

COUNTRY DOSSIER

Brazil

Water, climate, fertilisers and crops: National study and a study of each region, potential benefits of our products, external trade

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Monitoring the soybean harvest.

Foreword

This dossier describes Brazil from the angle of water, climate, fertilisers and crops. It is written for the ministries in charge of agriculture, water and trade, the regional directorates of agriculture, cooperatives and producer organisations. It answers three questions: Where is water short, for which crops, and in which regions? It then examines what our products can change, in rainfed as well as irrigated farming, and what that can mean for the country's external trade.

Reading the sources. Every figure refers to a source, named in the text and detailed in Annex A. Each source carries a confidence level:

How to read this document

- **A**: Official statistics or international database (World Bank, FAO, Brazilian public bodies (IBGE, ANA, Ministry of Agriculture MAPA)).
- **B**: Research institute, laboratory, United Nations agency or recognised climate model.
- **C**: Manufacturer statement, website, press or estimate.
- "M" means million; "Mm³" means million cubic metres; "t" means tonnes; "I$" means constant 2014-2016 international dollars.
- A "scenario" is a calculation based on the trials cited. It is not a measurement made in Brazil.

Contents

Summary
1. Green Solutions and our products
2. Brazil in figures
3. Sunshine, rainfall and climate change
4. Water: Resources, irrigated areas, withdrawals
5. Fertilisers: Quantities, purchases, spending
6. The regions at a glance
7. The twenty main crops: Three rankings
8. Extrapolation by crop: Irrigation and rainfed crops
9. Potential benefits of our products
10. External trade: Exports, imports, importing
11. A study of each region
Annex A. Sources and confidence levels
Annex B. Calculation method
Annex C. Photo credits

Summary

The points below summarise the dossier. The figures come from public sources: The World Bank, FAO (FAOSTAT, AQUASTAT), Brazilian public bodies (IBGE, ANA, Ministry of Agriculture MAPA), PVGIS and ERA5. The production gains and water savings are scenarios, described in Annex B.

212.81 M
Inhabitants in 2025 (World Bank)

45.91 M ha
Of soya beans harvested in 2024, the main crop

9.18 M ha
Equipped for irrigation (2024)

+4,639 t
Of maize per 10,000 ha treated, central scenario

4,643 Mm³
Of irrigation water saved a year, central scenario

141,895 M$
Of agricultural exports in 2024 (FAOSTAT)

Key points

• **Irrigation, a pillar of production.** 9.18 million hectares equipped for irrigation in 2024, or 14% of the 63.73 million hectares of cropland.

• **Soya beans: The main crop.** 45,906,902 ha harvested in 2024, for 144.47 million tonnes, or 3.15 t/ha.

• **Water is not short over the year, it is short between two rains.** National water stress is only 1.5%, but at Petrolina, the air demands 1,776 mm more than it rains.

• **In rainfed farming, the gain is counted in tonnes.** In the central scenario, 4,639 t of maize and 1,778 t of soybean more per 10,000 ha treated.

• **In irrigation, the water saved enlarges the schemes.** 4,642.6 Mm³ a year in the central scenario, enough to irrigate about 1,031,388 more ha, or 11.2% of the equipped area.

• **Fertilisers made locally.** 7,005,931 t of nitrogen used in 2024; the country produces 351,593 t and imports 6,937,342 t.

• **Farm trade.** $141,895 million of exports and $14,925 million of imports in 2024. First sale: Soya beans ($42,942 million). First purchase: Wheat ($1,808 million).

Key figures

Key indicators for Brazil

Indicator	Value	Year	Source (level)
Population	212.81 M	2025	World Bank (A1)
GDP per capita	10,713 $	2025	World Bank (A1)
Agriculture share of GDP	6.1%	2025	World Bank (A1)
Agricultural employment	7.6%	2025	World Bank (A1)
Cropland	63,729,900 ha	2024	FAOSTAT (A6)
Area equipped for irrigation	9,183,000 ha	2024	FAOSTAT (A6)
Harvested area: Soya beans	45,906,902 ha	2024	FAOSTAT (A2)
Agricultural exports	141,895 M$	2024	FAOSTAT (A4)
Agricultural imports	14,925 M$	2024	FAOSTAT (A4)
Mineral nitrogen, agricultural use	7,005,931 t	2024	FAOSTAT (A5)

Source: Table based on the sources indicated.

1. Green Solutions and our products

Green Solutions develops products for water, fertilisation and crop protection. Four families are of interest to this dossier. The yields cited are those published by the manufacturer or by the trials, with their confidence level.

Products covered by this dossier

Product	Claimed use	Published evidence (level)
EVERGREEN® (water-retention polymer)	Holds rain or irrigation water as a gel, near the roots.	Trials on maize, potato, watermelon, date palm and soybean. Level B to C.
ECOSORB® (water-retention polymer based on corn starch)	Same use; action lasting 2 to 3 years according to the website.	Soybean trial (China); laboratory acrylamide analysis. Level B to C.
ECOFERT® (fertiliser)	Fertiliser certified by SOHISCERT and EU Bio, usable in organic farming.	Published certificate; potato trial combined with EVERGREEN®. Level A (certificate), C (results).
Paulownia ALTIFOLIA®	Fast-growing tree for agroforestry.	Website figures; no trial in Brazil. Level C.
Water Vital®, NAPEMA®	Outside the scope of this dossier.	No independent source in the documents consulted.

Source: Green Solutions website (product sheets and published trials), Annex A.

The indicative dose published on the website is 30 to 75 kg/ha.



A maize field in Extrema, Minas Gerais.

2. Brazil in figures

Brazil had 212.81 million inhabitants in 2025, 12% of them in rural areas. Agriculture accounts for 6.1% of gross domestic product and employs 8% of the labour force. The country covers 8,358.1 thousand km², of which 28% is agricultural land. Undernourishment affects 2.5% of the population.

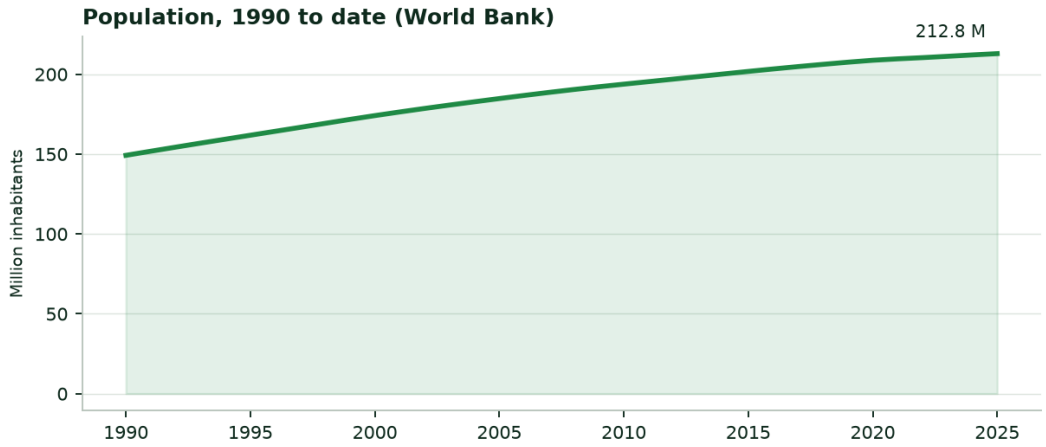


Figure 1. Population of Brazil, 1990 to date. Source: World Bank (A1)

