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Brazil, Factor 3: Biofuels

Fueling the Future, Threatening the Present: Biofuels, Land Use, and Food Security in Brazil

Brazil, one of the world's leading biofuel producers, is particularly known for its sugarcane ethanol industry (Brinkman et al., 2018). The biofuel sector has helped the country reduce dependence on fossil fuels, lower carbon emissions, and stimulate economic growth by creating jobs in agriculture and biofuel production (de Souza & Ribeiro, 2025). However, the rapid expansion of biofuel cultivation, especially sugarcane, has significantly contributed to deforestation in the Amazon and Cerrado regions, raising concerns about environmental sustainability (Sawyer, 2008). Additionally, the growing demand for biofuel crops has altered land use patterns, intensifying competition for agricultural resources and affecting smallholder farmers (Sakai et al., 2020).

As of 2024, Brazil's population is approximately 216 million people (*IBGE: Brazil's*, 2024). It is located in South America, bordered by numerous countries, including Argentina, Bolivia, Colombia, and Venezuela, and the Atlantic Ocean (*IBGE: Brazil's*, 2024). Brazil's climate is predominantly tropical and subtropical, with variations in different regions. The Amazon region is characterized by hot and humid conditions, with heavy rainfall. The central plateau has a savanna-like climate with distinct wet and dry seasons, while the southern region experiences more temperate conditions with cooler winters (*Brazil Climatology*, n.d.).

A typical Brazilian family consists of 3-4 members, with extended family often included due to the country's strong family bonds. Urban families tend to be smaller, whereas rural families may have more children due to agricultural labor needs (Dessen & Torres, 2019). The diet in Brazil is diverse and regionally varied, with staples such as rice, beans, meat, and fresh fruits (Nascimento et al., 2011). In urban areas, education is widely accessible, but rural schools often face challenges such as teacher shortages and inadequate infrastructure (*Education in Brazil*, 2011). Healthcare access also varies; urban regions have better facilities, while rural areas rely on underfunded public health clinics, limiting access to medical services (Roman, 2023).

Agricultural fields make up 29.7% of Brazil (*Brazil - Agricultural*, n.d.). The average farm size in Brazil ranges from small family farms—which make up 91% of Brazil's agricultural producers, occupy only 20% of the available agricultural land, and are less than 100 hectares each—to large agribusiness plantations that are over 1,000 hectares, represent 1% of producers, but occupy 48% of the agricultural land (*IBGE*, 2017). Common crops grown include soybeans, sugarcane, coffee, and corn, with livestock such as cattle, poultry, and pigs raised on many farms (*Overview of the Brazilian*, 2025). Agricultural practices vary from monocropping to agroforestry, with sustainable farming techniques like crop rotation being employed to prevent soil depletion (Valdes, 2022). Before the rise of biofuel production, farming in Brazil was more focused on diverse crop systems and less intensive land use. Smallholder farmers typically relied on traditional practices, including mixed cropping, which helped maintain soil health and support biodiversity (Sakai et al., 2020). However, with the expansion of biofuel crops like sugarcane, there has been a shift toward large-scale monoculture farming, where vast areas of land are dedicated to a single crop (Piccinini, 2024). 14% of Brazil's total agricultural land is being used to grow sugarcane, most of which is used to make ethanol (*Local Farmers*, n.d.). This shift has resulted in the displacement of food crops, reduced biodiversity, and increased pressure on local ecosystems (Piccinini, 2024). The focus on biofuel production has also led to more industrialized farming techniques, including heavier reliance on

synthetic fertilizers and pesticides, further altering the landscape and farming practices in Brazil (Sakai et al., 2020).

Approximately 87.4% of the Brazilian population lives in urban areas (*2022 Census*, 2025), where employment opportunities exist in manufacturing, services, and technology sectors, but low wages are prevalent, especially for informal workers (Gomes et al., 2025). Although urban residents have access to food, economic inequality means that not all families can afford a healthy diet (Louzada et al., 2022). Urban food production, such as community gardens and rooftop farms, is emerging but remains limited in scale (Ferreira et al., 2021). Additionally, the impact of food export on the local population worsens food insecurity (de Souza & Ribeiro, 2025). Brazil's focus on exporting crops like soybeans, sugarcane, and coffee often prioritizes export markets over local consumption, leading to higher food prices domestically. This leaves many Brazilians, particularly in lower-income urban areas, struggling to afford basic staples (de Souza & Ribeiro, 2025). As agricultural land is increasingly dedicated to biofuel and export crops, the availability of land for growing food for local populations becomes limited. Smallholder farmers, who could otherwise produce food for domestic consumption, are pushed out by large agribusinesses and the growing demand for export crops, further intensifying food insecurity (de Souza & Ribeiro, 2025). This shift toward export-oriented agriculture reduces the supply of affordable, locally grown food, making it difficult for vulnerable communities to access nutritious meals (Piccinini, 2024).

