

COUNTRY DOSSIER

Morocco

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

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The Agdz oasis, in the Drâa valley.

Foreword

This dossier describes Morocco 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, ADII, ONSSA, Moroccan administration).
- **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 Morocco.

Contents

Summary
1. Green Solutions and our products
2. Morocco 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), ADII, ONSSA, Moroccan administration, PVGIS and ERA5. The production gains and water savings are scenarios, described in Annex B.

38.43 M
Inhabitants in 2025 (World Bank)

1.76 M ha
Of wheat harvested in 2024, the main crop

1.97 M ha
Equipped for irrigation (2024)

1,270 Mm³
Of irrigation water saved a year, central scenario

5,690 M$
Of agricultural exports in 2024 (FAOSTAT)

Key points

• **Irrigation, a pillar of production.** 1.97 million hectares equipped for irrigation in 2024, or 22% of the 9.00 million hectares of cropland.

• **Wheat: The main crop.** 1,758,589 ha harvested in 2024, for 2.44 million tonnes, or 1.39 t/ha.

• **Water is scarce.** National water stress reaches 50.8%; at Dakhla, atmospheric water demand exceeds rainfall by 1,768 mm.

• **In irrigated farming, the water saved could allow irrigation schemes to be expanded.** 1,270.1 Mm³ a year in the central scenario, enough to irrigate about 269,174 more ha, or 13.7% of the equipped area.

• **An organic supply chain.** 12,200 ha of certified organic cropland in 2024: ECOFERT® is EU Bio certified.

• **Fertilisers made locally.** 177,191 t of nitrogen used in 2024; the country produces 1,396,311 t and imports 177,191 t.

• **Farm trade.** $5,690 million of exports and $9,353 million of imports in 2024. Leading export: Tomatoes ($1,201 million). Leading import: Wheat ($1,448 million).

Key figures

Key indicators for Morocco

Indicator	Value	Year	Source (level)
Population	38.43 M	2025	World Bank (A1)
GDP per capita	4,672 $	2025	World Bank (A1)
Agriculture's share of GDP	10.5%	2025	World Bank (A1)
Agricultural employment	27.9%	2025	World Bank (A1)
Cropland	9,000,000 ha	2024	FAOSTAT (A6)
Area equipped for irrigation	1,966,850 ha	2024	FAOSTAT (A6)
Harvested area: Wheat	1,758,589 ha	2024	FAOSTAT (A2)
Certified organic cropland	12,200 ha	2024	FAOSTAT (A6)
Agricultural exports	5,690 M$	2024	FAOSTAT (A4)
Agricultural imports	9,353 M$	2024	FAOSTAT (A4)
Mineral nitrogen, agricultural use	177,191 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 Morocco. 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.



Wheat and olive trees at Agouni, near Ouirgane (Al Haouz).

2. Morocco in figures

Morocco had 38.43 million inhabitants in 2025, 37% of them in rural areas. Agriculture accounts for 10.5% of gross domestic product and employs 28% of the labour force. The country covers 446.3 thousand km², of which 67% is agricultural land. Undernourishment affects 6.5% of the population.

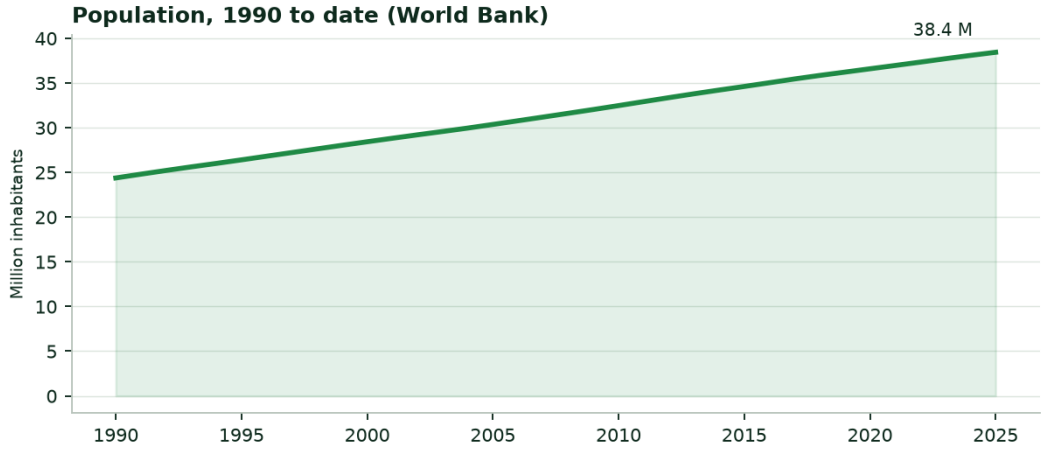


Figure 1. Population of Morocco, 1990 to date. Source: World Bank (A1)

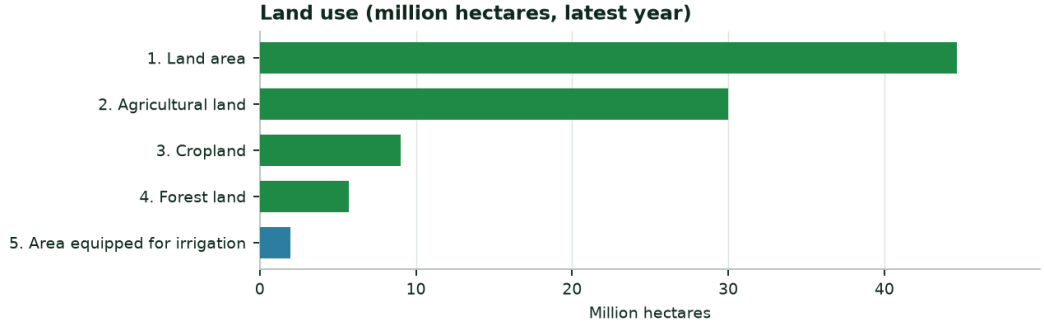


Figure 2. Land use, latest year published. Source: FAOSTAT (A6)

Agricultural and water indicators, latest year published

Indicator	Value	Year	Source
Cropland certified organic	12,200 ha	2024	FAOSTAT (A6)
Average cereal yield	1,240 kg/ha	2024	World Bank (A1)
Fertiliser use per hectare of arable land	56.5 kg/ha	2024	World Bank (A1)
Water withdrawals, agricultural share	87.8%	2022	World Bank (A1)
Internal freshwater resources	29.0 km³	2022	World Bank (A1)
Internal resources per inhabitant	777 m³	2022	World Bank (A1)



Arhbalou village and the High Atlas, in Al Haouz province.

