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INVENTORY OF
SHARED WATER RESOURCES IN WESTERN ASIA (ONLINE VERSION)

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OVERVIEW

SHARED WATER RESOURCES IN WESTERN ASIA

The sharing of water resources has been an influential feature affecting life, society and development in the Arabian Peninsula, the Mashrek and Mesopotamia for millennia. Historically, communities living in these arid and semi-arid regions always shared the water of rivers, springs and wadis, although this was more out of necessity than idealism. Water resources were traditionally managed at the local level, with tensions emerging between Bedouins, shepherds, pastoralists and growing urban centres. Water management and irrigation schemes – such as the underground aqueducts or falaj networks found in Bahrain, Oman, Saudi Arabia and Yemen – sustained different communal needs for dozens of centuries, while the marshes of Mesopotamia, the Tigris floodplain and the Jordan River

Shoyoukh Tahtani, Lake Tishreen, Syria, 2009. Source: Adel Samara.

Valley were cultivated and sustained successive civilizations since earliest of times. Hillside terraces from Lebanon to Yemen meanwhile demonstrated the early integration between water and land resources management schemes and local efforts to safeguard water for productive purposes. With the expansion of empires and the changing patterns of commerce between east and west, tradesmen tried to tame the waters of the Euphrates and Tigris Rivers for navigation purposes prior to the opening of the Suez Canal in 1869, albeit with limited success. Following the creation of modern nation states in Western Asia starting in the first half of the 20th century, most of the region's major rivers and many aquifer systems were found to cross political borders. However, their management did not emerge as a major problem until increasing freshwater scarcity exposed dependencies on internationally shared water resources.

During the second half of the 20th century, technological transformations, demographic changes, natural resource extraction, ethno-sectarian conflicts and development needs fundamentally altered the way that water resources were managed internally and addressed in international relations. Large-scale irrigation projects boosted investments in and socio-economic dependencies on the water and agricultural sectors. The damming of major rivers for hydropower generation and the expansion of irrigation networks created new economic opportunities upstream, while causing negative impacts on downstream water users and ecosystems in neighbouring countries, especially during the filling of reservoirs. Small-scale dams on tributaries and in catchment areas also impacted downstream flows, and affected the availability and seasonality of water in intermittent streams. Political conflicts and the occupation of Arab lands also prevented access to surface and groundwater resources, which had traditionally sustained the livelihoods of rural communities. Meanwhile, changing development paradigms and political uncertainties prompted the adoption of national policies to pursue food security through food self-sufficiency in many Western Asian countries, which led to the further extraction of surface and groundwater resources through the subsidization and centralization of large- and small-scale agricultural production. Considerable quantities of surface water were thus abstracted and increasingly diverted out-of-basin, while return flows from water-intensive agricultural projects polluted rivers and groundwater reserves. Water quality deteriorated, most notably through increased salinity, further affecting domestic and agricultural users downstream. In addition, exponential population growth rates throughout the region caused a sharp rise in demand.

Concurrently, agricultural production flourished with the introduction of groundwater pumps in the 1960s and 1970s, which resulted in the intensive development of groundwater resources. However, the arid climate and low rainfall levels meant that groundwater abstraction quickly exceeded recharge, which in turn led to the drying up of springs, streams and shallow groundwater bodies, some of which had flowed across national borders. Further advances in drilling and pumping technology allowed for the exploitation of deep groundwater reserves in the Arabian Peninsula, which were created thousands of years ago and are non-renewable under current climatic conditions. These deep fossil aquifers are often highly productive and constitute a unique kind of shared water resource in the region.

Today, water scarcity levels regionally are well below the water poverty level of 1,000 m^3 per capita. However, population growth rates and rural-to-urban migration patterns continue to fuel the expansion of the industrial and service sectors and to increase demand for freshwater resources, as well as water supply and sanitation services. Political unrest and the Arab-Israeli conflict also impede opportunities for constructive dialogue on shared water resources. Meanwhile, the agricultural sector remains the largest consumer of freshwater resources and shared water resources in the region. Climate variability and climate change evidenced by droughts and flash floods, in addition to the unsustainable abstraction of groundwater resources have affected agricultural productivity and further fuelled social unrest.

Some states in the Western Asia region have been able to adapt to this condition by increasing investments in desalination, dams, diversions and non-conventional water resources to enhance supply in the face of increasing demand. However, these supply side interventions have often been pursued unilaterally with limited consultation or coordination with downstream users within a shared basin. Water use efficiency improvements have also been pursued, but only to a moderate extent, despite the shared benefits that could be generated by reducing freshwater consumption. As such, dependency on shared surface and groundwater resources persists in the face of growing water scarcity and will continue to be a dominant influence on development policy and inter-state relations in Western Asia.

