

## Appendix C

# Transboundary Groundwater Governance Case Studies

International legal frameworks for groundwater governance offer important insights into how transboundary groundwater resources can be managed through cooperation, equitable use, and environmental protection. While these frameworks were primarily designed for international cooperation, they hold valuable lessons for managing shared water resources even within the United States, particularly in EPA Region 5, where multiple states may share critical aquifers and face similar challenges. For instance, states like Michigan and Ohio share groundwater resources that cross state lines, and international agreements provide valuable guidelines on cooperation, data-sharing, and the sustainable use of groundwater. Although the U.S. has its own legal frameworks governing water resources, such as the Clean Water Act and Safe Drinking Water Act, principles like equitable utilization and prevention of harm can inform policies in Region 5 to address issues such as over-extraction and contamination. Thus, while EPA Region 5 does not face international water governance in the traditional sense, residents can still draw on global principles to better manage its shared groundwater resources.

## The Franco-Swiss Genevese Aquifer System

The Franco-Swiss Genevese Aquifer, shared by France and Switzerland, is a critical transboundary groundwater resource providing drinking water. The Swiss side operates ten wells, while the French side uses four. In the 1960s and 1970s, over pumping led to a depletion of groundwater levels by more than 7 meters, with storage dropping by about one-third. To address this, artificial recharge from a nearby river was implemented successfully ([de los Cobos 2018](#)).

### Franco-Swiss Genevese Aquifer Agreement

In 1978, the Franco-Swiss Genevese Aquifer Agreement formalized groundwater management efforts. The agreement's objectives were to protect the shared aquifer and ensure its sustainable recharge.

#### Key Elements of the Agreement

- Bilateral Exploitation Committee
  - Composed of representatives from both countries' water authorities and water companies (SIG and SEA), it managed operational decisions, water abstraction limits, and monitoring.
- Joint Technical Committee
  - Focused on data sharing, artificial recharge, and ongoing collaboration between the two countries.
- The agreement was renewed in 2007, introducing provisions for dispute resolution under Swiss law and reinforcing water quality assessments aligned with European directives.

## Keys to Success

Several factors contributed to the success of the agreement:

- Legal Framework and Institutional Structure
  - A solid legal foundation provides a governance structure, ensuring accountability.
- Monitoring and Data Sharing
  - Regular monitoring and data transparency strengthened cooperation between parties.
- Adaptive Management
  - The agreement allowed for flexible adjustments in water extraction limits.
- Local Engagement
  - Direct involvement of local authorities fostered a sense of responsibility and efficiency.
- Focus on Shared Resource Knowledge
  - An understanding of the aquifer's hydrogeology supported the successful implementation of artificial recharge systems.

## The Guarani Aquifer System

The Guarani Aquifer System (GAS) spans Brazil, Argentina, Paraguay, and Uruguay, making it one of the largest transboundary groundwater reserves. Covering an area equivalent to the combined size of Texas and California, it is primarily recharged by rainfall, especially in higher-elevation regions ([Foster et al. 2009](#)).

### Precursor to the Agreement: The Guarani Aquifer Project

Before formalizing the agreement, the Guarani Aquifer Project facilitated scientific research and stakeholder engagement. It identified seven core components for effective governance:

- Expanding scientific knowledge
- Developing a shared management framework
- Promoting environmental education
- Implementing monitoring and evaluation
- Exploring geothermal energy potential

The project's success in localized studies and fostering informal cooperation networks provided a strong foundation for the Guarani Aquifer System Agreement (GASA).

### The Guarani Aquifer System Agreement (GASA)

Adopted in 2010 and ratified in 2018, GASA created a cooperative framework for managing and conserving the aquifer, balancing national sovereignty with shared responsibility. Key provisions

include:

- National Sovereignty and Shared Responsibility
  - Countries retain sovereign rights over their portion of the aquifer but must prevent harm to neighboring nations.
- Equitable Use
  - Water extraction must be equitable and reasonable, although specific guidelines remain flexible.
- Transparency and Information Sharing
  - States are required to share information and conduct environmental impact assessments for projects with potential transboundary consequences.
- Dispute Resolution
  - A Joint Commission oversees the agreement's implementation, with dispute resolution mechanisms including negotiation and mediation.

