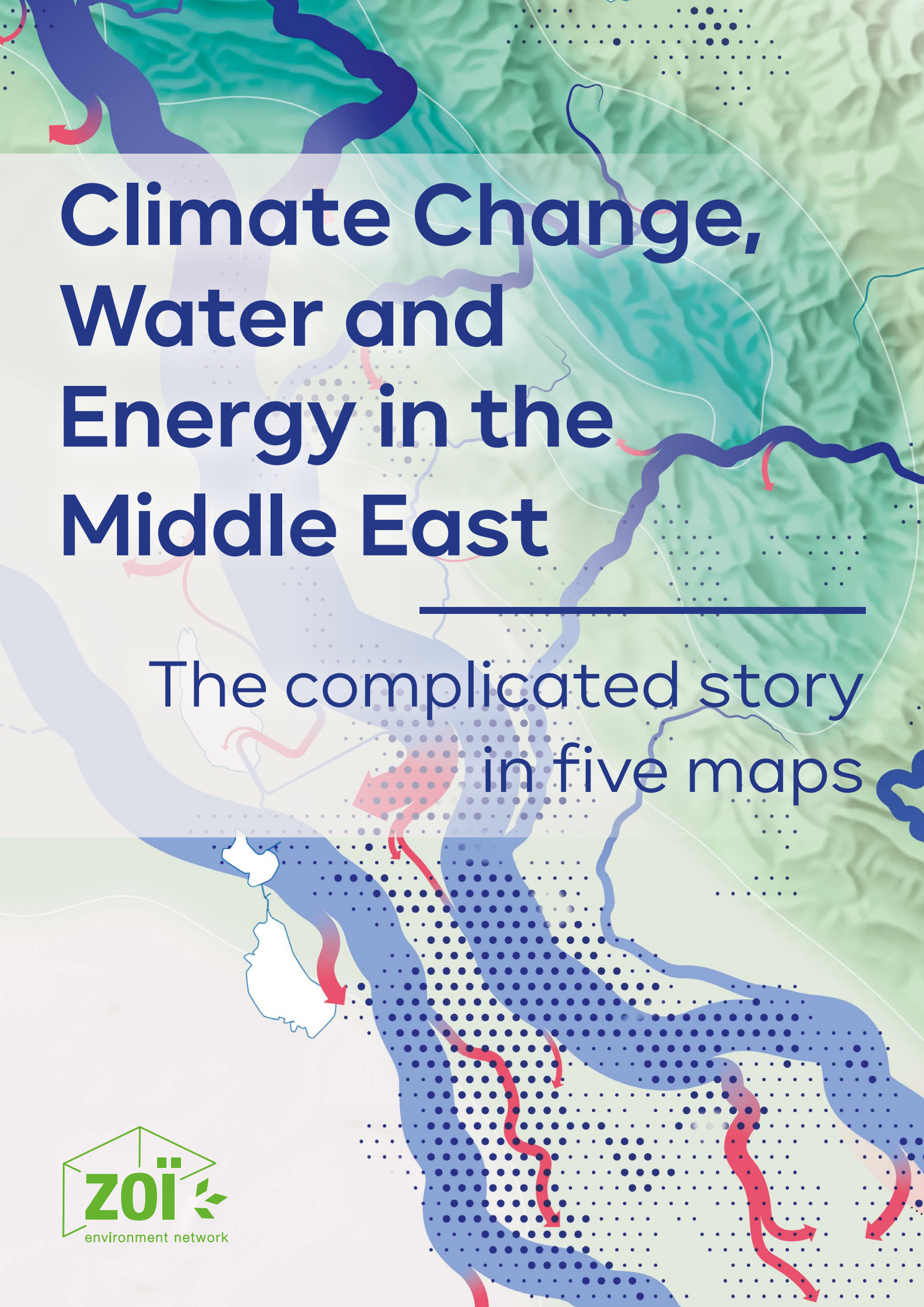
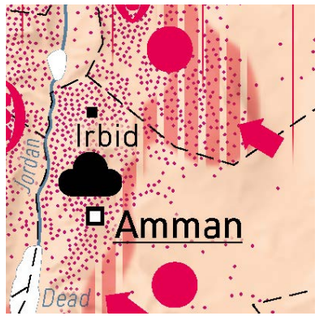
# Climate Change, Water and Energy in the Middle East

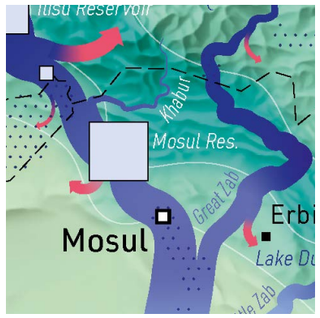
## The complicated story in five maps



zoï environment network




**01.**
Climate Change Impacts
... p.4 ...




**02.**
Surface Water
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**03.**
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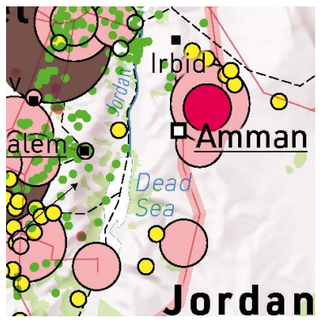