State of Knowledge on Shared Water Resources

GLOBAL AND REGIONAL EFFORTS TO ASSESS SHARED WATER RESOURCES

Several regional and global studies to assess transboundary water resources have been published in recent decades. The United Nations Educational, Scientific and Cultural Organization International Hydrological Programme (UNESCO-IHP) has collected a wealth of aggregate information on global water resources as part of its World Water Assessment Programme (WWAP), which has been regularly included in the World Water Development Report (WWDR). The Internationally Shared Aquifer Resources Management Initiative (ISARM), a multi-agency effort led by UNESCO and the International Association of Hydrogeologists, has also launched a number of global and regional initiatives to delineate and analyse transboundary aquifer systems and encourage riparian cooperation. However, to date, none of these initiatives have centred on the Middle East.

The World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP), another multi-agency consortium with BGR as executing institution, has produced several maps on river and groundwater basins around the world. This includes a map of river and groundwater basins of the world at a 1:50,000,000 scale.[1]

Several regional, political and economic organizations have also undertaken detailed assessments of transboundary water resources at the regional level which are often tied to multilateral agreements which regulate the management and use of transboundary waters, or the monitoring of environmental targets. The European Union Water Framework Directive is perhaps the most far-reaching agreement of this type, built on the river basin management approach and not limited to transboundary waters. The 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes is

The Tigris River in Baghdad, Iraq, 2007. Source: James Gordon.

an international environmental agreement negotiated by members of the United Nations Economic Commission for Europe (UNECE). Its Working Group on Monitoring and Assessment, a subsidiary body to the Convention's Meeting of the Parties, has conducted two comprehensive assessments of transboundary waters in Europe, which also inspired the preparation of this Inventory.

The global and regional initiatives outlined above all have a similar aim: to encourage and foster cooperation over shared water management and to protect and manage the resource in a sustainable manner for the benefit of all riparians. Many of these initiatives have used the assessment of shared surface and groundwater resources as a baseline and reference for bilateral and multilateral dialogue. The development of this Inventory is closely connected to the global and regional efforts outlined above, though it is a formally independent initiative of ESCWA and BGR in partnership with ESCWA member countries.

ASSESSMENT OF SHARED WATER RESOURCES IN WESTERN ASIA

The state of knowledge on shared surface and groundwater resources in the region is largely drawn from the literature available at the global level and reflects the historical context outlined above. Research on surface water resources has tended to dominate the literature. However, information on shared surface water is limited given the political context and national security concerns that are evoked regarding data sharing and exchange. Even less is known about groundwater resources hidden deep underground.

The region's few shared surface water basins are generally well known. Most basins have been subject to discussion and negotiations between riparian states, and some, most notably the Jordan River Basin, have been overshadowed by sustained political conflict. A wealth of literature exists on these disputed basins, although not necessarily on all relevant aspects. For example, the literature on the Jordan River Basin and, to a lesser extent, on the Euphrates and Tigris River Basins, is dominated by a focus on political relations, occupation and power asymmetry. However, the underlying scientific base is often limited and data is not publicly available, resulting in the republication of outdated maps, incomplete hydrological records and unreliable water use estimates.

At the same time, the focus on disputed rivers has diverted attention from smaller shared rivers and tributaries, which often play an important role on a local level and which may already have been affected by upstream water development projects.

Governments, scholars and international organizations have generally focused much less on shared groundwater resources in the region, and literature on the topic is limited and rarely publicly available. The Arab Centre for the Studies of Arid Lands and Dry Zones (ACSAD) published a comprehensive Hydrogeological Map of the Arab Region and Adjacent Areas in 1988.[2] ACSAD has also carried out a number of detailed groundwater studies in border areas on behalf of line ministries in ACSAD member countries. In addition, ESCWA has over the years worked on a range of projects with BGR, other partners and national governments to assess the state of shared water resources, such as the RJGC study,[3] the Basalt Study[4] and the study of Paleogene Aquifers,[5] all of which were released to experts.

However, the overwhelming majority of groundwater studies is undertaken by or on behalf of national governments, and rarely transcends political borders. Most groundwater maps delineate aquifers only up to the national borders and disregard the transboundary extent of the resource. The same goes for academic studies, which in this region can often only be implemented in close coordination with competent national authorities, who determine which information is released to the general public. Data from such studies is sometimes transferred into scholarly articles or sector assessments. The aquifers shared between Israel and Palestine form an exception. Here the political context, international interest and the continuous presence of local and foreign experts has allowed for the implementation and publication of technical and political studies, some of which were carried out on a basin-wide scale.

By contrast, little information is available on the deep fossil aquifers in the Arabian Peninsula. Over the last three decades, the exploitation of these extensive groundwater bodies has grown exponentially. In many cases, dealing with these aquifers and aquifer systems from a transboundary "basin" perspective raises complex conceptual questions (see 'Overview & Methodology: Groundwater' chapter).

