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Raya Marina Stephan

Alice Aureli

Aurélien Dumont

Annukka Lipponen

Sarah Tiefenauer-Linardon

See next page for additional authors

Authors

Raya Marina Stephan, Alice Aureli, Aurélien Dumont, Annukka Lipponen, Sarah Tiefenauer-Linardon, Christina Fraser, Alfonso Rivera, Shammy Puri, Stefano Burchi, Gabriel Eckstein, Christian Brethaut, Ziad Khayat, Karen Villholth, Lesha Witmer, Renee Martin-Nagle, Anita Milman, Francesco Sindico, and James Dalton

Chapter 12

Transboundary aquifers

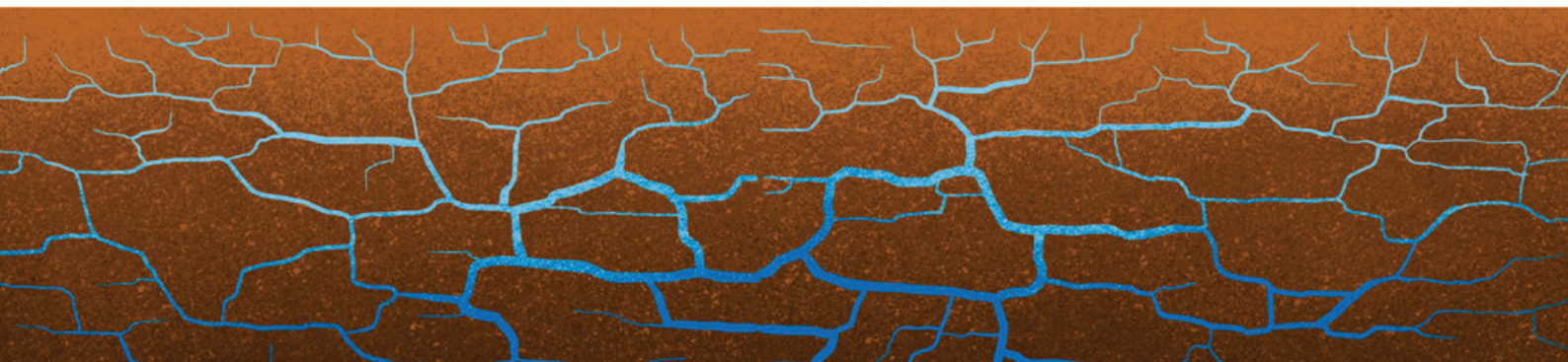
UNESCO-IHP
Raya Marina Stephan, Alice Aureli and Aurélien Dumont

UNECE
Annukka Lipponen* **and Sarah Tiefenauer-Linardon**

With contributions from:

Christina Fraser (IGRAC), Alfonso Rivera and Shammy Puri (IAH), Stefano Burchi (AIDA), Gabriel Eckstein (Texas A&M University School of Law), Christian Brethaut (University of Geneva), Ziad Khayat (UNESCWA), Karen Villholth (IWMI), Lesha Witmer (WfWP), Renee Martin-Nagle (Environmental Law Institute), Anita Milman (University of Massachusetts), Francesco Sindico (University of Strathclyde), and James Dalton (IUCN)

* with the Finnish Ministry of Agriculture and Forestry at the time of publishing



