

COUNTRY DOSSIER

Benin

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

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A rice field in Benin (AfricaRice photo).

Foreword

This dossier describes Benin 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, Beninese public bodies (INStaD statistics institute, Ministry of Agriculture, Livestock and Fisheries, tax directorate)).
- **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 Benin.

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Summary

The points below summarise the dossier. The figures come from public sources: The World Bank, FAO (FAOSTAT, AQUASTAT), Beninese public bodies (INStaD statistics institute, Ministry of Agriculture, Livestock and Fisheries, tax directorate), PVGIS and NASA POWER. The production gains and water savings are scenarios, described in Annex B.

14.81 M
Inhabitants in 2025 (World Bank)

1.76 M ha
Of maize (corn) harvested in 2024, the main crop

24,330 ha
Equipped for irrigation (2024)

+1,018 t
Of maize per 10,000 ha treated, central scenario

6.4 Mm³
Of irrigation water saved a year, central scenario

915 M$
Of agricultural exports in 2024 (FAOSTAT)

Key points

- **Predominantly rainfed farming.** 24,330 ha equipped for irrigation in 2024, out of 4.31 million hectares of cropland: Almost every harvest depends on rain.
- **Maize (corn): The main crop.** 1,759,588 ha harvested in 2024, for 2.09 million tonnes, or 1.19 t/ha.
- **Water is not scarce over the year as a whole; it is scarce between rainfall events.** National water stress is only 1.0%, but at Kandi, atmospheric water demand exceeds rainfall by 1,059 mm.
- **In rainfed farming, the gain is counted in tonnes.** In the central scenario, an additional 1,018 t of maize and 578 t of soybean per 10,000 ha treated.
- **In irrigated farming, the water saved could allow irrigation schemes to be expanded.** 6.4 Mm³ a year in the central scenario, enough to irrigate about 4,784 more ha, or 19.7% of the equipped area.
- **An organic supply chain.** 40,370 ha of certified organic cropland in 2024: ECOFERT® is EU Bio certified.
- **All nitrogen is imported.** 48,523 t of nitrogen used in 2024, 48,542 t imported, no national production.
- **Farm trade.** $915 million of exports and $1,039 million of imports in 2024. Leading export: Cotton lint, ginned ($501 million). Rice imports amount to $703 million.

Key figures

Key indicators for Benin

Indicator	Value	Year	Source (level)
Population	14.81 M	2025	World Bank (A1)
GDP per capita	1,658 $	2025	World Bank (A1)
Agriculture's share of GDP	22.9%	2025	World Bank (A1)
Agricultural employment	40.2%	2025	World Bank (A1)
Cropland	4,314,600 ha	2024	FAOSTAT (A6)
Area equipped for irrigation	24,330 ha	2024	FAOSTAT (A6)
Harvested area: Maize (corn)	1,759,588 ha	2024	FAOSTAT (A2)
Certified organic cropland	40,370 ha	2024	FAOSTAT (A6)
Agricultural exports	915 M$	2024	FAOSTAT (A4)

Indicator	Value	Year	Source (level)
Agricultural imports	1,039 M$	2024	FAOSTAT (A4)
Mineral nitrogen, agricultural use	48,523 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 Benin. 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 cassava field in Akassato (Atlantique).

2. Benin in figures

Benin had 14.81 million inhabitants in 2025, 47% of them in rural areas. Agriculture accounts for 22.9% of gross domestic product and employs 40% of the labour force. The country covers 112.8 thousand km², of which 43% is agricultural land. Undernourishment affects 11.1% of the population.

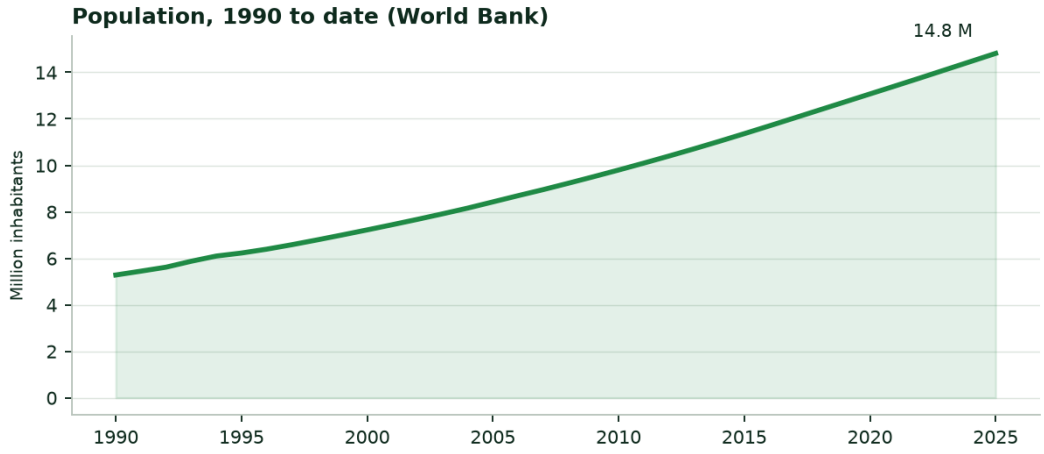


Figure 1. Population of Benin, 1990 to date. Source: World Bank (A1)

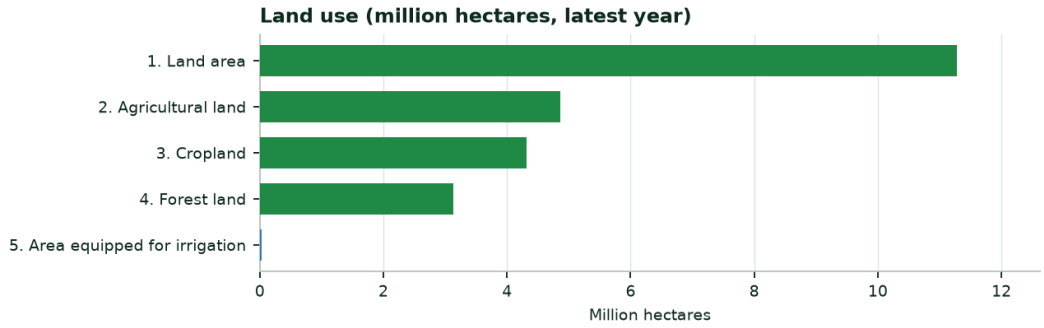


Figure 2. Land use, latest year published. Source: FAOSTAT (A6)

Agricultural and water indicators, latest year published

Indicator	Value	Year	Source
Cropland certified organic	40,370 ha	2024	FAOSTAT (A6)
Average cereal yield	1,356 kg/ha	2024	World Bank (A1)
Fertiliser use per hectare of arable land	25.5 kg/ha	2024	World Bank (A1)
Water withdrawals, agricultural share	25.2%	2022	World Bank (A1)
Internal freshwater resources	10.3 km³	2022	World Bank (A1)
Internal resources per inhabitant	749 m³	2022	World Bank (A1)



Threshing fonio with a small machine, near Natitingou.