3. Sunshine, rainfall and climate change

3.1 Sunshine

Global solar radiation reaches 1,912 to 2,315 kWh/m² a year depending on the region. Energy is not the limiting factor: Water available at the right time determines the harvest.

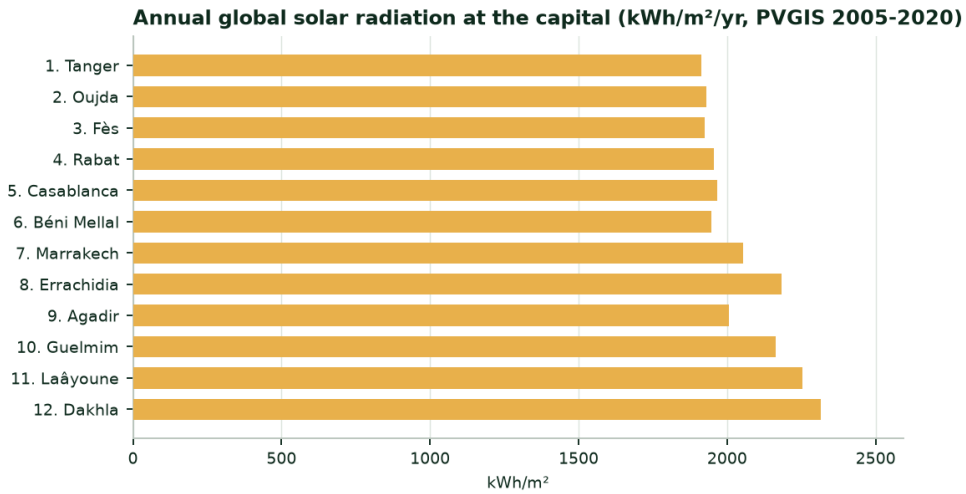


Figure 3. Annual global solar radiation at each region's capital. Source: PVGIS (A8)

3.2 Rainfall and evapotranspiration

Annual rainfall is 571 mm at Tanger, but only 29 mm at Dakhla, where reference evapotranspiration reaches 1,797 mm. Rain falls mostly from October to April; summer is dry everywhere. Rainfall decreases from the north-west towards the south and east, beyond the Atlas.

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

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tanger	75	63	67	54	29	7	1	2	26	69	87	92
Oujda	38	38	51	44	34	12	2	7	21	38	44	30
Fès	56	55	65	62	46	16	4	7	29	57	68	55
Rabat	60	48	49	38	23	6	1	2	14	47	72	60
Casablanca	43	38	36	30	15	3	0	1	11	33	52	44
Béni Mellal	61	61	71	59	47	17	9	11	24	44	64	52
Marrakech	34	31	41	37	17	7	4	7	12	24	37	28
Errachidia	10	13	11	10	10	5	2	3	9	20	14	7
Agadir	31	41	38	18	8	1	0	2	5	29	46	50
Guelmim	13	19	18	7	3	1	0	2	4	10	20	19
Laâyoune	7	6	6	1	1	0	0	0	4	7	5	8
Dakhla	4	2	3	2	1	0	0	1	5	5	2	5