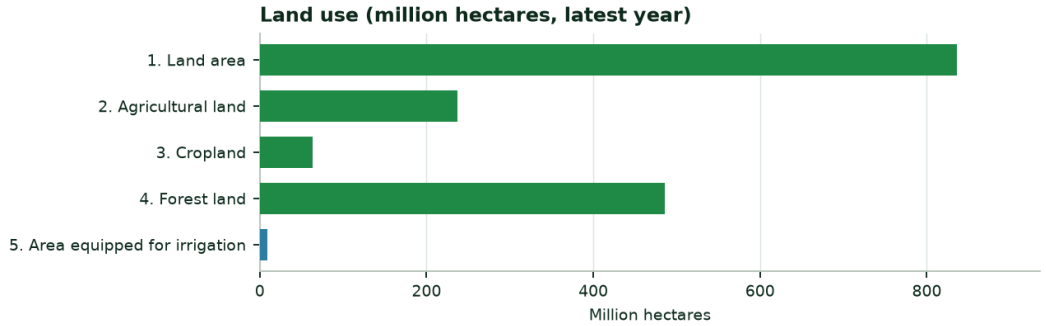


Figure 2. Land use, latest year published. Source: FAOSTAT (A6)

Agricultural and water indicators, latest year published

Indicator	Value	Year	Source
Average cereal yield	5,003 kg/ha	2024	World Bank (A1)
Fertiliser use per hectare of arable land	397.1 kg/ha	2024	World Bank (A1)
Water withdrawals, agricultural share	60.8%	2022	World Bank (A1)
Internal freshwater resources	5,661.0 km³	2022	World Bank (A1)
Internal resources per inhabitant	26,918 m³	2022	World Bank (A1)



Cocoa pods from a farm in Brazil.

3. Sunshine, rainfall and climate change

3.1 Sunshine

Global solar radiation reaches 1,642 to 2,213 kWh/m² a year depending on the region. Energy is not the limit: Water available at the right time makes the harvest.

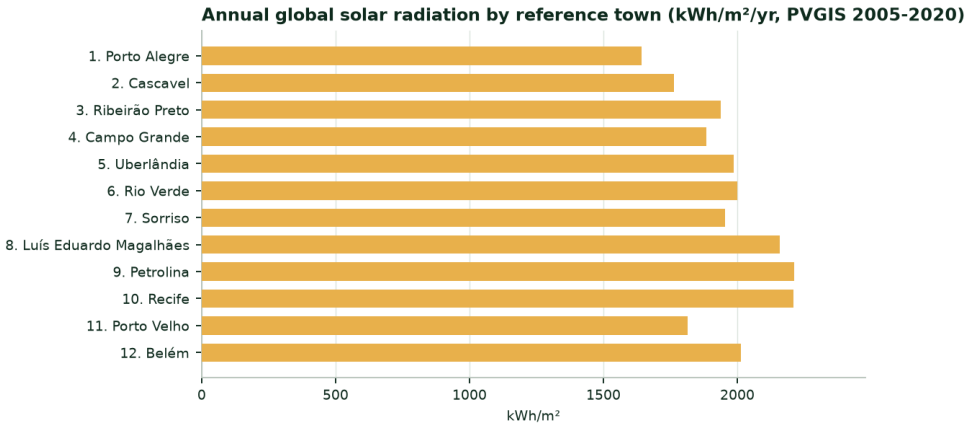


Figure 3. Annual global solar radiation in each reference town. Source: PVGIS (A8)

3.2 Rainfall and evapotranspiration

It rains 2,303 mm a year at Porto Velho, but only 400 mm at Petrolina, where reference evapotranspiration reaches 2,176 mm. In the Center-West and Southeast, the rainy season runs from October to April and the dry season from May to September. The South is rainy all year, the Amazon is humid, and the semi-arid Northeast receives little, very irregular rain.

Mean monthly rainfall, 1991-2020 (mm per month)

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Porto Alegre	138	127	111	107	108	118	140	122	149	173	125	123
Cascavel	165	166	127	126	153	136	106	97	150	193	149	182
Ribeirão Preto	248	175	159	65	46	27	18	18	68	111	166	225
Campo Grande	246	196	167	84	79	48	28	30	85	144	159	218
Uberlândia	239	179	172	64	28	10	7	8	44	109	181	247
Rio Verde	234	200	203	85	27	9	4	11	51	136	202	233
Sorriso	245	223	197	98	27	4	1	7	45	123	188	227
Luís Eduardo Magalhães	178	149	157	81	20	1	0	0	12	69	167	163
Petrolina	81	73	86	37	12	4	3	2	1	13	33	54
Recife	59	65	81	111	127	140	128	76	49	36	30	36
Porto Velho	315	319	336	242	142	46	23	43	102	176	255	303
Belém	236	311	400	402	262	115	72	38	27	32	46	113

Source: ERA5 via Open-Meteo (A9); author's calculation.



Figure 4. Monthly rainfall and reference evapotranspiration by city, 1991-2020. Source: ERA5 via Open-Meteo (A9)

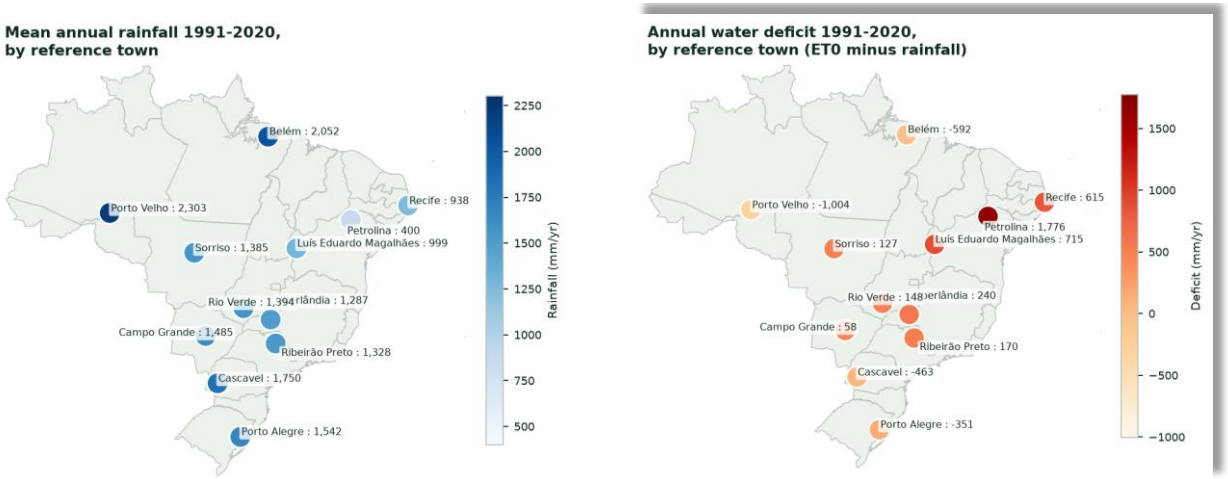


Figure 5. Mean annual rainfall 1991-2020, by region. Source: ERA5 (A9), Natural Earth (A10). *Annual water deficit, by region. Source: ERA5 (A9), Natural Earth (A10).*

3.3 Climate change

Mean annual temperature is rising. At Ribeirão Preto it went from 22.3 °C in 1981 to 23.9 °C in 2024, a trend of 0.21 °C per decade. At Petrolina the trend is 0.17 °C per decade, from 25.7 °C to 27.1 °C. Warmer air dries the soil faster between two rains.

