

The Setting – Climate and Soils of Brazil

What is the land like in which the history of modern Brazil takes place? How do its soils, climates and relief influence its evolution? To understand this, we need to have a basic idea of the natural features of this enormous territory. To begin with, Brazil as it exists today is one of the largest states in the world in terms of territory. Brazil with its 8.5 million square kilometers of land area is the fifth largest country in the world, surpassed in area only by Russia, Canada, China and the United States. It also accounts for a fifth of the American continent and half the territory of South America. Due to its outstanding position on the continent, it has a coastline of 7,400 kilometers and borders with ten of the twelve South American countries, covering over 15,800 kilometers of land borders. Only Chile and Ecuador do not share borders with this Portuguese speaking nation. Brazil is divided into twenty-six states and a federal district. Some of the states, such as Amazonia (1.6 million square kilometers) and Pará (1.3 million square kilometers) have dimensions equal to or greater than the sum of the areas of France, Germany, Spain and the United Kingdom (1.3 million square kilometers). The so-called Legal Amazon has an area of 5 million square kilometers, which represents 80 percent of the total area of Europe, excluding Russia. The state of São Paulo, the richest and most densely populated, has an area similar to the United Kingdom and half of France or Spain. Brazil extends for more than 4,000 kilometers from north to south and from east to west. Although the Equator crosses Brazilian territory, 93 percent of its territory is in the southern hemisphere, most of it between the Equator and the Tropic of Capricorn. This means that, 92 percent of Brazil is in the tropics and 8 percent in the southern temperate zone (see Map 1.1).¹

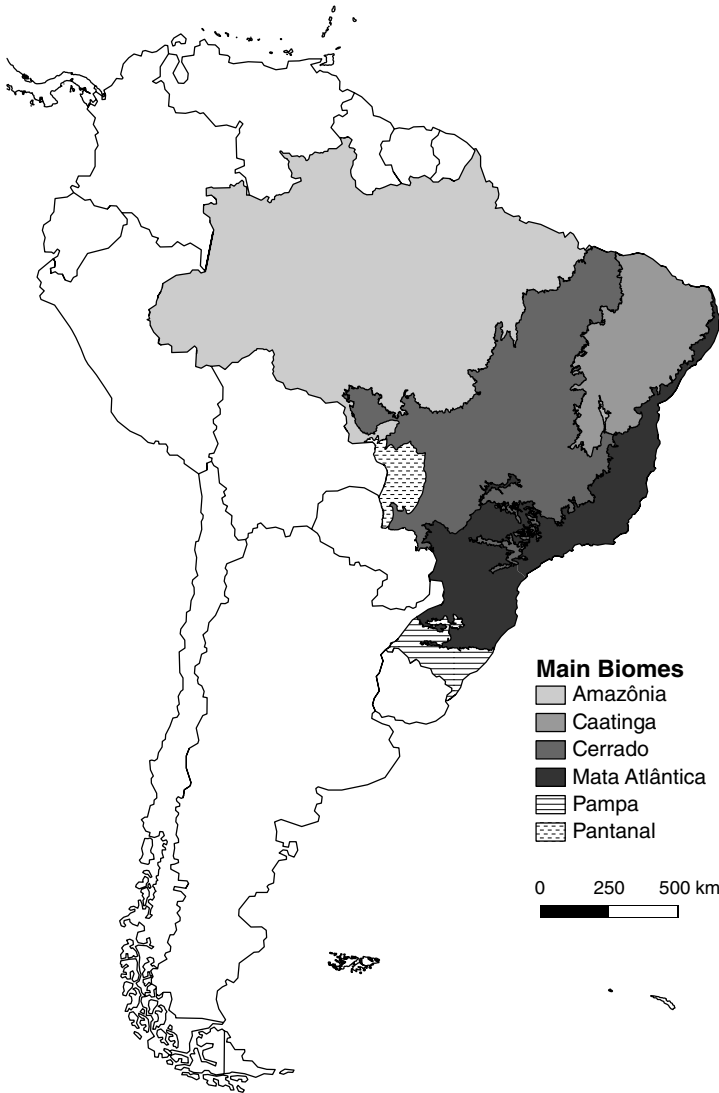
¹ For a general characterization of Brazilian geography, see Aroldo de Azevedo, *Brasil, a terra e o homem*, vol. I (São Paulo: Cia Editora Nacional, 1968).



MAP 1.1 South America and Brazil, including the Brazilian states

Brazil's frontier was finally settled with the treaty of Petrópolis, de 1903, which annexed the state of Acre from Bolivia.

Due to its large territorial extension, Brazil has a rich diversity distributed in six major biomes: the Amazon, the Atlantic Forest, the Cerrado,



MAP 1.2 Biomes of Brazil. Source: IBGE, *Bases Cartográficas – Biomas Brasil*

the Pantanal, the the Pampa and the Caatinga (see Map 1.2).² The Amazon is today the largest tropical forest in the world, covering about 5.4 million square kilometers. Approximately 80 percent of this forest is in

² On biomass in general see José Bueno Conti and Sueli Angelo Furlan, “Geoecologia, o clima, os solos e a biota,” in Jurandyr L. Sanches Ross, eds., *Geografia do Brasil* (São Paulo:

Brazil, and 60 percent of the protected part of this tropical forest is in Brazilian territory. Due to its size and characteristics, the Amazon is a great reservoir of the planet's biodiversity, which is home to around 20 percent of the known species of plants and animals. It is also recognized as a reservoir for the ecological needs not only of indigenous peoples and local communities, but also the rest of the world. According to the NGO WWF-Brazil, of all the tropical forests on Earth, the Amazon is the only one that still has its size and diversity preserved. Therefore, deforestation in the Amazon has a crucial impact on global warming. In addition, studies show that global warming could have drastic consequences for the forest, as it would reduce the timing and volume of local rains.³

The Cerrado has an area of approximately 2 million square kilometers. It is the second largest biome in South America and occupies about a quarter of Brazilian territory. Its area is contained in the states of Goiás, Tocantins, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Bahia, Maranhão, Piauí, Rondônia, Paraná, São Paulo and the Federal District, in addition to having enclaves in Amapá, Roraima and Amazonas. In the Cerrado are the headwaters of the three largest hydrographic basins in South America (Amazonas/Tocantins, São Francisco and Prata), which results in great availability of water resources. From the perspective of biological diversity, the Brazilian Cerrado is recognized as one of the richest savannas in the world. It houses more than 11,000 species of plants, 4,400 of which are native to the region. In 2018, the Cerrado had a native vegetation cover of approximately 1 million square kilometers, occupying 52 percent of the biome's area.⁴

Edusp, 2019): pp. 67–208. On the biomass of Brazil, see Azir Ab'Sáber, *Os domínios de natureza no Brasil*, Cotia (SP), Ateliê Editorial, 2021, www.wwf.org.br/natureza_brasileira/areas_prioritarias/amazonia1/bioma_amazonia/porque_amazonia_e_importante/.