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

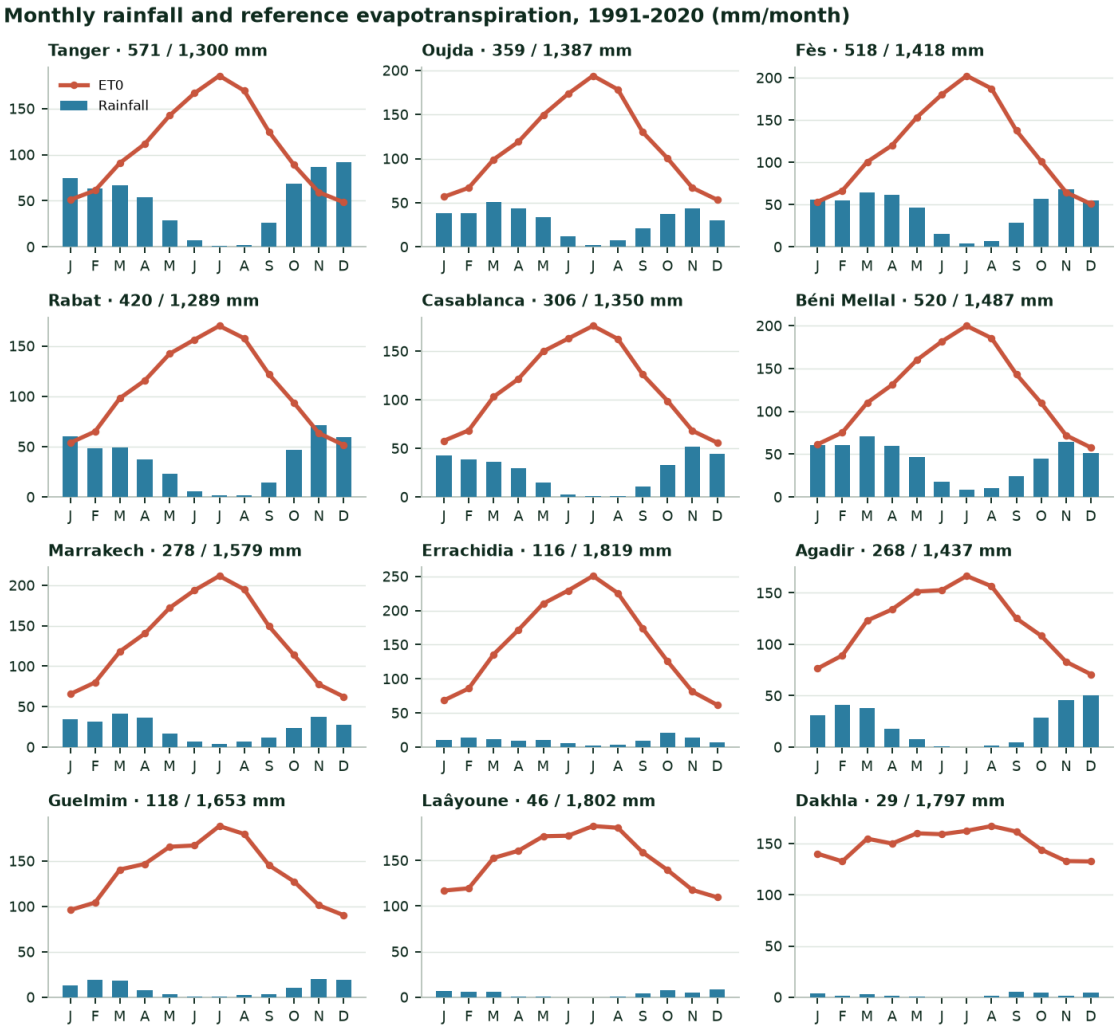


Figure 4. Monthly rainfall and reference evapotranspiration by city, 1991-2020. Source: ERA5 via Open-Meteo (A9)

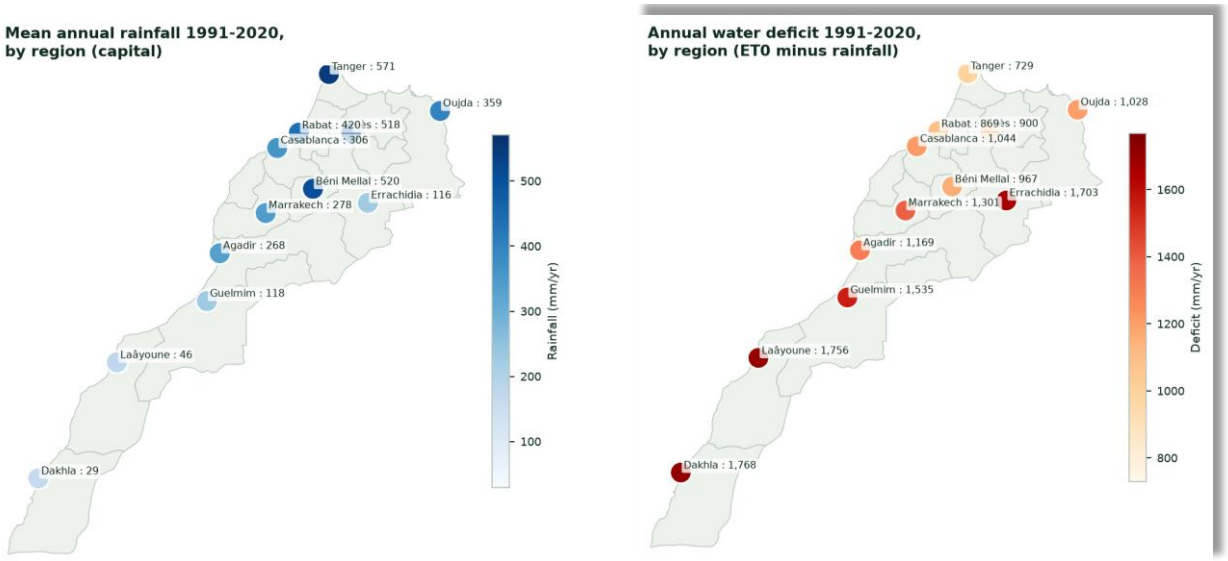


Figure 5. Mean annual rainfall 1991-2020, by region. Source: ERA5 (A9), Natural Earth (A10). *Annual water deficit, by region. Source: ERA5 (A9), Natural Earth (A10).*

3.3 Climate change

Mean annual temperature is rising. At Fès it went from 18.0 °C in 1981 to 19.6 °C in 2024, a trend of 0.44 °C per decade. At Errachidia the trend is 0.30 °C per decade, from 19.2 °C to 20.4 °C. Warmer air dries the soil faster between rainfall events.

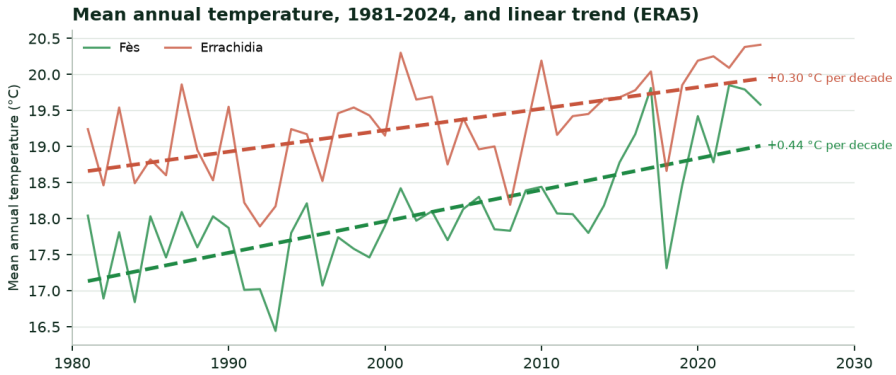


Figure 6. Mean annual temperature, 1981-2024, and linear trend. Source: ERA5 (A9)



The Ziz valley, in the south of the country.

4. Water: Resources, irrigated areas, withdrawals

4.1 Resources and withdrawals

Total freshwater withdrawals are 10,573 million m³ a year (2022). Agriculture accounts for 87.8% of these withdrawals, that is 9,281 Mm³. Internal resources are 29.0 km³ a year and water stress is 50.8%: The resource is already heavily used: Every cubic metre kept in the soil counts.

Freshwater: Withdrawals and resources

Indicator	Value	Year	Source
Total withdrawals	10,573 Mm³	2022	World Bank (A1)
Agricultural share	87.8%	2022	World Bank (A1)
Agricultural withdrawals	9,280.6 Mm³	2022	Calculated from A1
Area equipped for irrigation	1,966,850 ha	2024	FAOSTAT (A6)
Agricultural withdrawals per equipped hectare	4,719 m³/ha	—	Calculation (Annex B)
Water stress	50.8%	2022	World Bank (A1)

4.2 Irrigated areas

FAOSTAT counts 1,966,850 hectares equipped for irrigation in 2024. FAO estimates the country's irrigation potential at 1,664,000 ha (A11). Irrigation serves the large schemes (Gharb, Loukkos, Doukkala, Tadla, Haouz, Souss-Massa, Moulouya, Tafilalet, Ouarzazate), small and medium schemes in valleys and oases, and private pumping.



