

COUNTRY DOSSIER

Portugal

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

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Terraced vineyards along the Douro.

Foreword

This dossier describes Portugal 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 in short supply? For which crops? In which regions? It then examines what difference our products can make, 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, Portuguese public bodies (Statistics Portugal INE, Ministry of Agriculture, Tax and Customs Authority, INIAV) and the European Union).
- **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; "$" means current US dollars.
- A "scenario" is a calculation based on the trials cited. It is not a measurement made in Portugal.

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Summary

The points below summarise the dossier. The figures come from public sources: The World Bank, FAO (FAOSTAT, AQUASTAT), Portuguese public bodies (Statistics Portugal INE, Ministry of Agriculture, Tax and Customs Authority, INIAV) and the European Union, PVGIS, NASA POWER and ERA5. The production gains and water savings are scenarios, described in Annex B.

10.80 M
Inhabitants in 2025 (World Bank)

380,780 ha
Of olive groves harvested in 2024, the main crop

637,340 ha
Equipped for irrigation (2024)

445 Mm³
Of irrigation water saved a year, central scenario

11,004 M$
Of agricultural exports in 2024 (FAOSTAT)

Key points

• **Irrigation, a pillar of production.** 0.64 million hectares equipped for irrigation in 2024, or 37% of the 1.74 million hectares of cropland.

• **Olives: The main crop.** 380,780 ha harvested in 2024, for 1.34 million tonnes, or 3.52 t/ha.

• **Water is not scarce over the year as a whole; it is scarce between rainfall events.** National water stress is only 12.3%, but at Beja, atmospheric water demand exceeds rainfall by 813 mm.

• **In irrigated farming, the water saved could allow irrigation schemes to be expanded.** 445.1 Mm³ a year in the central scenario, enough to irrigate about 83,489 more ha, or 13.1% of the equipped area.

• **An organic supply chain.** 242,680 ha of certified organic cropland in 2024: ECOFERT® is EU Bio certified.

• **Fertilisers made locally.** 90,669 t of nitrogen used in 2024; the country produces 70,024 t and imports 153,775 t.

• **Farm trade.** $11,004 million of exports and $15,130 million of imports in 2024. Leading export: Olive oil ($1,705 million). Leading import: Olive oil ($649 million).

Key figures

Key indicators for Portugal

Indicator	Value	Year	Source (level)
Population	10.80 M	2025	World Bank (A1)
GDP per capita	32,082 $	2025	World Bank (A1)
Agriculture's share of GDP	2.0%	2025	World Bank (A1)
Agricultural employment	2.8%	2025	World Bank (A1)
Cropland	1,735,377 ha	2024	FAOSTAT (A6)
Area equipped for irrigation	637,340 ha	2024	FAOSTAT (A6)
Harvested area: Olives	380,780 ha	2024	FAOSTAT (A2)
Certified organic cropland	242,680 ha	2024	FAOSTAT (A6)
Agricultural exports	11,004 M$	2024	FAOSTAT (A4)
Agricultural imports	15,130 M$	2024	FAOSTAT (A4)
Mineral nitrogen, agricultural use	90,669 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 reported in 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 Portugal. 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 Silveira (Torres Vedras).

2. Portugal in figures

Portugal had 10.80 million inhabitants in 2025, 39% of them in rural areas. Agriculture accounts for 2.0% of gross domestic product and employs 3% of the labour force. The country covers 91.6 thousand km², of which 41% is agricultural land. Undernourishment affects 2.5% of the population.

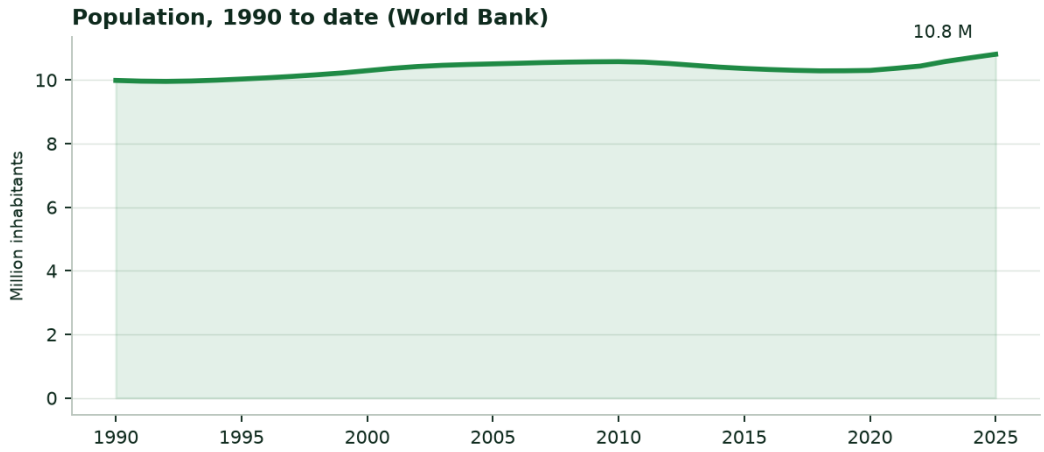


Figure 1. Population of Portugal, 1990 to date. Source: World Bank (A1)

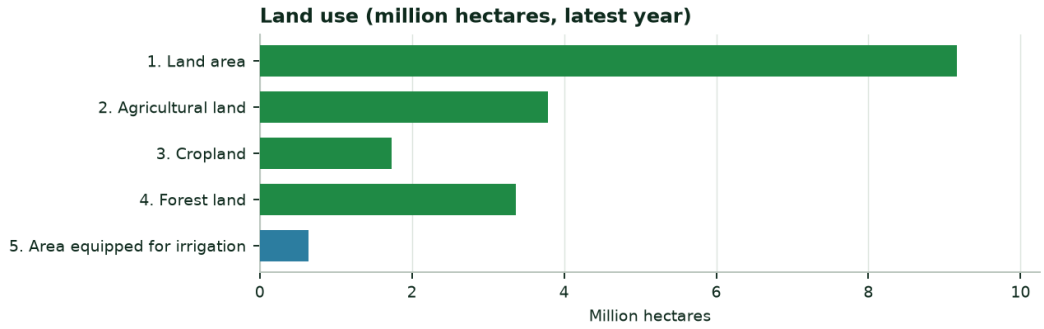


Figure 2. Land use, latest year published. Source: FAOSTAT (A6)

Agricultural and water indicators, latest year published

Indicator	Value	Year	Source
Cropland certified organic	242,680 ha	2024	FAOSTAT (A6)
Average cereal yield	5,309 kg/ha	2024	World Bank (A1)
Fertiliser use per hectare of arable land	190.5 kg/ha	2024	World Bank (A1)
Water withdrawals, agricultural share	55.4%	2022	World Bank (A1)
Internal freshwater resources	38.0 km³	2022	World Bank (A1)
Internal resources per inhabitant	3,642 m³	2022	World Bank (A1)



Pear orchards in Bombarral, in the Oeste.

3. Sunshine, rainfall and climate change

3.1 Sunshine

Global solar radiation reaches 1,490 to 1,901 kWh/m² a year depending on the region. Energy is not the limiting factor: Water available at the right time determines the harvest.

