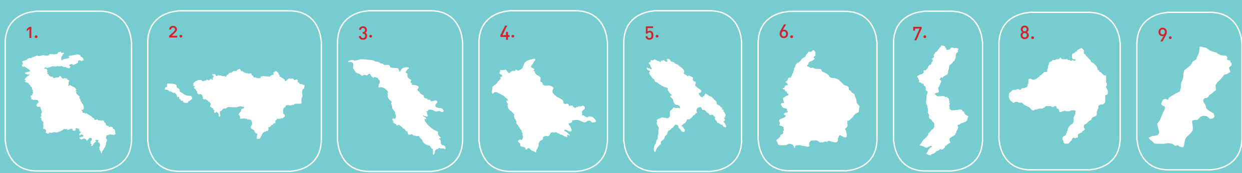
PART I

SURFACE WATER



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

german cooperation
DEUTSCHE ZUSAMMENARBEIT

BGR Bundesanstalt für Geowissenschaften und Rohstoffe

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OVERVIEW & METHODOLOGY:

SURFACE WATER

Part I of the Inventory provides a comprehensive overview of shared (transboundary)[1] surface water basins in Western Asia. This chapter presents the methodology and approaches used to identify, delineate, characterize and describe these shared water resources in the Inventory. After defining the terminology used in the surface water chapters, all shared surface water resources in the region are listed together with the list of chapters for Part I of the Inventory. The section also explains why certain shared tributaries were covered in a single chapter and why some river basins were dealt with in separate chapters. The second part of the chapter outlines the Inventory's approach to basin delineation, describes the structure of the surface water basin chapters and explains how the content of basin chapters was prepared and collated in a structured and unified way.

Definition of terminology

Water resources that cross national borders are most commonly referred to as international, transboundary or shared waters or watercourses. The terms are often used interchangeably although the terms transboundary waters and international watercourse are most commonly used. For instance, the latter is used in the United Nations Convention on the Law of Non-Navigational Uses of International Watercourses where it is defined as "a watercourse, parts of which are situated in different States".[2]

For reasons outlined in 'Overview: Introduction to the Inventory', the Inventory uses the term shared water, but generally follows the methodology and definitions put forward by the Transboundary Freshwater Dispute Database at Oregon State University. The Database defines a river basin as the area which contributes hydrologically (including both surface and groundwater) to a first order stream, which, in turn, is defined by its outlet to the ocean or to a terminal (closed) lake or inland sea. A river basin is defined as international if any perennial tributary crosses or represents the political boundaries of two or more nations.[3] A similar integrated understanding is put forward in the aforementioned United Nations Convention, which, however, refers only to the (system of) watercourses and not to the river basin as a whole.[4]

The Inventory deviates from the Database approach in two points. First, a strict differentiation between perennial, seasonal and intermittent streams (or tributaries) as a qualifying criterion for inclusion was not appropriate within the context of this Inventory. Rainfall and stream discharge in this predominantly arid region are highly variable, with pronounced seasonal and inter-annual cycles. In addition, hydrological information in the literature is scarce and often not comparable. Moreover, growing water use has had a tremendous impact on water resources in recent decades, leading to the drying up of springs and rivers on one side, but also to increasing flows downstream of urban and agricultural centers where once had been only dry wadis.

Second, the Inventory dedicates several chapters to the complex hydrology of the Euphrates-Tigris-Shatt al Arab basin, whereas the Database registers it as one basin based on its single outlet to the sea, the Shatt Al Arab. This is important to remember, particularly when findings of this Inventory are presented in an abbreviated or simplified way. For instance, the number of chapters in this Inventory does not necessarily match the number of shared basins identified in the study region, which, in turn, depends largely on the approach followed in the classification of river basins as well as the scale of study. At the same time, there may be a plethora of political, legal, administrative or management reasons why certain basins or sub-basins are dealt with as separate entities or vice versa. The added value of this Inventory lies in the identification, delineation and systematic description of shared basins and conditions – the number count of basins in itself is not its primary objective.[5]

Overview of Shared Surface Water Basins & Chapters

Shared surface water resources are only found in the Mashrek and Mesopotamia regions of Western Asia where humid conditions prevail in the northern, north-eastern and Mediterranean parts and where water resources are renewable. In the north, mountain ranges capture significant precipitation that feeds the Euphrates and Tigris Rivers; in the north-east, the Mediterranean mountain ranges feed the headwaters of the Jordan River, the Orontes River and the Nahr el Kabir (see Map 1).