An irrigation canal at Bni Hilal.

4.3 What the water saving represents

In the central scenario, the saving is 1,270.1 million m³ a year, or 13.7% of agricultural withdrawals. At 4,719 m³ per equipped hectare, this water would irrigate about 269,174 more hectares, or 13.7% of today's equipped area.

5. Fertilisers: Quantities, purchases, spending

5.1 Quantities used

In 2024, agricultural use reaches 177,191 tonnes of nitrogen, 172,600 tonnes of phosphate (P2O5) and 49,541 tonnes of potash (K2O). The country produces 1,396,311 tonnes of nitrogen and 6,200,000 tonnes of phosphate (P2O5); it imported 177,191 tonnes of nitrogen in the same year. Per hectare of arable land, use is 56.5 kg per hectare.

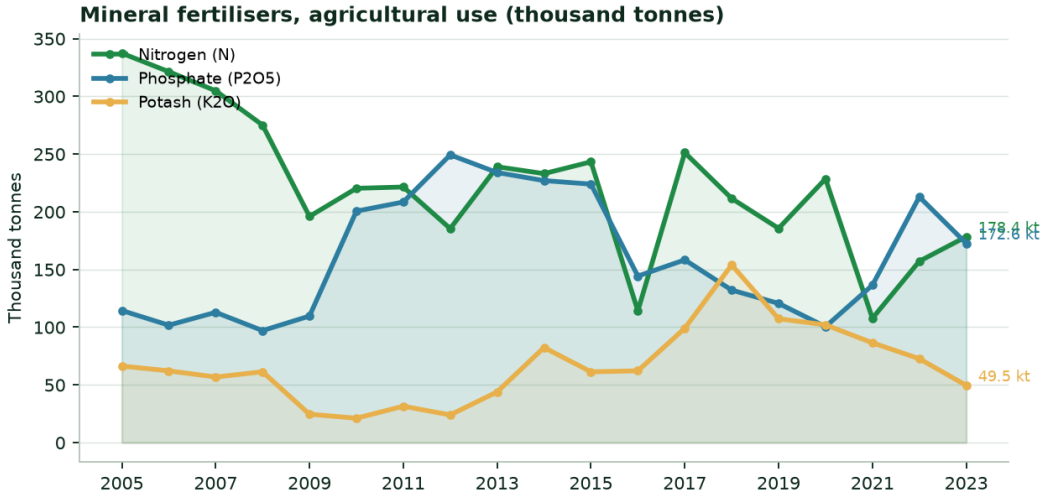


Figure 7. Mineral fertilisers, agricultural use, 2005-2023. Source: FAOSTAT (A5)

5.2 Regulatory framework

Law No. 53-18 on fertilising materials and growing media sets the rules for placing them on the market; ONSSA registers agricultural inputs before they are sold (A13).



A saffron field in bloom at Taliouine.

5.3 Indicative spending

In 2024, the indicative minimum spending on mineral fertilisers reaches $333 million, at international fertiliser prices (calculation in Annex B, lower bound).

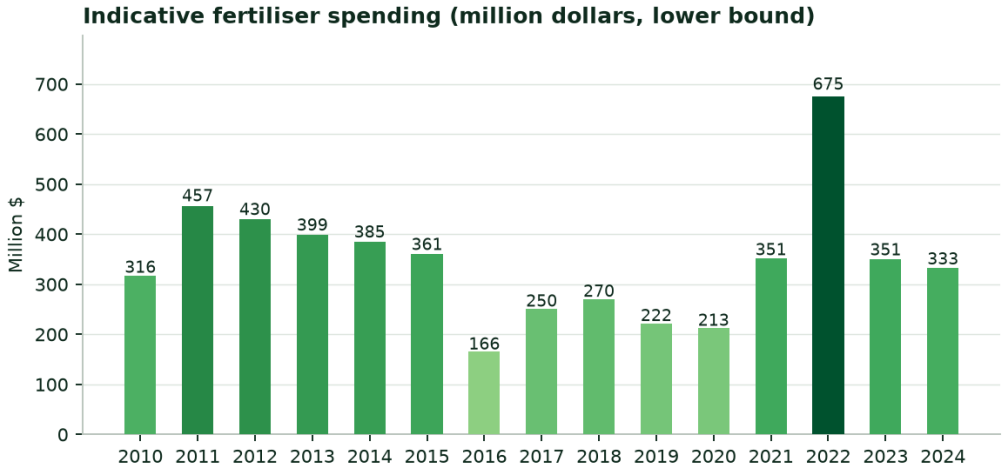


Figure 8. Indicative fertiliser spending, lower bound. Source: Author's calculation from A5 and A7

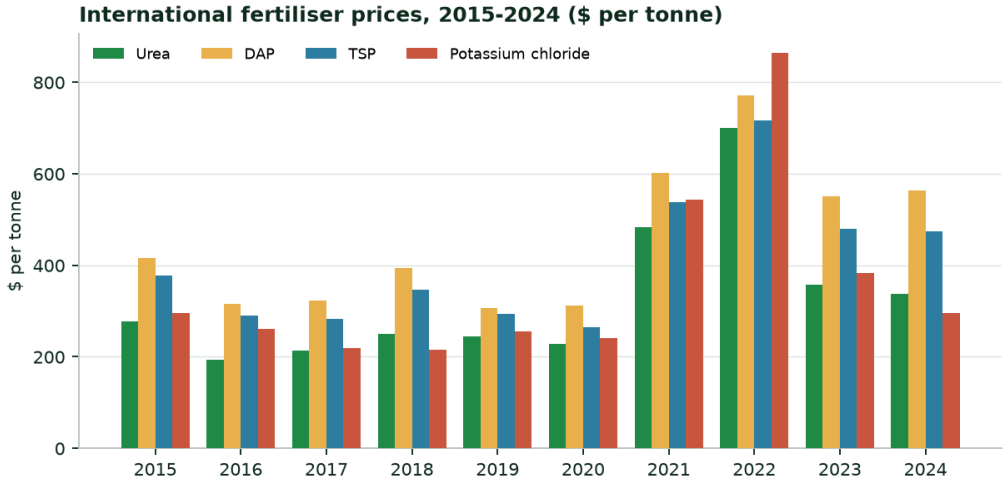


Figure 9. International prices of urea, DAP, TSP and potassium chloride. Source: World Bank, Pink Sheet (A7)