The Western Asia Region: Study Area

The Western Asia region has no clearly agreed-upon boundaries and various international institutions and agencies define the region differently (Box 1). The geographical coverage of this Inventory was first determined by the membership of ESCWA, which includes all Arab countries in Western Asia as well as some Arab countries situated in North Africa. This coverage was then modified according to the following four criteria:

- Focus was placed exclusively on shared surface and groundwater resources included in the Western Asia geographic sub-region covered by ESCWA, given that there exists no comprehensive study of shared drainage basins and aquifer systems in this sub-region and there was a clear mandate to examine water resources management within a regional, transboundary context.
- Surface and groundwater resources located on the African continent were excluded from the Inventory. These resources are covered extensively in other studies and are better addressed in an intra-African context.
- As the Inventory is intended to focus on shared water resources, parts of drainage basins or aquifer systems originating in or shared with non-ESCWA member countries are necessarily included in the Inventory. However, as the relevant countries – Iran, Israel and Turkey – are not members of ESCWA, they were not included in the consultative process undertaken with country representatives.[6]
- The study area excludes a number of shared basins in the northern part of Western Asia situated outside the ESCWA region, but these are covered to a large extent in a similar initiative undertaken by UNECE.[7]

Zagros Mountains, Iraq, 2010. Source: Stefan Jürgensen.

This Inventory therefore closes a geographical gap between similar assessments implemented in Africa and European-Central Asia.

The Western Asia region as defined in this Inventory thus extends from the Red Sea in the west to the Gulf coast in the east, and from the north-eastern shore of the Mediterranean Sea to the Gulf of Aden in the south to comprise 12 ESCWA member countries and Israel, Iran and Turkey (Table 1). From a geological perspective, the study region lies entirely within the Arabian Plate and is characterized by common geo-tectonic systems, which have contributed to the development of shared surface and groundwater systems. Furthermore, as will be explained in more detail below, the region can be divided into three sub-regions: the Mashrek, Mesopotamia and the Arabian Peninsula.

BOX 1

Defining the Western Asia Region

The Western Asia region is geographically not clearly defined and various institutions use the term to designate different geographical areas, depending on the scope of their operations. In its broadest geographic sense, the Western Asia region can comprise countries located from the eastern shores of the Red Sea and the Mediterranean Sea to the Gulf coast in the east, up to the Caucasus Mountains in the north. The United Nations Statistics Division defines Western Asia as a geographic sub-region of Asia that encompasses Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates and Yemen.[8]

However, some organizations, even within the UN system, refer only to a sub-section of this wider geographic definition, based on regional, cultural or political identities. For instance, the membership of the United Nations Economic and Social Commission of Western Asia (ESCWA) comprises only the Arab countries of Western Asia, sometimes also referred to as Arab Western Asia or the Arab Mashrek, plus most Arab countries situated in North Africa (Egypt,[9] Libya, Morocco, Tunisia and Sudan); as such, it excludes Cyprus, Iran, Israel, Turkey and other countries located further north towards the Caspian Sea.

Within the UN and other international organizations, Western Asia has also often come to replace the narrower terms "Middle East" and "Near East", which are regarded as Eurocentric as they designate the region in relation to Europe. Other institutions use Middle East in combination with "North Africa", resulting in the term "MENA region", which also includes non-Arab countries.

Table 1. General features of countries in the study area

SUB-REGION	COUNTRY	SURFACE AREA[a] (km^2)	POPULATION[b]	MEAN ANNUAL PRECIPITATION (mm/yr)[c]
Mashrek[d]	Egypt (Sinai Peninsula)	60,174	546,799	<100
	Israel	22,070	7,625,000	435
	Jordan	89,324	6,113,000	111
	Lebanon	10,452	4,227,597	661
	Palestine	6,020	4,048,403	402
	Syria[e]	185,180	20,619,000	252
Mesopotamia	Iraq	438,317	32,438,000	216
Arabian Peninsula	Bahrain	694	1,234,571	83
	Kuwait	17,818	2,672,926	121
	Oman	309,500	2,773,479	125
	Qatar	11,493	1,699,435	74
	Saudi Arabia	2,149,690	27,563,432	59
	United Arab Emirates	83,600	8,264,070	78
	Yemen	527,970	23,154,000	167
Other	Iran	1,745,150	74,339,576	228
	Turkey	783,560	72,698,000	593
TOTAL		6,441,012	290,017,288	-
TOTAL (Arab countries)		3,890,772	135,354,712	-

Source: Compiled by ESCWA-BGR.
(a) Figures based on UN-ESCWA, 2009a, except for Egypt (from CAPMAS, 2012) and Israel, Iran and Turkey (from World Bank, 2011).
(b) Figures referring to 2010 (census data or estimates), based on UN-ESCWA, 2011b except for Egypt (from CAPMAS, 2012) and Israel, Iran and Turkey (from UN-DESA, 2012).
(c) Figures referring to 2009, based on World Bank, 2011 except for Egypt (from CAPMAS, 2012).
(d) The Mashrek refers to the region located on the eastern Mediterranean coast between Anatolia in the north and the Sinai Desert in the south (Harris, 2003).
(e) North-eastern Syria is considered part of Mesopotamia (Encyclopédie Larousse, 2012).

