

COUNTRY DOSSIER

United States of America

Water, climate, fertilisers and crops: Figures by state, by region and by crop, potential benefits of our products, external trade, and a detailed study of each of the ten farm production regions

Green Solutions contact@green-solutions-group.com green-solutions-group.com



Foreword

This dossier describes the United States from the angle of irrigation water, climate, fertilisers and crops. It is intended for the authorities responsible for agriculture and water, and for the economic players of the sector. It answers three questions: Where is irrigation water used, for which crops, and with what reserves? It then examines what our products can change, and what that may be worth, for the country, for each of the ten farm production regions and for each state.

The dossier rests on the 2023 Irrigation and Water Management Survey of the US Department of Agriculture. For every state, it gives the water applied to each crop, its source, the irrigation methods, the price of purchased water and the energy spent on pumping.

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 (USDA, US Geological Survey, Bureau of Reclamation, FAO, World Bank, European Commission).
- **B**: Research institute, university, public body outside statistics, or recognised climate model.
- **C**: Manufacturer statement, non-independent demonstration, press, or estimate.
- One acre-foot is the water that covers one acre to a depth of one foot: 1,233 m³. One acre is 0.405 hectare.
- « bn » means billion; « M » means million; « af » means acre-feet.
- A « scenario » is a calculation based on the trials cited. It is not a measurement made in the United States.

What this dossier does not do. It does not turn a trial carried out elsewhere into an American result. Water savings and yield gains by crop are scenarios, built from the trials cited.

What remains to be completed. Some figures of the survey are withheld to protect individual farms. Section 12 gives the details.

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Summary

The seven points below summarise the dossier. The key figures come from public sources (USDA, US Geological Survey, FAO, World Bank, PVGIS). Water savings are scenarios, described in Annex B.

80.9 M af
Of irrigation water applied on farms in 2023 (99.8 bn m³), on 53.1 million acres (USDA).

54%
Of this water is pumped from wells. Several major aquifers are falling, the High Plains (Ogallala) aquifer first.

10.7 M af
Of water saved per year in the central scenario (13.2 bn m³), 13% of irrigation water.

$7.8 bn
Of annual value in the central scenario: Water saved at $94 per acre-foot and yield gain.

$172 bn
Of agricultural exports in 2024, for $212 bn of imports (FAOSTAT).

$14.3 bn
Of indicative spending on mineral fertilisers in 2024, lower bound, for 11.4 million tonnes of nitrogen.

Seven key points

1. **Irrigation feeds a large share of American farming.** 53.1 million acres were irrigated in 2023 on 212,714 farms. Four western regions (Pacific, Mountain, Northern and Southern Plains) apply 82% of the water.

2. **Groundwater is the first source, and it is being drawn down.** Wells supply 54% of the water applied. The High Plains aquifer has lost about 286 million acre-feet since 1950, about 10% of its recoverable water (US Geological Survey).

3. **A dry, hot West.** From June to August, the atmosphere demands 680 mm more water than the rain brings at Phoenix, and 663 mm at Fresno. In the East, rainfall covers most of the summer demand.

4. **The climate is warming and water is being rationed.** The contiguous United States has warmed by 2.5 °F (1.4 °C) since 1970. Arizona has been under a declared Colorado River shortage since 2022, with a cut of 512,000 acre-feet a year.

5. **The potential water saving is large.** In the central scenario, 10.7 million acre-feet per year, 13% of irrigation water. The range runs from 5.3 to 21.3 million acre-feet.

6. **Corn and three regions carry the result.** Corn for grain gives 21% of the central saving. The Pacific, Mountain and Northern Plains regions give 76%.

7. **A major agricultural exporter.** The United States exported $172 billion of agricultural products in 2024. Corn, soybeans, almonds, cotton and rice all depend on irrigation water in the regions that grow them.

Key figures

Key indicators for the United States

Indicator	Value	Year	Source (level)
Irrigation water applied on farms	80,937,415 acre-feet (99.8 bn m³)	2023	USDA IWMS (A6, A)
Irrigated acres (in the open)	53,076,539 acres (21.5 M ha)	2023	USDA IWMS (A6, A)
Water per irrigated acre	1.5 acre-feet	2023	USDA IWMS (A6, A)
Share pumped from wells	54%	2023	USDA IWMS (A6, A)
Solar radiation (20 farm stations)	1,381 to 2,136 kWh/m²/year	2005–2020	PVGIS (A11, A)
Rainfall (20 farm stations)	249 to 1,297 mm/year	1991–2020	ERA5-Land (A12, B)
Nitrogen used	11.43 million tonnes	2024	FAOSTAT (A5, A)
Potential water saving (central)	10.67 million acre-feet per year	Scenario	Calculation (Annex B)

Source: See the « Source » column; levels explained in the foreword.

1. Green Solutions and our products

Green Solutions develops products for water, fertilisation and crop protection. Four families concern this dossier. The performance figures quoted are those published by the manufacturer or by the trials, with their confidence level.

Products concerned by this dossier

Product	Claimed use	Published evidence	Level
EVERGREEN® (water retainer)	Holds rain or irrigation water as a gel, close to the roots	Trials on maize, potato, watermelon, date palm, soybean (sections 8 and 9)	B to C
ECOSORB® (water retainer based on maize starch)	Same use; effect lasts 2 to 3 years according to the website	Soybean trial (China); laboratory acrylamide analysis	B to C
ECOFERT® (fertiliser)	Fertiliser certified by SOHISCERT and EU Organic	Published certificate; potato trial combined with EVERGREEN	A (certificate), C (results)
Paulownia ALTIFOLIA®	Fast-growing tree for agroforestry	Website figures; no trial in the United States	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, sources A20 to A26.

The products are designed for the situations this dossier describes: Irrigated crops in dry summers, sandy soils that drain fast, and farms that pump their water from falling aquifers. The indicative dose published on the website is 30 to 75 kg per hectare.

2. The United States in figures

The United States has about 341.8 million inhabitants (2025) and a gross domestic product of 30.8 trillion dollars (2025). Agriculture accounts for 0.9% of gross domestic product and 1.5% of jobs, but covers 46% of the land area. The 2022 Census of Agriculture counted 284,598 farms that irrigated 54,930,363 acres, against 58,013,907 acres in 2017.

National benchmarks

Indicator	Value	Year	Source
Population	341.8 million inhabitants	2025	World Bank (A1)
Gross domestic product	30,770 billion current US$	2025	World Bank (A1)
GDP per capita	90,027 US$	2025	World Bank (A1)
Agricultural value added	0.9% of GDP	2021	World Bank (A1)
Agricultural employment	1.5% of jobs	2025	World Bank (A1)
Agricultural land	46.1% of land area	2024	World Bank (A1)
Farms that irrigate	284,598	2022	USDA Census of Agriculture (A6)
Irrigated acres	54,930,363 acres	2022	USDA Census of Agriculture (A6)
Acres equipped for irrigation	61,016,692 acres	2022	USDA Census of Agriculture (A6)
Fertiliser used	128 kg per hectare of arable land	2024	World Bank (A1)
Total freshwater withdrawals	444 bn m³, 40% for agriculture	2022	World Bank (A1)

Indicator	Value	Year	Source
Withdrawals / internal resources	15.8%	2022	World Bank (A1)
Water stress (SDG 6.4.2)	28.2%	2022	World Bank (A1)
Internal water resources	8,437 m³ per inhabitant per year	2022	World Bank (A1)
Average precipitation	715 mm per year	2022	World Bank (A1)
Cereal yield	8,414 kg/ha	2024	World Bank (A1)
Food exports	9.0% of merchandise exports	2025	World Bank (A1)
Food imports	6.7% of merchandise imports	2025	World Bank (A1)

Source: World Bank, WDI database (A1); USDA, 2022 Census of Agriculture (A6).

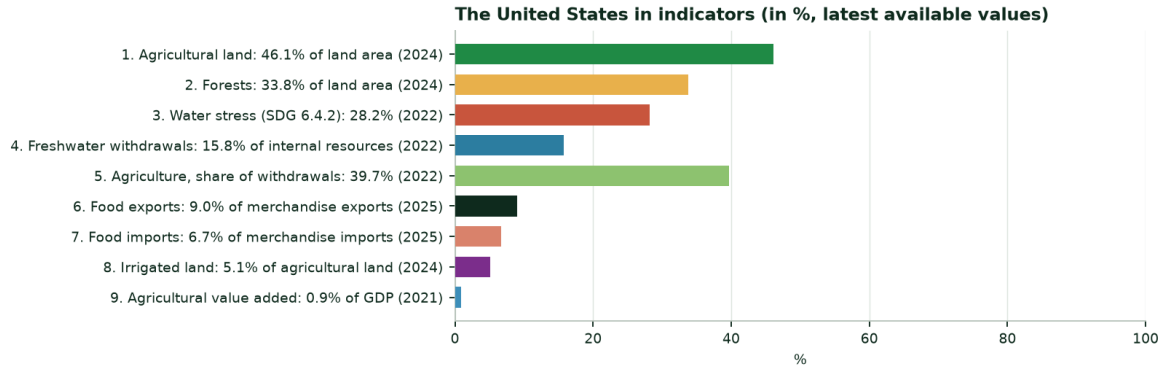


Figure 1. The United States in indicators (in %, latest available values). Source: World Bank (A1)

The World Bank counts 444 billion m³ of freshwater withdrawals in 2022, of which 40% for agriculture. This figure includes the water lost in canals before it reaches the fields, and the water for livestock. The USDA survey measures the water actually applied on farms: 99.8 billion m³ in 2023. The dossier uses the survey, which details the water by crop and by state.



Nebraska seen from the International Space Station: Irrigated fields along a river valley (NASA, public domain).

3. Sunshine, rainfall and climate change

The dossier follows two farm stations in each of the ten regions: Twenty towns at the heart of irrigated areas, from Fresno in California to Albany in New York. The values describe these towns, not whole regions.

3.1 Sunshine

Horizontal solar radiation ranges from 1,381 kWh/m² per year at Albany (New York) to 2,136 kWh/m² at Phoenix (Arizona). The stronger the radiation, the more water the atmosphere draws from soils and plants.

Climate of the twenty farm stations

Station	Region	Radiation (kWh/m²/yr)	Rainfall (mm/yr)	Reference ET (mm/yr)	Summer deficit (mm)
Phoenix, Arizona	Mountain	2,136	249	1,966	680
Fresno, California	Pacific	1,953	416	1,564	663
Boise, Idaho	Mountain	1,649	318	1,310	588
Lubbock, Texas	Southern Plains	2,008	449	1,781	524
Yakima, Washington	Pacific	1,553	342	1,109	523
Weslaco, Texas	Southern Plains	1,925	591	1,710	437
Garden City, Kansas	Northern Plains	1,829	507	1,529	418
Grand Island, Nebraska	Northern Plains	1,616	738	1,194	247
Stuttgart, Arkansas	Delta States	1,706	1,245	1,250	243
Greenville, Mississippi	Delta States	1,758	1,297	1,265	222
Springfield, Illinois	Corn Belt	1,522	1,009	1,075	168
Harrisburg, Pennsylvania	Northeast	1,459	1,064	983	144
Des Moines, Iowa	Corn Belt	1,500	944	1,041	131
Stevens Point, Wisconsin	Lake States	1,408	834	878	121
Saint Paul, Minnesota	Lake States	1,397	834	917	120
Tifton, Georgia	Southeast	1,819	1,048	1,339	119
Lexington, Kentucky	Appalachian	1,533	1,214	1,029	115
Raleigh, North Carolina	Appalachian	1,658	1,163	1,144	97
Albany, New York	Northeast	1,381	1,116	875	84
Immokalee, Florida	Southeast	1,887	1,185	1,447	-179

Source: PVGIS 5.2 (A11), 2005–2020; ERA5-Land (A12), 1991–2020; calculation by the author. Summer deficit: June to August.

3.2 Rainfall and summer deficit

The United States receives on average 715 mm of rain per year (World Bank). At the farm stations, rainfall ranges from 249 mm at Phoenix to 1,297 mm at Greenville (1991–2020 average). For agriculture, the decisive figure is the summer gap: From June to August, the atmosphere demands far more water than the rain provides in the West and the Plains.

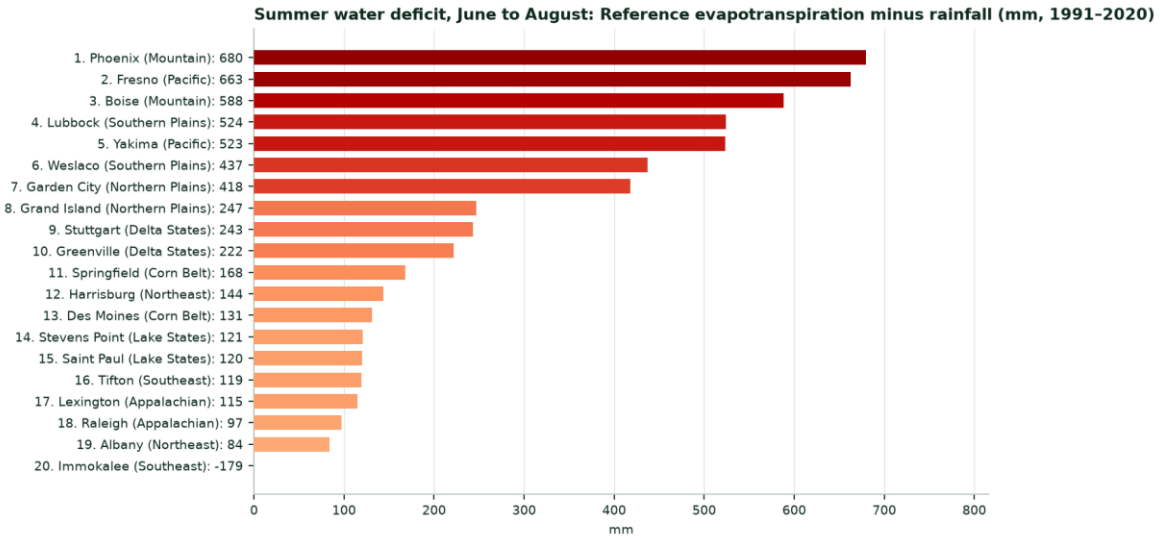


Figure 2. Summer water deficit by station: Reference evapotranspiration minus rainfall, June to August (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

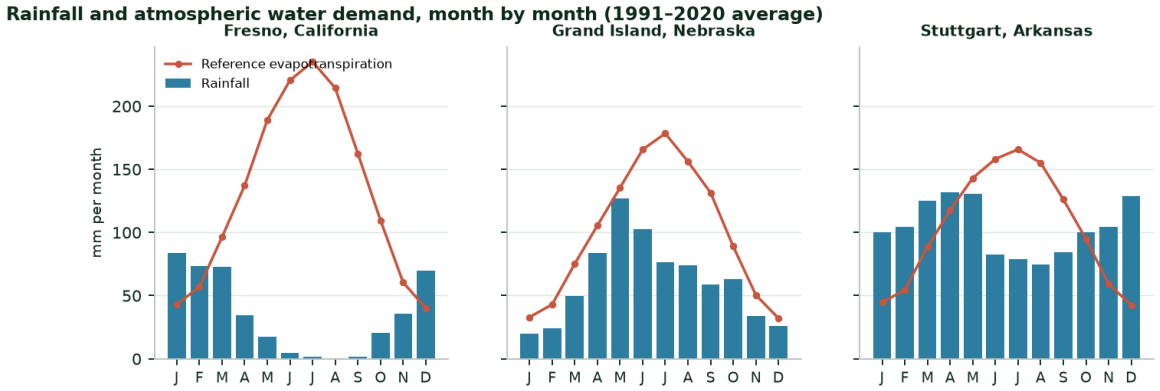


Figure 3. Rainfall and reference evapotranspiration month by month at Fresno, Grand Island and Stuttgart (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

At Fresno, in the Central Valley of California, almost no rain falls from May to September, while the atmosphere demands more than 200 mm a month from June to August. At Grand Island, in Nebraska, summer storms cover part of the demand. At Stuttgart, in the Arkansas Delta, the rain is abundant but falls in winter and spring; the rice and soybeans still need irrigation in July and August. Keeping water in the soil, close to the roots, reduces the water each irrigation must bring.

3.3 Climate change, aquifers and rivers

The Fifth National Climate Assessment (2023) finds that the contiguous United States has warmed by 2.5 °F (1.4 °C) since 1970, faster than the world as a whole (1.7 °F). Hotter summers raise the water demand of crops and shorten the snowpack that fills western reservoirs.

What warming and overuse change for farm water

Effect	What is observed	Source (level)
Temperature	+2.5 °F (1.4 °C) in the contiguous United States since 1970, against +1.7 °F worldwide	Fifth National Climate Assessment (A14, A)
High Plains (Ogallala) aquifer	About 286 million acre-feet lost since 1950, about 10% of the recoverable water; declines up to 203 feet in some wells	US Geological Survey, 2023 (A9, A)
Colorado River	First shortage declared for 2022 on the Lower Basin; Arizona loses 512,000 acre-feet a year, about 18% of its share	Bureau of Reclamation; Arizona Department of Water Resources (A10, A)
Irrigation interrupted	2,022,246 acres with lower yields in 2023 because irrigation was interrupted, 850,172 of them by a shortage of surface water	USDA IWMS (A6, A)

Source: See the « Source » column.

The High Plains aquifer lies under 111.8 million acres in eight states, from South Dakota to Texas. It supplies most of the irrigation of Nebraska, Kansas and the Texas High Plains. Where its water level falls, wells yield less and pumping costs more. Every acre-foot kept in the soil is an acre-foot left in the aquifer.



Farmland in Colorado during a drought, seen from the air (USDA, public domain).

4. Irrigation water: Volumes, sources, methods, prices

4.1 Volumes applied, state by state

American farms applied 80,937,415 acre-feet of irrigation water in 2023, that is 99.8 billion m³, on 53,076,539 acres. California alone applied 22.6 million acre-feet, 28% of the national total. Nebraska, Idaho, Arkansas and Texas follow.

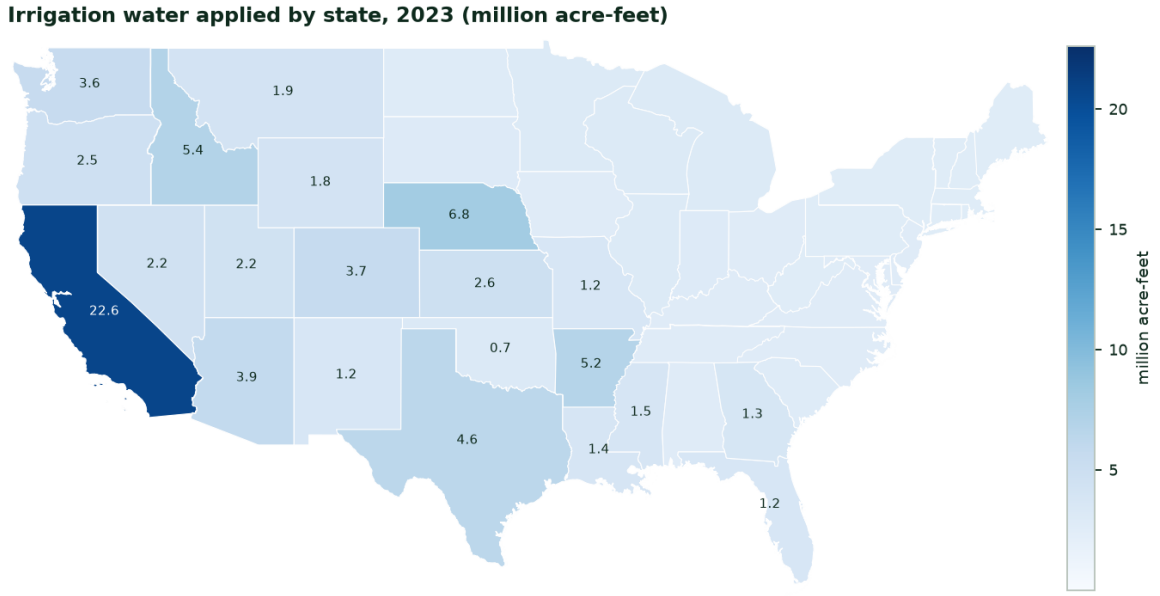


Figure 4. Irrigation water applied by state, 2023 (million acre-feet). Source: USDA IWMS (A6); boundaries Natural Earth, public domain (A15)

On average, each irrigated acre received 1.5 acre-feet. The figure ranges from less than one acre-foot in the humid East, where irrigation completes the rain, to 4.3 acre-feet in Arizona, where it replaces it.

