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Brazil, coffee production

**Climate Change’s Impact on Brazilian Coffee**

Brazil is the 5th largest country in the world, encompassing half of the total landmass of South America ( Britannica Brazil, 2024). In Brazil, the climate is mainly tropical, with southern temperate regions (CIA, 2024). The northern terrain contains Brazil’s tallest mountains (Encyclopedia Britannica, 2024). Further south lies the Amazon rainforest and river basin (Britannica Brazil, 2024). The Pantanal wetland region is part of Brazil’s southwest (Britannica Brazil, 2024). Much of the southern landscape is composed of the Brazilian Highlands, an area filled with cliffs and ravines (Britannica Brazil, 2024). Beaches, lagoons, and sand dunes form Brazil’s Atlantic coastline (Britannica Brazil, 2024). Brazil’s mainly southeastern farms grow sugarcane, soy, maize, cassava, oranges, and cotton (CIA, 2024). Iron, soy, crude oil, poultry, and sugar are Brazil’s main exports (CIA, 2024). Brazil contains 63.5 million hectares of cropland (USDA, 2022). The majority of Brazilian farms range from 500 to over 1,000 acres in size, about the size of Central Park in New York City (Stratfor and Measure).

The average household size in Brazil is 2.77 people (Global Data, 2024). Brazil’s total fertility rate is 1.75 children per woman (CIA, 2024). However, numbers fail to capture Brazilians’ sense of family. Many individuals have close ties with immediate and extended families and frequently attend family gatherings (Britannica Brazil, 2024). The least well-off families in big cities reside in favelas, with poor access to potable water and sanitation, causing vulnerability to infectious disease (Britannica Brazil, 2024). Those who can afford to live elsewhere typically reside in houses or apartments in the cities of Rio de Janeiro, São Paulo, and Brasilia (Habitat For Humanity, 2024 and CIA, 2024).The traditional Brazilian diet includes beans and rice as the main part of a meal, sometimes with small amounts of meat, seafood, nuts, vegetables, fruit, and dairy products (NIH, 2020). Most food is prepared at home, though the prevalence of Western fast food is increasing (Britannica Brazil, 2024).

Brazil has a population of 218,689,757, 87.8% of which reside in urban areas (CIA, 2024). Service industry jobs in restaurants, hotels, the government, and retail stores is the most common employment sector. (Britannica Brazil, 2024). 15% of the labor force works in agriculture, (USDA, 2022), while 10% manufactures items such as textiles, soap, and car components (Britannica Brazil, 2024). The average wage in Brazil is 3110 Brazilian reals (613.85 United States dollars) per month (Trading Economics). Education is free and required up to age 17 (Britannica Brazil, 2024). In some rural areas, families struggle to pay housing expenses for secondary school students, who must move to larger towns for education. (Britannica Brazil, 2024). Some poorer Brazilians must drop out from school to work, while wealthier Brazilians are more likely to complete secondary school and attend college (Britannica Brazil, 2024). This contributes to illiteracy among ⅙ of Brazilians 15 and older. (Britannica Brazil, 2024). Brazil has created Sistema Único de Śaude, a free universal healthcare system that has improved access to healthcare (Roman, 2023). However, healthcare inequality still remains an issue (Roman, 2023). Brazil has an expansive system of roads, but only around 10% of them are paved, mostly metropolitan streets (Britannica Brazil, 2024). Many roads are ill maintained, with over 30% of roads determined to be in poor condition (USDA, 2022). Undeveloped railroads, ports, roads and storage has delayed the exports of agricultural products, increasing costs to sell products such as coffee internationally. (USDA, 2022). 99.4% of Brazil’s population has access to electricity, with little difference between urban and rural areas (CIA, 2024). Brazil struggles with water access equality; 12% of the population doesn't have clean water, and half of the population can’t access a safe toilet (Water, 2024).

Climate change is a global shift in weather patterns, caused by greenhouse gas emissions in the atmosphere increasing absorption of the sun’s heat (UN). In Brazil, climate change is expected to raise temperatures, increase occurrences of drought, and promote the spread of diseases. (USAID, 2023). Brazil’s coffee industry is vulnerable to the effects of climate change. Brazil is the largest exporter of coffee, one of the globe’s most exported commodities (Development Aid, 2023). Brazil produced 69 million 60 kilogram bags of coffee in 2020, 39% of the world’s production (SEI, 2021). An estimated eight million jobs in Brazil are in coffee production (Foreign policy, 2016). In Brazil, the percentage of land suitable for coffee growing in Minas Gerais and São Paulo, the two largest coffee producing states, is expected to decline from 70-75% to 20-25% (SEI, 2021). Goiás state may become entirely inhospitable to coffee. (SEI, 2021)