³ Peter H. Raven, "Tropical floristic tomorrow," *Taxon*, 37(3) (1988): 549–560; Yadvinder Malhi, J. Timmons Roberts, Richard A. Betts, Timothy J. Killeen, Wenhong Li, and Carlos A. Nobre, "Climate change, deforestation and the fate of the Amazon," *Science*, 319 (2008): 169–172. <https://doi.org/10.1126/science.1146961>. On the Amazon forest see André de Arruda Lyra, "Estudo de Vulnerabilidade do Bioma Amazônia aos cenários de mudanças climáticas," PhD thesis, Instituto Nacional de Pesquisas Espaciais, São José dos Campos, 2015. Governo do Estado da Amazônia, *A floresta amazônica e seu papel nas mudanças climáticas* (Manaus: Secretaria de Meio Ambiente e Desenvolvimento Sustentável, 2009); Maria Alice Dias Rolim Visentin, "A floresta Amazônica e as mudanças climáticas: proteção da biodiversidade," *Revista CEJ* (Brasília), XVII (60) (2013): 96–102; Carlos A. Nobre, Gilvan Sampaio e Luís Salazar, "Mudanças climáticas e Amazônia," *Ciência e Cultura*, 59(3) (2007): 22–27, http://siscom.ibama.gov.br/monitora_biomias/PMDBBS%20-%20AMAZONIA.html.

⁴ http://siscom.ibama.gov.br/monitora_biomias/PMDBBS%20-%20CERRADO.html.

The Mata Atlântica, is the Brazilian biome with the smallest percentage of original natural vegetation cover, but it still harbors an important part of the country's biological diversity, with several endemic species and water resources that supply a population of more than 120 million people. Its remaining area is restricted to fragmented stretches, which unfortunately continue to be destroyed to extract exotic species and flora. Of the 1,103,961 square kilometers of this biome, only 17 percent of the original area is inhabited by more than two-thirds of the Brazilian population.⁵

The Pantanal, another important Brazilian biome, is one of the largest wetlands in the world with a plain that periodically floods. The region has been declared a Biosphere Reserve and a World Natural Heritage Site by UNESCO. It is spread over two states, Mato Grosso and Mato Grosso do Sul, and crosses the border into Bolivia. It occupies an area of 151,313 square kilometers – about 2 percent of Brazil – and still preserves 88 percent of its biome.⁶

The Pampa is located in the extreme south of Brazil and also extends into Uruguay and Argentina. One of the smallest Brazilian biomes, it occupies about two-thirds of the area of Rio Grande do Sul. It is a rural ecosystem with predominantly herbaceous and low-lying vegetation. The vegetation becomes denser, with trees in the vicinity of water courses and on the plateau slopes. The *Banhados*, wetlands close to the coast, are also part of this biome. In 2018, 45 percent of it was covered by native vegetation.⁷

The final major biome within Brazil is the Caatinga, located in the semi-arid region of Brazil, which contains 20 million inhabitants and is among the most populated semiarid regions in the world. The term “caatinga” denotes a dominant vegetation that extends over almost all the northeastern states and part of Minas Gerais. This ecosystem is extremely important from a biological point of view because it houses unique flora and fauna. It is estimated that at least 932 species have already been recorded in the region, of which 380 are endemic. Among the Brazilian biomes, this one is least studied, despite being one of the most threatened due to the inadequate and unsustainable use of its soils. The Caatinga occupies 844,453 square kilometers. In 2018 it had an area of native vegetation

⁵ http://siscom.ibama.gov.br/monitora_biomias/PMDBBS%20-%20MATA%20ATLANTICA.html.

⁶ http://siscom.ibama.gov.br/monitora_biomias/PMDBBS%20-%20PANTANAL.html.

⁷ http://siscom.ibama.gov.br/monitora_biomias/PMDBBS%20-%20PAMPA.html.

covering 546 thousand square kilometers, equivalent to 64 percent of the biome's area.⁸ From an economic point of view, it represents one of the areas with the highest concentration of poverty in the country and the poorest farms and farming land.

The Brazilian landscape is characterized by level plains with only modest elevations and without large mountain formations. The plateau corresponds to the largest portion of Brazilian territory, including a large part of the Amazon region. The highest point in Brazil, at around 3,000 meters, is located in the state of Amazonas, on the border with Venezuela.⁹ Nevertheless for most of its post-1500 history, the population has been concentrated on the coast, and intense occupation of the interior plains only occurred from the twentieth century onwards. But even today, a large part of the population and the generation of wealth is concentrated in the eastern Atlantic coastal portion of the territory. Most Brazilian state capitals are located on the coast or close to the coast, like the city of São Paulo, just over 50 km away from the sea.¹⁰

Brazil has about 12 percent of the fresh water available on the planet, but it is irregularly distributed in the territory and its availability is influenced by a wide variety of local climactic conditions. The average annual precipitation in Brazil is 1,765 millimeters, ranging from 500 millimeters per year in the Northeast to 3,000 millimeters per year in Amazonia. The Amazon basin, the Rio de la Plata Basin and the São Francisco Basin are the main Brazilian hydrographic basins, with the Brazilian Central Plateau which contains these important river basins.¹¹

⁸ http://siscom.ibama.gov.br/monitora_biomass/PMDBBS%20-%20CAATINGA.html.

⁹ For an analysis of the geographic characteristics of Brazil and its regions, see Aroldo de Azevedo, *Geografia do Brasil* (São Paulo: Cia Editora Nacional, 1976); *O Brasil e suas regiões* (São Paulo: Cia Editora Nacional, 1972); *Brasil, a terra e o homem*, 2 vols. (São Paulo: Cia Editora Nacional, 1968, 1970); Jurandyr L. Sanches Ross, ed., *Geografia do Brasil* (São Paulo: Edusp, 2019); Azir Ab'Sáber, *Os domínios de natureza no Brasil* (Cotia, SP: Ateliê Editorial, 2021).

¹⁰ In contrast to the Andes, which are relatively narrow, elongated in a north-south direction and exceeding 4,000 meters in many areas, terrain in the center and east of South America, where Brazil is located, is low, and mostly under 1,000 meters. For further geographical information, see Jurandyr L. Sanches Ross, "Os fundamentos da geografia da natureza," in *Geografia do Brasil*, 13–65.

¹¹ The Brazilian central plateau and the plateaus of the center-west are the main dispersing centers, separating the Amazon and Tocantins-Araguaia basins, from the Paraná and Paraguay basins and also from the São Francisco basin. In terms of area of the different basins, the Amazon represents 57%, Paraná 10%, São Francisco 7%, Paraguay 4% and Uruguay 2%. The groups of isolated basins represent 20 percent. See Ruth Simões Bezerra dos Santos, "Aspectos da hidrografia brasileira," *Revista Brasileira de Geografia*, XXIV(3) (1962): 327–375.