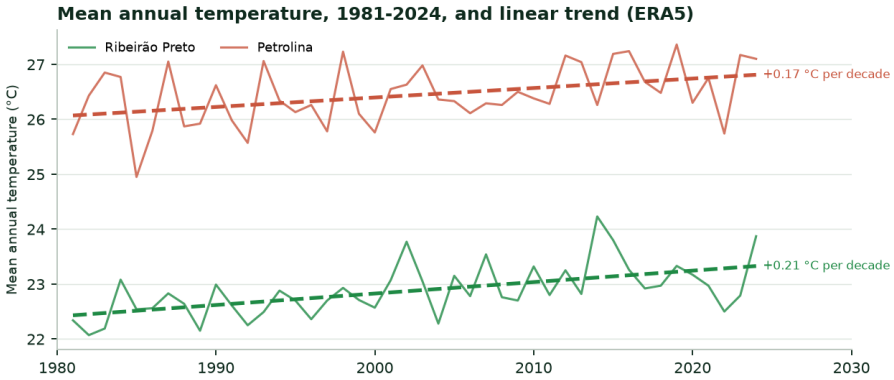
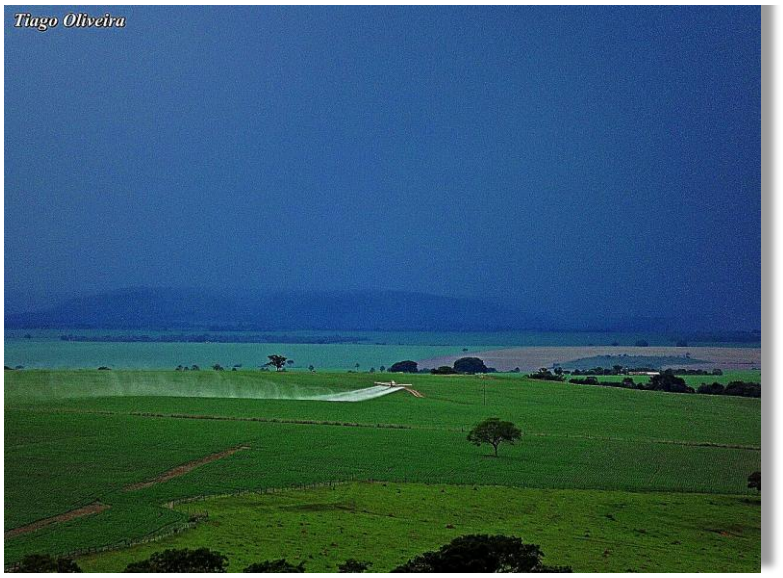


Figure 6. Mean annual temperature, 1981-2024, and linear trend. Source: ERA5 (A9)



Aerial application on soybean, in Catalão (Goiás).

4. Water: Resources, irrigated areas, withdrawals

4.1 Resources and withdrawals

Total freshwater withdrawals are 67,940 million m³ a year (2022). Agriculture withdraws 60.8% of it, that is 41,336 Mm³. Internal resources are 5,661.0 km³ a year and water stress is 1.5%: The country has water, but little of it is mobilised for crops.

Freshwater: Withdrawals and resources

Indicator	Value	Year	Source
Total withdrawals	67,940 Mm³	2022	World Bank (A1)
Agricultural share	60.8%	2022	World Bank (A1)
Agricultural withdrawals	41,336.0 Mm³	2022	Calculated from A1
Area equipped for irrigation	9,183,000 ha	2024	FAOSTAT (A6)
Agricultural withdrawals per equipped hectare	4,501 m³/ha	—	Calculation (Annex B)
Water stress	1.5%	2022	World Bank (A1)

4.2 Irrigated areas

FAOSTAT counts 9,183,000 hectares equipped for irrigation in 2024. FAO recorded 5.40 M ha equipped for irrigation in 2010, 8% of the cultivated area; the ANA irrigation atlas puts the equipped area at 8.2 M ha on the 2019 basis, of which 5.3 M ha irrigated with spring water and 2.9 M ha with reuse and fertigation water (A11). The growth of irrigation, mostly by centre pivot in the Cerrado, is the main source of new agricultural water demand.



Centre-pivot irrigation near Barreiras, in Bahia.

4.3 What the water saving represents

In the central scenario, the saving is 4,642.6 million m³ a year, or 11.2% of agricultural withdrawals. At 4,501 m³ per equipped hectare, this water would irrigate about 1,031,388 more hectares, or 11.2% of today's equipped area.

5. Fertilisers: Quantities, purchases, spending

5.1 Quantities used

In 2024, agricultural use reaches 7,005,931 tonnes of nitrogen, 6,198,762 tonnes of phosphate (P2O5) and 8,890,396 tonnes of potash (K2O). The country produces 351,593 tonnes of nitrogen and 1,989,607 tonnes of phosphate (P2O5); it imported 6,937,342 tonnes of nitrogen in the same year. Per hectare of arable land, use is 397.1 kg per hectare.

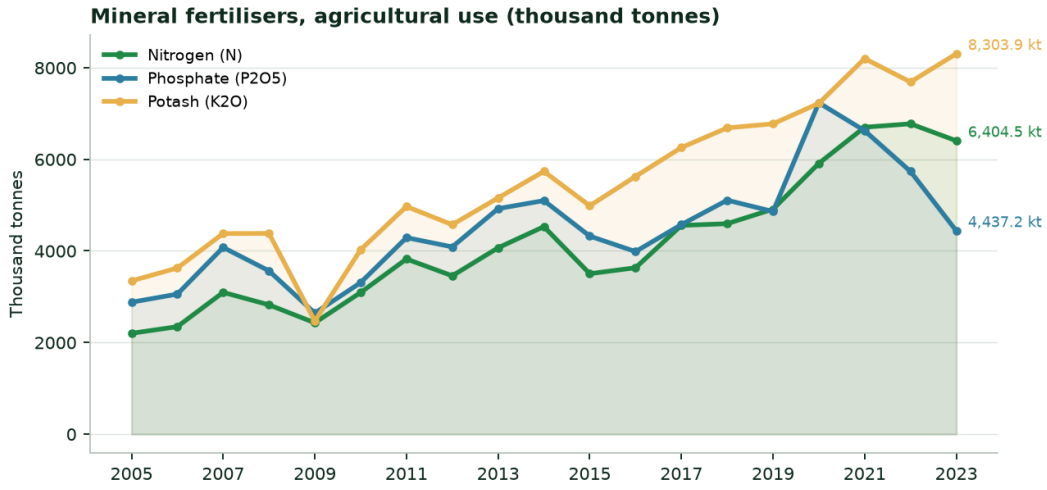


Figure 7. Mineral fertilisers, agricultural use, 2005-2023. Source: FAOSTAT (A5)

5.2 Regulatory framework

Fertilisers, correctives, inoculants and similar products are registered with the Ministry of Agriculture, under Decree No. 4,954 of 2004 (A13). The "condicionador de solo" is defined there as a product that improves soil properties; the classification of a water-retaining polymer is to be confirmed with the Ministry.