Small farmers face significant barriers, including land ownership issues, reliance on expensive fertilizers, and vulnerability to climate-related challenges like droughts (Chen et al., 2024). Informal labor markets lead to unstable job security, making it difficult for many families to access affordable food (Falavina & Ulbricht, n.d.). High food prices and supply chain disruptions further exacerbate food insecurity, particularly in low-income urban areas (*Food Insecurity*, 2023).

Brazil's biofuel industry, particularly sugarcane ethanol production, is a significant driver of land competition between food and fuel crops. The expansion of sugarcane plantations has displaced small farmers and contributed to rising food prices, as more land is used for biofuel production instead of food cultivation (Marques Postal et al., 2020). The trend is mixed: while biofuels reduce reliance on fossil fuels, they also limit the land available for growing food, thus affecting food security (Brinkman et al., 2018).

Furthermore, large-scale sugarcane plantations have led to deforestation in ecologically sensitive areas like the Amazon and Cerrado, threatening habitats for countless plant and animal species (Sawyer, 2008). As forests are cleared for biofuel crops, native wildlife loses critical ecosystems, leading to population declines and, in some cases, species extinction (Ferreira et al., 2012). Additionally, monoculture farming practices associated with biofuel production reduce biodiversity by depleting soil nutrients and increasing vulnerability to pests and diseases, often resulting in heavy pesticide and fertilizer use that further harms local ecosystems (Valera et al., 2024). The conversion of natural landscapes into agricultural land also disrupts water cycles, reducing water availability for native flora and fauna (Gutierrez, 2022; *Sugarcane Farming's*, 2015). While biofuels contribute to reducing carbon emissions, their environmental costs, including habitat destruction and species loss, underscore the need for more sustainable production methods.

To effectively address the pressing challenge of food security, a multifaceted and sustainable approach is necessary. Land reform on many levels could significantly strengthen local food supplies and provide urban populations with greater access to fresh, nutritious produce. Community gardens in Rio de Janeiro and Salvador demonstrate that urban agriculture can significantly lower household food expenses, increase access to vegetables in low-income areas, and bring the community together (*'Food Security*, 2021; Levenston, n.d.). These types of approaches are especially crucial in low-income neighborhoods, where access to fresh produce is limited. Additionally, vertical farming and hydroponic systems offer

year-round production of produce using far less water compared to traditional methods (Rajaseger, 2023; Avgoustaki & Xydis, 2020). These setups reduce dependency on farmlands and bring food supply closer to urban consumers, reducing transportation costs and increasing food quality (Ling & Altland, 2023). Implementation can be supported by municipal grants, private-public partnerships, and tax incentives for developers incorporating vertical farms in new urban buildings.

Regenerative farming offers a promising solution for all farmers by prioritizing practices that restore and enhance soil health while promoting biodiversity and resilience in agricultural systems (*Regenerative Agriculture*, 2024). Unlike conventional systems that often rely on monoculture, regenerative farming encourages diverse cropping, which helps stabilize food supplies and reduces dependence on singular crops used for biofuel production (*Regenerative Agriculture*, 2021). This benefits farmers by reducing input costs over time, ensuring long-term yield stability (*Achieving Economic*, 2024). Consumers can gain from more reliable, nutritious, and locally produced food.

One key regenerative agricultural technique is cover cropping, where plants are grown in the soil immediately after a cash crop is harvested. These cover crops maintain living roots in the soil, which play a vital role in improving water retention, supporting beneficial microbial life, soil health, reducing soil erosion, and enhancing overall soil fertility (*Regenerative Agriculture*, 2021). Implementation could be supported through government grants and microloans for seeds and training programs, financed by federal agricultural development funds such as those managed by Brazil's Ministry of Agriculture (*World Bank*, 2024) and local municipal initiatives, and reinforced by the Food and Land Use Coalition (FOLU). They are helping advance a global transition toward regenerative agriculture by aligning public policy with local practice, specifically working with Brazil since 2024 (Gillespy & Antonioli, 2025).

Tilling is the practice of turning soil to mix fertilizers, control weeds and pests, and prepare for planting (*Begin When*, n.d.; Wallander, 2025). This is a very commonly used technique in traditional agriculture (Rosenburg, 2025). However, regenerative farming promotes no-till methods as avoiding tilling minimizes soil disturbance, helps preserve fungi networks and root structures, and retains both moisture and organic matter, all of which greatly contribute to long-term soil vitality (*Regenerative Agriculture*, 2021). Farmers benefit from reduced costs for fertilizers and irrigation, while consumers enjoy higher-quality produce at stable prices.