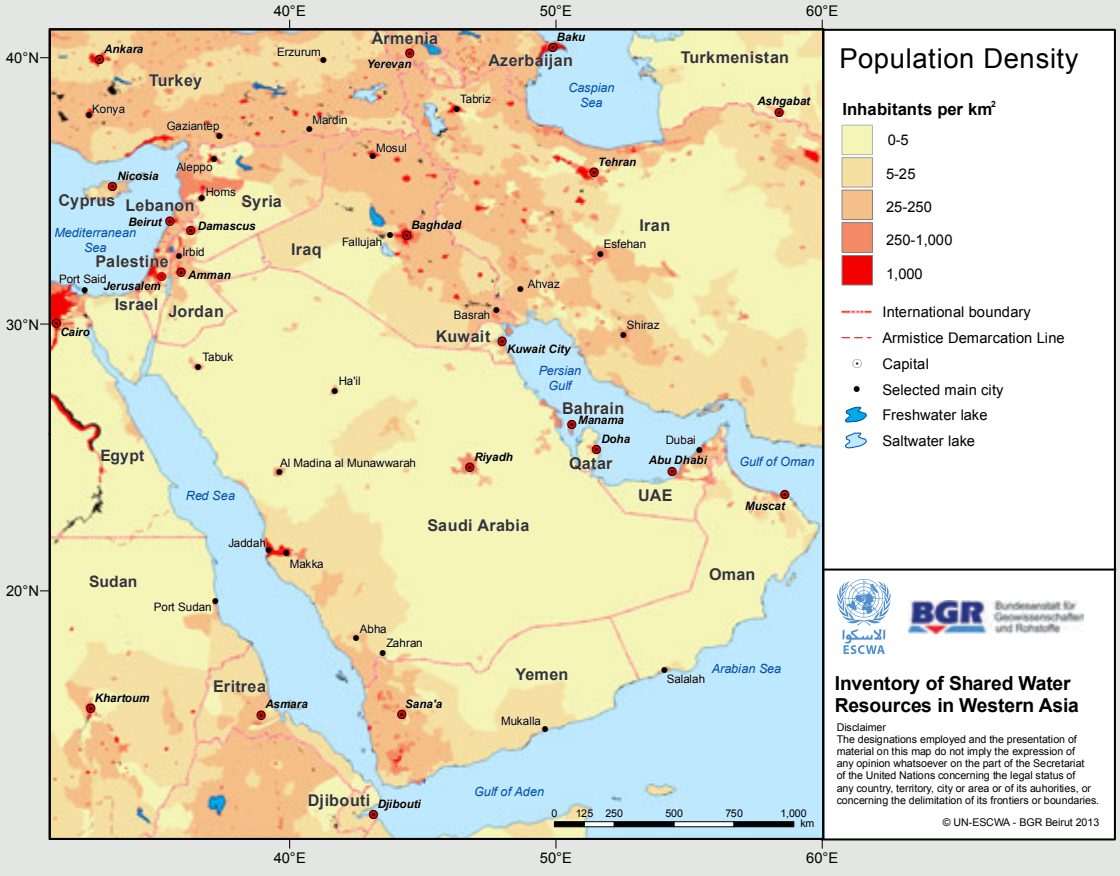
Population

The Western Asia region as defined in this Inventory covers an area of approximately 4 million km^2 or about 2.6% of the world's surface area.[10] The region's total population of around 135 million inhabitants[11] has more than tripled since 1970, and the populations of Iraq, Palestine and Yemen are expected to double between 2010 and 2050.[12]

Population increase in the region has in some cases contributed to very high population densities. The average population density in the region was estimated at 325 inh./km^2 in 2010, with the highest density found in Bahrain (1,818 inh./km^2) and the lowest in Oman (9 inh./km^2). Figure 1 shows that the region's population is unevenly distributed within and between countries, and is in general concentrated along major rivers on the coast or in mountain ranges near the coast. These relatively water-rich areas have fertile soils and are strategically located along major trade routes.

While population growth rates in the region have declined in recent years, the average growth rate (3.28%) still remains well above the world average.[13] Urban growth is an important challenge facing the region; the urban population is growing at a faster rate than the total population, indicating a continued urbanization trend.[14] Approximately three quarters of the region's population live in cities today,[15] with the highest urban population percentages found in the countries of the Gulf Cooperation Council (GCC).[16] Urban expansion in the region is a result of demographic growth, internal rural-to-urban migration, and the influx of displaced people fleeing conflicts in the region. Another important factor is the influx of expatriates attracted by the region's employment opportunities, particularly in the Gulf and in oil-producing countries.[17] This has led to the creation of new settlements in urban peripheries, especially along the coast, but also in reclaimed deserts.[18] Urban growth is placing increasing pressure on the region's already limited water resources, and spurring investment in non-conventional water resources such as desalination, particularly in the wealthier GCC countries.

Figure 1. Population density in the Western Asia region



Source: Compiled by ESCWA-BGR based on CIESIN, 2010.

