TRENDS
AGRICULTURE

How the coffee industry is dealing with climate change

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Coffee is the leading agricultural commodity on global markets in terms of value. All of the world's coffee producers are located in countries in the Global South, while nearly all of the processors and consumers are in the North, which puts the industry at the heart of the globalized economy: only 30% of the coffee volumes traded are consumed in the country they were produced in. The crop's vulnerability to climate change is therefore amplified by its likely impact on millions of small-scale farmers.

DATA OVERVIEW

Climate crisis, economic difficulties and rising demand: a hard-pressed coffee industry

Growing concentration of an expanding industry focused on export

The global production of coffee has grown 60% since the 1990s.[1] From 2000 and 2019 in particular, the production and consumption of coffee increased by an average 2% a year and forecasts based on demographic growth predict a doubling or tripling of demand by 2050,[2] depending on consumption patterns. Coffee is intensely traded on international markets: 70% of the world's production is exported, mostly from developing countries towards countries of the North. Fifty-six percent of global coffee consumption is concentrated in North America, Europe and Japan.[3] The increase in production since the 1990s is mainly driven by three countries,[4] with two different motors. In Brazil (+86%), the number one global producer, growth can be explained by the increased productivity of plantations,[5] while in Vietnam (+105%) and Ethiopia (+136%), the rise is due to an expansion of cultivated areas.[6,7] The high growth in production in these countries boosts their market share to the detriment of small producer countries. Thus, in 2018, the five biggest coffee producers took up 62% of market shares, compared to just 47% in 1995.[8]

The way that the industry is organized also generates inequalities. Coffee production is mainly the work of 25 million small producers that cover 80% of global production[9] but only marginally benefit from the profits created by actors upstream in the industry that are responsible for a large part of the value added in the chain, through coffee blends, different roasting methods, and symbolic attributes provided in bars and cafés.[10]

A series of shocks fuel already strong concerns about climate change

Despite this general upward production and consumption trend, in the short term, global economic and climate conditions and shocks create numerous variable factors in the supply and demand of coffee, reflected by a very volatile price. Following a strong downward trend since 2016, the price of coffee then doubled between 2020 and 2022, reaching 200 cents/pound after two years of successive shocks. In 2020, lockdowns all over the world saw a slump in consumption levels. Production was also perturbed by a lack of available labour and frozen international distribution channels.[11] In 2021, consumption took off again, but an exceptional drought and episodes of frost in Brazil saw global production take a dive: the price of coffee peaked. In 2022, consumption has dropped again in the wake of Russian and Ukrainian demand drops. The tension between supply and demand is easing slightly, but prices remain above 200 cents/pound.