**04.**
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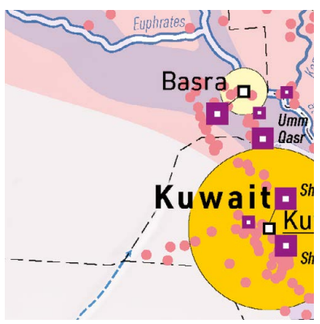


**05.**
Economic Activity and Trade
... p.20 ...

Our intended audience for this work is a bit different from our usual audience of scientists, government officials and a handful of lay readers with interests in environmental information. This time we are targeting map-lovers, aficionados (who do exist!), and all sorts of experts, scholars, politicians, dictators, autodidacts, artists, traders, students, cranks, and whatnot, or anyone, really, who is simply interested in geography or geopolitics. Whoever you are, dear readers, we encourage you to dive into these Zoï maps and discover things for yourselves.

For once, we want to put cartographer Matthias Beilstein at center stage. His maps, crafted with Swiss precision, may actually look a notch too complex and filigreed for instant consumption and indeed they are far from the fast food, "You-are-here" maps you see in shopping centers. Like a good meal, they are composed of many carefully balanced quality ingredients, but Matthias never loses sight of the overall aesthetics and content of the maps. These maps will reward you for the time you spend with them, and for our purpose here we have chosen to print them in a larger format.

In the Middle East — an already fragile region of ongoing conflicts — climate change is exacerbating pressures on resources. Rising temperatures, changes in precipitation patterns, and extreme weather events are increasing the risks to the livelihoods of almost half a billion people. The maps in this collection — Climate Change Impacts, Surface Water, Groundwater, Energy, and Economic Activity and Trade — provide the basis for exploring the relationships among these elements in the Water-Energy-Food-Environment nexus.

In the complex geopolitical situation of the Middle East, the environmental and climate change challenges have no simple solutions. But Zoï believes that an understanding of the geographic situation and the multifaceted forces at work will enable stakeholders at all levels to contribute to constructive solutions. We hope these maps meet our readers' expectations by shedding light on the profound challenges that lie ahead.

Zoï Environment Network, Geneva, 10 January 2025

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01.

# Climate Change Impacts

While the world aims to limit global warming to 1.5°C, much of the Middle East is already grappling with temperature increases of 2°C to 3°C. The projected temperature increases in Damascus and Adana reach up to 5°C and 6°C respectively by 2070. Temperature spikes compounded by more frequent heatwaves pose a direct threat to public health and water security, especially in densely populated areas.

Significant temperature increases and changing precipitation patterns across the region are changing ecosystem services and creating cascading impacts that threaten the food, water and energy security of the region. Desertification is particularly evident in Iraq and Syria but looms over the whole region, and is expected to reduce the availability of already limited arable land, further straining food security and hurting agriculture-dependent economies. Particularly striking is the appearance of the Fertile Crescent turning into a desert on the margins. Reduced river flow and rising temperatures may also disrupt fish populations, directly affecting food security and the local economies reliant on these resources. Coastal areas, such as Kuwait City and Adana, are vulnerable to sea-level rise, and are expecting increased flooding.

Water and food insecurity, compounded by extreme weather events and natural disasters, can displace populations and increase competition for resources, the results of which could create or exacerbate conflicts and fragility. This dynamic was a significant factor in the Syrian Civil War, where mass displacement from rural areas to cities contributed to urban unemployment and social unrest.

**Precipitation**
Global Precipitation Climatology Centre (GPCC), GPCC Landsurface Monitoring Monthly Product 1.0°

**Temperature**
GISS Surface Temperature Analysis (v4)

**Diagram temperature change and shift of climate zones**
National Geographic
Köppen-Geiger Global 1-km climate classification map GloH20

**Climate change impacts**
IPCC, Sixth Assessment Report

# Climate Change Impacts

Türkiye
Syria
Iraq
Iran
Lebanon
Israel
Palestine
Jordan
Egypt
Cyprus
Kuwait
Saudi Arabia
Armenia
Azerbaijan

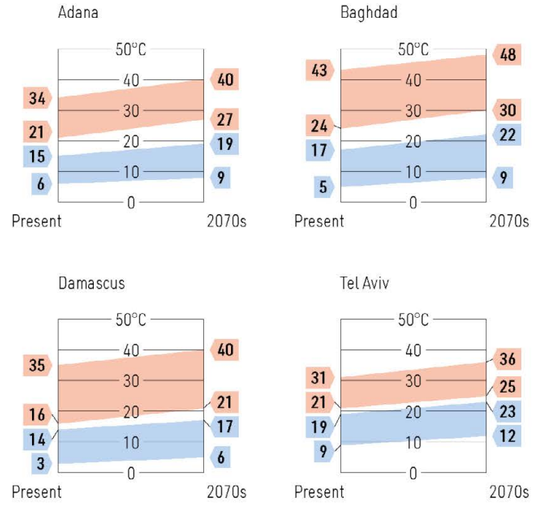
Black Sea
Caspian Sea
Mediterranean Sea
Red Sea
Persian Gulf
Syrian Desert
Anatolia
Taurus Mountains
Zagros Mountains
Euphrates
Tigris
Orontes
Jordan
Dead Sea
Lake Van
Lake Urmia
Lake Assad
Lake Qadisiyah
Lake Tharthar
Lake Habbaniyah
Lake Razazah
Keban Res.
Karakaya Res.
Atatürk Res.
Tishreen Reservoir
Mosul Res.
Little Zab
Karkheh
Karun
Shatt al-Arab