The shared perennial rivers that flow through Western Asia have generally been recorded and therefore do not need to be identified in the same way as shared groundwater resources. The challenge for the Inventory was to apply a unified approach in delineating shared surface basins, as their boundaries differ from one publication and/or map to another. Furthermore, the Inventory offers complete coverage of shared water resources in Western Asia,[6] featuring key shared basins such as the Euphrates, Tigris and Jordan Basins, but also less prominent basins such as the Nahr el Kabir and Qweik Basins.

LIST OF SHARED WATER RESOURCES

The list of shared surface basins presented in Table 1 comprises all perennial watercourses in Western Asia that are shared between two or more countries. In addition, the right-hand column features shared tributaries for each basin. The table distinguishes between shared basins in the Mashrek and Mesopotamia.

Table 2 lists the countries in the region and shows which surface water basins they share. As several basins are shared with other countries, the table also includes Iran, Israel and Turkey.

Identifying riparian countries in these basins is not always a straightforward affair. The Euphrates River Basin, for example, is commonly regarded to have three riparians, Iraq, Syria and Turkey, which also share the watercourse. Its topographic catchment as delineated in this Inventory, however, also stretches slightly into Jordan and Saudi Arabia. Given the aridity of these areas and their distance to the watercourse, an active hydrological contribution originating from these areas is highly theoretical or might occur only under extreme climatic conditions, through ephemeral wadis. These countries are therefore marked in red in Table 2.

The Tigris River, in turn, flows through Iraq, Syria and Turkey, while its basin also extends into Iran, which provides significant contributions to river discharge through a number of perennial and seasonal tributaries. Iran is also a riparian of the Shatt al Arab

Table 1. List of shared surface water basins in Western Asia

REGION	BASIN	RIVER	MAIN SHARED TRIBUTARIES
MESOPOTAMIA	Euphrates-Tigris-Shatt al Arab	Euphrates River	Sajur River Jallab/Balikh River Khabour River
		Tigris River	Feesh Khabour River Greater Zab River Lesser Zab River Diyala River
		Shatt al Arab River	Karun River[a] Karkheh River
MASHREK	Jordan River		Hasbani River Banias River ------ Yarmouk River
	Orontes River		Afrin River Karasu River
	Nahr el Kabir		-
	Qweik River		-

Source: Compiled by ESCWA-BGR.
(a) The Iranian Karun River does not cross any political boundary, but provides a significant freshwater contribution to the Shatt al Arab and forms an important part of the transboundary river system; it is thus included in the Inventory as part of the shared basin covered in the chapter related to the Shatt al Arab.

Fish farms on the Orontes River, Lebanon, 2008. Source: Andreas Renck.

Table 2. **Shared surface water basins and riparian countries**

		ESCWA MEMBER COUNTRIES													OTHER		
	Basin/ Country	Bahrain	Egypt	Iraq	Jordan	Kuwait	Lebanon	Oman	Palestine	Qatar	Saudi Arabia	Syria	UAE	Yemen	Iran	Israel	Turkey
MESOPOTAMIA	Euphrates			•	•						•	•					•
	Tigris			•								•			•		•
	Shatt al Arab[a]			•											•		
MASHREK	Jordan				•		•		•			•				▯	
	Orontes						•					•					•
	Nahr el Kabir						•					•					
	Qweik											•					•

• Riparians that contribute surface water only under extreme climatic conditions.

Source: Compiled by ESCWA-BGR.
(a) Iran and Iraq are only riparians to the river, however all riparians to the Euphrates and Tigris Rivers are riparians to the Euphrates-Tigris-Shatt al Arab basin.

River, which forms the border between Iran and Iraq in its lower part, and hosts most or all of the Karkheh and Karun river basins, which provide important freshwater inputs to the Mesopotamian marshlands and the estuary.

The Jordan Basin is shared between Israel, Jordan, Lebanon, Palestine and Syria.

LIST OF CHAPTERS

Table 3 features a complete list of the nine chapters on shared surface water resources in the Inventory. Four chapters cover the four shared basins in the Mashrek region.

The Euphrates-Tigris-Shatt al Arab river system constitutes by far the largest surface water resource in the study area. Given its importance and in order to adequately reflect the specific conditions as well as its complex hydrology, the Inventory dedicates five chapters to this river system.