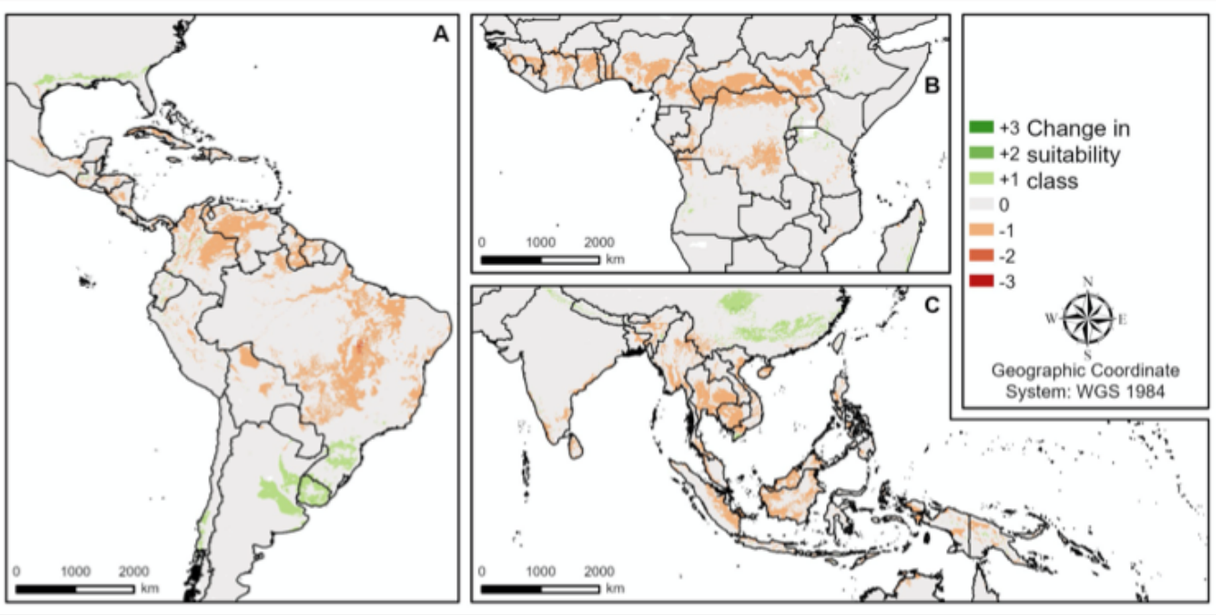
The medium-term effects of the Covid-19 crisis on coffee production are still unclear. Despite the price rise, which could encourage producers to invest, the economic difficulties facing small producers are reminiscent of the effects of the 2008 financial crisis. At that time, the drop in prices and the resources allocated to monitoring plantations led to the abandon of numerous plantations contaminated by a fungus causing coffee leaf rust, which then spread across the American continent from 2008 to 2013.[12] In 2022, the price of coffee is at its highest point but inflation is also pushing up the price of oil, and thus of fertilizers.

The industry's vulnerability to climate change is a cause for concern. Areas suitable for coffee crops could shrink by 50% by 2050 according to climate simulations.[13,14] Coffee plants only develop in specific climate zones: temperatures between 18 °C and 23 °C at altitudes between 1,000 and 2,000 m for arabica, which makes up 70% of global production; temperatures between 22 °C and 30 °C at altitudes below 800 m for robusta, although the optimal temperature was recently

FIGURE 1

CHANGE IN SUITABILITY OF LAND FOR GROWING COFFEE IN 2050 ACCORDING TO THE RCP 4.5 SCENARIO (INTERMEDIATE EMISSIONS)

Source: Grüter et al., 2021



reevaluated at around 20.5 °C.[15] Climate change brings five main risks for crops:[16,17] the shift of suitable areas to higher altitudes; an increase in water stress; temperatures too high for fruits to blossom and grow; the propagation of pests and diseases; and the increased vulnerability of small-scale producers.

Apprehensions not only concern plantations, but also the vulnerability of wild coffee plants, which are a reservoir of genetic diversity, since 60% of all wild coffee species are threatened by extinction due to climate change. In addition, deforestation and the proliferation of pathogenic attacks cause concern.[18,19]

The differing environmental footprints of coffee

The carbon footprint of coffee can be calculated using life cycle assessments (LCA), which add up the emissions at each stage of the coffee manufacturing process: manufacture of fertilizer from fossil gas, plantation, harvest, processing of coffee berries to produce green coffee, transport of coffee beans, and roasting. The scope of the analysis can be extended to include the commercialization stages with emissions related to packaging, distribution, manufacture and use of machines to prepare coffee right up to the consumer, the collecting and recycling of containers, and even emissions related to the company's operations. Despite standardized LCA methods, life cycle assessments evaluating the carbon footprint of a cup of coffee give very different results depending on the origin of the coffee, its cultivation, and transport. A global study of the carbon footprint of foodstuffs evaluated emissions related to coffee farming at 17 kgCO_2e/kg of green coffee.[20,21] But another study, focused on organic Costa Rican coffee consumed in Germany, gives a value of 5 kgCO_2e/kg of green coffee.[22] In Vietnam and Brazil, with conventional practices and exported production, the figures are reported as 16.04 and 14.61 kgCO_2/kg respectively, dropping to 3.64 and 3.37 kgCO_2/kg with sustainable practices, mostly thanks to transportation by cargo rather than air, which reduces the share of transportation in CO_2 emissions from 70% to 6% and 11% for Vietnam and Brazil respectively[23] and partly explains the variability between the different studies. When transport is left aside, as in a study on the local consumption of organic coffee in Thailand, the steps related to growing and harvesting represent up to 80% of total emissions.[24] With the cultivation stages being so important, conventional practices emit less than organic practices because they have a greater yield per surface unit.