3. Sunshine, rainfall and climate change

3.1 Sunshine

Global solar radiation reaches 1,872 to 2,218 kWh/m² a year depending on the region. Energy is not the limiting factor: Water available at the right time determines the harvest.

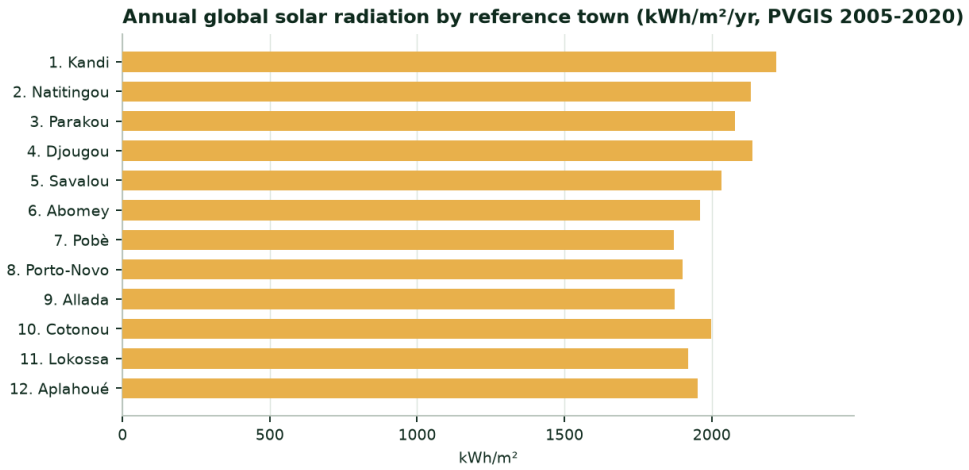


Figure 3. Annual global solar radiation in each reference town. Source: PVGIS (A8)

3.2 Rainfall and evapotranspiration

Annual rainfall is 1,368 mm at Savalou, but only 953 mm at Kandi, where reference evapotranspiration reaches 2,012 mm. The south has two rainy seasons (April to July, then September to November), the north a single one, from May to October, followed by a long dry season with the harmattan.

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

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kandi	0	1	10	34	92	127	190	266	177	55	2	0
Natitingou	1	4	16	73	132	184	255	315	223	94	6	0
Parakou	4	9	34	80	115	136	177	213	195	106	10	3
Djougou	4	10	34	88	121	142	190	221	199	111	9	2

City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Savalou	12	19	53	110	144	184	229	207	244	142	18	6
Abomey	14	27	70	106	137	175	172	132	182	137	30	12
Pobè	18	29	72	115	155	202	194	139	211	160	41	17
Porto-Novo	18	30	78	123	168	213	163	95	175	158	47	18
Allada	14	30	80	115	153	183	139	90	148	136	36	15
Cotonou	18	30	78	123	168	213	163	95	175	158	47	18
Lokossa	14	30	80	115	153	183	139	90	148	136	36	15
Aplahoué	14	27	70	106	137	175	172	132	182	137	30	12

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

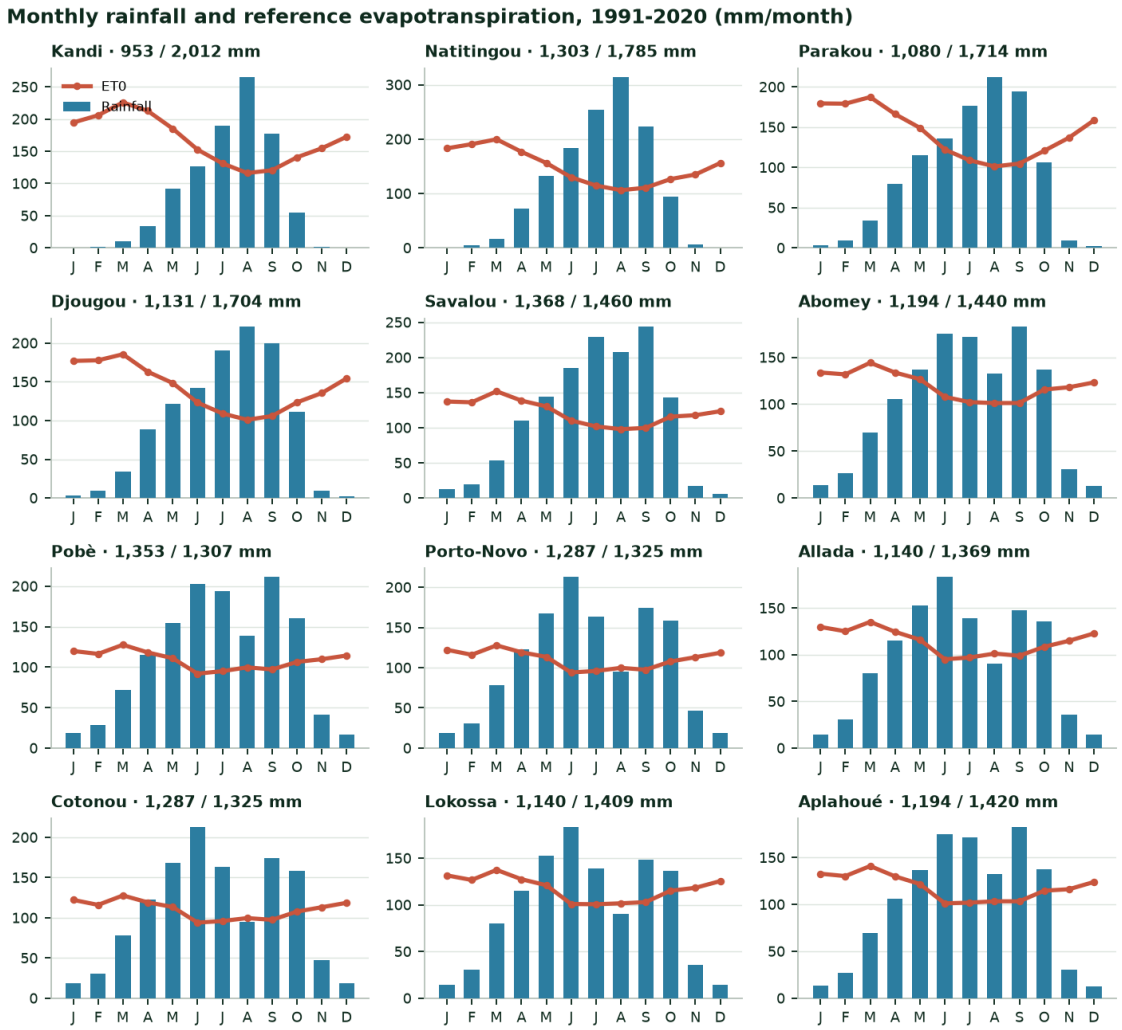


Figure 4. Monthly rainfall and reference evapotranspiration by city, 1991-2020. Source: NASA POWER (A9)