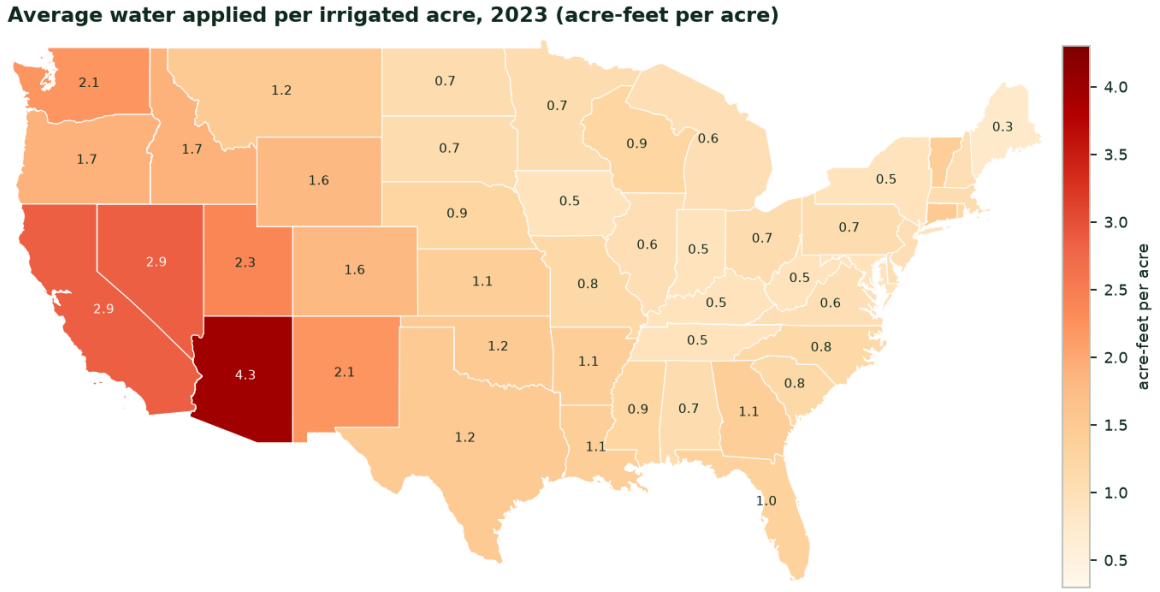


Figure 5. Average water applied per irrigated acre, 2023 (acre-feet per acre). Source: USDA IWMS (A6); Natural Earth (A15)

The fifteen states that apply the most irrigation water, 2023

State	Region	Irrigated acres	Water (acre-feet)	Acre-feet per acre	Share of US water
California	Pacific	7,755,846	22,599,562	2.9	27.9%
Nebraska	Northern Plains	7,305,558	6,813,805	0.9	8.4%
Idaho	Mountain	3,180,644	5,406,523	1.7	6.7%
Arkansas	Delta States	4,645,925	5,165,689	1.1	6.4%
Texas	Southern Plains	3,720,978	4,599,571	1.2	5.7%
Arizona	Mountain	920,420	3,927,289	4.3	4.9%
Colorado	Mountain	2,367,382	3,740,814	1.6	4.6%

State	Region	Irrigated acres	Water (acre-feet)	Acre-feet per acre	Share of US water
Washington	Pacific	1,704,878	3,636,947	2.1	4.5%
Kansas	Northern Plains	2,324,901	2,570,383	1.1	3.2%
Oregon	Pacific	1,445,030	2,478,499	1.7	3.1%
Nevada	Mountain	767,294	2,248,790	2.9	2.8%
Utah	Mountain	985,863	2,221,470	2.3	2.7%
Montana	Mountain	1,561,047	1,879,427	1.2	2.3%
Wyoming	Mountain	1,148,044	1,824,742	1.6	2.3%
Mississippi	Delta States	1,713,175	1,465,708	0.9	1.8%

Source: USDA IWMS 2023 (A6).

4.2 Where the water comes from

Wells supply 43.9 million acre-feet (54%). Irrigation districts, federal and state projects and other off-farm suppliers deliver 28.4 million, and farmers draw 8.6 million from their own streams, ponds and reservoirs. The West relies on snowmelt stored behind dams; the Plains and the Delta rely on aquifers.

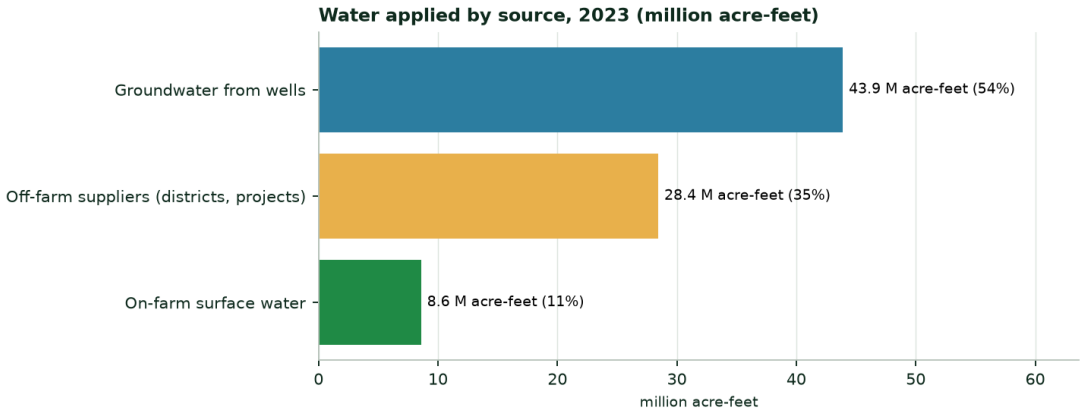


Figure 6. Water applied by source, 2023 (million acre-feet). Source: USDA IWMS (A6)



Farms and the California Aqueduct in Kern County (California), August 2014 (CC0).

4.3 Irrigation methods

Sprinklers, mostly centre pivots, water 30.8 million acres. Gravity methods (furrows, flooding, basins) still water 18.3 million acres, mostly rice, alfalfa, pasture and cotton. Drip and micro-irrigation cover 6.4 million acres, mostly orchards, vineyards and vegetables. Our water retainers work with all three methods: They hold the water each pass brings, whatever the way it is applied.

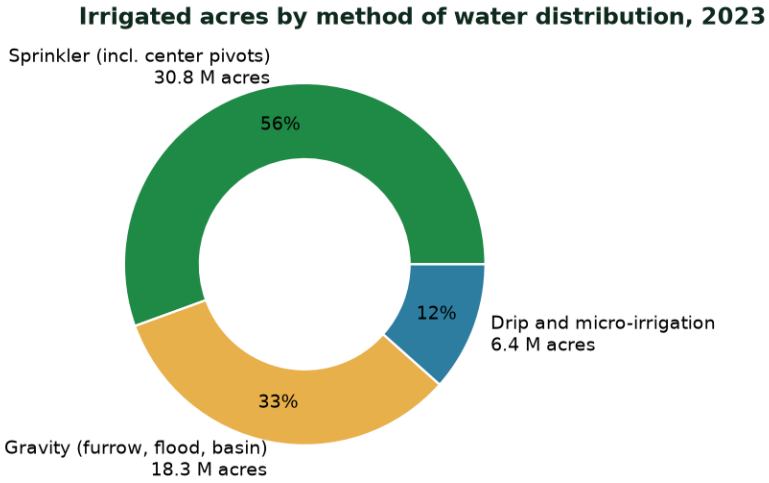


Figure 7. Irrigated acres by method of water distribution, 2023. Source: USDA IWMS (A6)

4.4 Water resource regions

Hydrologists divide the country into water resource regions, which follow the large river basins. The California basin applies the most water, ahead of the Missouri basin (Nebraska, Kansas, the Dakotas, Montana, Wyoming, Colorado) and the Pacific Northwest (the Columbia and Snake basins).

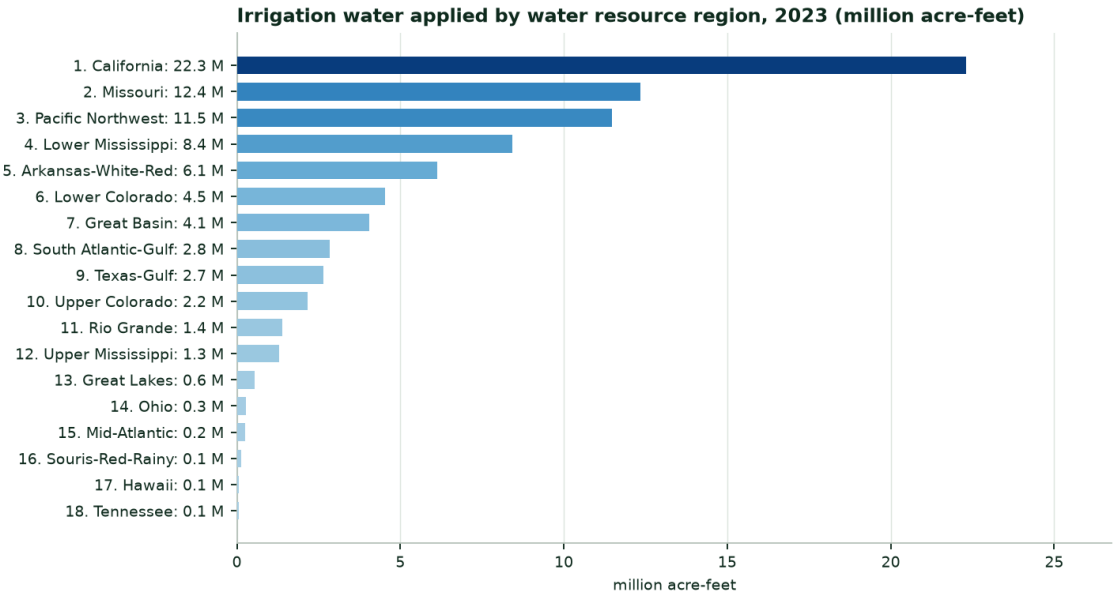


Figure 8. Irrigation water applied by water resource region, 2023 (million acre-feet). Source: USDA IWMS (A6)

4.5 The price of water

There is no single price of irrigation water. Farms that buy their water from a district or a project paid on average $54.22 per acre-foot in 2023, for a total of $1.14 billion. Farms that pump from wells pay the energy: $3.26 billion in 2023, of which $2.53 billion of electricity, for 608,288 pumps. Spread over all the water applied, the energy represents about $40 per acre-foot.

Price paid for off-farm water in the twelve states that buy the most

State	Off-farm water (acre-feet)	Share of the state's water	Average price ($ per acre-foot)
California	11,727,502	52%	71.98
Idaho	2,573,283	48%	23.35
Washington	2,332,172	64%	49.89
Arizona	1,841,784	47%	37.57
Colorado	1,826,481	49%	24.12
Utah	1,361,314	61%	24.24
Wyoming	1,244,337	68%	18.32
Montana	1,215,967	65%	17.90
Nevada	1,067,340	47%	8.57
Oregon	1,047,744	42%	37.67
Texas	643,238	14%	91.47
New Mexico	494,314	41%	24.91

Source: USDA IWMS 2023 (A6), table 18.

To value the water saved, the dossier therefore uses three reference values: $54.22 per acre-foot (the average price of purchased water), $94.48 (the same price plus the pumping energy per acre-foot) and $150 (a high value, for the dry years and the basins where water is scarce). These are assumptions, not the actual cost of each farm.

4.6 Interrupted irrigation

In 2023, 2,022,246 irrigated acres had lower yields because irrigation was interrupted. A shortage of surface water was the first cause (850,172 acres), ahead of equipment failures and a shortage of groundwater (510,222 acres). Water kept in the soil gives crops a reserve when a delivery is cut or a well runs short.

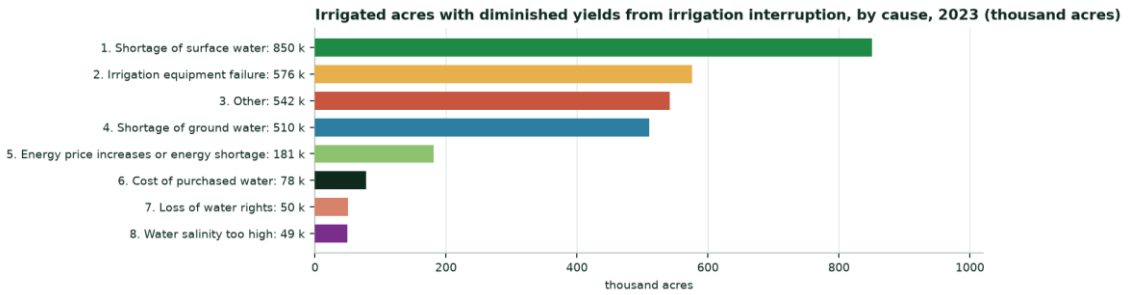


Figure 9. Irrigated acres with lower yields because irrigation was interrupted, by cause, 2023 (thousand acres). Source: USDA IWMS (A6), table 21

5. Fertilisers: Quantities, prices, spending

5.1 Quantities used

American agriculture used 11.43 million tonnes of nitrogen (N), 3.67 million tonnes of phosphate (P_2O_5) and 4.27 million tonnes of potash (K_2O) in 2024 (FAOSTAT). Corn takes the largest share of the nitrogen.

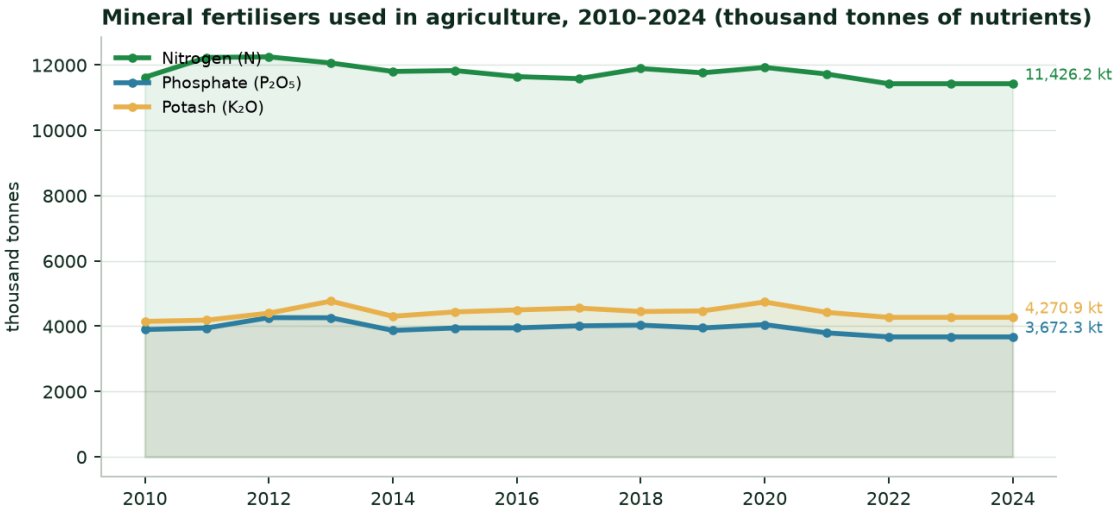


Figure 10. Mineral fertilisers used in agriculture, 2010–2024 (thousand tonnes of nutrients). Source: FAOSTAT, fertilisers by nutrient (A5)

Fertilisers used, in tonnes of nutrients

Year	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
2018	11,891,321	4,031,751	4,449,351
2019	11,760,172	3,946,337	4,468,817
2020	11,925,954	4,048,614	4,741,245
2021	11,722,823	3,796,003	4,423,220
2022	11,426,152	3,672,282	4,270,921
2023	11,426,152	3,672,282	4,270,921
2024	11,426,152	3,672,282	4,270,921

Source: FAOSTAT (A5).

5.2 Prices

International fertiliser prices doubled in 2021–2022, then fell back. In 2024, urea was worth 338 dollars a tonne and potassium chloride 295 dollars. The prices paid by farmers, with transport and margins, are higher.

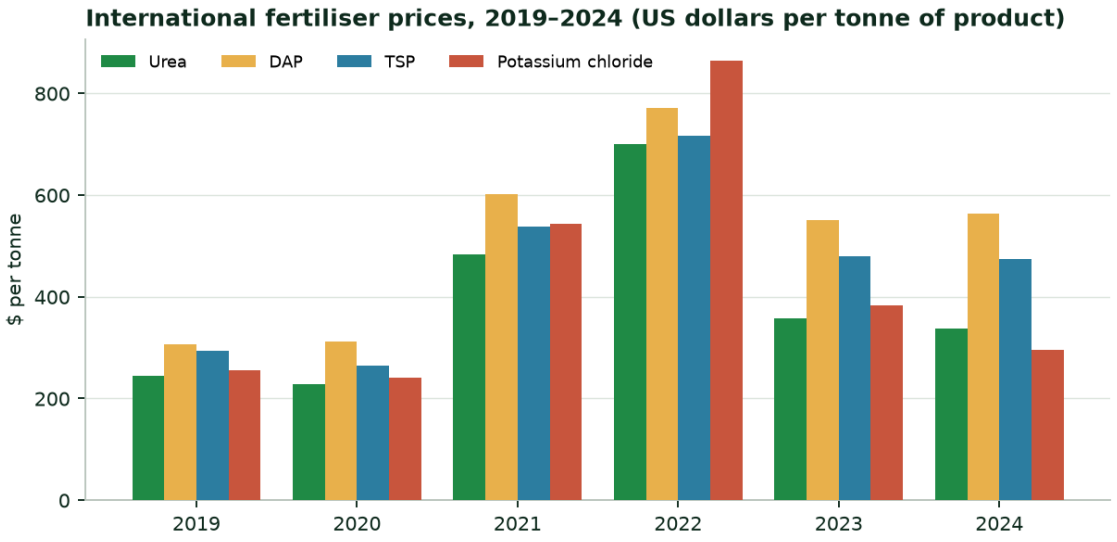


Figure 11. International fertiliser prices, 2019–2024 (dollars per tonne of product). Source: World Bank, Commodity Price Data (A13)

5.3 Indicative spending

Converted into urea, triple superphosphate and potassium chloride, the nutrients used represent spending of at least 14.3 billion dollars in 2024, and 29.3 billion in 2022, the year of the price peak. Nutrients washed below the roots by irrigation or heavy rain are lost to the crop; a water retainer that holds the water in the root zone also holds the nutrients dissolved in it.