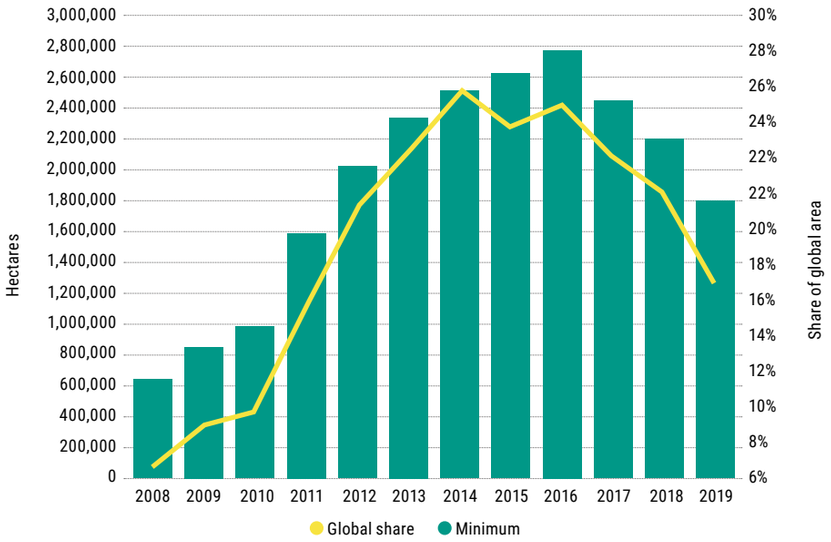
Drop in certification

Voluntary certification is one way of trying to respond to this concern. A reported 1.8 to 3.8 million hectares of cultivation are covered by one of the five voluntary standards available for coffee, which is between 16% and 34% of the global surface area of coffee crops.[25] Despite increasing demand from importing countries, and an initial rise in certifications of 78% from 2011 and 2016, coffee certification has in fact generally dropped since the mid-2010s: -31.5% between 2015 and 2019.[26,27] This contrasts with other certified raw materials following an upward trend, especially cotton and palm oil. The changing share of certified coffee is due to the investment difficulties faced by small-scale producers, at a time when production costs are rising, supply chains are disturbed, and demand is too low for these products that are sometimes sold without their label.[28] In fact, only 52% and 57% of the coffee production certified by the labels Rainforest Alliance and UTZ respectively is sold as such.

FIGURE 2

EVOLUTION OF THE SURFACE AREA OF COFFEE CROPS WITH A VOLUNTARY CERTIFICATION STANDARD

Source: ITC, 2021



THE OBSERVATORY'S LENS

The product life cycle as the primary lever of action for companies

For several years, stakeholders in the industry, from small-scale entrepreneurs to major distribution companies, have been trying to reduce the CO_2 emissions related to their activities and to coffee consumption in the Global North. Each company aims at one or more different stages of the product lifecycle.

At production level, generic tools directly target coffee growers. One example is "Cool Farm", a digital tool developed by a consortium of companies involved at all levels of the agribusiness industry. One of the objectives of Cool Farm is to put producers at the heart of action to combat climate change. In 2022, a pilot project distributed Cool Farm to organic coffee farms. Farmers use the application to input their yield, surface area, consumption of fertilizer, and energy consumption, and after several minutes receive an estimation of their carbon footprint with keys to understand the environmental implications of their practices. During this pilot project, 250 volunteer farmers will share their data and $200,000 of carbon bonuses will be distributed to those who demonstrate, using Cool Farm, the carbon sequestration in their farm.