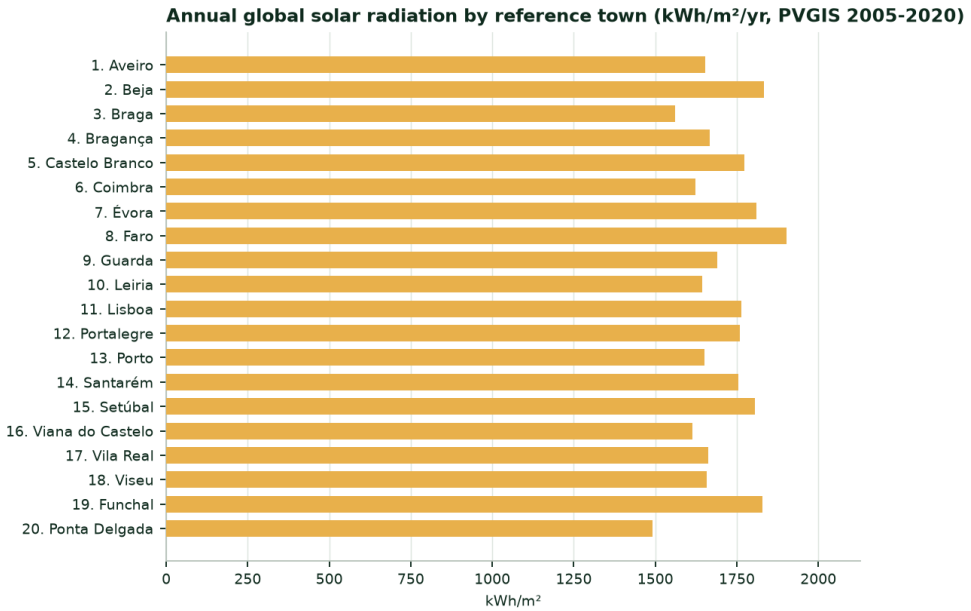


Figure 3. Annual global solar radiation in each reference town. Source: PVGIS (A8)

3.2 Rainfall and evapotranspiration

Annual rainfall is 1,070 mm at Braga, but only 505 mm at Beja, where reference evapotranspiration reaches 1,318 mm. The climate is Mediterranean: Rain falls from October to April, and the summer is dry. The Minho, in the north-west, is very wet; the Alentejo and the Algarve, in the south, receive little rain and go through long summer droughts, when crops need water most.

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

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Aveiro	122	84	81	87	70	26	11	19	53	120	134	124
Beja	60	46	50	50	38	9	2	4	25	67	78	77
Braga	135	89	98	96	78	36	19	28	61	136	151	142
Bragança	85	56	64	63	57	30	17	20	40	89	86	98
Castelo Branco	108	82	85	87	68	22	9	14	47	124	127	123
Coimbra	107	78	77	81	66	22	9	14	46	112	121	114
Évora	65	49	54	54	45	12	3	5	28	74	82	78
Faro	57	49	58	55	34	7	1	3	22	67	85	85
Guarda	130	94	97	101	75	27	12	20	55	135	142	141
Leiria	87	62	61	63	56	16	6	10	35	90	100	92
Lisboa	71	52	53	53	41	10	4	6	27	77	90	83
Portalegre	86	67	70	70	61	18	7	9	39	105	105	97
Porto	131	89	92	93	74	29	13	23	58	129	143	136
Santarém	74	54	56	56	50	14	5	7	31	81	90	83
Setúbal	66	50	53	54	44	12	3	5	28	74	85	80

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Viana do Castelo	136	90	97	95	78	34	17	28	61	135	151	145
Vila Real	124	83	92	90	73	33	16	24	55	124	133	138
Viseu	128	91	92	97	74	27	12	20	54	130	139	135
Funchal	53	57	60	52	30	17	6	7	28	71	71	86
Ponta Delgada	109	91	101	77	68	45	22	39	62	116	85	148

Source: NASA POWER (A9); author's calculation.

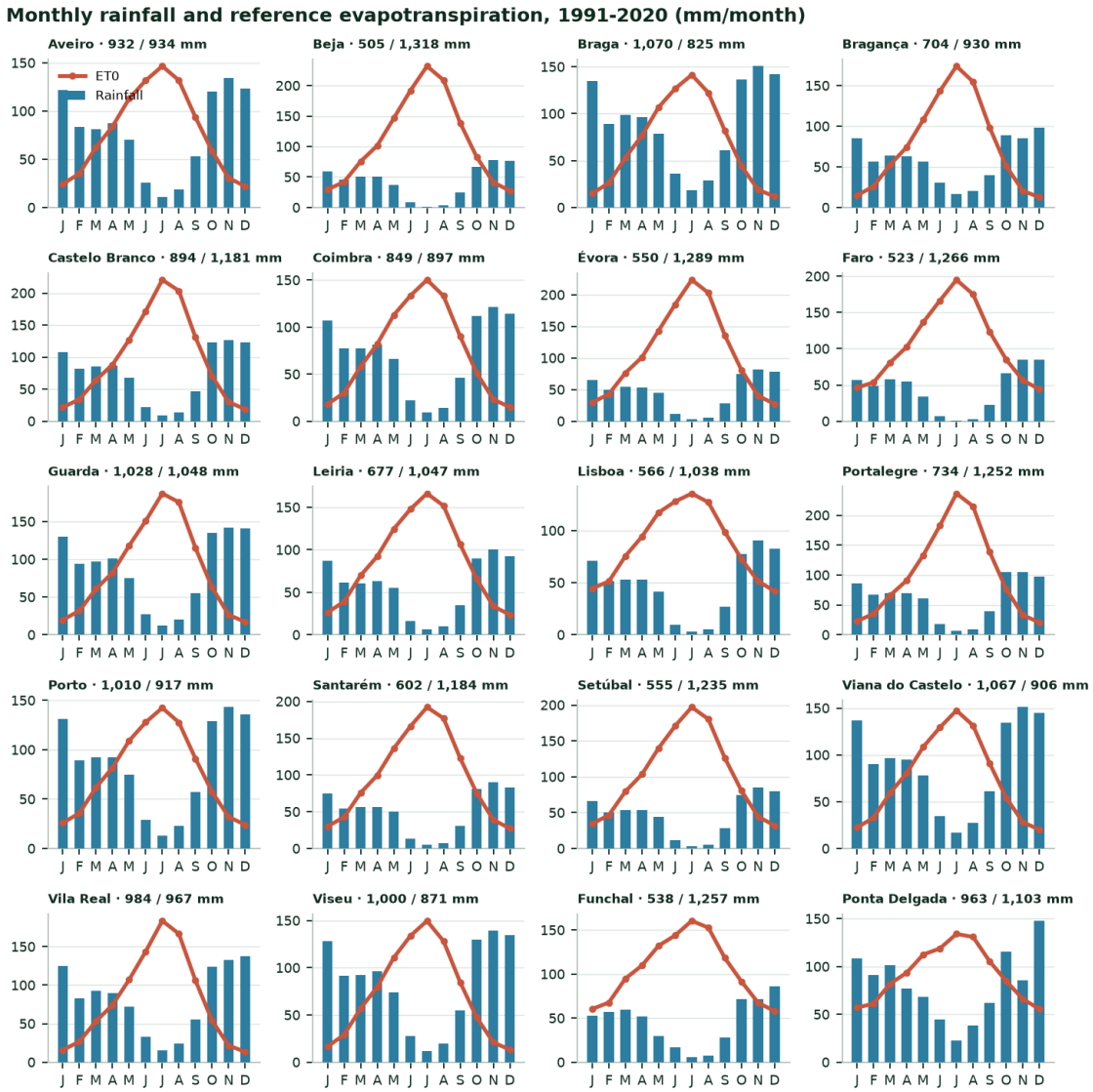


Figure 4. Monthly rainfall and reference evapotranspiration by city, 1991-2020. Source: NASA POWER (A9)