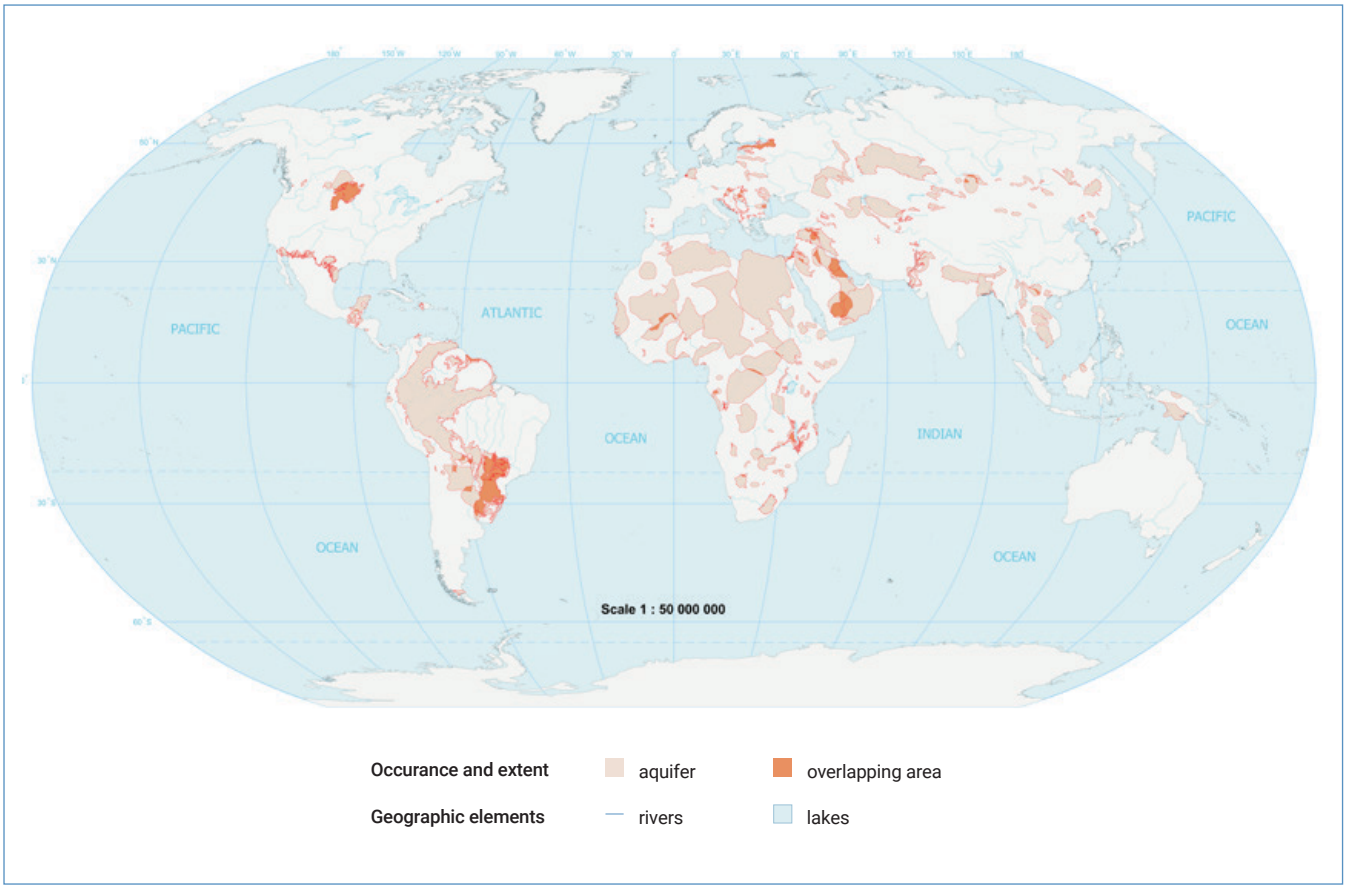
12.1 Introduction

This chapter gives an overview of the status of transboundary aquifers and the cooperation related to shared groundwater resources, highlighting the complexity of the assessment, analysis and management of these systems. It summarizes the main challenges regarding transboundary aquifers and the need for more comprehensive and integrated management, which would include technical, legal and organizational aspects as well as training and cooperation.

12.2 Current understanding of transboundary aquifers

When an aquifer or aquifer system is referred to as 'transboundary', that means that parts of it are situated in different states (UNGA, 2009). Transboundary aquifers include a natural subsurface path of groundwater flow, crossing an international boundary, such that water can flow from one side of the boundary to the other (UNESCO, 2001). The first global inventory of transboundary aquifer was undertaken by UNESCO-IHP, which launched the Internationally Shared Aquifers Resources Management initiative (ISARM) in 2000 (Box 12.1). The currently known global distribution of transboundary aquifers is shown in Figure 12.1, based on an inventory of global and regional projects and initiatives.[43] The first global baseline assessment of 300 of the world's largest transboundary aquifers was undertaken by the Transboundary Waters Assessment Programme (UNESCO-IHP/UNEP, 2016). This programme described transboundary aquifers in terms of human dependence on the resource. It elaborated scenarios based on population pressures and identified future hotspots in Sub-Saharan Africa, part of Eastern Asia and Central America. The exact delineation of a large number of transboundary aquifers is still incomplete, particularly at the local level where transboundary aquifers may be small but vital for communities' livelihoods (Eckstein, 2013; Fraser et al., 2020).