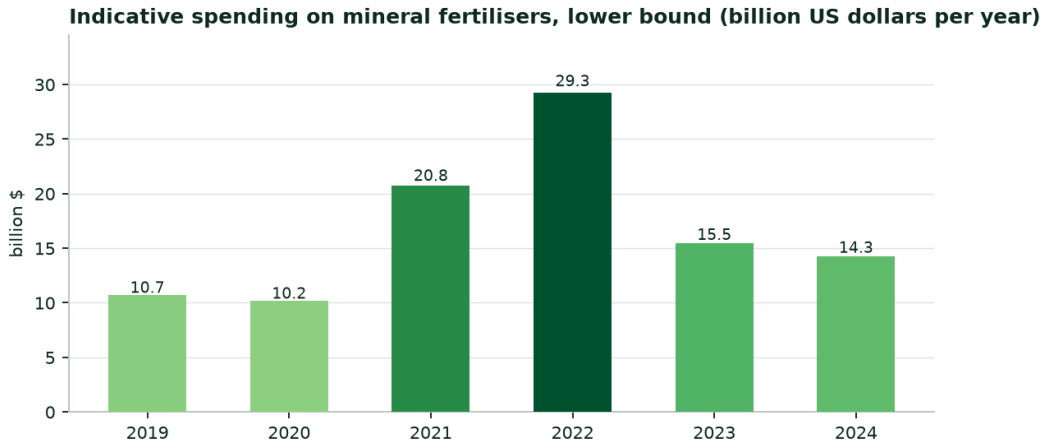


Figure 12. Indicative spending on mineral fertilisers, lower bound (billion dollars per year). Source: Calculation by the author from A5 and A13

Limits of the calculation

- International prices, without transport, duties or margins: Actual spending is higher.
- Compound, organic and foliar fertilisers are not distinguished.

6. The ten regions at a glance

The US Department of Agriculture groups the states into ten farm production regions. The dossier follows them: Each region brings together states with similar climates and crops. Alaska and Hawaii, very small irrigators, are counted in the Pacific region.

Acres, water and central saving by region

Region	States	Irrigated (M acres)	Water (M af)	Af per acre	From wells	Summer deficit (mm)	Central saving (M af/yr)
Pacific	5	10.91	28.77	2.6	37%	593	3.83
Mountain	8	11.51	22.46	2.0	32%	634	2.74
Northern Plains	4	10.26	9.81	1.0	94%	332	1.60
Southern Plains	2	4.26	5.26	1.2	84%	480	0.69
Corn Belt	5	3.04	2.07	0.7	95%	150	0.29
Lake States	3	1.78	1.25	0.7	85%	120	0.22
Delta States	3	7.66	8.03	1.0	89%	232	0.93
Southeast	4	2.36	2.74	1.1	73%	-30	0.37
Appalachian	5	0.41	0.28	0.6	57%	106	0.04
Northeast	11	0.15	0.26	0.6	70%	114	0.04

Source: USDA IWMS 2023 (A6); ERA5-Land (A12), average of the two stations; calculation by the author (Annex B). Acres and acre-feet per acre: States with published acres only.

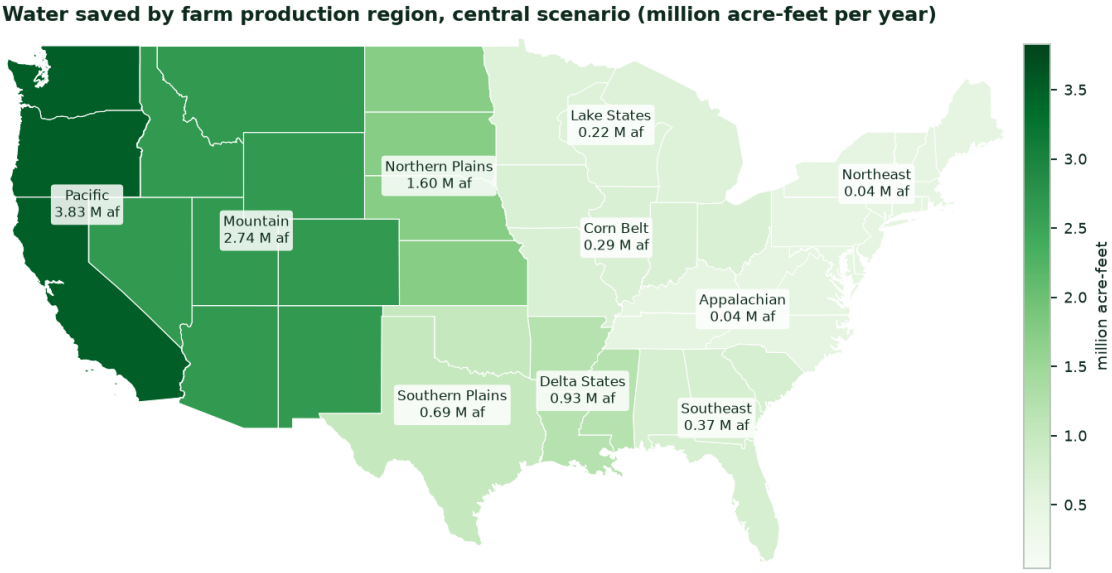


Figure 13. Water saved by farm production region, central scenario (million acre-feet per year). Source: Calculation by the author (Annex B); Natural Earth (A15)

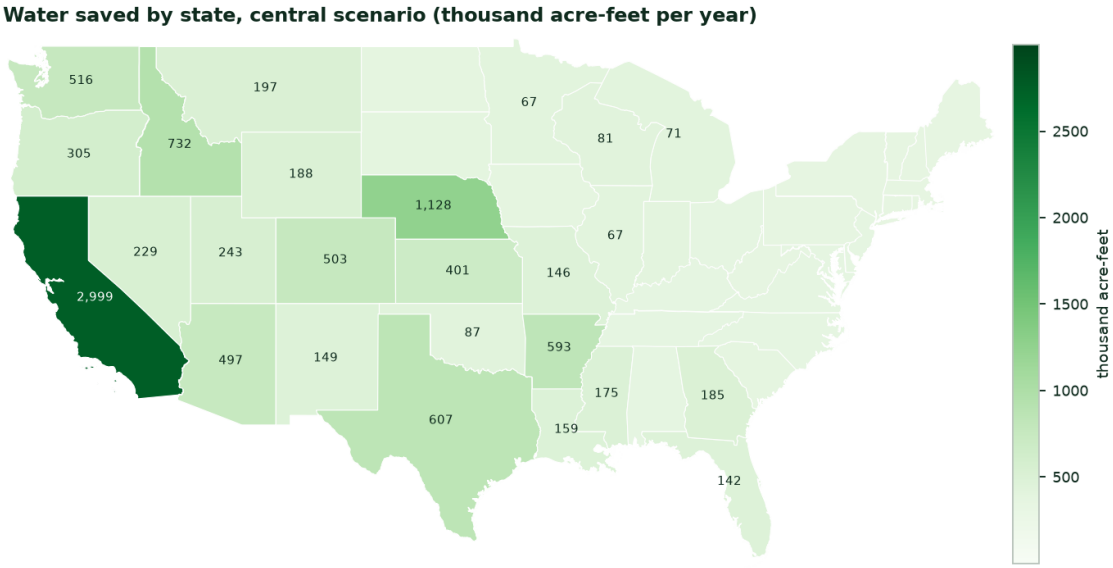


Figure 14. Water saved by state, central scenario (thousand acre-feet per year). Source: Calculation by the author (Annex B); Natural Earth (A15)

7. The twenty main crops: Three rankings

Three rankings complement each other: Area, production and value. Corn and soybeans cover by far the largest areas, mostly without irrigation in the Corn Belt. Irrigation weighs most on alfalfa, orchards and nut trees, vegetables, rice, cotton and the corn of the Plains.

7.1 By area

Twenty main crops by harvested area (2023)

Rank	Crop	Area (ha)	Production (t)	Yield (t/ha)
1	Maize (corn)	35,010,950	389,694,460	11.1
2	Soya beans	33,294,250	113,272,630	3.4

Rank	Crop	Area (ha)	Production (t)	Yield (t/ha)
3	Wheat	15,083,610	49,313,930	3.3
4	Seed cotton, unginned	2,858,970	8,094,429	2.8
5	Sorghum	2,474,680	8,071,090	3.3
6	Rice	1,154,990	9,901,510	8.6
7	Barley	1,033,980	4,028,680	3.9
8	Rape or colza seed	942,650	1,894,950	2.0
9	Groundnuts, excluding shelled	630,100	2,666,020	4.2
10	Almonds, in shell	558,472	1,751,770	3.1
11	Sunflower seed	511,330	1,024,070	2.0
12	Beans, dry	460,580	1,070,843	2.3
13	Sugar beet	456,210	31,956,490	70.0
14	Potatoes	388,580	19,992,090	51.4
15	Peas, dry	377,580	814,060	2.2
16	Sugar cane	376,970	29,897,180	79.3
17	Grapes	360,579	5,351,940	14.8
18	Oats	336,300	828,010	2.5
19	Millet	231,480	443,890	1.9
20	Lentils, dry	211,650	258,410	1.2

Source: FAOSTAT, crop production 2023 (A2); aggregates excluded.

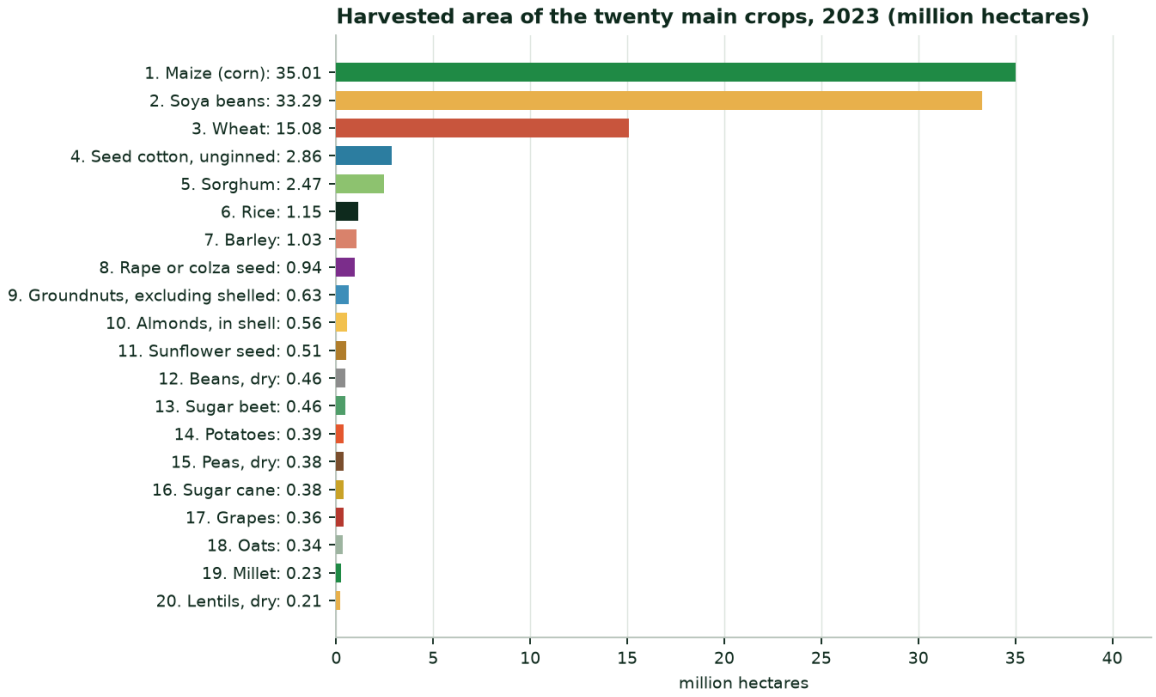


Figure 15. Harvested area of the twenty main crops, 2023 (million hectares). Source: FAOSTAT (A2)

7.2 By production

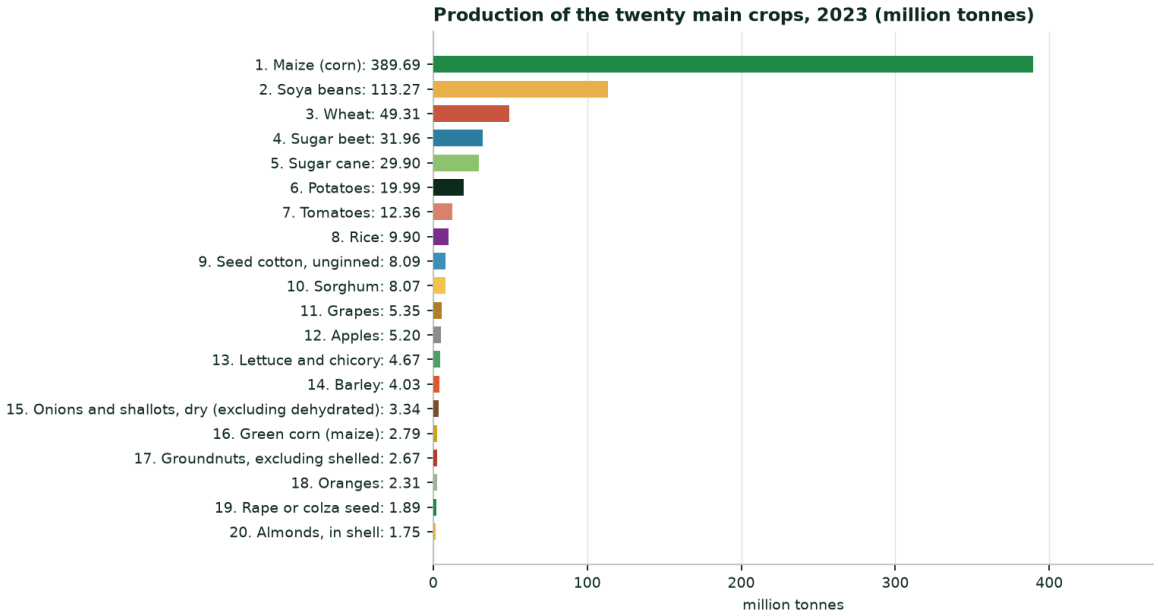


Figure 16. Production of the twenty main crops, 2023 (million tonnes). Source: FAOSTAT (A2)

7.3 By value of production

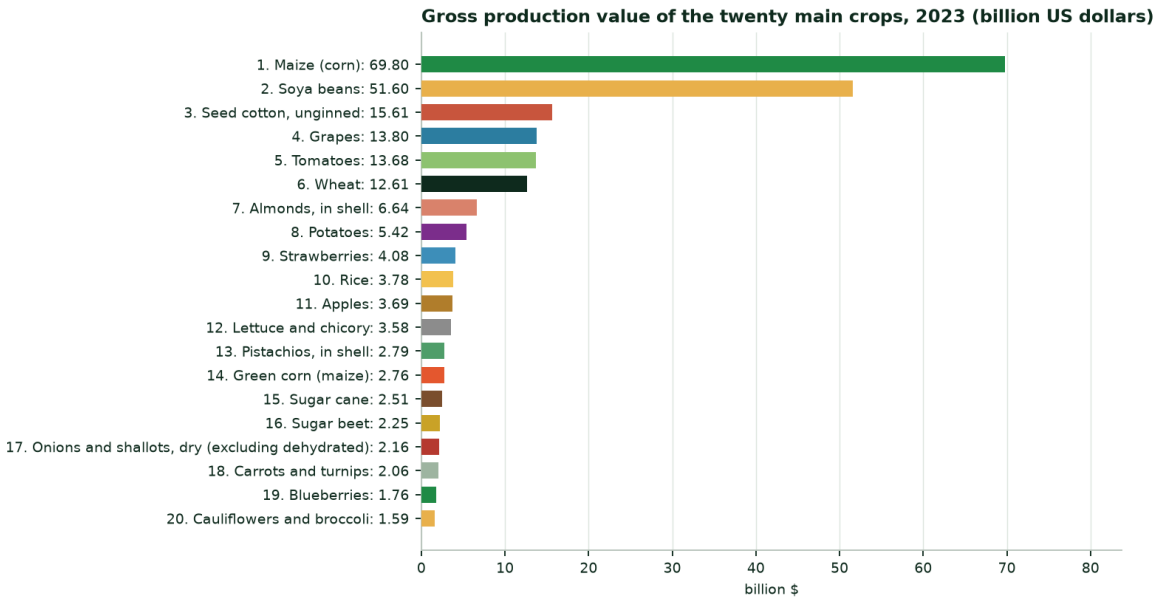


Figure 17. Gross production value of the twenty main crops, 2023 (billion US dollars). Source: FAOSTAT, value of agricultural production (A7)

7.4 Irrigated crops

The irrigation survey ranks the crops by the water they receive. Alfalfa (12.4 million acre-feet), orchards, vineyards and nut trees (12.3 million) and corn for grain (11.6 million) together receive nearly half of the water.

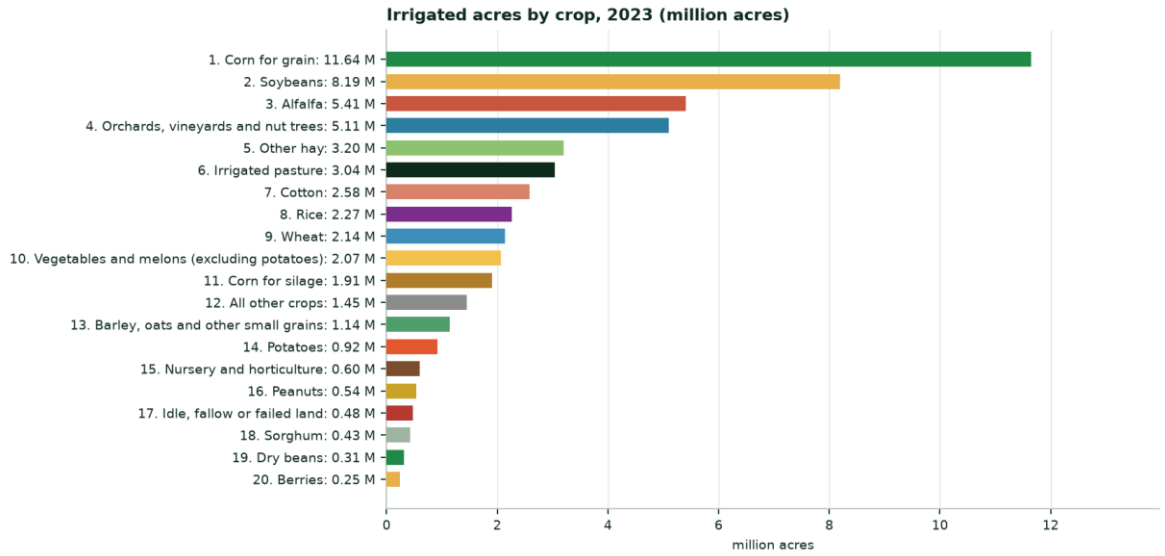


Figure 18. Irrigated acres by crop, 2023 (million acres). Source: USDA IWMS (A6), table 39

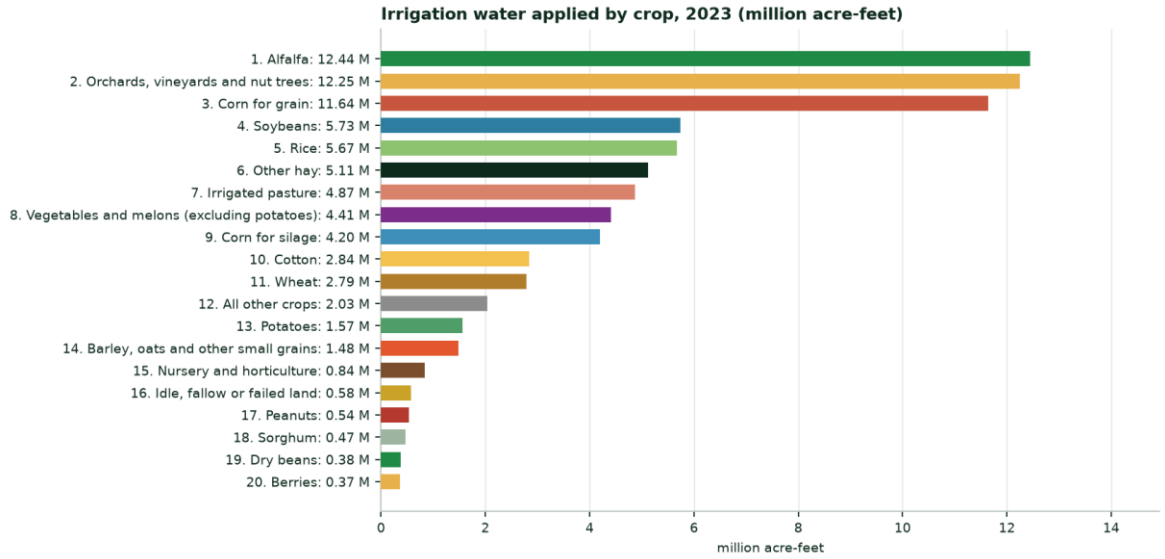


Figure 19. Irrigation water applied by crop, 2023 (million acre-feet). Source: USDA IWMS (A6), table 39; vegetables exclude potatoes