The Euphrates River Basin and Tigris River Basin each have a different dynamic and set of characteristics, particularly with regard to their riparian countries, tributaries and contribution to discharge, as well as water use patterns and water quality. The shared tributaries of the Euphrates River and the major shared tributaries of the Tigris River are covered in more detail in two separate chapters in order to highlight the role of these rivers and draw attention to local water issues and transboundary impacts. Finally, the Shatt al Arab River is discussed together with two additional major tributaries, the Karkheh and the Karun Rivers, which discharge directly into the Mesopotamian Marshes or the Shatt al Arab itself, and are hence neither part of the Euphrates or Tigris River basins. The Karun is not a shared river, but as it discharges into the Shatt al Arab, it is considered part of the Shatt al Arab basin and is therefore included in the Inventory.

Table 3. **List of chapters**

	CHAPTER	SHARED RIVER BASIN
MESOPOTAMIA	1	Euphrates River Basin
	2	Shared Tributaries of the Euphrates River
	3	Tigris River Basin
	4	Shared Tributaries of the Tigris River
	5	Shatt al Arab, Karkheh and Karun Rivers
MASHREK	6	Jordan River Basin
	7	Orontes River Basin
	8	Nahr el Kabir Basin
	9	Qweik River Basin

Source: Compiled by ESCWA-BGR.

Structure & Content of Surface Water Basin Chapters

Each chapter follows a set structure, introducing the basin through a list of facts and figures, a summary of key basin features and an overview map. Information presented in the main text is organized in four main sections:

1. Geography
2. Hydrological Characteristics
3. Water Resources Management
4. Agreements, Cooperation & Outlook

The two chapters on shared tributaries and the chapter on the Shatt al Arab, Karkheh and Karun are organized slightly differently. After a short introduction, these chapters discuss each river/tributary separately with respect to its hydrological characteristics and water resources management. Information on water quality and environmental issues, groundwater linkages and the section on agreements, cooperation and outlook is presented for all rivers/tributaries together.

Before presenting the four sections, it is important to clarify the approach applied to the delineation of surface water basins, which helped refine and standardize basin information.

Basin delineation

The following procedure was applied to delineate the surface water basins using the topographical database HydroSHEDS[a]: the regional digital elevation model (DEM) with a grid resolution of 30x30 m was converted into contours representing lines of equal altitude similar to common topographic maps using standard Geographical Information System (GIS) software (ESRI ArcMap 9.3). The contour lines reflect topographical features such as valleys, ridges and plateaus and therefore allowed to manually delineate the surface boundary of a watershed from which theoretically all water drains towards a defined point or outlet. GIS software MapInfo 9 was used for this task.

For this analysis, manual basin delineation was preferred over automatic algorithms due to the relatively coarse spatial resolution of the regional DEM and large floodplain areas with little or no topographical features. In those cases, a manual approach was considered to provide greater consistency. This also explains the discrepancies between basin area estimates of different literature references. Furthermore, topographical and hydrogeological (below ground) watersheds are not necessarily similar. Also, depressions (or sinks) occurring in nature represent endorheic (or inland) basins, which have no visible topographic outlet to the ocean, but may be geologically connected to the basin (e.g. Lake Van in Turkey). Additionally, the delineation of a drainage basin over large, flat areas challenges the definition of drainage directions and may lead to unrealistic boundaries.

(a) See 'Overview: Introduction to the Inventory', Box 4 for more information on HydroSHEDS.