Figure 12.1 Transboundary aquifers of the world



Source: IGRAC (2021). © IGRAC, December 2021. Attribution Non-Commercial Share Alike (CC BY-NC-SA 4.0).

[43] Including the First and Second UNECE assessment of transboundary aquifers located in South-Eastern Europe, Caucasus and Central Asia (UNECE, 2007, 2011); Inventory of Shared Water Resources in Western Asia (UNESCWA/BGR, 2013).

Box 12.1 International Shared Aquifer Resource Management Initiative

In 2000, UNESCO's Intergovernmental Hydrological Programme launched the Internationally Shared Aquifer Resource Management initiative (ISARM) (Resolution XIV-12 – UNESCO-IHP, 2000), aimed at preparing a global inventory of transboundary aquifers and developing and supporting cooperation between countries through the improvement of knowledge of transboundary aquifers (TBAs). The initiative carried out regional studies designed to delineate the aquifers, as well as to assess and analyse hydrogeological, legal, socio-economical, institutional and environmental aspects. The regional inventories revealed that some of the most important aquifers in Africa and in Latin America are transboundary (UNESCO-IHP, 2009).

The initiative contributed towards building the knowledge base and provided guidance for countries' cooperation on TBAs. Substantial advancement has also been achieved with regards to the legal component. UNESCO-IHP assisted the International Law Commission (ILC) in the preparation of a set of 19 draft articles on the Law of Transboundary Aquifers that are annexed and mentioned in several resolutions of the General Assembly of the United Nations (UNGA).

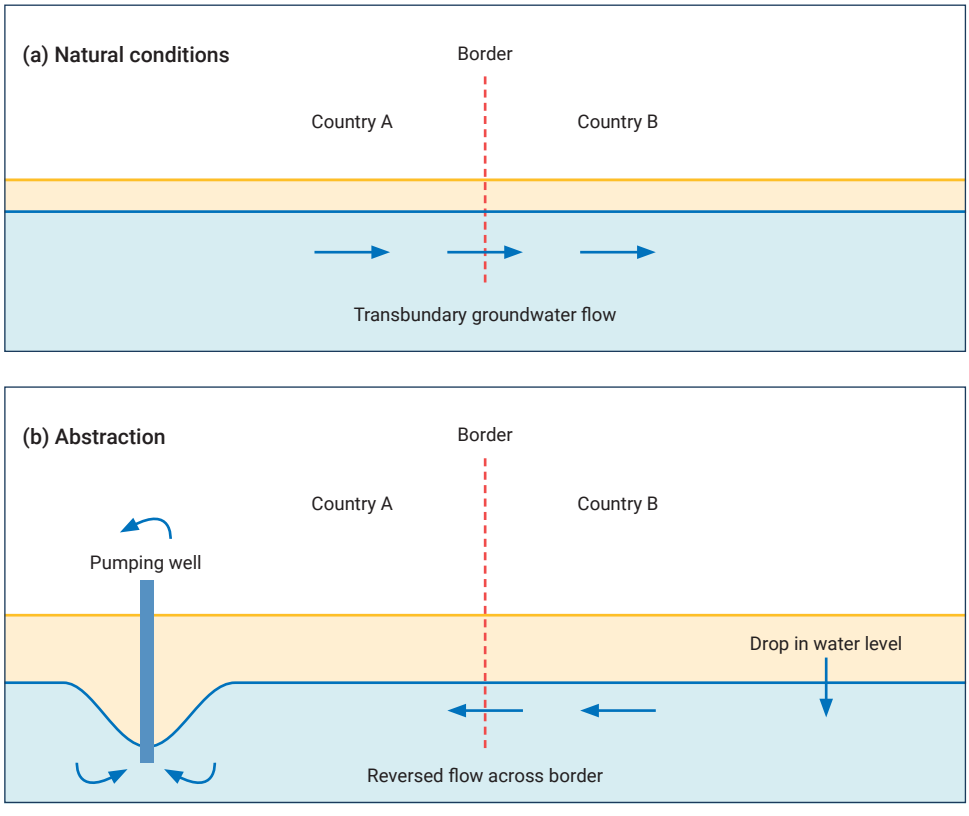
As a result of ISARM's activities, projects have been initiated in different regions to help countries in establishing cooperative mechanisms for the management of TBAs.

