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E1 - Regulation of the Environment-Support Function of Groundwater Systems

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Scope: This class will introduce participants to regulatory norms that can be used to ensure the environment-support functioning of groundwater resources at the domestic and international levels. The lecture component of the class will be divided into two parts. The first will highlight the physical functioning of aquifers, the role they play in the natural environment, and the effects that human activity can have on those processes. Building on part one, the second part will address legal mechanisms (at the domestic and international levels) that may be used to ensure the continued environment-support functioning of groundwater systems. Special attention will be paid in both parts to protections related to the recharge zone, the aquifer matrix, the discharge zone, and aquifer-dependent ecosystems.

Purpose: This class is intended to familiarize participants with the environment-support functioning of groundwater resources and the chief legal mechanisms used to support and ensure those processes. The class will also introduce participants to the physical and scientific context in which the principles can be appropriately applied.

Methodology: The class will begin with a lecture on the environment-support function of groundwater systems. This discussion will use diagrams, graphics, and other illustrative material to allow participants to "see" what is happening under the ground. Building on part one, the lecture will then proceed to a discussion of legal mechanisms (at the domestic and international levels) that may be used to ensure the continuation of those functions. This presentation will use examples from the domestic laws of various nations as well as from international instruments.

Thereafter, participants will engage in a series of practical exercises that will task them with formulating regulatory norms to address specific concerns related to the functioning of a groundwater system and its relationship to the natural environment.

Site: UNITED NATIONS INFORMATION PORTAL ON MULTILATERAL ENVIRONMENTAL AGREEMENTS
Course: The "Greening" of Water Law: Implementing Environment-Friendly Principles in Contemporary Water Law
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1. Key points

- Groundwater is a critical freshwater resource worldwide that is indispensable to community well-being and economic development worldwide. Communities and nations benefit from the functioning of groundwater and aquifers, including from their natural filtration, energy production, habitat support, and other characteristics.
- Because of the “invisible” nature of groundwater resources, as well as the complex nature of their presence, origins, and interaction with the hydrologic cycle, groundwater resources are often threatened by human activities, such as destruction of the aquifer matrix, groundwater mining, saltwater intrusion, and groundwater pollution.
- To properly regulate and manage groundwater resources sustainably, governance regimes must be based on a clear understanding of how groundwater and aquifers function, as well as on the services and benefits that groundwater and aquifers provide to people and the environment.
- Domestic groundwater legal mechanisms include regulations to secure sustainable groundwater supplies, protect groundwater quality, and ensure aquifer integrity and functioning.
- International groundwater legal mechanisms for transboundary aquifers are less specific and less developed as compared with their domestic counterparts and focus on procedural obligations.

2. Introduction and Overview

Groundwater resources are widely acknowledged as critical sources of freshwater for communities worldwide. Today, more than half of humanity is dependent on subsurface waters to meet their daily freshwater needs for drinking, cooking and basic hygiene. As a result, regulation and management of these important waterbodies have become increasingly important as nations begin to recognize the multitude of threats facing their groundwater supplies.

2.1. Understanding Groundwater

The term “groundwater” pertains to subsurface water found within the saturated zone of a porous geologic formation. The saturated zone is the portion of the geologic profile where the pores or voids between the soil particles are completely filled with water. A geologic formation is called an aquifer if it contains water in a saturated section and has the capacity to store and transmit that groundwater. Although extraction of water can be achieved from an aquifer’s unsaturated zone, it is extremely expensive and technically complex. Hence, extraction activities focus exclusively on the saturated zone of an aquifer.

The “hidden” nature of groundwater resources, located below the surface under dozens or hundreds of meters of soil where they cannot be viewed or explored easily, can make their assessment a financial and technological challenge. Nonetheless, hydrogeologists and other water professionals have techniques and technologies that can allow them to describe the characteristics of aquifers, including their sources of natural recharge, flow regimes, and functioning. The extent to which such information can be made available is usually related to the availability and extent of a government’s resources and technical capacity.