Intercontinental distances between producers and consumers make transport a key process in CO_2 emissions linked to coffee. The Grain de Sail company, established in 2010, works to reduce the level of carbon emitted by international transportation of agricultural commodities. Four years of research and development resulted in the manufacture of an innovative cargo-carrying sailboat that complies with international expedition standards certified by independent experts (Bureau Veritas and the Marine Safety Centre). The boat can transport goods with a load capacity of 50 tonnes in a refrigerated hold using green energy. Thus, high-quality organic coffee is transported in a cargo-carrying sailboat to be roasted using high-end methods in an enterprise centred on the professional integration of people with disabilities.

Downstream in the value chain, one capsule market actor stands out for its efforts to tackle emissions relating to the final preparation of coffee by the consumer, by looking at the way that its coffee machines are made. French coffee roaster Malongo launched its ethical coffee machine, Eoh, in 2021, comprising 60% French-made parts and assembled in the Vendée region. The machine operates using pods made from unbleached paper and is guaranteed over a period of five years – compared to a legal obligation of two years.

Nespresso is a market leader in the coffee capsule segment and keeps a close watch on the entire life cycle of its coffee. According to the LCA carried out for Nespresso in 2020, 49% of emissions from a cup of coffee are generated during the coffee-growing stages, mainly as a result of fertilization (14%) and deforestation (13%).[29] In 2014, Nespresso invested €600 M in developing "The Positive Cup" plan, which aims to make its permanent "Grands Crus" range from 100% sustainable sources, increase capacities to collect aluminium capsules,

and only sell "carbon-neutral"[a] capsules from 2022 on five of its markets (USA, France, Austria, Australia, New Zealand) covering 41% of Nespresso's carbon footprint in the world.[30] The final report on the plan[31] describes the progress made. Concerning coffee-growing, 93% of the coffee purchased by Nespresso in 2021 respects the rules of its own AAA sustainable quality program, compared to 84% in 2014; 48% is certified by the Fairtrade or Rainforest Alliance labels compared to 39% in 2014. Since 2014, over five million trees have been planted, agroforestry being one of the pillars of the AAA program, which also supports the UN Sustainable Development Goals (SDGs). The recycling rate of capsules was 32% in 2020. The target of 100% "ASI" certified virgin aluminium in capsules has nevertheless been postponed and redirected towards targets to integrate recycled aluminium.

The plan implemented to reach "carbon neutrality" for capsules centres on six types of mitigation and compensation action: regeneration of parcels cultivated at each cycle to avoid deforestation, eco-design of coffee capsules and packaging using recycled and/or recyclable materials, the use of renewable energy sources for factories and stores, recycling of collected used capsules and coffee grounds, optimization of distribution logistics, and planting of trees and reforestation in and around coffee plantations. In 2021, the remaining emissions that Nespresso must compensate through the funding of certified carbon projects on voluntary markets to reach carbon neutrality in the five targeted markets amount to 506,760 tCO_2e/year. The amount of offsets required is therefore high and is likely to remain so, with an objective to reduce emissions by 20% from 2018 to 2025 established in its commitment to carbon neutrality. Nespresso's compliance with its carbon footprint and carbon neutrality objectives is assessed by a third party, the Carbon Trust Assurance, based on ISO 14067 standards (carbon footprint of products) and PAS 2060 (carbon neutrality),[b] which leave large room to carbon offsets.

Therefore, despite considerable efforts, the share of Nespresso activity covered by these commitments, in other words the production and distribution of capsules commercialized by Nespresso on five of its markets, only represents 41% of the company's overall emissions, and with a high dependence on carbon offsets.

In Costa Rica, the coffee produced by the Coopedota company has been certified as carbon neutral since 2011, also by the PAS 2060 institute. Certification was obtained after the cooperative changed its techniques, including a move to use biomass residue to produce energy, either by producing ethanol from waste to create fuel, or by burning plant waste in an electricity-producing unit, or using their own compost as fertilizer. From 2007 to 2009, Coopedota reduced its emissions from 3,889 tCO_2e to 938 tCO_2e, which is a 75% decrease.