GEOGRAPHY

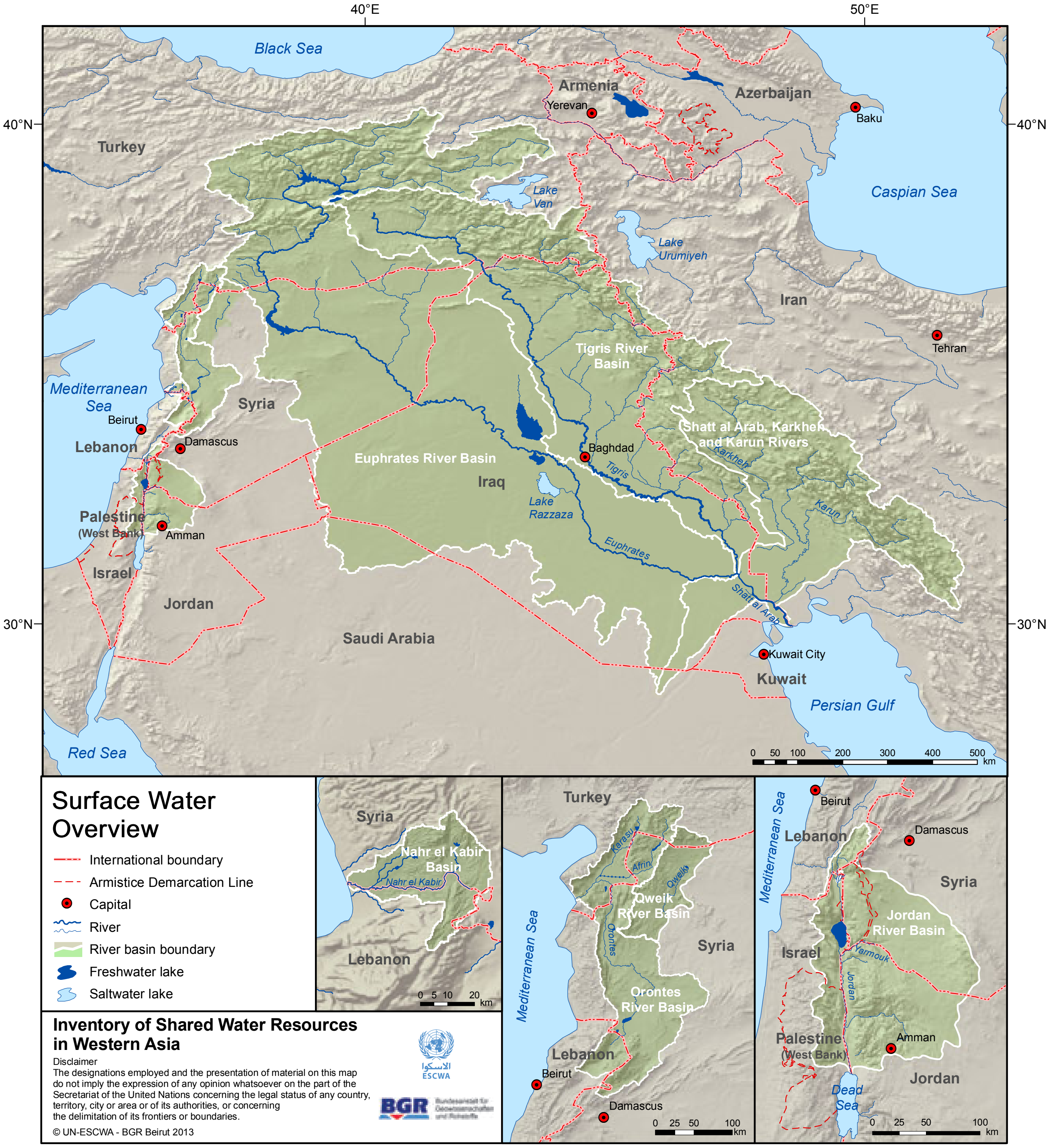
The objective of this section is to present the main features of a river as it flows through the riparian countries. This includes information on the basin area according to own calculations and its distribution among the riparian countries as well as a short description of the river course. Furthermore, the section features a climate diagram, a table on the estimated basin population and, in most chapters, a precipitation map of the basin (see 'Introduction to the Inventory', Box 4). The climate diagram displays monthly precipitation and air temperature averages over the period of a year for representative cities in the basin. Data is provided by WorldClim, 2011, Climate Diagrams, 2009 and the Phytosociological Research Center, 2009.

The inclusion of basin population estimates is a distinguishing feature of the Inventory. Most literature cites total country population figures rather than the population living in the basin in each riparian country. The population estimates in the Inventory are based on basin delineations and country borders. They were compiled using the latest available (national) statistics on population within administrative divisions such as provinces or governorates. Whenever an administrative division does not fall entirely in the basin, only the population of larger cities and smaller administrative areas is included.

The population figures presented in the Inventory should therefore be considered as estimates.

In addition, it is important to note that basin population estimates do not necessarily reflect the number of people that make use of the respective water resources. Often water resources are transferred out of the basin as is the case with Israel's National Water Carrier (see Chap. 6) that supplies populations outside the basin boundaries with water for domestic and agricultural purposes.