12.3 Challenges specific to transboundary aquifers

Generally, drivers of stress are the same for domestic and transboundary aquifers. Political boundaries add specific challenges. Actions on the aquifer in one country can have a significant impact on the other side of the border. Figure 12.2 illustrates a simple example of the effects that abstracting groundwater from a transboundary aquifer can have across borders. Heavy abstraction on one side of the border can cause the lowering of the water table in a neighbouring country. It can even at times cause groundwater flows to reverse across the border. Groundwater abstraction can also impact systems that are hydraulically connected to the transboundary aquifer, for instance by reducing river flows or affecting groundwater-dependent ecosystems. In addition, contamination of the aquifer on one side of the border can flow across political boundaries, causing potentially severe impacts for neighbouring states and complicating any remediation efforts.

Figure 12.2

Pumping groundwater from a well in country A can have an impact on the part of the aquifer in country B



Source: Adapted from Fraser et al. (2018, fig. 6, p. 45).

The integration of gender considerations into transboundary cooperation represents an element for creating opportunities of more socially equitable management of transboundary groundwater resources

The extent of transboundary aquifers can vary greatly, from a few to over a million square kilometres, and from tens to several thousands of metres in depth. This raises the question whether joint management and monitoring should necessarily encompass the total extent of a transboundary aquifer, or rather concentrate on specific hotspot areas where transboundary impacts may be most likely to occur. One possible approach to this dilemma is found in the agreement on the Saq-Disi aquifer (shared between Jordan and Saudi Arabia), which considers the establishment of protection areas around the border.

Cooperative management of transboundary aquifers can be complex due to obstacles in aquifer-sharing countries, which may include (AFD, 2011):

- lack of perception of the transboundary character among the authorities, managers and concerned populations;
- absence of a specific legal and institutional framework;
- different management and governance approaches and priorities;
- lack of political will for cooperation and implementation of long-term management;
- tensions between countries, unequal resource partitioning, groundwater quantity and quality decline, and different management capacities within the social, economic and environmental contexts of aquifer-sharing countries;
- fragmented knowledge of the aquifers;
- precise data not being shared (see Table 12.1 below);
- insufficient financing;
- lack of knowledge and capacity for developing and executing scientific/technical studies, and for setting up formal institutions; and
- different languages spoken, or different cultural or political orientations, on both sides of the border.

Furthermore, the integration of gender considerations into transboundary cooperation represents an element for creating opportunities of more socially equitable management of transboundary groundwater resources.

Training and capacity-building programmes are key for empowering technical and administrative staff to understand the different challenges involved in the assessment and management of transboundary aquifers (Nijsten et al., 2016).

Sharing data represents the first step in cooperation between neighbouring countries, as it is essential to reaching an agreement about a reliable conceptual model of the aquifer, which is in turn a prerequisite for the formulation of management plans.

When data are lacking, or states are unwilling to share them, this can hamper the sustainable management of transboundary groundwater systems. Transboundary aquifer management often suffers from a lack of institutional will and insufficient resources to collect the necessary information (AFD, 2011). Although global data can enlighten general trends, a more detailed understanding at the regional and local level is required for joint decision-making and transboundary aquifer management (IGRAC/UNESCO-IHP, 2015; Fraser et al., 2018; Rivera, 2015, 2020).