Topographical Features

The Western Asia region is characterized by large mountainous zones and vast deserts that cover most of the Arabian Peninsula (Figure 2).The Taurus-Zagros Mountain range, which extends from southern Turkey to the Iraq-Iran border, bounds the Western Asia study region to the north. Two other mountain chains run along the Mediterranean shore. The Lebanon Western Mountain range extends along the eastern Mediterranean coast in Lebanon, with Qurnat as Sawda as its highest peak (3,090 m).[19] The Eastern Mountain Range (Anti-Lebanon) runs parallel to the western range and stretches to the Golan Heights Plateau in the south, where Mount Hermon (2,814 m) on the Lebanese-Syrian border forms the highest peak. Towards the east, the Zagros Mountain range in northern Iraq reaches into western and southern Iran. Zard Kuh in Iran (4,548 m) is the highest peak here.[20]

In the Arabian Peninsula, the Hijaz and Asir Mountain ranges extend along the length of the Red Sea coast with elevations of approximately 2,000 m.[21] Situated along the southern stretch of the Red Sea coast, the Yemen Mountain range rises up to 3,666 m (the highest elevation in the Arab countries included in the study area) and then runs parallel to the Gulf of Aden as the Hadhramaut Mountain range.[22] The Hadhramaut Plateau is situated in the same area, covering a total area of 158,000 km^2.[23] The fertile Najd Plateau in the centre of the Arabian Peninsula slopes from west to east with elevations of up to 1,500 m.[24] There are also many wadis (Box 2) and large salt marshes or sabkhas (Box 3) scattered

BOX 2

Wadis

A common feature in the Arabian Peninsula, wadis (singular: wadi) are seasonal streams with lengths that can vary from a few tens of kilometres to hundreds of kilometres. For example, Wadi al Batin covers 970 km and crosses Iraq, Kuwait and Saudi Arabia (see Chap. 26, Box 1). Despite their seasonal nature, some wadis have been crucial in supplying populations with water for domestic and irrigation purposes in Oman, Saudi Arabia and Yemen.

Source: Compiled by ESCWA-BGR based on Shahin, 2007; Edgell, 2006.

Afrin dam, Syria, 2009. Source: Andreas Renck.

through the peninsula. In the south-east, the Oman Mountain range borders the Gulf of Oman with a peak elevation of more than 3,000 m at Jebel Shams.[25] In addition to mountain ranges and highlands, the region also features areas well below sea level, such as the Dead Sea which is considered the lowest point on earth at 422 m bsl.[26]

One of the region's most distinctive topographical features is its extensive desert areas. The Syrian Desert (500,000 km^2) in the north covers more than half of Syria, as well as parts of western Iraq, Jordan and Saudi Arabia.[27] In the Arabian Peninsula, the An Nafud Desert (65,000 km^2) spans north-western Saudi Arabia to the Dahna Desert. It is connected to the Rub' al Khali Desert (the Empty Quarter), one of the world's largest sand deserts which extends over 650,000 km^2 in the southern third of the Arabian Peninsula. The Rub' al Khali is mainly situated in Saudi Arabia, but also covers parts of Oman, the United Arab Emirates and Yemen.[28] Smaller deserts also exist in the region, such as the Negev Desert (Al Naqab in Arabic), which borders the Sinai Peninsula Desert in Egypt and has a surface area of 13,000 km^2.[29]

Other important topographical bearings in the region are plains, such as the coastal Tihama Plain along the Red Sea in western Saudi Arabia and Yemen, the Batinah Plain in northern Oman and the Hasa Plain along the eastern shores of the Arabian Peninsula . In addition, alluvial plains formed by river sedimentation exist along the Euphrates and Tigris Rivers and on the banks of other rivers situated in Lebanon and Syria.[30]