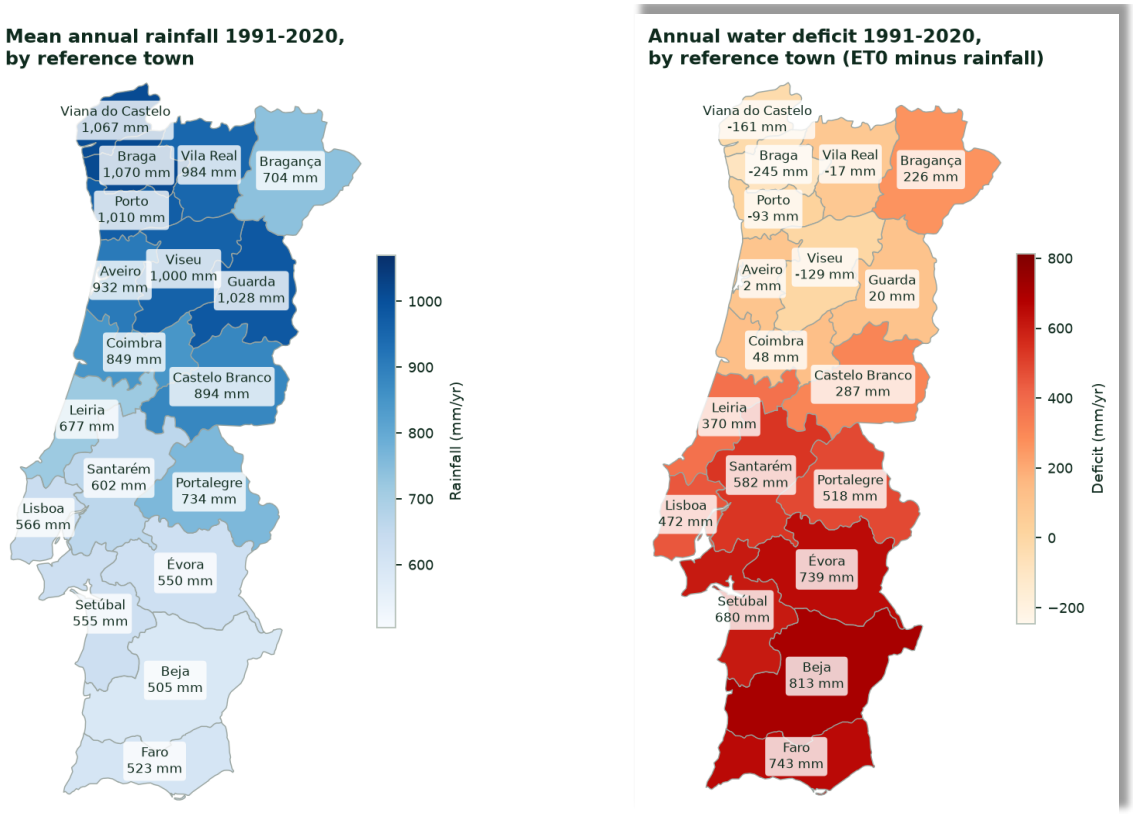


Figure 5. Mean annual rainfall 1991-2020, by region. Source: NASA POWER (A9), Natural Earth (A10).

Annual water deficit, by region. Source: NASA POWER (A9), Natural Earth (A10).

3.3 Climate change

Mean annual temperature is rising. At Évora it went from 17.1 °C in 1981 to 17.6 °C in 2024, a trend of 0.19 °C per decade. At Braga the trend is 0.20 °C per decade, from 13.0 °C to 14.0 °C. Warmer air dries the soil faster between rainfall events.

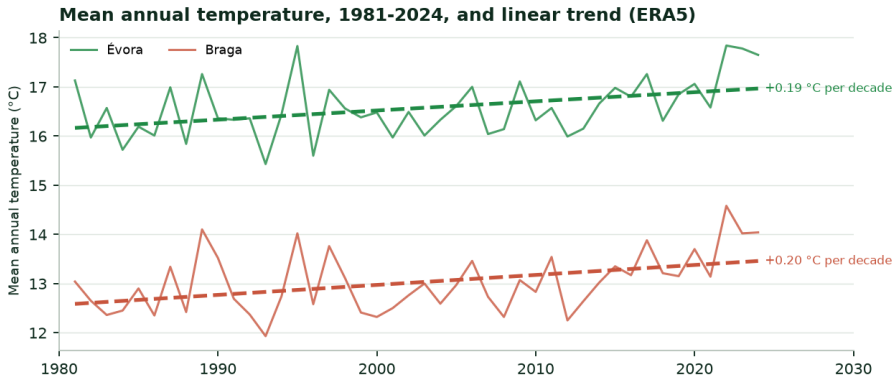


Figure 6. Mean annual temperature, 1981-2024, and linear trend. Source: NASA POWER (A9)



The Alentejo countryside in September, near Elvas.

4. Water: Resources, irrigated areas, withdrawals

4.1 Resources and withdrawals

Total freshwater withdrawals are 6,130 million m³ a year (2022). Agriculture accounts for 55.4% of these withdrawals, that is 3,398 Mm³. Internal resources are 38.0 km³ a year and water stress is 12.3%: The country has water, but little of it is mobilised for crops.

Freshwater: Withdrawals and resources

Indicator	Value	Year	Source
Total withdrawals	6,130 Mm³	2022	World Bank (A1)
Agricultural share	55.4%	2022	World Bank (A1)
Agricultural withdrawals	3,397.5 Mm³	2022	Calculated from A1
Area equipped for irrigation	637,340 ha	2024	FAOSTAT (A6)
Agricultural withdrawals per equipped hectare	5,331 m³/ha	—	Calculation (Annex B)
Water stress	12.3%	2022	World Bank (A1)

4.2 Irrigated areas

FAOSTAT counts 637,340 hectares equipped for irrigation in 2024. This is 36.7% of the cropland; 585,340 ha are actually irrigated (A6). The Alqueva scheme, in the Alentejo, is the largest: In 2024, olive trees cover 74,059 ha there and permanent crops 83% of the irrigated area (A23).



An irrigation canal near the Pego do Altar dam.

4.3 What the water saving represents

In the central scenario, the saving is 445.1 million m³ a year, or 13.1% of agricultural withdrawals. At 5,331 m³ per equipped hectare, this water would irrigate about 83,489 more hectares, or 13.1% of today's equipped area.

5. Fertilisers: Quantities, purchases, spending

5.1 Quantities used

In 2024, agricultural use reaches 90,669 tonnes of nitrogen, 39,075 tonnes of phosphate (P2O5) and 33,082 tonnes of potash (K2O). The country produces 70,024 tonnes of nitrogen and 48,062 tonnes of phosphate (P2O5); it imported 153,775 tonnes of nitrogen in the same year. Per hectare of arable land, use is 190.5 kg per hectare.

