Economic and Social Commission for Western Asia

Overview of Shared Groundwater Resources in Western Asia

Building Capacity for Accessing Disruptive Technologies for Improved Water Resources Management under Climate Change, Beirut, 14-15 January 2020

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Shared Prosperity **Dignified Life**

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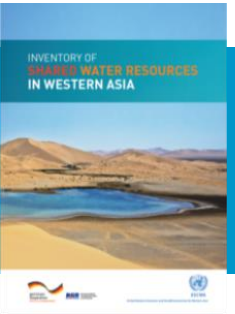
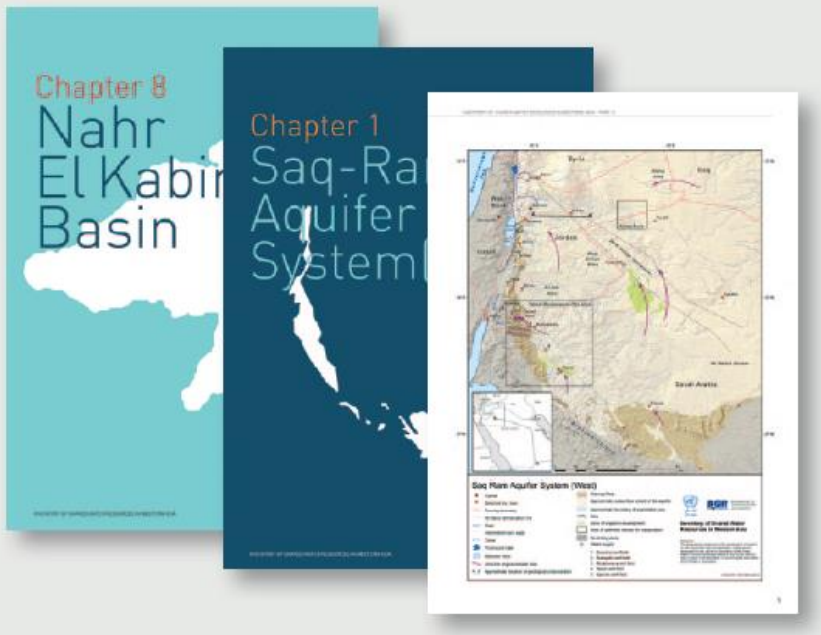
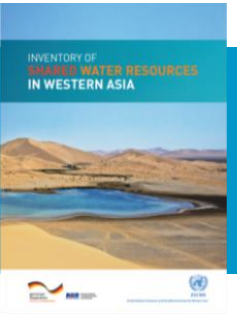


Inventory of Shared Water Resources in Western Asia
Part II: Groundwater



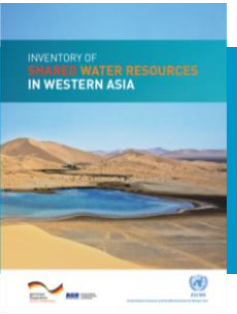
- A total of 22 shared aquifer systems compared to 6 shared river basins were identified.
- 9 chapters on shared surface waters compared to 17 chapters on shared aquifer systems, each following a standardized structure and methodology.



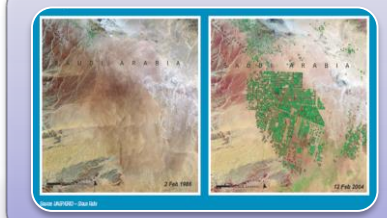
Data Availability and Implications

- Data and information on transboundary aquifer systems available to the public is often outdated, obsolete, contradictory or of different nature and scale.
- Some information, especially data on large aquifer systems that cross the borders of several countries, is classified in national databases and unpublished reports to which the ESCWA-BGR team did not have access.
- The Inventory's Country Consultation process and consultation with experts produced only a limited amount of new data.
- The descriptions and findings contained in the Inventory should therefore be understood as the best possible approximation, based on the information available to the ESCWA-BGR team and in view of the overview character and regional scale of this desk study.
- The aim was to provide a starting point for future technical deliberations on transboundary aquifer systems in Western Asia among riparian countries and within the expert community.

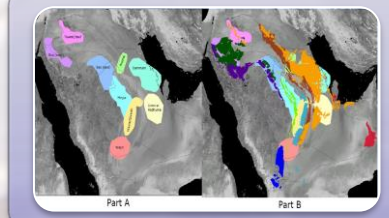
Euphrates River – Syrian Arab Republic



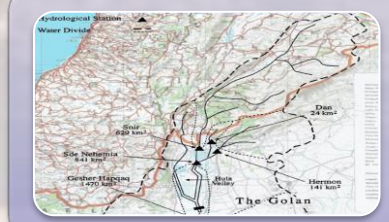
Challenges with Transboundary Aquifers



Renewable / Non-renewable Groundwater



Differences in Recharge and Use Areas



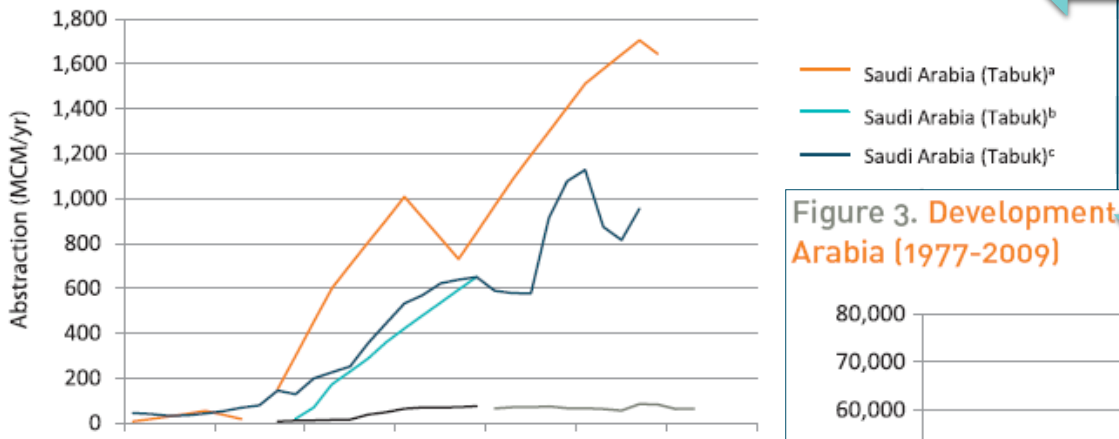
Spatial Extent of Surface and Groundwater Catchments

Aquifer Management Units ≠
Entire Aquifer / Aquifer System

Euphrates River – Syrian Arab Republic

Added Value: Compilation of various data sources

Figure 2. Historical abstraction from the Saq-Ram Aquifer System (West) (1975-2007)



Example: Water Use
Remote Sensing Studies

Agricultural Statistics (proxy)

Figure 3. Development of total crop area in the Tabuk region of Saudi Arabia (1977-2009)

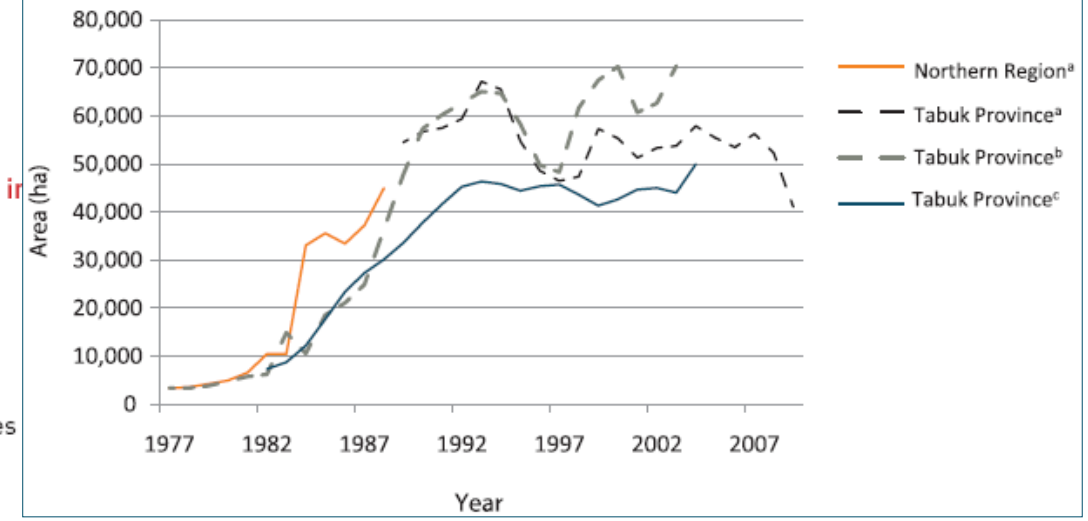
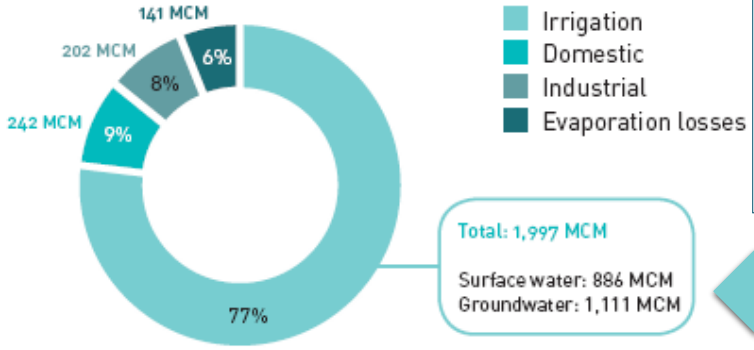
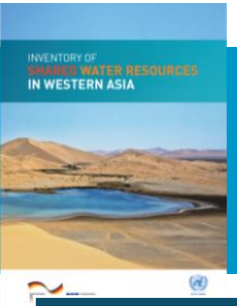


Figure 7. Mean water use across sectors in the Orontes Basin in Syria (1992-2009)



National Sector data

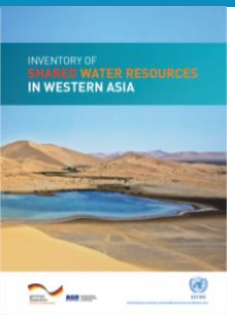
Source: Compiled by ESCWA-BGR based on data provided by Ministry of Irrigation in the Syrian Arab Republic, 2012.

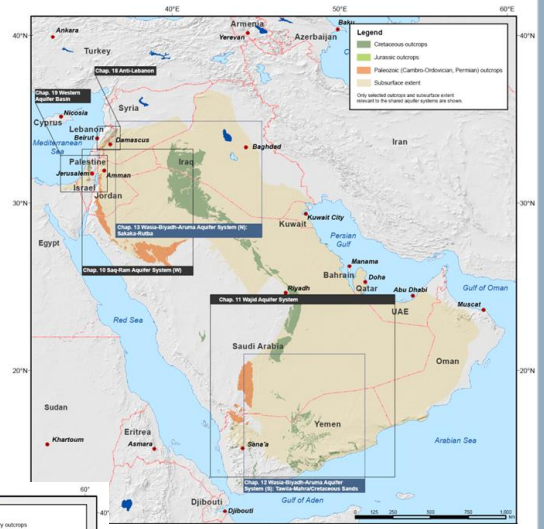


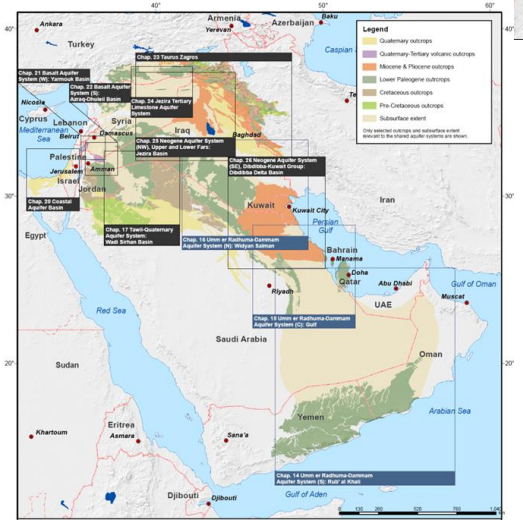
Chapter Structure

HEADING	CONTENT
Summary	Executive summary, Basin facts.
Introduction	Location, Area, Climate, Population, Other aquifers in the area, Information sources.
Hydrogeology – Aquifer Characteristics	Aquifer configuration (geometry, depth, outcrop areas, subsurface extent), Stratigraphy, Aquifer thickness, Aquifer type (confined/unconfined) and Aquifer parameters (transmissivity, storativity).
Hydrogeology - Groundwater	Recharge, Flow regime (water levels, gradients, flow direction), Storage, Discharge (springs, vertical leakage), Water quality, Exploitability.
Groundwater Use	Groundwater abstraction and use (timeline of development, areas and sector of use, abstraction volumes), Groundwater quality issues (return flows, salinization, pollution), Sustainability issues (trends, over-abstraction).
Agreements, Cooperation and Outlook	Agreements (treaties, Memoranda of Understanding, ongoing negotiations), Cooperation (timeline, form, mechanism, issues of conflict), Outlook (main management issues, opportunities).

