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Conceptual Framework of the Transboundary Aquifer Management: Legal Analysis

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Abstract

The conceptual framework of the transboundary aquifers is complex, while the term used in legal text are tested by legal experts, still are scientific, and can be used by hydrologist and geographics, thus, and due to sensitivity of the subject, it been challenging to address the aquifers and the transboundary aquifers in the legal text, by merging between the scientific nature of the terms, and their extension in legal text, the discussion about these terms triggered several legal discussions including the different between the aquifer and the groundwater, and when the aquifers can be considered as transboundary, using a qualitative method by focusing on legal research, analysis, and comparison, the aim of this article is to highlight the main concept regarding the transboundary aquifers management, particularly the terms than been emphasized in the Draft Articles on the Law of Transboundary Aquifers 2008, emphasizing the main legal discussion, and putting them in the international context.

Keywords: Aquifer, Transboundary Aquifer, Conceptual Framework.

1. INTRODUCTION

Groundwater is crucial for meeting basic human needs, it serves different domains such as urban, industrial, agriculture, and others, approximately 50% of the world's population drinks groundwater daily and a big portion of it is considered transboundary (www.un-igrac.org), however, the term transboundary aquifer was not used till the early 1990's and the beginning of the 2000's, particularly, when is International Shared Aquifer Resources Management been launched, which highly contributes on the development of transboundary aquifers management all over the world, before that, the early recognition of the aquifers was domestic, and due to the Post-World War Two and the De-colonialization in many parts of the world, the transboundary aquifers term was considered politically sensitive, rather countries preferred terms, such as regional aquifers, international watercourses, or other related terms, nowadays, transboundary aquifers term and other related terms are increasingly used in the international legal texts, particularly after the Draft Articles on the Transboundary aquifers dropped to light, however, the terms is not without legal debates, and still getting attention of many researchers in the field, therefore, the aim of this articles is to define and emphasize the main term related to the transboundary aquifer or what I am going to refer to as TBAs, and putting in the context of the management which highly affected by these terms, by addressing the international effort that been done to manage the transboundary aquifers and the transboundary aquifers system.

2. What is the aquifer?

The term 'aquifer' according to its etymological origin is Latin origin: "Aqui" comes from "aqua",

meaning “water”, and “fer”, from “Ferre”, meaning “to bear” or in another word “to carry”, thus, in Latin it literally means “I carry water”, an aquifer is a term used for a porous geological formation that contains water at full saturation means that the entire interconnected void space is filled with water, and permits water to move through it under ordinary field conditions, or we can simply said that in terms of geology, an aquifer is an underground geological formation that houses water (www.agrocorrn.com , Accessed 2024).

From an international legal perspective, the Draft articles address couple of definitions including the aquifer, as mentioned earlier, while these definitions have been carefully examined by legal experts, they are technical and intended for use by water engineers, scientists, and water management administrators, this is largely based on the Special Rapporteur's effort to seek the counsel of hydrogeologists, water policy specialists, and other experts, as well as his desire to ensure that the terminology used and the principles formulated are both technically precise and legally sound (Bear, 2010: 65).

In the case of “the aquifer” the Draft Articles define it as “a permeable water-bearing geological formation underlain by a less permeable layer, and the water contained in the saturated zone of the formation” (Draft Articles, 2008: 3), in other words, the aquifer is essentially a geological formation composed of two layers: one layer that water-bearing and permeable allowing the water to flow through, and the other one that is less permeable, therefore the groundwater storage which is the ability of aquifers to hold water, and groundwater flow that refers to water that can move through them concerned as two key characteristics, one of the ways of conceptualizing an aquifer is by linking it to a sponge: the latter will have water in it, but unless you squeeze it you will not see the water flowing, that means that whether a geological formation can be designated as an aquifer, or not, depends on its ability to store and transmit water relative to other formations in the vicinity, different geological formations vary widely in the degree to which they exhibit these properties and the size of aquifers can range from a few square kilometers to many thousand square kilometers. (Yamada, 2004: 6)