Map 1. Overview Map of shared surface water basins in Western Asia



Source: Compiled by ESCWA-BGR.

HYDROLOGICAL CHARACTERISTICS

The section on hydrology contains more complex scientific information, targeting a specialized audience of academics and technical experts. Therefore it is technical in language and analytical in the sense that it attempts to give a hydrological description of the respective water resources. The following section briefly explains some of the common methods and concepts applied in hydrology. Readers are referred to textbooks and literature for more in-depth information.

The characteristics of the basins were analysed and presented in three sub-sections according to data availability:

1. Annual discharge variability and long-term trends
2. Flow regime
3. Groundwater linkages

Generally, all analysis is geared towards facilitating comparison between rivers and basins. In larger and/or more complex basins and wherever discharge data was available, a comparison between time periods and data from monitoring stations along the river's course was included.

The hydrological data is mainly drawn from public databases that provide monthly and/ or yearly time series of discharge data (e.g. Global Runoff Data Centre). In addition, ESCWA member countries provided discharge data through the Inventory's Country Consultation process (see 'Introduction to the Inventory' for further information).

The section on Hydrological Characteristics outlines the riparian country contribution to the annual discharge of the river using data from the literature. As measured water balance data is not available in all cases and the literature often presents widely varying data, riparian contributions are sometimes expressed in ranges.

Annual discharge variability

The annual flow volume dynamics is summarized in a table, which shows the mean, maximum, minimum and the coefficient of variation (CV). The CV is a statistical measure to describe the variability inherent in a time series with respect to the mean and standard deviation. This can be applied to any time series, but here it is used to express the variability of annual discharge data. The annual discharge variability figures present both the discharge and the specific discharge, which allows for a comparison of the water yield across different river basins regardless of their size. The specific discharge is expressed as a unit volume per time and area, while discharge is expressed as a unit volume per time. In addition, a Mann-Kendall trend and student T-test were performed on the annual discharge series to assess whether a statistically significant long-term trend could be observed. The trend line is only included when the trend is statistically significant; otherwise no trend line is displayed. Furthermore, the discharge anomaly is shown as a deviation from the long-term mean to assess periods of water surplus or deficit, reflecting wet or dry conditions.

Flow regime

In the following section on stream-flow regimes, the mean monthly discharge is illustrated over the available period of record. This allows to distinguish periods of low- and high-flow and seasonality. Flow regimes also allow for an interpretation of some of the dominant hydrological processes generating runoff, for example when snow-melt causes a period of high flow. Different rivers and their basins can be compared if their flow regimes are normalized using a discharge coefficient, for example over the mean annual discharge. In the case of unregulated or natural river systems, the term natural flow regime is frequently used.

Groundwater linkages

The interaction between surface water and groundwater can occur both ways and may vary over the course of the river or with the seasons. Groundwater can feed a river through discharge at springs or discharge through the riverbed (gaining conditions) supporting the base flow of the river. Alternatively, a river or lake can recharge the groundwater through leakage in the riverbed (loosing conditions). Especially in cases where the connectivity is high, the separation between the two is not straightforward, creating a risk of counting and allocating the same water twice.

Groundwater linkages addressed in the Inventory are based on available information and on the relative importance and size of the respective resource. Wherever this information is available, the surface water chapter elaborates on connectivity to groundwater, including a brief description of the relevant aquifer system and formation(s) and a list of important springs in the area including discharge data. Groundwater chapters also address the issue of discharge to surface water wherever applicable and when information is available.

WATER RESOURCES MANAGEMENT

Information on water development and use is presented for each riparian country and tackles two main issues: water infrastructure projects and irrigated agriculture. Details of water use by other sectors in the basin are also mentioned whenever available.

Information for this section was collected from a wide range of sources. One set of references are national and official sources such as data provided during the Country Consultation process, content from national yearbooks and statistical reports, water resources and irrigation master plans, publications from national research centres, etc. Data was also compiled from reports of international organizations or research centres, as well as scientific articles published in peer-reviewed journals.

As irrigated agriculture infrastructure development and river flow characteristics are strongly interlinked, this section systematically analyses the connection between water regulation projects, irrigation schemes, changes in hydrological characteristics and water use. Wherever possible, trends are displayed or estimated. The water quality and environmental issues sub-section further examines the link between infrastructural developments and environmental conditions in the basin.