Data management and data sharing within transboundary aquifers can be supported by both information management systems and and web-based platforms that assist in data collection, storage, processing, visualization and sharing (IGRAC/UNESCO-IHP, 2015),

such as the Global Groundwater Information System (GGIS) (IGRAC, n.d.). Advances in technologies, from space-based observations to telemetry, combined with citizen science, may facilitate the heavy burden and cost of data collection (see Chapter 9).

The data and information requirements suggested in Table 12.1 apply both to domestic and transboundary aquifers, except for the legal and institutional components. Data that have been collected and analysed at the national level, using different methods and approaches, may need to be harmonized before they can be used across borders.

A vital component of transboundary aquifer management is monitoring, which should include time series observation of groundwater levels and quality (IGRAC/UNESCO-IHP, 2015). For monitoring to be effective, data should be coordinated, harmonized and shared among aquifer states (SADC-GMI/IGRAC/IGS, 2019b). In view of the complexities in transboundary aquifer assessment and monitoring, guidelines have been developed to assist aquifer states and stakeholders in the process (e.g. the UNECE Task Force on Monitoring and Assessment, 2000; AFD, 2011; IGRAC/UNESCO-IHP, 2015).

12.4 International legal and institutional aspects

International water law was initially developed for surface waters. Considerations on groundwater started progressively with the growing awareness of the importance of transboundary aquifers. The Convention on the protection and use of transboundary watercourses and international lakes[44] (Water Convention – UNECE, 1992) covers any surface or groundwater bodies that mark, cross or are located on boundaries between two or more states. It has provided the basis for various bilateral and multilateral agreements (UNECE, 2013). The Convention on the law of non-navigational uses of international watercourses (United Nations, 1997)[45] considers transboundary groundwater only when it is connected to an international surface water system and flows to the same terminus. It does not consider the specific characteristics of the diverse types of aquifers.

To fill this gap, the International Law Commission (ILC) prepared an international law instrument composed of 19 draft articles that contemplate all types of aquifer characteristics (Stephan, 2011). The articles are the topic of five non-binding UN General Assembly (UNGA) resolutions.[46]

The UNGA commends the draft articles to the attention of governments, "*as guidance for bilateral or regional agreements and arrangements for the proper management of transboundary aquifers*" (UNGA, 2013, 2016, 2019). All types of transboundary aquifers, including non-recharging aquifers, are covered in the scope of these draft articles. They also consider land use, as they apply to "*other activities that have or are likely to have an impact*" (art. 1§b). The draft articles have adapted the core principles of international water law to the aquifers' characteristics. They include considerations related to non-rechargeable aquifers, groundwater management and monitoring, and the protection of ecosystems and the aquifer recharge and discharge zones. In 2012, the Meeting of the Parties to the Water Convention adopted the Model Provisions on Transboundary Groundwaters (UNECE, 2014), which build upon the draft articles, aiming to provide guidance for the implementation of the principles of the Convention to transboundary groundwater, and to improve cooperation on integrated management of transboundary surface water and groundwater bodies.

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[44] In force since 1996, 44 Parties.

[45] In force since 2014, 37 Parties.

[46] These resolutions are 63/124, 66/104, 68/118, 71/150 and 74/193 (UNGA, 2009, 2012, 2013, 2016, 2019). The draft articles are annexed to resolutions 63/124 and 68/118.

Table 12.1

Data and information required to assess and manage a transboundary aquifer

Hydrogeology, physiography and climate	
Aquifer geometry (boundary, type, depth of water table, aquifer thickness)	Climate (temperature, precipitation, evapotranspiration)
Aquifer recharge and discharge identification	Land use
Lithology and soil type	Topography
Porosity, permeability	Surface water network (rivers, lakes)
Transmissivity and vertical conductivity	Groundwater volume
Groundwater levels and flow direction	Groundwater flow systems
Environmental	
Groundwater quality	Groundwater-dependent ecosystems
Pollution sources	Solid waste and wastewater control
Socio-Economic	
Population	Abstraction rates/well density
Refugee/Internally displaced people (IDP) camps	Human groundwater dependency
Groundwater use	Surface water use
Legal and institutional	
Transboundary legal framework	Domestic legal framework
Transboundary institutional framework	Domestic institutional framework
Ownership of groundwater	Water resource planning and protection
Groundwater abstraction control	Groundwater pollution control
Enforcement of legislation	Water institutions

Sources: Based on Rivera (2015, 2020) and IGRAC/ UNESCO-IHP (2015).