Deforestation casts a shadow over the industry's climate footprint and worries consumers

As coffee demand continues to rise by 2% a year, climate change is threatening coffee yields. Concerns are emerging on the risk of deforestation already observed in some countries. In Vietnam, for example, production went from 19,400 tonnes a year in 1980 to 1.76 million tonnes in 2016. Although the boom can be partly explained by increased yields, currently 3.5 tonnes per hectare (compared to 0.8 tonnes in Thailand, for example), it is mostly the expansion of cultivated areas that has turned the country into the world's number two coffee producer. The production surface shot up from 50,000 hectares in 1986 to over 1.4 hectares in 2015, and continues its upward trend, with the coffee crop surface increasing by another 21% from 2010 to 2018. The Forest Trends report estimates that in 2019, deforestation to make way for coffee crops in Vietnam generated a million tonnes of CO_2 emissions.[32,33]

Action to combat deforestation in the coffee industry is organized at several levels. At institutional level, regulations are becoming stricter. In Europe, in September 2022, the European Parliament amended the proposal by the European Commission aimed at obliging private companies to ensure that agricultural products sold in the European Union, including coffee, do not come from deforested land after 31 December 2019.[34]

At company level, consortiums have been created. The "Sustainable Coffee Challenge", launched in 2015 at the initiative of Starbucks and the NGO Conservation International, now gathers 164 partners involved in the industry. Of these partners, 105 have signed 166 commitments on their actions to ensure the sustainability of the sector, including 33% roasters, 21% retailers, 19% investors, and 17% NGOs.[35] Sustainable Coffee Challenge encourages its partners to align their commitments with the UN SDGs. As a result, 50% of commitments are aligned with SDG 12 "responsible consumption and production", 39% with SDG 8 "decent work and economic growth", 31% with SDG 2 "zero hunger", 35% with SDG 13 "climate action", and 32% with SDG 15 "life on land". However, the 2021 report on partner commitments observed that only 10% of commitments made for 2020 had been met, and the 2022 report[36] esteems that only 36% of partners report on their progress after signing the commitment.

The large number of small-scale coffee farmers makes monitoring and verification of deforestation complex. Digital tools are now therefore widely used by governments, NGOs, companies and certifying bodies to evaluate the risks of deforestation. One example is GRAS (Global Risk Assessment Services).[c] Financed by the German Ministry of Food and Agriculture and developed by a multidisciplinary team comprising, among others, a consultancy firm on the use of