6. The regions at a glance

The table compares the country's twelve regions using each region's capital. 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)
Tangier-Tetouan-Al Hoceima (Tanger)	571	1,300	729	1,912	17.8
Oriental (Oujda)	359	1,387	1,028	1,930	16.5
Fès-Meknès (Fès)	518	1,418	900	1,925	18.0
Rabat-Salé-Kénitra (Rabat)	420	1,289	869	1,955	18.3
Casablanca-Settat (Casablanca)	306	1,350	1,044	1,966	18.4
Béni Mellal-Khénifra (Béni Mellal)	520	1,487	967	1,946	19.1
Marrakech-Safi (Marrakech)	278	1,579	1,301	2,053	18.4
Drâa-Tafilalet (Errachidia)	116	1,819	1,703	2,182	19.2
Souss-Massa (Agadir)	268	1,437	1,169	2,006	19.3
Guelmim-Oued Noun (Guelmim)	118	1,653	1,535	2,164	18.8
Laâyoune-Sakia El Hamra (Laâyoune)	46	1,802	1,756	2,253	20.1

Region (city)	Rainfall (mm/yr)	ET0 (mm/yr)	Deficit (mm/yr)	Radiation (kWh/m²/yr)	Temperature (°C)
Dakhla-Oued Ed-Dahab (Dakhla)	29	1,797	1,768	2,315	20.7

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

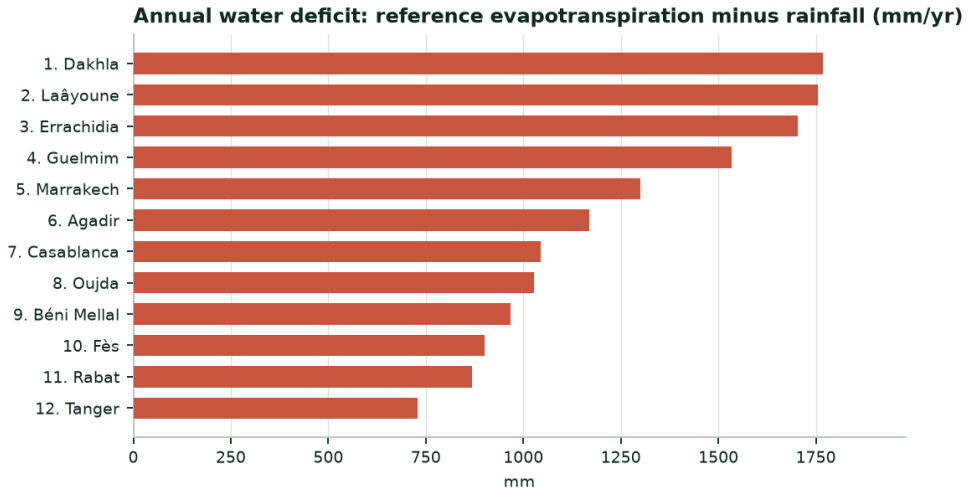


Figure 10. Annual water deficit: Reference evapotranspiration minus rainfall. Source: ERA5 (A9)



Trees and terraces at Arhbalou, at the foot of the High Atlas.

7. The twenty main crops: Three rankings

7.1 By harvested area

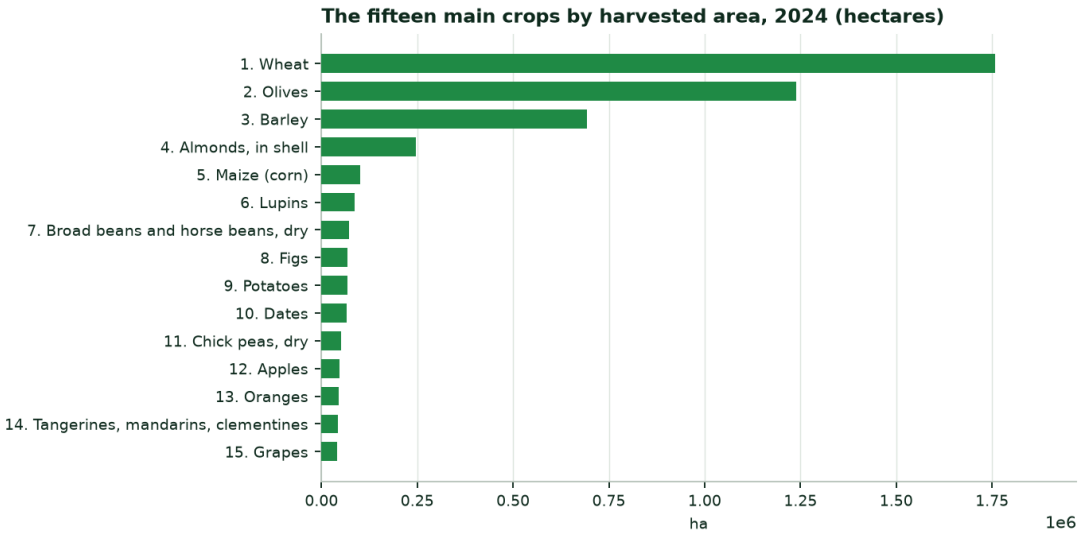


Figure 11. The fifteen main crops by harvested area, 2024 (hectares). Source: FAOSTAT (A2)

The ten main crops by area, 2024

Crop	Harvested area (ha)	Production (t)	Yield (t/ha)
Wheat	1,758,589	2,441,670	1.39
Olives	1,238,815	1,079,874	0.87
Barley	693,793	659,225	0.95
Almonds, in shell	246,275	163,616	0.66
Maize (corn)	101,364	73,227	0.72
Lupins	86,738	57,946	0.67
Broad beans and horse beans, dry	72,255	49,326	0.68
Figs	68,421	106,237	1.55
Potatoes	66,932	2,194,126	32.78
Dates	66,055	111,887	1.69

Source: FAOSTAT (A2).