12.5 Cooperation over transboundary aquifers

Transboundary relations can involve different degrees of cooperation.

There are very few cases worldwide of interstate agreements regarding transboundary aquifers in force (Burchi, 2018b): the Genevese aquifer (France, Switzerland), the North Western Sahara Aquifer System (Algeria, Libya, Tunisia), the Nubian Sandstone Aquifer System (Chad, Egypt, Libya, Sudan), the Guarani Aquifer (Argentina, Brazil, Paraguay, Uruguay), the Saq-Disi Aquifer (Jordan, Saudi Arabia), and the Calcaires Carbonifères (Belgium, France).

Frequently, transboundary aquifers are part of a broader water cooperation agreement developed for transboundary river basins. Such broader agreements may apply to transboundary groundwater to different degrees. They do not necessarily consider the aquifer in its complete extension, as the areal extents of surface water basins often do not align with the underlying groundwater systems.

Scientific cooperation initiatives exist around the world in the framework of technical projects on transboundary aquifers. Such initiatives can have various scopes, some of them aiming at joint scientific assessment, while some others tackle the management of specific issues. In these cases, the role of regional and international organizations and donors can be critical, particularly when the countries concerned are not on a par as regards to capacity, knowledge, information and confidence. The study of the Dinaric Karst Aquifer, one of the world's largest karst aquifer systems, is an example of collaborative efforts between countries. The project facilitated the establishment of technical cooperation that resulted in political commitments to adopt management measures (Box.12.2).

Until now, experiences in setting up and operationalizing a fully empowered and functional institution charged with the governance of a transboundary aquifer system have remained limited. Recent progress has been made in establishing consultation mechanisms within existing institutions, such as for the Stampriet Aquifer (Box 12.3) shared by Botswana, Namibia and South Africa. Experience suggests that formal institutional arrangements favourable for transboundary cooperation can be achieved when neighbouring countries first build trust through the joint identification of needs and interests, and by carrying out multidisciplinary assessments of the aquifer they share.

Box 12.2 Protection and use of the Dinaric Karst Transboundary Aquifer System (DIKTAS)

Some of the countries sharing the Dinaric Karst Transboundary Aquifer System (Albania, Bosnia and Herzegovina, Croatia, and Montenegro) initiated in 2010 a collaborative effort to facilitate its equitable and sustainable management of the aquifer system, and to protect the unique ecosystems that depend on it. The project improved the knowledge of karst aquifers in the area and the coordination among countries, agencies and other stakeholders. Being the first major project globally to address transboundary karst aquifers, it has been used as an opportunity for introducing new, integrated management principles in shared karst aquifers of such magnitude. The project identified regional management actions, such as measures regarding policy and legislation, monitoring and data management, training and awareness-raising, as well as necessary investments.

Further information on the DITKAS project can be found here: http://diktas.iwlearn.org/

Box 12.3 The Stampriet Multi-Country Cooperation Mechanism: The first transboundary aquifer cooperative mechanism nested in a River Basin Organization

The Stampriet Transboundary Aquifer System (STAS) lies entirely within the Orange-Senqu River basin, in an area shared by Botswana, Namibia and South Africa. In 2017, the countries sharing the STAS agreed to establish a Multi-Country Cooperation Mechanism, nested in the structure of the Orange-Senqu River Commission (ORASECOM), that considers surface water and groundwater conjunctive management. The mechanism set the baseline for institutionalizing the cooperation for the joint governance and management of the aquifer. The Stampriet aquifer is the first example of the establishment of a transboundary aquifer coordination mechanism in the southern Africa region.

Through its inclusion of Sustainable Development Goal (SDG) Target 6.5, the 2030 Agenda for Sustainable Development has raised awareness of the need to "*implement integrated water resources management [IWRM] at all levels, including through transboundary cooperation as appropriate*". The SDG Indicator 6.5.2 monitors progress towards SDG Target 6.5 by assessing the proportion of transboundary basin area (rivers, lakes and aquifers) covered by an operational arrangement for water cooperation. The indicator allows for an assessment of whether transboundary aquifers are covered by their own specific arrangements or are covered within river and/or lake basin arrangements or broader bilateral arrangements.