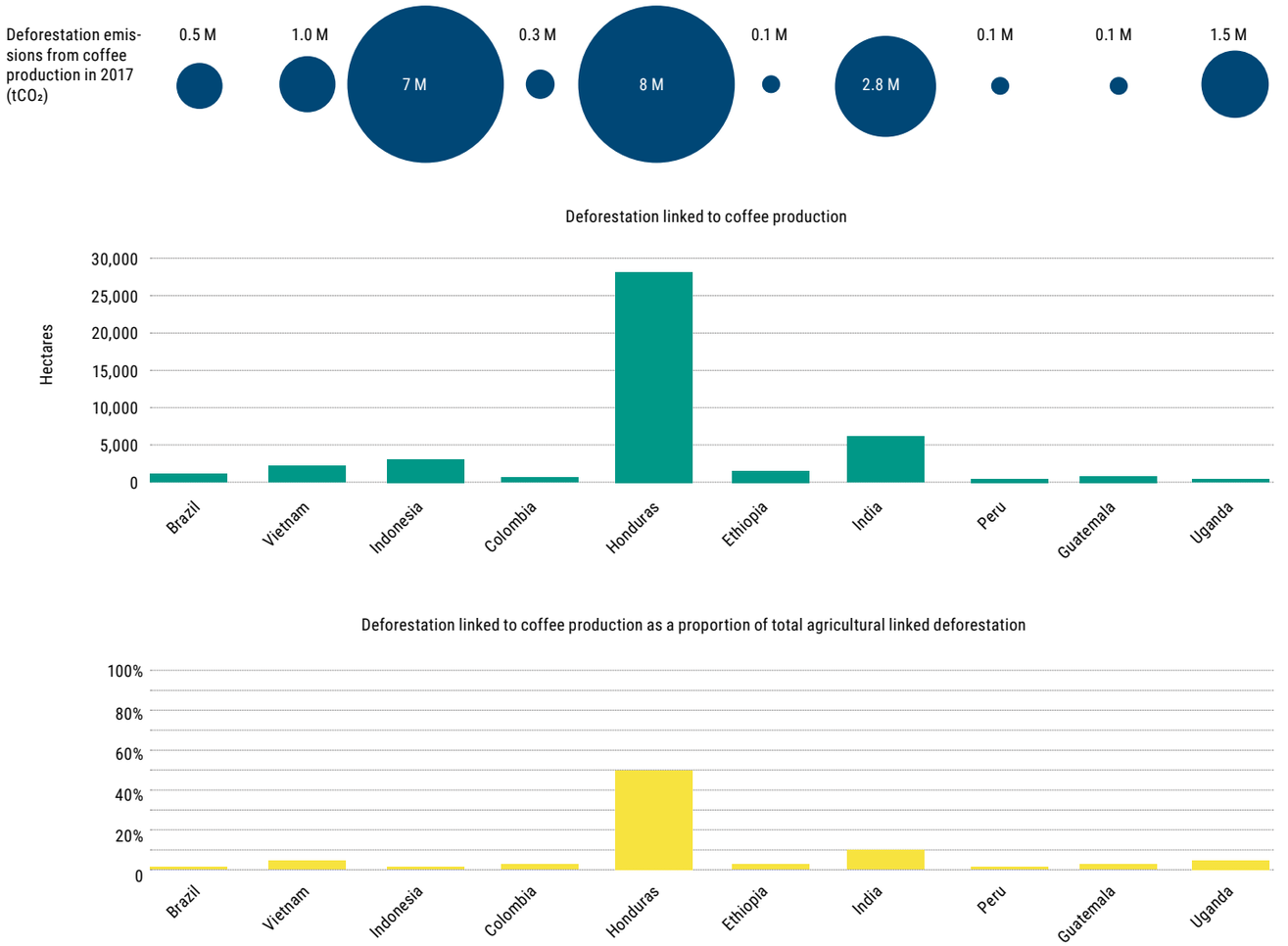
a The application of the concept of carbon neutrality at the scale of a product is controversial. To find out more, see *The Net Zero Target: The Voluntary Carbon Market Enters a New Dimension* in Global Observatory on Non-state Climate Action (2022). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

b *Idem*. For more information on PAS 2060, see *The Net Zero Target: The Voluntary Carbon Market Enters a New Dimension* in Global Observatory on Non-state Climate Action (2022). Global Synthesis Report on Climate Action by Sector. *Climate Chance*

c https://www.gras-system.org/

FIGURE 3

LOSS OF FOREST SURFACE AND CO_2 EMISSIONS RELATED TO DEFORESTATION FOR COFFEE PRODUCTION IN THE TOP TEN PRODUCING COUNTRIES - *Source: Treanor, N.B., Saunders, J., 2021*



natural resources, a certifying body, and an aerospace research centre, GRAS employs high-resolution satellite images and data on forest areas, protected zones, and the timeline of past deforestations, to estimate the risk of deforestation for each plantation. The 4C coffee certification scheme uses this mapping tool to carry out its audits.