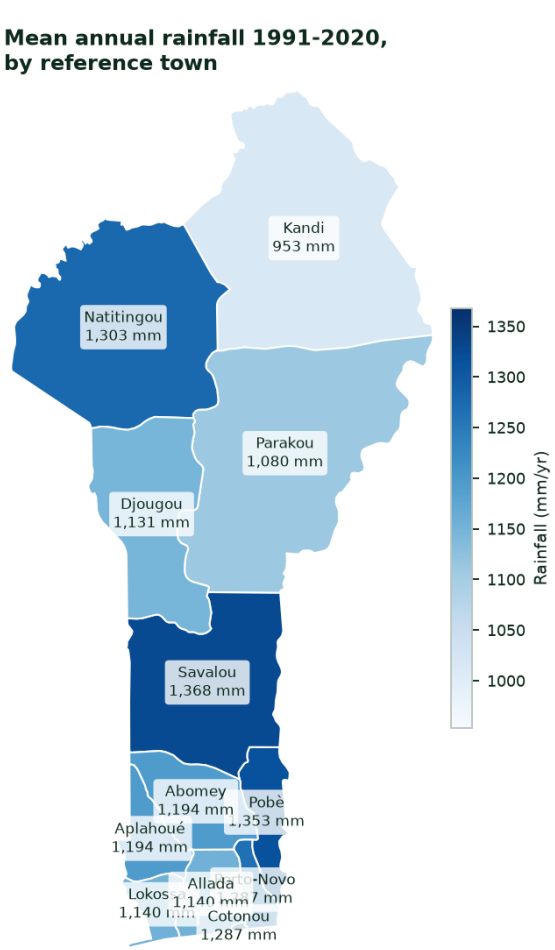
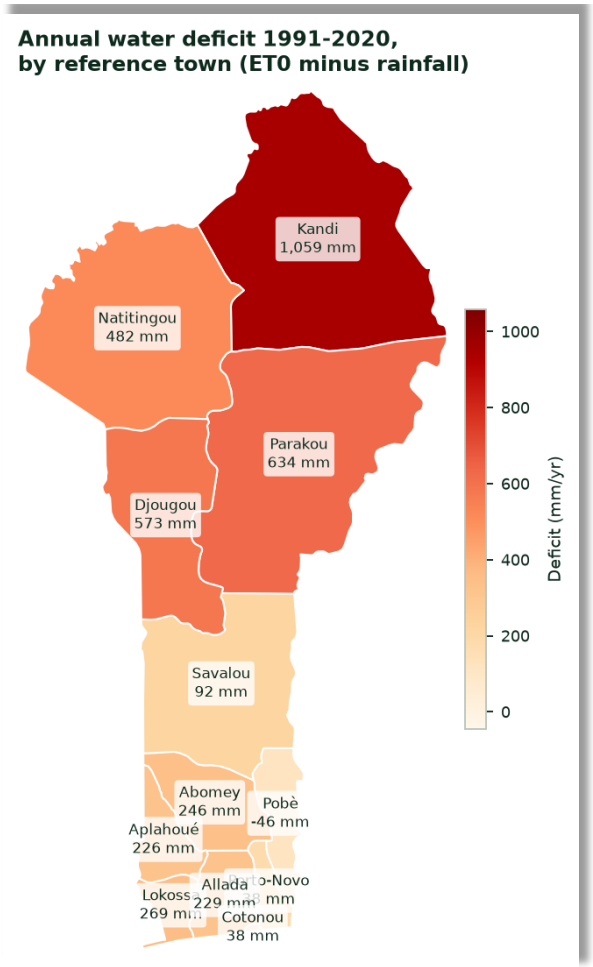


Figure 5. Mean annual rainfall 1991-2020, by region. Source: NASA POWER (A9), Natural Earth (A10).



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

3.3 Climate change

Mean annual temperature is rising. At Parakou it went from 24.8 °C in 1981 to 26.8 °C in 2024, a trend of 0.14 °C per decade. At Cotonou the trend is 0.15 °C per decade, from 26.1 °C to 26.9 °C. Warmer air dries the soil faster between rainfall events.

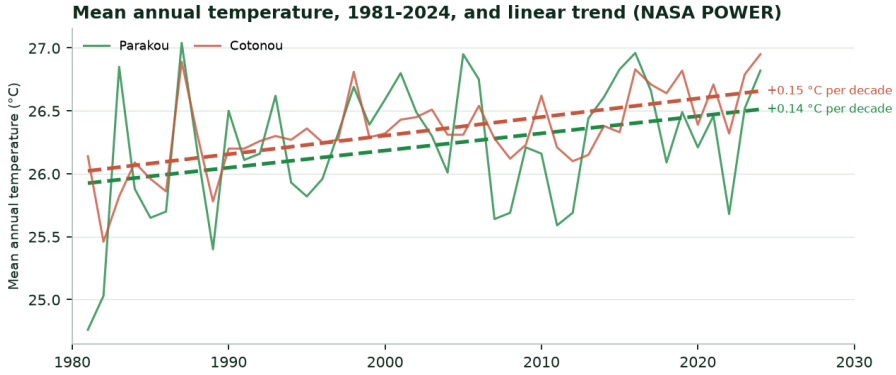


Figure 6. Mean annual temperature, 1981-2024, and linear trend. Source: NASA POWER (A9)



Natitingou, at the foot of the Atacora range.

4. Water: Resources, irrigated areas, withdrawals

4.1 Resources and withdrawals

Total freshwater withdrawals are 130 million m³ a year (2022). Agriculture accounts for 25.2% of these withdrawals, that is 33 Mm³. Internal resources are 10.3 km³ a year and water stress is 1.0%: The country has water, but little of it is mobilised for crops.