There are also important underground water resources, such as the Guarani Aquifer in southern Brazil.¹²

In terms of soils, there is enormous variety in the country, with predominance of Latosols, Argisols and Neosols, which together account for approximately 70 percent of the national territory. Latosols and Argisols occupy approximately 58 percent of the area and are deep, highly weathered, acidic soils with low natural fertility and, in certain cases, with high aluminum saturation. Soils of medium and high fertility also occur, but are generally shallow due to a low degree of weathering.¹³

The Amazon basin is the largest river in the world in area and in volume of water and extends over seven countries, although it is predominantly in Brazil. It discharges into the Atlantic a volume of water that represents approximately 15 percent of water contributions to the oceans.¹⁴ The Amazon River, rises in the Peruvian Andes and flows into the Atlantic through the states of Pará and Amazonas.¹⁵ Its tributaries many of which are quite large include the Madeira, which starts in Bolivia and flows into the Amazon (3,300 kilometers), the Purus which originates in Peru (3,200 kilometers), the Tocantins and the Araguaia, which rise in Central Brazil, both longer than 2,500 kilometers. The river network is essential for life in the Amazon and its main means of transport. Cargo transport and human mobility depend on the fluvial network, from the region's large rivers to the smallest water courses, such as streams, navigable by small canoes.¹⁶ The region has

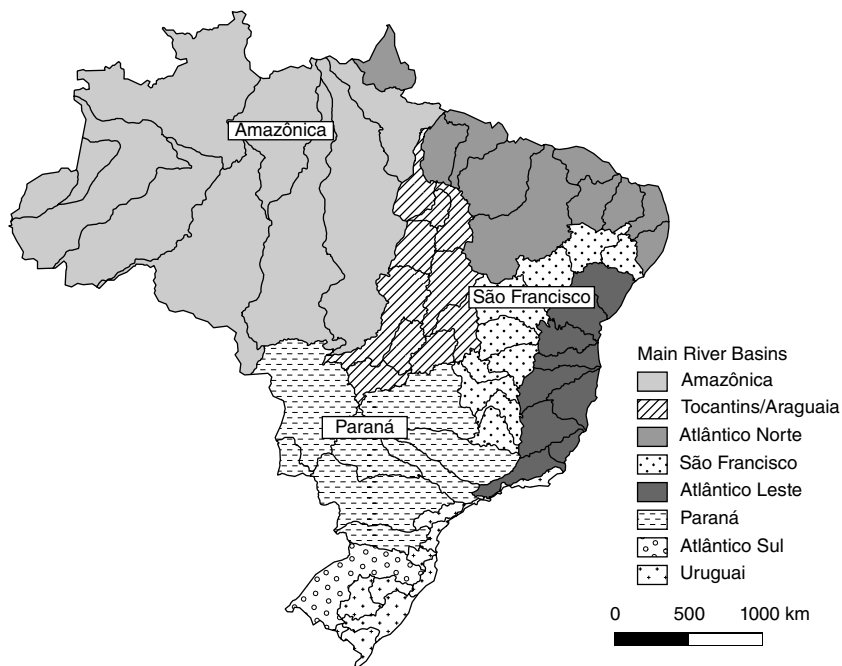
¹² José Galizia Tundisi, ed., *Recursos hídricos no Brasil: problemas, desafios e estratégias para o futuro* (Rio de Janeiro: Academia Brasileira de Ciências, 2014): 4–7.

¹³ Embrapa, *Solos brasileiros*, www.embrapa.br/tema-solos-brasileiros/solos-do-brasil.

¹⁴ The basin extends across Brazil (63%), Peru (16%), Bolivia (12%), Colombia (6%), Ecuador (2%), Venezuela (0.8%) and Guyana (0.3%), and covers 6,112,000 square kilometers, approximately 5% of the emerged lands. Michel Moliner et al., “Hidrologia da bacia do Rio Amazonas,” *Ciência e Tecnologia*, https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_6/b_fdi_35-36/41720.pdf.

¹⁵ From new measurements carried out by the National Institute for Space Research (INPE), it was concluded that the Amazon is also the longest river in the world, with 6,992.06 km, exceeding the length of the Nile by 140 km. INPE, accessed at www.inpe.br/noticias/noticia.php?Cod_Noticia=1501. On the formation of the Amazonic basin, see Tacio Cordeiro Bicudo, “Estudo da formação da bacia hidrográfica do rio Amazonas através da modelagem numérica de processos tectônicos e sedimentares,” Master's thesis, USP, São Paulo, 2017.

¹⁶ The Amazon region is irrigated by large rivers and water courses of varying size and flow volume, which makes water transport the basic part of the Amazon transport network and all other modes of transport complement this water system. José Alex Sant'Anna, *Rede básica de transporte da Amazônia* (Brasília: Ipea, TD 562, 1998): 11. Also see BNDES, *Transportes na Amazonia*. Informe Infraestrutura 22 (BNDES, maio/1998);



MAP 1.3 Main river basins of Brazil. Source: CPRM

also become important in power generation, with large power plants such as Belo Monte (the fourth largest in the world), the one at Tucuruí (the seventh largest in the world), the two at Jirau and Santo Antônio (see Map 1.3).¹⁷

Juliana Terezinha da Silva Medeiros. “O transporte fluvial e o direito à dignidade da pessoa humana na Amazônia,” Master’s thesis, Universidade do Estado da Amazonia, Manaus, 2012.

¹⁷ The construction of hydroelectric plants in the Amazon basin, despite its high potential in terms of energy, faces opposition from environmentalists due to their perverse effects on the environment. Mayana Bento Silva, Mario M. A. G. Herreros and Fabrício Quadros Borges, “Análise dos aspectos econômicos e socioambientais no projeto hidrelétrico Belo Monte, Pará,” *Revista de Ciências Ambientais*, 8(1) (2014): 15–27; Savannah Tâmara Lemos da Costa et al., “Usina Hidrelétrica de Belo Monte: Análise Multitemporal da produção de energia e impactos ambientais,” *Revista Brasileira de Energias Renováveis*, 8(1) (2019): 224–237; Lorena Candido Fleury and Jalcione Almeida, “The construction of the Belomonte Hydroelectric power planta: environmental conflict and the development dilemma,” *Ambiente & Sociedade*, 16(4) (2013): 141–156; Greenpeace, *Hidrelétricas na Amazonia. Um mau negócio para o Brasil e para o mundo* (São Paulo: Greenpeace, 2016): 68, www.greenpeace.org/static/planet4-brasil-stateless/2018/07/relatorio_hidreletricas_na_amazonia.pdf. The source for Map 1.6 CPRM is http://siagasweb.cprm.gov.br/layout/visualizar_mapa.php.