This suggests that any water resources lacking these elements might not be considered as aquifers, however, it is important to point that Subsurface water, or groundwater, groundwater reservoir (or basin) and water-bearing zone (or formation), are a terms used to denote the waters found beneath ground surface some groundwater hydrologists use the term subsurface water to denote all the water below the ground surface, and use the term of groundwater to donate certain type of the surface water, and according Second report the term “groundwaters” has been consistently used by the Commission causing confusion because it doesn’t specify which underground waters it refers to, although it is perfectly adequate to use the term in normal writing, it lacks precision as a legal term, instead the Special Rapporteur propose using the technical term “aquifer” that refers to a specific body of underground water that can be extracted and leaves no room for ambiguity (Yamada, 2004: 5).

The discussion about the “Aquifer” and the “Groundwater” still catch attention of some researcher in their work, while in one hand, most of the researches if not all of them in the matter of the “Aquifers” or the “Groundwater” from transboundary perspective or domestic perspective, use the both terms to refer to same thing in the other hand, the both term cannot match with the utilization concept which does not include only the use of the underground water or the water within the aquifer, but any other activity that might affect the aquifer, same concept that been referred to in scope of the Draft Articles, same thing repeatedly used in the Arabic research, which most of the time make no difference between the “Aquifer” and the “Groundwater”, from domestic legal point of view, the underground water terms do no seems to be priority in the legal text and most of the time they refer to groundwater as any source of

water that is located underground, nevertheless, I will use in the research the term "groundwater" to refer to the aquifer.

The aquifer can exist independently from and can also be linked with other aquifers which is called the aquifer system: "a series of two or more aquifers that are hydraulically connected" (Draft Articles, 2008: 3) when we say aquifers are "hydraulically connected," it means they have a physical link between them and they are linked with the water that can flow from one aquifer to another, and with these connections, they can exchange water with each other the quantity of water that is capable of being transmitted is important since an insignificant or de minimis quantity of water may not translate into a true hydraulic (Sindico, 2020: 12), while the hydrological connection is rarely mentioned in domestic legislation at least in the region of study, in international level plays crucial role in defining whether the aquifer is transboundary or not, and proving this connection might lead to new map of aquifers system, and thus a another transboundary aquifers map, accordingly states should leave space to other countries to join the cooperation of TBAs management if the hydrological connection has been proved, as example the article four of the joint authority constitution of the Nubian Sandstone Aquifer System allow the other countries to join, provided that such countries are within the NSAS states.

From a management perspective, the special reporter suggests that an aquifer linked with other aquifers should be treated as one aquifer, and emphasizes that aquifers should be managed as a single system which means treating interconnected aquifers together for better management, for example, if aquifer "A" is entirely within a single State, it is considered a domestic aquifer It won't be subject to international regulations because it's contained within one country, however, if aquifer "A" has a hydraulic link with other aquifers "B" and "C", if aquifer "B" or "C" is transboundary (crossing national borders), then aquifer "A" becomes part of a transboundary aquifer system, thus we treat aquifers "A", "B", and "C" together for management purposes (Eckstein, 2007: 552).

Moreover, the concept of hydrologic unity isn't new to the United Nations International Law Commission (UNILC), it was previously recognized in their work on the Watercourse Convention according to it a "watercourse" is a system of both surface waters and groundwaters that form a unitary whole and typically flow into a common endpoint, conjunctive use is related to this idea It involves combining surface water and groundwater to optimize resource utilization by using both sources together (Yamada, 2004: 5), however, the watercourse convention exclude confined aquifers that are disconnected from surface water, as well as non-recharging aquifers, which been latter recognized by the Draft Articles that refer to recharging and non-recharging aquifers and the ILC commentary on the Draft Articles expands on the difference between confined and unconfined aquifers.