A lack of groundwater knowledge has proven to be a key limitation in the calculation of the overall value of SDG Indicator 6.5.2. Thirty-five of the countries that reported in 2020 could not produce an indicator value for their aquifers, and a lack of groundwater data may have deterred others from submitting national reports. In turn, the efforts of countries to gather basic aquifer information and data (e.g. transboundary aquifer delineation) can be an important first step towards awareness and progressing cooperation on transboundary aquifers. The number of

countries that provided information about aquifers-related cooperative arrangements in their report has increased in 2020 as compared to 2017 (Table 12.2). By preparing the national reports through a consultative process, at the national level or with neighbours, countries were able to establish new cooperation programmes such as the one regarding the Senegalo-Mauritanian aquifer (Box 12.4).

Table 12.2 Summarized outcomes of global monitoring Indicator 6.5.2, 2017 and 2020

	2017	2020
Countries sharing transboundary basins (rivers, lakes and aquifers)	153	153
Countries having reported on the status of their transboundary cooperative arrangements	107	129
Countries having reported that 100% of their transboundary basin area was covered by operational cooperative arrangements	17	24
Countries reporting on having at least one operational aquifer-specific cooperative arrangement in place	5	12
Countries reporting about at least one aquifer covered by an operational river basin arrangement or bilateral arrangement	36	47

Source: Based on UNECE/UNESCO (2021).

12.6 Benefits of transboundary cooperation

Transboundary aquifer cooperation has the potential to generate significant benefits. For example, in the case of the North-Western Sahara Aquifer System, countries sharing the aquifer pursue benefits that include social, economic and environmental aspects (UNECE, 2015). An example could be the resilience of local communities, which is increased through enhanced capacity and mutual learning to resolve common challenges related to natural resources scarcity and security, food safety and climate change; as well as preservation of sensitive wetland ecosystems (NWSAS Consultation Mechanism, 2020).

The sharing of benefits provided by the use of groundwater represents an important facet of hydro-diplomacy (Grech-Madin et al., 2018), a process that can be applied at different stages of actors' interactions (from preventing tensions to contributing to the effective resolution of conflicts) and levels of intervention (from local to international power dynamics) (Vij et al., 2020; Bréthaut et al., 2019).