2.2. Functions of Groundwater and Aquifers

Groundwater and aquifers provide numerous benefits to communities and the environment through their natural functioning. For example, the natural filtration capacities of many aquifers can cleanse groundwater from various contaminants as the water flows through the aquifer matrix. Geothermal groundwater can be used to heat homes and communities, as well as provide a source of energy. Springs emanating from aquifers often serve as habitats for various species and supply surface waterbodies with some of their volumes.

2.3. Threats to Groundwater and Aquifers

Groundwater resources and aquifers often face considerable hazards resulting from human activities. For example, excessive withdrawals of groundwater, whether in excess of natural recharge or where no recharge occurs, can deplete the aquifer. It can also result in the subsidence of overlying land, which can destroy the storage and transmission characteristics of the formation. In a similar vein, the mining of an aquifer's matrix (for its hydrocarbon or mineral content) also results in the destruction of an aquifer's storage and transmission characteristics. In both subsidence and mining scenarios, as well as certain contamination situations, an aquifer's filtration capacity also can be negatively affected. Further, contamination from various land-based human activities, such as, agricultural, industrial, and mining activities, can detrimentally affect groundwater quality, while excessive withdrawals of groundwater from a coastal aquifer, or from an aquifer in the vicinity of a formation containing saline water, can cause saline water to flow into the aquifer and affect groundwater salinity.

3. Protection of Groundwater Resources in Domestic Legislation

Given the importance of groundwater resources for communities worldwide, regulations designed to protect these resources focus on ensuring the quantity and quality of water found within aquifers, as well as the integrity of aquifers.

3.1. Protecting Groundwater Supplies

Aquifers are typically recharged from rain-soaked ground, from lakes and streams, and, to some extent, from other aquifers. In order to ensure the long-term sustainability of an aquifer, the rate of groundwater withdrawals must be gauged in relation to the rate of natural recharge. This typically requires regulation to quantify and monitor groundwater storage in the aquifer, the sources and rates of an aquifer's natural recharge, and the sources and rates of an aquifer's natural discharge. In addition, to maintain a balance between the recharge and withdrawal rates, regulations are usually necessary to manage pumping activities. These latter regulations are often in the form of well permits, well-spacing rules, well metering and withdrawal limitations, and restrictions on activities that use or can affect groundwater supplies.

As an example, the *Water Resources Management Act of Namibia, No. 11 of Dec. 2013* provides:

- *Para. 63 – Wastage of groundwater:A person may not cause or allow any groundwater to run to waste from a borehole, well, shaft, mine or other excavation, except -*

  (a) for the purpose of testing the capacity or quality of the supply, or to clean, sterilize, examine or repair a borehole;

  (b) when the water interferes or threatens to interfere with mining operations or performance of any other underground work; or

  (c) when groundwater poses a threat to life or property.

- *Para. 66 – Protection of aquifers: (1) For the purpose of promoting the sustainable use and protection of aquifers, the Minister may -*

  (a) cause the groundwater potential of any aquifer to be investigated;

  (b) by notice published in a manner appropriate for the area, impose restrictions or limitations to ensure that the total abstraction of water permitted from an aquifer does not exceed the groundwater potential;

  (c) determine and define aquifer boundaries based on available hydrogeological information;

  (d) prescribe, or impose as licence conditions, special requirements and restrictions with respect to the drilling and use of artesian and subartesian boreholes for the purpose of preventing –

    (i) the wastage of water;

    (ii) the leakage of water from confined artesian aquifers to other aquifers;

    (iii) the contamination of the aquifer; or

    (iv) the reduction or loss of artesian pressure;

  (e) investigate the need or advisability of the construction of works to enhance the natural recharge of aquifers or to facilitate the artificial recharge of aquifers where feasible;

  (f) prescribe procedures and conditions for the artificial recharge of aquifers, including standards for the quality of water that may be injected;

  (g) prescribe, or impose as licence conditions, special requirements for enhancement of natural recharge to lower the risk of aquifer pollution;

  (h) direct the owner or occupier of land to seal off any borehole situated on the land –

    (i) which was drilled without the necessary licence; or

    (ii) which may be leaking water from the confined artesian aquifer into the surrounding unconfined aquifers.