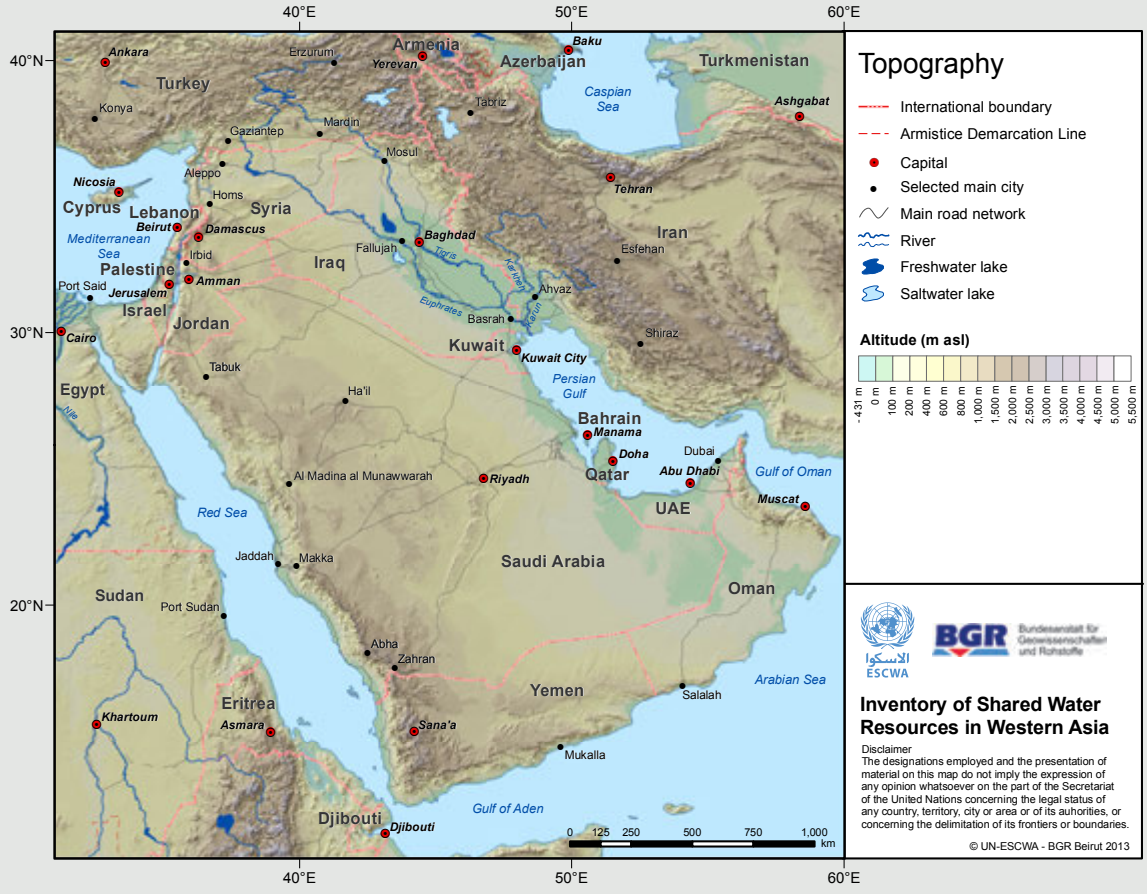
BOX 3

Sabkhas

A very common physiographic feature in the Arab region, sabkhas (singular: sabkha) are salt flats or salt-crusted depressions lying just above the water table. These sandy or silty areas have impermeable floors where salt brine has accumulated due to episodic flooding and evaporation. Sabkhas are commonly found in the eastern Arabian Peninsula and in parts of Iraq and Syria. With an elevation of 100 m, the Umm es Sammim Sabkha in the east of the Rub' al-Khali Desert is probably one of the highest salt formations in the region.

Source: Compiled by ESCWA-BGR based on West, 2012; Ghazanfar, 2006; Jabbul Consultative Committee, 2008.

Figure 2. Topography of the Western Asia Region



Source: Compiled by ESCWA-BGR based on SRTM, 2000.

Climate

The Western Asia region is dominated by a dry, arid or semi-arid climate with limited rainfall and high evaporation rates. The mountain ranges along the Mediterranean and Red Sea coasts and winds from the Atlantic and Indian Oceans play an important role in determining precipitation patterns. While certain mountainous areas receive more than 1,000 mm/yr of precipitation, the largest part of the study area receives less than 100 mm/yr (Figure 3). Most countries experience a critical combination of low rainfall and high spatial and temporal rainfall variability, which impacts water availability.

The western areas of Jordan, Lebanon, Palestine and Syria have a Mediterranean climate with warm, dry summers and rainy, cold winters. In the east, the vast deserts of Iraq, Jordan and Syria are arid with excessively hot, dry summers. In winter, daytime temperatures here are mild, while nights can be very cold. Temperatures in the highlands of north-eastern Iraq, Lebanon and northern Syria are below 10˚C in January, rising to 20˚C to the south and the east. July and August are generally the warmest months on the Mediterranean and Red Sea coasts and temperatures can reach 50˚C or more in parts of Iraq and Saudi Arabia.[31]

A hot desert climate[32] characterizes most of the Arabian Peninsula, including the narrow coastal strip along the Red Sea and the vast desert plain along the Gulf coast. In the elongated plateau parallel to the Dead Sea and on the Oman Plateau along the western coast of the Gulf of Oman, a hot steppe climate[33] prevails. Finally, the south-western corner of the Arabian Peninsula has a warm temperate rainy climate,[34] with temperatures reaching around 25˚C in January along the Red Sea coast. Temperatures in northern coastal zones of the peninsula are slightly lower and much lower in inland areas (13˚C-14˚C).[35]

Precipitation is one of the most influential climatic features, and in the northern mountainous areas[36] it is a result of cold fronts coming in from Siberia and the Atlantic Ocean between November and February. These fronts become saturated with moisture as they reach the Mediterranean and generate precipitation until April or early May, and especially from December to February. In Mount Lebanon and western Syria, precipitation can reach 1,500 mm/yr, gradually diminishing to the east as fronts cross the coastal mountain ranges and reach Jordan, northern Saudi Arabia and western Iraq.