Samsun
Trabzon
Kars
Yerevan
Baku
Sivas
Erzurum
Kayseri
Konya
Adana
Mersin
Gaziantep
Diyarbakir
Van
Tabriz
Urmia
Rasht
Tehran
Qom
Arak
Sanliurfa
Mardin
Mosul
Erbil
Sulaymaniya
Kirkuk
Hamadan
Kermanshah
Ahvaz
Basra
Bushehr
Jubail
Dammam
Gulf of Alexandretta
Antakya
Aleppo
Latakia
Homs
Tripoli
Nicosia
Beirut
Damascus
Irbid
Amman
Tel Aviv
Hadera
Jerusalem
Port Said
Suez
Aqaba
Sharm el-Sheikh
Tabuk
Hail
Sakakah
Baghdad
Karbala
Najaf
Kuwait City

24
26
28

## Maximum temperatures in selected cities, worst case scenario

Winter
Summer




## Climate change

Anomaly of the period 2013 to 2022 compared to the period 1951 to 2000

Temperature difference in °C

1.8 2.0 2.2 2.4 2.6 2.8

Precipitation difference

More

Less

## Potential climate change impacts

- Ecosystem changes in mountain areas
- More extreme weather patterns
- Increase of heat waves and droughts
- Impacts on farming and livestock
- Impacts on aquatic ecosystems and fishery
- Risk of sea level events
- Expansion of desert climate zone, worst case scenario

## Other elements

- State borders
- Population density

0 100 km

Map produced by Zoi Environment Network, January 2025

# 02.

# Surface Water

The Middle East is largely dependent on transboundary rivers such as the Tigris and Euphrates to provide water for agriculture, industry, and domestic use. But climate change in the mountains is increasing temperatures and the rate of evaporation, disrupting precipitation patterns, and reducing the snowpack across the Taurus and Zagros mountains where the Tigris and Euphrates originate. The resulting changes in the timing and volume of river flows can create a doom loop where decreased water availability limits energy generation, exacerbates drought conditions, and both reduces the recharge of, and increases the demand for, groundwater.

In the absence of transboundary water management agreements, upstream dams, particularly in Türkiye, have significantly reduced downstream water flows, compounding the problems associated with water shortages for downstream users. In the Basra basin, increasing sandstorms and saltwater intrusion have diminished freshwater availability and quality in an area where limited precipitation falls far below the limit for rain-fed agriculture. Desalination is an expensive proposition, and is currently an option only for the stronger economies of Kuwait, Saudi Arabia and Israel.

Long-term unsustainable water diversions and efforts to improve national water security have reduced the Jordan River, a source of many conflicts among its riparian states, to a mere creek. As a primary source for the Dead Sea, the Jordan River now lacks the water flow necessary to sustain the sea, which is in danger of evaporating.

As these dynamics play out across the region, traditional agriculture may lose productivity, livelihoods may suffer, and communities may need to further deplete groundwater for agricultural and domestic use. Concerns that water and food insecurity and competition for limited resources might intensify regional conflicts are well placed.

**River discharge**
HydroRIVERS, HydroSHEDS
Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems; Lehner, B., Grill G. in Hydrological Processes (2013)
Water Resources of Iraq, Nadhir Al-Ansari (2021)
Water Resources of the Euphrates River Catchment. Nadhir Al-Ansari, Nasrat Adamo, Varoujan Sissakian, Sven Knutsson, Jan Laue (2018)
Expected Future of Water Resources within Tigris-Euphrates Rivers Basin, Iraq. Issa Issa, Nadhir Al-Ansari, Govand Sherwani, Sven Knutsson (2014)