7.2 By production

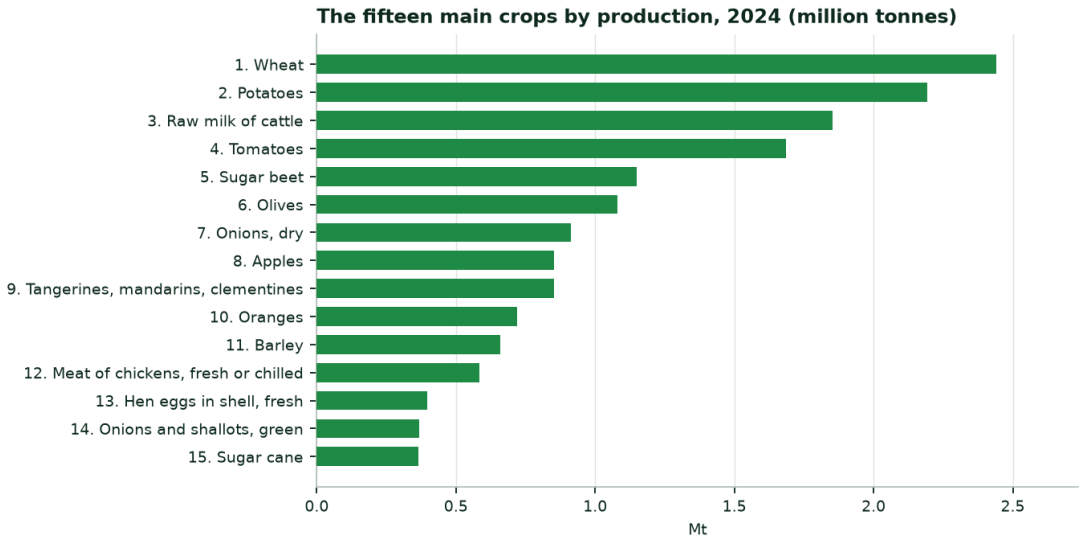


Figure 12. The fifteen main crops by production, 2024 (million tonnes). Source: FAOSTAT (A2)

7.3 By production value

By production value, the three main crops are: Olives, wheat and almonds, in shell (FAOSTAT, 2023, constant international dollars).

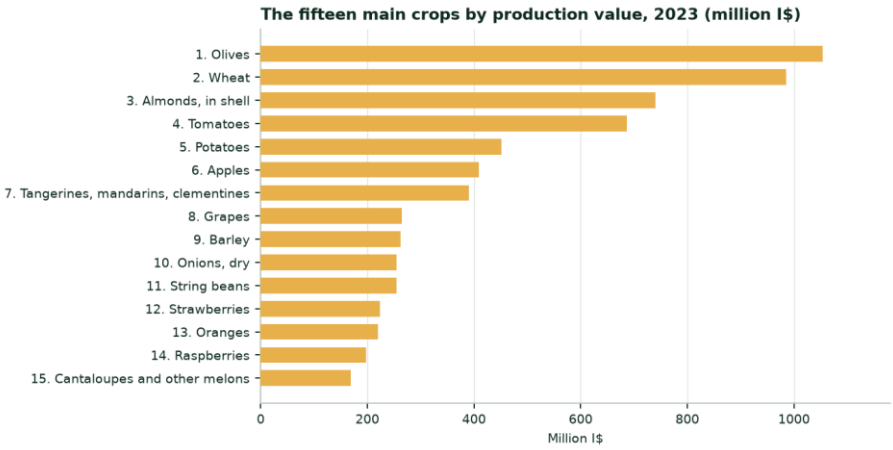


Figure 13. The fifteen main crops by production value, 2023 (million I$). Source: FAOSTAT (A3)



An argan tree in the Essaouira region.

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, date palm, maize, citrus, other fruit, sugar beet and sugar cane and other irrigated land), 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%	Date palm: Water and yield

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

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

8.3 Irrigation: Vegetables and melons, Potato, Date palm 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 (tomato, onion, carrot, others)	156,412	8.0%	Watermelon, Mexico (2023)	223.3
Potato	66,932	3.4%	Potato, South Africa (2025)	82.1
Date palm	66,055	3.4%	Date palm, UAE (ICBA, 2021)	127.8
Maize	101,364	5.2%	Maize, Türkiye (TIGEM, 2025)	93.3
Citrus (orange, clementine, others)	93,439	4.8%	Generic assumption, no trial	44.1
Other fruit (apple, grape, plum, peach, avocado, berries)	171,160	8.7%	Generic assumption, no trial	80.8
Sugar beet and sugar cane	28,419	1.4%	Generic assumption, no trial	13.4
Other irrigated land (cereals, olive, fodder)	1,283,069	65.2%	Generic assumption, no trial	605.4

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	635.1	134,587	584,570
Central	1,270.1	269,174	1,169,141
High	2,540.2	538,348	2,338,281

Source: Author's calculation (Annex B).

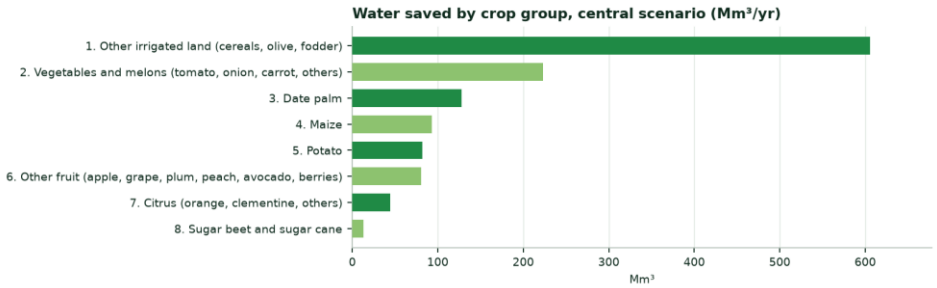


Figure 14. Water saved by crop group, central scenario. Source: Author's calculation