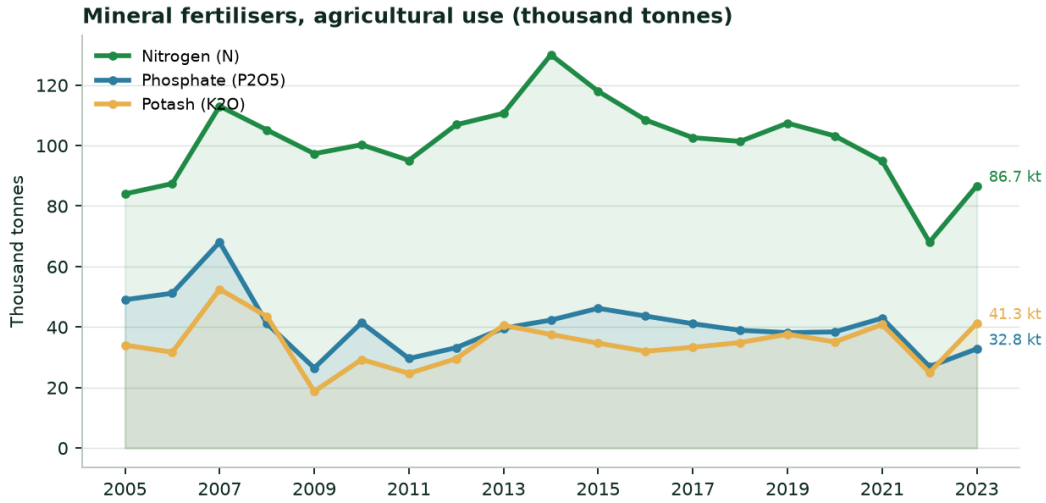


Figure 7. Mineral fertilisers, agricultural use, 2005-2023. Source: FAOSTAT (A5)

5.2 Regulatory framework

A fertilising product can be sold in Portugal under the national regime of Decree-Law No. 30/2022 or with CE marking under Regulation (EU) 2019/1009. A field efficacy trial must be notified in advance to INIAV. For water-retention polymers, Delegated Regulation (EU) 2024/2770 sets biodegradability criteria applicable from 17 October 2028 (A13).



Cultivated fields near Atouguia da Baleia (Peniche).

5.3 Indicative spending

In 2024, the indicative minimum spending on mineral fertilisers reaches $123 million, at international fertiliser prices (calculation in Annex B, lower bound).

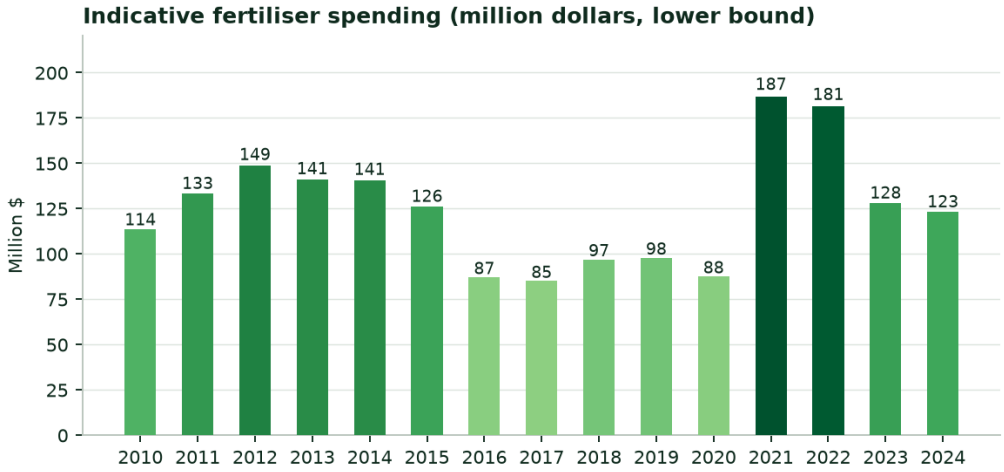


Figure 8. Indicative fertiliser spending, lower bound. Source: Author's calculation from A5 and A7

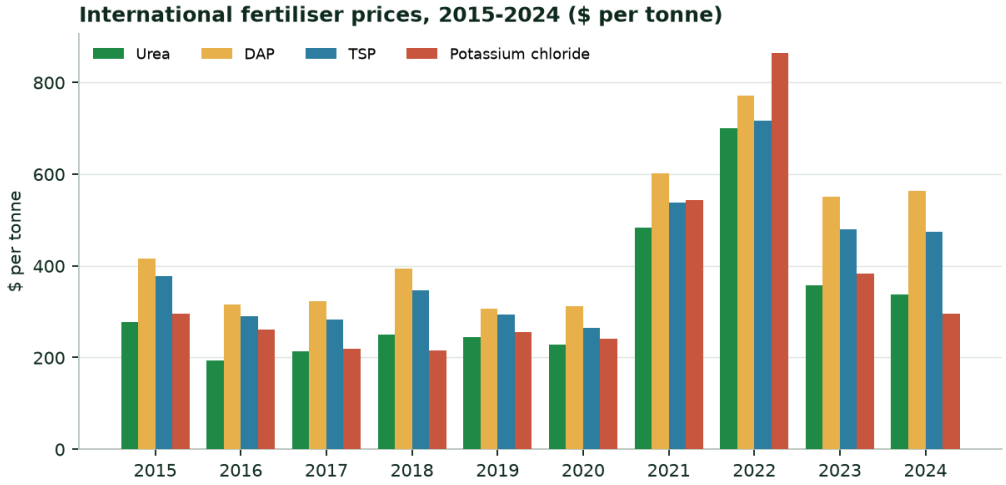


Figure 9. International prices of urea, DAP, TSP and potassium chloride. Source: World Bank, Pink Sheet (A7)

6. The regions at a glance

The table compares the eighteen mainland districts and the two autonomous regions, Madeira and the Azores, each represented by a reference town. For the two archipelagos, the climate comes from ERA5, whose finer grid follows the terrain better (A24). 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)
Aveiro (Aveiro)	932	934	2	1,654	15.5
Beja (Beja)	505	1,318	813	1,833	16.8
Braga (Braga)	1,070	825	-245	1,560	12.9
Bragança (Bragança)	704	930	226	1,666	10.8
Castelo Branco (Castelo Branco)	894	1,181	287	1,773	14.6

Region (city)	Rainfall (mm/yr)	ET0 (mm/yr)	Deficit (mm/yr)	Radiation (kWh/m²/yr)	Temperature (°C)
Coimbra (Coimbra)	849	897	48	1,624	14.1
Évora (Évora)	550	1,289	739	1,811	16.4
Faro (Faro)	523	1,266	743	1,901	17.8
Guarda (Guarda)	1,028	1,048	20	1,691	12.8
Leiria (Leiria)	677	1,047	370	1,643	15.5
Lisbon (Lisboa)	566	1,038	472	1,764	16.6
Portalegre (Portalegre)	734	1,252	518	1,759	15.6
Porto (Porto)	1,010	917	-93	1,651	15.2
Santarém (Santarém)	602	1,184	582	1,754	16.3
Setúbal (Setúbal)	555	1,235	680	1,806	16.8
Viana do Castelo (Viana do Castelo)	1,067	906	-161	1,615	15.0
Vila Real (Vila Real)	984	967	-17	1,663	12.5
Viseu (Viseu)	1,000	871	-129	1,658	14.5
Madeira (Funchal)	538	1,257	719	1,829	19.8
Azores (Ponta Delgada)	963	1,103	140	1,490	17.8