Water infrastructure

The first part of the Water Resources Management section provides information on water regulation structures in the basin, such as dams, storage reservoirs, barrages, channels and diversion structures.[7] Each chapter includes an overview table of dams, which lists the completed and planned structures of each country, with basic information such as completion year, capacity and purpose[8] as well as some relevant background information. In heavily developed basins, generally only the main dams with a storage capacity of 5 MCM or more are listed.

In addition, information boxes focus on larger or more controversial infrastructure projects which may have a social, political or environmental impact in the region, such as the Southeastern Anatolia Project (See Chap. 1, Box 2) or the Mesopotamian Marshes (See Chap. 3, Box 2).

Irrigated agriculture

Agriculture is the main water consumer in all the surface water basins featured in the Inventory and thus one of the most important factors to be taken into consideration in water resources planning and management. This is why the Water Resources Management section largely focuses on this sector, providing information on established and projected irrigated areas in the basin for each riparian country. In cases where no data is available on irrigated areas in the basin, existing irrigated area is estimated using agricultural data from the administrative division(s). Details of annual agricultural water withdrawal in the basin are also included, specifying the share of groundwater and surface water wherever possible.

This sub-section also deals with existing and planned irrigation schemes in the basin, highlighting main characteristics, progress made, and impacts on the basin in terms of additional irrigated surface area, irrigation return flows, hydrological characteristics, etc. Based on the above, total projected irrigated area in the basin is estimated from data on established and planned irrigated surface for each riparian country.

Agriculture near Raqqah, Syria, 2009. Source: Adel Samara.

In addition to agriculture, data on annual water withdrawal for other sectors is also included when available, i.e. for domestic, municipal and industrial use.

Water quality & environmental issues

The aim of the sub-section is to provide an overview of the basin's environmental conditions, with a focus on river water quality. Other notable environmental threats and issues of particular concern within the basin are also mentioned where relevant. The following describes the methodology used for the assessment of river water quality and provides definitions for related terms commonly used in the basin chapters.

For each basin chapter, water quality information was gathered from extensive research in the available literature such as scientific publications and reports, as well as data provided by member countries through the Country Consultation process. Generally, the core of the compiled information comprises results of water quality monitoring, including analysis of different water quality parameters from river samples.

Relevant data is presented in tables, graphs or figures and is then used to analyse whether the water is suitable for designated uses and meets international standards. The analysis mainly evaluates the suitability of water for agricultural use, which is generally the major consumer of water in the region, as well as its environmental status with respect to the aquatic ecosystem. For these purposes, the main water quality parameters taken into consideration are: salinity, nutrient concentrations, dissolved oxygen and oxygen demand levels. Other selected parameters such as bacteriological indicators and heavy metal concentrations are also mentioned when available.

A substantial part of the section is dedicated to identifying the causes of observed environmental conditions by systematically linking the presence of pollution indicators to potential sources in the basin, whether natural or anthropogenic. In addition, whenever long-term information was available, the data was used to determine trends over time and thus relate variations in water quality to other physical factors in the basin, such as changes in river flow, infrastructure development, etc.

Table 4. **Water quality parameters used in the Inventory**

INDICATOR/PARAMETER	DESCRIPTION	GUIDELINE
Salinity indicators		
Total Dissolved Solids (TDS) in mg/L or ppm **Electrical Conductivity (EC)**[b] in µS/cm	The total concentration of soluble salts or ions in a given volume of water.	The guideline[a] set by FAO, 1994 limits salinity at <700 µS/cm (as EC) or <450 mg/L (as TDS) for agricultural use. This level indicates that a full yield potential should be obtainable for nearly all crops (in particular salt-sensitive crops). Water with salinities higher than 3,000 µS/cm (or 2,000 mg/L) would have severe restrictions on use for irrigation.
Chloride (Cl^-) in mg/L	One of the major constituents of saltwater. It originates from natural minerals, saltwater intrusion into estuaries, irrigation return flows, and industrial pollution.[c]	The guideline for irrigation differs according to crop tolerance (range: 106-109 mg/L).[d] The guideline for drinking water (<250 mg/L) is only taste-based and no health-based guideline is proposed.[e]
Nutrients		
Total Nitrogen (TN) in mg/L	The sum of total organic and reduced nitrogen, ammonia and nitrate-nitrite.	An acceptable range in water bodies is 2-6 mg/L, while higher levels cause eutrophic conditions.[f]
Ammonia (NH_3 or NH_4^+) in mg/L	High concentrations of ammonia could indicate organic pollution from domestic sewage, industrial waste and fertilizer run-off. This results in toxicity to aquatic life at certain pH levels.[g]	There is no clearly defined guideline, but total ammonia concentrations measured in surface waters are typically less than 0.2 mg/L as nitrogen.[g]
Nitrate (NO_3^-) in mg/L	Essential nutrient for aquatic plants, but high concentrations tend to stimulate algal growth and stimulate the onset of eutrophication.	Natural nitrate-nitrogen (NO_3-N) concentrations are typically less than 0.1 mg/L, but may be enhanced by municipal and industrial wastewaters, leachates from waste disposal, animal wastes, sanitary landfills and fertilizers. Concentrations in excess of 0.2 mg/L create possible eutrophic conditions and human activities can increase nitrate concentrations to 1-5 mg/L.[g]