The Rio de la Plata basin, the second largest in Latin America, occupies 17 percent of the region's territory. Brazil, Argentina, Bolivia, Paraguay and Uruguay share the basin, formed by large rivers such as the Paraná, Paraguay and Uruguay. The Rio de la Plata which flows into the South Atlantic is formed at the confluence of the Paraná and Uruguay rivers.¹⁸ The Brazilian portion of the basin corresponds to approximately 1.4 million square kilometers, and includes the Federal District and the states of Minas Gerais, Goiás, Mato Grosso, Mato Grosso do Sul, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul. The Paraguay River, born in Mato Grosso, is a tributary of the Paraná River and has a length of 2,550 kilometers, of which 1,683 kilometers is in Brazil. It occupies part of the Brazilian Cerrado and the Pantanal. The Uruguay River starts in Santa Catarina, is 2,200 kilometers long and flows into the Rio de la Plata, also bathing areas in Argentina and Uruguay. The largest river in this basin is the Paraná, which is some 4,880 kilometers long and mainly in Brazilian territory, with stretches in Argentina and Paraguay.¹⁹ This basin concentrates the richest and most densely populated region in South America, and plays a fundamental role in various economic and social aspects in this area. It is the basin with the largest installed capacity for electricity in the country. There are fifty-seven large reservoirs in the basin, including the multinational Itaipu reservoir, and contains the second largest hydroelectric plant in the world, with a generation capacity of 14,000 megawatts.²⁰ The La Plata basin also represents a fundamental means of transport in the region and links the countries and regions (the Brazilian states of São Paulo, Paraná, Mato Grosso, Mato Grosso do Sul, Goiás and Minas Gerais) on its periphery via the Tietê-Paraná waterway, connecting production areas to sea ports and serving the main centers of Mercosur. It is 2,400 kilometers long, comprising 1,600 kilometers on the Paraná River and 800 kilometers on the Tietê River.²¹

Another important basin is formed by the São Francisco River, located entirely in Brazil, consisting of an area of 650 thousand square kilometers. The São Francisco River in its long course of 2,700 km crosses

¹⁸ Vera Lucia Fortes Zeni, "Bacia do Prata: o território das águas," PhD thesis, Universidade Federal de Santa Catarina, Florianópolis, 2018: 13, 55–56.

¹⁹ Zeni, "Bacia do Prata," 58.

²⁰ Itaipu Binacional, www.itaipu.gov.br/energia/bacia-do-rio-parana.

²¹ *Hidrovia Tietê-Paraná*, Departamento Hidroviário do governo do Estado de São Paulo, www.dh.sp.gov.br/hidrovia-tiete-parana/. The Tietê, 1,150 km in length, rises less than 30 km from the coast and moves inland, east to west, flowing into the Paraná River.

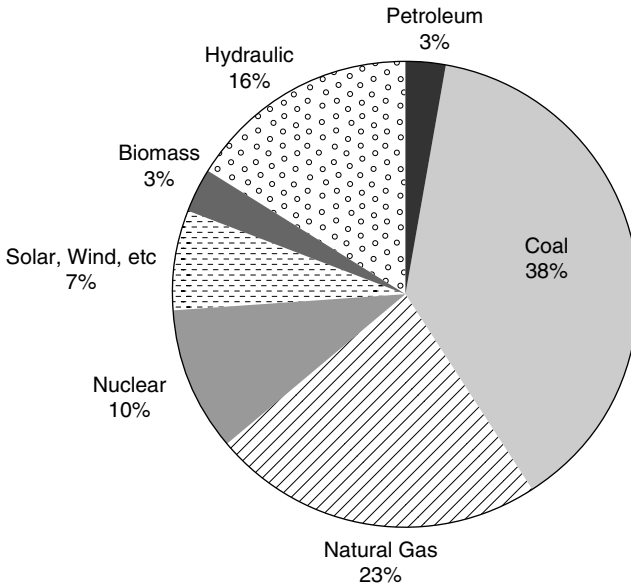
five Brazilian states: Minas Gerais, where it starts, Bahia, Pernambuco, Sergipe and Alagoas. It flows into the Atlantic Ocean on the border of these last two states. The São Francisco is called the river of national integration, as it links the northeast to the southeast. Since the beginning of European colonization, it has played a fundamental role in the economic and social life of a large portion of the Brazilian territory. It was traditionally the main means of transport in the region, as it is navigable for around 1,300 kilometers. In addition to being a source of water for all types of use, the São Francisco River basin has become, throughout the twentieth century, essential for the generation of energy. Hydroelectric plants exist at Três Marias, in Minas Gerais, Paulo Afonso (4,279 megawatts), Xingó (3,162 megawatts) and Sobradinho (1,050 megawatts). Of the great Brazilian rivers, the São Francisco is probably the most environmentally affected by the intensive use of water, uncontrolled deforestation and urban, agricultural and industrial pollution released into its waters, directly or brought by tributaries, degrading river waters and decreasing its flow.²² In addition to the problems directly related to the pollution of the river, attempts to divert its water to drier regions such as the Caatinga biome are major areas of contention.²³

Given its vast territorial extension, Brazil has different precipitation and temperature regimes. The north of the country has a rainy equatorial climate, with practically no dry season; in the Northeast, the rainy season, with low rainfall, is restricted to a few months, characterizing a semiarid climate. The Southeast and Midwest are influenced by both tropical and mid-latitude systems, with a well-defined dry season in winter and a rainy season in the summer with convective rainfall. Southern Brazil, due to its latitudinal location, is more influenced by mid-latitude systems, where frontal systems are the main cause of rainfall throughout the year.²⁴

²² Andrea Zelhuber and Ruben Siqueira, “Rio São Francisco em descaminho: degradação e revitalização,” *Cadernos do CEAS*, Salvador, n. 227 (2007); César Nunes de Castro and Caroline Nascimento Pereira, “Revitalização do Rio São Francisco,” *IPEA, Boletim regional, urbano e ambiental*, 17 (2017).

²³ André Tomé de Assis, “A transposição do Rio São Francisco na voz dos diretamente atingidos em Cabrobó (PE),” PhD thesis, Universidade Federal de Minas Gerais, Belo Horizonte, 2015; Zelhuber and Siqueira, “Rio São Francisco”; Carolina Jessica Domschke, “A Transposição do rio São Francisco: contradições da presença-ausência da obra ao longo de seus eixos,” Master’s thesis, FAU-USP, São Paulo, 2019; Francisco Jácome Sarmiento, *Transposição do Rio São Francisco: custo da água*, www.academia.edu/8941808/TRANSPOSI%C3%87%C3%83O_DO_RIO_S%C3%83O_FRANCISCO_Custo_da_%C3%A1gua.

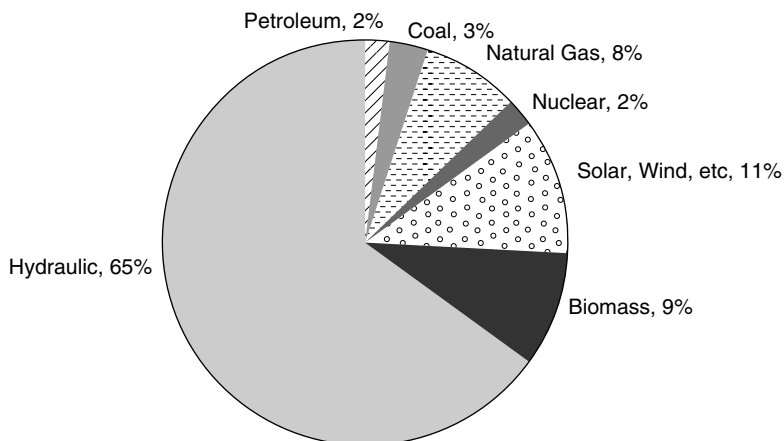
²⁴ Mario F. Leal de Quadro et al., “Climatologia de precipitação e temperatura,” INPE, <http://climanalise.cptec.inpe.br/~rclimanl/boletim/cliexp10a/chuesp.html>.