Potatoes irrigated by centre pivot, in Luziânia (Goiás).

5.3 Indicative spending

In 2024, the indicative minimum spending on mineral fertilisers reaches $15,921 million, at international fertiliser prices (calculation in Annex B, lower bound).

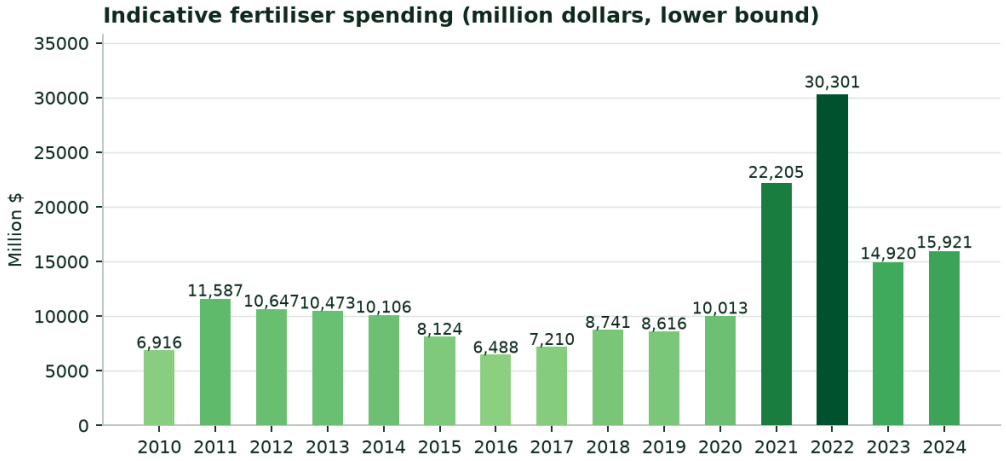


Figure 8. Indicative fertiliser spending, lower bound. Source: Author's calculation from A5 and A7

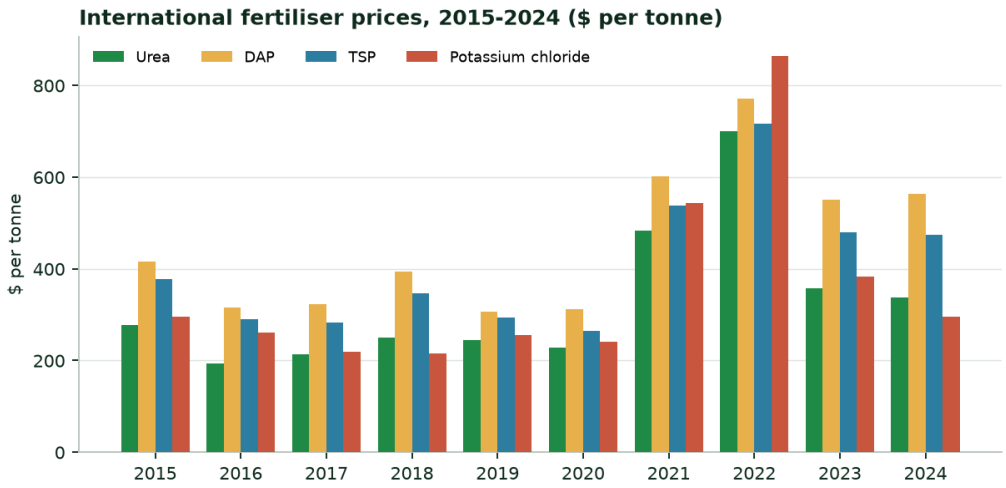


Figure 9. International prices of urea, DAP, TSP and potassium chloride. Source: World Bank, Pink Sheet (A7)

6. The regions at a glance

The table compares twelve reference towns, from Rio Grande do Sul to the Amazon. Climate figures are 1991-2020 averages, except radiation (2005-2020).

Climate of the capitals, 1991-2020 means

Region (city)	Rainfall (mm/yr)	ET0 (mm/yr)	Deficit (mm/yr)	Radiation (kWh/m²/yr)	Temperature (°C)
Porto Alegre (Porto Alegre)	1,542	1,191	-351	1,642	19.7
Cascavel (Cascavel)	1,750	1,287	-463	1,763	19.5
Ribeirão Preto (Ribeirão Preto)	1,328	1,498	170	1,937	23.0
Campo Grande (Campo Grande)	1,485	1,543	58	1,884	23.7
Uberlândia (Uberlândia)	1,287	1,527	240	1,986	22.2
Rio Verde (Rio Verde)	1,394	1,542	148	1,999	23.3
Sorriso (Sorriso)	1,385	1,512	127	1,954	25.4
Luís Eduardo Magalhães (Luís Eduardo Magalhães)	999	1,714	715	2,159	23.8
Petrolina (Petrolina)	400	2,176	1,776	2,213	26.5
Recife (Recife)	938	1,553	615	2,210	25.9

Region (city)	Rainfall (mm/yr)	ET0 (mm/yr)	Deficit (mm/yr)	Radiation (kWh/m²/yr)	Temperature (°C)
Porto Velho (Porto Velho)	2,303	1,299	-1,004	1,813	26.1
Belém (Belém)	2,052	1,460	-592	2,013	26.6

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

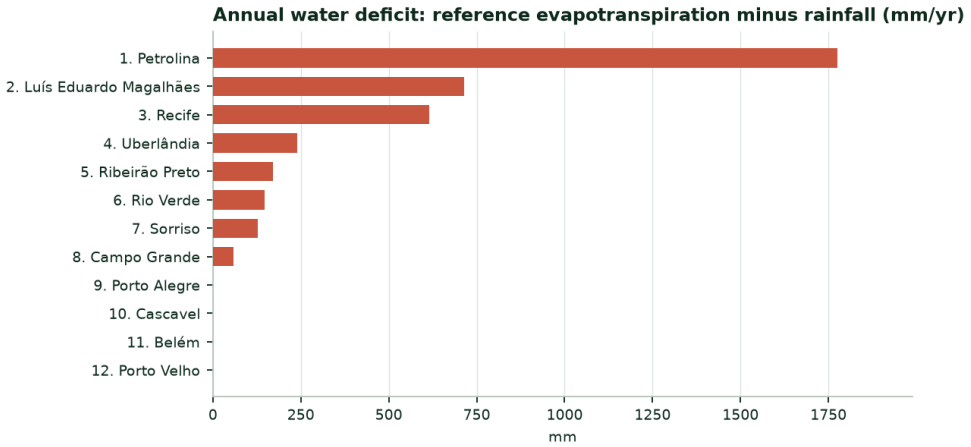


Figure 10. Annual water deficit: Reference evapotranspiration minus rainfall. Source: ERA5 (A9)



Agricultural landscapes near Perdizes, in Minas Gerais.