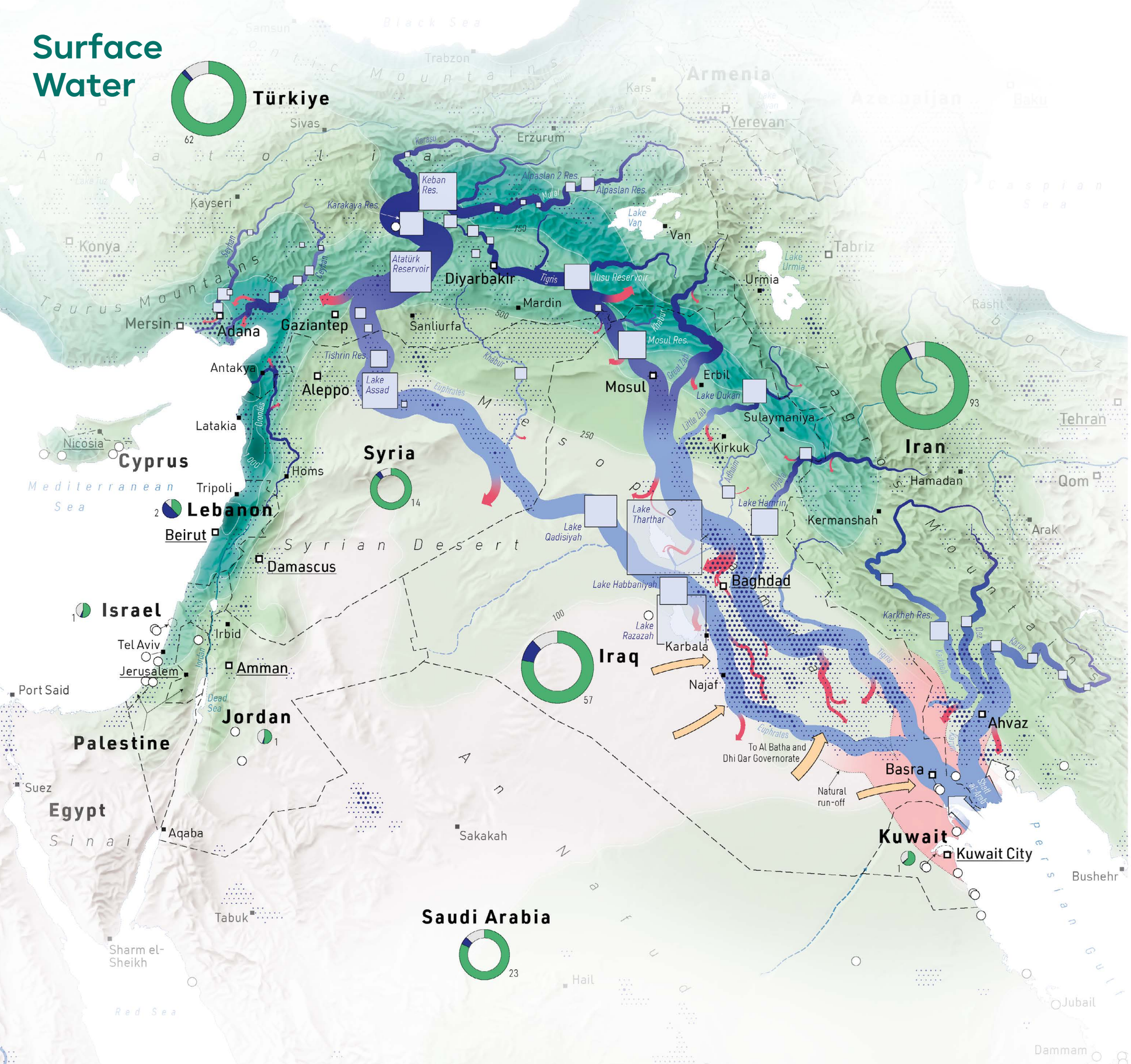
**Precipitation**
WorldClim

**Irrigation**
Aquastat, FAO

**Non-revenue water**
Quantifying the Global Non-Revenue Water Problem, R Liemberger, A Wyatt (2018)

**Desalination plants**
Tableau Public; Erin Otwell (2023)

# Surface Water




## Surface water in the Middle East

Water abstraction

River run-off

100 200 400 800

Average river run-off ($m^3/s$)

## Irrigated areas

25 to 50 percent of total area

More than 50 percent of total area

## Surface area of major reservoirs and lakes

2 000 $km^2$

1 000

500

250

100

## Precipitation

Annual average precipitation (mm)

100 250 500 750 1 000

Limit for rainfed agriculture

## Water consumption by sector 2020, billion $m^3$

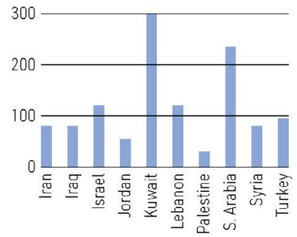
Agriculture

Industry

Domestic

50 20 10 5 2 1

## Water consumption per capita (litre/day)




## Other elements

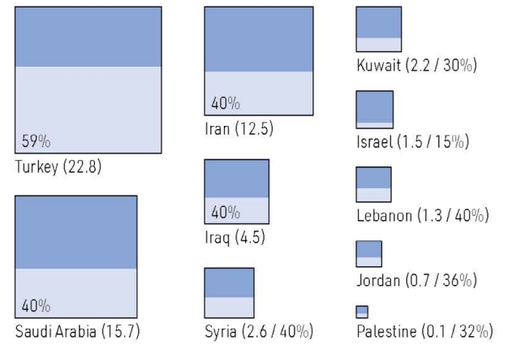
Desalination plant

Salt water intrusion

High occurance of sand storms

State borders

## Water system input volume (million $m^3$/day) and non-revenue water (percent) *




** The water system input volume refers to the volume of water that enters a water supply system. Non-revenue water is water that has been produced and is "lost" before it reaches the customer.*

0 100 km

Map produced by Zoi Environment Network, January 2025

# 03.

# Groundwater

In areas such as the Jordan Valley and the Arabian Peninsula, where rivers and lakes can no longer meet the water demands of agriculture, industry, and growing populations, groundwater serves as the critical, often sole, source of fresh water. The reduced river flows downstream of dams in Türkiye, compounded by population density and industrial demand, drive the rapid extraction of groundwater in the Tigris-Euphrates basin. The pie charts show — as is the case almost everywhere on Earth — the predominance of water use in agriculture; thus possible solutions will need to give high priority to how we produce food.