GRAPH 1.1 Sources of electricity in the world

The abundance of water resources in Brazil has influenced the formation of the Brazilian electrical matrix, which is radically different from the world standard. While 16 percent of the world's electricity is generated through hydraulic sources, in Brazil the figure is 66 percent. Adding solar and wind sources to water, brings these non-carbon sources to 76 percent of total electricity generated (see Graphs 1.1 and 1.2). By opting for the intensive use of electricity from hydraulic sources, the country took advantage of the varieties of the Brazilian climate to reduce climate risk, through the implementation of a large and interconnected electrical system throughout Brazil. With the variety of climates, large reservoirs and an interconnected system, shortfalls in power generation in one region can be compensated by other regions. This was the way to base the electrical system on a source that depends on uncontrollable climatic variations. The current global intensification of climatic change jeopardizes the Brazilian position, and encourages the discovery of other alternative renewable energy sources. This is the case of biomass and solar/wind energy.²⁵ Brazil, for its size, diversity and geographical position,

²⁵ EPE (Empresa de Pesquisa Energética), www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-letrica.



GRAPH 1.2 Source of electricity in Brazil

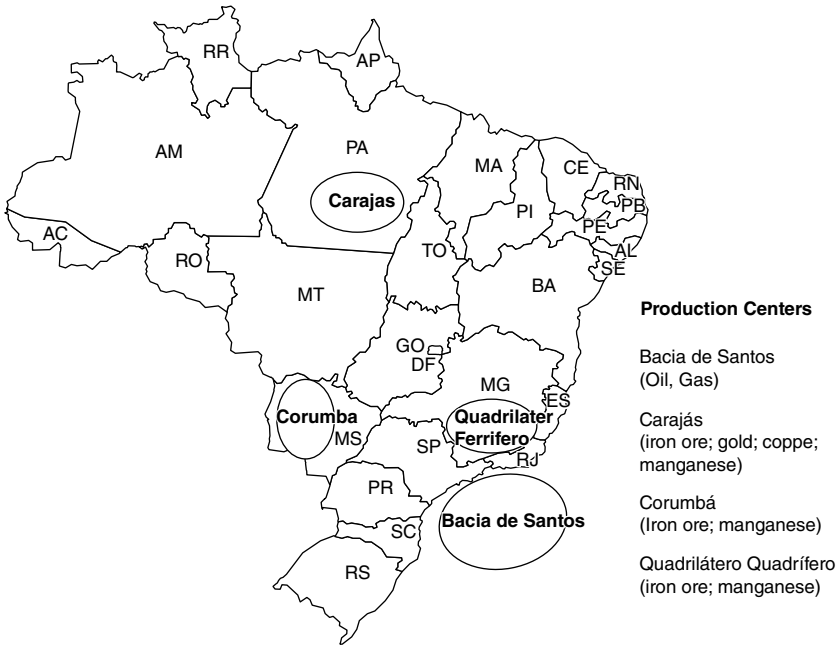
presents excellent conditions to significantly expand the participation of these new renewable sources in its energy matrix, a challenge faced by all the countries of the world today.

Brazil, due to its size and physical diversity, is rich in mineral products, being one of the producers and exporters of several important minerals.²⁶ It is the second largest producer of iron ore in the world and has niobium (90 percent of reserves and 80 percent of world supply),²⁷ bauxite (second largest producer in the world), and magnesite (fifth largest producer). The mineral deposits are situated in the regions known as the Quadrilátero Ferrífero, in south-central Minas Gerais, the so-called Carajás Mineral Province in Pará and the region of Corumbá (Mato Grosso do Sul).²⁸ In addition, Brazil has significant coastal and undersea

²⁶ Onildo João Marini, "Potencial mineral do Brasil," in Adolpho José Melfi, Aroldo Misi, Diogenes de Almeida Campos and Umberto Giuseppe Cordani, eds., *Recursos minerais no Brasil: problemas e desafios* (Rio de Janeiro: Academia Brasileira de Ciências, 2016): 18. Jairo Yunis and Elmira Aliakbari, *Survey of mining companies 2020* (Vancouver: Fraser Institute, 2021): 12–14, www.fraserinstitute.org/sites/default/files/annual-survey-of-mining-companies-2020.pdf.

²⁷ Brasilminingsite, accessed at: <https://brasilminingsite.com.br/producao-recorde-de-niobio-em-2019-posiciona-o-brasil-como-lider-mundial-neste-tipo-de-exploracao/>.

²⁸ IBRAM: Setor Mineral 2020, <https://ibram.org.br/publicacoes/page/2/#publication>. On iron mining, see Pedro Sergio Landim de Carvalho et al., *Minério de ferro*. BNDES, https://web.bnDES.gov.br/bib/jspui/bitstream/1408/4802/1/BS%2039%20min%C3%A9rio%20de%20ferro_P.pdf. The Carajás mineral province is one of the most important in the world, and the second largest producer of iron ore in Brazil. It is also rich in gold, copper, manganese, nickel-chromium and other products. About Carajás,



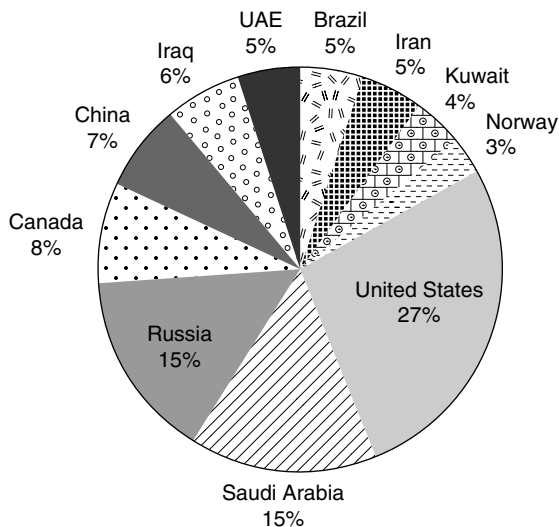
MAP 1.4 Main mineral and hydrocarbon centers of Brazil

deposits of petroleum (Graph 1.3) in the pre-salt region in the Santos Basin, which includes the coast of the states of São Paulo, Rio de Janeiro and Espírito Santo (see Map 1.4).²⁹

Brazil, due to its continental size, contains a diversity of climates, reliefs, rainfall and biomes, which is reflected in the special economic and demographic characteristics of its various regions. Over the years, the Brazilian government has divided the country into what are assumed to be coherent and separate regions. The latest of these regional definitions

see Vale, *Projeto Ferro Carajás*, www.vale.com/brasil/PT/initiatives/innovation/s11d/Documents/Final-Book-S11D-PORT.pdf; Sérgio Marguilis, *O desempenho do governo brasileiro e do Banco Mundial com relação à questão ambiental do projeto de ferro Carajás* (Brasília: Ipea, TD 193, 1990); Marcio Zonta and Charles Trocate, *Projeto grande Carajás. Trinta anos de desenvolvimento frustrado* (Marabá: Editorial iGuana, 2015); Gilciandro Prestes de Andrade, “A Amazônia e o Projeto Grande Carajás: entre as tentativas de desenvolvimento da região e os problemas causados às populações indígenas,” *Mundo Amazônico*, 6(2) (2015): 5–19.