Freshwater: Withdrawals and resources

Indicator	Value	Year	Source
Total withdrawals	130 Mm³	2022	World Bank (A1)
Agricultural share	25.2%	2022	World Bank (A1)
Agricultural withdrawals	32.8 Mm³	2022	Calculated from A1
Area equipped for irrigation	24,330 ha	2024	FAOSTAT (A6)
Agricultural withdrawals per equipped hectare	1,347 m³/ha	—	Calculation (Annex B)
Water stress	1.0%	2022	World Bank (A1)

4.2 Irrigated areas

FAOSTAT counts 24,330 hectares equipped for irrigation in 2024. In 2024, the area equipped for irrigation reaches 24,330 ha (A6), a very small share of cropland. Irrigation serves mostly rice in lowlands and valleys (Ouémé, Niger) and vegetables around the towns; cotton, maize and soybean remain rainfed.



Lake Nokoué at Ganvié.

4.3 What the water saving represents

In the central scenario, the saving is 6.4 million m³ a year, or 19.7% of agricultural withdrawals. At 1,347 m³ per equipped hectare, this water would irrigate about 4,784 more hectares, or 19.7% of today's equipped area.

5. Fertilisers: Quantities, purchases, spending

5.1 Quantities used

In 2024, agricultural use reaches 48,523 tonnes of nitrogen, 19,113 tonnes of phosphate (P2O5) and 25,478 tonnes of potash (K2O). The country produces no nitrogen fertiliser: It imported 48,542 tonnes of nitrogen in the same year. Per hectare of arable land, use is 25.5 kg per hectare.

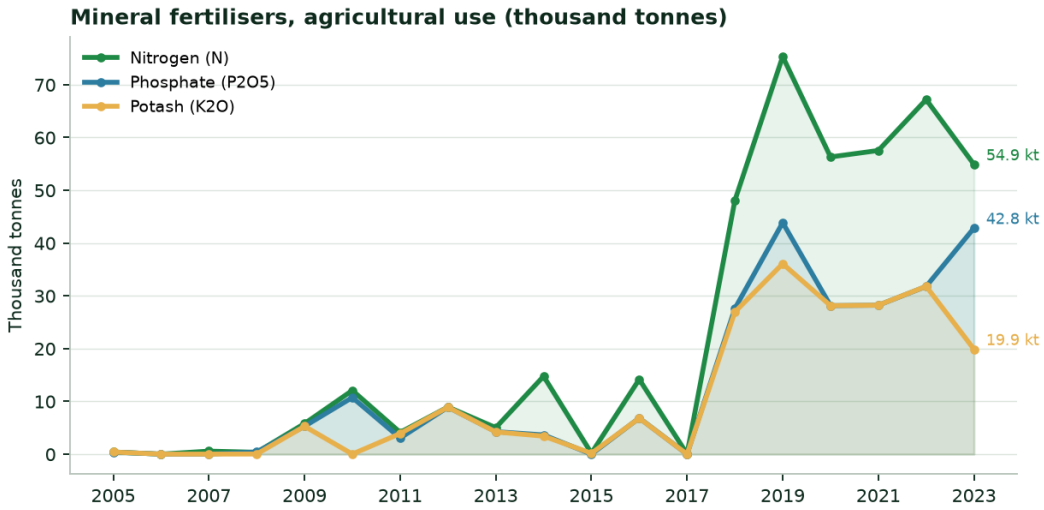


Figure 7. Mineral fertilisers, agricultural use, 2005-2023. Source: FAOSTAT (A5)

5.2 Regulatory framework

ECOWAS Regulation C/REG.13/12/12 harmonises the registration and quality control of fertilisers in member states (A13). A water-retaining polymer may also require registration, depending on its classification, to be confirmed with the Ministry of Agriculture.



A cotton field and palmyra palms in Atacora.

5.3 Indicative spending

In 2024, the indicative minimum spending on mineral fertilisers reaches $68 million, at international fertiliser prices (calculation in Annex B, lower bound).

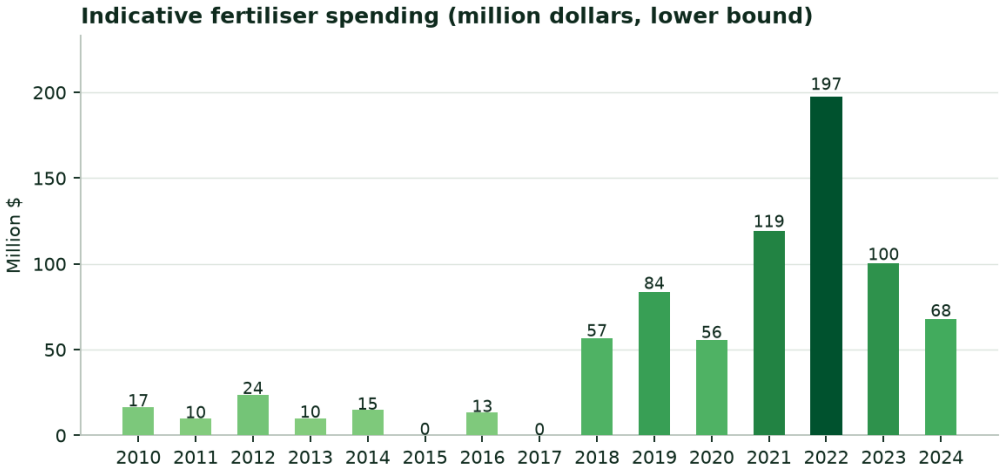


Figure 8. Indicative fertiliser spending, lower bound. Source: Author's calculation from A5 and A7

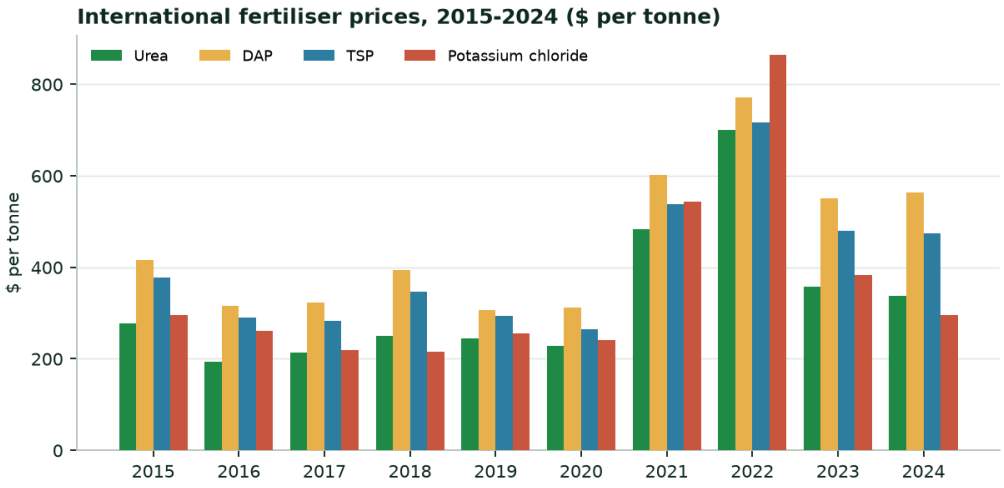


Figure 9. International prices of urea, DAP, TSP and potassium chloride. Source: World Bank, Pink Sheet (A7)

