TRANSBOUNDARY GROUNDWATER AND INTERNATIONAL LAW: PAST PRACTICES AND CURRENT IMPLICATIONS

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Abstract

Despite their significance, physical interactions between surface and groundwater have largely been ignored in international water law. While surface water has been given considerable attention as a transboundary natural resource, groundwater has not received the same recognition. International legal doctrines regarding water, such as the 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses, only recognized one aspect of groundwater, excluding confined aquifers. This study discusses how international freshwater treaties have addressed groundwater resources in the past, and considers current trends. While the issue of transboundary groundwater in international treaties is becoming increasingly relevant as disputes over groundwater resources come to the fore, it is usually only indirectly mentioned in treaties. Groundwater and surface water should be considered together as part of the hydrological cycle and reflected as such in the legal realm. The uncertainty of physical properties is not an excuse for the delay of a concrete framework. The "precautionary principle" should play a role as a guiding factor. An Interactive Coordinated Approach (ICA) is recommended as a guideline for future implementation of transboundary groundwater management. The purpose of this study is to demonstrate the need to develop comprehensive transboundary groundwater management schemes.

KEY TERMS: Transboundary Aquifer, Groundwater, Uncertainty, Precautionary Principle, Interactive Coordinated Approach (ICA), International Environmental Law

TRANSBOUNDARY GROUNDWATER AND INTERNATIONAL LAW: PAST PRACTICES AND CURRENT IMPLICATIONS

1. Introduction

Over the past century, maintaining adequate freshwater resources for all humans and environmental communities has become a focal point in the academic and political arenas (Albert 2000, Falkenmark 2000, Feitelson 2000, Gleick 2002, and Wouters 2000). Furthermore, conflicts resulting from water competition and degradation are frequently discussed in the literature (Homer-Dixon1994, Lowi 1999, Postel and Wolf 2001, Yoffe 2001). The inadequacy of water is expected to be severe in the future, although "the amount available to the world today is almost the same as it was when the Mesopotamians traded blows 4500 years ago, even as global demand has steadily increased" (Postel and Wolf 2001). The reasons for the water deficit in the world are not only geographical problems, but also increased population growth, land development, insufficient water management techniques, and a combination of other non-physical factors.

Concern over the availability of *groundwater*[1] is well warranted, since groundwater comprises 31 percent of the total freshwater in the world, compared with 0.3 percent for rivers and lakes (Shiklomanov 1993). Additionally, "aquifers are in many ways an ideal source of water", providing ready availability for local users and an optimum storage place (Postel 1999, p. 33). The value of groundwater cannot be overlooked especially in light of the increasing demand for water.

Despite the significance of groundwater availability and the necessity of groundwater management, in terms of laws and institutional approaches, management is still in its infancy at the international level (Barberis 1991, Hayton 1982, Krishina and Salman 1999, and Utton 1982), although some States have begun to expand regulations. In

[1] In this paper, the term 'groundwater' includes water in aquifers. *Aquifer* is defined as, "a subsurface waterbearing geologic formation from which significant quantities of water may be extracted" (Hayton and Utton, 1989, p. 678).

comparison, *transboundary*[2] surface water has been studied in order to pursue equity and sustainable development, and management has thoroughly evolved over the last few decades.

There are marked differences in the status of the recognition for transboundary surface water and groundwater. Consequently, transboundary groundwater directives have been omitted from overall water management regulations. The two primary reasons for this absence are also points of contention in transboundary groundwater management. First, groundwater characteristics vary in each aquifer. Groundwater is often deep or unevenly distributed geographically. These uncertainties make groundwater seemingly impossible to regulate, as well as ill defined. The other reason is the transboundary element. Dealing with transboundary issues has been intensively studied in surface water; as a result, the difficulties as well as the necessity for management structures are understood. By contrast, in terms of transboundary groundwater, even the delineations of an aquifer are a challenge. Under the best use of monitoring and modeling techniques to identify groundwater characteristics, the definition of an aquifer cannot provide concrete conclusions about groundwater ownership. Because of these difficulties, in addition to the rapidly increasing population and the rising demand for water, groundwater quality and quantity have become serious environmental, economic, political, and socioeconomic concerns. Therefore, the establishment of an apparent management framework is critical.