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

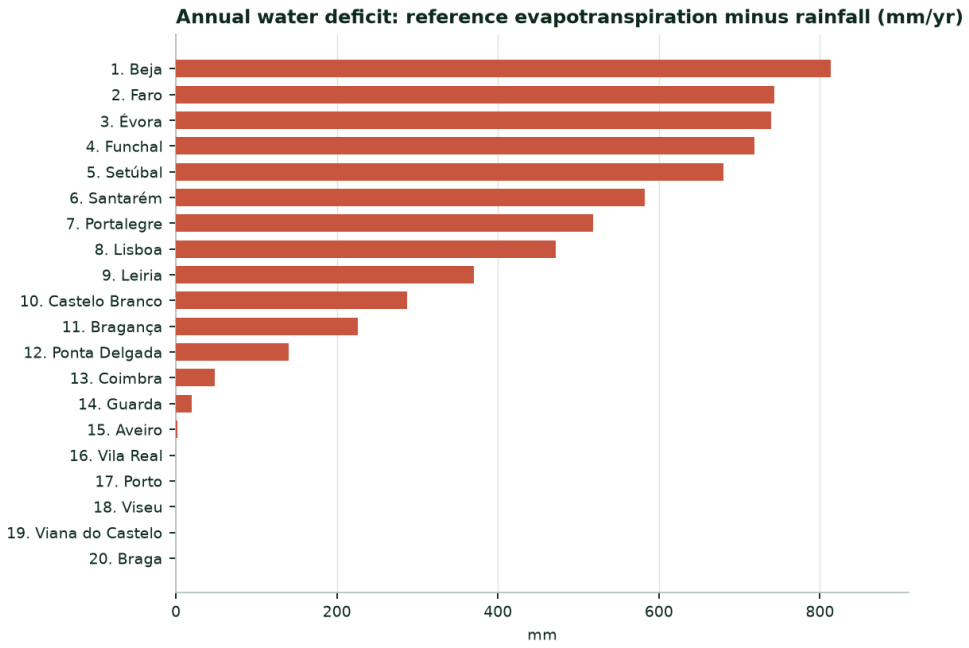


Figure 10. Annual water deficit: Reference evapotranspiration minus rainfall. Source: NASA POWER (A9)



Cultivated fields at Carrasqueira, Alcácer do Sal.

7. The twenty main crops: Three rankings

7.1 By harvested area

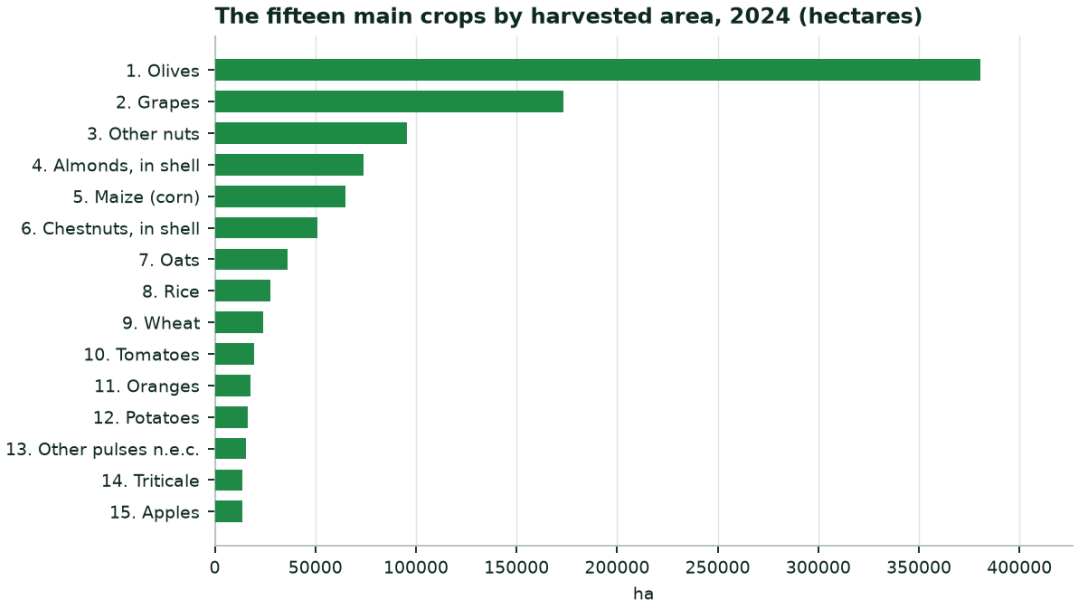


Figure 11. The fifteen main crops by harvested area, 2024 (hectares). Source: FAOSTAT (A2)

The ten main crops by area, 2024

Crop	Harvested area (ha)	Production (t)	Yield (t/ha)
Olives	380,780	1,340,820	3.52
Grapes	173,210	917,890	5.30
Other nuts	95,640	0	0.00
Almonds, in shell	73,770	90,760	1.23
Maize (corn)	65,160	617,530	9.48
Chestnuts, in shell	51,170	27,160	0.53
Oats	36,100	58,820	1.63
Rice	27,720	172,120	6.21
Wheat	24,110	81,350	3.37
Tomatoes	19,400	1,762,480	90.85

Source: FAOSTAT (A2).

7.2 By production

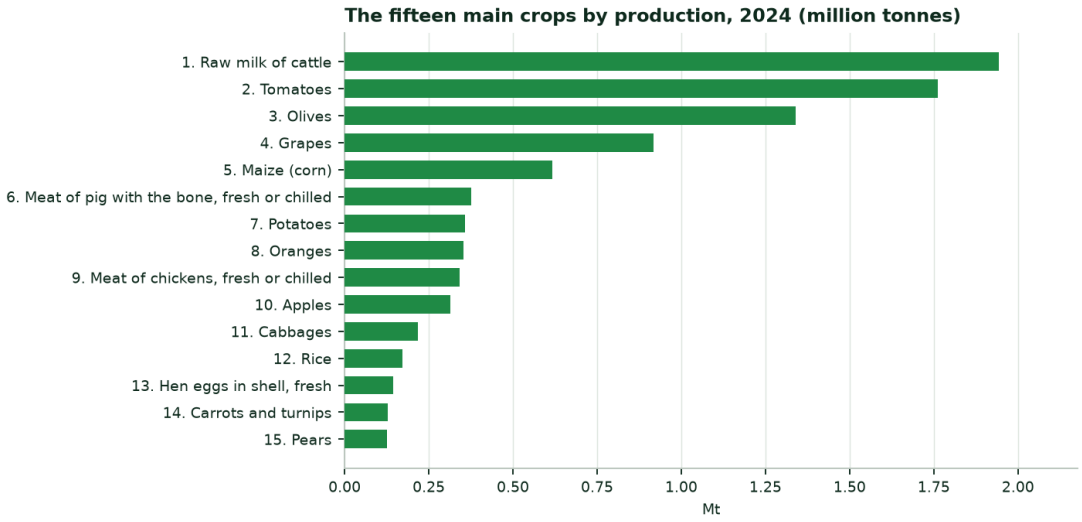


Figure 12. The fifteen main crops by production, 2024 (million tonnes). Source: FAOSTAT (A2)

7.3 By production value

By production value, the three main crops are: Tomatoes, olives and grapes (FAOSTAT, 2023, current US dollars).