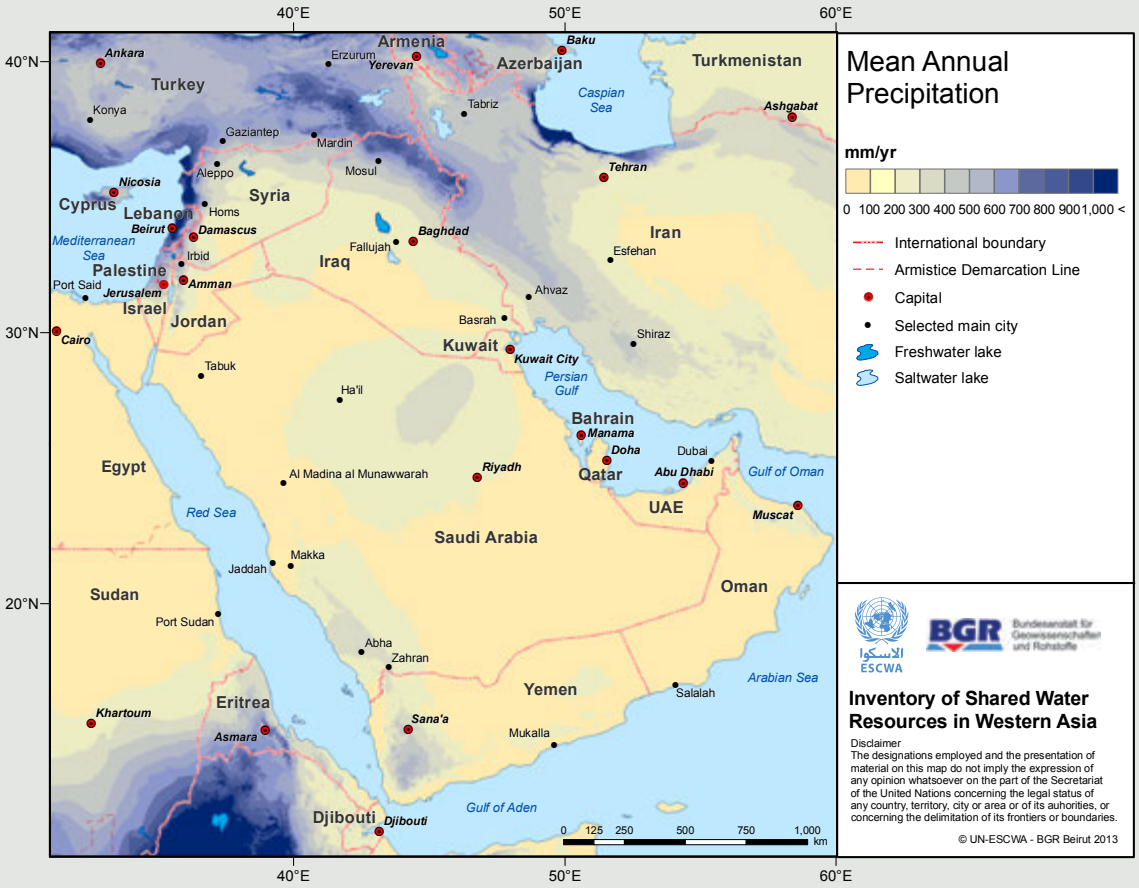
Precipitation in the Arabian Peninsula is affected by seasonal (monsoon) winds, which bring moist air masses from the Indian Ocean with them, causing rainfall in the coastal zones of eastern Oman, Saudi Arabia (Hijaz region) and Yemen.[37] Most of the precipitation occurs in May and continues until August in the uplands, but often appears as early as March. In this area, precipitation mainly occurs in the form of heavy showers followed by flash floods. Precipitation levels can reach up to 1,500 mm/yr on the south-western mountain slopes in Yemen.[38] Some moderate seasonal shifts in rainfall patterns and intensities have also been observed in the region in recent years.

Over the past decade, climate change has become increasingly prominent within the regional debate surrounding sustainable water resources management. According to the IPCC Fourth Assessment Report,[39] the Arab region is highly vulnerable to the potential impacts of climate change, which include higher average temperatures, less and more erratic precipitation and sea-level rise.

Despite this, the issue of climate change does not feature prominently in this Inventory, which was conceived as a desk study to compile and consolidate past and current data on hydrology, water use, and agreements and cooperation in shared water basins in the region. As such, the Inventory aims to take stock of the recent development and current state of shared water basins, without making projections into the future. In most cases the literature on the basins covered in this Inventory has not yet

Agriculture in the Disi-Mudawwara area, Jordan, 2009. Source: Andreas Renck.

Figure 3. Mean annual precipitation distribution across the Western Asia region



Source: Compiled by ESCWA-BGR based on WorldClim, 2011.

reached a clear conclusion as to the impact of climate change. In most cases, too few studies have been undertaken and insufficient data is available. More fundamentally, the intensive development of all available water resources in this arid region makes it difficult to identify the underlying causes of hydrological changes.