The fight against deforestation is also driven by consumer pressure in high-income countries, where the market for certified sustainable coffee is growing as citizens become more aware of the climate crisis. In response to this demand, roasters and retailers are undertaking different types of action. The French roaster Malongo has been committed to a sustainable approach since the 1990s. In 2022, 65% of the volume of coffee imported by Malongo is certified Max Havelaar, and 28% is certified AB (*Agriculture Biologique*). To make coffee more traceable for consumers, Malongo now includes a QR code on all of its coffee tins to inform consumers on the supplier villages, the timeline of the coffee's journey through different ports, the dates of control and roasting, and the means of preparation.[37,38] Along with roasters, some retail giants are making commitments on coffee featuring their own brands. In Europe this is the case for example for Aldi, Lidl and Sainsbury's, which only obtain their supplies from coffee certified UTZ, Fairtrade, Fairtrade USA or Rainforest Alliance. In 2022, 53% of everyday coffee sold by Aldi is certified to be sustainable, and 100% of its Simply Nature brand.[39] Retailer commitments also involve funding projects close to producers, such as the "Guatemala project" launched by Lidl in 2018. Given that women in Guatemala have less access to funding, land, and technology than men, and only 70% of women can read and write, the "Guatemala project" aims at both environmental and social issues. Its action involves supporting 92 small farms managed by women in order to help them increase their productivity and their resilience to climate change thanks to climate plans, training and technical assistance to adapt cultural practices and the introduction of new varieties, along with support to develop skills in business, management and gender issues to make women more independent.[40]

Adapting varieties and practices: intensive farming versus agroecology

Although 214 varieties of coffee plants are known today, global production turns around only two: arabica with 56% of global production, and robusta, with 43%. Arabica has a low tolerance for temperature increases and is very sensitive to coffee leaf rust, making it more vulnerable to climate change. Robusta is more resilient and resists high temperatures and leaf rust, but it has an inferior taste.

The first way of adapting coffee growing while maintaining the varieties currently cultivated involves changing practices. Coffee can in fact be grown in direct sunlight or in agroforestry, with trees planted between the coffee shrubs to give them shade. Developing crops using agroforestry currently appears to be a useful practice for adaptation and mitigation because it is a way of reducing the temperature for coffee plants by protecting them from the sun's rays while increasing carbon sequestration in land parcels.[41] The carbon stored in agroforestry parcels could be three to four times greater than in monocultures.[42,43]

A second option involves working with the genetic diversity of coffee plants to look for other varieties adapted to future climate conditions and resistant to diseases and pathogens while maintaining the quality of the coffee berries. The difficulty of this strategy is the near-extinction of wild coffee varieties. A study in 2019 estimated that 60% of coffee varieties were threatened.[44] Ethiopia and Sudan are the only two countries in which arabica grows in the wild. On the other side of the continent, in Sierra Leone, researchers working with historic specimens conserved by the Royal botanic gardens (United Kingdom) have located a planting of Coffea Stenophylla, a formerly cultivated variety that had not been observed in the wild since the 1950s.[45] The interest of this variety is that it resists temperatures 6 °C higher than arabica and 2 °C higher than robusta, and tolerates periods of drought. In addition, tasting tests carried out in a sensory analysis laboratory by a panel of experts judged that it had similar qualities to arabica.[46] Agronomic tests are being launched in Sierra Leone and on Réunion Island.[47]

Another approach is based on genetic selections from among the same variety and involves collaborations between genetic researchers, agronomists and farmers. The Breed CAFS research project, which received EU funding of €6 M, gathered researchers and farmers to select coffee varieties that are both resistant to health and climate risks and taste good in order to maintain farming revenues. Researchers have developed hybrid F1 varieties (first generation) of arabica by crossing American varieties with wild accessions originating from Ethiopia. These hybrids, which were selected for their good capacity for adapting to shade while maintaining high productivity, were tested in Vietnam, Cameroon, Nicaragua and Costa Rica. In Vietnam, for example, 40,000 seedlings were distributed to twelve farmers, planted in parallel with the Catimor arabica variety used as a control. The farmers then cultivated the hybrid plants in their farms located at different altitudes, using shading trees and sometimes interweaving annual crops in between the coffee shrubs. The Vietnam Academy of Agricultural Sciences and the Agricultural Genetics Institute then monitored the growth and health of the young plants up to the first harvest, which was then evaluated for its quantity and taste properties.[48] In the four countries where the experiment was carried out, the productivity gains ranged from 10% to 20% and the resistance to disease led to a 15% to 20% drop in the use of pesticides. The experiment has therefore been extended and a process to accredit new varieties is under way.