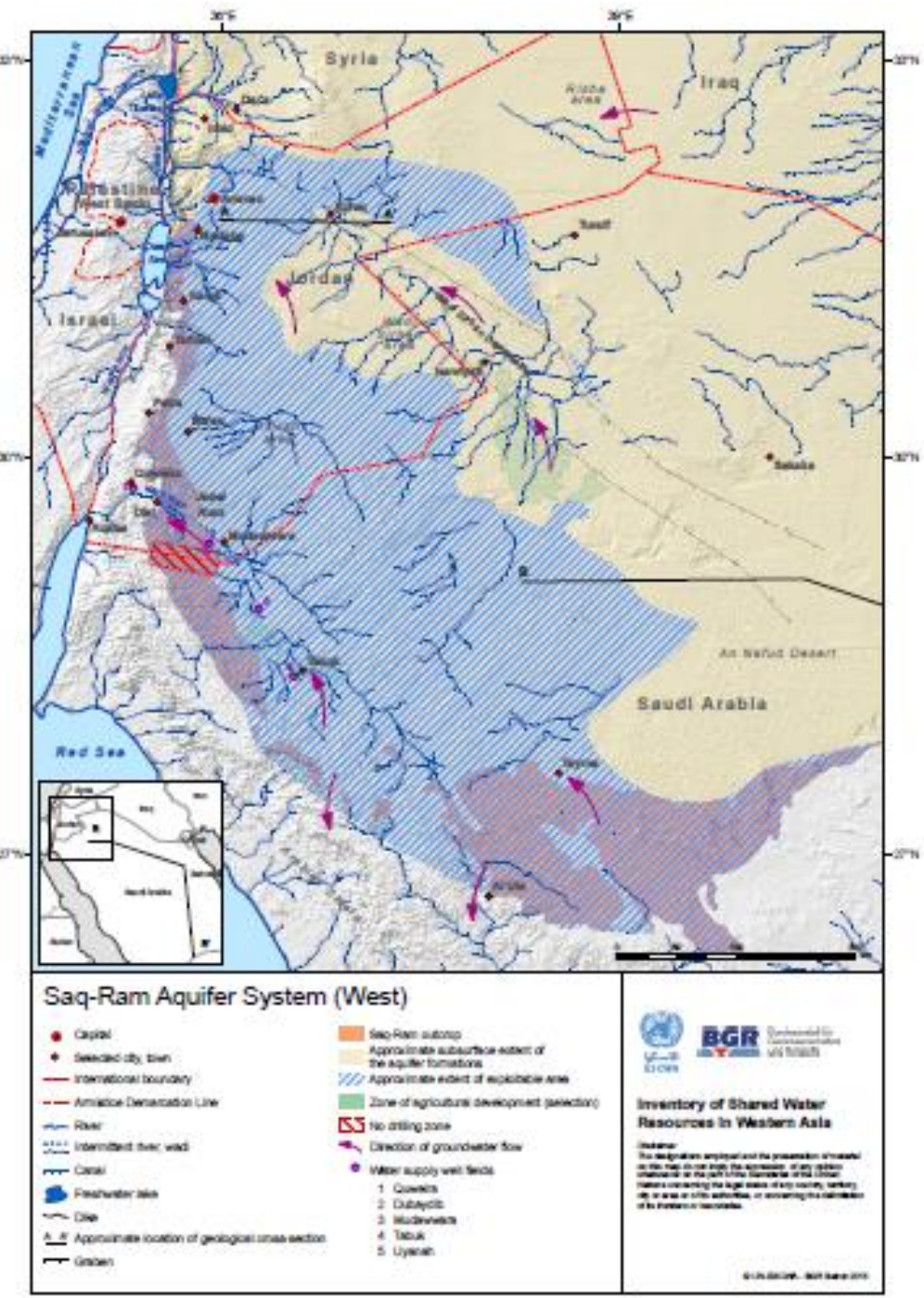
Transboundary aquifer systems in Western Asia based on geological age



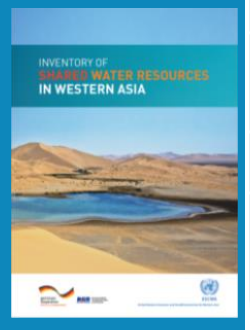




ERA	SHARED AQUIFER SYSTEM	CHAPTER	RIPARIAN COUNTRIES	ROCK TYPE	
Cenozoic	Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman	16	Iraq, Kuwait, Saudi Arabia	Fractured/karstic	Non-Renewable
	Umm er Radhuma-Dammam Aquifer System (Centre): Gulf	15	Bahrain, Qatar, Saudi Arabia	Fractured/karstic	
	Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali	14	Oman, Saudi Arabia, United Arab Emirates, Yemen	Fractured/karstic	
	Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin	26	Iraq, Kuwait, Saudi Arabia	Fractured/karstic	
	Neogene Aquifer System (North-West), Upper and Lower Fars: Jezira Basin	25	Iraq, Syria	Mixed	
	Tawil-Quaternary Aquifer System: Wadi Sirhan Basin	17	Jordan, Saudi Arabia	Porous	
	Central Hammad Basin[a]	-	Jordan, Syria	Fractured/karstic	
	Basalt Aquifer System (South): Azraq-Dhuleil Basin	22	Jordan, Syria	Mixed	
	Basalt Aquifer System (West): Yarmouk Basin	21	Jordan, Syria	Mixed	
	Coastal Aquifer Basin	20	Egypt, Israel, Palestine	Porous	Renewable
	Eastern Aquifer Basin[a]	-	Israel, Palestine	Fractured/karstic	
	North-Eastern Aquifer Basin[a]	-	Israel, Palestine	Fractured/karstic	
	Jezira Tertiary Limestone Aquifer System	24	Syria, Turkey	Fractured/karstic	
	Western Galilee Basin[a]	-	Israel, Lebanon	Fractured/karstic	
	Taurus-Zagros[b]	23	Iran, Iraq, Turkey	Fractured/karstic	
	Anti-Lebanon[a]	18	Lebanon, Syria	Fractured/karstic	
Mesozoic	Western Aquifer Basin	19	Egypt, Israel, Palestine	Fractured/karstic	
	Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba	13	Iraq, Saudi Arabia	Porous	
	Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands	12	Saudi Arabia, Yemen	Porous	Non-Renewable
	Ga'ara Aquifer System[a]	-	Iraq, Jordan, Saudi Arabia, Syria	Mixed	
Paleozoic	Saq-Ram Aquifer System (West)	10	Jordan, Saudi Arabia	Porous	
	Wajid Aquifer System	11	Saudi Arabia, Yemen	Porous	



Saq-Ram Aquifer System (West)



RIPARIAN COUNTRIES	Jordan, Saudi Arabia
ALTERNATIVE NAMES	Disi, Disi Mudawwara, Ram, Rum, Saq, Saq-Tabuk
RENEWABILITY	Low (2-20 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Weak
ROCK TYPE	Porous
AQUIFER TYPE	Unconfined in shallow layers; confined or leaky in deeper layers
EXTENT	308,000 km²
AGE	Paleozoic (Cambro-Ordovician)
LITHOLOGY	Sandstones
THICKNESS	250-700 m Eastern Jordan: ≥1,000 m Risha Area: 500 m
AVERAGE ANNUAL ABSTRACTION	Jordan: 90 MCM Saudi Arabia: >1,000 MCM
STORAGE	Jordan: 4-10 BCM Saudi Arabia: ~740 BCM
WATER QUALITY	Fresh (mostly <1,000 mg/L TDS)
WATER USE	Mainly agricultural. A rise in municipal and industrial use is expected.
AGREEMENTS	**2015 Disi Agreement**
SUSTAINABILITY	Overexploitation due to agricultural development. Possible health risk due to high natural radioactivity (Ra).

Saq-Ram Aquifer System (West)

- The Saq-Ram Aquifer System (West) extends on the surface from northern Saudi Arabia into Jordan.
- At present, it is exploited from the Tabuk Plain in Saudi Arabia to Wadi Rum in Jordan, in an area delineated in this Inventory as the Tabuk-Mudawwara-Disi area.

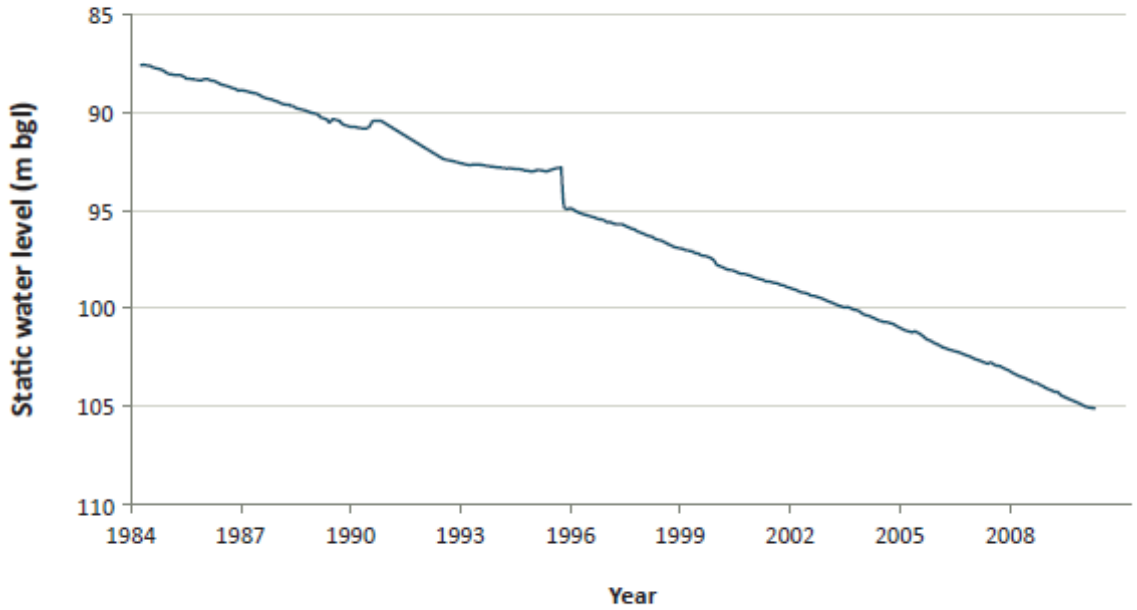
KEY CONCERNS

- Groundwater abstraction in the Tabuk area has increased drastically from about 29 MCM/yr in 1983 to between 1,050-1,700 MCM/yr in 2004, mostly in the **agricultural sector**, while recharge remains at 3-10 MCM/yr.
- The **heavy mining** of the aquifer system has resulted in water level drops of up to 32 m/yr in the late 1980s in Saudi Arabia.
- There are indications that the exploitable part of the resource may be exhausted, unless abstraction can be controlled on both sides of the border.