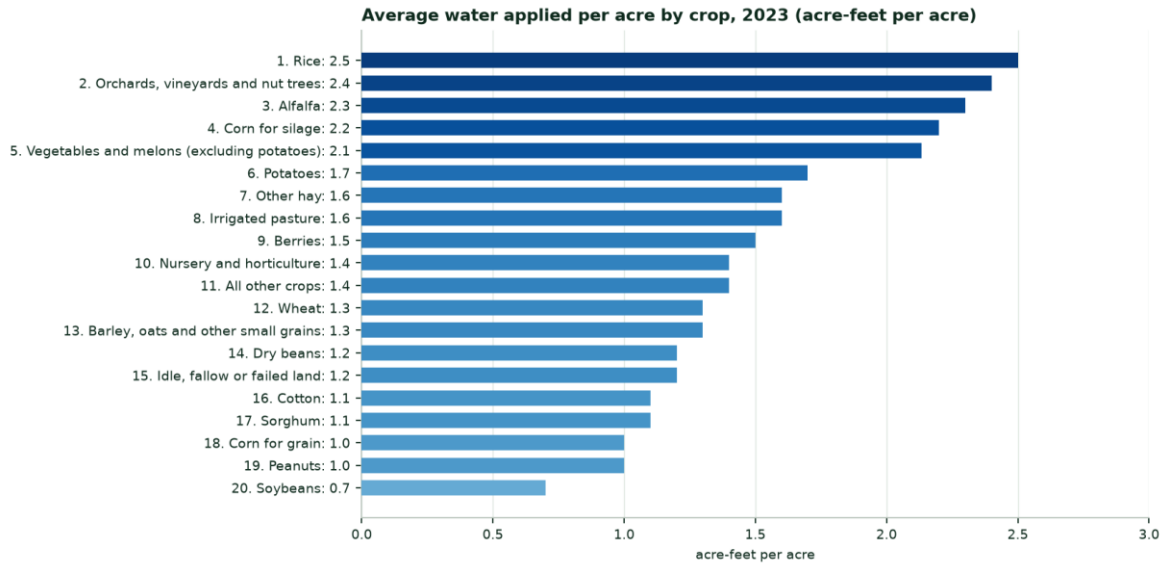


Figure 20. Average water applied per acre by crop, 2023 (acre-feet per acre). Source: USDA IWMS (A6), table 39



Orchard in California (USDA Natural Resources Conservation Service, public domain).

8. Extrapolation by crop and water savings

8.1 Method

Method in brief

• **Irrigation water**: 80.9 million acre-feet applied in 2023 (USDA), measured crop by crop and state by state in the survey.

• **Water saving**: For each crop, a quarter (cautious), half (central) or all (strong) of the saving measured in the closest trial. Without a trial, 5%, 10% or 20%.

• **Yield gain**: Same rule, applied to the national yields of 2023 (FAOSTAT) and valued at the implicit 2023 price (value of production ÷ production).

• **Value of water**: $54.22, $94.48 or $150 per acre-foot (section 4.5).

• **By state and by region**: Same calculation, with the irrigated acres and the water per acre of each crop in each state.

• **What the calculation does not contain**: No product price, no application cost.

8.2 Trials used as analogues

Trials cited and their use in the calculation

Trial	Water saving published	Yield gain published	Use in this dossier	Level
Maize, Turkey (TIGEM, 2025)	−39%	+17.1%	Corn for grain (water and yield), corn for silage (water)	C
Potato, South Africa (2025–2026)	−52%	+31.4%	Potatoes	C
Watermelon, Mexico (2023)	−60.5%	+30%	Vegetables and melons	C
Soybean, China (Shandong)	Not measured	+11.2 to 11.4%	Yield of soybeans, wheat, small grains, peanuts, sorghum and dry beans	B
Date palm, United Arab Emirates (ICBA, 2020–2021)	−82%	+20%	Not used (few date palms in the United States)	B

Source: Trials published on the Green Solutions website (A20 to A24).

8.3 Parameters by crop

Water saving used by scenario (cautious / central / strong)

Crop	Analogue	Water
Alfalfa	Generic assumption	5% / 10% / 20%
Orchards, vineyards and nut trees	Generic assumption	5% / 10% / 20%
Corn for grain	Maize, Turkey	9.8% / 19.5% / 39%
Soybeans	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
Rice	Generic assumption	5% / 10% / 20%
Other hay	Generic assumption	5% / 10% / 20%
Irrigated pasture	Generic assumption	5% / 10% / 20%
Vegetables and melons (excluding potatoes)	Watermelon, Mexico	15.1% / 30.2% / 60.5%
Corn for silage	Water: Maize, Turkey; yield not counted	9.8% / 19.5% / 39%
Cotton	Generic assumption	5% / 10% / 20%
Wheat	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
All other crops	Generic assumption	5% / 10% / 20%
Potatoes	Potato, South Africa	13% / 26% / 52%
Barley, oats and other small grains	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
Nursery and horticulture	Generic assumption	5% / 10% / 20%
Idle, fallow or failed land	Generic assumption	5% / 10% / 20%
Peanuts	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
Sorghum	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
Dry beans	Water: Generic assumption; yield: Soybean, China	5% / 10% / 20%
Berries	Generic assumption	5% / 10% / 20%

Source: Calculation by the author (Annex B).

8.4 National results

10.7 M af
Of water saved per year in the central scenario (13% of irrigation water).

5.3 to 21.3
Million acre-feet per year, from the cautious to the strong scenario.

13.1 Mt
Of extra production in the central scenario (corn, potatoes, vegetables, soybeans, small grains).

Water saving and value per year, by scenario and value of water

Scenario	Water saved (M af/yr)	Water saved (bn m³/yr)	Water at $54 (M$)	Water at $94 (M$)	Water at $150 (M$)	Yield (M$)
Cautious	5.34	6.58	289	504	800	3,400
Central	10.67	13.16	579	1,008	1,601	6,800
Strong	21.34	26.32	1,157	2,016	3,201	13,600

Source: Calculation by the author (Annex B).

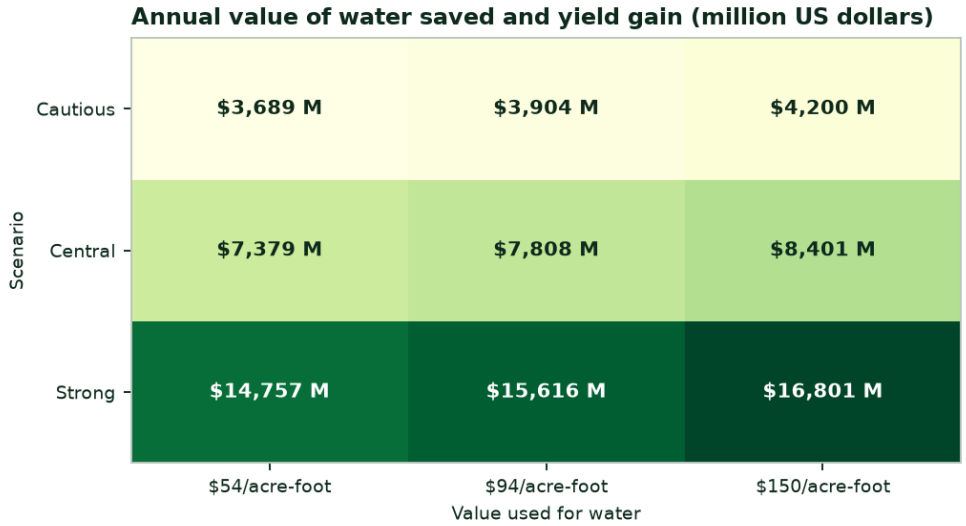


Figure 21. Annual value of water saved and yield gain (million US dollars), by scenario and value of water. Source: Calculation by the author

In the central scenario, the total value reaches about 7.8 billion dollars per year: 1.0 billion for the water at $94 per acre-foot, and 6.8 billion for the yield gain. The yield gain weighs more than the water, because purchased water remains cheap in most states.

8.5 Water saved by crop (central scenario)

Water saved by crop (central scenario)

Crop	Irrigated acres	Water (thousand af)	Saved (thousand af/yr)	Yield gain (t)
Corn for grain	11,641,724	11,642	2,270	4,483,549
Vegetables and melons (excluding potatoes)	2,065,378	4,407	1,333	4,634,287
Alfalfa	5,408,531	12,440	1,244	—
Orchards, vineyards and nut trees	5,105,937	12,254	1,225	—
Corn for silage	1,909,521	4,201	819	—
Soybeans	8,190,426	5,733	573	637,131
Rice	2,268,904	5,672	567	—
Other hay	3,196,249	5,114	511	—
Irrigated pasture	3,043,010	4,869	487	—
Potatoes	920,681	1,565	407	3,009,572
Cotton	2,584,479	2,843	284	—
Wheat	2,143,635	2,787	279	160,244
All other crops	1,452,288	2,033	203	—
Barley, oats and other small grains	1,141,657	1,484	148	101,707
Nursery and horticulture	598,980	839	84	—
Idle, fallow or failed land	482,367	579	58	—
Peanuts	540,245	540	54	52,265
Sorghum	430,947	474	47	32,137
Dry beans	314,147	377	38	16,700
Berries	246,361	370	37	—

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B).

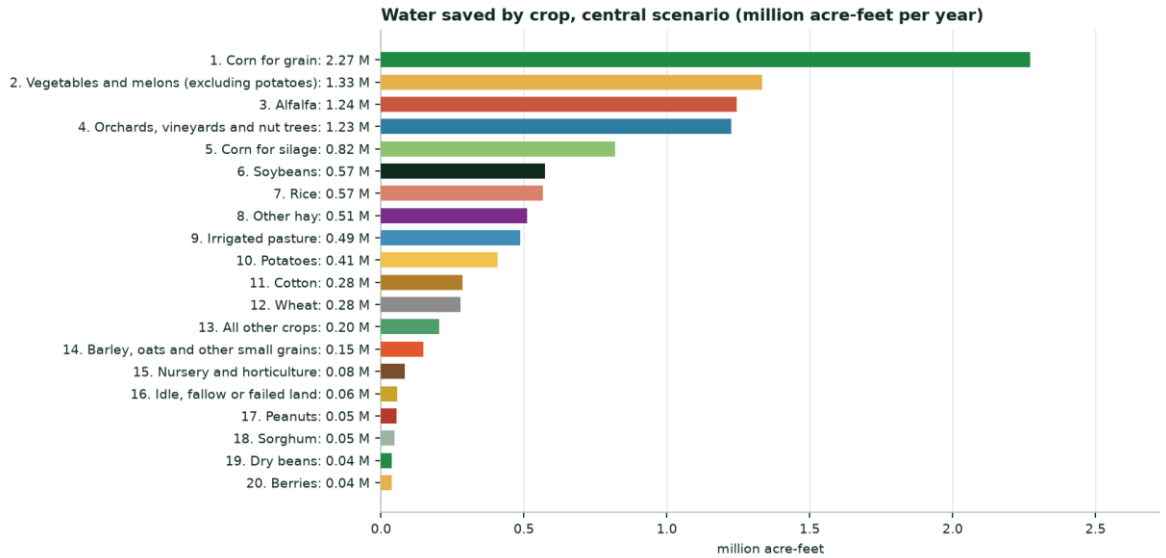


Figure 22. Water saved by crop, central scenario (million acre-feet per year). Source: Calculation by the author

Key takeaways

• The central saving (10.7 million acre-feet per year) equals 13% of the irrigation water applied in 2023, or the yearly water of about 7.1 million irrigated acres.

• Corn for grain gives 21% of the result; vegetables and potatoes give 16%. These are the irrigated crops for which published trials exist.

• Alfalfa, orchards, pasture, rice and cotton rest on a generic assumption: A trial in the United States on these crops would change the result strongly.

• The survey gives the water per acre of each crop; the calculation therefore follows the real weight of each crop, state by state.

9. Potential benefits of our products

The table matches each expected benefit with what has been published, its source and its limit. It contains no yield promise.

Benefits, evidence and limits

Benefit	What is published	Source (level)	Limit
Less irrigation water	−39% (maize), −52% (potato), −60.5% (watermelon), −82% (date palm)	Green Solutions and ICBA trials (A20 to A24, B to C)	Trials outside the United States, often on a single plot
Yield maintained or increased	+17.1% (maize), +31.4% (potato), +30% (watermelon), +11% (soybean)	Same trials (B to C)	No statistical replication for most
Resistance to heat and drought	Date palms without visible stress with watering spaced out	ICBA (A20, B)	One season, one site
Sandy soils	Trial carried out in sandy, saline soil	ICBA (A20, B)	To be confirmed on American soils
Fewer fertiliser losses	Higher nutrient levels in the root zone (date palm)	ICBA (A20, B)	Not quantified as fertiliser saved
Less pumping	Follows from less water applied: Each acre-foot saved from a well saves its pumping energy	Calculation; USDA IWMS (A6)	Depends on the depth of the well and the energy price
Organic fertilisation	ECOFERT® certified by SOHISCERT and EU Organic	Certificate (A25, A)	Agronomic effect not isolated

Source: See the « Source » column.

What this dossier does not include

- The cotton figures from Turkey (+93% yield): A demonstration under extreme stress, not representative.
- The effects claimed for Water Vital® and NAPEMA®: No independent source in the documents consulted.
- Any product or application price.

10. External trade: Exports and imports

10.1 Overview

Agricultural trade of the United States

Indicator	2023	2024	Change
Agricultural exports (bn$)	171.0	172.4	0.8%
Agricultural imports (bn$)	194.5	212.4	9.2%
Agricultural balance (bn$)	-23.6	-40.0	—

Source: FAOSTAT, trade in agricultural products (A3); aggregate « crops and livestock products ».

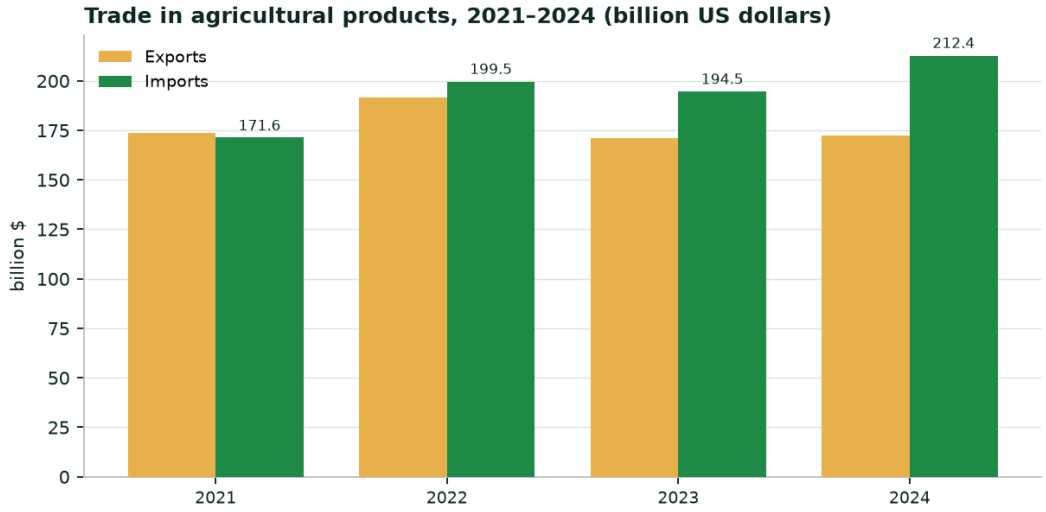


Figure 23. Trade in agricultural products, 2021–2024 (billion dollars). Source: FAOSTAT (A3)

The United States exports soybeans, corn, almonds, beef, pork, cotton and wheat; it imports wine and spirits, fresh fruit and vegetables out of season, coffee, cocoa and processed foods. In 2023 and 2024, imports exceeded exports: $212.4 billion against $172.4 billion in 2024.

10.2 Exports

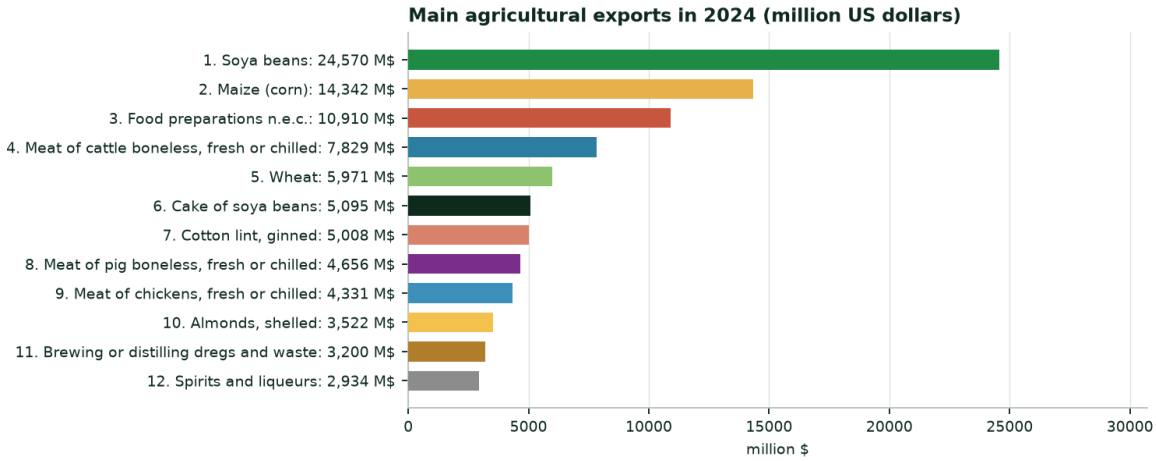


Figure 24. Main agricultural exports in 2024 (million dollars). Source: FAOSTAT (A3)

10.3 Imports

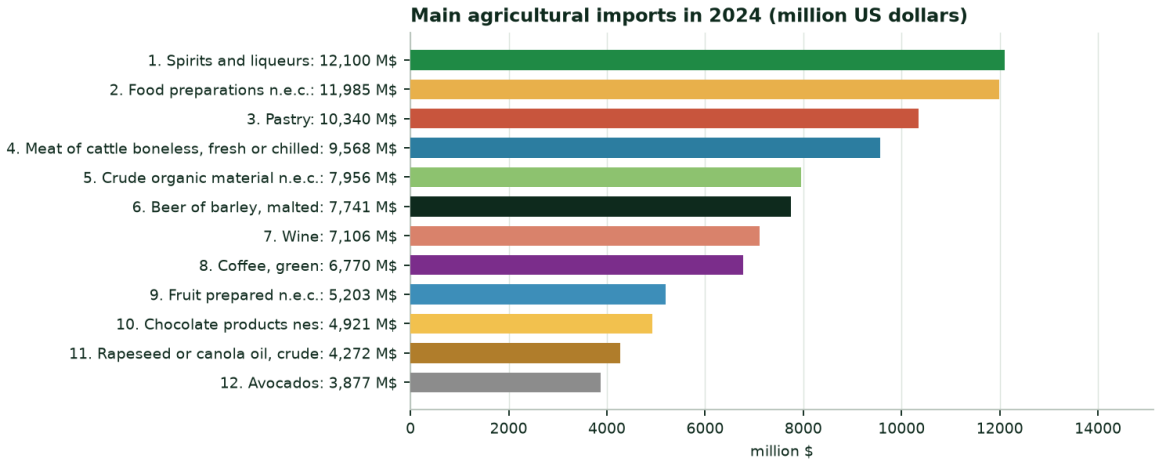


Figure 25. Main agricultural imports in 2024 (million dollars). Source: FAOSTAT (A3)

Irrigated products among the exports, 2024

Product	Exports (M$)	Exports (t)	Production 2023 (t)
Corn	14,342	62,589,862	389,694,460
Soybeans	24,570	52,327,703	113,272,630
Wheat	5,971	21,803,349	49,313,930
Cotton lint	5,008	2,491,894	2,627,060
Rice (milled equivalent)	2,438	3,143,664	9,901,510
Almonds, shelled	3,522	716,374	1,751,770
Pistachios, in shell	2,509	348,308	675,850
Potatoes, frozen	1,569	934,863	19,992,090

Source: FAOSTAT (A2, A3). Production of almonds in shell, of rice as paddy, of potatoes for all uses.