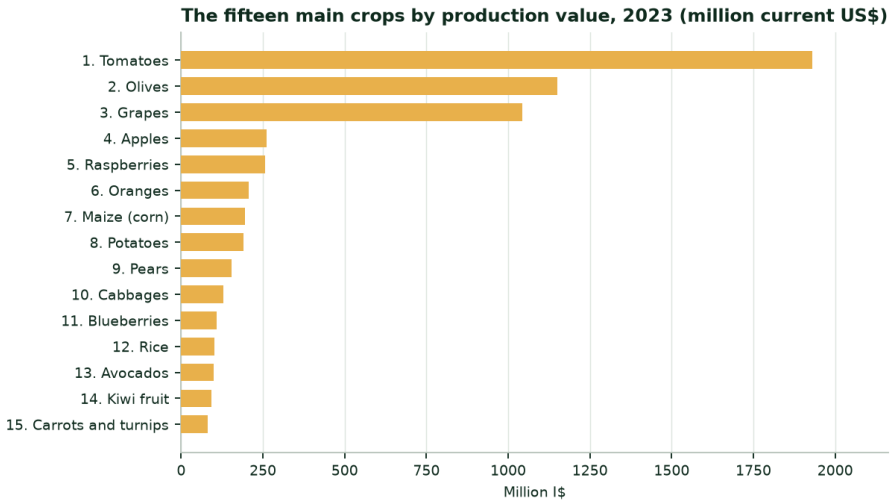


Figure 13. The fifteen main crops by production value, 2023 (million current US$). Source: FAOSTAT (A3)



A citrus orchard at Vale de Paraíso (Albufeira).

8. Extrapolation by crop: Irrigation and rainfed crops

8.1 Method

Method in brief

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

• Each calculation applies the effect of the trial cited: A quarter (cautious), half (central) or the full effect (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: Water and yield
Soybean, China	Soybean	Assumption	+11.3%	Not used; cited for reference
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 Portugal: The figures below apply the results of the cited trials to the country's average yields.

8.3 Irrigation: Vegetables and melons, Potato, Fruit and Maize

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

Crop group	Equipped area (ha)	Share	Trial or assumption	Water saved (Mm³/yr)
Vegetables and melons (processing tomato, cabbage, squash, others)	53,980	8.5%	Watermelon, Mexico (2023)	87.0
Potato	16,460	2.6%	Potato, South Africa (2025)	22.8
Fruit (orange, apple, pear, cherry, avocado, others)	83,790	13.1%	Generic assumption, no trial	44.7
Maize (irrigated)	65,160	10.2%	Maize, Türkiye (TIGEM, 2025)	67.7
Rice (irrigated)	27,720	4.3%	Generic assumption, no trial	14.8
Rest of the equipped area (irrigated olive groves and almond orchards, vines, fodder)	390,230	61.2%	Generic assumption, no trial	208.0

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	222.5	41,744	255,351
Central	445.1	83,489	510,702
High	890.1	166,978	1,021,403

Source: Author's calculation (Annex B).

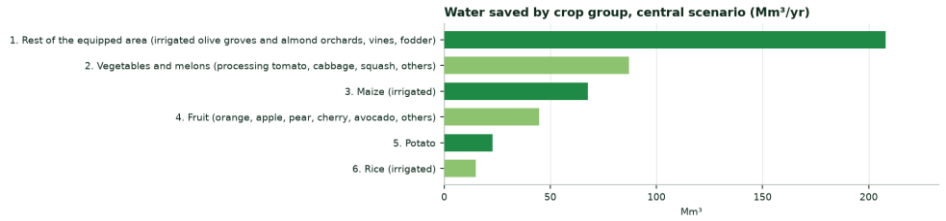


Figure 14. Water saved by crop group, central scenario. Source: Author's calculation

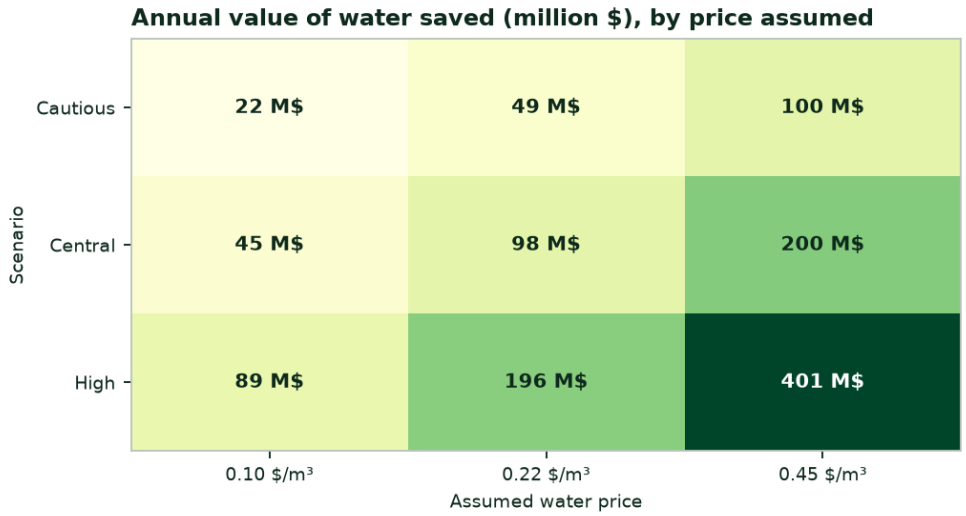


Figure 15. Annual value of the water saved, by price assumed per cubic metre. Source: Author's calculation; prices assumed, no national tariff

8.4 Reading the results

Key points

• The "rest of the equipped area" group gives 47% 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 the confidence level and limitations of each.

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 Portugal
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
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 Portugal

Source: Annex A.



An almond orchard in Paderne, in the Algarve.

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)	10,134	11,004
Agricultural imports (crops and livestock)	14,950	15,130
Exports, all merchandise	83,901	85,794
Imports, all merchandise	113,475	115,951

Source: FAOSTAT (A4).

10.2 Exports

The three main farm products exported in 2024 are: Olive oil ($1,705 million), wine ($1,044 million) and cigarettes ($924 million).

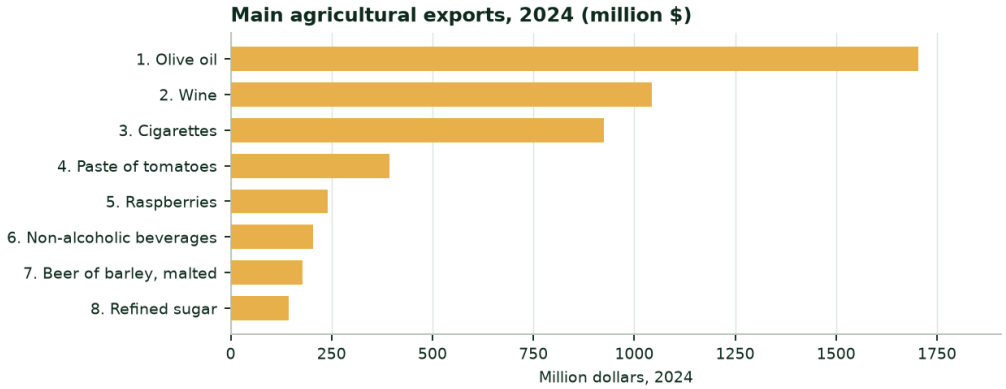


Figure 16. Main agricultural exports, 2024. Source: FAOSTAT (A4)

10.3 Imports

The main farm purchases are: Olive oil ($649 million), boneless beef ($604 million) and soybeans ($523 million).