6. The regions at a glance

The table compares the twelve departments, each represented by a reference town. 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)
Alibori (Kandi)	953	2,012	1,059	2,218	27.2
Atakora (Natitingou)	1,303	1,785	482	2,132	26.0
Borgou (Parakou)	1,080	1,714	634	2,079	26.3
Donga (Djougou)	1,131	1,704	573	2,138	26.1
Collines (Savalou)	1,368	1,460	92	2,032	26.0
Zou (Abomey)	1,194	1,440	246	1,959	26.3
Plateau (Pobè)	1,353	1,307	-46	1,872	26.0
Ouémé (Porto-Novo)	1,287	1,325	38	1,900	26.4
Atlantique (Allada)	1,140	1,369	229	1,873	26.6
Littoral (Cotonou)	1,287	1,325	38	1,997	26.4
Mono (Lokossa)	1,140	1,409	269	1,921	26.6
Kouffo (Aplahoué)	1,194	1,420	226	1,953	26.3

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

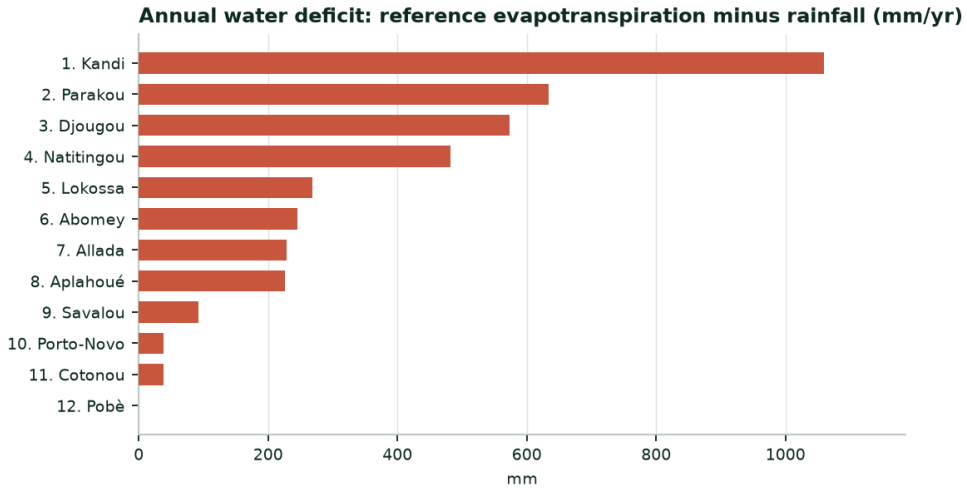


Figure 10. Annual water deficit: Reference evapotranspiration minus rainfall. Source: NASA POWER (A9)



Pineapple growing in Tori (Atlantique).

7. The twenty main crops: Three rankings

7.1 By harvested area

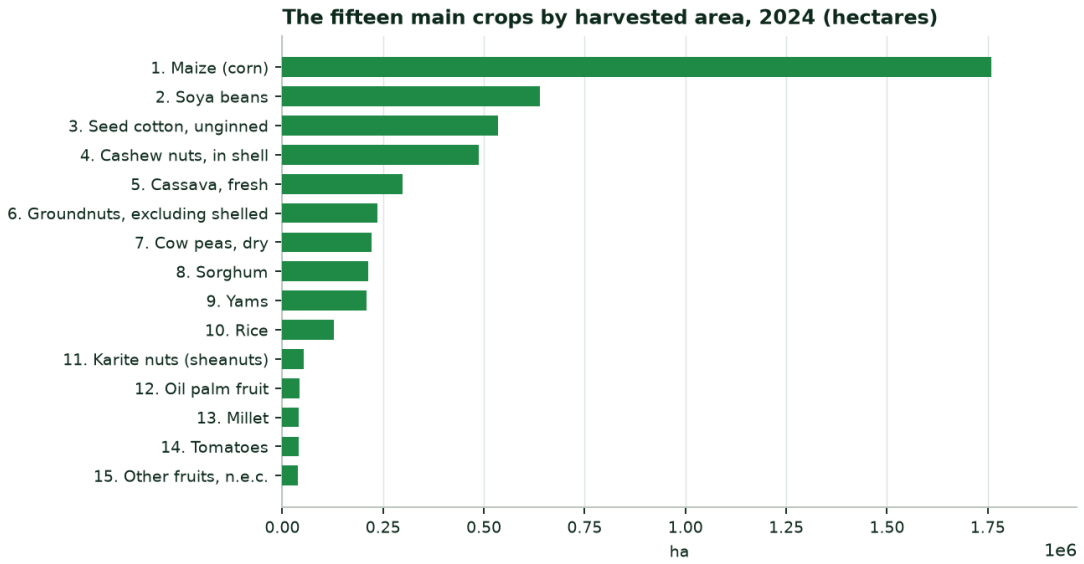


Figure 11. The fifteen main crops by harvested area, 2024 (hectares). Source: FAOSTAT (A2)

The ten main crops by area, 2024

Crop	Harvested area (ha)	Production (t)	Yield (t/ha)
Maize (corn)	1,759,588	2,094,824	1.19
Soya beans	638,098	652,454	1.02
Seed cotton, unginned	535,579	635,976	1.19
Cashew nuts, in shell	487,479	212,624	0.44
Cassava, fresh	298,564	4,448,391	14.90
Groundnuts in shell	236,816	221,119	0.93
Cow peas, dry	220,485	184,466	0.84
Sorghum	212,347	279,269	1.32
Yams	209,313	3,353,473	16.02
Rice	128,501	500,605	3.90

Source: FAOSTAT (A2).