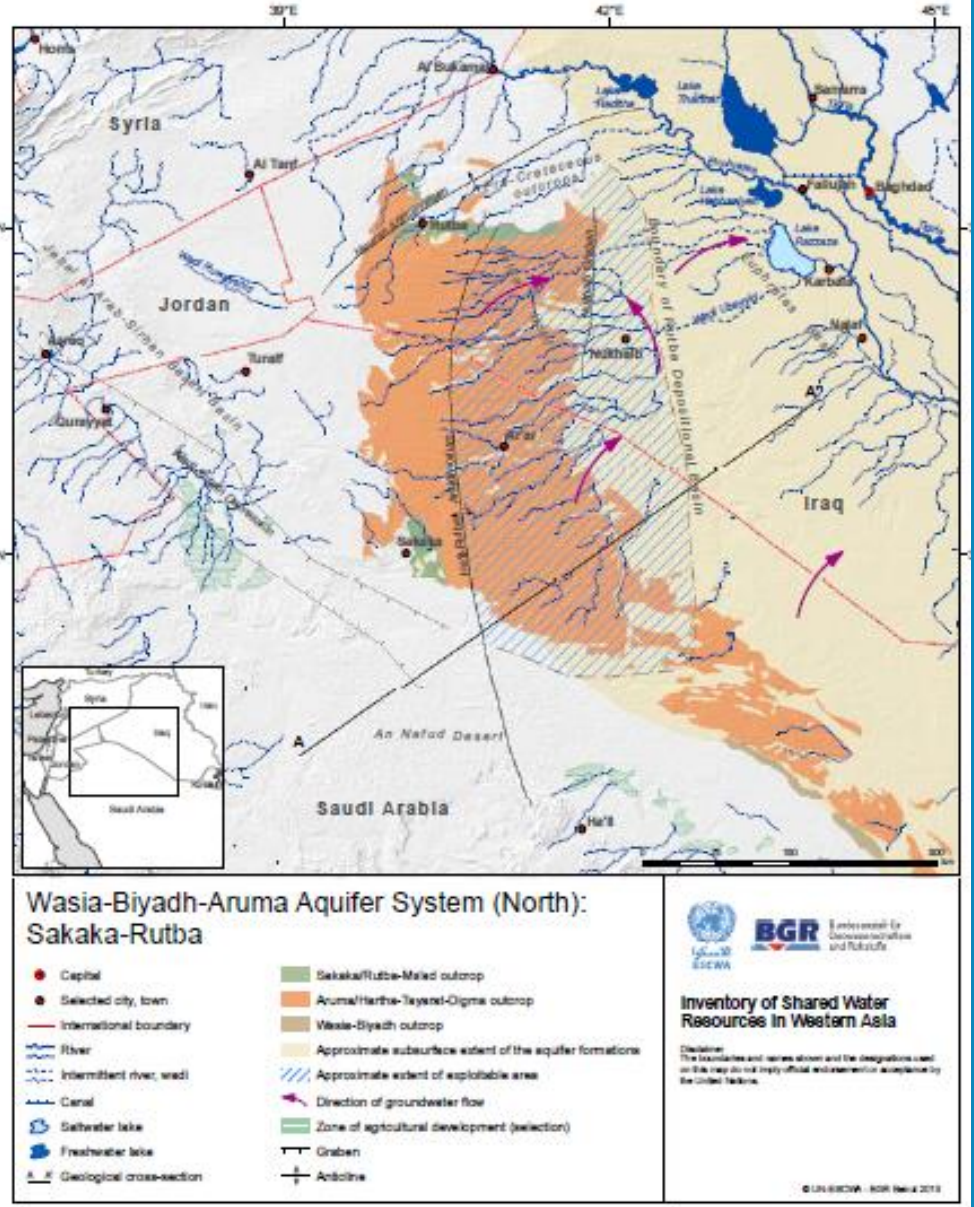
RIPARIAN COOPERATION

- Only Aquifer in the region with a bilateral agreement signed between Jordan and Saudi Arabia in 2015
- Manages groundwater use in the Saq/Disi aquifer and set up a technical commission

Figure 5. Groundwater decline in the Ram Aquifer in the South Wadi Araba Basin in Jordan (1984-2010)

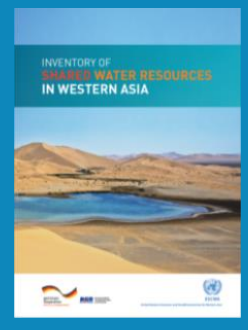


Source: Compiled by ESCWA-BGR based on Ministry of Water and Irrigation in Jordan, 2010.
Note: Water level measured from ED1203L Q'A Abu Suwana Observation well.



Wasia-Biyadh-Aruma Aquifer System (North)

Sakaka-Rutba



RIPARIAN COUNTRIES	Iraq, Saudi Arabia
ALTERNATIVE NAMES	Iraq: Rutba-Ms'ad-Hartha-Tayarat Saudi Arabia: Wasia Group Sakaka-Aruma
RENEWABILITY	Very low to low (0-20 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Weak
ROCK TYPE	Mixed
AQUIFER TYPE	Unconfined at/near outcrop areas Confined further away
EXTENT	~112,000 km²
AGE	Mesozoic (Middle to Late Cretaceous)
LITHOLOGY	Sandstones, locally calcareous or argillaceous
THICKNESS	Iraq: 250 m Saudi Arabia: 400 m
AVERAGE ANNUAL ABSTRACTION	≥ 30-35 MCM
STORAGE	..
WATER QUALITY	Fresh to slightly brackish (400-3,000 mg/L TDS)
WATER USE	Domestic and irrigation
AGREEMENTS	-
SUSTAINABILITY	-

Wasia-Biyadh-Aruma Aquifer System (North)Sakaka-Rutba

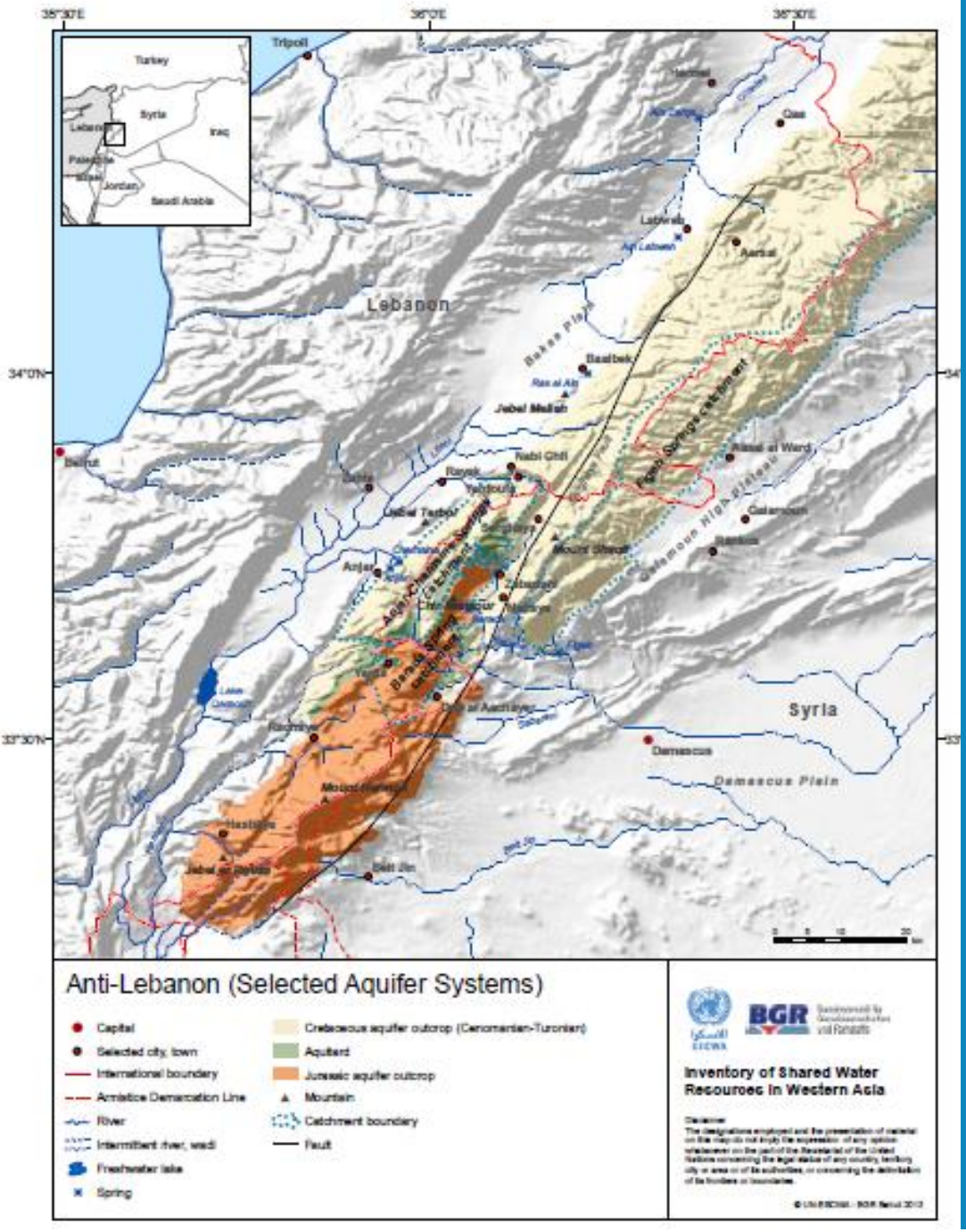
- The Wasia-Biyadh-Aruma Aquifer System (North) lies on a high plain (400-800 m) that extends across the western Rutba High in Iraq and the Widyan Plain in Saudi Arabia.
- The Aquifer System constitutes an important aquifer system in the area with freshwater flowing through six aquiferous units (Rutba-Ms'ad-Hartha-Tayarat in Iraq and Sakaka-Aruma in Saudi Arabia).
- Exploitation depth ranges between 200 and 400 m bgl.

KEY CONCERNS

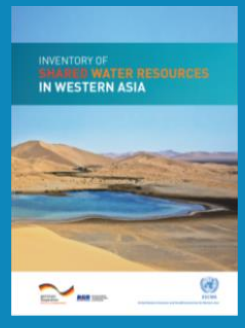
- The **use of this aquifer system is currently limited** due to its remoteness and the harsh environment in the area but the towns of Ar'ar and Sakaka in Saudi Arabia and Rutba in Iraq presumably rely on the aquifer system for their water supply.
- The Wasia-Biyadh-Aruma Aquifer System (North) is a **promising aquifer** system that could be used to encourage agricultural development in this pediment region, especially around the wadi areas where soils are fertile.

RIPARIAN COOPERATION

- There are no water agreements in place for the northern section of the Wasia-Biyadh-Aruma Aquifer System which is shared between Iraq and Saudi Arabia.