10.4 Water and trade

Almonds, pistachios, rice, cotton and the corn of the Plains are both irrigated crops and export products. Every acre-foot saved on these crops protects export earnings in the dry years, when water deliveries are cut or wells run short.

11. Regional studies: The ten farm production regions

Each region has its own study: Its irrigated agriculture, its summer climate, the water it applies and where that water comes from, its states one by one, its crops, and what our products could change there in the central scenario. The figures come from the same sources as the rest of the dossier; the calculation is that of section 8, applied to the irrigated crops of each state.

11.1 Pacific

States: California, Oregon, Washington, Alaska and Hawaii.

California's Central Valley and Imperial Valley grow almonds, pistachios, grapes, vegetables, alfalfa and rice. Washington's Columbia Basin and Yakima Valley grow apples, cherries, potatoes and hops; Oregon irrigates in the Willamette Valley and the Klamath basin. The water comes from the snowmelt of the Sierra Nevada and the Cascades, stored behind dams and carried by large federal and state projects, and from wells. California now regulates its groundwater under the Sustainable Groundwater Management Act of 2014.

Pacific: Key figures

Indicator	Value	Source (level)
Irrigated acres	10,905,754 acres, 20.5% of the country (figure withheld for Alaska and Hawaii)	USDA IWMS 2023 (A6, A)
Farms that irrigate	62,922	USDA IWMS 2023 (A6, A)
Irrigation water applied	28,771,756 acre-feet (35.49 bn m³), 35.5% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	2.63 acre-feet (states with published acres)	Calculation
Water by source	Wells 37%, off-farm suppliers 53%, on-farm surface water 11%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 31%, gravity 29%, drip 41%	USDA IWMS 2023 (A6, A)
Energy for pumping	$1,280 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	229,627 acres	USDA IWMS 2023 (A6, A)
Rainfall at Fresno / Yakima	416 mm / 342 mm per year	ERA5-Land (A12, B)
Summer deficit at Fresno / Yakima	663 mm / 523 mm, June to August	ERA5-Land (A12, B)
Radiation at Fresno / Yakima	1,953 / 1,553 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	3,827,091 acre-feet per year, 13% of the region's water, 35.6% of the national saving	Calculation (Annex B)
Range, cautious to strong	1,913,546 to 7,654,183 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	3,515,637 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$3,364.6 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Cherry orchard in the Yakima Valley (Washington) (CC0).

Pacific: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
California	7,755,846	22,600	2.9	38%	13% / 52%	71.98	2,999.0
Washington	1,704,878	3,637	2.1	27%	80% / 16%	49.89	515.6
Oregon	1,445,030	2,478	1.7	37%	72% / 8%	37.67	304.6
Hawaii	—	56	1.6	15%	22% / 70%	216.27	7.6
Alaska	—	1	0.7	90%	79% / 16%	550.00	0.2

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

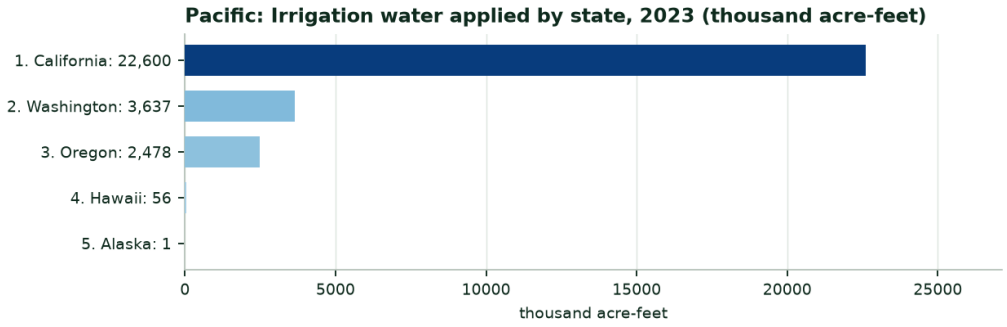


Figure 26. Pacific: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Pacific: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Orchards, vineyards and nut trees	4,386,260	11,179	2.5	1,117.9
Alfalfa	1,207,321	3,622	3.0	362.2
Vegetables and melons (excluding potatoes)	1,210,352	3,231	2.7	977.5
Rice	430,483	1,937	4.5	193.7
Corn for silage	650,434	1,915	2.9	373.5
Other hay	757,423	1,575	2.1	157.5
Irrigated pasture	612,516	1,316	2.1	131.6

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
All other crops	475,135	894	1.9	89.4
Wheat	382,044	661	1.7	66.1
Corn for grain	218,251	545	2.5	106.2
Potatoes	204,181	463	2.3	120.4
Cotton	153,218	429	2.8	42.9

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

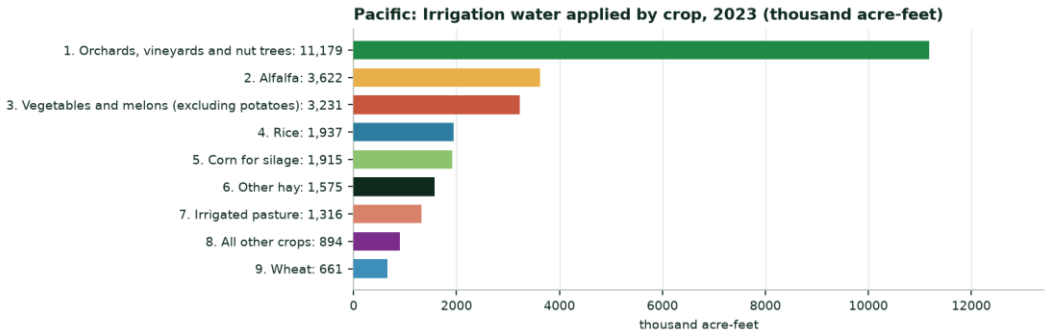


Figure 27. Pacific: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

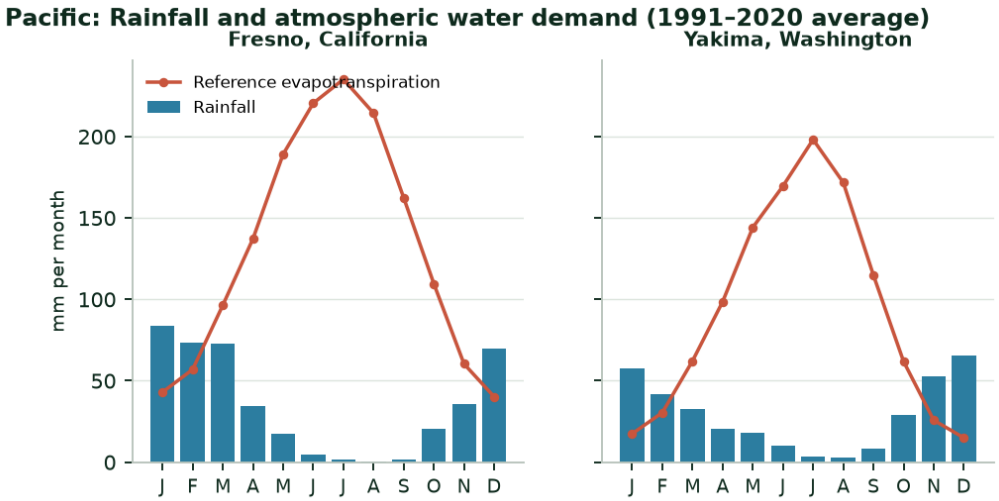


Figure 28. Pacific: Rainfall and reference evapotranspiration at Fresno and Yakima (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Orchards, vineyards and nut trees; alfalfa; vegetables and melons (excluding potatoes). First source of saving in the central scenario: Orchards, vineyards and nut trees (1,117,898 acre-feet per year). With a summer deficit of 593 mm on average at its two stations, the region is among the most exposed in the country.

11.2 Mountain

States: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming.

Almost no crop grows here without irrigation. The Snake River Plain in Idaho grows potatoes, sugar beets, alfalfa and the feed of its dairies. Colorado and Utah irrigate corn, alfalfa and pasture in their valleys; Arizona grows winter vegetables at Yuma, and cotton and alfalfa in its central valleys. The Colorado River and its shortage rules weigh on Arizona and Nevada.

Mountain: Key figures

Indicator	Value	Source (level)
Irrigated acres	11,514,108 acres, 21.7% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	59,153	USDA IWMS 2023 (A6, A)
Irrigation water applied	22,460,014 acre-feet (27.70 bn m³), 27.7% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	1.95 acre-feet	Calculation
Water by source	Wells 32%, off-farm suppliers 52%, on-farm surface water 16%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 54%, gravity 45%, drip 1%	USDA IWMS 2023 (A6, A)
Energy for pumping	$476 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	584,472 acres	USDA IWMS 2023 (A6, A)
Rainfall at Boise / Phoenix	318 mm / 249 mm per year	ERA5-Land (A12, B)
Summer deficit at Boise / Phoenix	588 mm / 680 mm, June to August	ERA5-Land (A12, B)
Radiation at Boise / Phoenix	1,649 / 2,136 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	2,737,606 acre-feet per year, 12% of the region's water, 25.5% of the national saving	Calculation (Annex B)
Range, cautious to strong	1,368,803 to 5,475,213 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	2,204,705 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$1,197.6 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Carrot harvest in Arizona (USDA Natural Resources Conservation Service, public domain).

Mountain: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Idaho	3,180,644	5,407	1.7	37%	82% / 1%	23.35	731.5
Arizona	920,420	3,927	4.3	45%	19% / 10%	37.57	496.7
Colorado	2,367,382	3,741	1.6	33%	53% / 1%	24.12	503.2
Nevada	767,294	2,249	2.9	31%	27% / 3%	8.57	229.1
Utah	985,863	2,221	2.3	34%	60% / 0%	24.24	243.3
Montana	1,561,047	1,879	1.2	3%	45% / 0%	17.90	196.7
Wyoming	1,148,044	1,825	1.6	6%	29% / 0%	18.32	188.2
New Mexico	583,414	1,211	2.1	55%	51% / 2%	24.91	148.9

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

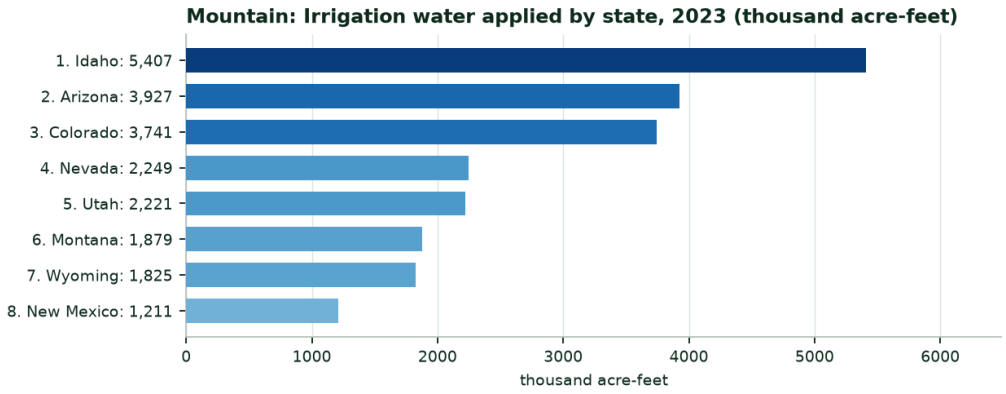


Figure 29. Mountain: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Mountain: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Alfalfa	3,631,941	8,361	2.3	836.1
Irrigated pasture	1,968,357	3,105	1.6	310.5
Other hay	1,644,411	2,619	1.6	261.9
Corn for silage	675,094	1,470	2.2	286.7
Corn for grain	719,817	1,196	1.7	233.2
Wheat	738,330	1,187	1.6	118.7
Barley, oats and other small grains	744,030	1,041	1.4	104.1
Potatoes	404,237	766	1.9	199.1
Vegetables and melons (excluding potatoes)	212,011	606	2.9	183.3
All other crops	290,992	576	2.0	57.6
Cotton	124,329	461	3.7	46.1
Orchards, vineyards and nut trees	118,492	406	3.4	40.6

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

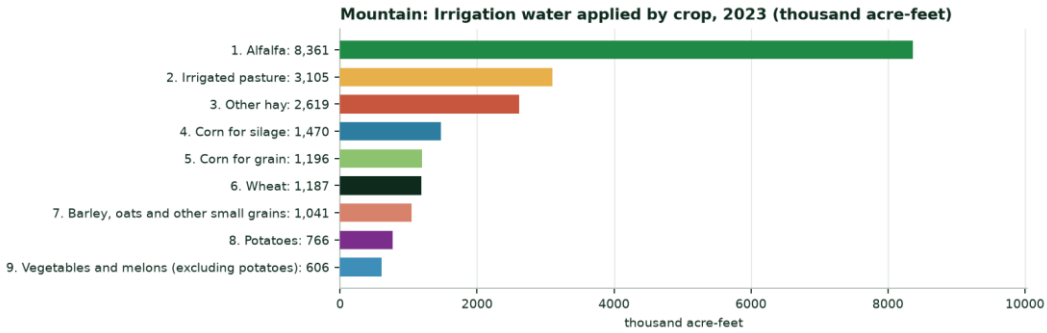


Figure 30. Mountain: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

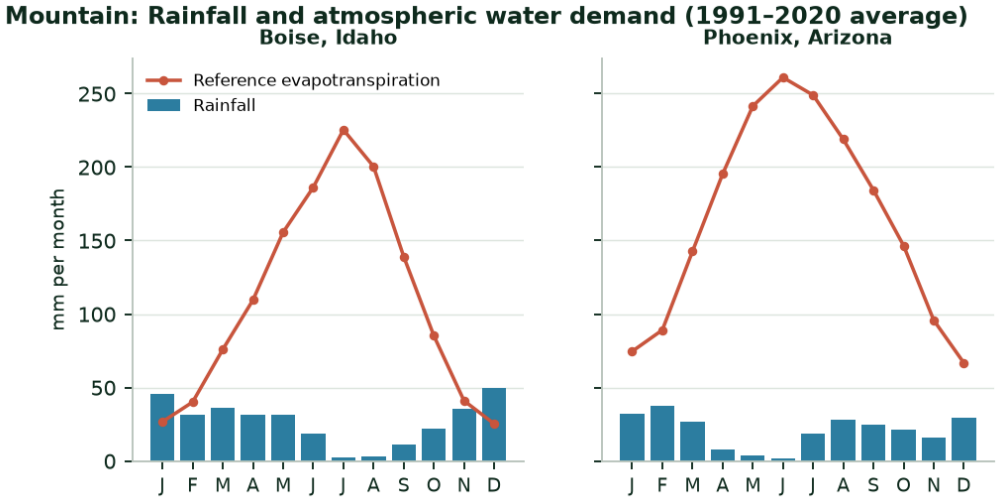


Figure 31. Mountain: Rainfall and reference evapotranspiration at Boise and Phoenix (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Alfalfa; irrigated pasture; other hay. First source of saving in the central scenario: Alfalfa (836,147 acre-feet per year). With a summer deficit of 634 mm on average at its two stations, the region is among the most exposed in the country.

11.3 Northern Plains

States: Kansas, Nebraska, North Dakota and South Dakota.

Nebraska is the most irrigated state east of the Rocky Mountains. Its centre pivots draw on the High Plains (Ogallala) aquifer to grow corn, soybeans and alfalfa. Western Kansas irrigates corn, wheat and sorghum for its feedlots, where the aquifer is falling. The Dakotas irrigate little.

Northern Plains: Key figures

Indicator	Value	Source (level)
Irrigated acres	10,256,245 acres, 19.3% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	19,269	USDA IWMS 2023 (A6, A)
Irrigation water applied	9,809,670 acre-feet (12.10 bn m³), 12.1% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	0.96 acre-feet	Calculation
Water by source	Wells 94%, off-farm suppliers 5%, on-farm surface water 1%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 94%, gravity 5%, drip 1%	USDA IWMS 2023 (A6, A)
Energy for pumping	$504 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	420,889 acres	USDA IWMS 2023 (A6, A)
Rainfall at Grand Island / Garden City	738 mm / 507 mm per year	ERA5-Land (A12, B)

Indicator	Value	Source (level)
Summer deficit at Grand Island / Garden City	247 mm / 418 mm, June to August	ERA5-Land (A12, B)
Radiation at Grand Island / Garden City	1,616 / 1,829 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	1,596,891 acre-feet per year, 16% of the region's water, 14.9% of the national saving	Calculation (Annex B)
Range, cautious to strong	798,446 to 3,193,783 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	2,757,538 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$728.2 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Centre-pivot fields in southwestern Kansas, seen by the ASTER satellite instrument (NASA, June 2001, public domain).