7. The twenty main crops: Three rankings

7.1 By harvested area

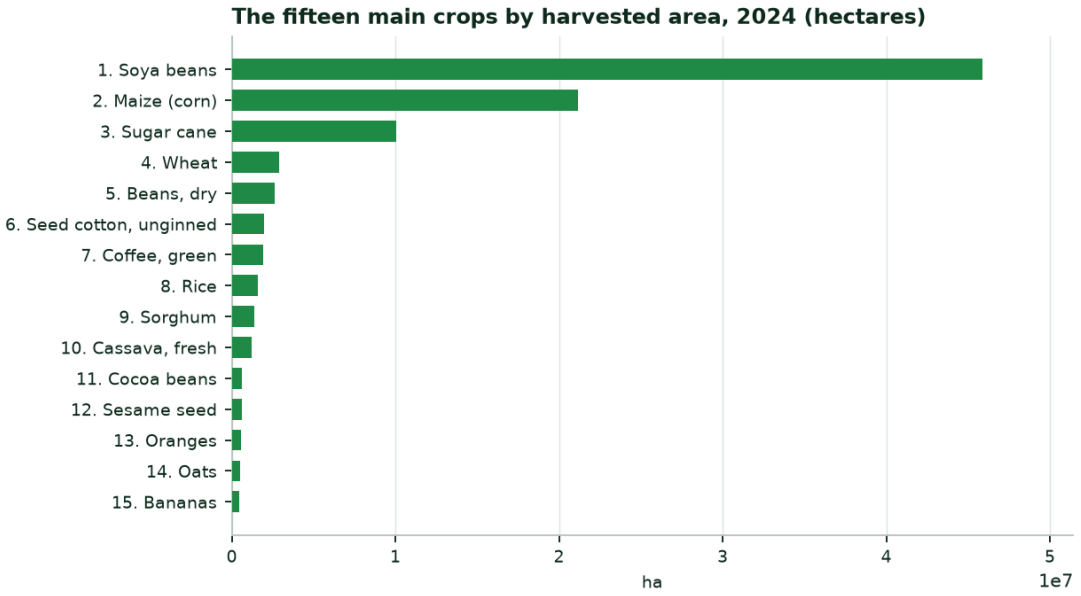


Figure 11. The fifteen main crops by harvested area, 2024 (hectares). Source: FAOSTAT (A2)

The ten main crops by area, 2024

Crop	Harvested area (ha)	Production (t)	Yield (t/ha)
Soya beans	45,906,902	144,473,768	3.15
Maize (corn)	21,186,816	114,953,303	5.43
Sugar cane	10,051,272	759,662,482	75.58
Wheat	2,921,518	7,633,178	2.61
Beans, dry	2,631,805	3,018,459	1.15
Seed cotton, unginned	1,990,328	8,523,606	4.28
Coffee, green	1,943,977	3,387,724	1.74
Rice	1,586,100	10,671,490	6.73
Sorghum	1,363,415	4,090,428	3.00
Cassava, fresh	1,232,882	19,066,096	15.46

Source: FAOSTAT (A2).

7.2 By production

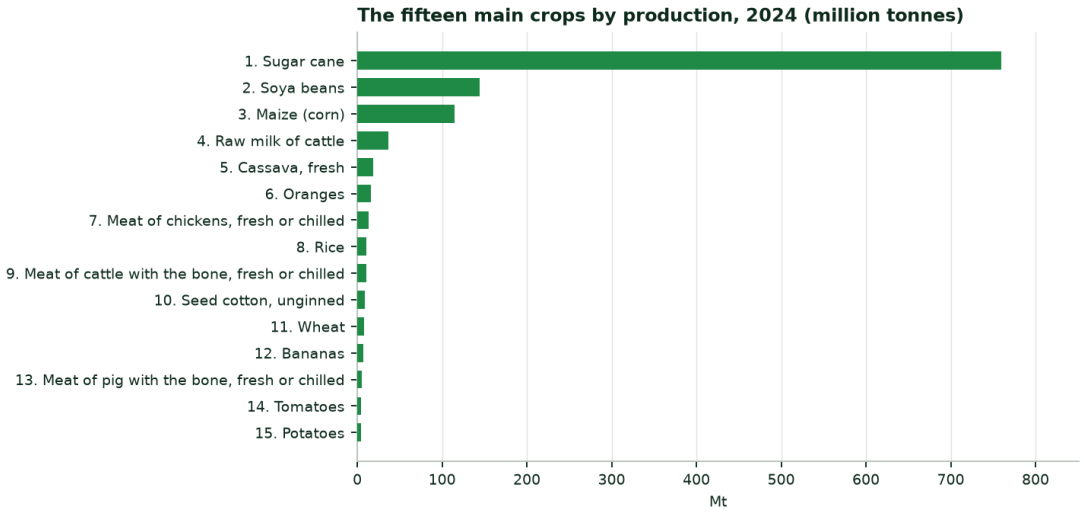


Figure 12. The fifteen main crops by production, 2024 (million tonnes). Source: FAOSTAT (A2)

7.3 By production value

By production value, the three main crops are: Soya beans, sugar cane and maize (corn) (FAOSTAT, 2023, constant international dollars).

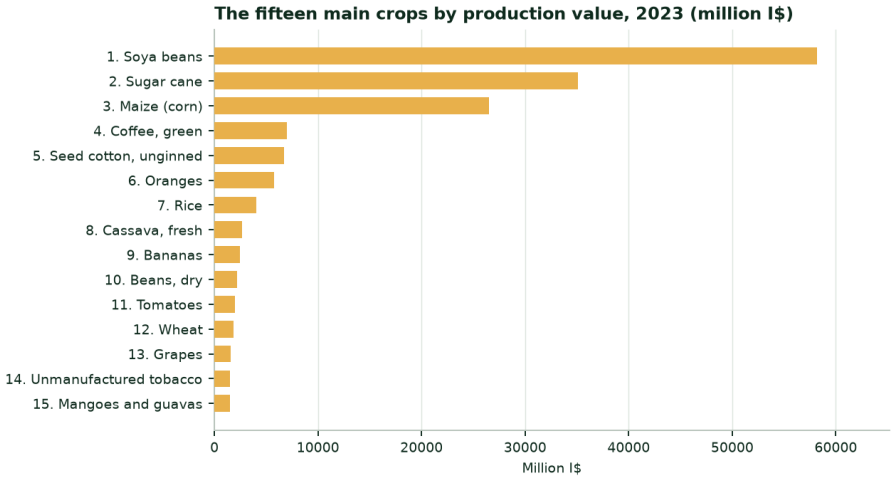


Figure 13. The fifteen main crops by production value, 2023 (million I$). Source: FAOSTAT (A3)



A sugar cane field after mechanical harvest.

8. Extrapolation by crop: Irrigation and rainfed crops

8.1 Method

Method in brief

• **Irrigation.** National agricultural water is shared between irrigated crops (irrigated rice, vegetables and melons, potato, fruit and other irrigated land), in proportion to their harvested areas; the equipped area is shared the same way.

• **Rainfed crops.** For crops that have a trial (maize and soybean), the production gain is calculated per 10,000 ha treated, at the national average 2024 yield.

• Each calculation applies the effect of the trial cited: A quarter (cautious), half (central), all of it (high). Without a trial: 5, 10 and 20% of water, with no yield gain.

8.2 Trials used as analogues

Trials cited and their use in the calculation

Trial	Crop	Water	Yield	Use in the calculation
Maize, Türkiye (TIGEM, Konya, 2025)	Maize	-38.9%	+17.1%	Maize: Yield
Soybean, China	Soybean	Assumption	+11.3%	Soybean: Yield
Watermelon, Mexico (2023)	Watermelon	-60.5%	+30.0%	Vegetables and melons: Water and yield
Potato, South Africa (2025)	Potato	-52.0%	+31.4%	Potato: Water and yield
Date palm, UAE (ICBA, 2021)	Palm	-82.0%	+20.0%	Not used; cited for reference

Source: A14 to A18 (published trials and manufacturer's website, levels B and C).