Another component of regenerative systems is composting, which recycles organic matter into nutrient-rich soil amendments. Beyond traditional composting, the implementation of a pyrolysis reactor converts agricultural waste into both usable energy and biochar (Afshar & Mofatteh, 2024). Combining bio-char with no-till practices further enhances the soil as bio-char improves soil fertility, water retention, water retention, and microbial activity (*Biochar and No-Till*, 2025). This benefits farms by reducing reliance on diesel and external energy sources, generating biofuel for internal use, and selling surplus biochar and biofuel as an additional revenue stream. Local governments can support this through subsidies for small-scale pyrolysis units and technical training programs.

Land reform policies should be enacted to provide small farmers with secure land rights, ensuring they can continue producing food despite the expansion of biofuel crops. Brazil already has several national programs related to biofuels, including the National Biodiesel Program (Adolphe & Fritsche, 2007) and mandatory blending requirements for both ethanol and biodiesel, which aim to reduce fossil fuel use and boost the renewable energy sector (Krueger, 2025). However, these programs currently favor large agribusinesses, creating tension between biofuel expansion and food production (Cordonnier, 2011).

Evidence from previous land reform initiatives in Brazil shows that granting secure land titles increases agricultural productivity, reduces rural poverty, and encourages investment in sustainable practices (Fitz, 2018). Policies like RenovaBio, which incentivize efficient biofuel production through

decarbonization credits, should explicitly reward small farmers who maintain food crops alongside biofuel crops (Grangeia et al., 2022). By incorporating social and land-use criteria, the program can ensure equitable benefits: farmers gain secure livelihoods and market access, biofuel producers gain more sustainable supply chains, and consumers gain stable food availability

Furthermore, emerging policies such as the Fuels of the Future Law and the Sustainable Aviation Fuel Regulation (SAF) present new opportunities to integrate sustainable land use practices directly into biofuel legislation (*The Brazilian*, n.d.). These could include provisions that prioritize biofuel cultivation on degraded or marginal lands and penalize the conversion of food-producing or ecologically sensitive areas. Local governments can enforce zoning regulations and provide financial incentives for biofuel farmers who adhere to these sustainable practices, creating alignment between urban and rural land-use planning. Expanding financial support mechanisms, such as subsidies or tax incentives for small farmers practicing sustainable agriculture, could mitigate the pressures imposed by industrial biofuel expansion.

This multifaceted solution has many interconnected processes. For example, biochar produced from agricultural waste in rural areas can enrich urban garden soils, while land reform ensures small farmers can sustainably produce food that feeds nearby cities. Local governments can coordinate programs across regions, linking rural regenerative farms with urban food hubs to stabilize supply chains. Funding can come from federal agricultural programs, environmental grants, and urban development funds, creating a comprehensive network of support.

Promoting sustainable biofuel practices, such as cultivating sugarcane on degraded land rather than displacing food farms, reduces environmental degradation, stabilizes food availability, and maintains income for small farms. Government subsidies for these practices, combined with technical assistance and monitoring programs, ensure adoption and measurable impact.

In conclusion, Brazil's food security is facing significant challenges due to biofuel expansion, economic inequality, and competition for land between food and fuel production. Biofuel production benefits large agribusinesses and the national economy, but can harm subsistence farmers and low-income consumers if mismanaged. A focused solution lies in land reform that secures small farmers' rights and supports them in adopting regenerative farming practices. Regenerative farming benefits farmers, consumers, and the environment; land reform secures rights and increases productivity; together, they provide a foundation for sustainable food systems. Urban agriculture can serve as a complementary tool in cities, enhancing access to fresh produce and strengthening communities, but securing farmland for smallholders comes first. While biofuels offer both economic and environmental benefits, they also pose risks to food security by reducing the land available for food crops, thereby impacting food prices and accessibility. The government, driven by energy policy and global competitiveness, must now take responsibility for regulating land use in ways that support both climate goals and food sovereignty. Farmers, especially subsistence farmers in comparison to commercial ones, are the ones most impacted by this, often losing land or being pushed into unsustainable practices. Consumers, particularly in low-income urban areas, bear the cost of rising food prices and reduced access to fresh produce. To truly fuel a just future, Brazil must return to the vision outlined at the beginning: one where biofuels and food systems coexist not in competition, but in collaboration. By embracing sustainable farming practices, land reforms, and urban agriculture initiatives, Brazil can mitigate these challenges and improve food security for all of its citizens.

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