With regions of intensive oil production coinciding with areas of low surface water and groundwater, the water-intensive processes of oil drilling, extraction, and refinement place additional demands on groundwater resources. Drilling often leads to groundwater and soil contamination, further reducing the availability of fresh water for irrigation and drinking, and creating health risks.

The continued pressure on groundwater resources poses long-term sustainability challenges, especially in areas with limited recharge potential. This depletion could be particularly alarming in transboundary aquifers, where uncoordinated extraction can lead to conflicts between neighbouring countries over dwindling water supplies.

**Transboundary aquifers**
IGRAC (International Groundwater Resources Assessment Centre), 2021. Transboundary Aquifers of the World [map]. Scale 1 : 50 000 000

**Groundwater Resources of the World**
World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP), Groundwater Resources of the World 1:25,000,000

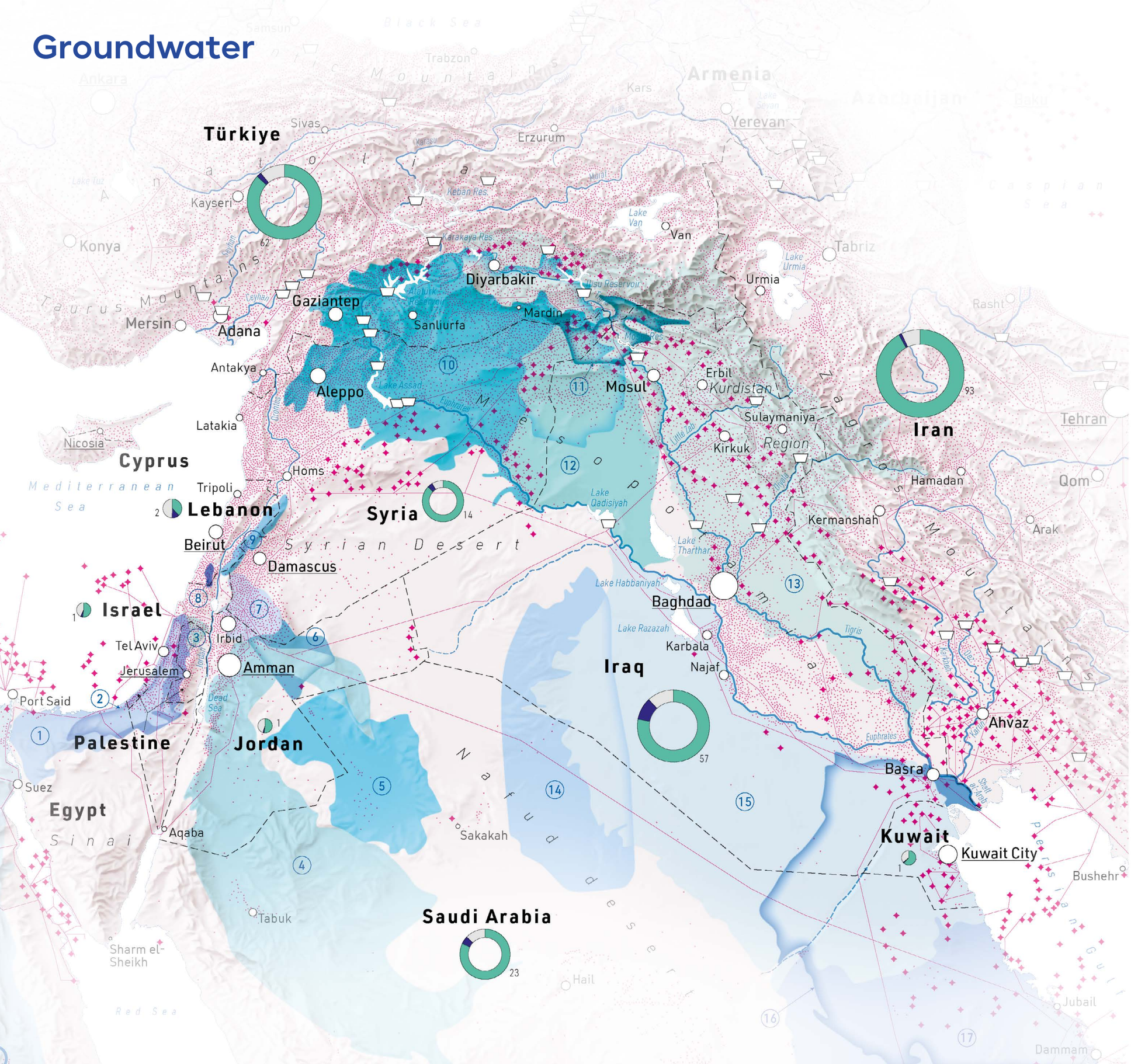
**Desalination plants**
Tableau Public; Erin Otwell (2023)