### **Keys to Success**

- Scientific Foundation
  - Reliable data from the Guarani Aquifer Project strengthened the case for cooperation.
- Public Participation
  - Local communication strategies ensured the viability of the governance framework.
- Institutional Networks
  - The informal cooperation networks played a crucial role in resolving technical and operational challenges.
- Continuous Support
  - Financial and technical backing, particularly from organizations like the World Bank, helped sustain momentum.

## **The Nubian Sandstone Aquifer System**

The Nubian Sandstone Aquifer System (NSAS) is one of the world's largest groundwater reserves, covering approximately 2 million square kilometers across Libya, Egypt, Chad, and Sudan. It is primarily recharged in the southwestern region and serves as a crucial water source in this arid region, where surface water is scarce. In response to the need for coordinated governance, the four countries established the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer in 1992, with Sudan joining in 1996 and Chad in 1999 ([International Water Law Project Blogspot 2013](#)).

## Joint Authority Governance Structure

The governance framework for NSAS is centered on the Joint Authority, which is headquartered in Tripoli, Libya. The main components of the governance structure include:

- Board of Directors
  - Comprising three representatives from each member state, appointed by the relevant ministries. The board oversees aquifer management.
- Administrative Secretariat
  - Includes legal, technical, and policy staff to assist in operations.
- Regional Project Steering Committee
  - Approves work plans and budgets, evaluates recommendations from the Regional Technical Review Committee.
- Nubian Project
  - Works to develop a rational and equitable management system that balances socio-economic development with environmental protection.

## Key Objectives and Goals

The NSAS governance framework aims to:

- I. Identify Priority Threats
  - A. Focus on key transboundary threats and their root causes.
- II. Improve Data and Methodologies
  - A. Fill critical data gaps, especially using isotope techniques under the International Atomic Energy Agency (IAEA).
- III. Develop a Strategic Action Program (SAP)
  - A. Guide future cooperation and sustainable management efforts.
- IV. Establish Long-Term Institutional Framework
  - A. Create lasting structures for the implementation of the SAP.

## Joint Authority Agreement

The Joint Authority Agreement includes several provisions to ensure effective governance:

- **Article 3:** Outlines key responsibilities, including data collection, water quality and quantity assessments, and public information dissemination.
- **Article 8:** Defines decision-making procedures, requiring a majority vote for most decisions, with a two-thirds majority for critical matters such as budget approval and international cooperation

proposals.

- **Dispute Resolution:** While no explicit dispute resolution mechanism is provided, the agreement encourages negotiation and cooperation to resolve conflicts.

## Significant Achievements

One of the most significant achievements has been the Nubian Aquifer Regional Information System (NARIS). This system stores, analyzes, and displays critical aquifer data, facilitating informed management decisions. Member states share annual data on water extractions, water levels, and electrical conductivity, formalized in the 2000 Agreements on Monitoring and Data Sharing, which enhanced transparency and cooperation.

## Key Lessons

Several lessons can be drawn from the governance of NSAS:

- Strong Administrative Structure
  - A well-defined governance body with authority and clear responsibilities is essential for effective management.
- Data Sharing and Transparency
  - A dedicated information center like NARIS strengthens cooperation and enhances scientific understanding of the aquifer.
- Equitable Apportionment System
  - A fair system that accounts for geographic, political, and economic factors ensures equitable and sustainable water use.