Northern Plains: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Nebraska	7,305,558	6,814	0.9	94%	93% / 0%	72.03	1,128.4
Kansas	2,324,901	2,570	1.1	97%	97% / 1%	35.65	401.1
South Dakota	379,485	258	0.7	74%	97% / 0%	65.28	39.6
North Dakota	246,301	168	0.7	74%	92% / 0%	58.74	27.8

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

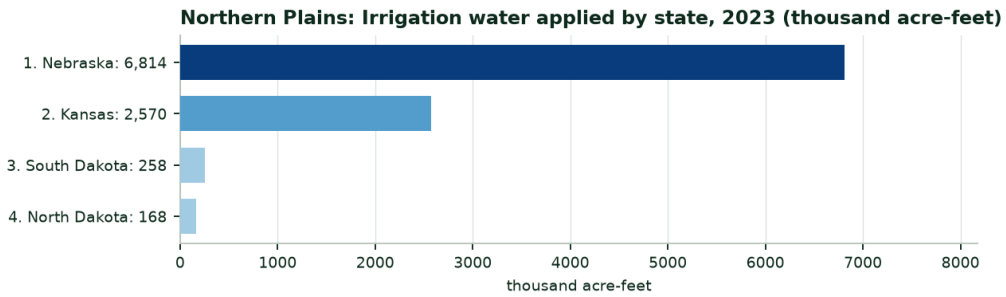


Figure 32. Northern Plains: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Northern Plains: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Corn for grain	5,894,017	6,031	1.0	1,176.0
Soybeans	2,455,317	1,984	0.8	198.4
Alfalfa	418,283	428	1.0	42.8
Wheat	479,302	374	0.8	37.4
Corn for silage	233,992	249	1.1	48.5
Other hay	234,928	212	0.9	21.2
All other crops	125,183	167	1.3	16.7
Sorghum	122,920	109	0.9	10.9
Potatoes	73,882	94	1.3	24.5
Irrigated pasture	84,597	61	0.7	6.1
Dry beans	80,997	54	0.7	5.4
Idle, fallow or failed land	46,046	32	0.7	3.2

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

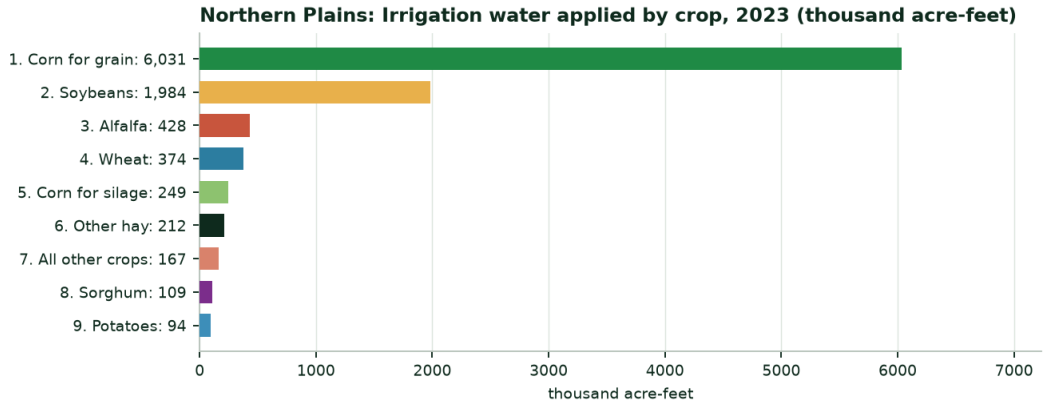


Figure 33. Northern Plains: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

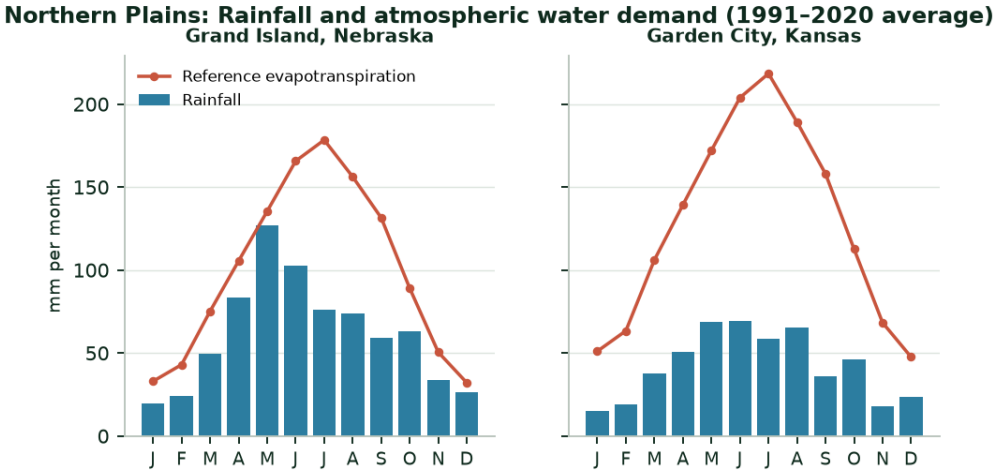


Figure 34. Northern Plains: Rainfall and reference evapotranspiration at Grand Island and Garden City (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Corn for grain; soybeans; alfalfa. First source of saving in the central scenario: Corn for grain (1,176,007 acre-feet per year). With a summer deficit of 332 mm on average at its two stations, the region is in the middle of the country's range.

11.4 Southern Plains

States: Oklahoma and Texas.

The Texas High Plains, around Lubbock and Amarillo, grow cotton, corn, sorghum and wheat on the southern part of the High Plains aquifer, where its level has fallen the most. The Rio Grande Valley grows citrus and vegetables; the Oklahoma panhandle irrigates corn and wheat.

Southern Plains: Key figures

Indicator	Value	Source (level)
Irrigated acres	4,259,912 acres, 8.0% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	12,630	USDA IWMS 2023 (A6, A)
Irrigation water applied	5,264,862 acre-feet (6.49 bn m³), 6.5% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	1.24 acre-feet	Calculation
Water by source	Wells 84%, off-farm suppliers 13%, on-farm surface water 4%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 76%, gravity 12%, drip 12%	USDA IWMS 2023 (A6, A)
Energy for pumping	$318 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	533,351 acres	USDA IWMS 2023 (A6, A)
Rainfall at Lubbock / Weslaco	449 mm / 591 mm per year	ERA5-Land (A12, B)
Summer deficit at Lubbock / Weslaco	524 mm / 437 mm, June to August	ERA5-Land (A12, B)
Radiation at Lubbock / Weslaco	2,008 / 1,925 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	693,165 acre-feet per year, 13% of the region's water, 6.5% of the national saving	Calculation (Annex B)
Range, cautious to strong	346,583 to 1,386,330 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	584,471 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$295.4 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Cotton harvester in a field at Batesville, Texas (USDA, public domain).

Southern Plains: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Texas	3,720,978	4,600	1.2	82%	74% / 13%	91.47	606.6
Oklahoma	538,934	665	1.2	94%	92% / 4%	440.79	86.5

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

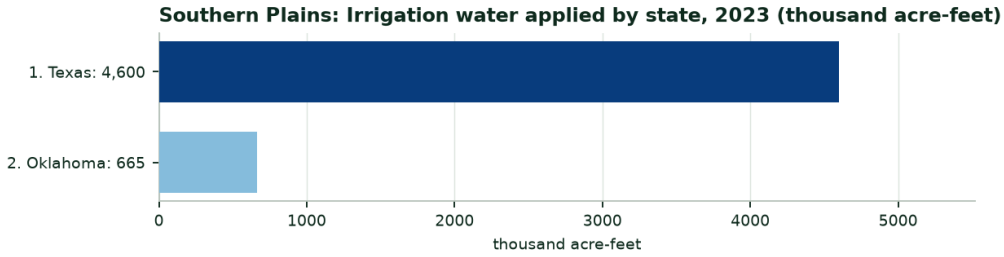


Figure 35. Southern Plains: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Southern Plains: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Cotton	1,056,025	950	0.9	95.0
Corn for grain	648,308	933	1.4	181.9
Other hay	488,067	593	1.2	59.3
Wheat	390,676	441	1.1	44.1
Corn for silage	234,930	412	1.8	80.4
Irrigated pasture	326,286	342	1.0	34.2
Sorghum	232,460	256	1.1	25.6
Idle, fallow or failed land	217,757	234	1.1	23.4
Barley, oats and other small grains	149,302	170	1.1	17.0
Orchards, vineyards and nut trees	64,837	152	2.3	15.2
Rice	62,495	144	2.3	14.4
Alfalfa	73,024	134	1.8	13.4

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

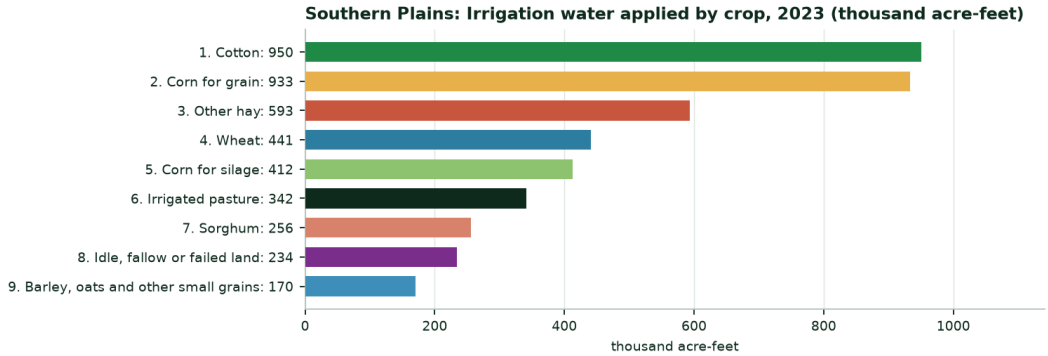


Figure 36. Southern Plains: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

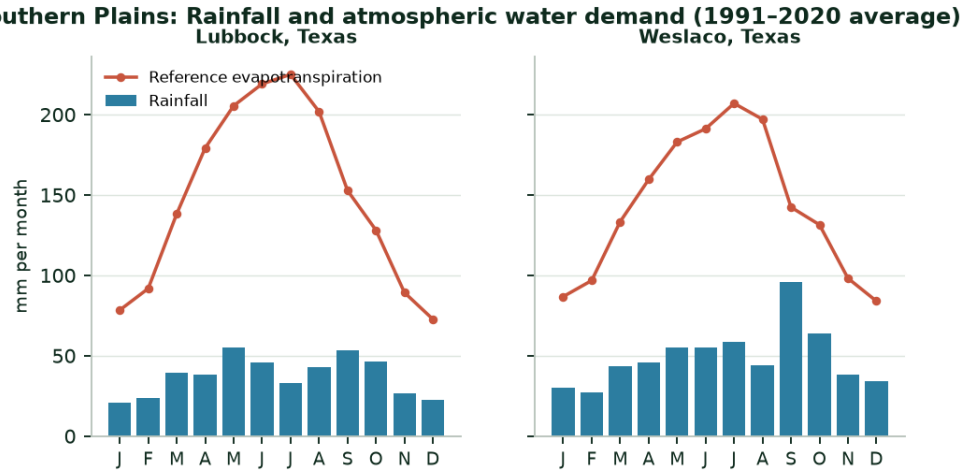


Figure 37. Southern Plains: Rainfall and reference evapotranspiration at Lubbock and Weslaco (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Cotton; corn for grain; other hay. First source of saving in the central scenario: Corn for grain (181,937 acre-feet per year). With a summer deficit of 480 mm on average at its two stations, the region is among the most exposed in the country.

11.5 Corn Belt

States: Illinois, Indiana, Iowa, Missouri and Ohio.

Corn and soybeans are mostly rain-fed. Irrigation is concentrated on sandy soils and river bottoms: The Missouri bootheel (rice, cotton, corn, soybeans), the sands of central Illinois and northern Indiana. There, a centre pivot secures the yield in the dry weeks of July.

Corn Belt: Key figures

Indicator	Value	Source (level)
Irrigated acres	3,036,365 acres, 5.7% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	9,883	USDA IWMS 2023 (A6, A)
Irrigation water applied	2,066,403 acre-feet (2.55 bn m³), 2.6% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	0.68 acre-feet	Calculation
Water by source	Wells 95%, off-farm suppliers 1%, on-farm surface water 4%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 69%, gravity 29%, drip 1%	USDA IWMS 2023 (A6, A)
Energy for pumping	$108 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	50,781 acres	USDA IWMS 2023 (A6, A)
Rainfall at Des Moines / Springfield	944 mm / 1,009 mm per year	ERA5-Land (A12, B)
Summer deficit at Des Moines / Springfield	131 mm / 168 mm, June to August	ERA5-Land (A12, B)
Radiation at Des Moines / Springfield	1,500 / 1,522 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	292,159 acre-feet per year, 14% of the region's water, 2.7% of the national saving	Calculation (Annex B)
Range, cautious to strong	146,079 to 584,317 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	750,085 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$294.2 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Fertiliser applied to a corn field (USDA Natural Resources Conservation Service, public domain).

Corn Belt: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Missouri	1,486,605	1,192	0.8	98%	40% / 1%	381.68	146.2
Illinois	679,401	410	0.6	98%	98% / 2%	383.62	66.9
Indiana	581,477	304	0.5	86%	98% / 1%	324.74	51.6
Iowa	234,886	125	0.5	94%	99% / 1%	1,229.00	21.7
Ohio	53,996	35	0.7	62%	83% / 16%	232.46	5.7

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

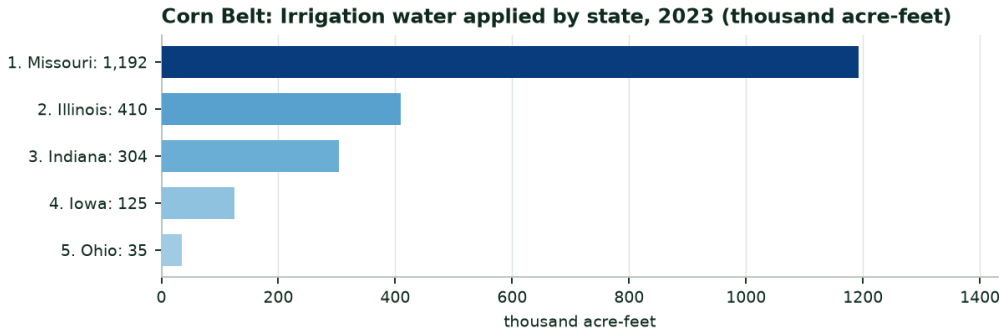


Figure 38. Corn Belt: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Corn Belt: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Corn for grain	1,266,601	799	0.6	155.7
Soybeans	1,157,054	709	0.6	70.9
Cotton	273,892	219	0.8	21.9
Rice	122,248	183	1.5	18.3
Nursery and horticulture	32,501	34	1.0	3.4
Other irrigated land (not itemised)	—	30	—	3.0

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Vegetables and melons (excluding potatoes)	53,610	28	0.5	8.5
All other crops	26,645	16	0.6	1.6
Wheat	46,885	15	0.3	1.5
Potatoes	14,367	13	0.9	3.3
Corn for silage	17,841	8	0.5	1.6
Peanuts	11,840	7	0.6	0.7

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

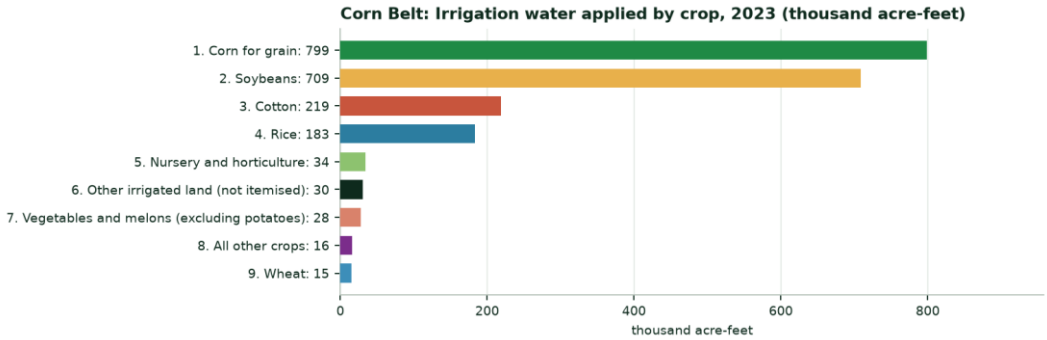


Figure 39. Corn Belt: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

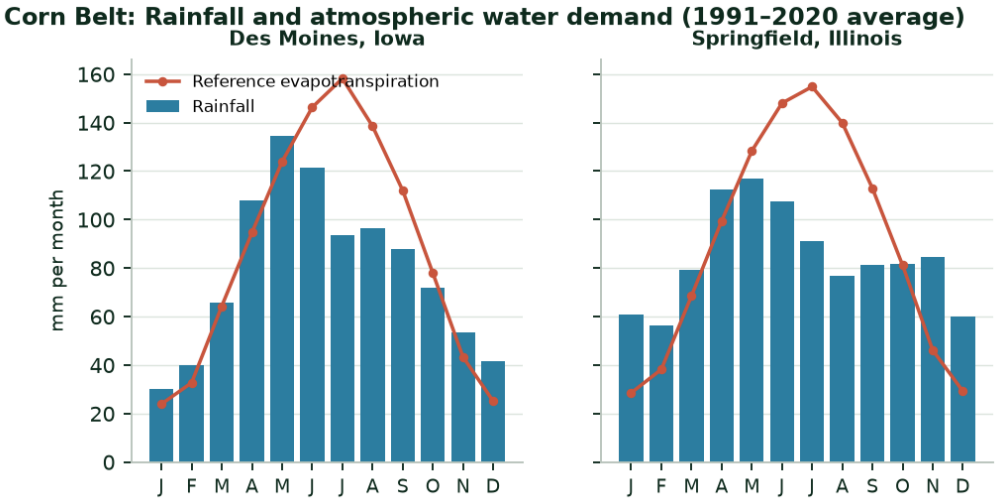


Figure 40. Corn Belt: Rainfall and reference evapotranspiration at Des Moines and Springfield (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Corn for grain; soybeans; cotton. First source of saving in the central scenario: Corn for grain (155,708 acre-feet per year). With a summer deficit of 150 mm on average at its two stations, the region is among the least exposed in the country.

11.6 Lake States

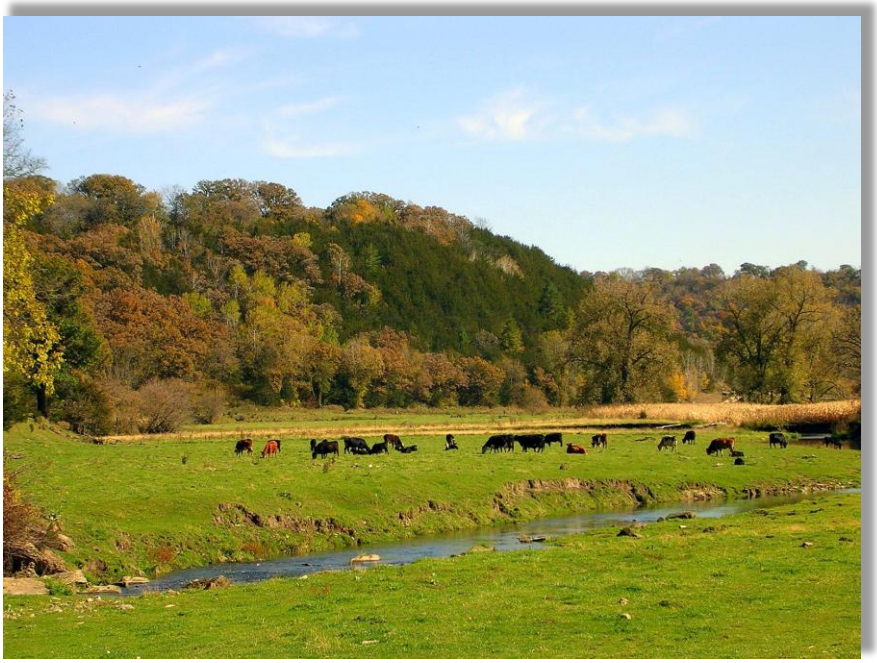
States: Michigan, Minnesota and Wisconsin.

Dairy farms, corn and soybeans, mostly rain-fed. Irrigation waters sandy soils: The Central Sands of Wisconsin (potatoes, vegetables, sweet corn), central Minnesota and southwest Michigan (seed corn, vegetables). Sandy soils hold little water, which favours water retainers.

Lake States: Key figures

Indicator	Value	Source (level)
Irrigated acres	1,784,573 acres, 3.4% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	9,762	USDA IWMS 2023 (A6, A)
Irrigation water applied	1,251,724 acre-feet (1.54 bn m³), 1.5% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	0.70 acre-feet	Calculation
Water by source	Wells 85%, off-farm suppliers 3%, on-farm surface water 12%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 95%, gravity 1%, drip 4%	USDA IWMS 2023 (A6, A)
Energy for pumping	$78 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	47,987 acres	USDA IWMS 2023 (A6, A)
Rainfall at Stevens Point / Saint Paul	834 mm / 834 mm per year	ERA5-Land (A12, B)
Summer deficit at Stevens Point / Saint Paul	121 mm / 120 mm, June to August	ERA5-Land (A12, B)
Radiation at Stevens Point / Saint Paul	1,408 / 1,397 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	218,558 acre-feet per year, 17% of the region's water, 2.0% of the national saving	Calculation (Annex B)
Range, cautious to strong	109,279 to 437,115 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	1,339,016 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$763.1 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Cattle grazing in Fillmore County, Minnesota (public domain).