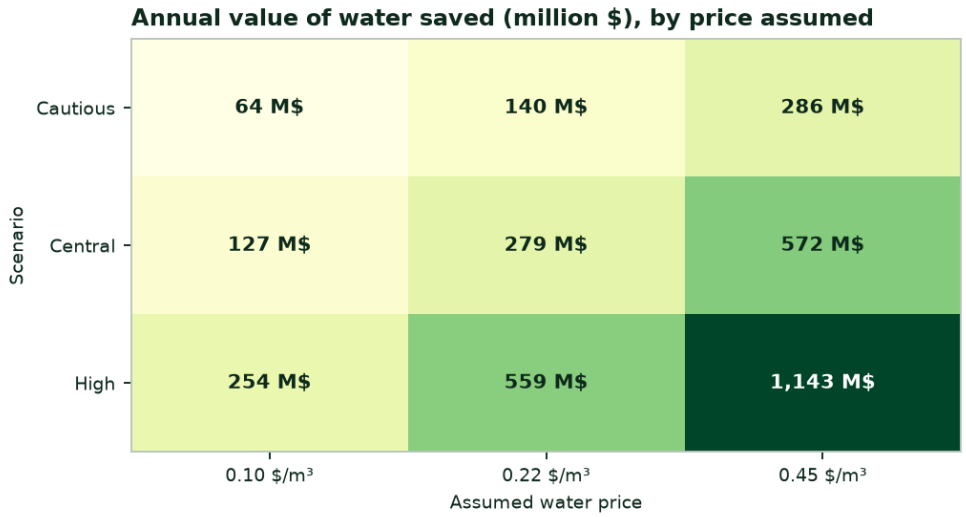


Figure 15. Annual value of the water saved, by price assumed per cubic metre. Source: Author's calculation; prices assumed, no national tariff

8.4 Reading the results

Key points

• The "other irrigated land" group gives 48% 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 Morocco
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 Morocco

Source: Annex A.



Inside the Igrane oasis, near Hassilabied.

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)	5,233	5,690
Agricultural imports (crops and livestock)	9,726	9,353
Exports, all merchandise	41,642	45,039
Imports, all merchandise	68,632	75,116

Source: FAOSTAT (A4).

10.2 Exports

The three main farm products exported in 2024 are: Tomatoes ($1,201 million), raspberries ($468 million) and refined sugar ($441 million).

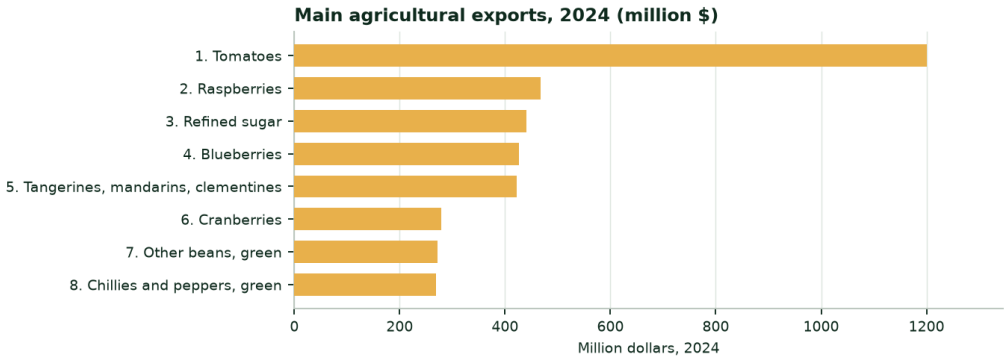


Figure 16. Main agricultural exports, 2024. Source: FAOSTAT (A4)

10.3 Imports

The main farm purchases are: Wheat ($1,448 million), raw sugar ($1,023 million) and maize (corn) ($665 million).

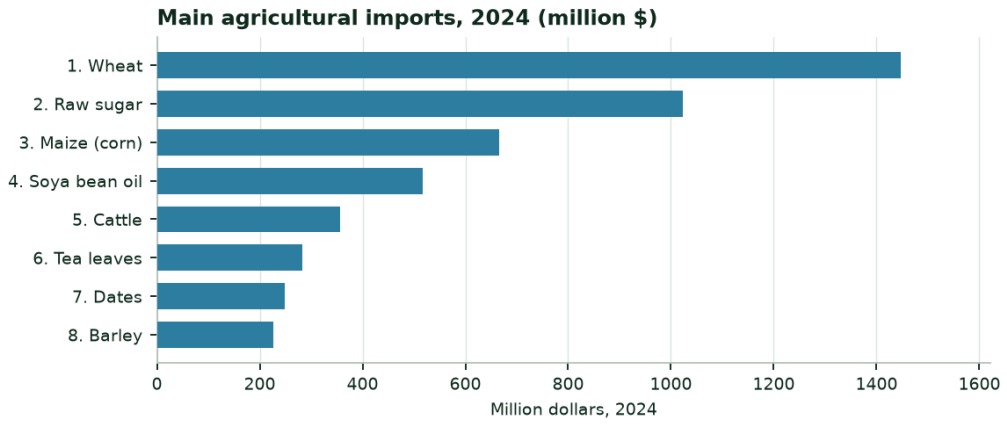


Figure 17. Main agricultural imports, 2024. Source: FAOSTAT (A4)



Figure 18. Greenhouse tomatoes near Oualidia.



A fruit and vegetable stall in Marrakech.

10.4 Importing water-retention polymers into Morocco

What to know

• **Import duty (heading 3906.90, acrylic polymers in primary forms):** 2.5% for acrylic polymers in primary forms, according to chapter 39 of the ADII tariff (A12).

• **European Union or EFTA origin (including Switzerland):** 0% for originating industrial products, under the association agreement with the European Union and the free trade agreement with EFTA (A12).

• **VAT:** 20% (A12).

• **Parafiscal import tax:** 0.25% of the customs value (A12).

• **Registration:** Law No. 53-18 governs the placing on the market of fertilising materials and growing media; ONSSA handles applications (A13).

• **Classification:** Code 3906.90 is an inference for our products; an ADII tariff ruling confirms 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.



Anraz village and its olive trees, below the High Atlas.

Tangier-Tetouan-Al Hoceima (Tanger)

The rainy north: Cereals, market gardening, berries and rice, with the Loukkos irrigation scheme.