3.2. Protecting Groundwater Quality

While many aquifers serve as natural water filtration mechanisms, the slow flow regime of most aquifers makes aquifer contamination a serious concern, since pollutants can stay in the aquifer matrix for years, decades, or longer. As a result, regulations designed to protect groundwater quality are often applied to bore holes (e.g., water wells), activities in aquifer recharge zones (e.g., agricultural and industrial activities), activities involving the intentional injection of contaminants into the ground (e.g., fracking), and pumping activities that may inadvertently result in the intrusion of saline water into the aquifer from surrounding saline sources. For more on groundwater pollution, see Module E, Class 2.

3.3. Protecting Aquifer Integrity and Functioning

To ensure the integrity and functioning of aquifers, states may impose restrictions on activities that could result in the destruction of an aquifer's storage, filtration, and transmission characteristics. For example, regulations are often imposed on groundwater withdrawal in areas prone to land subsidence. Likewise, mining activities may be prohibited from aquifer formations containing critical groundwater supplies. In the case of geothermal groundwater, to ensure the long-term sustainability and integrity of such resources, regulations may restrict usage solely for heating and/or power generation, while geothermal groundwater rich in certain minerals may be restricted to medicinal and spa-related purposes. Where certain species and habitats are dependent on the natural functioning of an aquifer, such as from spring flows, regulations may restrict withdrawals from the aquifer to ensure the viability of those springs, while restrictions on activities in the aquifer's natural discharge zones (e.g., springs) may be imposed to protect those species and habitats.

3.4. Protecting Aquifer Integrity and Functioning (Contd)

As an example, the *Australia New South Wales Water Management Act No. 92 of Dec. 2000* provides:

- *Para. 5(8) – In relation to aquifer interference activities:*

  (a) the carrying out of aquifer interference activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated, and

  (b) the impacts of the carrying out of aquifer interference activities on other water users must be avoided or minimised.

- *Para. 32 – Core provisions*

  The controlled activity and aquifer interference activity planning provisions of a management plan for a water management area must deal with the following matters:

  (a) identification of the nature of any controlled activities or aquifer interference causing impacts, including cumulative impacts, on water sources or their dependent ecosystems, and the extent of those impacts,

  (b) specification of controlled activities or aquifer interferences which are to require controlled activity approvals or aquifer interference approvals in the area.

- *Para. 33 – Additional provisions*

  The controlled activity and aquifer interference activity provisions of a management plan for a water management area may also deal with the following matters:

  (a) the undertaking of work for the purpose of restoring or rehabilitating a water source or its dependent ecosystems,

  (b) protecting, restoring or rehabilitating the habitats or pathways of animals and plants,

  (c) specific controls on activities causing unacceptable impacts,

  (d) the preservation and enhancement of the quality of water in the water sources in the area affected by controlled activities or aquifer interference

- *Para. 345 – Harm to aquifers and waterfront land*

  (1) A person who harms an aquifer or waterfront land, and does so intentionally or negligently, is guilty of an offence: Tier 1 penalty.

  (2) A person who harms an aquifer or waterfront land is guilty of an offence: Tier 2 penalty.

  (4) In this section, "harm" , in relation to an aquifer or waterfront land, means any act or omission that adversely affects, the capacity of the aquifer or waterfront land to hold or carry water.