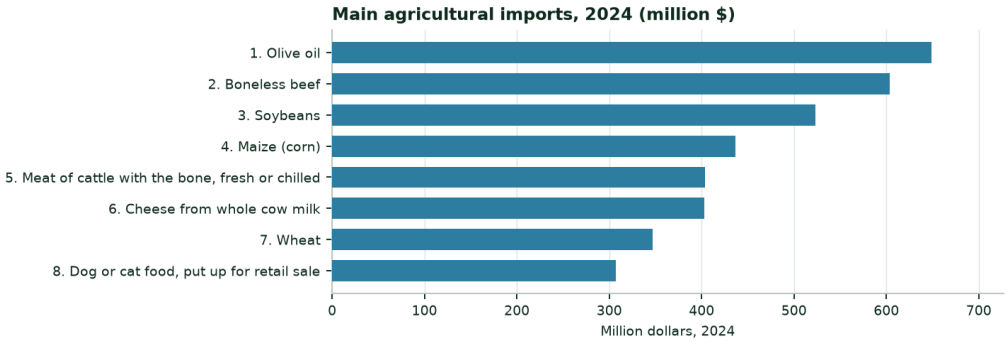


Figure 17. Main agricultural imports, 2024. Source: FAOSTAT (A4)



Figure 18. Pineapple greenhouses in Ponta Delgada, Azores.



Fruit stalls at the Mercado da Ribeira, in Lisbon.

10.4 Importing water-retention polymers into Portugal

What to know

• **Customs duty (subheading 3906.90):** The European Union common tariff, from 0 to 6.5% depending on the line; the "other" line (3906.90.90) is at 6.5% (A11). Products made in the Union move duty-free.

• **VAT (IVA):** Standard rate of 23% on the mainland, 22% in Madeira and 16% in the Azores; intermediate rate of 13% and reduced rate of 6% for lists of goods set by law (A12). The rate applicable to a water-retaining agent is to be confirmed with the Tax and Customs Authority.

• **Placing on the market:** A fertilising product can be sold under the Portuguese regime of Decree-Law No. 30/2022 or with CE marking under Regulation (EU) 2019/1009. A field efficacy trial must be notified in advance to INIAV. For water-retention polymers, Delegated Regulation (EU) 2024/2770 sets biodegradability criteria applicable from 17 October 2028 (A13).

• **Classification:** Code 3906.90 is an inference for our products; Portuguese Customs 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 scarcest. The description of crops is qualitative.



The fields of the lower Mondego, near Montemor-o-Velho.

Aveiro (Aveiro)

Aveiro: Maize, meadows and dairy farming of the Baixo Vouga; Bairrada vines.

Indicator	Value
Annual rainfall, 1991-2020	932 mm
Reference evapotranspiration	934 mm
Annual water deficit	2 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,654 kWh/m²
Mean temperature	15.5 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Beja (Beja)

Beja: The heart of the Alqueva scheme, irrigated olive groves and almond orchards; berry greenhouses on the Odemira coast.

Indicator	Value
Annual rainfall, 1991-2020	505 mm
Reference evapotranspiration	1,318 mm
Annual water deficit	813 mm
Months with less than 50 mm of rain	6
Global solar radiation	1,833 kWh/m²
Mean temperature	16.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Braga (Braga)

Braga: Vinho verde vines, fodder maize and dairy farming, on small plots.

Indicator	Value
Annual rainfall, 1991-2020	1,070 mm
Reference evapotranspiration	825 mm
Annual water deficit	-245 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,560 kWh/m²
Mean temperature	12.9 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Bragança (Bragança)

Bragança: Chestnuts, olives, almonds and livestock, in a harsh climate.

Indicator	Value
Annual rainfall, 1991-2020	704 mm
Reference evapotranspiration	930 mm
Annual water deficit	226 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,666 kWh/m²
Mean temperature	10.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Castelo Branco (Castelo Branco)

Castelo Branco: Olives, Cova da Beira cherries and sheep farming.

Indicator	Value
Annual rainfall, 1991-2020	894 mm
Reference evapotranspiration	1,181 mm
Annual water deficit	287 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,773 kWh/m²
Mean temperature	14.6 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Coimbra (Coimbra)

Coimbra: Rice and maize of the lower Mondego, Bairrada vines and forests.

Indicator	Value
Annual rainfall, 1991-2020	849 mm
Reference evapotranspiration	897 mm
Annual water deficit	48 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,624 kWh/m²
Mean temperature	14.1 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Évora (Évora)

Évora: Cork and holm oak montado, vines, olives and cereals.

Indicator	Value
Annual rainfall, 1991-2020	550 mm
Reference evapotranspiration	1,289 mm
Annual water deficit	739 mm
Months with less than 50 mm of rain	6
Global solar radiation	1,811 kWh/m²
Mean temperature	16.4 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Faro (Faro)

Faro: Citrus, avocados, berries and vegetables of the Algarve, with very dry summers.

Indicator	Value
Annual rainfall, 1991-2020	523 mm
Reference evapotranspiration	1,266 mm
Annual water deficit	743 mm
Months with less than 50 mm of rain	6
Global solar radiation	1,901 kWh/m²
Mean temperature	17.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Guarda (Guarda)

Guarda: Sheep farming of the Serra da Estrela, chestnuts and apple orchards of the Beira Alta.

Indicator	Value
Annual rainfall, 1991-2020	1,028 mm
Reference evapotranspiration	1,048 mm
Annual water deficit	20 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,691 kWh/m²
Mean temperature	12.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Leiria (Leiria)

Leiria: Rocha pears, apples and vegetables of the Oeste, near the Atlantic.

Indicator	Value
Annual rainfall, 1991-2020	677 mm
Reference evapotranspiration	1,047 mm
Annual water deficit	370 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,643 kWh/m²
Mean temperature	15.5 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Lisbon (Lisboa)

Lisbon: Vegetables, pear orchards and vines, around the capital.

Indicator	Value
Annual rainfall, 1991-2020	566 mm
Reference evapotranspiration	1,038 mm
Annual water deficit	472 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,764 kWh/m²
Mean temperature	16.6 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Portalegre (Portalegre)

Portalegre: Montado, olives, cereals and livestock of the Upper Alentejo.

Indicator	Value
Annual rainfall, 1991-2020	734 mm
Reference evapotranspiration	1,252 mm
Annual water deficit	518 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,759 kWh/m²
Mean temperature	15.6 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Porto (Porto)

Porto: Vinho verde, maize, vegetables and dairy farming around the city.