**Water use**
World Bank, World Development Indicators

**Oil and gas**
Mapstand. Location Data for Energy Transition and Energy Infrastructure

**Population**
United Nations Population Division

# Groundwater




## Transboundary Water Resources in the Middle East

Transboundary aquifers

1. Coastal Aquifer Basin
2. Western Aquifer Basin
3. Northeastern Aquifer
4. Saq-Ram Aquifer System (West)
5. Tawil Quaternary Aquifer System: Wadi Sirhan Basin
6. Basalt Aquifer System (South): Azraq-Dhuleil Basin
7. Basalt Aquifer System (West): Yarmouk Basin
8. Ecocene Aquifer
9. Anti-Lebanon
10. Jezira Tertiary Limestone Aquifer System
11. Upper Jezira
12. Neogene Aquifer System (North-West): Upper and Lower Fars
13. Taurus-Zagros
14. Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba
15. Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman
16. Neogene Aquifer System (South-East): Dibdibba-Kuwait Group
17. Umm er Radhuma-Dammam Aquifer System (Centre): Gulf

## Other elements

- Major hydropower plant
- Gas or oil production and exploration area
- Gas or oil pipeline
- State borders
- Regional borders
- Population density

## Water consumption by sector 2020, billion m³

- Agriculture
- Industry
- Domestic

50, 20, 10, 5, 2, 1

## City population in million, latest available data

5, 2, 1, 0.5, 0.2, 0.1

## Country population in million, 2022 (2000 in grey and figures in brackets)

- Iran 89 (66)
- Turkey 85 (64)
- Iraq 45 (25)
- Saudi Arabia 36 (22)
- Syria 22 (16)
- Jordan 11 (5)
- Israel 9 (6)
- Lebanon 5 (4)
- Palestine 5 (3)
- Kuwait 4 (2)

0 100 km

Map produced by Zoi Environment Network, January 2025

# 04.

# Energy

The Middle East relies heavily on fossil fuels, particularly oil and gas, and significant clusters of energy infrastructure are concentrated in areas with critical groundwater reserves where intensive energy extraction is depleting water resources. The offshore drilling in coastal regions also brings the risks of oil spills and the degradation of marine ecosystems with far-reaching effects on biodiversity and on local communities reliant on fishing.

Some parts of the region, particularly Türkiye and Israel, rely on coal for power plants that are significant contributors to carbon emissions and air and water pollution. This fossil fuel reliance is expected to exacerbate environmental degradation and increase public health risks across the region, and diminishing water resources may be insufficient to meet the cooling needs at thermal plants.

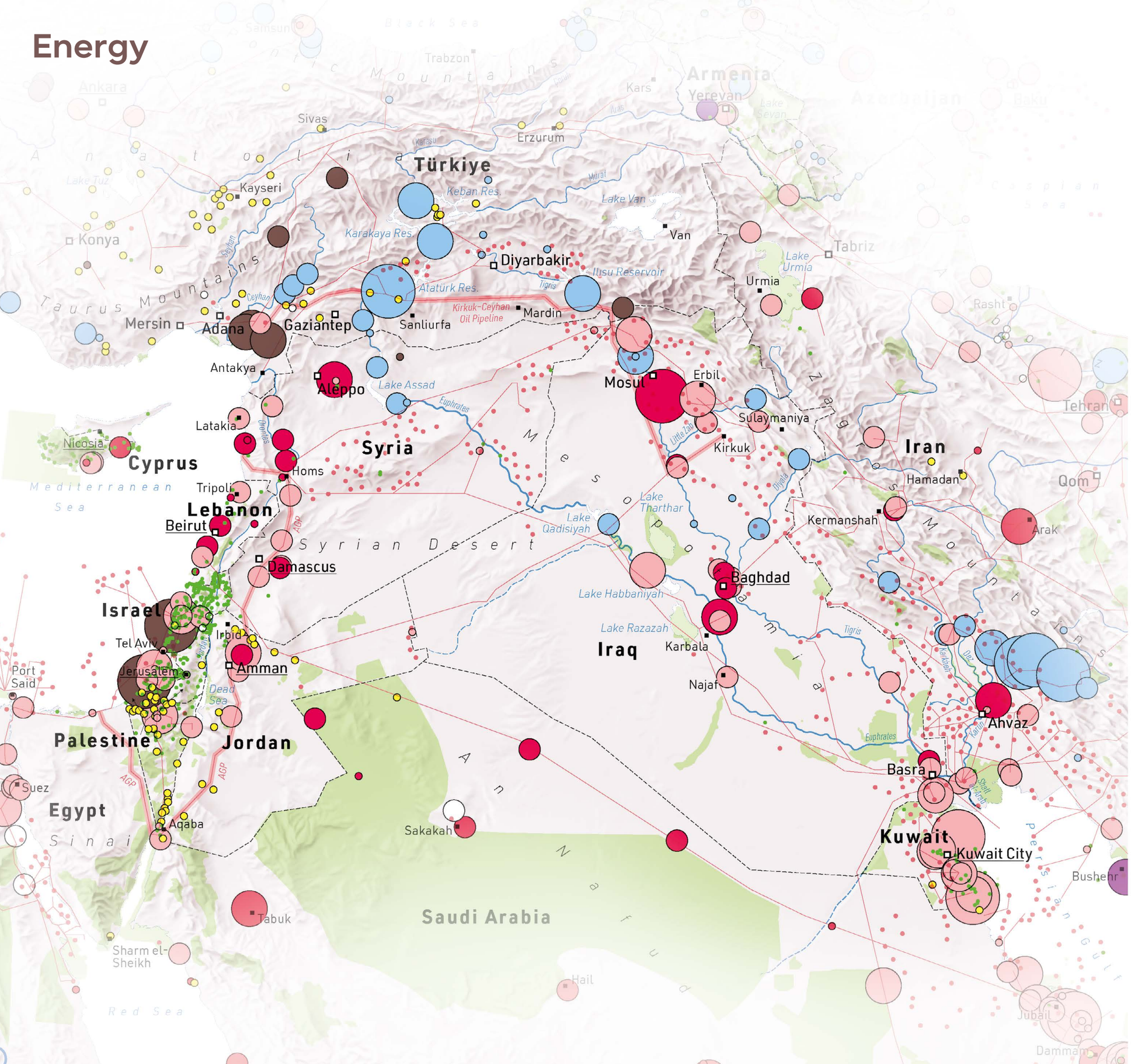
Hydropower is the region's key renewable energy source in the effort to mitigate environmental degradation and enhance resilience, but hydropower can become increasingly unreliable due to increased evaporation and reduced river flows, particularly in areas downstream of major dams. The potential of solar and wind energy in the region is vast.