3. What is a transboundary aquifer?

Historically, the early recognition of the aquifers in the international agendas was domestic, and the term of the transboundary was not used in the beginning, the early track of the scientific studies in the aquifers was in the 1950's, when The UN's Economic and Social Council started a global inventory to increase the scientific knowledge of hydrogeology in the interest of the growing attention to water, when start being noticeable that countries shared aquifers as continuance of the aquifers withing national borders, till the 1970's the term "transboundary" was considered too political sensitive due to the post-World War Two tensions and the de-colonization in many part of the world, rather, the term "regional aquifer" was preferred, even in the 1977 Burdon's regional maps of the aquifers did not include indications of national borders, in the 1990's reference of transboundary aquifers were more explicit,

leading to the first international reference to “shared aquifer resources”, where the Tripoli statement of 1999 following the international conference on “Regional Aquifer Systems in Arid Zones” considered clearly “the Shared Aquifer resources”.(Puri & Villholth, 2017: 2-3)

Nowadays, groundwater serves the drinking water needs of approximately 50% of the global population, it contributes to over 40% of the worldwide production of irrigated crops, and transboundary water resources represent approximately 40% of the world freshwater (Rivera et all, 2022: 21), the transboundary aquifers, transboundary aquifers system, transboundary groundwater, or other relevant terms are increasingly used by the researcher, and it start being more familiar in legal filed, the Draft Articles define “transboundary aquifer” or “transboundary aquifer system” as “respectively, an aquifer or aquifer system, parts of which are situated in different States”(UN, 2008: 3), in simple words, the transboundary aquifer or transboundary aquifer system refers to an underground water source that extends across national boundaries, initially, the special rapporteur addressed groundwater resources as part of “shared natural resources” , however, some UNILC members expressed concerns about using the term “shared”, since the term “shared” implies collective ownership and raises questions about common heritage and some UNILC members opposed the idea that a transboundary aquifer could be collectively owned. (Yamada, 2004: 553)

Determine whether the aquifer is domestic or transboundary is crucial, to know if it will be under the application of domestic or international regulations, however, it is not that easy task as how it looks like, especially for a hidden resource such as the groundwater, and this required cooperation with different stakeholders, and takin into account multiple jurisdictions, language, cultural differences, and governance frameworks, from another perspective, defining groundwater or water resources as transboundary is likely to take different forms in the future, for instance, in Morocco a water linkage projects been lunched, between water basins and between dams to ensure flexibility and better integrated management (www.telexpresse.com accessed 2025), while the aim of this project is mainly to secure the water domestic needs, it is likely to observe such kind of project between states in future, based on agreements and conventions, additionally, a link between the water security and the food security can be observed, since portion of daily water use goes to irrigation, accordingly and due to the fact that water resources are often used for agricultural purposes, which often exported to other countries, a question remains will we see cooperation between countries other than the basis of water being transboundary by its nature, but rather on the purpose of its use?

Regardless of that, an aquifer or aquifer system is considered ‘transboundary’ when it extends beneath the territory of more than one state, however, discerning whether an aquifer is domestic or transboundary needs establishing comprehensive criteria that consider all relevant factors.

First, We can determine whether the aquifer or the aquifer system is transboundary if an aquifer spans the borders of two or more countries, for that, the presence of the aquifer in multiple states is a fundamental criterion, even though the existence portion of an aquifer in a states affect the need of cooperation in that state, and accordingly considered that aquifer is transboundary for the same state, for example, The Ethio-Djibouti Aquifer which spans the border between Ethiopia, Djibouti and Eritrea, for the sustainable management of these aquifer, the Ethio-Djibouti Transboundary Water Project (EDTWP) has been launched (Grönwall, 2022: 8), as can be observed in the Ethio-Djibouti Aquifer map which is referred to as AF059 in the TBAs in Africa, is shared primarily between Ethiopia and Djibouti, with a minor portion extending into Eritrea, while there are no available data explaining Eritrea’s lack of involvement in the project which can be political, this situation suggests that the presence of an aquifer

within a state is a critical factor in determining whether it is considered transboundary.

