that provide ecological niches and specific habitats that are found only in forests. In addition, protecting existing rainforest does not contribute to restoring biodiversity and fertility lost in deforested lands.

Combining all these observations, a land sparing management scenario as mentioned below, would also provide 7 tons of cacao within the same 14 ha., while sequestering similar amounts of carbon dioxide as the previous scenario cited above, and offering greater ecological benefits : • 50% of agroforestry systems with over 25% shade trees • 26% of agroforestry systems with less than 25% shade trees • 12% of land under reforestation • 12% of existing forest This review does not consider any cost analysis regarding the investment necessary to put in place and manage each of the models studied, however, carbon sequestration could also be seen as a significant source of revenue given the current market price of about USD 25/ton.

This could generate a revenue of over USD 5,000 per year while producing enough cacao to manufacture 10 tons of chocolate under the different models pre-cited. According to 2015 Synapse report, projections regarding the price for a ton of CO2 over the 30 next year's range from an increase of +60% to +380% offering even higher potential for this additional source of income. (Romain Lebrun Agro Paris Tech)

One adaptation strategy could be providing cacao growers with selectively bred seeds that have superior drought resistance. Another strategy involves a traditional cacao cultivation method that takes advantage of the conditions under which cacao naturally grows.

Cacao harvesting in Colombia. Photo by the U.S. Agency for International Development (USAID).

Known in Brazil as *cabruca*, this approach involves retaining, or in some cases replanting, other rainforest trees, which provide cacao trees with shade. (Like Northern European tourists in the Mediterranean, cacao trees benefit enormously from shade.) This approach could help decrease both temperature and evapotranspiration.

The taller trees also provide protection from wind and soil erosion, and nutrient-rich leaf litter. Cacao trees cultivated in this approach appear less vulnerable to pests, and the soil better retains its ability to support cacao over the long term.

Cabruca offers one more advantage: Carbon that would otherwise be released into the atmosphere when forests are cleared isn't. It remains stored in the trees. A study conducted in southern Cameroon and published in 2009 found that cacao forests in that region store on average 243 metric tons per hectare (about 2.5 acres). (For comparison, in 2011–2015, the World Bank reported, U.S. citizens released about 17.0 metric tons of carbon dioxide per person per year.) Another study, conducted in Brazil and published in 2014, concluded that judicious cabruca practices could double cacao production in a climate-friendly manner.

Distribution and domestication

T. cacao is widely distributed from southeastern Mexico to the Amazon basin. There were originally two hypotheses about its domestication; one said that there were two foci for domestication, one in the Lacandon Jungle area of Mexico and another in lowland South America. More recent studies of patterns of DNA diversity,

however, suggest that this is not the case. One study[11] sampled 1241 trees and classified them into 10 distinct genetic clusters. This study also identified areas, for example around Iquitos in modern Peru and Ecuador, where representatives of several genetic clusters originated more than 5000 years ago, leading to development of the variety, Nacional cocoa bean.[12] This result suggests that this is where T. cacao was originally domesticated, probably for the pulp that surrounds the beans, which is eaten as a snack and fermented into a mildly alcoholic beverage.[13] Using the DNA sequences and comparing them with data derived from climate models and the known conditions suitable for cacao, one study refined the view of domestication, linking the area of greatest cacao genetic diversity to a bean-shaped area that encompasses Ecuador, the border between Brazil and Peru and the southern part of the Colombian–Brazilian border.[14] Climate models indicate that at the peak of the last ice age 21,000 years ago, when habitat suitable for cacao was at its most reduced, this area was still suitable, and so provided a refugium for the species.