Indicator	Value
Annual rainfall, 1991-2020	1,010 mm
Reference evapotranspiration	917 mm
Annual water deficit	-93 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,651 kWh/m²
Mean temperature	15.2 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Santarém (Santarém)

Santarém: Processing tomatoes, maize, rice and vines on the Tagus plain.

Indicator	Value
Annual rainfall, 1991-2020	602 mm
Reference evapotranspiration	1,184 mm
Annual water deficit	582 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,754 kWh/m²
Mean temperature	16.3 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Setúbal (Setúbal)

Setúbal: Sado rice, vines of the Setúbal peninsula, montado and pines.

Indicator	Value
Annual rainfall, 1991-2020	555 mm
Reference evapotranspiration	1,235 mm
Annual water deficit	680 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,806 kWh/m²
Mean temperature	16.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Viana do Castelo (Viana do Castelo)

Viana do Castelo: Alvarinho vines, maize and meadows, in the wettest region.

Indicator	Value
Annual rainfall, 1991-2020	1,067 mm
Reference evapotranspiration	906 mm
Annual water deficit	-161 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,615 kWh/m²
Mean temperature	15.0 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Vila Real (Vila Real)

Vila Real: Terraced Douro vineyards, olives and chestnuts.

Indicator	Value
Annual rainfall, 1991-2020	984 mm
Reference evapotranspiration	967 mm
Annual water deficit	-17 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,663 kWh/m²
Mean temperature	12.5 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Viseu (Viseu)

Viseu: Dão vines, apple orchards, chestnuts and livestock, on a granite plateau.

Indicator	Value
Annual rainfall, 1991-2020	1,000 mm
Reference evapotranspiration	871 mm
Annual water deficit	-129 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,658 kWh/m²
Mean temperature	14.5 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Madeira (Funchal)

Madeira: Bananas, vines and vegetables, on terraces watered by the levadas.

Indicator	Value
Annual rainfall, 1991-2020	538 mm
Reference evapotranspiration	1,257 mm
Annual water deficit	719 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,829 kWh/m²
Mean temperature	19.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Azores (Ponta Delgada)

Azores: Meadows and dairy farming, greenhouse pineapples and tea.

Indicator	Value
Annual rainfall, 1991-2020	963 mm
Reference evapotranspiration	1,103 mm
Annual water deficit	140 mm
Months with less than 50 mm of rain	3
Global solar radiation	1,490 kWh/m²
Mean temperature	17.8 °C

Source: NASA POWER (A9); PVGIS (A8); author's calculation.

Annex A. Sources and confidence levels

Ref.	Source	Level
A1	World Bank, World Development Indicators (WDI), Portugal	A
A2	FAOSTAT, crops and livestock (QCL), areas, production, 2014-2024	A
A3	FAOSTAT, value of production (QV), current US dollars, 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
A8	PVGIS (European Commission Joint Research Centre), radiation, 2005-2020	B
A9	NASA POWER (NASA Langley Research Center), daily data: Rainfall, temperature, humidity, wind and radiation, 1981-2024; reference evapotranspiration calculated by the author with FAO-56 (Penman-Monteith)	B
A10	Natural Earth, first-level administrative boundaries and country outline	B
A11	World Bank, WITS (UNCTAD TRAINS database), European Union (common customs tariff, applied in Portugal), applied MFN duties, subheading 3906.90, 2023	A
A12	PwC, Worldwide Tax Summaries, Portugal, other taxes: VAT (IVA) rates, mainland, Madeira and the Azores	C
A13	Decree-Law No. 30/2022 of 11 April (Diário da República) on placing fertilising materials on the market; Regulation (EU) 2019/1009 (CE marking); Delegated Regulation (EU) 2024/2770, biodegradability criteria for water-retention polymers from 17 October 2028; INIAV, efficacy trials	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
A23	EDIA, Alqueva Agricultural Yearbook 2024, figures reported by the regional press (Correio Alentejo, Rádio Pax): Olive 74,059 ha, permanent crops 83% of the irrigated area	C
A24	ERA5 (Copernicus), via Open-Meteo: Rainfall, reference evapotranspiration and temperature, 1991-2020 means, for Funchal (Madeira) and Ponta Delgada (Azores)	B

Annex B. Calculation method

1. Agricultural water. Total withdrawals (6,130 Mm³, 2022) × agricultural share (55.43%) = 3,397.5 Mm³.

2. Irrigation. The equipped area (637,340 ha) and agricultural water are shared between irrigated groups (vegetables and melons, potato, fruit, maize, rice and rest of the equipped area) in proportion to their harvested areas (637,340 ha), without exceeding each group's harvested area. Our sources provide no irrigation statistics by crop. Other crops are treated as rainfed and receive no irrigation water in the calculation. Vegetables, potato, fruit, maize and rice are treated as irrigable; the equipped area is attributed to them in proportion to their harvested area. The rest of the equipped area forms a separate group: Irrigated olive groves and almond orchards, mostly in the Alentejo, vines and irrigated fodder. Olives, vines, tree nuts, winter cereals and pulses are counted over their whole area in the rainfed crop tables. FAOSTAT does not publish Portugal's production value by crop in international dollars at constant prices: Values are therefore in current US dollars.

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

4. Extra hectares. Water saved ÷ water per equipped hectare (5,331 m³/ha).

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 NASA POWER grid cell containing each city; radiation: PVGIS, 2005-2020. Temperature trends are linear regressions over 1981-2024. NASA POWER combines reanalyses and satellite data on a grid of about 50 km: Two nearby cities can share the same cell, and its rainfall can differ from local station records. On the maps, each mainland district is coloured according to the value of its reference town; Madeira and the Azores appear in the tables. For these two archipelagos, rainfall, evapotranspiration and temperature come from ERA5, via Open-Meteo (A24): The NASA POWER grid there is mostly ocean.

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.

Annex C. Photo credits

File (Wikimedia Commons)	Author	Licence
Terraced vineyards in the douro valley.jpg	Rosino	CC BY-SA 2.0
2026-07-19 Pear orchards in Bombarral.jpg	Alexkom000	CC BY 4.0
2025-09-24 Corn Field in Silveira.jpg	Alexkom000	CC BY 4.0
Alentejo September 2013-1.jpg	Alvesgaspar	CC BY-SA 3.0
Irrigation canal near the Pego do Alter dam, Alcácer do Sal, Portugal	Jules Verne Times Two	CC BY-SA 4.0
Arredores da Atouguia da Baleia - Portugal PT (54038462071).jpg	Vitor Oliveira from Torres Vedras, PORTUGAL	CC BY-SA 2.0
Campos de cultivo na Carrasqueira, Alcácer do Sal.jpg	Rúdisicyon	CC BY-SA 4.0
Citrus Orchard, Vale de Paraíso, Albufeira, 19 January 2016 (1).JPG	Kolforn	CC BY-SA 4.0
Portugal - Algarve - Paderne - Almond grove (25552460570).jpg	Muffinn	CC BY 2.0
Arruda Pineapple Plantation in Ponta Delgada 02.jpg	Kritzolina	CC BY-SA 4.0
Lisbon, Mercado da Ribeira, fruits.JPG	Dguendel	CC BY 4.0
Arredores de Montemor-o-Velho - Portugal (53490409741).jpg	Vitor Oliveira from Torres Vedras, PORTUGAL	CC BY-SA 2.0
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Vines and the Atlantic Ocean at Colares.

Green Solutions

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