Lake States: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Wisconsin	480,561	440	0.9	83%	97% / 1%	57.69	81.3
Michigan	746,242	418	0.6	82%	91% / 9%	2,301.05	70.6
Minnesota	557,770	393	0.7	92%	98% / 0%	936.69	66.7

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

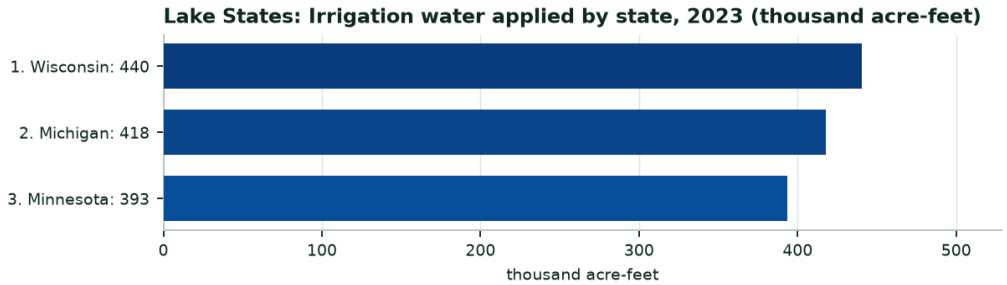


Figure 41. Lake States: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Lake States: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Corn for grain	736,614	493	0.7	96.1
Soybeans	330,781	199	0.6	19.9
Vegetables and melons (excluding potatoes)	235,061	120	0.5	36.2
Potatoes	151,914	119	0.8	30.9
Berries	42,384	90	2.1	9.0
Corn for silage	67,421	43	0.6	8.3
Alfalfa	62,442	36	0.6	3.6
Dry beans	49,302	36	0.7	3.6
Nursery and horticulture	39,713	33	0.8	3.3
All other crops	20,262	29	1.4	2.9
Orchards, vineyards and nut trees	23,414	14	0.6	1.4
Wheat	30,821	13	0.4	1.3

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

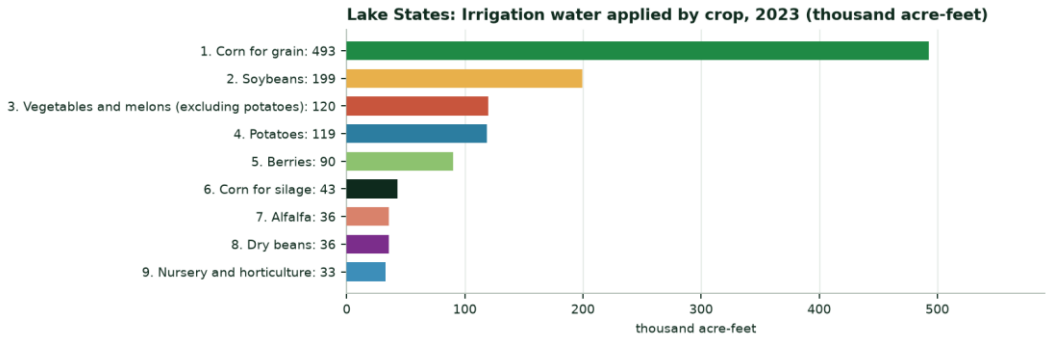


Figure 42. Lake States: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

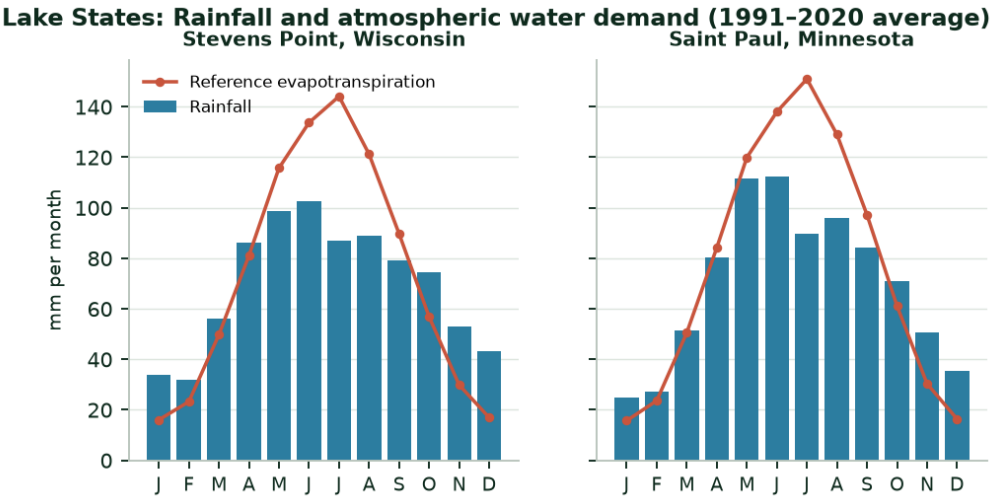


Figure 43. Lake States: Rainfall and reference evapotranspiration at Stevens Point and Saint Paul (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Corn for grain; soybeans; vegetables and melons (excluding potatoes). First source of saving in the central scenario: Corn for grain (96,059 acre-feet per year). With a summer deficit of 120 mm on average at its two stations, the region is among the least exposed in the country.

11.7 Delta States

States: Arkansas, Louisiana and Mississippi.

The Mississippi Delta grows rice, soybeans, corn and cotton, irrigated by flooding and furrows. Most of the water comes from the Mississippi River Valley alluvial aquifer, whose level is falling in eastern Arkansas. Louisiana also grows sugarcane.

Delta States: Key figures

Indicator	Value	Source (level)
Irrigated acres	7,664,672 acres, 14.4% of the country	USDA IWMS 2023 (A6, A)
Farms that irrigate	6,387	USDA IWMS 2023 (A6, A)
Irrigation water applied	8,034,841 acre-feet (9.91 bn m³), 9.9% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	1.05 acre-feet	Calculation
Water by source	Wells 89%, off-farm suppliers 1%, on-farm surface water 10%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 9%, gravity 91%, drip 0%	USDA IWMS 2023 (A6, A)
Energy for pumping	$274 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	81,648 acres	USDA IWMS 2023 (A6, A)
Rainfall at Stuttgart / Greenville	1,245 mm / 1,297 mm per year	ERA5-Land (A12, B)
Summer deficit at Stuttgart / Greenville	243 mm / 222 mm, June to August	ERA5-Land (A12, B)
Radiation at Stuttgart / Greenville	1,706 / 1,758 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	926,682 acre-feet per year, 12% of the region's water, 8.6% of the national saving	Calculation (Annex B)
Range, cautious to strong	463,341 to 1,853,364 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	871,940 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$335.1 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Rice field in Clay County, Arkansas (CC0).

Delta States: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Arkansas	4,645,925	5,166	1.1	88%	8% / 0%	27.24	592.7
Mississippi	1,713,175	1,466	0.9	95%	13% / 0%	173.45	174.5
Louisiana	1,305,572	1,403	1.1	85%	6% / 0%	882.55	159.4

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

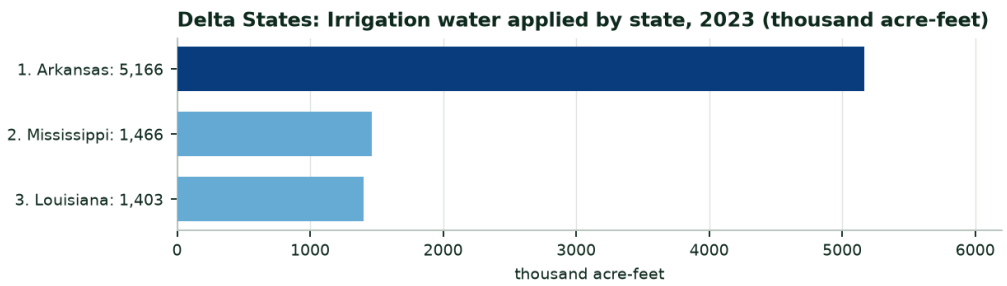


Figure 44. Delta States: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Delta States: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Rice	1,645,983	3,267	2.0	326.7
Soybeans	3,934,317	3,109	0.8	310.9
Corn for grain	1,444,258	1,222	0.8	238.4
Cotton	522,779	427	0.8	42.7
All other crops	50,228	35	0.7	3.5
Peanuts	24,235	17	0.7	1.7
Nursery and horticulture	13,512	9	0.7	0.9
Other hay	9,078	6	0.6	0.6
Irrigated pasture	5,414	2	0.4	0.2
Sorghum	3,492	2	0.6	0.2

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Berries	3,010	1	0.5	0.1
Orchards, vineyards and nut trees	2,774	1	0.5	0.1

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

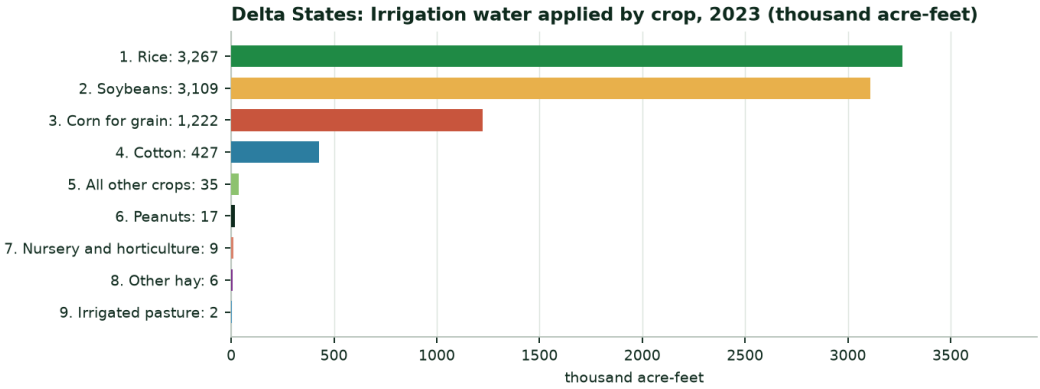


Figure 45. Delta States: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

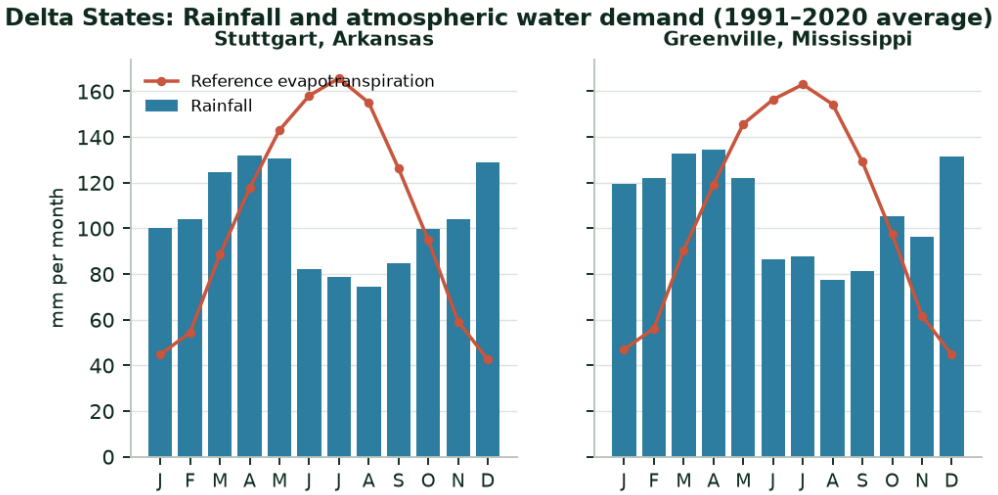


Figure 46. Delta States: Rainfall and reference evapotranspiration at Stuttgart and Greenville (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Rice; soybeans; corn for grain. First source of saving in the central scenario: Rice (326,725 acre-feet per year). With a summer deficit of 232 mm on average at its two stations, the region is in the middle of the country's range.

11.8 Southeast

States: Alabama, Florida, Georgia and South Carolina.

Southwest Georgia irrigates peanuts, cotton and corn with centre pivots supplied by the Floridan aquifer. Florida irrigates citrus, vegetables, sugarcane and nurseries; South Carolina and Alabama irrigate to complete the rain on sandy soils.

Southeast: Key figures

Indicator	Value	Source (level)
Irrigated acres	2,357,456 acres, 4.4% of the country (figure withheld for Alabama and South Carolina)	USDA IWMS 2023 (A6, A)
Farms that irrigate	14,339	USDA IWMS 2023 (A6, A)

Indicator	Value	Source (level)
Irrigation water applied	2,738,369 acre-feet (3.38 bn m³), 3.4% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	1.05 acre-feet (states with published acres)	Calculation
Water by source	Wells 73%, off-farm suppliers 13%, on-farm surface water 15%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 63%, gravity 16%, drip 21%	USDA IWMS 2023 (A6, A)
Energy for pumping	$152 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	39,444 acres	USDA IWMS 2023 (A6, A)
Rainfall at Tifton / Immokalee	1,048 mm / 1,185 mm per year	ERA5-Land (A12, B)
Summer deficit at Tifton / Immokalee	119 mm / -179 mm, June to August	ERA5-Land (A12, B)
Radiation at Tifton / Immokalee	1,819 / 1,887 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	365,782 acre-feet per year, 13% of the region's water, 3.4% of the national saving	Calculation (Annex B)
Range, cautious to strong	182,891 to 731,565 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	639,099 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$517.9 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Orange grove in Florida (CC0).

Southeast: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Georgia	1,221,632	1,299	1.1	83%	90% / 9%	229.64	185.1
Florida	1,135,824	1,178	1.0	60%	26% / 36%	42.15	142.3
South Carolina	—	147	0.8	88%	89% / 11%	2,315.31	23.5
Alabama	—	114	0.7	61%	96% / 2%	55.52	14.8

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

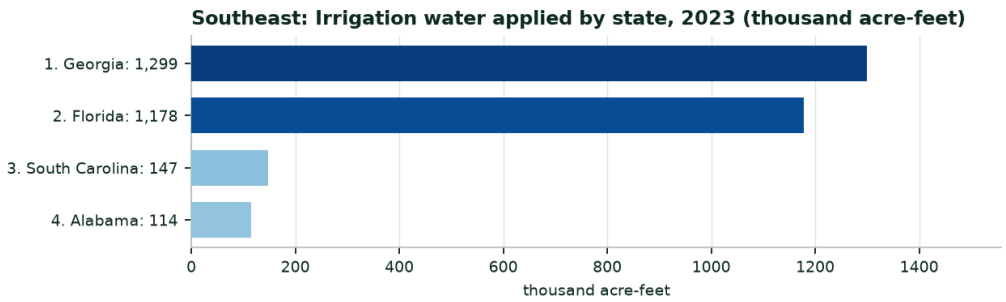


Figure 47. Southeast: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Southeast: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Orchards, vineyards and nut trees	478,964	546	1.1	54.6
Corn for grain	422,409	425	1.0	82.8
Peanuts	385,421	392	1.0	39.2
Cotton	390,993	350	0.9	35.0
All other crops	382,547	265	0.7	26.5
Nursery and horticulture	161,730	249	1.5	24.9
Vegetables and melons (excluding potatoes)	183,713	223	1.2	67.4
Other hay	49,154	59	1.2	5.9
Wheat	38,825	44	1.1	4.4
Berries	31,837	39	1.2	3.9
Soybeans	78,225	35	0.4	3.5
Corn for silage	18,965	30	1.6	5.9

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

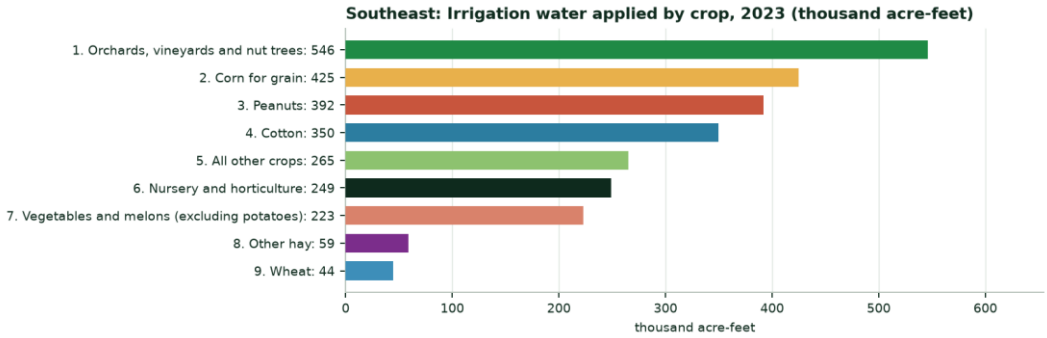


Figure 48. Southeast: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

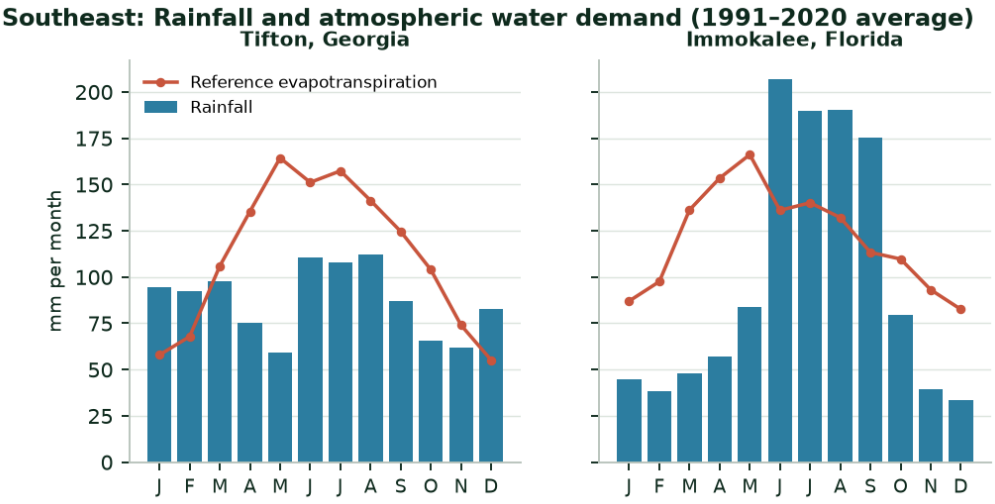


Figure 49. Southeast: Rainfall and reference evapotranspiration at Tifton and Immokalee (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Orchards, vineyards and nut trees; corn for grain; peanuts. First source of saving in the central scenario: Corn for grain (82,802 acre-feet per year). With a summer deficit of -30 mm on average at its two stations, the region is among the least exposed in the country.

11.9 Appalachian

States: Kentucky, North Carolina, Tennessee, Virginia and West Virginia.

Tobacco, vegetables, nurseries, soybeans and corn. Most crops are rain-fed; irrigation completes the rain for vegetables, nurseries, Christmas trees and some row crops in the dry weeks of summer.

Appalachian: Key figures

Indicator	Value	Source (level)
Irrigated acres	406,602 acres, 0.8% of the country (figure withheld for Virginia)	USDA IWMS 2023 (A6, A)
Farms that irrigate	7,471	USDA IWMS 2023 (A6, A)
Irrigation water applied	281,164 acre-feet (0.35 bn m³), 0.3% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	0.61 acre-feet (states with published acres)	Calculation
Water by source	Wells 57%, off-farm suppliers 6%, on-farm surface water 37%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 93%, gravity 1%, drip 6%	USDA IWMS 2023 (A6, A)
Energy for pumping	$23 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	19,680 acres	USDA IWMS 2023 (A6, A)
Rainfall at Raleigh / Lexington	1,163 mm / 1,214 mm per year	ERA5-Land (A12, B)
Summer deficit at Raleigh / Lexington	97 mm / 115 mm, June to August	ERA5-Land (A12, B)
Radiation at Raleigh / Lexington	1,658 / 1,533 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	44,473 acre-feet per year, 16% of the region's water, 0.4% of the national saving	Calculation (Annex B)
Range, cautious to strong	22,237 to 88,947 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	199,717 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$137.4 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.



Christmas tree farm in Alleghany County, North Carolina (CC0).