Nitrite (NO_2^-) in mg/L	When present in elevated concentrations, it is highly toxic to vertebrates including fish.[h] High concentrations generally indicate the presence of industrial effluents and are associated with unsatisfactory microbiological water quality.[g]	Nitrite-nitrogen (NO_2-N) levels are usually in the order of 0.001 mg/L in freshwaters, and rarely higher than 1 mg/L.
Total Phosphorus (TP) in mg/L	Phosphorus is a nutrient required by all organisms for the basic processes of life and is naturally found in rocks, soils and organic material. It is rarely found in high levels in freshwaters as it is actively taken up by plants. However, domestic wastewater, industrial effluents and fertilizer runoff contribute to elevated levels.	In most surface water that is not contaminated by algal blooms, levels range between 0.01 and 0.03 mg/L. When levels exceed 0.075 mg/L the river is considered eutrophic.[j]
Phosphate (PO_4^{3-}) in mg/L	Phosphate itself does not have notable adverse human health effects but high concentrations are largely responsible for eutrophic conditions as it is generally the limiting nutrient for algal growth.[i]	The maximum acceptable phosphate-phosphorus (PO_4-P) level to avoid accelerated eutrophication is 0.1 mg/L.[k]
Other parameters		
Biochemical Oxygen Demand (BOD)[l] in mg/L	An indicator of the amount of biochemically degradable organic matter present in a water sample, originating from natural sources as well as anthropogenic sources such as domestic sewage, fertilizer runoff, etc.	The acceptable BOD limit for fisheries and aquatic life is set at 3-6 mg/L and usually ranges between 20 and 100 mg/L in treated sewage waters, depending on the treatment type.[g]
Dissolved Oxygen (DO) in mg/L	Concentration of oxygen in a given volume of water. It is a measure of the degree of pollution by organic matter, the destruction of organic substances and the level of self-purification of the water. Waste discharges high in organic matter and nutrients can cause decreases in DO concentrations as a result of the increased microbial activity occurring during the degradation of the organic matter. Very low DO levels threaten aquatic life.[m]	Concentrations below 5 mg/L may adversely affect the functioning and survival of biological communities and levels below 2 mg/L lead to the death of most fish.[n]
Coliform bacteria[o] in cfu/100 ml	Sanitary indicators of water and food quality. High levels in a water sample indicate either an inefficient water treatment or the presence of other disease-causing organisms, including pathogenic bacteria, viruses or parasites.[p]	The guidelines for drinking, irrigation and bathing waters are respectively 0 cfu/100ml, 1,000 cfu/100ml and 10,000 cfu/100 ml.[q]
Heavy metals	Can originate from natural or anthropogenic sources and some, when present in trace concentrations, are important for the physiological functions of living organisms. When discharged into natural waters in increased concentrations (in sewage, industrial effluents or from mining operations) they can have severe toxicological effects on humans and on the aquatic ecosystem.[g]	International guidelines for specific heavy metals are mentioned in the chapters where relevant.