There are currently a number of initiatives underway to improve data availability and projections for the study region, such as the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region which is led by ESCWA, the League of Arab States and other specialized organizations. This initiative aims to assess the impact of climate change on freshwater resources and its associated implications for socio-economic vulnerability in the region. It draws on the findings and basin chapters of the Inventory to inform its integrated assessment methodology comprised of regional climate modelling, regional hydrological modelling, and vulnerability assessment tools.[40]

BOX 4

Availability of Water Resources in the Region

The prevailing semi-arid to arid climate in the Western Asia region governs the occurrence of freshwater. Although the region's aridity is mainly a result of low precipitation, high evaporation rates also severely reduce the amount of water that remains as surface runoff or groundwater recharge.

In the north, the Taurus-Zagros Mountain range captures significant precipitation from moist westerly winds, which feeds the Euphrates and Tigris Rivers. Similarly, precipitation from the eastern Mediterranean mountain ranges feed the headwaters of the Jordan and Orontes Rivers, the Nahr el Kabir and smaller Lebanese and Syrian rivers. Perennial rivers are thus confined to the Mashrek region where humid conditions prevail and where water resources are renewable.

In the Arabian Peninsula, scarce rainfall and very high evaporation rates limit the occurrence of surface water and groundwater recharge. Nevertheless, the irregular but heavy rainfall that occurs in the mountainous areas of the Arabian Peninsula accumulates and infiltrates along the extensive network of wadi channels (Box 2), often constituting important local sources of freshwater. The climate in this area cannot sustain perennial river systems. Groundwater occurrence is also affected by the arid climate and by the region's geology and geo-tectonics (e.g. tectonic faults and structure, types of rock formation/aquifer, lithological and structural features, etc.).

Many aquifer systems in the region occur in large geological formations that cover tens or even hundreds of kilometres. Significant volumes of groundwater are stored in these sedimentary formations, which stem mainly from past pluvial periods. Recharge under current conditions is very limited. Smaller aquifer systems also exist: for example in wadi discharge areas where several channels join together and enhance the accumulation of thick alluvial deposits to form wadi aquifers.

Notes

1. WHYMAP, 2012.
2. ACSAD-UNESCO, 1988.
3. RJGC, 1995.
4. UN-ESCWA et al., 1996.
5. UN-ESCWA and BGR, 1999.
6. ESCWA member countries have been involved at all stages of the preparation of this Inventory through a consultation process aimed at improving and enriching basin chapter content through visits, regional workshops and tailored basin questionnaires. For further information, see 'Introduction to the Inventory'. Libya, Morocco and Tunisia joined ESCWA in August 2012 and, as they are not geographically situated in Western Asia, they were not included in the consultative process with countries.
7. UNECE, 2011, 'Drainage basins draining to the Caspian Sea', features the riparian countries Armenia, Azerbaijan, Georgia and Iran, among others.
8. UNStats, 2011.
9. The Sinai Peninsula is the only part of Egypt that is located in Western Asia.
10. UN-DESA, 2011. Excluding Iran, Israel and Turkey.
11. 2010 estimates.
12. Mirkin, 2010.
13. UN-DESA, 2011.
14. UN-HABITAT, 2012.
15. With the exception of Yemen (32%), urban population shares in the region make up between 55% (Syria) and 98% (Kuwait) of the total population (UN-ESCWA, 2009b).
16. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates.
17. UN-HABITAT, 2012. Moreover, most of the countries in the region are characterized by relatively high levels of foreign migration, such as Qatar and Kuwait where 75% of the population are migrants, and Jordan, where nearly 50% are migrants (UN-ESCWA, 2011b).
18. UNESCO, 2012.
19. Ministry of Tourism in Lebanon, 2012.
20. Encyclopaedia Britannica, 2012b.
21. Teach Middle East, 2010.
22. OWNO, 2012.
23. Edgell, 2006, p. 431.
24. Hussein et al., 1992.
25. Ministry of Tourism in Oman, 2012.
26. Khlaifat et al., 2010.
27. Graphic Maps, 2011.
28. Central Department of Statistics and Information in Saudi Arabia, 2011.
29. Metz, 1988.
30. Encyclopaedia Britannica, 2012a; Al-Jassar, 2005.
31. Shahin, 2007; Treehugger, 2010.
32. Characterized by sparse vegetation, negligible annual rainfall and some seasonal variation in temperature (National Geographic Society, 2008).
33. The hot steppe climate is milder than the hot desert climate with some rain in spring and winter (Benders-Hyde, 2010).
34. Characterized by rainfall throughout the year with maxima in spring and summer, and a dry winter season (Ibid).
35. Shahin, 2007.
36. Referring to Lebanon, the West Bank in Palestine and the northern parts of Iraq, Jordan and Syria.
37. Encyclopaedia Britannica, 2012a.
38. UN-ESCWA, 2007.
39. IPCC, 2007.
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