No trial has yet been conducted in Brazil: The figures below apply the trials cited to the country's average yields.

8.3 Rainfed crops: Maize and Soybean

Average 2024 yields (FAOSTAT): Maize 5.43 t/ha and soybean 3.15 t/ha. A water-retention polymer keeps the water of each rain near the roots and helps the crop through dry days during the season.

Extra production per 10,000 ha treated (tonnes a year)

Crop	Average yield (t/ha)	Cautious	Central	High
Maize	5.43	2,319	4,639	9,278
Soybean	3.15	889	1,778	3,556

Source: FAOSTAT (A2); trials A14 to A18; author's calculation (Annex B).

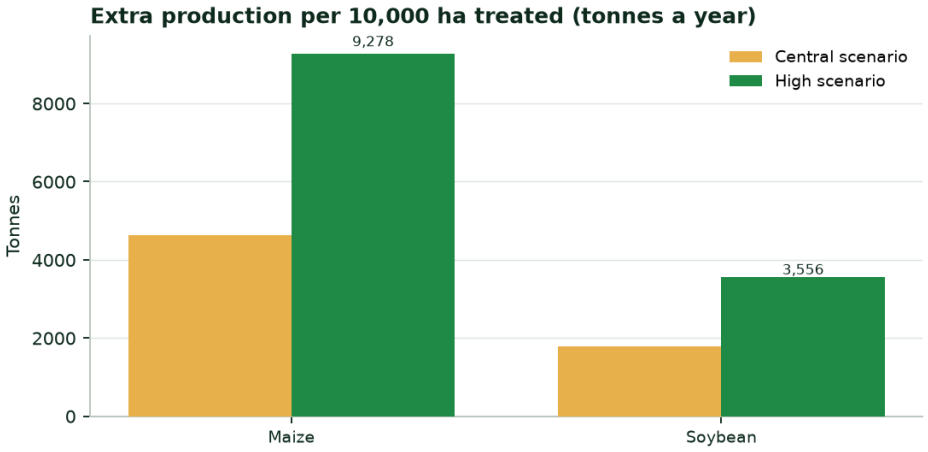


Figure 14. Extra production per 10,000 ha treated, central and high scenarios. Source: Author's calculation

8.4 Irrigation: Irrigated rice, Vegetables and melons, Potato and Fruit

Equipped area assigned, trial used and water saved (central scenario)

Crop group	Equipped area (ha)	Share	Trial or assumption	Water saved (Mm³/yr)
Irrigated rice	1,586,100	17.3%	Generic assumption, no trial	714.0
Vegetables and melons (tomato, onion, watermelon, others)	459,837	5.0%	Watermelon, Mexico (2023)	626.1
Potato	124,818	1.4%	Potato, South Africa (2025)	146.1
Fruit (orange, banana, grape, mango, papaya, pineapple)	2,009,790	21.9%	Generic assumption, no trial	904.7
Other irrigated land (soybean, maize, cane, coffee, bean)	5,002,455	54.5%	Generic assumption, no trial	2,251.8

Source: Author's calculation (Annex B).

Water saved, extra irrigable hectares and production gain, by scenario

Scenario	Water (Mm³/yr)	Extra hectares	Production (t/yr)
Cautious	2,321.3	515,694	1,237,956
Central	4,642.6	1,031,388	2,475,912
High	9,285.3	2,062,776	4,951,823

Source: Author's calculation (Annex B).

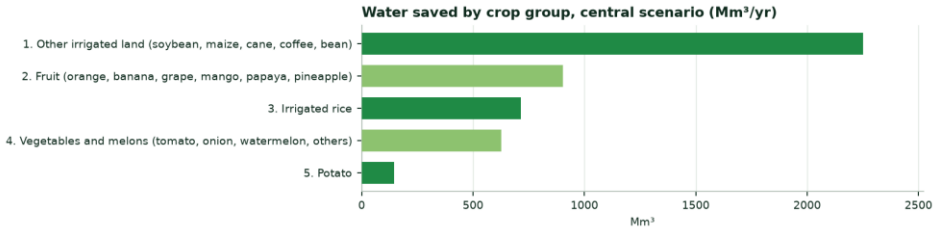


Figure 15. Water saved by crop group, central scenario. Source: Author's calculation

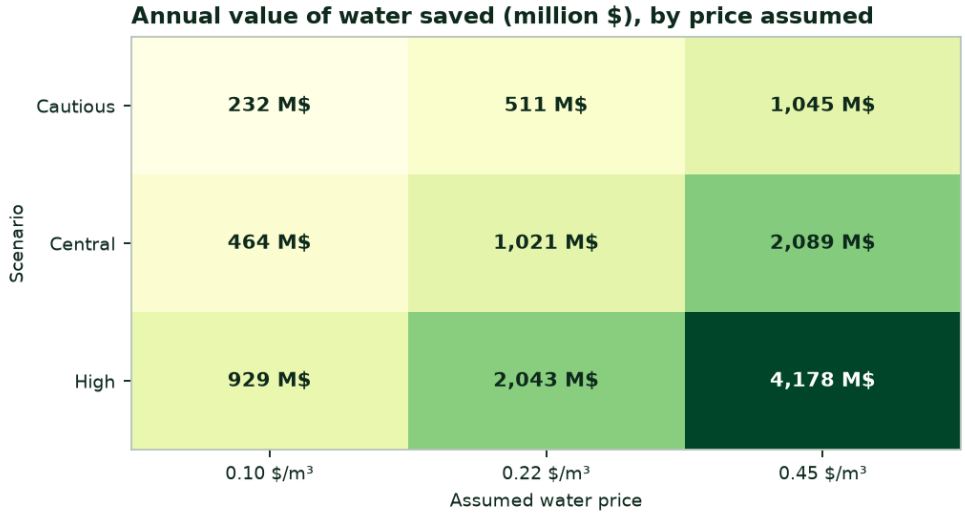


Figure 16. Annual value of the water saved, by price assumed per cubic metre. Source: Author's calculation; prices assumed, no national tariff

8.5 Reading the results

Key points

• The "other irrigated land" group gives 49% of the irrigation water saving (generic assumption, no trial).

• The gains are counted by scenario and, in rainfed farming, per 10,000 ha treated: A cooperative or a public programme can scale them to its own area.

9. Potential benefits of our products

The table lists what the products may bring according to the documents available, with their confidence level and their limit.

Potential benefits, by situation

Benefit	Published figures	Source (level)	Limit
Irrigation water saving	Date palm −82%; watermelon −60.5%; potato −52%; maize −38.9%	A14 to A18 (B, C)	One trial per crop; none in Brazil
Yield	Maize +17.1%; potato +31.4%; watermelon +30%; date palm +20%; soybean +11.2 to +11.4%	A14 to A18 (B, C)	Trials conducted under irrigation or in other climates
Organic farming (ECOFERT®)	Certified by SOHISCERT and EU Bio	A21 (A)	Valid for the certified product
Safety: Acrylamide (ECOSORB®)	Below 3.0 µg/g	A19 (B)	One laboratory, one date

Benefit	Published figures	Source (level)	Limit
REACH compliance (EVERGREEN®)	≤ 0.1% of substances of very high concern in 233 substances tested	A20 (B)	Screening, not an approval
Agroforestry (Paulownia ALTIFOLIA®)	13 to 15 m in 6 to 8 years (website)	A22 (C)	No trial in Brazil

Source: Annex A.