## Stampriet Transboundary Aquifer System

The Stampriet Transboundary Aquifer System (STAS) is a vital groundwater resource shared by Botswana, Namibia, and South Africa, situated in the arid Kalahari Basin. This aquifer is essential for local communities, livestock, and agriculture, providing the only permanent and dependable water source in the region. It spans approximately 87,000 square kilometers, covering central Namibia, western Botswana, and South Africa's Northern Cape Province ([UNESCO 2016](#)).

## Governance Framework

In 2017, the three countries agreed to establish a Multi-Country Cooperation Mechanism under the Orange-Senqu River Commission (ORASECOM). This initiative aims to integrate the management of surface water and groundwater resources, emphasizing data harmonization, transparency, equitable and reasonable use, and the prevention of significant harm to other states.

## Key Initiatives

- Internationally Shared Aquifer Resources Management (ISARM):
  - This initiative supports the STAS by promoting the sustainable management of shared aquifer resources.
- Governance of Groundwater Resources in Transboundary Aquifers (GGRETA):
  - The GGRETA project plays a pivotal role in advancing the shared hydrogeological assessment of the aquifer and improving scientific understanding of its characteristics.
  - It has facilitated the development of a harmonized monitoring framework for groundwater levels, quality, and use across the three countries.
  - Additionally, capacity-building workshops for technical experts and policymakers have enhanced institutional capabilities, fostering collaboration through data sharing and dialogue among stakeholders from Botswana, Namibia, and South Africa

## Assessment and Data Harmonization

A comprehensive assessment of the STAS was undertaken using a multidisciplinary methodology developed by the UNESCO International Hydrological Programme (IHP) and the International Groundwater Resources Centre (IGRAC). This approach involved the collection and processing of national data—hydrogeological, socio-economic, environmental, legal, and institutional—and the harmonization of data across all three countries to enable a joint assessment of the transboundary resource.

## Challenges and Future Outlook

While significant progress has been made in establishing a cooperative framework and enhancing data sharing, the long-term success of the STAS governance initiative depends on sustained commitment from all parties. Ongoing efforts are necessary to address emerging challenges, such as climate variability, population growth, and the need for sustainable water management practices. The foundation for cooperation has been established, and there has been an increase in collaboration, particularly in data sharing and decision-making processes among the countries involved.

## North-Western Sahara Aquifer System

The North-Western Sahara Aquifer System (NWSAS) is a significant transboundary groundwater resource shared by Algeria, Libya, and Tunisia, covering over 1,000,000 square kilometers. It comprises two main aquifers: the Intercalary Continental and the Terminal Complex. These aquifers are crucial for agriculture, domestic use, and livelihoods in the region ([United Nations Economic Commission for Europe 2020](#)).

## **Governance Framework**

In 2002, the Permanent Consultation Mechanism (PCM) was established under the Observatoire du Sahara et du Sahel (OSS) to manage the NWSAS jointly. The PCM's responsibilities include:

- Managing the hydrogeological database and simulation model.
- Developing and overseeing a reference observation network.
- Processing, analyzing, and validating data related to the aquifer.
- Creating databases on socio-economic activities related to water use.
- Developing public indicators on the resource and its uses.
- Promoting joint studies and research.
- Implementing training programs.
- Regularly updating the aquifer model.
- Formulating proposals for the evolution of the Consultation Mechanism.

These efforts have led to increased cooperation among the three countries, establishment of a shared monitoring system, and development of sustainable water management policies, helping to reduce overexploitation of the aquifer.

## **Key Objectives**

The governance framework for NWSAS aims to:

- Prevent harm to other states.
- Ensure sustainable use of the aquifer.
- Encourage collaborative management.

These objectives are guided by the principles outlined in the SDAC Protocols, which offer a legal framework emphasizing the equitable use and protection of shared water resources.

## **Recent Developments**

In 2023, the three countries agreed to establish a consultation mechanism in Algiers to manage the shared groundwater resources of the NWSAS. This agreement outlines the creation of a consultation body to oversee the sustainable use and protection of the aquifer.