3.5. Protecting Aquifer Integrity and Functioning (Contd)

Another example can be found in the U.S. State of Texas, *Edwards Aquifer Authority Act of May 1993 (as amended)*, which provides:

- *Sec. 1.14 – Withdrawals*

  (a) Authorizations to withdraw water from the aquifer and all authorizations and rights to make a withdrawal under this Act shall be limited in accordance with this section to:

  (1) protect the water quality of the aquifer;

  (2) protect the water quality of the surface streams to which the aquifer provides springflow;

  (3) achieve water conservation;

  (4) maximize the beneficial use of water available for withdrawal from the aquifer;

  (5) recognize the extent of the hydro-geologic connection and interaction between surface water and groundwater;

  (6) protect aquatic and wildlife habitat;

  (7) protect species that are designated as threatened or endangered under applicable federal or state law; and

  (8) provide for instream uses, bays, and estuaries.

  (c) … the amount of permitted withdrawals from the aquifer may not exceed or be less than 572,000 acre-feet of water for each calendar year …

  (h) To accomplish the purposes of this article, the authority, through a program, shall implement and enforce water management practices, procedures, and methods to ensure that … the continuous minimum springflows of the Comal Springs and the San Marcos Springs are maintained to protect endangered and threatened species to the extent required by federal law …

4. Protection of Groundwater Resources Under International Law

International law does not apply to groundwater resources that are entirely contained within a nation’s territorial boundaries. International law, however, has begun to evolve with respect to aquifers that traverse an international political boundary. Today, trends can be identified in the evolution of legal norms that pertain to transboundary aquifers.

4.1. Unique Challenges

While all of the challenges noted in the section on *Threats to Groundwater and Aquifers* apply equally to aquifers that traverse an international political boundary, transboundary groundwater resources face a number of unique concerns related to their international transboundary character. Principally, the management of transboundary aquifers is challenged by notions of sovereignty under international law and its implications for transboundary impacts. Many states view groundwater as a fixed natural resource that is "owned" by the nation under which it is found. Since groundwater is a fluid substance that tends to flow, sometimes across borders, such notions of ownership complicate the development and application of international norms for the sustainable use of these subsurface resources.

In addition, sustainable management of and cooperation over transboundary aquifers are often constrained by a lack of data and information about their location, volumes, flow regimes, chemistry, and other characteristics. Moreover, while some neighbouring nations have researched groundwater resources on their respective side of the border, the datasets are often incongruous due to differing priorities, methodologies, and expertise.

Lastly, the development of regulatory and governance regimes for aquifers traversing international borders is challenged by a lack of experience and state practice. Simply put, the international community has very little experience with the governance of transboundary aquifers. Accordingly, international law for transboundary aquifers is less specific and less developed as compared with its domestic counterpart.

4.2. Sources of International Law for Transboundary Aquifers

References to transboundary groundwater resources have appeared in international instruments for more than 150 years. For example, an 1888 agreement between the United Kingdom and France provided both parties the common rights to use the wells of Hadou, which lay on the newly created border of the Somali coast. Such references, however, were secondary or even tertiary concerns under their respective agreement. Only in the 1970s did transboundary aquifers begin to garner growing interest warranting individualized attention in both treaty-making and international law. However, even the much-lauded UN Convention on the Non-navigational Uses of International Watercourses focuses on transboundary rivers and lakes and incorporates transboundary aquifers within its scope as a secondary concern. We could also make reference to the UN Convention to Combat Desertification. Regional treaties could also be listed, such as the Espoo Convention, the Aarhus Convention, the UNECE Water Convention and its Protocol on Water and Health, the SADC Protocol, the Carpathians Convention, the African Convention on the Conservation of Nature and Natural Resources, and the ASEAN Agreement on the Conservation of Nature and Natural Resources. Also, treaties concerning specific river/lake basins could be included (Danube, Rhine, Sava, Lake Tanganyika, Lake Victoria)

4.3. Sources of International Law for Transboundary Aquifers (Contd)

1. Primary References in International Instruments

The best known, and still the only treaty crafted to manage and specifically allocate the waters of a transboundary aquifer, is the *Convention on the Protection, Utilization, Recharge and Monitoring of the Franco-Swiss Genevese Aquifer*. Originated in 1978 and revised in 2008, this singular arrangement addresses groundwater quality, quantity, abstraction, and recharge largely through the creation of a joint Genevese Aquifer Management Commission. The Genevese Convention is particularly significant because it strikes a balance between state sovereignty and state responsibility in its management scheme, which is based almost exclusively on principles of transparency, good faith dealings, and cooperation.