Anti-Lebanon



RIPARIAN COUNTRIES	Lebanon, Syria
MAIN AQUIFERS	Cretaceous (Cenomanian-Turonian), Jurassic
ALTERNATIVE NAMES	-
SHARED BASINS	Anjar-Chamsine, Barada, Figeh
RENEWABILITY	Medium to high (20 -> 100 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Strong
ROCK TYPE	Carbonate, karstic
AQUIFER TYPE	Anjar-Chamsine: unconfined-confined Barada: .. Figeh: unconfined, semi-confined, confined
EXTENT OF CATCHMENT	Anjar-Chamsine: 248 km² Barada: 149 km² Figeh: 658 km²
AGE	Mesozoic (Upper Cretaceous, Jurassic)
LITHOLOGY	Limestone, dolomites, marls
THICKNESS	Anjar-Chamsine: 900 m (AVG) Barada: 2,000-2,200 m Figeh: 480-680 m
AVERAGE ANNUAL ABSTRACTION	-
STORAGE	-
WATER QUALITY	Anjar-Chamsine: .. Barada: <500 mg/L TDS Figeh: 200-600 mg/L TDS
WATER USE	Agricultural, domestic and industrial
AGREEMENTS	-
SUSTAINABILITY	Local abstractions and contamination in catchments may impact quantity and quality of discharge from springs

Anti-Lebanon

- The Anti-Lebanon Mountain range is located at the Lebanese-Syrian border between the Bekaa Plain in the west and the Damascus Plain in the east.

- The mountain range stretches from the Homs Plain in the north to beyond its highest peak, Jebel El Sheikh, in the south.

- The Anti-Lebanon receives significant precipitation, and is an important source of water, both locally and in the wider regional context, as it forms the source of a number of rivers in the Mashrek.

KEY CONCERNS

- The hydrology and hydrogeology of this deeply faulted mountain range is highly complex and poorly understood to date, also in terms of the transboundary nature of surface and groundwater basins.

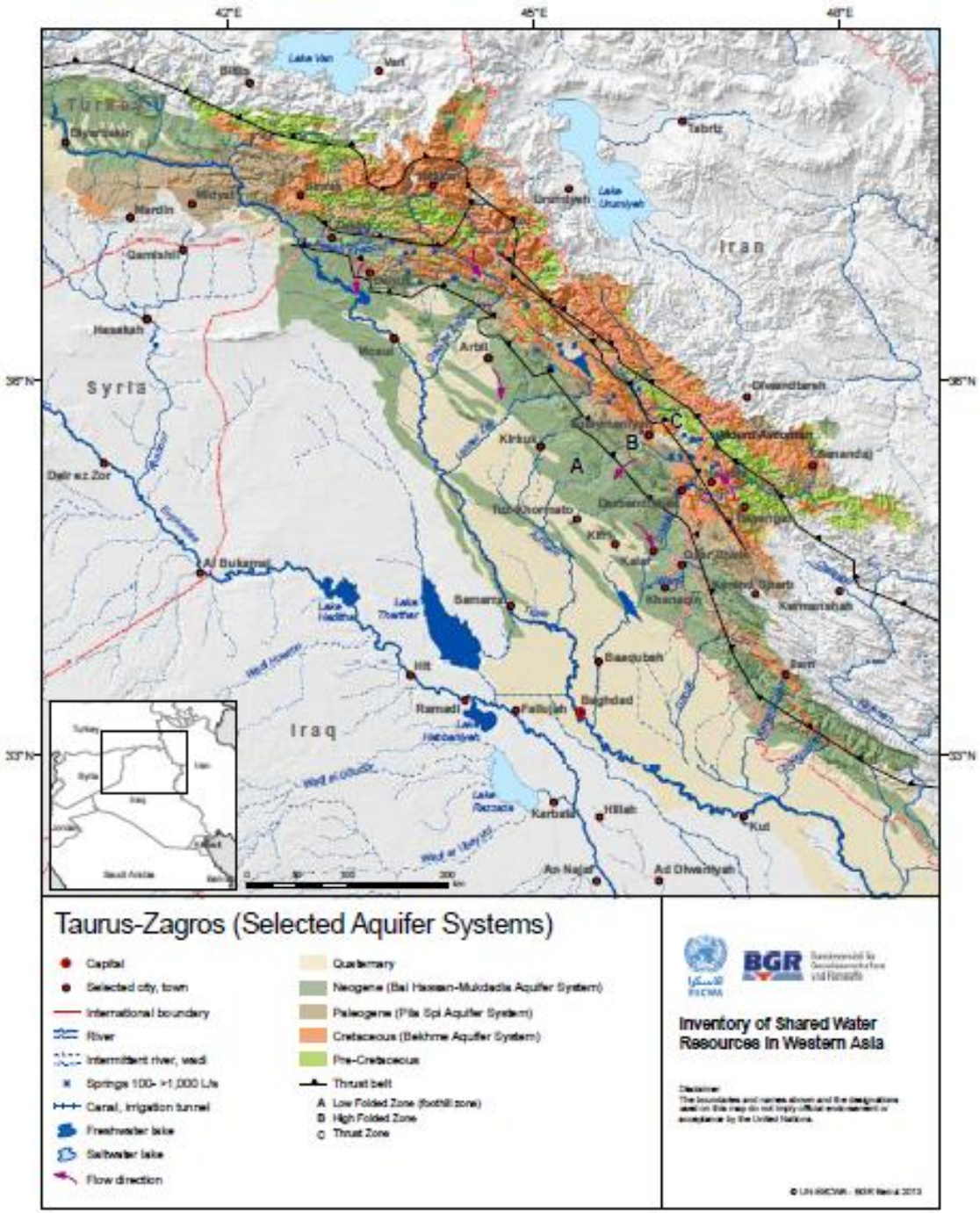
- The riparian countries could benefit from closer cooperation in the domain of joint research into shared catchments, including the detailed delineation of catchment areas and protection zones, the determination of water balances and the potential impact of climate change.

RIPARIAN COOPERATION

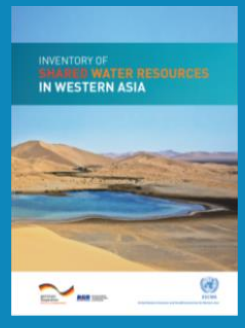
- There are no water agreements in place for any part of the Anti-Lebanon Mountain range, nor for the three shared spring catchments.

- Shared water resources management issues are coordinated through the Syrian-Lebanese Joint Committee for Shared Water, which implements the agreements in place over the Nahr el Kabir and the Orontes River.

- Not clear whether the shared aquifer systems in the Anti-Lebanon Mountain range have been addressed under this cooperation.



Taurus-Zagros



RIPARIAN COUNTRIES	Iran, Iraq: Halabja-Khurmal and Central Diyala Basins Iraq, Turkey: Zakho Basin
MAIN AQUIFERS	Bai Hassan, Bekhme, Pila Spi
ALTERNATIVE NAMES	-
SHARED BASINS	Central Diyala, Halabja-Khurmal, Zakho
RENEWABILITY	Medium to high (20-300 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Strong
ROCK TYPE	Bekhme, Pila Spi: carbonate, karstic Bai Hassan: intergranular
AQUIFER TYPE	Semi-confined
EXTENT OF CATCHMENT	Central Diyala: 11,760 km² Halabja-Khurmal: 566 km² Zakho: 1,960 km²
AGE	Bai Hassan, Pila Spi: Cenozoic Bekhme: Mesozoic
LITHOLOGY	Shale, limestone, sandstone
THICKNESS	Bekhme: ≤1,000 m Pila Spi: ~1,500 m Bai Hassan: ≥2,500 m
AVERAGE ANNUAL ABSTRACTION	-
STORAGE	-
WATER QUALITY	Fresh (≤1,000 mg/L TDS) except in deeper layers of Central Diyala Basin saline (3,000 mg/L TDS)
WATER USE	Mainly agricultural
AGREEMENTS	-
SUSTAINABILITY	-

Taurus-Zagros

- The Taurus-Zagros Mountain range extends across Iran, northern Iraq and Turkey. Geological formations within this range constitute shared aquifer systems in some areas along the boundaries of these countries.

- Three such areas are identified: the Halabja-Khurmal and the Central Diyala Basins between Iran and Iraq, and the Zakho Basin between Iraq and Turkey.

Table 1. Main aquifer systems in the Folded Zones of the Taurus-Zagros Mountain range

ZONE	AQUIFER TYPE	MAIN FORMATION	OTHER FORMATIONS/ DEPOSITS
High Folded Zone	Karst	Bekhme	Qamchuga, Dokan, Kometan, Bekhme, Akra, Sarmord
	Fissured-karstic	Pila Spi	Sinjar, Khurmal
Low Folded (Foothill) Zone	Intergranular	Bai Hassan (Upper Bakhtiari)	Mukdadia (Lower Bakhtiari), unconsolidated sediments (Quaternary)

Source: Compiled by ESCWA-BGR based on Stevanovic and Markovic, 2004.

KEY CONCERNS

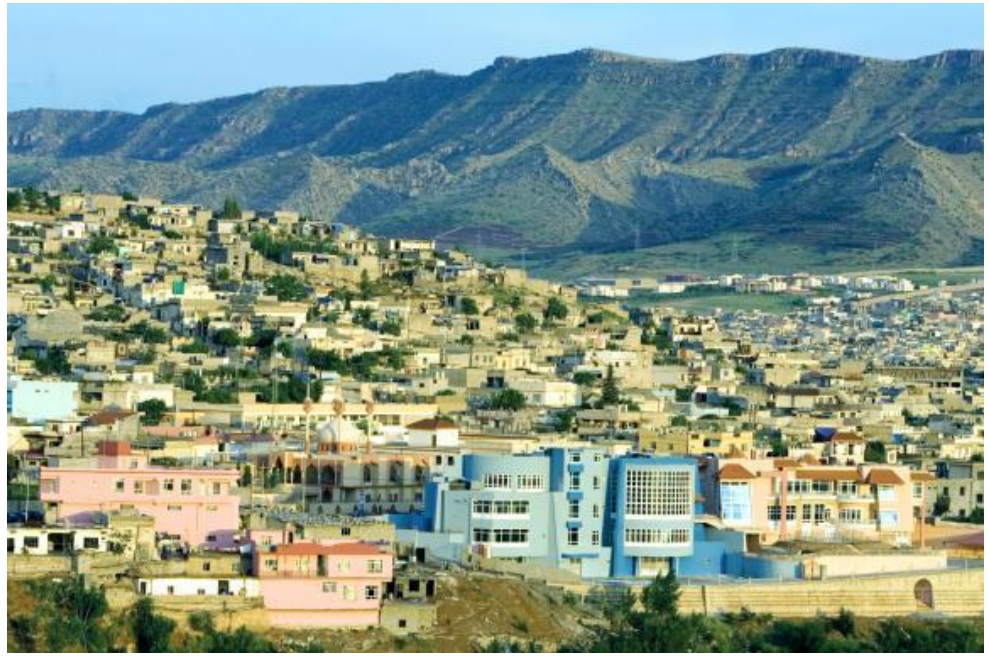
- The strong interaction between surface water and groundwater in the Taurus-Zagros Thrust Belt entails that future cooperation will have to address conjunctive development and use of the two resources.