## **Challenges and Future Directions**

Despite these collaborative efforts, the NWSAS faces challenges such as overexploitation, water scarcity, and the impacts of climate change. Ongoing cooperation and the implementation of sustainable management practices are essential to address these challenges and ensure the long-term viability of the aquifer system.

## Al-Sag/Al-Disi Aquifer System

The Al-Sag/Al-Disi Aquifer System is shared by Jordan and Saudi Arabia, with both nations beginning significant groundwater extraction in the 1970s and 1980s, shortly after the aquifer's discovery. Initially, Saudi Arabia increased its extractions substantially to support wheat production, causing a reversal of flow from Jordan to the Saudi well fields. By 2008, withdrawals from the aquifer were estimated to exceed 1,000 million cubic meters (MCM). To address the shared use and sustainability of this important resource, the two countries signed a formal agreement in 2015 to manage the aquifer cooperatively ([Inventory of Shared Water Resources in Western Asia 2013](#)).

### Governance Framework

The governance framework is outlined in the Al-Sag/Al-Disi Aquifer Agreement, which consists of four main articles:

- **Article One** defines key terms and concepts related to aquifer management.
- **Article Two** establishes management norms, including the creation of a "Protected Area" of approximately 400 square kilometers on each side of the border, where all groundwater extraction activities must cease within five years.
  - It also defines a broader "Management Area" of 1,000 square kilometers in each country, where extractions are only allowed for municipal purposes, and groundwater pollution is heavily restricted.
- **Article Three** outlines the formation of a Joint Saudi/Jordanian Technical Committee (JTC), which will monitor extraction quantity and quality, collect and exchange information, and submit findings to the authorities of both nations.
- **Article Four** addresses administrative provisions for implementing the agreement, ensuring proper execution and compliance.

The JTC plays a central role in overseeing the agreement's implementation, though it does not have decision-making authority.

### Successes

- **Formalized Cooperation**
  - The 2015 agreement marks a significant step in formalizing cooperation between Jordan and Saudi Arabia for the joint management of the aquifer, particularly after decades of uncoordinated extraction.
- **Protected Area**
  - The establishment of a Protected Area ensures a buffer zone between the well fields of the two countries, preventing further depletion and contamination of the shared resource.
  - This demonstrates a collaborative effort to protect the aquifer from over-extraction and pollution.
- **Joint Monitoring**

- The creation of the Joint Technical Committee enables effective data sharing, monitoring of extraction rates, and quality control for both countries, promoting transparency and evidence-based decision-making.
- Data Sharing
  - A critical success of the governance framework has been the commitment to data sharing between Jordan and Saudi Arabia.
  - The Joint Technical Committee is tasked with the exchange of data related to groundwater levels, quality, and extractions, which enhances transparency and facilitates better management of the resource.
  - However, the effectiveness of data sharing depends on the capacity and willingness of both countries to continuously update and analyze the information.

## **Challenges**

- Enforcement of Management Areas
  - While the agreement establishes management norms, there are no clear numerical limits on extractions, leaving some uncertainty about long-term sustainability.
  - The Protected Area and Management Area stipulations, while important, might be challenging to enforce over the long term without strict monitoring and compliance mechanisms.
- Dispute Resolution
  - Although the agreement establishes cooperative norms, it lacks a formal dispute resolution mechanism.
  - This could be problematic if tensions arise over extraction limits or water quality concerns, particularly since both countries rely heavily on the aquifer for water supply.
- Technical and Financial Constraints
  - Implementing the monitoring framework and the broader provisions of the agreement may face challenges related to technical capacity and financial resources, especially as both countries work to develop their monitoring systems and data collection infrastructure.