Secondly, the aquifers are interconnected underground, if parts of an aquifer system are hydraulically connected by underground or surface water across borders, it is likely to be considered as a transboundary, and the movement of groundwater between different portions of the aquifer supports this connection, as an example, the Lockyer Valley is a region in Queensland, Australia, consists of loose sandy material deposited by ancient rivers, to understand this aquifer-hydrological connection imagine the Lockyer Valley as a giant underground sponge with water-filled pores, the water flows through these pores, connecting the surface water (rivers and streams) to the aquifers below, when it rains, water seeps into the ground, and recharges the alluvial aquifers, and during dry periods, plants and farmers extract water from these aquifers which are also connected to deeper bedrock aquifers, which store water over longer periods (Raiber & all, 2019: 1).

In the same context, we must also consider the hydro-geological formation, recharge, and discharge zones, these factors are crucial in determining whether an aquifer is transboundary or domestic, and influence groundwater movement across borders, accordingly, two countries become aquifer states if a permeable, water-bearing geological formation lies beneath their territories, if an aquifer system spans multiple countries, it is a transboundary aquifer system, the precise location of the hydraulic connection creating the aquifer system is irrelevant for definition purposes, however, focusing on the permeable water-bearing geological formation does (Draft Articles, 2008: 3), hydrologically, recharge and discharge zones are connected to the aquifer, however, the draft article's definition focuses solely on the permeable formation without mentioning these zones, draft Article 11 emphasizes cooperation between states on recharge and discharge zones, the goal is to protect the aquifer or aquifer system and related resources. (Sindico, 2020: 15)

The Hydrological approach in the international law of the transboundary aquifers is crucial, while the aquifers can be independently existed, they are often linked with hydrological circle where the surface and groundwater and other hydro-geological formations are involved, thus, and from management purposes, treating the whole hydrogeological formation as one unit is essential for sustainable water use, however, considering the formation as transboundary is complex and involved other element in the process, for clear understanding of the hydro-geological approach in TBAs management, Dr Gabriel Eckstein & Yoram Eckstein article present six models are illustrative of the main scenarios in which ground water resources can have transboundary implications, including model where an unconfined aquifer that is linked hydraulically with a river, both of which flow along an international border, and model where an unconfined aquifer that is completely within the territory of one state but that is linked hydraulically to a river flowing across an international border (Gabriel Eckstein & Yoram Eckstein , 2003: 235-248)

Third, the aquifer or aquifer system can be considered transboundary based on the legal and political context, in which international law and agreements play a role, if states recognize an aquifer as shared and cooperate in its management, it becomes transboundary, formal agreements or treaties may explicitly appoint an aquifer as transboundary, while this often applicable in the federal states such the US, Australia, and Germany, its application might extend to other states and regions particularly, the one with similar political agendas, the principle aquifers present an example of case that might be subject of this matter, which can be define as geologic formations or aquifer systems that can potentially yield significant quantities of water to wells and springs, they play a crucial role in determining groundwater availability for the entire nation, by considering the hydrological connections these aquifers can be

defined as transboundary based on the agreement and legal perspective as the principal aquifer is regionally extensive and can be used as a potable (drinkable) water source, these aquifers are fundamental for meeting water supply needs (www.usgs.gov , Accessed 2024).

Lastly, the shared interests and challenges could lead to defining the aquifer as transboundary, if the aquifer's use, protection, or management affects multiple states, it is likely transboundary, common challenges (e.g., over-extraction, pollution) necessitate cooperation, transboundary aquifers require awareness and cooperation among neighboring states, joint assessments, data sharing, and collaborative governance are essential, however with the lack of the International legal framework that governs these valuable resources, it seems like the definition of an aquifer whether is transboundary or not is driven by the common interest and the will of the states to cooperate to manage the transboundary aquifers, thus, in wait to Draft articles being adopted by the states there is hope that the current agreements and conventions will reach the point that it will be considered as customary international law.

In short, the task of defining whether and aquifer or aquifer system is transboundary or not is complex, in one hand, by their natural many aquifers and aquifers system have been already mapped as transboundary aquifers, however, with absent of any cooperation between the aquifer states, the use of these aquifers is likely to cause over-exploitation and pollution and other mismanagement circumstances, which trigger the urgent need for joint cooperation regarding these aquifers, in the other hand, scientific researches regarding the aquifers is still running and its likely to extend the TBAs existing map to other states, then from a management perspective is it beneficial to take into account hydrological characteristics of the aquifers, including the hydrological connections between the aquifers, surface and underground water, accordingly treating the hydrological circle as one unit, additionally, taking into account not only the hydrological nature of the aquifer, but also the purpose of the use.