Indicator	Value
Annual rainfall, 1991-2020	571 mm
Reference evapotranspiration	1,300 mm
Annual water deficit	729 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,912 kWh/m²
Mean temperature	17.8 °C

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

Oriental (Oujda)

The irrigated Moulouya and Berkane plain: Citrus, clementines, olives and market gardening; livestock farming on the high plateaus to the south.

Indicator	Value
Annual rainfall, 1991-2020	359 mm
Reference evapotranspiration	1,387 mm
Annual water deficit	1,028 mm
Months with less than 50 mm of rain	11
Global solar radiation	1,930 kWh/m²
Mean temperature	16.5 °C

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

Fès-Meknès (Fès)

Saïs plain and Middle Atlas: Cereals, olive, apples and plums, vines and market gardening.

Indicator	Value
Annual rainfall, 1991-2020	518 mm
Reference evapotranspiration	1,418 mm
Annual water deficit	900 mm
Months with less than 50 mm of rain	5
Global solar radiation	1,925 kWh/m²
Mean temperature	18.0 °C

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

Rabat-Salé-Kénitra (Rabat)

Gharb plain: Cereals, sugar beet and sugar cane, citrus, berries, rice and irrigated market gardening.

Indicator	Value
Annual rainfall, 1991-2020	420 mm
Reference evapotranspiration	1,289 mm
Annual water deficit	869 mm
Months with less than 50 mm of rain	9
Global solar radiation	1,955 kWh/m²
Mean temperature	18.3 °C

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

Casablanca-Settat (Casablanca)

Chaouia and Doukkala: Rainfed cereals, sugar beet and market gardening in the Doukkala irrigation scheme, dairy farming.

Indicator	Value
Annual rainfall, 1991-2020	306 mm
Reference evapotranspiration	1,350 mm
Annual water deficit	1,044 mm
Months with less than 50 mm of rain	11
Global solar radiation	1,966 kWh/m²
Mean temperature	18.4 °C

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

Béni Mellal-Khénifra (Béni Mellal)

Tadla plain: Irrigated sugar beet, cereals, citrus and olives, and dairy farming; the Middle Atlas to the north-east.

Indicator	Value
Annual rainfall, 1991-2020	520 mm
Reference evapotranspiration	1,487 mm
Annual water deficit	967 mm
Months with less than 50 mm of rain	6
Global solar radiation	1,946 kWh/m²
Mean temperature	19.1 °C

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

Marrakech-Safi (Marrakech)

Haouz and the Atlas valleys: Olive, cereals, citrus and market gardening.

Indicator	Value
Annual rainfall, 1991-2020	278 mm
Reference evapotranspiration	1,579 mm
Annual water deficit	1,301 mm
Months with less than 50 mm of rain	12
Global solar radiation	2,053 kWh/m²
Mean temperature	18.4 °C

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

Drâa-Tafilalet (Errachidia)

Tafilalet, Ziz and Drâa oases: Date palm, alfalfa and cereals; Midelt apples.

Indicator	Value
Annual rainfall, 1991-2020	116 mm
Reference evapotranspiration	1,819 mm
Annual water deficit	1,703 mm
Months with less than 50 mm of rain	12

Indicator	Value
Global solar radiation	2,182 kWh/m²
Mean temperature	19.2 °C

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

Souss-Massa (Agadir)

Souss-Massa: Early vegetables in greenhouses, including tomatoes, as well as citrus and argan, on a heavily used aquifer.

Indicator	Value
Annual rainfall, 1991-2020	268 mm
Reference evapotranspiration	1,437 mm
Annual water deficit	1,169 mm
Months with less than 50 mm of rain	11
Global solar radiation	2,006 kWh/m²
Mean temperature	19.3 °C

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

Guelmim-Oued Noun (Guelmim)

Gateway to the Sahara: Date palm, cactus, camel and goat farming.

Indicator	Value
Annual rainfall, 1991-2020	118 mm
Reference evapotranspiration	1,653 mm
Annual water deficit	1,535 mm
Months with less than 50 mm of rain	12
Global solar radiation	2,164 kWh/m²
Mean temperature	18.8 °C

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

Laâyoune-Sakia El Hamra (Laâyoune)

Desert climate: Greenhouse market gardening and camel farming; water limits agriculture.

Indicator	Value
Annual rainfall, 1991-2020	46 mm
Reference evapotranspiration	1,802 mm
Annual water deficit	1,756 mm
Months with less than 50 mm of rain	12
Global solar radiation	2,253 kWh/m²
Mean temperature	20.1 °C

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

Dakhla-Oued Ed-Dahab (Dakhla)

Early greenhouse crops, such as cherry tomatoes and melons, irrigated from boreholes; a desalination irrigation project.

Indicator	Value
Annual rainfall, 1991-2020	29 mm

Indicator	Value
Reference evapotranspiration	1,797 mm
Annual water deficit	1,768 mm
Months with less than 50 mm of rain	12
Global solar radiation	2,315 kWh/m²
Mean temperature	20.7 °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), Morocco	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
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, Morocco country profile (2015): Irrigation potential	A
A12	Customs and Indirect Taxes Administration (ADII), customs tariff, chapter 39; Morocco-European Union association agreement and Morocco-EFTA free trade agreement; general tax code (VAT); parafiscal import tax	A
A13	Law No. 53-18 on fertilising materials and growing media; ONSSA, registration of agricultural inputs	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 (10,573 Mm³, 2022) × agricultural share (87.78%) = 9,280.6 Mm³.

2. Irrigation. The equipped area (1,966,850 ha) and agricultural water are shared between irrigated groups (vegetables and melons, potato, date palm, maize, citrus, other fruit, sugar beet and sugar cane and other irrigated land) in proportion to their harvested areas (1,966,850 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. The equipped area exceeds the harvested area of the selected irrigable crops: The difference forms an "other irrigated land" group (cereals, olive, fodder), with the generic assumption. Cereals and olive are otherwise treated as rainfed for the rest of their area.

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 (4,719 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 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 region is shown as a point at its capital: Natural Earth only provides the former sixteen-region boundaries.

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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The Tislit gorges, at Taliouine.

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