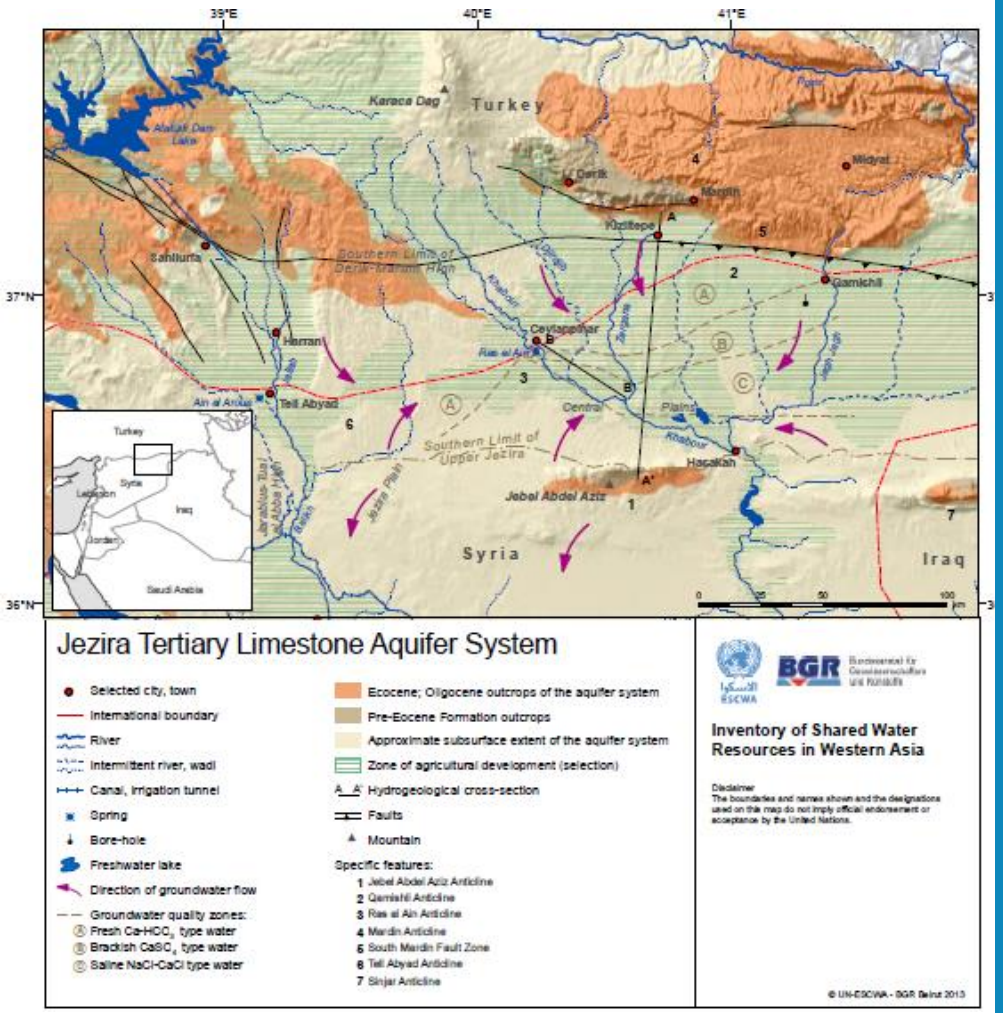
RIPARIAN COOPERATION

- There are no water agreements in place for any of the shared aquifer systems that occur in the Taurus-Zagros Thrust Belt.

- Iraq and Turkey have established a number of technical committees on water issues in the past . However, they mainly deal with surface water issues.

- No record of Iran cooperation with Iraq or Turkey over issues of shared groundwater management.





Jezira Tertiary Limestone Aquifer System

- Selected city, town
- International boundary
- River
- Intermittent river, wadi
- Canal, irrigation tunnel
- Spring
- Bore-hole
- Freshwater lake
- Direction of groundwater flow
- Groundwater quality zones:
  - (A) Fresh Ca-HCO_3 type water
  - (B) Brackish $CaSO_4$ type water
  - (C) Saline NaCl-CaCl type water
- Eocene; Oligocene outcrops of the aquifer system
- Pre-Eocene Formation outcrops
- Approximate subsurface extent of the aquifer system
- Zone of agricultural development (selection)
- A–A' Hydrogeological cross-section
- Faults
- Mountain

Specific features:
1 Jebel Abdel Aziz Anticline
2 Garnishi Anticline
3 Ras el Ain Anticline
4 Mardin Anticline
5 South Mardin Fault Zone
6 Tell Abyad Anticline
7 Sinjar Anticline

ESCWA BGR Bundesanstalt für Geowissenschaften und Rohstoffe

Inventory of Shared Water Resources in Western Asia

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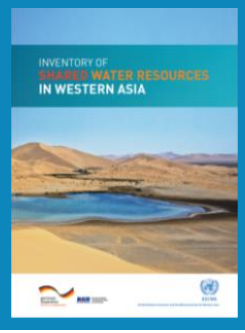
Jezira Tertiary Limestone Aquifer System



RIPARIAN COUNTRIES	Syria, Turkey
ALTERNATIVE NAMES	Turkey: Midyat Aquifer
RENEWABILITY	Medium to high (20 ->100 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Strong
ROCK TYPE	Karstic
AQUIFER TYPE	Confined
EXTENT	14,000 km^2
AGE	Tertiary (Eocene to Oligocene)
LITHOLOGY	Limestone
THICKNESS	200-300 m ≥700 m in the east
AVERAGE ANNUAL ABSTRACTION	3,000 MCM
STORAGE	7,400 MCM
WATER QUALITY	Fresh (220-700 mg/L TDS) to saline (1,400-4,700 mg/L TDS)
WATER USE	Mainly agricultural/domestic
AGREEMENTS	-
SUSTAINABILITY	The springs which used to feed the Balikh and Khabour Rivers have dried up

Jezira Tertiary Limestone Aquifer System

- The Jezira Tertiary Limestone Aquifer System extends from the Jezira Plain on Syria's northern border (Upper Jezira area) into the south-eastern Anatolian Highlands in Turkey.

- Large volumes of groundwater flow from recharge areas in the highlands to groundwater discharge areas along the Syrian border, where many springs, most importantly the Ras al Ain and Ain al Arous Springs, discharge from the aquifer system.

KEY CONCERNS

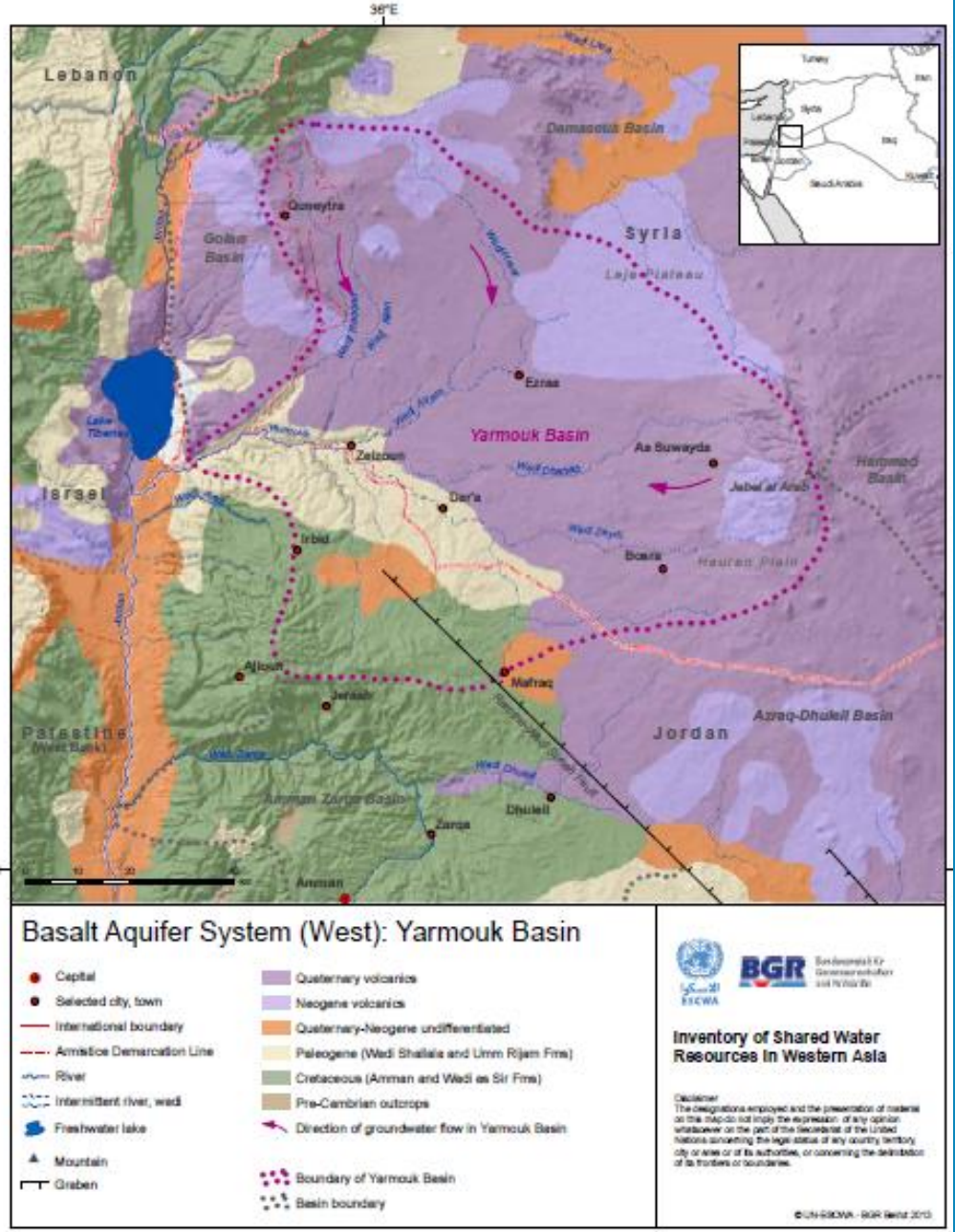
- The significant shift away from rain-fed irrigation to groundwater irrigation has significantly affected the groundwater regime and led to a dramatic decrease in springs discharge.

- Thus the springs at Ras al Ain, which used to supply 87% of the total discharge from the aquifer have practically dried up.

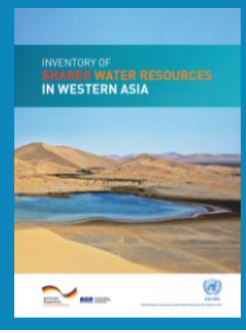
RIPARIAN COOPERATION

- Cooperation between Syria and Turkey on surface water issues in the past did not explicitly mention or take into consideration the need to cooperate over groundwater issues.

- The present state of the Aquifer System suggests that while it was reasonable to focus on the Ras al Ain area in the past, a wider and more regional approach to hydrogeological investigation and groundwater resource management would be more appropriate in the future.



Basalt Aquifer System (West): Yarmouk Basin



RIPARIAN COUNTRIES	Jordan, Syria
ALTERNATIVE NAMES	-
RENEWABILITY	High
HYDRAULIC LINKAGE WITH SURFACE WATER	Medium (20-100 mm/yr)
ROCK TYPE	Fractured to mixed
AQUIFER TYPE	Unconfined
EXTENT	~7,000 km²
AGE	Neogene-Quaternary, Paleogene (Upper Cretaceous)
LITHOLOGY	Basalt, limestone
THICKNESS	<100 m ->300 m
AVERAGE ANNUAL ABSTRACTION	..
STORAGE	..
WATER QUALITY	Mainly fresh
WATER USE	Agricultural and domestic
AGREEMENTS	Groundwater-related provisions in the 1987 agreement regarding the utilization of the waters of the Yarmouk River
SUSTAINABILITY	Over-exploitation of groundwater, reduced spring flow in discharge zone, local groundwater pollution

Basalt Aquifer System (West): Yarmouk Basin

- The Yarmouk Basin constitutes the western section of the Basalt Aquifer Complex. It extends between the Jebel al Arab Mountain, the Hauran Plateau and the south-eastern foothills of Mount Hermon. In the south-west, the Basalt Aquifer stretches into the Golan Heights to Lake Tiberias.

- Groundwater flow is generally directed from topographically higher catchments to the major discharge zone around Wadi Hreer-Mzeirib in the Yarmouk Basin, while the western part of the Golan Heights drains towards Lake Tiberias.