²⁹ Petrobrás, Pré-Sal, https://petrobras.com.br/pt/nossas-atividades/areas-de-atuacao/exploracao-e-producao-de-petroleo-e-gas/pre-sal/?gclid=CjoKCQjw8p2MBhCiARIsADDUFVEQMPPYaElpfEGLh4EO7WU7WA7rJbKgtQ1EbcmeOLwgeU-wQfH3_JEaAiscEALw_wcB.



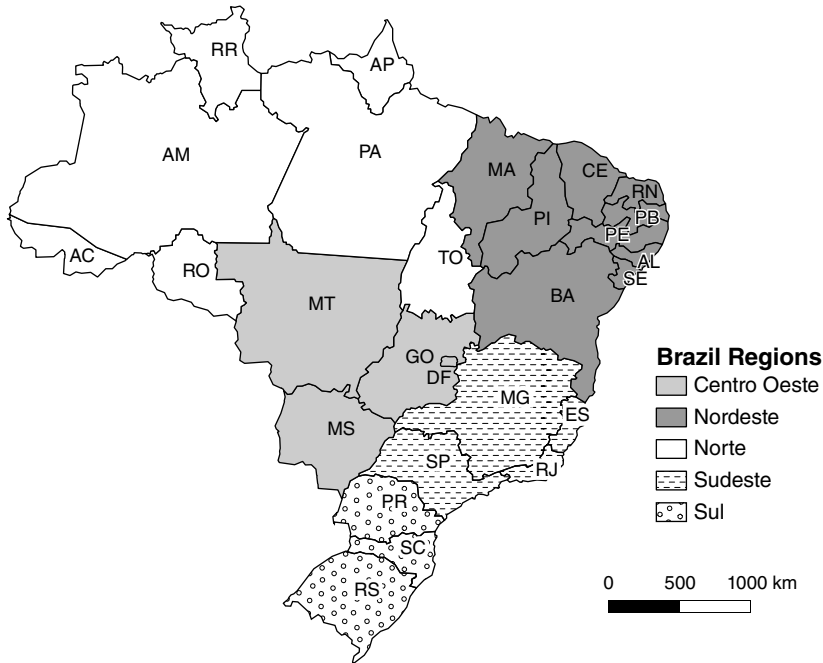
GRAPH 1.3 The world's major petroleum producers, BPD, 2021 (% world total).
Source: US EIA International.

occurred in 1970.³⁰ Since then the country has been divided into five coherent regions: the North, the Northeast, the Southeast, the South and the Center-West (Map 1.5).³¹

The North region, with an area 3,853,676 square kilometers represents 45 percent of the Brazilian territory and has an area greater than the sum of the ten largest European countries, excluding Russia, or 91 percent of the total area of the European Union. The seven states which form the North Region are Acre, Amapá, Pará, Rondônia, Roraima and Tocantins. More than 80 percent of the territory of the Northern region is part of the Amazon Biome, with portions of Cerrado on the periphery of the Amazon valley, in several states, such as Tocantins, Amapá and Roraima. The physical characteristics of the region have influenced the occupation and economic activities in the region and explain the reduced population density. Some 20 million people currently live in the region, representing only 9 percent of the Brazilian population, with a

³⁰ According to the IBGE, the regional divisions differed over time. In 1942, these were grouped into eight regions. Then in 1970 came the current five-scheme regional division: North Region, Northeast Region, Southeast Region, South Region and Central-West Region, www.ibge.gov.br/geociencias/organizacao-do-territorio/divisao-regional/15778-divisooes-regionais-do-brasil.html?=&t=o-que-e.

³¹ The classic study of the regions is Azevedo, *O Brasil e suas regiões*.



MAP 1.5 Current regions and states of Brazil. Source: IBGE, *Bases Cartográficas*

population density of 4.9 inhabitants per person, against 25.1 in Brazil.³² The most populous state is Pará; the least populated is Roraima, and from an economic point of view, the region represents only 6 percent of the national GDP.³³ Roraima and the Northeast region are the nation's poorest regions.³⁴ From an economic point of view, it is a region devoted to agriculture and extractive activities.³⁵ The regional transport infrastructure is poor and river transport is important.³⁶

³² IBGE, Estimativas da População, www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=resultados.

³³ IBGE, Estimativa do IBGE para o ano de 2020, www.ibge.gov.br/explica/pib.php.

³⁴ IBGE, Índice de Desenvolvimento Humano (IDH), 2010, <https://cidades.ibge.gov.br/brasil/ac/pesquisa/37/30255?tipo=ranking&ano=2010>.

³⁵ The Free Zone, created in 1967, was designed to create an industrial hub in the interior of the Amazon using important tax incentives, Suframa, www.gov.br/suframa/pt-br/zfm/industria. There are permanent criticisms of the existence of this free zone, vigorously defended by the region's community. See Ricardo Nunes de Miranda, "Zona Franca de Manaus: desafios e vulnerabilidade" (Brasília: TD 126, Senado Federal, 2013).

³⁶ On the system of transport in the region see Joel Castro de Nascimento and Ocilde Custódio da Silva, "Análise da logística e infraestrutura de transporte de carga do pólo industrial de Manaus," *XXXII Encontro Nacional de Engenharia de Produção, Bento*

TABLE 1.1 *Areas destined for the protection and preservation of native vegetation and other land uses in Brazil 2018*

| Categories | Area (hectares) | Percent of area of Brazil |
|--|-----------------|---------------------------|
| Areas for the preservation of native vegetation registered in the CAR (rural world – cattle raising, agriculture, forestry, extractivism...) | 218,245,801 | 25.6 |
| Full conservation units | 88,429,181 | 10.4 |
| Indigenous lands | 117,338,721 | 13.8 |
| Native vegetation on unregistered vacant land | 139,722,327 | 16.5 |
| Native pastures | 68,022,447 | 8.0 |
| Planted pastures | 112,237,038 | 13.2 |
| Crops | 66,321,886 | 7.8 |
| Planted forests | 10,203,367 | 1.2 |
| Infrastructure, cities and others | 29,759,821 | 3.5 |
| TOTAL | 850,280,589 | 100.0 |

Source: Embrapa, *Síntese Ocupação e Uso das Terras no Brasil* (2018), [www.embrapa.br/car/sintese#:~:text=O%20mundo%20rural%20brasileiro%20utiliza,nacional%20\(25%2C6%25\)](http://www.embrapa.br/car/sintese#:~:text=O%20mundo%20rural%20brasileiro%20utiliza,nacional%20(25%2C6%25))