**Power plants**
Mapstand. Location Data for Energy Transition and Energy Infrastructure

**Energy production**
United Nations Statistics

**Protected areas**
The Protected Planet Initiative

# Energy




## Power plants *

- Coal
- Oil
- Gas
- Hydro
- Solar
- Wind
- Nuclear

- Less than 200 MW
- 200–1 000 MW
- 1 000–2 000 MW
- More than 2 000 MW

** Coverage may contain gaps; installed capacity, if available*

## Other elements

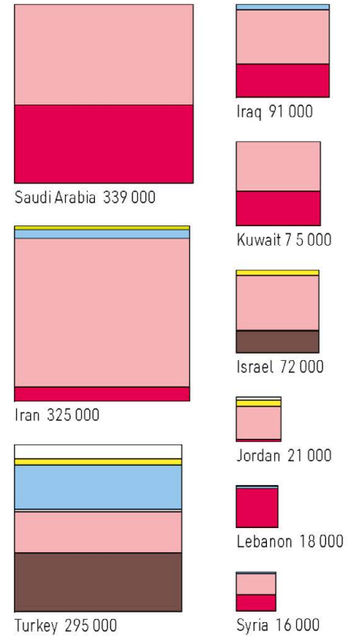
- Gas or oil production and exploration area
- Gas or oil pipeline
- Prominent gas or oil pipeline
- State borders

## Protected areas

- Larger than 100 km²
- Smaller than 100 km²

## Electricity production by sector 2020, million kilowatt-hours

- Coal
- Oil
- Gas
- Hydro
- Solar
- Wind
- Nuclear
- Other




0 100 km

Map produced by Zoi Environment Network, January 2025

05

# Economic Activity and Trade

The economies in the Middle East, particularly in Saudi Arabia, Kuwait, and Iraq, depend heavily on oil and gas exports, and these economies may struggle to adapt without significant shifts towards sustainable and varied activities.

The trade connections across the region are extensive with a high potential for growth. Connectivity can offer a critical opportunity for regional cooperation by facilitating the sharing of resources, technology, and knowledge, and by enabling the region to collectively address challenges within the Water-Energy-Food-Environment nexus. Economic power, however, is unevenly distributed across the region. Countries with stronger economies, such as Saudi Arabia and the UAE, may have greater capacity to adapt and mitigate the impacts of climate change, while less wealthy nations and those that are fragile may struggle.

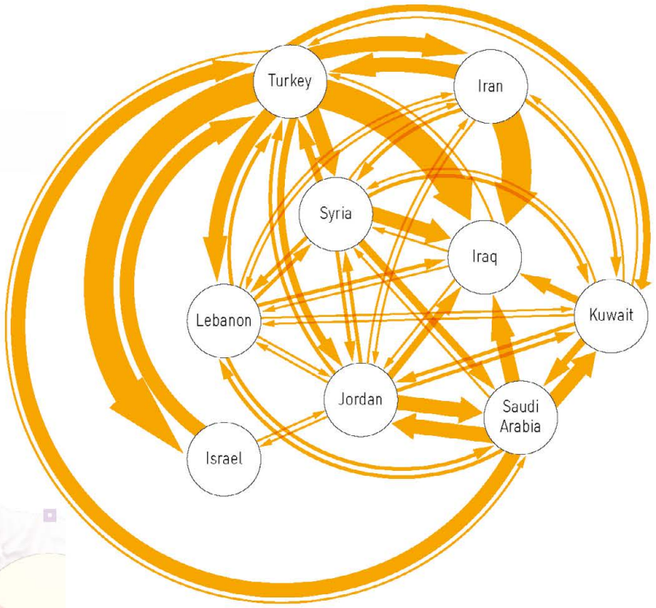
**Ports**
World Port Source

**Transport corridors**
Global Maritime Traffic
OpenStreetMap

**GDP per capita**
World Bank, World Development Indicators

**Trade**
World Integrated Trade Solution (WITS)

# Economic Activity and Trade



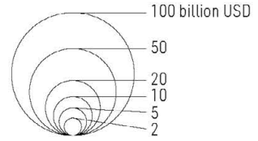

**Exports in the Middle east, million USD, latest available data ***

- Less than 100 million
- 100 to 500 million
- 500 million to 1 billion
- 1 to 5 billion
- More than 5 billion