Appalachian: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
North Carolina	150,265	120	0.8	48%	91% / 9%	277.98	17.8
Tennessee	173,528	81	0.5	91%	95% / 4%	198.31	13.9
Kentucky	81,034	45	0.5	51%	97% / 3%	177.22	6.8
Virginia	—	34	0.6	15%	90% / 10%	1,256.00	5.8
West Virginia	1,775	1	0.5	54%	39% / 52%	157.09	0.2

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.

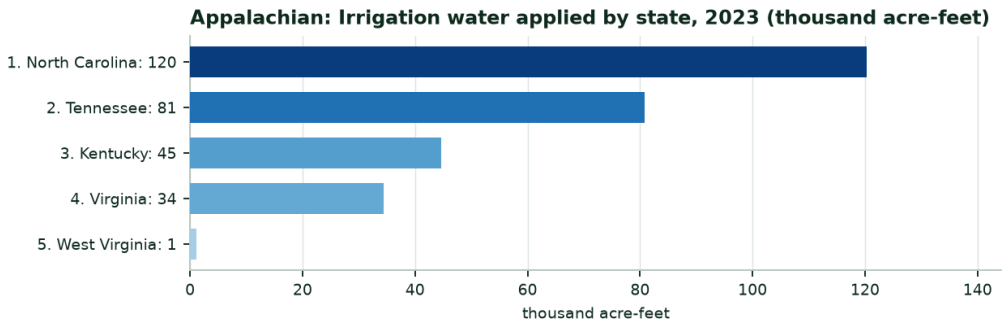


Figure 50. Appalachian: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Appalachian: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Corn for grain	156,122	72	0.5	13.9
Nursery and horticulture	34,288	46	1.3	4.6
Soybeans	113,126	40	0.4	4.0
Vegetables and melons (excluding potatoes)	48,724	39	0.8	11.7
Cotton	43,030	20	0.5	2.0
Wheat	14,510	16	1.1	1.6
Berries	14,113	12	0.9	1.2

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Peanuts	7,258	9	1.3	0.9
Other hay	7,831	8	1.0	0.8
Corn for silage	4,774	6	1.2	1.1
Other irrigated land (not itemised)	—	5	—	0.5
Potatoes	6,000	4	0.7	1.1

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

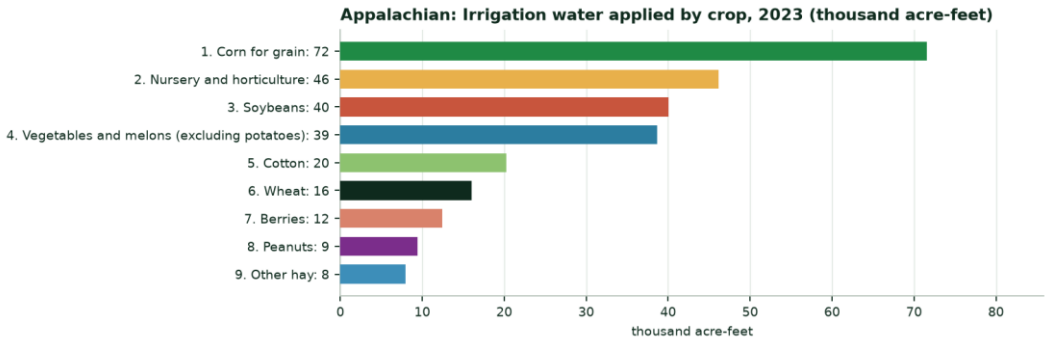


Figure 51. Appalachian: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

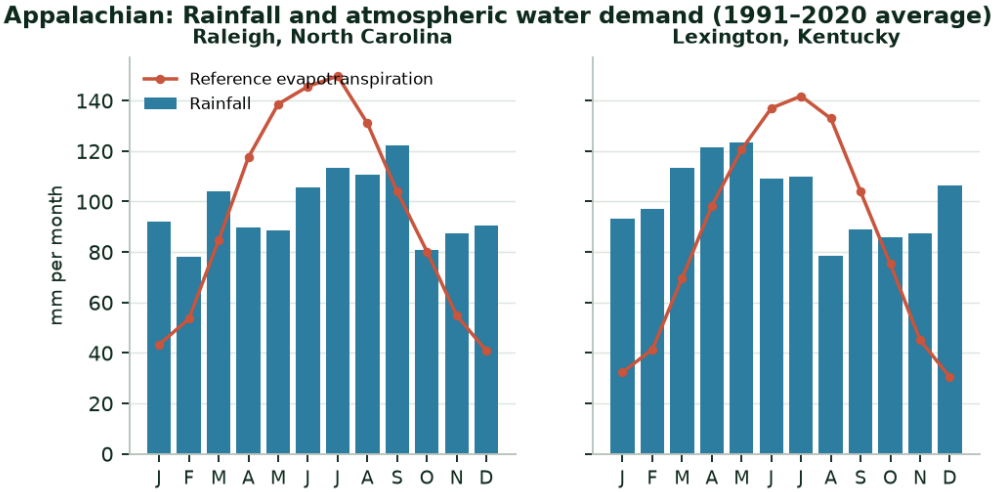


Figure 52. Appalachian: Rainfall and reference evapotranspiration at Raleigh and Lexington (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Corn for grain; nursery and horticulture; soybeans. First source of saving in the central scenario: Corn for grain (13,949 acre-feet per year). With a summer deficit of 106 mm on average at its two stations, the region is among the least exposed in the country.

11.10 Northeast

States: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont.

Dairy farms, vegetables, orchards and nurseries, and potatoes in Maine. Irrigation is concentrated on the Delmarva peninsula (corn, soybeans, vegetables), in New Jersey and in the vegetable and fruit areas of New York and Pennsylvania.

Northeast: Key figures

Indicator	Value	Source (level)
Irrigated acres	152,335 acres, 0.3% of the country (figure withheld for Delaware, Maine, Maryland, Massachusetts and Rhode Island)	USDA IWMS 2023 (A6, A)
Farms that irrigate	10,898	USDA IWMS 2023 (A6, A)
Irrigation water applied	258,612 acre-feet (0.32 bn m³), 0.3% of the country	USDA IWMS 2023 (A6, A)
Water per irrigated acre	0.58 acre-feet (states with published acres)	Calculation
Water by source	Wells 70%, off-farm suppliers 5%, on-farm surface water 24%	USDA IWMS 2023 (A6, A)
Irrigation methods (acres)	Sprinkler 79%, gravity 3%, drip 18%	USDA IWMS 2023 (A6, A)
Energy for pumping	$46 million in 2023	USDA IWMS 2023 (A6, A)
Acres hit by interrupted irrigation	14,367 acres	USDA IWMS 2023 (A6, A)
Rainfall at Harrisburg / Albany	1,064 mm / 1,116 mm per year	ERA5-Land (A12, B)
Summer deficit at Harrisburg / Albany	144 mm / 84 mm, June to August	ERA5-Land (A12, B)
Radiation at Harrisburg / Albany	1,459 / 1,381 kWh/m² per year	PVGIS (A11, A)
Water saved, central scenario	42,581 acre-feet per year, 16% of the region's water, 0.4% of the national saving	Calculation (Annex B)
Range, cautious to strong	21,290 to 85,161 acre-feet per year	Calculation (Annex B)
Extra production, central scenario	227,266 tonnes per year	Calculation (Annex B)
Annual value, central scenario	$166.8 million (water at $94 per acre-foot and yield)	Calculation (Annex B)

Source: See the « Source » column.

Northeast: State by state

State	Irrigated acres	Water (thousand af)	Af per acre	From wells	Sprinkler / drip	Off-farm water ($/af)	Saved, central (thousand af/yr)
Delaware	—	86	0.6	93%	97% / 3%	—	15.2
Maryland	—	63	0.5	77%	91% / 9%	905.00	10.0
New Jersey	69,373	38	0.6	79%	67% / 26%	132.67	6.1
New York	47,118	23	0.5	51%	43% / 52%	581.13	3.6
Pennsylvania	28,104	19	0.7	28%	45% / 51%	170.30	3.6
Massachusetts	—	13	0.7	12%	63% / 18%	353.21	1.5
Maine	—	5	0.3	37%	89% / 10%	605.00	1.0
Connecticut	3,645	5	1.2	18%	48% / 50%	1,204.09	0.7
Rhode Island	—	3	0.8	40%	80% / 12%	1,902.99	0.3
Vermont	2,330	3	1.1	24%	28% / 48%	—	0.4
New Hampshire	1,765	1	0.6	25%	59% / 32%	583.33	0.2

Source: USDA IWMS 2023 (A6); calculation by the author (Annex B). « — »: Figure withheld or not applicable.



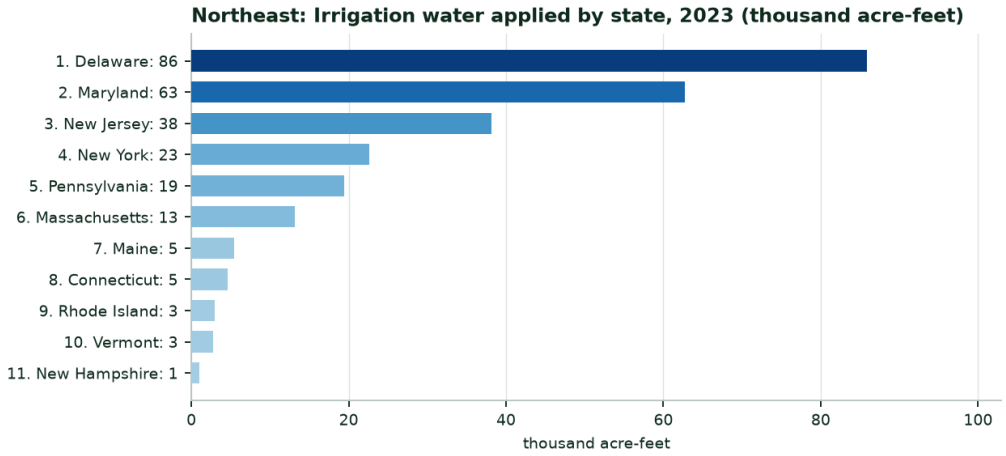


Figure 53. Northeast: Irrigation water applied by state, 2023 (thousand acre-feet). Source: USDA IWMS (A6)

Northeast: Water by crop and central saving

Crop	Irrigated acres	Water (thousand af)	Af per acre	Saved, central (thousand af/yr)
Corn for grain	135,327	73	0.5	14.2
Nursery and horticulture	62,568	44	0.7	4.4
Vegetables and melons (excluding potatoes)	61,575	43	0.7	13.0
Soybeans	94,375	42	0.4	4.2
Berries	37,688	19	0.5	1.9
Orchards, vineyards and nut trees	21,433	12	0.5	1.2
Other irrigated land (not itemised)	—	6	—	0.6
All other crops	11,594	5	0.4	0.5
Wheat	18,425	4	0.2	0.4
Potatoes	8,531	4	0.4	1.0
Corn for silage	5,139	3	0.7	0.7
Idle, fallow or failed land	2,983	3	1.0	0.3

Source: USDA IWMS 2023 (A6), table 39; crops withheld in a state are estimated from the national water per acre; calculation by the author.

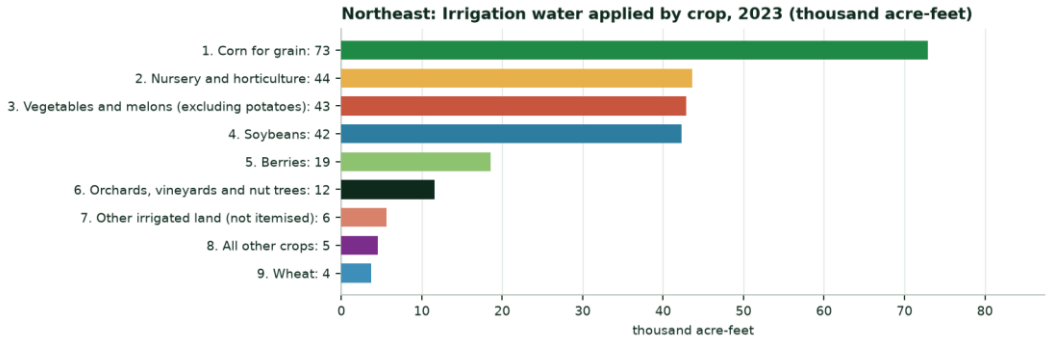


Figure 54. Northeast: Irrigation water applied by crop, 2023 (thousand acre-feet). Source: USDA IWMS (A6)



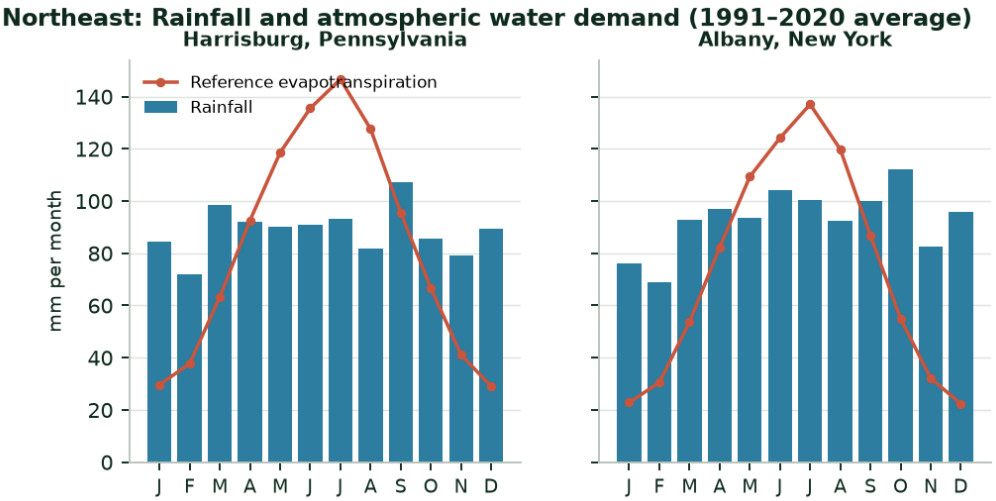


Figure 55. Northeast: Rainfall and reference evapotranspiration at Harrisburg and Albany (mm, 1991–2020 average). Source: ERA5-Land (A12); calculation by the author

Crops that receive the most water: Corn for grain; nursery and horticulture; vegetables and melons (excluding potatoes). First source of saving in the central scenario: Corn for grain (14,211 acre-feet per year). With a summer deficit of 114 mm on average at its two stations, the region is among the least exposed in the country.

12. Limits and points to complete

What remains to be completed

• **Water by crop**: The survey withholds some figures to protect individual farms. When a crop's water per acre is withheld in a state, the calculation uses the national average for that crop.

• **Unitemised water**: Where the water of the listed crops falls short of the state total, the difference is counted as « other irrigated land » with the generic assumption.

• **Climate**: Two stations per region, taken from a reanalysis model with a grid of about 9 km; they do not describe a whole region.

• **Price of water**: Three reference values frame the average price of purchased water; water rights and drought-year market prices in the West are not priced.

• **Fertilisers**: International prices, not the prices paid by American farmers.

• **Trials**: No trial of our products has yet been published on irrigated crops in the United States; all results are scenarios.

Annex A. Sources and confidence levels

List of sources

Ref.	Source	Publisher or author	Vintage	Level	Link or reference
A1	World Development Indicators (WDI)	World Bank	2021–2025	A	api.worldbank.org
A2	Crop production (QCL)	FAO, FAOSTAT	2023	A	fao.org/faostat
A3	Trade in agricultural products (TCL)	FAO, FAOSTAT	2021–2024	A	fao.org/faostat
A4	Land use (RL)	FAO, FAOSTAT	2010–2023	A	fao.org/faostat

Ref.	Source	Publisher or author	Vintage	Level	Link or reference
A5	Fertilisers by nutrient (RFN)	FAO, FAOSTAT	2010–2024	A	fao.org/faostat
A6	2023 Irrigation and Water Management Survey; 2022 Census of Agriculture	USDA, National Agricultural Statistics Service	2022–2023	A	nass.usda.gov
A7	Value of agricultural production (QV)	FAO, FAOSTAT	2023	A	fao.org/faostat
A8	Farm production regions	USDA, Economic Research Service	—	A	ers.usda.gov
A9	Water-level and recoverable water in storage changes, High Plains aquifer, predevelopment to 2019 (SIR 2023-5143)	US Geological Survey	2023	A	pubs.usgs.gov
A10	Colorado River shortage declaration for 2022; Arizona fact sheet	Bureau of Reclamation; Arizona Department of Water Resources	2021	A	usbr.gov; azwater.gov
A11	PVGIS 5.2, monthly radiation	European Commission, JRC	2005–2020	A	re.jrc.ec.europa.eu/pvg_tools
A12	ERA5-Land reanalysis, daily rainfall and evapotranspiration	European Centre (ECMWF), via Open-Meteo	1991–2020	B	open-meteo.com
A13	Commodity Price Data (Pink Sheet)	World Bank	2019–2024	A	worldbank.org/commodities
A14	Fifth National Climate Assessment, chapter 2	US Global Change Research Program	2023	A	nca5.globalchange.gov
A15	Administrative boundaries	Natural Earth (public domain)	Version 5	A	naturalearthdata.com
A20	Date palms, Dubai	ICBA	2020–2021	B	Green Solutions website, trials
A21	Watermelons, Hermosillo (Mexico)	Green Solutions	2023	C	Green Solutions website, trials
A22	Maize, Konya (Turkey)	Green Solutions, D.I.S. and TIGEM	2025	C	Green Solutions website, trials
A23	Potatoes, Bloemfontein (South Africa)	Afrinest Farm Group	2025–2026	C	Green Solutions website, trials
A24	Soybean, Shandong (China)	Shandong Institute of Soil and Fertiliser	Undated	B	Green Solutions website, trials
A25	ECOFERT® certificate	SOHISCERT	Current	A	Green Solutions website
A26	Claimed performance, doses and uses	Green Solutions	2026	C	Green Solutions website
A27	Calculations in this dossier	Author of the dossier	—	—	Annex B
A28	Photographs	NASA, USDA and Wikimedia Commons contributors	—	—	Public domain or CC0, commons.wikimedia.org

Annex B. Calculation method

Radiation. Sum of the monthly horizontal radiation values from PVGIS, divided by the number of years, at each of the twenty stations.

Rainfall and evapotranspiration. 1991–2020 averages of the daily ERA5-Land values at each station; summer deficit = reference evapotranspiration minus rainfall, June to August.

Irrigation water. Water applied in the open from all sources in 2023 (USDA IWMS, table 7): 80,937,415 acre-feet nationally, and the same figure for each state.

Water by crop. Irrigated acres harvested × average acre-feet applied per acre, for each crop and each state (table 39). Vegetables = all vegetables minus potatoes. When a state's water per acre is withheld, the national value for the crop is used. Water not itemised = state total minus the sum of the crops.

Water saved. Water of the crop × water saving of the scenario.

Yield gain. Irrigated acres × 0.405 × national yield 2023 (FAOSTAT) × gain of the scenario.

Value created. Water saved in acre-feet × value of water ($54.22, $94.48 or $150) + yield gain × implicit 2023 price (value of production ÷ production).

Scenarios. Cautious: 25% of the trial effect. Central: 50%. Strong: Published effect. Crops without a trial: 5%, 10% and 20% water saving, without yield gain.

Regions. Sum of the states of each USDA farm production region; Alaska and Hawaii are counted in the Pacific region.

Fertiliser spending. Nitrogen ÷ 0.46 × urea price + phosphate ÷ 0.46 × TSP price + potash ÷ 0.60 × potassium chloride price, at World Bank international prices. It is a lower bound.

General limits. One coefficient per crop; national yields and prices; no product cost is included in the calculations of the dossier.



Green Solutions

contact@green-solutions-group.com green-solutions-group.com