The Northeast region, with an area of 1,554,292 square kilometers, represents 18 percent of the Brazilian territory (see Table 1.1). Nine states form the Northeast region: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe. Three different biomes the Mata Atlântica, the Caatinga and the Cerrado are part of the Northeast. The original European occupation of Brazilian territory was initially consolidated in the Mata Atlântica, where the sugar industry was established by the Portuguese colonizers. The Northeast, although containing 27 percent of the Brazilian population, represents only 14 percent of the national GDP.³⁷

Within the Northeast region the Caatinga area has a semiarid climate, and was gradually occupied by cattle ranching as a subsidiary of coastal

Gonçalves, 2012; Cristianne da Silva Macêdo, “Infraestrutura de transporte hidroviário de carga no estado do Amazonas: um diagnóstico a partir de políticas públicas de investimento,” Master’s thesis, Universidade Federal do Amazonas, Manaus, 2012; Thiago Oliveira Neto, “Rodovias na Amazônia e as mudanças recentes na circulação regional,” *Revista Tamoios*, 16(3) (2020): 63–84. On investment project see ABDIB *Forum: Infraestrutura Regional* (Belém: Edição Norte, 2020).

³⁷ IBGE estimates for the year 2020, www.ibge.gov.br/explica/pib.php.

activity. Due to its climatic conditions and poor water resources, it is one of the poorest areas of the country to date and is densely populated, representing about 12 percent of the Brazilian population, but 43 percent of the population in the Northeast region. It has a population density of 23.05 inhabitants per square kilometer, “which characterizes it as the most populous semiarid region in the world. The high population density for a semiarid region imposes strong pressure on natural resources.”³⁸

The Cerrado area contained in the Northeast occupies parts of the states of Maranhão, Piauí, Bahia, Ceará, Pernambuco and Sergipe. There is a sub-region of the Cerrado called Matopiba, made up of parts of the states of Maranhão, Piauí and Bahia (in the Northeast region) and Tocantins (in the North region), which has become one of the main poles of modern, large-scale, high productivity agriculture and a world grain producer.³⁹

The Southeast region, the richest and most populated zone of the country, has an area of 924,511 square kilometers, representing 11 percent of the Brazilian territory, but accounts for 42 percent of the population. It contains four states, São Paulo, Rio de Janeiro, Minas Gerais and Espírito Santo. The Tropic of Capricorn passes through the region, so all the states in the region are found in the tropical area. But its breadth in terms of latitude from the north of Minas Gerais to the south of São Paulo (latitude 14 degrees and 25 degrees respectively), incorporates various climatic conditions. São Paulo, Rio de Janeiro and Espírito Santo are located in the Mata Atlântica biome. Minas Gerais has areas divided between the Mata Atlântica and the Cerrado, with a small portion of the Caatinga as well. The region contains excellent soils as well as major mineral deposits.⁴⁰

The South region, with an area of 576,774 square kilometers, is located entirely in the temperate zone, below the Tropic of Capricorn. It

³⁸ Iana Alexandra Alves Rufino and Simone Tavares da Silva, “Análise das relações entre dinâmica populacional, clima e vetores de mudança no semiárido brasileiro: uma abordagem metodológica,” *Boletim de Ciências Geodésicas*, 23(1) (2017): 171; Aziz Nacib Ab’Sáber, “Sertões e sertanejos: uma geografia humana sofrida,” *Dossiê Nordeste Seco, Estudos Avançados*, 13(36) (1999): 7–59.

³⁹ Embrapa, www.embrapa.br/tema-matopiba/sobre-o-tema. Also see Caroline Nascimento Pereira, Gabriela Lanza Porcionato and Cesar Nunes de Castro, “Aspectos socioeconômicos da região do Matopiba,” *Boletim Regional, urbano e ambiental*, 18 (2018); Clovis Caribé Menezes dos Santos, “Matopiba: uma nova fronteira agrícola ou um reordenamento geográfico do agronegócio e dos espaços produtivos de ‘cerrados’,” *Cadernos CEAS*, 245 (2018).

⁴⁰ IBGE, *Censo Agrícola de 2017*, Sidra, tables 6904, 6955 and 6957.

is made up of just three states: Paraná, Santa Catarina and Rio Grande do Sul, and borders on three countries, Paraguay, Uruguay and Argentina and shares many of the soils and biomes of these nations. Here the Mata Atlântica predominates in its northern portion. The Pampa is another biome which Brazil shares with Paraguay and Uruguay, which is the broad plains of the extreme southern region of the continent. It was lightly populated by the Portuguese in the colonial period and in the eighteenth and nineteenth centuries European immigrants established smallholdings. This colonization process and the terrain and climate conditions led to the formation of a different economic and social structure from the rest of the country. Smallholdings in the northern portion and extensive livestock in the south defined the region.⁴¹

The last major region is the Center-West which represents the most recent frontier of territorial occupation in the country. With an area of 1,612,000 square kilometers, slightly smaller than Mexico, and representing 19 percent of the national territory, it comprises the states of Goiás, Mato Grosso, Mato Grosso do Sul and the Federal District. Here the Cerrado is the predominant biome along with portions of the Amazon and Pantanal biome. Located in the center of the country, it represents the cradle of the main Brazilian hydrographic basins. Little explored until the middle of the twentieth century, it has become the main grain production center in Brazil and one of the most important in the world.⁴²

In spite of intense use by agriculture and cattle ranching, most of the land area consists of native flora preservation regions, conservation units, indigenous lands and native vegetation on vacant and unregistered land, totaling 563 million hectares, which represents 66 percent of the national territory. This untouched area is equivalent to forty-three countries and five European territories. Native and cultivated pastures represent 21 percent, crops only 8 percent and planted forests only 1 percent of the total land area of Brazil (see Table 1.1).

The population of Brazil today is obviously not evenly distributed across the country. The Southeastern and Southern regions are the most

⁴¹ Vicente Eudes Lemos Alves, "A mobilidade sulista e a expansão da fronteira agrícola brasileira," *Revista de Saúde Pública*, 2 (2005): 40–68; Fabiano André Marion, "Expansão da fronteira agrícola e reordenação territorial," *III Simpósio Nacional de Geografia Agrária*, 2005; Pedro Simon, *A diáspora do povo gaúcho* (Brasília: Senado Federal, 2009).

⁴² Data from January to September 2021, Ministério da Agricultura, Pecuária e Abastecimento, www.gov.br/agricultura/pt-br/assuntos/politica-agricola/valor-bruto-da-producao-agropecuaria-vbp.