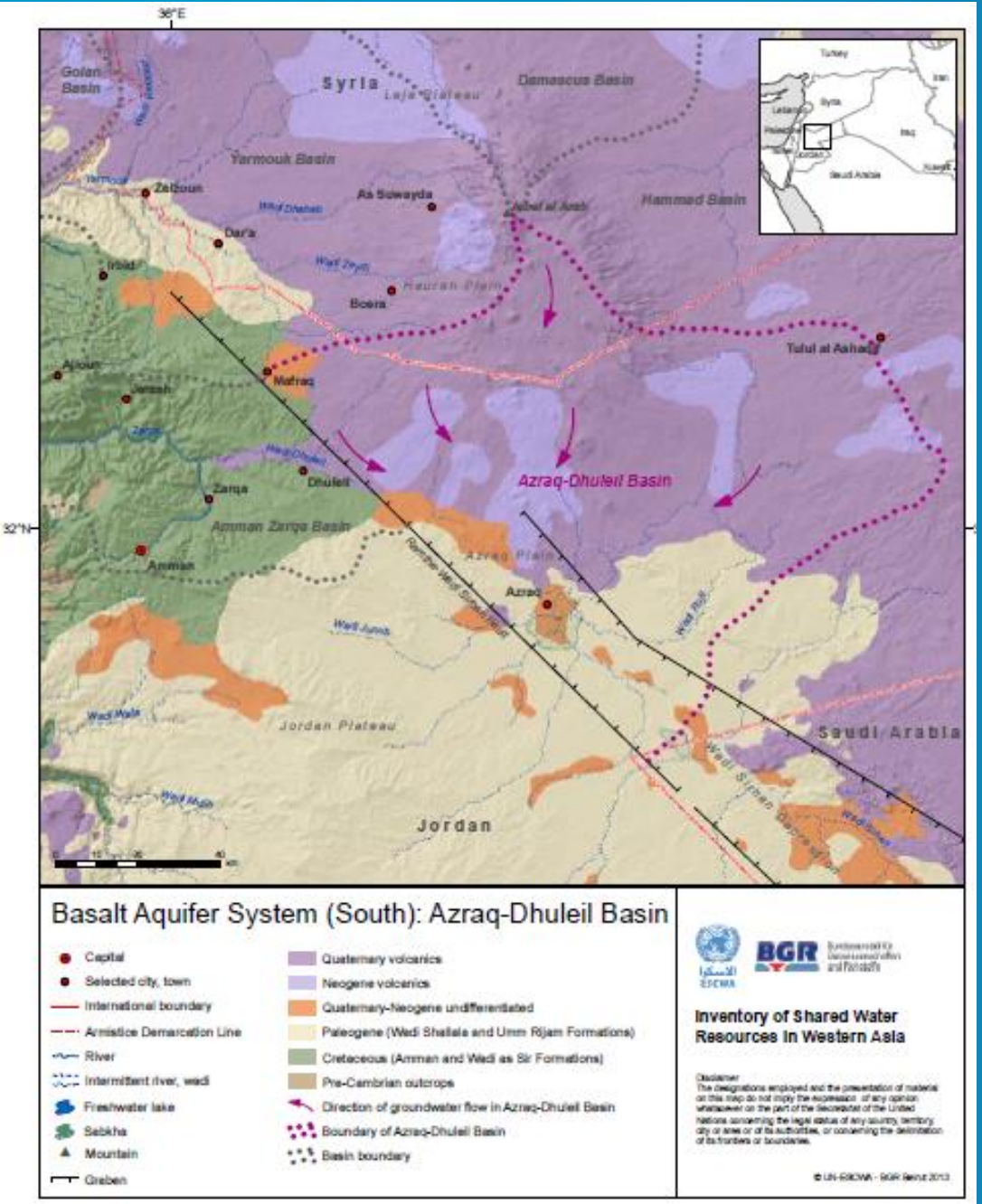
KEY CONCERNS

- **Groundwater and surface water are closely interlinked** in this region and the Basalt Aquifer constitutes an important source of water for the Yarmouk River and the Jordan Basin as a whole.

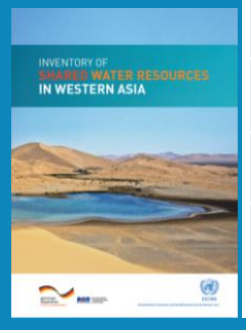
- **Large-scale expansion of groundwater abstraction** in some parts of the Yarmouk Basin is likely to have affected natural flow and discharge patterns within a larger radius and may have contributed to the hydrological decline of the Yarmouk River.

RIPARIAN COOPERATION

- In accordance with the 1987 bilateral agreement, Jordan and Syria established the Jordanian-Syrian Yarmouk River Basin Higher Committee, which brings together representatives from the Jordan Valley Authority and the Syrian Ministry of Irrigation in regular meetings to discuss issues such as floodwater storage, prevention of illegal agricultural activities and the control of unregulated groundwater pumping.



Basalt Aquifer System (South): **Azraq-Dhuleil Basin**



RIPARIAN COUNTRIES	Jordan, Syria
ALTERNATIVE NAMES	-
RENEWABILITY	South: medium North: high
HYDRAULIC LINKAGE WITH SURFACE WATER	Medium to low (2-100 mm/yr)
ROCK TYPE	Fractured to mixed
AQUIFER TYPE	Unconfined
EXTENT	8,500 km²
AGE	Neogene-Quaternary, Paleogene, Upper Cretaceous
LITHOLOGY	Basalt, limestone
THICKNESS	<100m - >500m
AVERAGE ANNUAL ABSTRACTION	Northern part: 15-20 MCM
STORAGE	-
WATER QUALITY	Mainly fresh, brackish in some areas
WATER USE	Agricultural and domestic
AGREEMENTS	..
SUSTAINABILITY	Groundwater level decline and salinization due to over-abstraction

Basalt Aquifer System (South): Azraq-Dhuleil Basin(South)

- The Azraq-Dhuleil Basin extends over the south-eastern part of the Jebel al Arab basalt field in south-western Syria and north-eastern Jordan, comprising the catchment of the Azraq groundwater discharge area between the Jebel al Arab Mountain range in the north, the northeastern desert in Jordan and the Azraq Plain.

- Groundwater in the Basalt Aquifer System of the Azraq-Dhuleil Basin flows from topographically higher parts of the catchment to the major discharge zone in the Azraq area in the south.

KEY CONCERNS

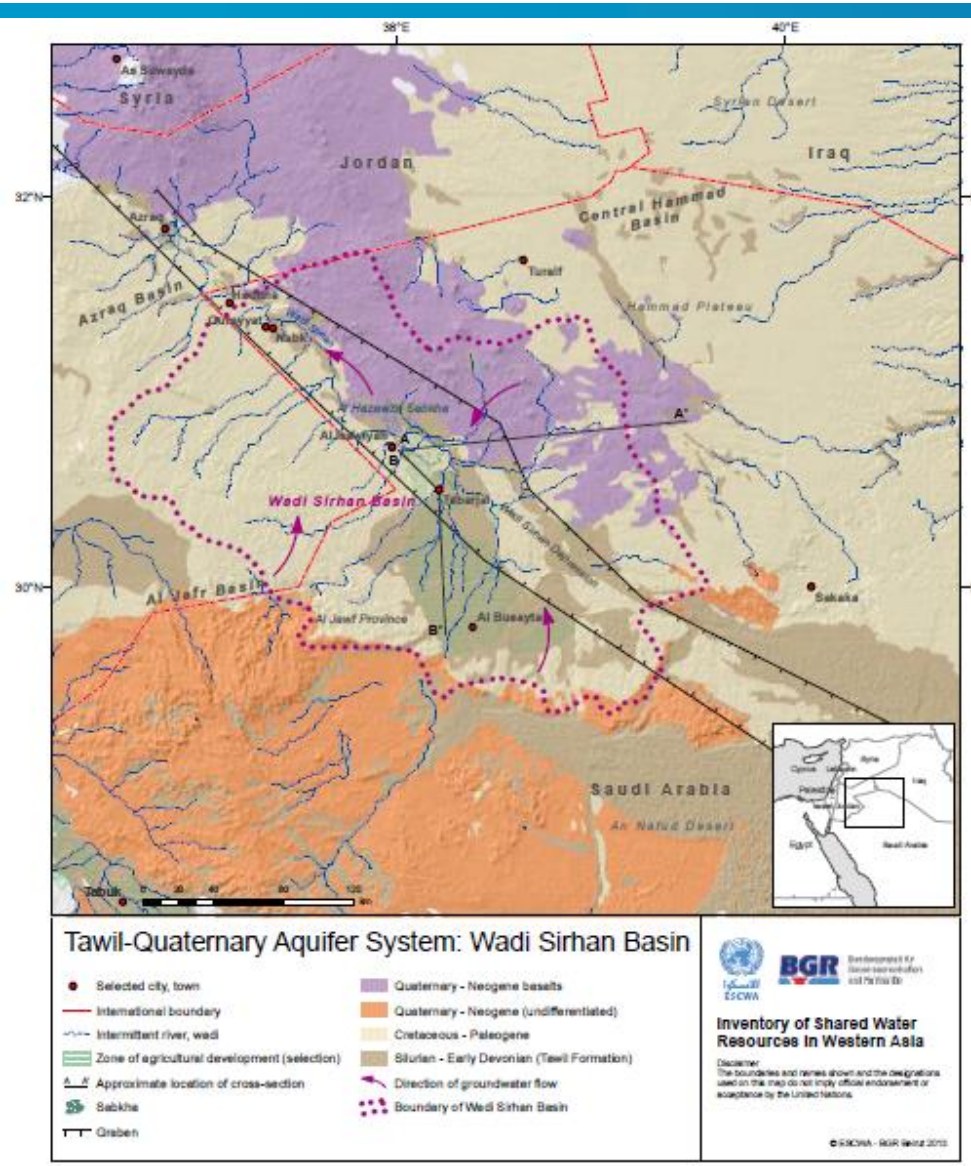
- Groundwater discharge appears to be maintained largely by present-day recharge over wide catchment areas with travel periods of more than 20,000 years.

- Discharge from springs in the Azraq area ceased completely after the creation of a large well field in the area in 1980.

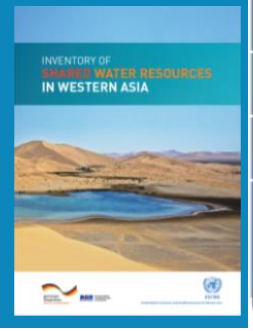
- Groundwater quality has deteriorated as a result of the infiltration of irrigation return flows in downstream areas where intensive irrigation takes place.

RIPARIAN COOPERATION

- There are no formal water agreements in place for the Azraq-Dhuleil Basin, which is shared between Jordan and Syria.