A rice plantation near Rio do Sul (Santa Catarina).

10. External trade: Exports, imports, importing

10.1 Overview, 2023 and 2024

Agricultural products and total merchandise trade (million $)

Indicator	2023	2024
Agricultural exports (crops and livestock)	146,661	141,895
Agricultural imports (crops and livestock)	12,744	14,925
Exports, all merchandise	339,696	337,046
Imports, all merchandise	252,710	277,954

Source: FAOSTAT (A4).

10.2 Exports

The three main farm products exported in 2024 are: Soya beans ($42,942 million), raw sugar ($15,933 million) and meat of cattle boneless, fresh or chilled ($11,617 million).

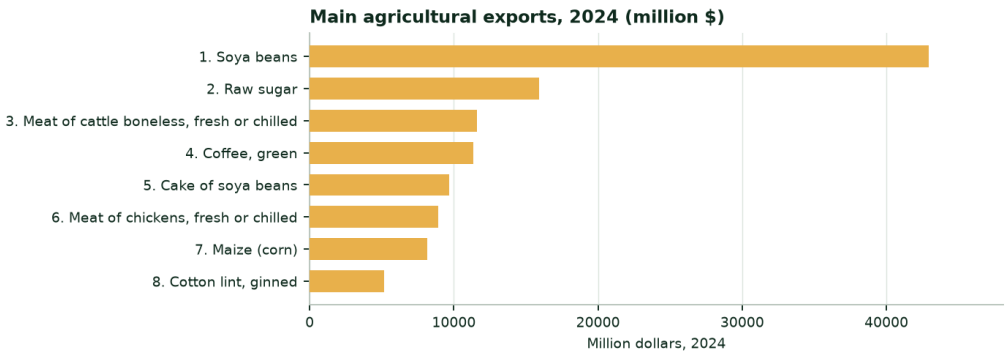


Figure 17. Main agricultural exports, 2024. Source: FAOSTAT (A4)

10.3 Imports

The main farm purchases are: Wheat ($1,808 million), olive oil ($787 million) and malt, whether or not roasted ($780 million). Rice weighs $508 million (husked, broken and milled rice): Every tonne grown locally reduces this bill.

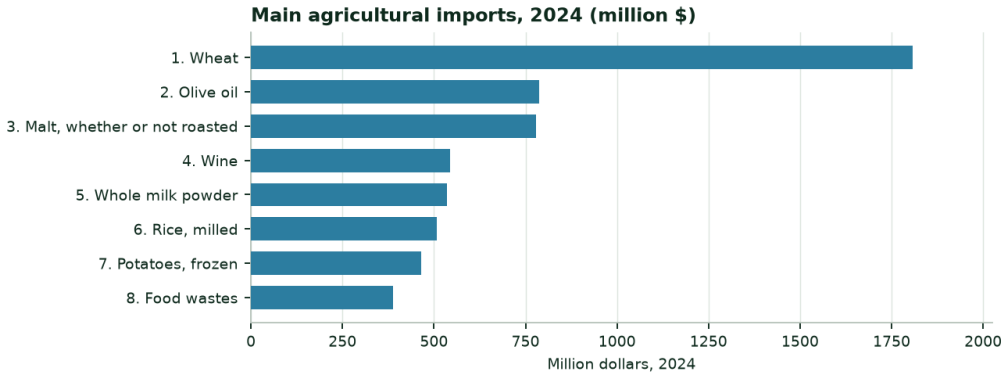


Figure 18. Main agricultural imports, 2024. Source: FAOSTAT (A4)



Figure 19. Mechanical coffee harvest in the Cerrado.



Preserves on a stall of the São Paulo municipal market.

10.4 Importing water-retention polymers into Brazil

What to know

• **Import duty (subheading 3906.90.11, poly(acrylic acid) and its salts):** 12.6%, with an IPI of 3.25% (A12). Other lines of the same subheading are listed at 0% or 12.6%: The rate depends on the exact line (A12).

• **Other taxes:** Other federal and state taxes are added on import; they are not detailed here, for lack of an official

source consulted.

• **Registration:** Fertilisers, correctives, inoculants and similar products must be registered with the Ministry of Agriculture (A13). The regulation defines the "condicionador de solo" as a product that improves the physical or physico-chemical properties or the biological activity of the soil (A13). No text specific to water-retaining agents was found: Registration in this category is to be confirmed with the Ministry.

• **Classification:** Code 3906.90 is an inference for our products; the Receita Federal settles it.

11. A study of each region

Each region is described through the city that represents it. The figures describe the climate; the water deficit (evapotranspiration minus rainfall) shows where water is most short. The description of crops is qualitative.



Irrigation canal of the Capané dam, in Rio Grande do Sul.

Porto Alegre (Porto Alegre)

The temperate south: Flooded rice, soybean, maize, vines and livestock, with winter frosts and increasingly frequent summer droughts.

Indicator	Value
Annual rainfall, 1991-2020	1,542 mm
Reference evapotranspiration	1,191 mm
Annual water deficit	-351 mm
Months with less than 50 mm of rain	0
Global solar radiation	1,642 kWh/m²
Mean temperature	19.7 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Cascavel (Cascavel)

Western Paraná: Soybean, second-season maize, wheat and poultry, on large deep clay soils.

Indicator	Value
Annual rainfall, 1991-2020	1,750 mm

Indicator	Value
Reference evapotranspiration	1,287 mm
Annual water deficit	-463 mm
Months with less than 50 mm of rain	0
Global solar radiation	1,763 kWh/m²
Mean temperature	19.5 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Ribeirão Preto (Ribeirão Preto)

Inland São Paulo: Sugar cane, citrus, coffee, soybean and fruit crops; the country's oldest agro-industrial hub.

Indicator	Value
Annual rainfall, 1991-2020	1,328 mm
Reference evapotranspiration	1,498 mm
Annual water deficit	170 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,937 kWh/m²
Mean temperature	23.0 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Campo Grande (Campo Grande)

Mato Grosso do Sul: Soybean, maize, sugar cane and extensive cattle farming, on sandy to clayey soils.

Indicator	Value
Annual rainfall, 1991-2020	1,485 mm
Reference evapotranspiration	1,543 mm
Annual water deficit	58 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,884 kWh/m²
Mean temperature	23.7 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Uberlândia (Uberlândia)

The Minas Gerais Cerrado: Coffee, soybean, maize, potato and livestock, with centre-pivot irrigation on the plateaus.

Indicator	Value
Annual rainfall, 1991-2020	1,287 mm
Reference evapotranspiration	1,527 mm
Annual water deficit	240 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,986 kWh/m²
Mean temperature	22.2 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Rio Verde (Rio Verde)

Goiás: Soybean, maize, sugar cane, poultry and pigs; a marked dry season from May to September.