TABLE 1.2 Area, population and population density of Brazil
(census 2010)

| States and regions | Area (km ²) | Population | Density (Persons/km ²) |
|---------------------|-------------------------|-------------|---------------------------------------|
| Brazil | 8,502,728 | 190,755,799 | 22.4 |
| North | 3,853,576 | 15,864,454 | 4.1 |
| Rondônia | 237,591 | 1,562,409 | 6.6 |
| Acre | 164,122 | 733,559 | 4.5 |
| Amazonas | 1,559,162 | 3,483,985 | 2.2 |
| Roraima | 224,301 | 450,479 | 2.0 |
| Pará | 1,247,950 | 7,581,051 | 6.1 |
| Amapá | 142,828 | 669,526 | 4.7 |
| Tocantins | 277,622 | 1,383,445 | 5.0 |
| Northeast | 1,554,388 | 53,081,950 | 34.1 |
| Maranhão | 331,936 | 6,574,789 | 19.8 |
| Piauí | 251,577 | 3,118,360 | 12.4 |
| Ceará | 148,921 | 8,452,381 | 56.8 |
| Rio Grande do Norte | 52,811 | 3,168,027 | 60.0 |
| Paraíba | 56,470 | 3,766,528 | 66.7 |
| Pernambuco | 98,146 | 8,796,448 | 89.6 |
| Alagoas | 27,779 | 3,120,494 | 112.3 |
| Sergipe | 21,918 | 2,068,017 | 94.4 |
| Bahia | 564,831 | 14,016,906 | 24.8 |
| Southeast | 924,596 | 80,364,410 | 86.9 |
| Minas Gerais | 586,520 | 19,597,330 | 33.4 |
| Espírito Santo | 46,099 | 3,514,952 | 76.2 |
| Rio de Janeiro | 43,780 | 15,989,929 | 365.2 |
| São Paulo | 248,197 | 41,262,199 | 166.2 |
| South | 563,802 | 27,386,891 | 48.6 |
| Paraná | 199,317 | 10,444,526 | 52.4 |
| Santa Catarina | 95,704 | 6,248,436 | 65.3 |
| Rio Grande do Sul | 268,782 | 10,693,929 | 39.8 |
| Center-West | 1,606,367 | 14,058,094 | 8.8 |
| Mato Grosso do Sul | 357,146 | 2,449,024 | 6.9 |
| Mato Grosso | 903,330 | 3,035,122 | 3.4 |
| Goiás | 340,104 | 6,003,788 | 17.7 |
| Distrito Federal | 5,788 | 2,570,160 | 444.1 |

Source: IBGE, *Sidra tables 1301, 1378* and Censo Demográfico de (2010)

densely populated regions of Brazil, with the North and Center-West the least populated (see Table 1.2). The country as a whole has half the world population density level of 53.3 persons per square kilometer in 2010. Even in South America, its population density is comparable to

Peru and Chile, but well below Colombia, Ecuador and Venezuela, but double the rate of its neighbors to the South – Uruguay and Argentina.⁴³

Thus Brazil covers an enormous variety of lands and climates being both a tropical and semi-tropical country and is moderately populated by world standards. The majority of its lands are open plains with relative few mountain ranges and it has a long coast facing the Atlantic. It was these physical features which defined and limited the economic and social evolution of Brazil. Most of its geographic space is relatively flat, made up of plains and plateaus, without obstacles such as the Andes mountain range that extends from north to south on the west side of the South American continent. A fundamental characteristic of Brazil is its wide Atlantic coast, more than 7,000 in length. It appears that early man entered the region from the Andean range moving slowly from west to east, extensively exploiting the Andean eastern foothills and the central floodplains as they moved toward the coast over several centuries. One group even used the Amazon basin as a base to settle and explore the major Caribbean islands before the arrival of the Europeans in the late fifteenth century.

For Europeans, the movement was in the opposite direction. The European conquerors came from east to west and remained close to the coast to maintain their ties to the metropolis via control over the Southern Atlantic. Despite the relative ease of movement into the interior, with few dense forests and an abundance of open plains, for centuries the Europeans kept to the coast. Their ties to Europe via the sea were closer than their connection to the interior lands. Most of the frontier remained unexplored and unexploited except for cattle ranching in the Northeast.

Until the end of the seventeenth century, except in the northeast of the country, the European and mestizo population was limited to little more than 100 kilometers from the coast as in the case of the São Paulo plateau. The opening up of gold mines and demand for gold in the Center-West region in the eighteenth century was the first really important movement inland by Europeans. Even then the majority of the population and economic activity remained close to the coast and its natural and deep ports, such as Salvador, Recife and Rio de Janeiro. Even then such harbors as Santos were of little importance until the nineteenth century since the

⁴³ United Nations, Population Division, table POP/6: Population density by region, sub-region and country, 1950–2100 (persons per square kilometer), <https://population.un.org/wpp/Download/Standard/Population/>.

population was concentrated to the north of the paulista littoral. The region south of São Paulo was not effectively settled by colonists until the late eighteenth and early nineteenth centuries, but was inhabited by both nomadic and seminomadic Amerindian tribes, as was the case for most of the interior regions of Brazil. It was only gradually that these groups were incorporated into Brazilian society.

But even the discovery of gold in the hinterland, in territories of the current states of Minas Gerais, Goiás and Mato Grosso, brought intense exploration of Brazilian territory to only a part of the hinterland in the eighteenth century. Mineral extraction and livestock would be the main activities to explain the territorial expansion in the central regions of the center south of Brazil. This was the first great moment of national integration, uniting, by cabotage and inland routes maintained by mule trains the coast with these new interior zones. But the quality of frontier lands in the Southeastern region, above all those of the province/state of São Paulo, provided the incentive to open up new regions, largely driven by sugar and coffee plantations which maintained their productivity primarily via exploiting ever new virgin frontier lands. The post-1870 construction of railroads permitted the exploitation of these lands and the final settlement of the southeastern frontier. It was only after the railroads came into being that the settled territory of São Paulo finally reached the Paraná River, more than 500 kilometers from the coast. But the northern and Amazonian frontiers would not be settled, even partially, despite the expansion of modern paved roads in the middle of the twentieth century.

There were also numerous regions with poor soil, such as the Cerrado, which in turn would not be exploited until the late twentieth century through modern scientific agriculture and the application of new nutrients to the arid soils. Much of Brazilian agriculture is defined by temperature, soils and altitude. Given the dominance of agriculture in the contemporary Brazilian economy, these geographic factors have determined the location and development of individual crops. Permanent crops like coffee and oranges for example are confined to given soils, altitudes and temperature conditions, while until recently only a limited area of Brazil was viable for the production of wheat, the only grain imported into Brazil.

Geography has also defined and limited urban settlement. First came the harbors, then interior rivers and finally railroads and paved roads which have influenced the location of cities. Some places along the coast were only modestly inhabited due to local diseases, which only ended with modern sanitation and inoculations and enabled their full development. Clearly the western frontier is still far from the coast and has still to be

fully inhabited. But there has been a new population movement to the North and the Amazon, as Brazil attempts to both expand the modern agricultural frontier to the Northern region's rich soils, and open up the Amazon estuary as a modern shipping center for the Center-West, which still sends most of its products through the Southeastern port of Santos.

Recent trends in climate also have a profound effect on Brazilian populations and economies. Whole sectors of agriculture have been forced to move to warmer or wetter climates. This is especially the case with permanent crops. In turn weather conditions over large areas of agricultural production have been influenced by changes in the Amazonian biome which has been steadily reduced. More and more the geographical possibilities and restraints define the current and future evolution of Brazil, especially now as it has just recently become one of the largest grain producers in the world.