7.2 By production

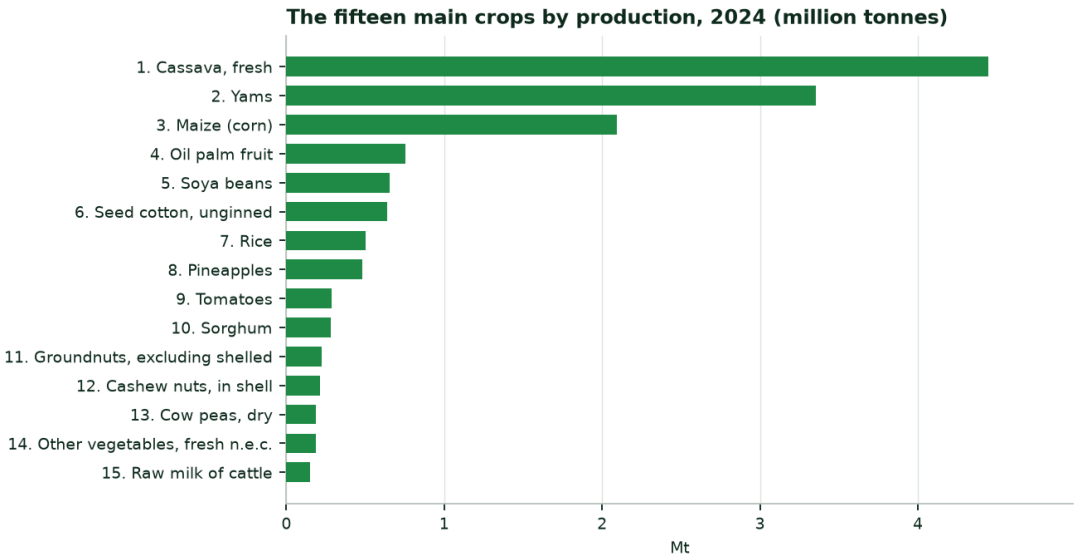


Figure 12. The fifteen main crops by production, 2024 (million tonnes). Source: FAOSTAT (A2)

7.3 By production value

By production value, the three main crops are: Yams, cassava, fresh and seed cotton, unginned (FAOSTAT, 2023, constant international dollars).

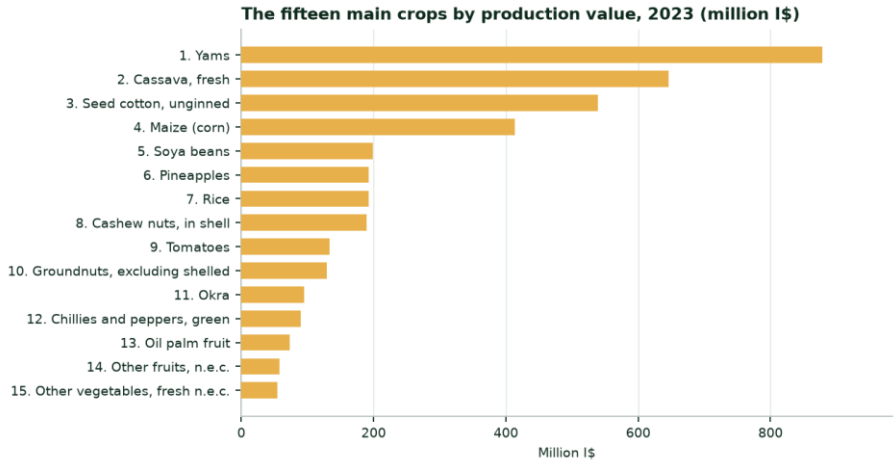


Figure 13. The fifteen main crops by production value, 2023 (million I$). Source: FAOSTAT (A3)



Rice growing in Benin (AfricaRice photo).

8. Extrapolation by crop: Irrigation and rainfed crops

8.1 Method

Method in brief

• **Irrigation.** National agricultural water is shared between irrigated crops (vegetables, rice and sugar cane), 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) 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: Yield
Soybean, China	Soybean	Assumption	+11.3%	Soybean: Yield
Watermelon, Mexico (2023)	Watermelon	-60.5%	+30.0%	Vegetables: Water and yield
Potato, South Africa (2025)	Potato	-52.0%	+31.4%	Not used; cited for reference
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 Benin: The figures below apply the results of the cited trials to the country's average yields.

8.3 Rainfed crops: Maize and Soybean

Average 2024 yields (FAOSTAT): Maize 1.19 t/ha and soybean 1.02 t/ha. A water-retention polymer retains water from each rainfall event 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	1.19	509	1,018	2,036
Soybean	1.02	289	578	1,155

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

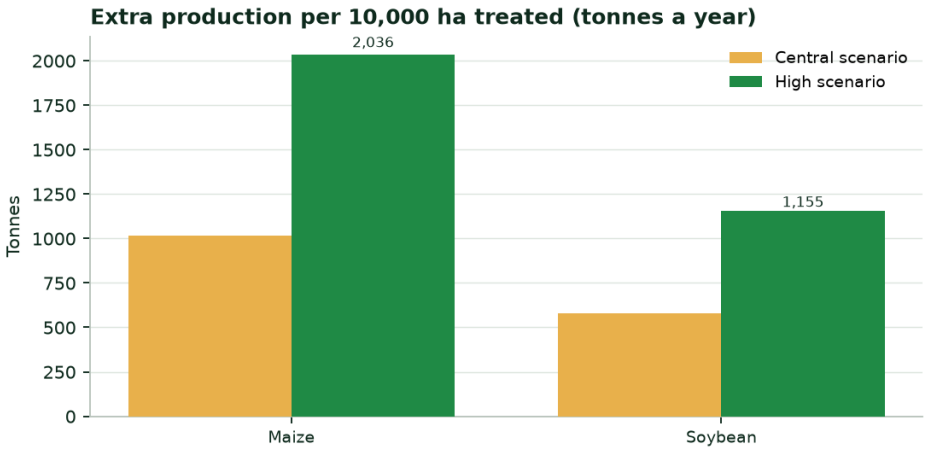


Figure 14. Extra production per 10,000 ha treated, central and high scenarios. Source: Author's calculation

8.4 Irrigation: Vegetables, Rice and Sugar cane

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

Crop group	Equipped area (ha)	Share	Trial or assumption	Water saved (Mm³/yr)
Vegetables (tomato, chilli, okra, onion, others)	11,609	47.7%	Watermelon, Mexico (2023)	4.7
Rice	12,489	51.3%	Generic assumption, no trial	1.7
Sugar cane	232	1.0%	Generic assumption, no trial	0.0

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	3.2	2,392	5,402
Central	6.4	4,784	10,803
High	12.9	9,568	21,606

Source: Author's calculation (Annex B).