## **Future Outlook**

While the 2015 agreement laid a solid foundation for the sustainable management of the Al-Sag/Al-Disi Aquifer, the long-term success of the agreement will depend on:

- Strict enforcement of management norms, especially regarding the Protected Area and Management Area.
- Sustained collaboration and data sharing through the Joint Technical Committee to avoid over-extraction and contamination of the aquifer.
- Addressing the technical and financial challenges involved in maintaining monitoring systems and ensuring that both countries have the resources and capacity to adhere to the management plan.

Given the increasing water scarcity in the region, the agreement is a positive step toward more collaborative, sustainable water management practices. However, it will require continuous adaptation and cooperation to meet future challenges.

## Mexico-United States Aquifer Systems

The Mexico-United States Transboundary Aquifer Systems consist of several groundwater systems that span the shared border between the two countries. These aquifers are crucial water resources for both nations, particularly in arid regions where surface water is limited. Given their transboundary nature, these aquifers face complex governance challenges, including ensuring equitable water distribution, managing water quality, and addressing cross-border environmental impacts.

The management of these shared aquifers has been facilitated through various agreements and collaborative frameworks, most notably the International Boundary and Water Commission (IBWC), established in 1889. Over time, the IBWC has expanded its scope to include groundwater governance, leading to the establishment of joint programs such as the Transboundary Aquifer Assessment Program (TAAP). This initiative focuses on research and data sharing between U.S. and Mexican agencies, with the goal of improving water management and addressing sustainability concerns for these vital water resources. The collaboration between the two countries serves as a model for addressing shared groundwater challenges in other transboundary regions ([University of Arizona, Water Resources Research Center 2009](#)).

### Governance Framework

The governance of the Mexico-United States transboundary aquifer systems is primarily managed through the International Boundary and Water Commission (IBWC), established in 1889. The IBWC oversees the application of boundary and water treaties between the two nations and addresses disputes arising from their implementation.

In 2006, the U.S.-Mexico Transboundary Aquifer Assessment Act was enacted, authorizing the U.S. Geological Survey (USGS) to collaborate with Mexican agencies, including the National Water Commission (CONAGUA), universities, and local water management authorities. This collaboration focuses on joint research, data collection, and analysis of shared aquifers.

A significant milestone in this collaboration was the signing of the "Joint Report of the Principal Engineers Regarding the Joint Cooperative Process United States-Mexico for the Transboundary Aquifer Assessment Program" on August 19, 2009. This agreement established the framework for joint studies of shared aquifers, emphasizing mutual benefits, respect for each country's legal frameworks, and the non-restrictive nature of the agreement on independent actions within each country's territory.

### Successes

The Transboundary Aquifer Assessment Program (TAAP) has been instrumental in enhancing the scientific understanding of shared aquifers. Notable achievements include:

- **Binational Studies**
  - Conducting comprehensive studies of transboundary aquifers, such as the San Pedro Aquifer, which have provided valuable data on groundwater availability and quality.

- Data Sharing
  - Facilitating the exchange of groundwater data between the U.S. and Mexico, leading to improved water management practices and policy development.
- Capacity Building
  - Organizing workshops and training sessions for technical experts and policymakers, thereby strengthening institutional capabilities in both countries.

## **Challenges**

Despite these successes, several challenges persist:

- Data Gaps
  - There are still significant gaps in data regarding the extent and functioning of shared aquifers, which complicates effective management.
- Legal and Jurisdictional Issues
  - Differences in legal frameworks and water rights between the two countries can hinder collaborative efforts.
- Resource Allocation
  - Balancing the equitable distribution of water resources between the nations remains a complex issue, especially in times of drought or water scarcity.

## **Lessons Learned**

The experience of the Mexico–United States transboundary aquifer systems offers several lessons for effective groundwater governance:

- Bilateral Cooperation
  - Establishing formal agreements and joint committees can facilitate collaborative research and data sharing.
- Scientific Collaboration
  - Joint scientific studies enhance mutual understanding and inform policy decisions.
- Flexibility and Adaptability
  - Agreements should be adaptable to changing circumstances, such as shifts in water availability or climate conditions.