Indicator	Value
Annual rainfall, 1991-2020	1,394 mm
Reference evapotranspiration	1,542 mm
Annual water deficit	148 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,999 kWh/m²
Mean temperature	23.3 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Sorriso (Sorriso)

Mato Grosso: The soybean capital, with second-season maize and cotton, on huge unirrigated fields.

Indicator	Value
Annual rainfall, 1991-2020	1,385 mm
Reference evapotranspiration	1,512 mm
Annual water deficit	127 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,954 kWh/m²
Mean temperature	25.4 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Luís Eduardo Magalhães (Luís Eduardo Magalhães)

Western Bahia, the Matopiba frontier: Soybean, cotton, maize and coffee under centre pivots, on a plateau with a long dry season.

Indicator	Value
Annual rainfall, 1991-2020	999 mm
Reference evapotranspiration	1,714 mm
Annual water deficit	715 mm
Months with less than 50 mm of rain	5
Global solar radiation	2,159 kWh/m²
Mean temperature	23.8 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Petrolina (Petrolina)

The semi-arid São Francisco valley: Grapes, mango, banana and guava, irrigated all year from the river; one of the main fruit export hubs.

Indicator	Value
Annual rainfall, 1991-2020	400 mm
Reference evapotranspiration	2,176 mm
Annual water deficit	1,776 mm
Months with less than 50 mm of rain	8
Global solar radiation	2,213 kWh/m²
Mean temperature	26.5 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Recife (Recife)

The Zona da Mata of the Northeast: Sugar cane, banana and livestock, on a humid coast with winter rain.

Indicator	Value
Annual rainfall, 1991-2020	938 mm
Reference evapotranspiration	1,553 mm
Annual water deficit	615 mm
Months with less than 50 mm of rain	4
Global solar radiation	2,210 kWh/m²
Mean temperature	25.9 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Porto Velho (Porto Velho)

Rondônia, southern Amazon: Expanding soybean, coffee, cocoa and cattle on land won from the forest.

Indicator	Value
Annual rainfall, 1991-2020	2,303 mm
Reference evapotranspiration	1,299 mm
Annual water deficit	-1,004 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,813 kWh/m²
Mean temperature	26.1 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Belém (Belém)

Pará, eastern Amazon: Oil palm, cocoa, açaí, cassava and pepper, under a very humid equatorial climate.

Indicator	Value
Annual rainfall, 1991-2020	2,052 mm
Reference evapotranspiration	1,460 mm
Annual water deficit	-592 mm
Months with less than 50 mm of rain	4
Global solar radiation	2,013 kWh/m²
Mean temperature	26.6 °C

Source: ERA5 via Open-Meteo (A9); PVGIS (A8); author's calculation.

Annex A. Sources and confidence levels

Ref.	Source	Level
A1	World Bank, World Development Indicators (WDI), Brazil	A
A2	FAOSTAT, crops and livestock (QCL), areas, production, 2014-2024	A
A3	FAOSTAT, value of production (QV), constant 2014-2016 I$, 2019-2024	A
A4	FAOSTAT, trade in crops and livestock products, 2018-2024	A
A5	FAOSTAT, mineral fertilisers, agricultural use, production and imports, 2005-2023	A
A6	FAOSTAT, land use, areas equipped for irrigation, organic farming	A
A7	World Bank, Pink Sheet (world prices of urea, DAP, TSP and potassium chloride)	A

Ref.	Source	Level
A8	PVGIS (European Commission Joint Research Centre), radiation, 2005-2020	B
A9	ERA5 (Copernicus), via Open-Meteo: Rainfall, reference evapotranspiration, temperature, 1981-2024	B
A10	Natural Earth, first-level administrative boundaries and country outline	B
A11	FAO, AQUASTAT, country profile Brazil: Area equipped for irrigation (5.40 M ha in 2010, after ANA); ANA, "Atlas Irrigação" (2021), equipped area of 8.2 M ha on the 2019 basis, of which 5.3 M ha irrigated with spring water	A
A12	Brazil's Mercosur Common Nomenclature (NCM), subheading 3906.90.11 (poly(acrylic acid) and its salts), as listed by Treayo (official schedule): Import duty and IPI; Camex Resolution No. 272 of 2021	C
A13	Decree No. 4,954 of 14 January 2004, regulation of Law No. 6,894 of 1980: Inspection and control of the production and trade of fertilisers, correctives, inoculants and biofertilisers (definition of the "condicionador de solo"); Ministry of Agriculture (MAPA), product register	A
A14	Soybean trial, China (yield), manufacturer's website	C
A15	Date palm trial, UAE (ICBA, 2021), manufacturer's website	B
A16	Watermelon trial, Mexico (2023), manufacturer's website	C
A17	Potato trial, South Africa (2025), manufacturer's website	C
A18	Maize trial, Türkiye (TIGEM, Konya, 2025), manufacturer's website	B
A19	ECOSORB® acrylamide analysis (Polymex laboratory, 2024)	B
A20	EVERGREEN® REACH / SVHC screening (SGS, 2023)	B
A21	ECOFERT® certificate (SOHISCERT, EU Bio)	A
A22	Paulownia ALTIFOLIA® sheet figures (website)	C

Annex B. Calculation method

1. Agricultural water. Total withdrawals (67,940 Mm³, 2022) × agricultural share (60.84%) = 41,336.0 Mm³.

2. Irrigation. The equipped area (9,183,000 ha) and agricultural water are shared between irrigated groups (irrigated rice, vegetables and melons, potato, fruit and other irrigated land) in proportion to their harvested areas (9,183,000 ha), without exceeding each group's harvested area. Our sources have no irrigation statistic by crop. Other crops are treated as rainfed and receive no irrigation water in the calculation. The equipped area exceeds the harvested area of the irrigable crops retained: The difference forms an "other irrigated land" group (soybean, maize, cane, coffee, bean under pivots), with the generic assumption. Soybean, maize, cane, cotton and bean are otherwise treated as rainfed for the rest of their area, most of it being unirrigated.

3. Scenarios. Water saved = group water × trial effect: A quarter (cautious), half (central), all of it (high). Without a trial: 5, 10 and 20%.

4. Extra hectares. Water saved ÷ water per equipped hectare (4,501 m³/ha).

5. Rainfed crops. Gain per 10,000 ha = 10,000 × average 2024 yield (production ÷ harvested area, FAOSTAT) × trial effect on yield (maize 17.1% and soybean 11.3%), with the same quarter, half and whole.

6. Value of water. Three assumed prices (0.10; 0.22 and 0.45 $/m³); no national tariff was adopted.

7. Fertilisers. Minimum spending = nitrogen ÷ 0.46 × urea price + phosphate ÷ 0.46 × TSP price + potash ÷ 0.60 × potassium chloride price (A7).

8. Climate. Rainfall, reference evapotranspiration (FAO-56) and temperature: 1991-2020 means of the ERA5 grid cell containing each city; radiation: PVGIS, 2005-2020. Temperature trends are linear regressions over 1981-2024. ERA5 is a reanalysis: Its rainfall can differ from local station records. On the maps, each broad area is shown as a point at its reference town: The twenty-seven states are not coloured, because one town does not represent a whole state.

9. Trade. Totals are those of the FAOSTAT crops and livestock line; products are listed one by one, without aggregates. Rice amounts add husked rice, broken rice and milled rice.

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A coffee plantation in Alto Caparaó (Minas Gerais).

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