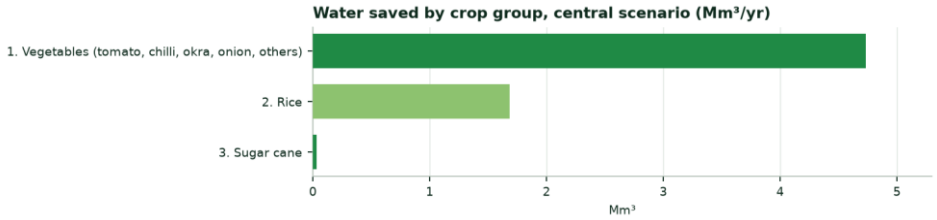


Figure 15. Water saved by crop group, central scenario. Source: Author's calculation

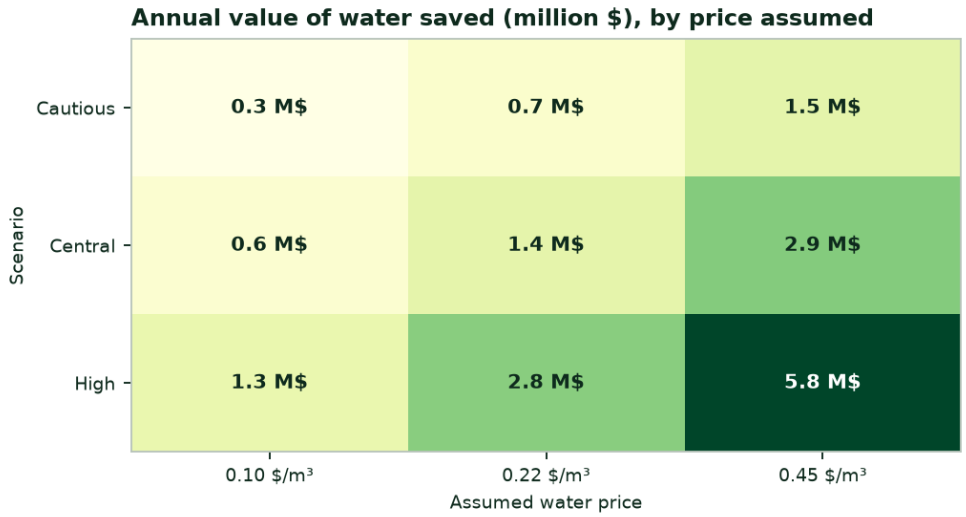


Figure 16. Annual value of the water saved, by price assumed per cubic metre. Source: Author's calculation; prices assumed, no national tariff

8.5 Reading the results

Key points

• In Benin, the main challenge is rainfed farming: Only 24,330 ha are equipped for irrigation, out of 4,314,600 ha of cropland.

• The "vegetables" group gives 73% of the irrigation water saving (watermelon, Mexico (2023)).

• 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 Benin
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 Benin

Source: Annex A.



A banana field in Akassato.

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)	848	915
Agricultural imports (crops and livestock)	1,187	1,039
Exports, all merchandise	4,071	3,772
Imports, all merchandise	4,234	5,230

Source: FAOSTAT (A4).

10.2 Exports

The three main farm products exported in 2024 are: Cotton lint, ginned ($501 million), soya bean cake ($82 million) and karite nuts (sheanuts) ($77 million).

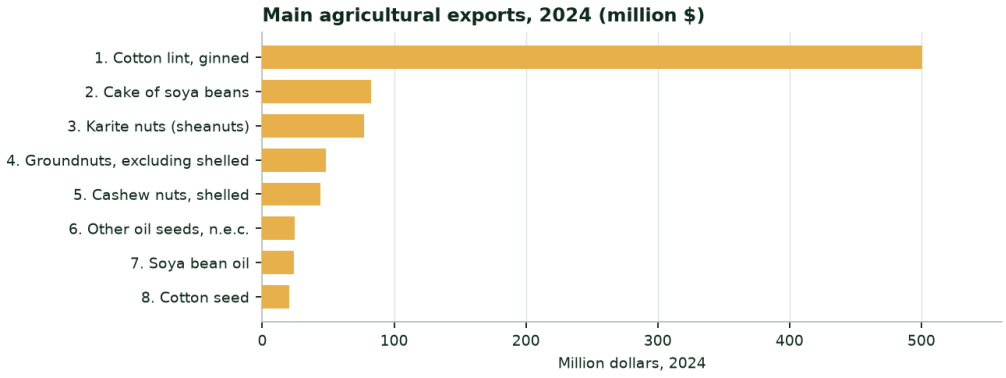


Figure 17. Main agricultural exports, 2024. Source: FAOSTAT (A4)

10.3 Imports

The main farm purchases are: Refined sugar ($48 million), wheat ($48 million) and meat of chickens, fresh or chilled ($39 million). Rice imports amount to $703 million (husked, broken and milled rice): Every tonne grown locally reduces this bill.

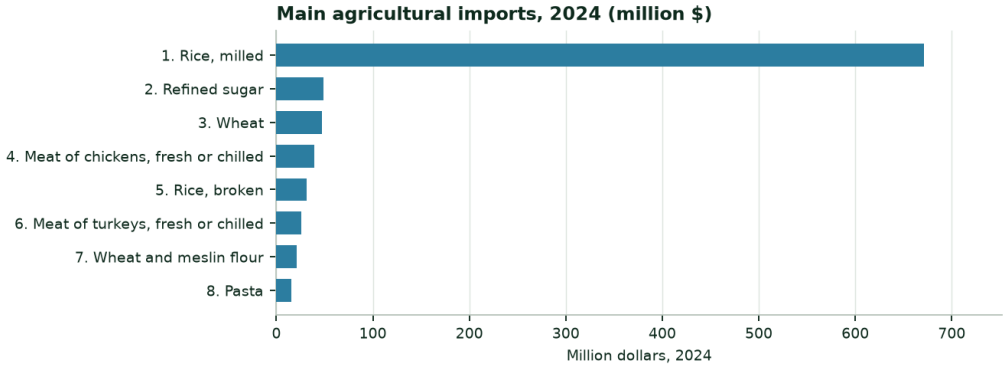


Figure 18. Main agricultural imports, 2024. Source: FAOSTAT (A4)



Figure 19. A stall of melons, cabbages, avocados and cucumbers.



Pineapples for sale in Avrankou (Ouémé).

10.4 Importing water-retention polymers into Benin

What to know

• **Customs duty (subheading 3906.90):** 5%, the ECOWAS common external tariff rate applied by Benin (A11).

• **Import VAT:** 18% (A12). Other community levies and a statistical fee are added on import; their exact amount is to be confirmed with a forwarding agent.