Cacao trees grow well as understory plants in humid forest ecosystems. This is equally true of abandoned cultivated trees, making it difficult to distinguish truly wild trees from those whose parents may originally have been cultivated. (Wikipedia)

History of use

Cacao residues on pottery in Ecuador suggest that the plant was consumed by humans as early as 5,000 years ago. The tree was likely domesticated in the upper Amazon region and then spread northward. It was widely cultivated more than 3,000 years ago by the Maya, Toltec, and Aztec peoples, who prepared a beverage from the bean (sometimes using it as a ceremonial drink) and also used the bean as a currency. (Britania)

Small-Scale Producers and Carbon Sequestration

Throughout the developing world, population growth and the related economic and farming activities put tremendous pressure on forested areas. To reduce the stress on natural habitats, long-term sustainability must be reconciled with medium- and short-term gains. In rural areas where agriculture and forests compete for land, the forest is at greater risk because farmers will not protect and preserve the environment unless they have an economic incentive to do so.

For this reason, tree crops such as cocoa offer significant economic and environmental benefits. Small producers

can plant cocoa under tree canopies to provide continuous cash income from fruit.

Harvesting; thereby, preventing the burning of forested areas and destruction of biodiversity habitats. Protection of these standing forests offers an immediate solution to sequester carbon. In denuded regions, tree crops are planted which in addition to improving soil filtration and reducing soil erosion, offset carbon. Substitution of composting and other organic techniques for fertilizers and pesticides also allows for increased carbon storage. Sequestration can become an additional crop for farmers. (Smithsonian Institute)

According to Brazilian research, one hectare of cacao plantation under an agroforestry system can remove *165 tons of carbon* from the atmosphere per year[1]. This significant carbon sequestration potential makes cacao plantations an attractive opportunity for carbon markets, especially for farmers in the Amazon. It's part of a broader effort to fight deforestation and promote sustainable agriculture in the region[1].

Source: Conversation with Bing, 12/4/2023

(1) Amazon-produced cacao offers climate solutions - Conservation news. https://news.mongabay.com/2022/12/amazon-produced-cacao-offers-climate-solutions/.

(2) Science refutes United Cacao’s claim it didn’t deforest Peruvian Amazon. https://news.mongabay.com/2021/05/science-refutes-united-cacaos-claim-it-didnt-deforest-peruvian-amazon/.

(3) Carbon stocks and the use of shade trees in different coffee growing .... https://www.cambridge.org/core/journals/journal-of-agricultural-science/article/carbon-stocks-and-the-use-of-shade-trees-in-different-coffee-growing-systems-in-the-peruvian-amazon/EFBC4767DB3C355403F162F6286E2373.

(4) Supporting cacao production and restoration in Brazil | IUCN. https://www.iucn.org/news/forests/201712/supporting-cacao-production-and-restoration-brazil.

The number of cacao trees that can be planted per hectare varies depending on

the planting density and the agricultural practices used. However, a commonly referenced range is between *1,000 to 1,200 cacao trees per hectare*[3]. This density allows for optimal growth and yield while ensuring that the trees have enough space to develop properly. It's important to note that the exact number can vary based on factors such as the variety of cacao and the specific conditions of the plantation.

Conclusion:

1 hectare consist of approx. 1000 cacao trees that sequester a total of 165 ton CO2 per year = 1650 kg / 1000= 165 kg (0,165 ton) per tree per year

Source: Conversation with Bing, 12/4/2023

(1) How to establish modern cocoa plantations - The Guardian Nigeria News. https://guardian.ng/features/how-to-establish-modern-cocoa-plantations/.

(2) Cacao Production Guide - Department of Agriculture. https://library.buplant.da.gov.ph/images/1581571953Cacao%20Production%20Guide.pdf.

(3) Philippine Cacao Farming and Production Guide. https://agraryo.com/agriculture/cacao-farming-cacao-production-guide/.

(4) The Best Way to Prepare Land for Higher-Yielding Cocoa Plantation. https://nobowa.com/land-preparation-cocoa-farming/.

(5) How many bags of cocoa can an acre of land produce?. https://sage-answers.com/how-many-bags-of-cocoa-can-an-acre-of-land-produce/.