4. International Efforts in Managing Transboundary Aquifers

Over the past two decades, international efforts to manage transboundary aquifers have been gaining momentum, these efforts have mainly focused on collecting information to build a global baseline, assessing methodology, identification, mapping, fostering cooperation and trust, and most importantly, developing the legal framework (www.un-igrac.org , Accessed 2024), these efforts reflect a growing recognition of the importance of TBAs for global water security, especially as pressures on groundwater resources increase due to human activities and climate change, the ongoing work aims to ensure the sustainability of these vital resources and peaceful cooperation between countries sharing them.

Transboundary aquifers are crucial components of global water resource systems, like transboundary rivers, therefore, their recognition in international water policy and legislation is limited, therefore, the International Association of Hydrogeologists and UNESCO’s International Hydrological Program established the Internationally Shared (transboundary) Aquifer Resource Management (ISARM) Program, ISARM aims to address the deficiency by focusing on transboundary aquifers and their resources. UNESCO and the International Association of Hydrogeologists (IAH) lead the ISARM Initiative, a multi-agency effort that has launched global and regional initiatives. (www.un-igrac.org, accessed 2025)

These initiatives aim at delineating and analyzing transboundary aquifer systems and encouraging riparian states (countries sharing the same aquifer) to collaborate in mutually beneficial and sustainable aquifer development, the ISARM Program works to promote the recognition and understanding of transboundary groundwater resources (S. Puri and A. Aureli, 2005: 661), it encourages collaboration

among countries sharing the same aquifer to reach a consensus on legal and institutional frameworks, this includes developing agreements that govern the use, management, and protection of shared aquifer resources, ensuring equitable and sustainable utilization, this cooperation helps streamline groundwater management as an enabler for achieving water-related Sustainable Development Goals (SDGs), especially the SDG 6 which is Clean Water and Sanitation. (Organization of American States, 2010: 1-2)

The legal framework for the transboundary aquifers management mainly known by pluralism or as Dr. Conti and Gupta in their article referred to as "Fragmentation of international water law" and this not only in international level but also in regional or national level , thus, the first attempt to address the aquifers or the groundwater was in 1966, the International Law Association (ILA) explicitly included groundwater in their Helsinki Rules .

The Helsinki rules addressed surface and groundwater flowing to a common terminus, they endorsed many international water principles that have since been adopted in international treaties and agreements, the Helsinki rules define the transboundary drainage basin or international drainage basin as "a geographical area extending over two or more states determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus", however, the rules do not include the aquifers not connected with surface water, since these rules did not fully cover other groundwater flows, in 1986, the ILA developed the Seoul Rules, which specifically address transboundary groundwater, The Seoul Rules focus on hydraulic interdependence, protection of groundwater, and groundwater management in conjunction with surface waters, however, the Helsinki rules and Seoul rules have not been regarded as formal international rules, but they significantly influence the development of the international water law. (Albrecht & all, 2017: 47)

The Helsinki Rules contributed to the Convention on the Law of Non-Navigational Uses of International Watercourses, which was adopted by the UN General Assembly in 1997, the UN International Law Commission recognized the importance of transboundary waters and laid out many general principles which have guided many international treaties and agreements, the principles includes the equitable and reasonable utilization, no significant harm, good faith cooperation, information exchange, prior notification, and dispute settlement, while the watercourse convention defines an "International watercourse" " a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus" in its second article the use of term it did avoid using the term "watershed" intentionally, however by this definition the convention exclude the confined aquifers and non-recharging aquifers that disconnected with surface water. (Albrecht & all, 2017: 47)