Arabica coffee (*Coffea arabica)*, the most common coffee species grown, prefers temperatures of 18-21 degrees celsius (64.4-69.8 degrees fahrenheit); temperatures above 30 degrees celsius (86 degrees fahrenheit) begins damaging the coffee trees (SEI, 2021). Robusta coffee (*Coffea canephora)* can tolerate higher temperatures and produces almost twice as much coffee as Arabica, but Arabica is more valuable and popular, making up 60% of coffee grown globally (Reuters, 2021). Robusta, the other 40% of traded coffee, is worth up to half the price of Arabica, since the latter has a sweeter, more complex flavor (Reuters, 2021 and NIH, 2022). Historically, most robusta has been domestically consumed, while Arabica coffee is grown for export to wealthier countries such as the United States (Reuters, 2021 and SEI, 2021). A strong example of the preference for arabica is Starbucks, a large coffee buyer that refuses to purchase robusta due to its flavor (SEI, 2021 and Starbucks). Bitter, high caffeine content robusta is used only to make espresso or instant coffee (NPR, 2016)

Robusta coffee’s ability to grow in higher temperatures makes it a potential substitute for Arabica coffee. However, both species require large amounts of water, making them vulnerable to the droughts that will likely become more common in Brazil (SEI, 2021). A years-long drought that began in 2013 in Espirito Santo decreased production of robusta by 30% in the state (NPR, 2016). Additionally, coffee diseases and pests in Brazil are likely to increase as a result of climate change, such as coffee nematode, leaf miner, and coffee leaf rust (Saladino, 2021 and NIH, 2022). Recently, Brazil has shifted towards growing more robusta and adapting the crop to tolerate heat and drought (SEI, 2021 and Reuters, 2021). Robusta coffee’s mostly untapped genetics have potential to forge the species into the dominant coffee species cultivated (Research robusta). Farmers don’t need to apply as much pesticide and herbicide to robusta, as the species is hardier and more resistant to disease (Research robusta). On the other hand, research suggests that robusta’s heat and disease resistance may have been overestimated (Research robusta). Climate change may negatively impact the production of both robusta and arabica (SEI, 2021).

Another factor that makes coffee vulnerable to climate change is the limited genetic diversity of the crop (Saladino, 2021). Arabica and robusta coffee are the most commonly grown coffee types (Saladino, 2021). Both species of coffee are already closely related, with Arabica coffee being a hybrid of robusta coffee and another species, *Coffea eugenioides* (Saladino, 2021). Most Arabica coffee, grown outside of where the species originated in Ethiopia, can be traced back to only a few plants (Saladino, 2021) . As a result, cultivated coffee has a very narrow gene pool. This increases coffee’s vulnerability to pests and weather changes, as individual plants are less likely to have resistant genes (Research Hybrids).

Coffee growing regions are in mostly rural, agricultural regions (Britannica Brazil, 2024). The majority of Brazil’s 360,000 coffee plantations are smaller and family operated (Foreign policy, 2016). Laborers hired by larger coffee farms tend to be male, migrants, and of Afro-Brazilian ancestry, a socially disadvantaged group (Foreign policy, 2016 and (Britannica Brazil, 2024). Coffee’s role as a commodity also makes incomes unpredictable, as increases in the amount of coffee produced lowers prices (Saladino, 2021). Coffee farmers are already being forced to adapt by switching to other crops, or from Arabica to robusta coffee ( NPR, 2016 and SEI, 2021).

Most coffee in Brazil is sun grown, a cultivation practice where solely coffee plants are grown in close proximity to each other (University, 2013). Growing coffee this way is good for efficiency and productivity, but is responsible for numerous environmental challenges (Smithsonian). Growing the coffee trees close together makes them susceptible to pests and diseases that are treated with heavy amounts of pesticide, in addition to fertilizers (Saladino, 2021 and University, 2013). Purchasing these substances can be a steep financial burden, especially for small scale farmers (University, 2013). Additionally, pesticides present a health risk to the community by leaching into groundwater (Smithsonian). Sun grown coffee plantations are typically only profitable for 10-15 years (University, 2013). Once many of the soil nutrients are depleted, rainforest is destroyed to create a new farm (University, 2013). The abandoned plantation is essentially an ecological deadzone, unable to grow crops or provide habitat for wild species (University, 2013).

Shade growing coffee is a method where coffee trees grow in a forest-like environment underneath taller trees. (Saladino, 2021). Interplantings of other species that can supply fruit, medicine, and wildlife habitat grow alongside the coffee (Smithsonian). The decreased density of coffee plants reduces the amount produced, but shade growing coffee can still be financially viable for a producer (University, 2013). Medicinal plants grown with coffee for example, are profitable when sold at local markets (University, 2013). The higher quality coffee produced can also fetch a higher price (Smithsonian).