• **Quality control:** The 2012 ECOWAS regulation harmonises the registration and quality control of fertilisers in member states, Benin included (A13). No text specific to water-retaining agents was found: Their classification (fertiliser, soil conditioner or other) is to be confirmed with the Ministry of Agriculture.

• **Classification:** Code 3906.90 is an inference for our products; Benin 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 landscape of Bassila (Donga).

Alibori (Kandi)

Northern cotton basin: Cotton, maize, sorghum and livestock; irrigated rice and onions in the Niger valley, towards Malanville.

Indicator	Value
Annual rainfall, 1991-2020	953 mm
Reference evapotranspiration	2,012 mm
Annual water deficit	1,059 mm
Months with less than 50 mm of rain	6
Global solar radiation	2,218 kWh/m²
Mean temperature	27.2 °C

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

Atakora (Natitingou)

Atacora range: Sorghum, millet, fonio, yams and cotton on thin, sloping soils.

Indicator	Value
Annual rainfall, 1991-2020	1,303 mm
Reference evapotranspiration	1,785 mm
Annual water deficit	482 mm
Months with less than 50 mm of rain	5
Global solar radiation	2,132 kWh/m²
Mean temperature	26.0 °C

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

Borgou (Parakou)

Borgou plateau: Cotton, maize, soybean, yams and cashew, with a single rainy season.

Indicator	Value
Annual rainfall, 1991-2020	1,080 mm
Reference evapotranspiration	1,714 mm
Annual water deficit	634 mm

Indicator	Value
Months with less than 50 mm of rain	5
Global solar radiation	2,079 kWh/m²
Mean temperature	26.3 °C

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

Donga (Djougou)

Donga: Yams, maize, cashew and shea, between savannah and open woodland.

Indicator	Value
Annual rainfall, 1991-2020	1,131 mm
Reference evapotranspiration	1,704 mm
Annual water deficit	573 mm
Months with less than 50 mm of rain	5
Global solar radiation	2,138 kWh/m²
Mean temperature	26.1 °C

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

Collines (Savalou)

Collines: Cashew, cotton, soybean, yams and maize, in the transition zone between south and north.

Indicator	Value
Annual rainfall, 1991-2020	1,368 mm
Reference evapotranspiration	1,460 mm
Annual water deficit	92 mm
Months with less than 50 mm of rain	4
Global solar radiation	2,032 kWh/m²
Mean temperature	26.0 °C

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

Zou (Abomey)

Zou plateau: Maize, cotton, cassava, groundnut and oil palm, on red ferralitic soils.

Indicator	Value
Annual rainfall, 1991-2020	1,194 mm
Reference evapotranspiration	1,440 mm
Annual water deficit	246 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,959 kWh/m²
Mean temperature	26.3 °C

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

Plateau (Pobè)

Plateau: Oil palm, maize, cassava and citrus, near the Nigerian border.

Indicator	Value
Annual rainfall, 1991-2020	1,353 mm

Indicator	Value
Reference evapotranspiration	1,307 mm
Annual water deficit	-46 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,872 kWh/m²
Mean temperature	26.0 °C

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

Ouémé (Porto-Novo)

Ouémé valley: Off-season vegetables and rice on flood land, oil palm and fishing.

Indicator	Value
Annual rainfall, 1991-2020	1,287 mm
Reference evapotranspiration	1,325 mm
Annual water deficit	38 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,900 kWh/m²
Mean temperature	26.4 °C

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

Atlantique (Allada)

Allada plateau: The main pineapple area, with maize, cassava and vegetables.

Indicator	Value
Annual rainfall, 1991-2020	1,140 mm
Reference evapotranspiration	1,369 mm
Annual water deficit	229 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,873 kWh/m²
Mean temperature	26.6 °C

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

Littoral (Cotonou)

Economic capital: Irrigated urban and peri-urban vegetable growing, on sandy soils that hold water poorly.

Indicator	Value
Annual rainfall, 1991-2020	1,287 mm
Reference evapotranspiration	1,325 mm
Annual water deficit	38 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,997 kWh/m²
Mean temperature	26.4 °C

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

Mono (Lokossa)

Mono: Maize, cassava, oil palm and vegetables on the coastal strip.

Indicator	Value
Annual rainfall, 1991-2020	1,140 mm
Reference evapotranspiration	1,409 mm
Annual water deficit	269 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,921 kWh/m²
Mean temperature	26.6 °C

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

Kouffo (Aplahoué)

Couffo: Maize, cassava, oil palm and vegetables, on densely populated land.

Indicator	Value
Annual rainfall, 1991-2020	1,194 mm
Reference evapotranspiration	1,420 mm
Annual water deficit	226 mm
Months with less than 50 mm of rain	4
Global solar radiation	1,953 kWh/m²
Mean temperature	26.3 °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), Benin	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	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), Benin, applied MFN duties (ECOWAS common external tariff), subheading 3906.90, 2023	A
A12	Benin General Tax Code, 2025 edition (Ministry of Economy and Finance): VAT rate	A
A13	ECOWAS, Regulation C/REG.13/12/12 of 2 December 2012 on fertiliser quality control in the ECOWAS region	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

Ref.	Source	Level
A22	Paulownia ALTIFOLIA® sheet figures (website)	C

Annex B. Calculation method

1. Agricultural water. Total withdrawals (130 Mm³, 2022) × agricultural share (25.21%) = 32.8 Mm³.

2. Irrigation. The equipped area (24,330 ha) and agricultural water are shared between irrigated groups (vegetables, rice and sugar cane) in proportion to their harvested areas (250,332 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 is much smaller than the harvested area of irrigable crops (vegetables, rice, sugar cane): It is shared among them pro rata, and the rest of their area is rainfed. Maize and soybean are treated as rainfed: Their yield gain is given for 10,000 ha treated.

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 (1,347 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%), using the same quarter, half and full trial effect.

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 department is coloured according to the value of its reference town.

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
Rice cultivation in Benin - panoramio (22).jpg	Africa Rice Center	CC BY-SA 3.0
Threshing fonio with a small-scale machine, Natitingou, northern Benin	Crop Trust	CC BY-SA 4.0
Champ de manioc à Akassato au Bénin.jpg	Hadeou Jacob	CC BY-SA 4.0
Benin Natitingou.JPG	Baliola	CC BY-SA 3.0
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Ensemble de légumes et fruits (melon, choux, avocats) sur étalage.jpg	Hadeou Jacob	CC BY-SA 4.0

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Benin village on water Ganvié.jpg	Dr. Ondřej Havelka (cestovatel)	CC BY-SA 4.0

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Laden canoes in the lake village of Ganvié.

Green Solutions

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