Source: Compiled by ESCWA-BGR.
(a) Guidelines differ between countries.
(b) A high EC means a high salt concentration (more ions in solution conduct more current). Havlin et al., 2004; FAO, 1999.
(c) Rice University, 2006; FoEME, 2010.
(d) FAO, 1994.
(e) WHO, 2003.
(f) US-EPA, 2011b; NCSU, 2006.
(g) Chapman, 1996.
(h) Eddy and Williams, 1987.
(i) Chapman, 1996; NCSU, 2006.
(j) Varol et al., 2011; NCSU, 2006.
(k) Pütz, 2009; Oram, 2009.
(l) Measure of the amount of oxygen used by microorganisms (e.g. aerobic bacteria) in the oxidation of organic matter present in a given water sample at certain temperature over a specific time period.
(m) Chapman, 1996; US-EPA, 2011a.
(n) Chapman, 1996; Varol et al., 2011.
(o) Colony forming units (cfu) per 100 ml of water.
(p) Faecal coliform bacteria appear in great quantities in the intestines and faeces of people and animals, and their presence in water samples often indicates recent faecal contamination. Washington State Department Of Health, 2011.
(q) Woerden and Berkel, 2004 in World Bank, 2006.

Water salinity is a prominent water quality indicator throughout the chapters (Table 4). Crop tolerance to salinity depends on climate, soil conditions, cultural practices, etc. National guidelines in basin countries are often less strict than international guidelines.[9] The region is prone to water and soil salinization due to several factors such as seawater intrusion into coastal aquifers and the upward flow of brackish and saline water supplies from lower aquifers. Accordingly, agriculture in these areas is mostly restricted to highly salt-tolerant crops such as date palms, which allows for the application of irrigation guidelines that are less stringent than the international standards.

Irrigation return flows and eutrophication are also frequently referred to in the surface water chapters. Irrigation or drainage return flow represents the part of applied water that is not consumed by plants or evaporation, and that eventually flows into a surface water body or seeps into an aquifer. It usually contains high levels of salts, agricultural chemical residues and nutrients. Eutrophication refers to the enrichment of a body of water with high concentrations of nutrients, typically compounds containing nitrogen, phosphorus or both. It may occur naturally but can be accelerated by human activity in the form of fertilizer runoff and sewage discharge. This can cause excessive growth of algae, whose decomposition depletes the oxygen supply in the water, leading to the death of aquatic organisms and the loss of biodiversity.[10] Table 4 briefly describes specific water quality parameters mentioned in the chapters along with their respective recommended guidelines.

AGREEMENTS, COOPERATION & OUTLOOK

This section focuses on water agreements among riparian countries, interstate cooperation on rivers as well as future developments and key concerns in the basin.

Water treaties and agreements are listed in a table, specifying year, signatories and significance. Only agreements that refer explicitly to the respective rivers are listed. Key water treaties are described in more detail and in chronological order in the text.

The section on cooperation touches on interstate relations in general and then elaborates on institutions and committees responsible for cooperation if applicable. The Inventory does not attempt to assess or analyse the status of water cooperation in any specific or scientific way; the main aim is to present institutions and mechanisms that were established to foster interstate water cooperation.

The Shatt al Arab at Basrah, Iraq, 2003. Source: Christian Briggs.

Notes

1. The terms "transboundary" and "shared" are used interchangeably in the Inventory. See 'Overview: Introduction to the Inventory', Box 3 for more information.
2. United Nations General Assembly, 1997.
3. Wolf et al., 1999. The term river basin is therefore synonymous with the terms watershed and catchment. Perennial streams flow year-round, as opposed to intermittent streams, which have periods of no flow.
4. The 1997 UN Convention on Non-Navigational Uses of International Watercourses defines a watercourse as a system of surface and underground waters constituting by virtue of their physical relationship a unitary whole and flowing into a common terminus. An international watercourse is a watercourse, parts of which are situated in different States.
5. See Wolf et al., 1999. Due to the grouping of complex basins by outlet and first-order river, the number of international basins in the Transboundary Freshwater Dispute Database is lower than in other assessments, which were, for instance, based on management aspects or had a more local focus.
6. See 'Overview: Shared Water Resources in Western Asia' for scope and regional extent.
7. A key difference between a barrage and a dam is that the latter is built to store water in a reservoir which raises the water level significantly. A barrage, on the other hand, diverts water, and is generally built on flat terrain across wide meandering rivers whereby the water level is raised only a few metres.
8. Such as: irrigation, flood management, power generation or water supply; or a combination in the case of multi-purpose dams.
9. For instance, the Jordanian guideline for salt-sensitive crops is set at <1,700 μS/cm and can even exceed 7,500 μS/cm for highly salt-tolerant crops (JVA and GTZ, 2006); while FAO, 1994 considers that a salinity of 6,000 μS/cm is generally the limit for highly salt-tolerant crops.
10. Chapman, 1996.

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