Tawil-Quaternary Aquifer System: **Wadi Sirhan Basin**



RIPARIAN COUNTRIES	Jordan, Saudi Arabia
ALTERNATIVE NAMES	Azraq Graben, Secondary-Tertiary-Quaternary Aquifer Complex (STQ), Sharawra, Sirhan Basin, Sirhan-Hamza Graben
RENEWABILITY	Very low (0-2 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Weak
ROCK TYPE	Porous to fractured
AQUIFER TYPE	Mainly unconfined
EXTENT	~44,000 km²
AGE	Upper part: Upper Cretaceous to Quaternary Lower part: Early Devonian-Silurian
LITHOLOGY	Basalt, alluvium, limestone and sandstones with some marl
THICKNESS	Upper part: <1,300 m Lower part: 200-300 m
AVERAGE ANNUAL ABSTRACTION	1984: 100 MCM 2004: 3,500 MCM
STORAGE	22 BCM
WATER QUALITY	Fresh to saline
WATER USE	Irrigation
AGREEMENTS	-
SUSTAINABILITY	Over-exploitation of the upper part of the aquifer system, especially in the south for irrigation

Tawil-Quaternary Aquifer System: Wadi Sirhan Basin

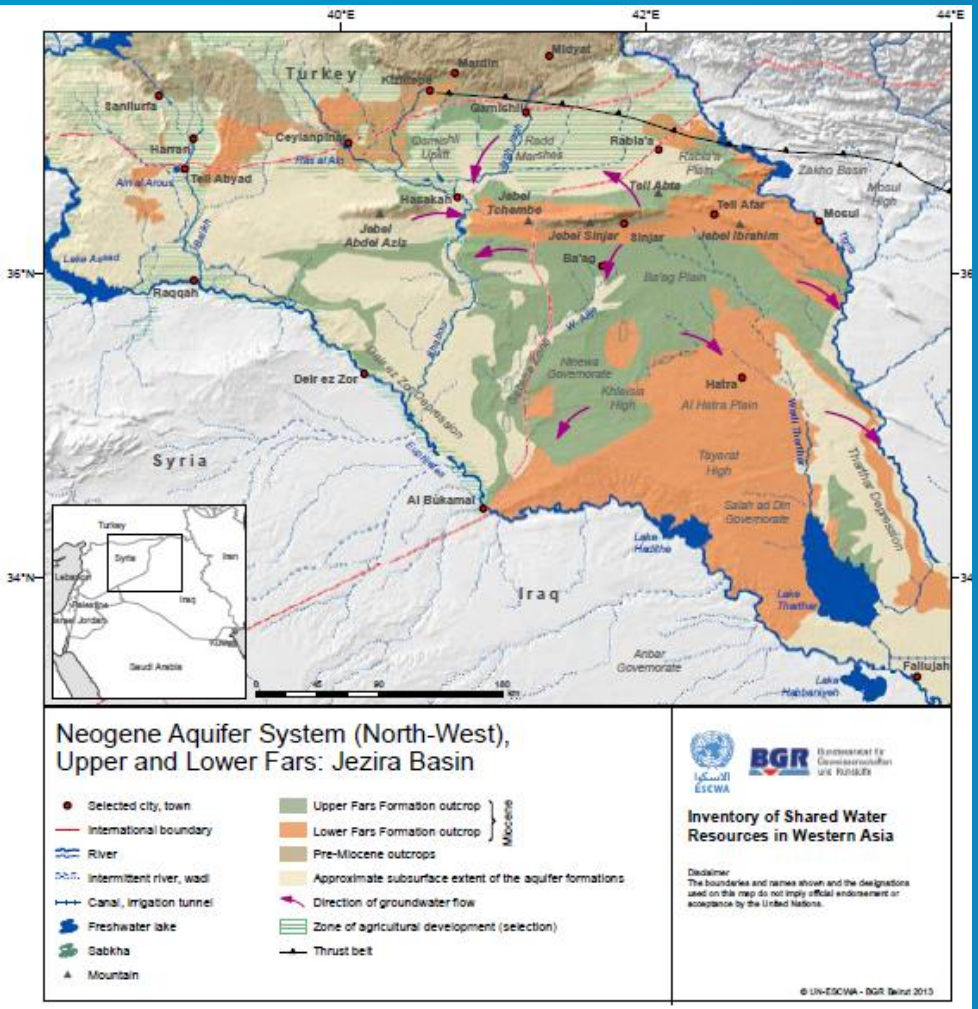
- The Wadi Sirhan Basin is situated in Jordan and Saudi Arabia and forms a central depression surrounded by basalt and sedimentary plateau areas in the north and south.

KEY CONCERNS

- This aquifer appears to have evolved as part of the groundwater system in the Sakaka- Azraq areas, with limited recharge entering the system in the form of Mediterranean-type rainwater.
- Since exploitation of the aquifer system started in 1986, annual abstraction for irrigation purposes has risen from about 100 MCM in 1984 to almost 3,500 MCM in 2004.
- However, the lower part of the aquifer system appears to have potential for further exploitation as only a few of the approximately 100 wells tapping this part of the aquifer system show signs of significant drawdown.

RIPARIAN COOPERATION

- There are no water agreements in place for the Tawil Quaternary Aquifer System, which is shared between Jordan and Saudi Arabia.



Neogene Aquifer System (North-West), Upper and Lower Fars: Jezira Basin

- Selected city, town
- International boundary
- River
- Intermittent river, wadi
- Canal, irrigation tunnel
- Freshwater lake
- Sabkha
- Mountain
- Upper Fars Formation outcrop
- Lower Fars Formation outcrop
- Miocene
- Pre-Miocene outcrops
- Approximate subsurface extent of the aquifer formations
- Direction of groundwater flow
- Zone of agricultural development (selection)
- Thrust belt

ESCWA BGR

Inventory of Shared Water Resources in Western Asia

Disclaimer
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

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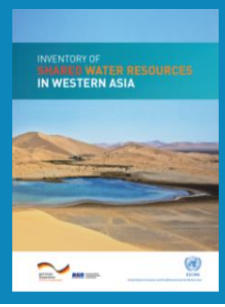
Neogene Aquifer System (North-West): Upper and Lower Fars **Jezira Basin**



RIPARIAN COUNTRIES	Iraq, Syria
ALTERNATIVE NAMES	Iraq: Fatha-Injana Syria: Lower and Upper Fars
RENEWABILITY	Medium to High (20 - >100 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Good
ROCK TYPE	Porous
AQUIFER TYPE	Unconfined to confined
EXTENT	65,000 km^2
AGE	Cenozoic (Neogene)
LITHOLOGY	Sandstones
THICKNESS	Generally 500-550 m with a pronounced decrease in thickness north of the Sinjar Uplift
AVERAGE ANNUAL ABSTRACTION	--
STORAGE	--
WATER QUALITY	Most common: brackish to saline (2,000-4,000 mg/L TDS) Recharge areas: ≤ 1,000 mg/L TDS Discharge areas: 5,000 - ≥ 20,000 mg/L TDS
WATER USE	Agriculture and domestic
AGREEMENTS	-
SUSTAINABILITY	Risk of salinization if wells are deepened and/or infiltration of surface water from irrigated areas

Neogene Aquifer System (North- West): Upper and Lower Fars: Jezira Basin

- The eastern part of the Upper and Middle Neogene Formations beneath the Mesopotamian Plain constitutes a shared aquifer system between Iraq and Syria.

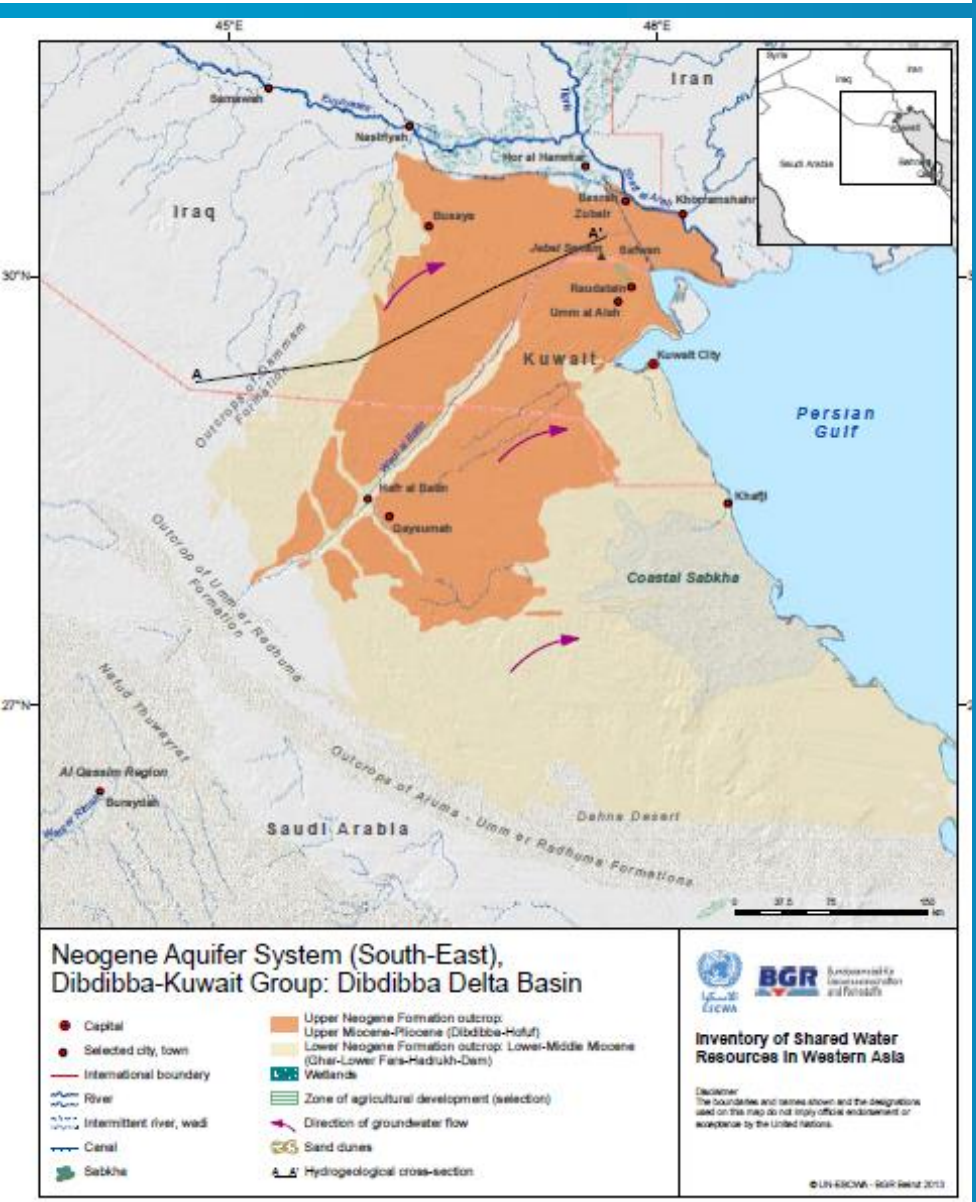
KEY CONCERNS

- Groundwater is generally brackish (4,000-≥20,000 mg/L TDS), with relatively more freshwater in the upper layers (<1,000 mg/L) especially in the northern areas where the aquifer is recharged by precipitation and surface water.

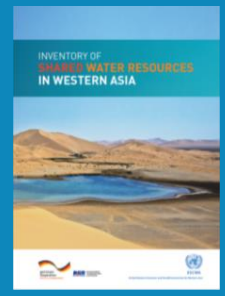
- Groundwater use is generally restricted by high salinity levels and low well yields, and water for domestic consumption can only be abstracted from the upper aquifer up to a depth of 25 m bgl

RIPARIAN COOPERATION

- There are no water agreements in place for the Neogene Aquifer System (North- West), which is shared between Iraq and Syria.



Neogene Aquifer System (South-East), Dibdibba-Kuwait Group **Dibdibba Delta Basin**



RIPARIAN COUNTRIES	Iraq, Kuwait, Saudi Arabia
ALTERNATIVE NAMES	Ad Dibdibba Stony Desert, Ad Dibdibba Alluvial Fan, Dibdibba Plain, Kuwait Plain
RENEWABILITY	Very low to low (0-20 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Medium
ROCK TYPE	Porous
AQUIFER TYPE	Unconfined (central areas), Confined (coastal areas)
EXTENT	153,000 km²
AGE	Cenozoic
LITHOLOGY	Predominantly sands and gravel
THICKNESS	30-200 m (common range) Max.: 550 m
AVERAGE ANNUAL ABSTRACTION	Iraq: ~370 MCM Kuwait: 88 MCM
STORAGE	Iraq: 1.26 BCM
WATER QUALITY	Brackish to saline (2,500 mg/L to 15,000 mg/L TDS)
WATER USE	Mainly agricultural
AGREEMENTS	-
SUSTAINABILITY	Water level decline and inversion of vertical flow due to over-exploitation

Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

- The aquifer system is located mainly within the boundaries of the Dibdibba Delta basin, which is formed by the Wadi ar Rimah- Wadi al Batin that extends from the Arabian Shield in the west to the mouth of Shatt al Arab.