The newest arrangement for a transboundary aquifer is the 2015 *Agreement between the Government of the Hashemite Kingdom of Jordan and the Government of the Kingdom of Saudi Arabia for the Management and Utilization of the Ground Waters in the Al-Sag/Al-Disi Layer*. In contrast to the Genevese Convention, the Al-Sag/Al-Disi Agreement was created for the singular purpose of restricting groundwater extraction and protecting groundwater quality in a limited portion of the aquifer. In a similar vein, the 1973 interpretation of the 1944 *Mexico-US Treaty Relating to the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande* known as *Minute 242* also focused on restricting groundwater extractions in a small area along the border of the US and Mexico.

4.4. Sources of International Law for Transboundary Aquifers (Contd)

Other official international instruments that reference transboundary groundwater resources as a primary focus include:

- The series of agreements over the Nubian Sandstone Aquifer (Chad, Egypt, Libya, and Sudan): 1992 *Constitution of the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer Waters*; 2000 *Programme for the Development of a Regional Strategy for the Utilisation of the Nubian Sandstone Aquifer System*: *Agreement No. 1 - Terms of Reference for the Monitoring and Exchange of Groundwater Information of the Nubian Sandstone Aquifer System, done in Tripoli* and *Agreement No. 2 - Terms of Reference for Monitoring and Data Sharing, done in Tripoli*;
- 2002 *Establishment of a Consultation Mechanism for the Northwestern Sahara Aquifer System* (Algeria, Tunisia, and Libya).

The 2009 *Agreement on the Guarani Aquifer* was negotiated by Argentina, Brazil, Paraguay, and Uruguay, but to date only Argentina and Uruguay have ratified it, so the agreement is not in force.

4.5. Sources of International Law for Transboundary Aquifers (Contd)

2. Primary References in Non-binding Arrangements

Formal agreements are not the only evidence of trends and priorities in the development of customary international law. State conduct in the form of informal, and/or non-binding arrangements can also serve as indications of emerging State practice:

- 2014 *Memorandum of Understanding for the Establishment of a Consultation Mechanism for the Integrated Management of the Water Resources of the Iullemeden, Taoudeni/Tanezrouft Aquifer System (ITAS)* (Algeria, Benin, Burkina Faso, Mali, Mauritania, Niger, and Nigeria);
- 1999 *Memorandum of Understanding between the City of Juárez, Mexico Utilities and the El Paso Water Utilities Public Services Board (PSP) of the City of El Paso, Texas*;
- 1996 *Memorandum of Agreement Related to Referral of Water Right Applications* (British Columbia, Canada, and State of Washington, USA).

4.6. Sources of International Law for Transboundary Aquifers (Contd)

3. 2008 Draft Articles on Transboundary Aquifers and 2012 UNECE Model Provisions on Transboundary Groundwaters

The most profound milestones in the on-going development of international law applicable to transboundary aquifers are the nineteen Draft Articles on Transboundary Aquifers prepared by the UN International Law Commission, and the nine model provisions contained in the Model Provisions on Transboundary Groundwaters and developed under the auspices of the UN Economic Commission for Europe. While both instruments were issued in the spirit of advancing international law applicable to transboundary groundwater resources and were couched with reference to existing state practice, both are non-binding and serve as guidelines for nations with aquifers that traverse political boundaries.