** Iran (2018), Iraq (2014), Israel (2021), Jordan (2021), Kuwait (2021), Lebanon (2021), Saudi Arabia (2021), Syria (2010), Turkey (2021)*

**Economic power of major cities, purchasing power parity (USD), 2022**

Gross domestic product per city




Gross domestic product per capita

- More than 50 000 USD
- 20 000 to 50 000
- 10 000 to 20 000
- Less than 10 000

**Economy**

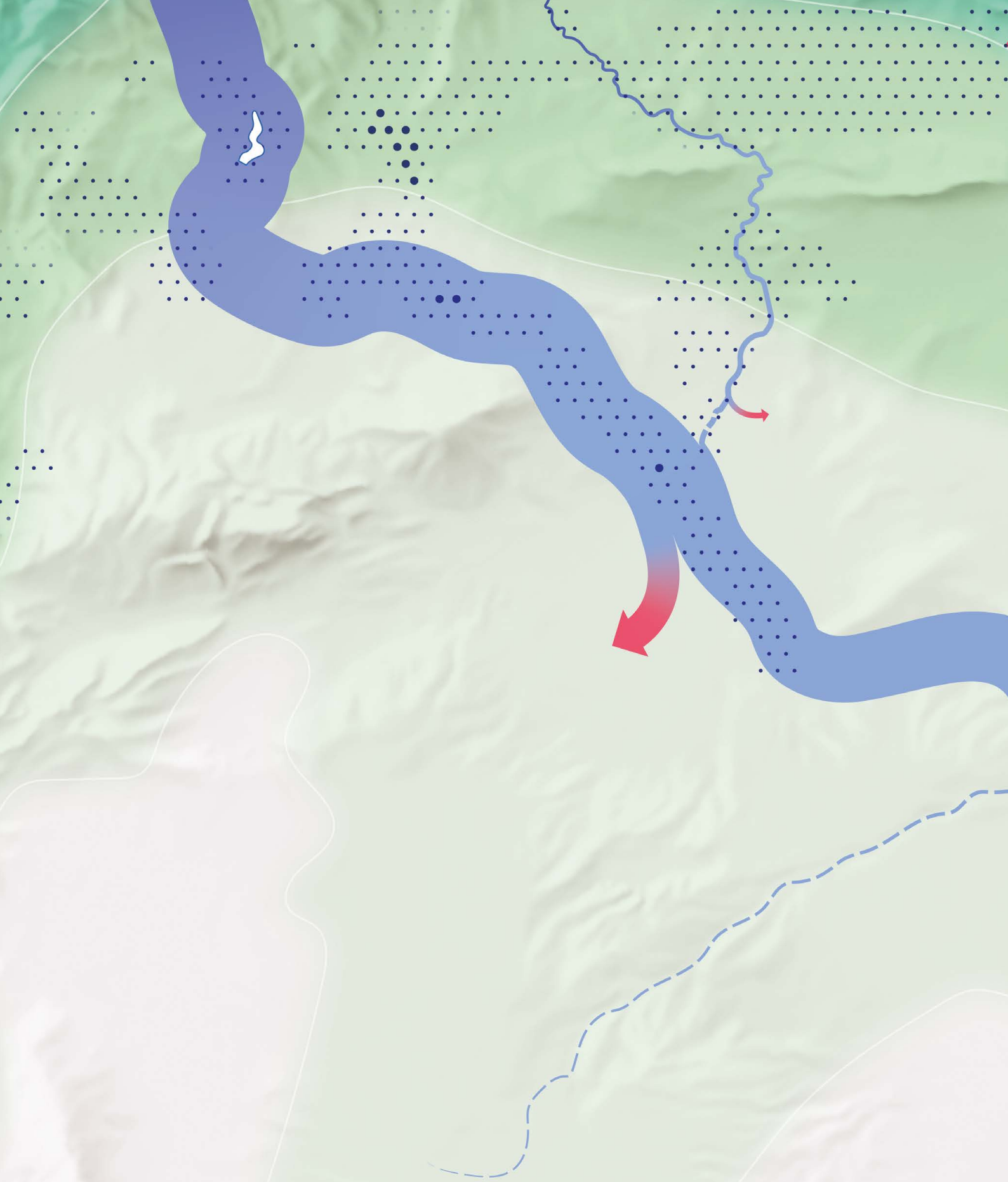
- Main transport corridor
- Dry canal Turkey–Persian Gulf–East Asia
- Belt and road corridor
- Major port · Other port
- Navigable river
- Major industrial area (larger than 1 km²)

**Other elements**

- State borders

0 100 km

Map produced by Zoi Environment Network, January 2025



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