- The basin stretches across three countries and comprises three aquiferous formations, known as Dibdibba, Lower Fars and Ghar Formations in Iraq and Kuwait, and Hofuf, Dam and Hadrukh Formations in Saudi Arabia

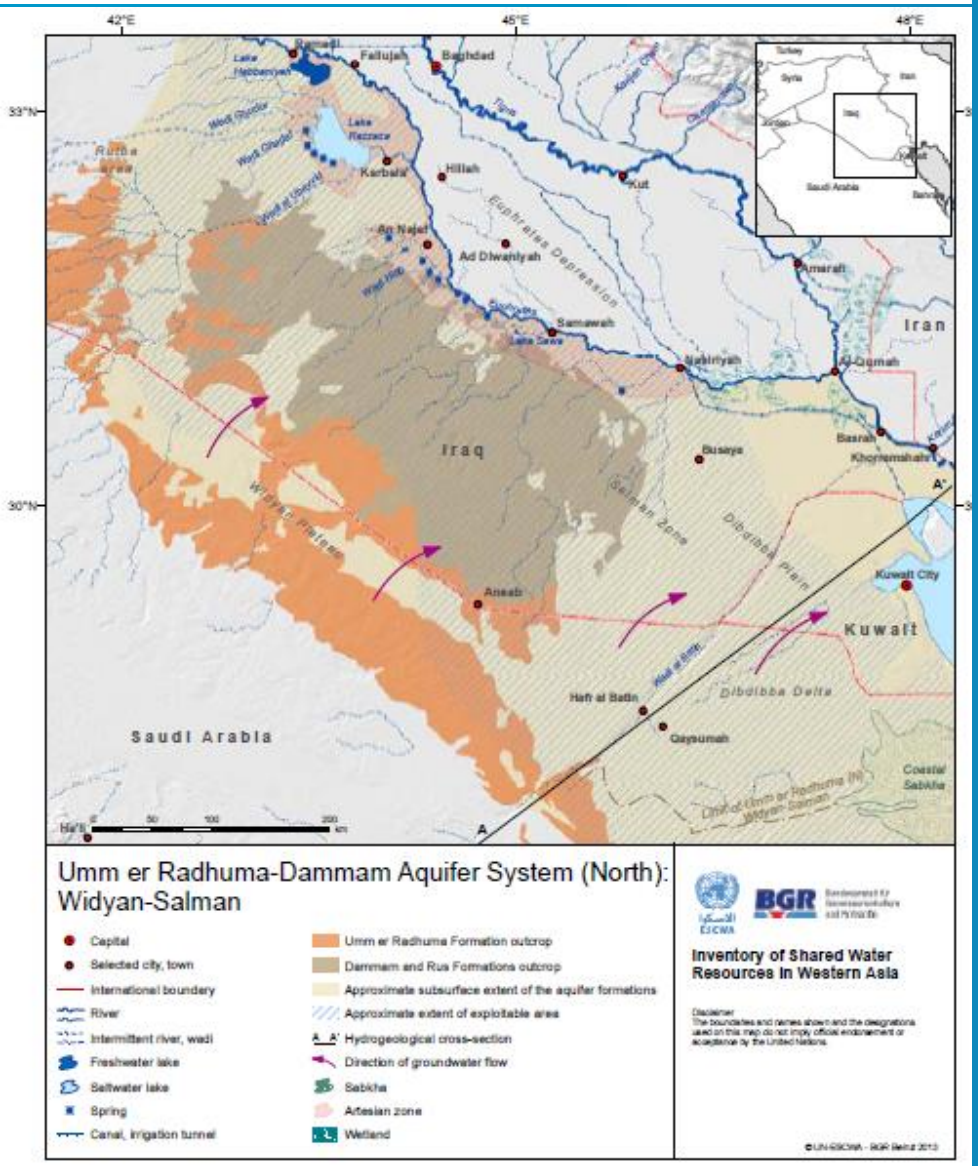
KEY CONCERNS

- Groundwater in the Dibdibba Delta Basin is **not suitable for human consumption** with the exception of limited freshwater lenses near in northern Kuwait and in the Sabriah and Barjisiyah oilfields near Zubair in southern Iraq.

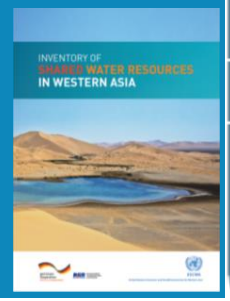
- In recent years, abstraction of groundwater from these aquifers seems to be limited by two main factors: dewatering of the Dibdibba Formation and inversion of downward groundwater flow from the Neogene to the Paleogene Formations in heavy abstraction areas.

RIPARIAN COOPERATION

- There are no water agreements in place for the Neogene Aquifer System (South- East), which is shared between Iraq, Kuwait and Saudi Arabia.



Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman



RIPARIAN COUNTRIES	Iraq, Kuwait, Saudi Arabia
ALTERNATIVE NAMES	Euphrates-Northern Gulf Basin, Euphrates-Dibdibba
RENEWABILITY	Very low to low (0-20 mm/yr)
HYDRAULIC LINKAGE WITH SURFACE WATER	Weak
ROCK TYPE	Fissured/karstic
AQUIFER TYPE	Unconfined to semi-confined or confined
EXTENT	~246,000 km²
AGE	Cenozoic (Paleogene)
LITHOLOGY	Mainly limestone and dolomite, with some evaporates
THICKNESS	Dammam: 30-80 m Umm er Radhuma: 240-600 m
AVERAGE ANNUAL ABSTRACTION	Iraq: ~45 MCM (early 1990s) Kuwait: ~90 MCM (1993) Saudi Arabia: ..
STORAGE	..
WATER QUALITY	Fresh to hypersaline
WATER USE	Agricultural, industrial and domestic use except for drinking
AGREEMENTS	-
SUSTAINABILITY	Over-abstraction resulting in lowering of the water table and salinity increase due to upconing of saline water and seawater intrusions

Umm er Radhuma- Dammam Aquifer System (North): Widyan-Salman

- The aquifer system stretches from the Rutba-Widyan area eastward through the Salman Zone to the Dibdibba Delta, forming a shared aquifer system between Iraq, Kuwait and Saudi Arabia.

KEY CONCERNS

- Limited recharge occurs mainly through the Umm er Radhuma outcrops.
- Available information indicates that the three riparian countries currently exploit the aquifer system, primarily in the Dammam and the upper part of the Umm er Radhuma Formations, resulting in a waterlevel decline of up to 60 m in both formations.
- The aquifer system is at risk from salinization, and deteriorating groundwater quality may become an increasingly limiting factor to groundwater use.
- Nevertheless, the aquifer system remains exploitable in most of this section, except in the Widyan Plateau that straddles the Saudi-Iraqi border and coastal areas where it is either dry or contains saline water.

RIPARIAN COOPERATION

- There are no water agreements in place for the Neogene Aquifer System (South- East), which is shared between Iraq, Kuwait and Saudi Arabia.
- Monitoring of groundwater quality in general and the groundwater-seawater interface in particular would allow for the detection of increasing salt concentrations.
- Effective joint management decisions could decrease the risk of salinization and make the aquifer system more sustainable.

Key Findings

1. There are more shared water resources in Western Asia than generally assumed.
2. Water quantity and allocation dominate the discourse on shared water resources in this water-scarce region.
3. Water quality is rapidly deteriorating, a fact that is largely neglected.
4. The lack of accurate data hampers joint water resources management.
5. Cooperation over shared water exists, but is never basin-wide.
6. There is only one agreement on shared groundwater resources in the region.
7. The region's groundwater is largely non-renewable and aquifers are rapidly being depleted.
8. Groundwater plays an important role in surface water basins, a link which is often overlooked.
9. A new thinking is required to deal with large regional aquifer systems from a shared perspective.
10. It is already too late to save some shared waters.

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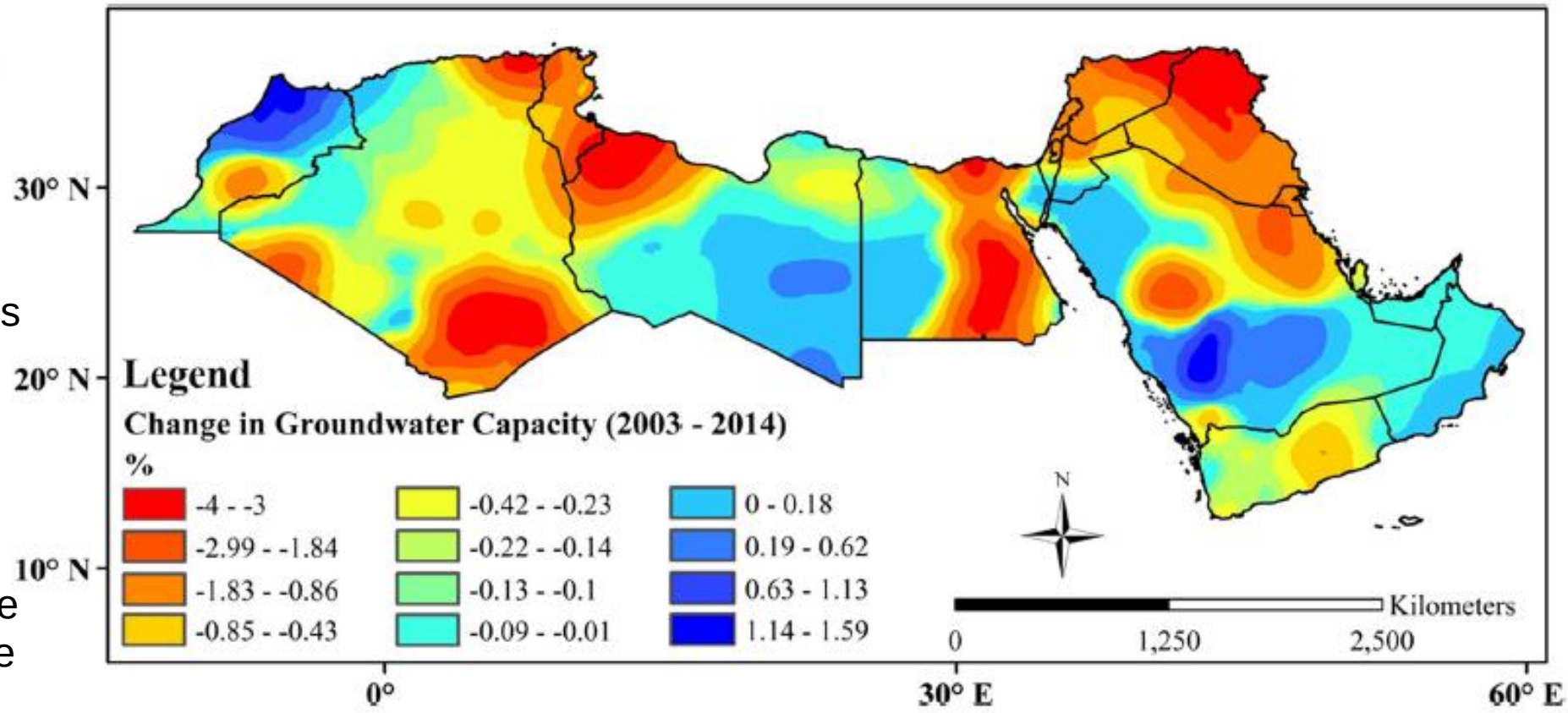
ESCWA

Use of GRACE Satellite date to assess groundwater resources in the Middle East and North Africa region

- The study used a distributed ArcGIS model, parametrized with gridded data sets, to estimate groundwater storage reserves in the region based on generated aquifer saturated thickness and effective porosity estimates.

- Furthermore, monthly gravimetric datasets (GRACE) and land surface parameters (GLDAS) were used to quantify changes in groundwater storage between 2003 and 2014.



Khalil Lezzaik and Adam Milewski, 2018. A quantitative assessment of groundwater resources in the Middle East and North Africa region. Hydrogeology Journal, 26:251–266.

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