4.7. Trends in the Evolution of International Law for Transboundary Aquifers: Procedural Obligations

Regular exchange of data and information

Possibly the most palpable and consistent conduct emerging from state practice is a recognized procedural obligation to regularly exchange data and information over transboundary aquifers. With respect to the type of data that should be exchanged, the Al-Sag/Al-Disi Agreement refers to, "The collection and exchange of information, statements and studies and their analysis", the Model Provisions reference "the exchange of information and available data on the condition of transboundary groundwaters", and Article 8 of Draft Articles provides that such data and information should include material of a "geological, hydrogeological, hydrological, meteorological and ecological nature and related to the hydrochemistry of the aquifers or aquifer systems, as well as related forecasts".

Monitoring and generation of supplemental data and information

Corollary to the duty to regularly exchange data and information is the obligation to generate supplemental data and information on an on-going basis through monitoring and related activities. The Genevese Convention, for example, explicitly references monitoring in its title and addresses "Quantitative and Qualitative Monitoring of the Resource" in Chapter Four of the agreement. In addition, it mandates in Article 17 that the Parties "maintain a monitoring network … intended for the issuance of warnings in the case of accidental pollution likely to affect the water quality of the aquifer." In a similar vein, Agreement No. 2 under the NSAS Agreements, entitled "Monitoring and Data Sharing", provides clear guidance on the types of information the parties should gather: "Yearly extraction in every extraction site, specifying geographical location and number of producing wells and springs in every site; Representative Electrical Conductivity measurements (EC), taken once a year in each extraction site, followed by a complete chemical analysis if drastic changes in salinity is [*sic*] observed; Water level measurements taken twice a year in the locations shown in the attached maps and tables."

4.8. Trends in the Evolution of International Law for Transboundary Aquifers: Procedural Obligations (Contd)

Prior notification of planned activities

Another procedural obligation emerging from state practice is the duty to provide prior notification of planned activities. The purpose of these notifications is to allow potentially affected states to evaluate the possible consequences of an activity and to seek an understanding or compromise with the acting state if detrimental consequences are foreseen. Under Minute 242, Mexico and the US agreed to "consult with each other prior to undertaking any new development of either the surface or the groundwater resources, or undertaking substantial modifications of present developments, in its own territory in the border area that might adversely affect the other country". Similarly, Article 15 of the Draft Articles would require aquifer states to provide "timely" notification "accompanied by available technical data and information ... to enable the notified State to evaluate the possible effects of the planned activities" (UNGA Resolution 2008). Indirectly emphasizing consultation in good faith, Article 11 of the Guarani Agreement imposes the additional obligation that the party proposing an action that may have a transboundary impact must delay implementation of those measures for at least six months while negotiating with the potentially affected state. Moreover, Provision 8 of the Model Provisions mandates an environmental impact assessment for all planned activities that are likely to have a significant effect on transboundary groundwater resources, and requires that the assessment be transmitted to all potentially impacted state upon request.

Creation of institutional mechanisms to facilitate or implement the arrangement

The creation of joint institutional mechanisms to carry out the objectives of the various regimes is another procedural obligation emerging from state practice. The Model Provisions and Guarani Agreement provide the simplest iteration of this obligation and offer no additional instructions about the structure and operation of such an entity. The Al-Sag/Al-Disi Agreement notes that the institutional mechanism is composed of representatives of the national water resources agencies in the two member states, and its mandate includes "the supervision and observation" of groundwater levels, quality, and extraction, "the collection and exchange of information, statements and studies and their analysis" related to the aquifer, and the submission of such information and analyses to the two governments.

In a similar vein, the Genevese Convention creates a commission whose purpose is to implement the agreement. The Genevese Aquifer Management Commission, however, has more extensive authority than under the above-noted arrangements. Its mandate, for example, includes proposing an annual aquifer utilisation program, providing technical opinions on construction of new groundwater extraction operations and modification of existing equipment, and performing audits of investment and operational costs related to the recharge installation. It is also responsible for overseeing waterworks and equipment construction, recording water extractions, collecting water level and quality data, establishing water quality analysis criteria.