Other rules been drafted after that to address the groundwater were the Berlin rules developed by ILA in 2004, in terms of regards for consideration of environmental water need, the rules were more comprehensive and progressive and did emphasize managing a shared watercourse in an equitable and reasonable manner, and place the principle of no significant harm on equal footing with equitable and reasonable use, and include ample consideration for environmental needs and the human right to water, unlike the watercourse convention the Berlin rules did not seek to be legally binding, however, seeks to operate as kind of "practitioners" or "best practice" guide. (Albrecht & all, 2017: 47)

In 2008, the Draft articles on law of transboundary aquifers was dropped into the light, to fill the gaps in the watercourse convention by including the confined and non-recharging aquifers, moreover, the Draft articles also included the principle of sovereignty, unlike the watercourse convention , while the watercourse convention entered into force on 17 August 2014 (www.unece.org , accessed in 2025), the

Draft articles have still not been finalized, however, the main focus of these research will be on the Draft Artiles rather than other legal frameworks, since it more relevant in this case, and covers most of the principles that other legal frameworks come up with, thus, it is beneficial for us at this level to address why the Draft article didn't adopted yet? Especially, the Draft Articles already been served as basis to negotiate independent international treaties and conventions on this subject, and it will facilitate the way for sustainable management of these valuable resources.

Dr. Eckstein and Dr. Sindico mentioned in their article a couple of points that highly affected the Draft Articles' adoption. They argued that the development of international law for transboundary aquifers is a gradual process, and the Draft Articles' impact will be measured by their adoption and implementation by states, they believe that Draft article didn't adopt yet for the following reasons:

First, there is no consensus among UN member states on whether the Draft Articles should be adopted as a binding treaty, a non-binding declaration, or remain in their current form, moreover, the lack of consensus goes further to the level that the countries have differing views on the necessity and timing of codifying these principles into a formal treaty, and the topic has been discussed multiple times at the UN General Assembly (UNGA) without reaching a consensus on the final form of the Draft Articles. This lack of agreement has stalled progress.

Second, the draft article progress suffers from legal disagreements, while some countries argue that the Draft Articles do not fully reflect current international law and state practice regarding transboundary aquifers and believe that more evidence of state practice is needed before codifying these principles, there are also concerns about potential conflicts with other international legal instruments, such as the UN Watercourses Convention.

Third, from a political perspective there is constraints about the Draft articles as the support for a binding treaty is limited, thus, some countries believe that a global treaty on transboundary aquifers would not garner sufficient ratifications to enter into force, similar to the slow ratification process of the UN Watercourses Convention, moreover, some countries may lack the political will to commit to a binding treaty due to domestic priorities or geopolitical considerations.

Forth, following the same path, the local contexts is important for the continuance of the progress, some states like Israel and Guatemala prefer local or regional agreements that can address specific needs and conditions; thus, they argue that transboundary aquifer management should be tailored to local hydrogeological and political contexts rather than governed by a global treaty.

Fifth, as important the government of the transboundary aquifers some government due to Socio-Economic sensitivities they ignore the subject as the management of transboundary aquifers involves complex socio-economic, political, and environmental interests, for them they hesitant to commit to a global treaty due to these sensitivities and the potential impact on their national interests.

Sixth, some stakeholders, including the original Special Rapporteur, Ambassador Chusei Yamada, advocate for a slow and methodical approach, and they suggest allowing countries to test and adapt the principles in the Draft Articles through bilateral or regional agreements before considering a binding global treaty, and the hope is that the principles in the Draft Articles might eventually rise to the level of customary international law through state practice, even without being codified in a binding legal instrument.

Seventh, several countries prefer maintaining the status quo, where the Draft Articles serve as non-binding guidance for bilateral or regional agreements. This approach provides flexibility and allows states to incorporate the principles as they see fit without the pressure of binding obligations.

5. Conclusion

In short, the international community made remarkable efforts to secure sustainable transboundary aquifers management, which impacted the discussion about the use of terms in the related legal text, these terms that even though it looks simple for the non-familiars with the field, it is technical and needs more attention in the future research, the terms used in the International legal text, and also the domestic are crucial to define the rage of the application of the laws, on the other hand, the use of terms should take into account the hydrological connection of the aquifers, transboundary aquifers, with the other part of the hydrological circle, to support the unity management perspective.

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