Shade grown coffee plants are better protected from rising temperatures, droughts, and diseases caused by climate change (Smithsonian). Coffee is an understory tree species in the wild, so the shade protects their leaves from burning in the sunlight along with the higher temperatures of climate change (University, 2013 and Smithsonian). Leaf litter from trees in shade grown environments improves soil health, increasing water retention in the soil and carbon dioxide sequestered (Smithsonian, NIH, 2020). This means more water in the soil is available to thirsty coffee plants. Another benefit of healthy soil is that soil nutrients take longer to deplete in shade grown coffee plantations (University, 2013). Because the coffee plants are grown less densely, the spread of diseases such as coffee leaf rust is reduced (Saladino, 2021).

The Brazilian government has many avenues to support coffee growing. To provide economic support, especially so small farmers can weather price fluctuations, the state-owned coffee company, Companhia Nacional de Abastecimiento, sets a price floor on coffee (University, 2013). The National Environment System, in conjunction with the National Institute of Agricultural Reform, gives credit to and subsidizes farmers who increase rainforest biodiversity (University, 2013). Non governmental organizations such as the Rainforest Alliance play a similar role, while also allowing certification to stand out to consumers (University, 2013). Most certified shade grown coffee is also fair trade and organic, which benefits producers and laborers (Smithsonian). Shade grown coffee workers have safer working conditions because they don’t have to apply pesticides required by most sun grown coffee plantations (Foreign policy, 2016).

Brazil’s government could potentially reduce funding and attention given to coffee, as exports have shifted away from tropical agricultural products like coffee and sugar towards soybeans, grain, and meat since the mid 2000s (USDA, 2022). Brazil is the 7th largest emitter of greenhouse gasses that contribute to climate change and challenges in coffee production (UN). Greenhouse gasses are released when parts of the Amazon rainforest, an important ecosystem in Brazil that pulls carbon dioxide from the atmosphere, are cleared (USAID, 2023 and USAID, 2023) Jair Bolsonaro, the previous president of Brazil, weakened and failed to enforce environmental laws that protected the rainforest from deforestation (Britannica Bolsonaro, 2024). As a result, clear cutting of the land in order to farm cattle and soybeans increased ( Briannica Bolsonaro, 2024 and USDA, 2022). In 2022, the people elected Luiz Inácio “Lula” da Silva, who signed laws protecting the Amazon rainforest, showing that ordinary Brazilians have the power to reduce climate change (USAID, 2023).

Another solution is to breed F1 hybrid coffee that is resistant to the effects of climate change (Research hybrids). It takes 2-3 years for coffee trees to mature, slowing down the process for breeding new hybrids (Research hybrids). Hybrids tend to be more vigorous than species or pure-line coffee, resulting in useful traits such as greater yields, disease resistance, and heat tolerance that are especially valuable in a world with altered climate (Research hybrids). Compared to pure-line or open pollinated coffee varieties, it takes less time to go from development to market release, from 25-30 years for open pollinated coffee to 10-20 years for hybrid (Research hybrids). A drawback of F1 hybrids is that any offspring is unlikely to have its F1 parent’s traits it was selected for (Research hybrids). This makes farmers dependent on pricey specialized clonal propagation nurseries if they want to grow more coffee trees (Research hybrids). Farmers unused to F1 coffee will need to be educated that hybrid offspring aren't true to seed (Research hybrids). However, since coffee plantations can last for 30 years, farmers could have several productive decades without having to purchase more hybrids (SEI, 2021). Hybrids produced by World Coffee Research have the same or improved quality and disease resistance, while yielding 22-47% more coffee (Research hybrids). F1 coffee became commercially available in 2010, with only a few hybrids available (Research hybrids). Hybrids tend to fruit earlier, after one or two years, compared to three or four, with yields increasing over time (Research hybrids). On the other hand, more fertilizer is required by the plants (Research hybrids). F1 Hybrid coffee varieties aren't yet commercially available in Brazil, but they present another promising solution (Research hybrids).

Genetically modifying coffee, or introducing genes from different species to coffee’s genotype, could be another method of creating coffee cultivars better suited to Brazil’s changing climate (NIH, 2016 and Research varieties). While F1 hybrids are commercially available in certain countries, no genetically modified coffee varieties have ever been sold in the commercial market (Research varieties). If a genetically modified (GM) coffee variety existed, it would likely be approved in Brazil, the second largest grower of GM crops in the world (NIH, 2016). However, GM coffee is unlikely to be produced, since many coffee breeding institutes are plagued by inconsistent funding, outdated breeding technology, and the inability to conduct long-term projects. As a result, coffee is an “orphan crop” within plant breeding (Research breeding). GM coffee is also unfeasible because of its unpopularity among coffee importers (NIH, 2016). The European Union, consumer of 24% of the globe’s coffee, grows and imports very few GM crops, making it likely unworthwhile to create and grow GM coffee. (SEI, 2021 and NIH, 2016 )

There is hope for the future of coffee in Brazil. Shade growing coffee is a promising solution; it contributes to sequestering carbon, provides cooler and wetter conditions for coffee trees, and is more accessible and profitable to small-scale farmers. (Smithsonian). Buyers of coffee strongly influence the market; if enough consumers prefer sustainable coffee, governments and organizations are likely to follow.

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