Cooperatives get together to boost the industry's socio-ecological resilience

Cooperatives constitute resilient organizations to tackle climate change and economic crises. Thanks to cooperatives, producers can access training on agricultural practices adapted to climate change and pool their processing and distribution services, thus increasing their profits and so boosting their investments.

Uganda features more than 1.5 million coffee producers and cultivates both varieties of coffee: robusta in the central plains, and arabica in the eastern highlands. The country also has the second youngest population in the world, with 78% of inhabitants aged under 30. Farms differ on a number of criteria – altitude, the surface area allocated to crops, the type of crops combined with coffee shrubs, the household members working outside the plantation, and the presence of livestock or not. A recent study explored the connections between the characteristics of a farm, the perception of climate risks, and the adoption of adaptation strategies.[49] The researcher showed that the adoption of adaptation practices differs depending on the level of education of the head of the family, the size of the farm, the share of dependent household members (children or old people), and the share of banana trees and coffee plants on the cultivated surface. In fact, a high level of education results in heads of family implementing more complex strategies that take into account the economic results of the farm, but that are further removed from indigenous practices. A small farm size and a high number of dependent household members weigh heavily on possibilities for investment, whereas a high share of banana and coffee trees, which are commercial crops, increases investment capacities. The gender of the head of the family also has an influence. The solutions chosen by women tend to be directed towards providing food by increasing the size of animal rearing or subsistence crops on fragile soil, while men are more likely to make structural changes, extend the surface rented, or change the varieties cultivated, with no direct relation to providing food for the household.

Faced with this diagnosis, cooperative groups make great sense and are often put forward as prerequisites to adaption action. For example, International Coffee Partners (ICP), which has an objective to support and develop the potential of small producers around the world, works with twelve cooperatives in Uganda to help each of them develop an action plan to adapt to climate change in line with their own characteristics.[50] A central component of this project is training farmers to use resourceful agricultural practices for the climate with

the aim of developing more resilient crops. Raising awareness about gender issues is also a key part of the action proposed in order to increase the number and influence of women in managing cooperatives. The current project includes 41% women on training courses and in activities organized by the projects, which concern 50,000 households.

In Rwanda, a collective of 3,000 women has gone further still by gathering female coffee farmers from six cooperatives to launch their own products under the brand *Angelique's Finest*, established in 2018 and now distributed in over 800 stores in Germany.[51] Thanks to taking charge of the entire value chain, from growing to distributing, the women have seen their profits increase by 55% compared to only selling green beans. For these women, selling their own coffee means having their own income and so financial independence. Support for this initiative from Fairtrade International is part of a goal to reduce gender inequalities in the coffee industry, where women only represent 15% of the 656 certified farmers.

KEY TAKEAWAYS

One of the most commercialized agricultural commodities in the world, coffee is facing a profound shift in its growing and consumption conditions due to climate change. Coffee production is concentrated among a handful of developing countries, and depends on very specific climate conditions. For this reason, changes in the aptitude of land to grow coffee crops is threatening the genetic diversity of species, increasing the vulnerability of plants, and exposing small farmers to revenue losses.

For producers, the industry's adaptation is taking place in two stages. One of them involves the transformation of farming practices via the development of agroecology, the selection of species, and the hybridization of varieties, all aimed at adapting coffee crops to a changing climate. The other involves the socio-economic reorganization of production units, designed to protect the farming communities that feed into and live from coffee production from the risks related to climate change. These cooperatives are a good way of pooling knowledge, disseminating practices, and boosting the resilience of producers.

In countries in the North, consumer pressure is pushing retail and producer companies to better control their impact on deforestation and its consequences for biodiversity and greenhouse gas emissions. Multilateral initiatives organize companies' implementation of their commitments to reduce emissions and deforestation. Major industry players are adopting life cycle assessment approaches to measure and trace the impact of their products throughout the industry; nevertheless, the volumes of certified coffee have been on a downward trend since the mid-2010s, due to the increase in investment costs and insufficient promotion of labelled products.

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