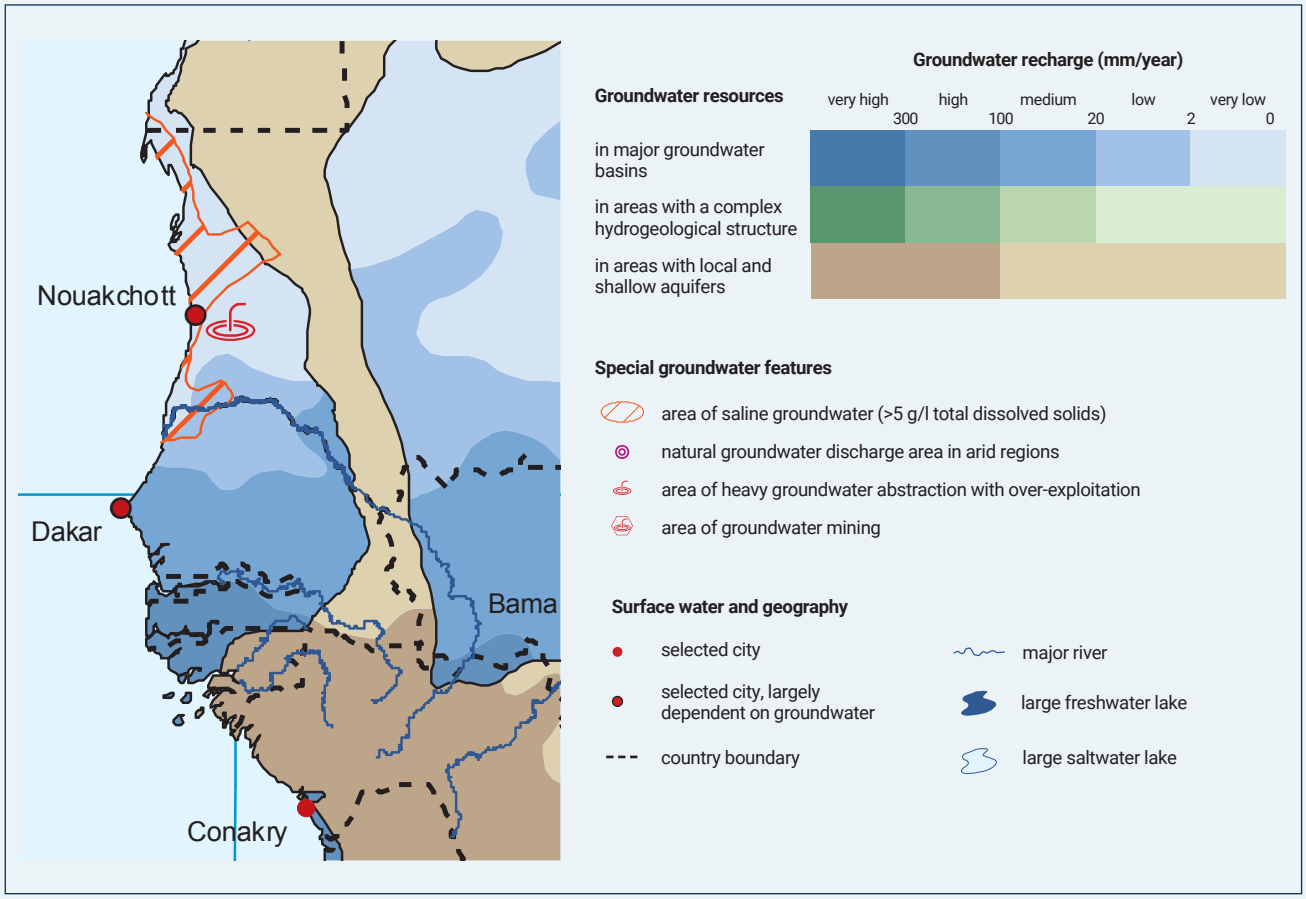
Box 12.4 Towards cooperation in the Senegalo-Mauritanian Aquifer Basin to promote peace and resilience among States

The Senegalo-Mauritanian Aquifer Basin (SMAB), shared between Gambia, Guinea Bissau, Mauritania and Senegal, extends over approximately 1,300 km and underlies a surface area of 331,450 km² with an estimated population of over 15 million inhabitants. The resource is under pressure due to an increasing demand for water caused by population growth, rapid urbanization and the development of agriculture for food self-sufficiency.

The first monitoring on SDG Indicator 6.5.2 highlighted that this transboundary aquifer is not yet subject to a bilateral or multilateral agreement or arrangement for cooperation. Riparian states have begun discussions with a view to developing transboundary collaboration. A Regional Working Group (RWG) for Transboundary Cooperation on the SMAB, comprising the states as well as the transboundary basin organizations in place in the Senegalo-Mauritanian aquifer basin, namely, the Organization for the Development of the Gambia River and the Senegal River Basin Development Authority, was established in May 2020. The RWG has the mandate to provide support and advice to establish transboundary cooperation for the concerted sustainable management of the SMAB. The RWG is engaged in the project conception and action plan in order to fulfil this mandate, with the support of the Geneva Water Hub, the Secretariat of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes provided by the United Nations Economic Commission for Europe (UNECE), and the International Groundwater Resources Assessment Centre (IGRAC).

Ministers from The Gambia, Guinea-Bissau, Mauritania and Senegal signed, in September 2021, a declaration on the establishment of institutional transboundary cooperation around the Senegal–Mauritanian Aquifer Basin. The ministers also agreed to begin talks on the creation of a mechanism to ensure the concerted and sustainable management of their shared groundwater resources.

The experience of Senegalo-Mauritanian Aquifer basin cooperation provides an example of how the SDG reporting process can help to identify gaps in cooperation and lead to concrete improvements.



Source: Adapted from BGR/UNESCO (2008).