In contrast, the NWSAS Agreement, the Iullemeden MoU, and the NSA Constitution of the Joint Authority were formulated and implemented specifically to create a joint cooperative mechanism. The NWSAS Agreement, for example, created a "Consultative Mechanism" to "coordinate, promote and facilitate the rational management of the NWSAS water resources"," while the Iullemeden MoU created an identically-named mechanism "to promote and foster cooperation between the Signatory States … based on solidarity and reciprocity for a sustainable, equitable, coordinated and collaborative use of the ITAS water resources".

4.9. Trends in the Evolution of International Law for Transboundary Aquifers: Substantive Obligations

The norms of equitable and reasonable use and of no significant harm are the primary cornerstone principles of international water law. They are best represented in the 1997 UN Watercourses Convention, but also have counterparts in the Draft Articles that are tailored to the particular characteristics of groundwater resources.

For example, the Draft Articles require Aquifer States to abide by the principle of equitable and reasonable use by ensuring that all uses are "consistent with the equitable and reasonable accrual of benefits therefrom to the aquifer States concerned". Such uses must maximize "the long-term benefits derived from the use of water contained therein". Further, the parties "shall establish individually or jointly a comprehensive use plan, taking into account present and future needs of, and alternative water sources for, the aquifer States", and "they shall not use a recharging transboundary aquifer or aquifer system at a level that would prevent continuance of its effective functioning". In determining what constitutes equitable and reasonable, States must take into account all relevant factors, including:

(a) the population dependent on the aquifer or aquifer system in each aquifer State;

(b) the social, economic and other needs, present and future, of the aquifer States concerned;

(c) the natural characteristics of the aquifer or aquifer system;

(d) the contribution to the formation and recharge of the aquifer or aquifer system;

(e) the existing and potential use of the aquifer or aquifer system;

(f) the actual and potential effects of the use of the aquifer or aquifer system in one aquifer State on other aquifer States concerned;

(g) the availability of alternatives to a particular existing and planned use of the aquifer or aquifer system;

(h) the development, protection and conservation of the aquifer or aquifer system and the costs of measures to be taken to that effect;

(i) the role of the aquifer or aquifer system in the related ecosystem.

Aquifer States also must use transboundary aquifers and aquifer systems in ways that minimize "significant harm to other aquifer States or other States in whose territory a discharge zone is located." The obligation to prevent significant harm to other aquifer States and States in whose territory a discharge zone is located is also applicable to "activities other than utilization of a transboundary aquifer or aquifer system that have, or are likely to have, an impact upon that transboundary aquifer or aquifer system". Finally, "[w]here significant harm nevertheless is caused to another aquifer State or a State in whose territory a discharge zone is located, the aquifer State whose activities cause such harm shall take, in consultation with the affected State, all appropriate response measures to eliminate or mitigate such harm, having due regard for the provisions" related to equitable and reasonable use.

4.10. Trends in the Evolution of International Law for Transboundary Aquifers: Gaps in International Law

There currently exist several notable gaps in international law applicable to groundwater resources traversing international boundaries. Among others, these include clear protections for the recharge and discharge zones, for ecosystems and habitats dependent on transboundary aquifers and for the aquifer's geological matrix. Additionally, norms are needed to better address transboundary aquifer pollution, cross-border public participation, the harmonization of metadata and methodologies, and the exploitation of non-recharging transboundary aquifers.

5. Conclusion

Groundwater resources today play a critical role in providing fresh water for people, industries, nations and the environment worldwide. For billions of people, they serve as the bulwark against the challenges posed by expanding demands for freshwater and the declining supplies resulting from overexploitation and climatic changes. As a result, states must ensure that these critical resources, regardless of whether they are entirely domestic or transboundary, are managed and regulated in a sustainable manner.

Regulations designed to protect these resources at the domestic level focus on ensuring the quantity and quality of water found within aquifers, as well as the integrity of aquifers. At the international level, procedural trends related to the management of transboundary aquifers, such as sharing data and information, can be identified, but trends in substantive norms have yet to coalesce.