Based on the uncertainties of physical characteristics and transboundary elements of transboundary groundwater, I will explore three components of transboundary groundwater management: 1) international groundwater management in environmental law, 2) past trends in groundwater management, and 3) an institutional framework for transboundary groundwater.

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[2] 'Transboundary' in this context refers to more than one State sharing natural resources. In this paper, the resource is the aquifer.

2. The Notion of Transboundary Groundwater

In order to understand transboundary groundwater management, it is important to closely look at how the terms *groundwater, aquifer,* and *transboundary*[3] are defined in the literature. There are many ways to describe the aquifer. Freeze and Cherry (1979, p. 47) describe the ambiguity of the definition of the aquifer from the hydrological science perspective: "of all the words in the hydrologic vocabulary, there are probably none with more shades of meaning than the term aquifer." Mazor (1995, p. 183) states "[A]quifer, the basic term of hydrology, has a countless number of definitions and applications, and as a result the term is esoteric." The physical characteristics of the aquifer are indistinctly defined; for example, "An aquifer is best defined as a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydrologic gradients" (Freeze and Cherry 1979, p. 47). Fetter (1994) defines an aquifer as, "a geologic unit that can store and transmit water at rates fast enough to supply reasonable amounts to well"(Fetter 1994, p.110). None of the above definitions completely cover all of the unique characteristics of aquifers; however, one universal definition for the term aquifer is not important. Instead, it is more important to identify aquifers' properties by measurements, where possible, because their geologic formations differ from place to place. Uncertainty over the physical properties of aquifers is a primary problem for management.

Furthermore, the difficulty of groundwater management often relates to transboundary issues between States. There are many scholars debating the best management of transboundary resources, such as the atmosphere, oceans, surface water, and even outer space. The complexity of the boundary issue is described by Feitelson: "Boundaries complicate the management of resources, as they create discrepancies between spheres of control and natural systems" (Feitelson 2000, p. 534). Compared with surface water, the delineation of the boundaries of groundwater is a challenging issue because of spatial considerations. Groundwater disperses beneath the surface, irrespective of State

[3] See definition: footnote 2 in this paper.

boundaries. Although management of groundwater may include a number of ground-boring and monitoring activities, as well as modeling to delineate the boundaries of the water body, nevertheless, in many areas the picture may still be incomplete.

Additionally, groundwater is influenced by land-development patterns. These influences can cause decreasing water levels and contamination of groundwater. It is important to protect the recharge area, which primarily captures precipitation on the surface, in order not to disturb water flow into the ground. Unfortunately, the question of how much land needs to be protected for the recharge area is currently unanswerable because scientists do not fully understand how groundwater behaves.

Without considering the properties of the land, groundwater management could not be complete. To account for these unique characteristics, transboundary groundwater management should utilize the three-dimensional approach, rather than the two-dimensional approach used for surface water. In the two-dimensional approach, scientists study the behavior of surface water on a single plane. With groundwater, water percolates into the soil, drawn by gravity. It moves along more than one plane. The three-dimensional approach takes into account this complexity of behavior.

It is hard to determine sovereignty for an aquifer with respect to the scale of both surface development and belowground structure. However, five different cases can be used to determine sovereignty (Barberis 1991, p. 168):

1) A State-owned aquifer, which is the entire aquifer in a State
2) A confined aquifer divided by an international boundary
3) An aquifer that is entirely in the territory of a State linked hydrologically with an international river
4) An aquifer that is entirely in the territory of one State but is hydrologically linked with another aquifer in a neighboring State
5) An aquifer that is entirely in the territory of one State but whose area of recharge is in a foreign State.

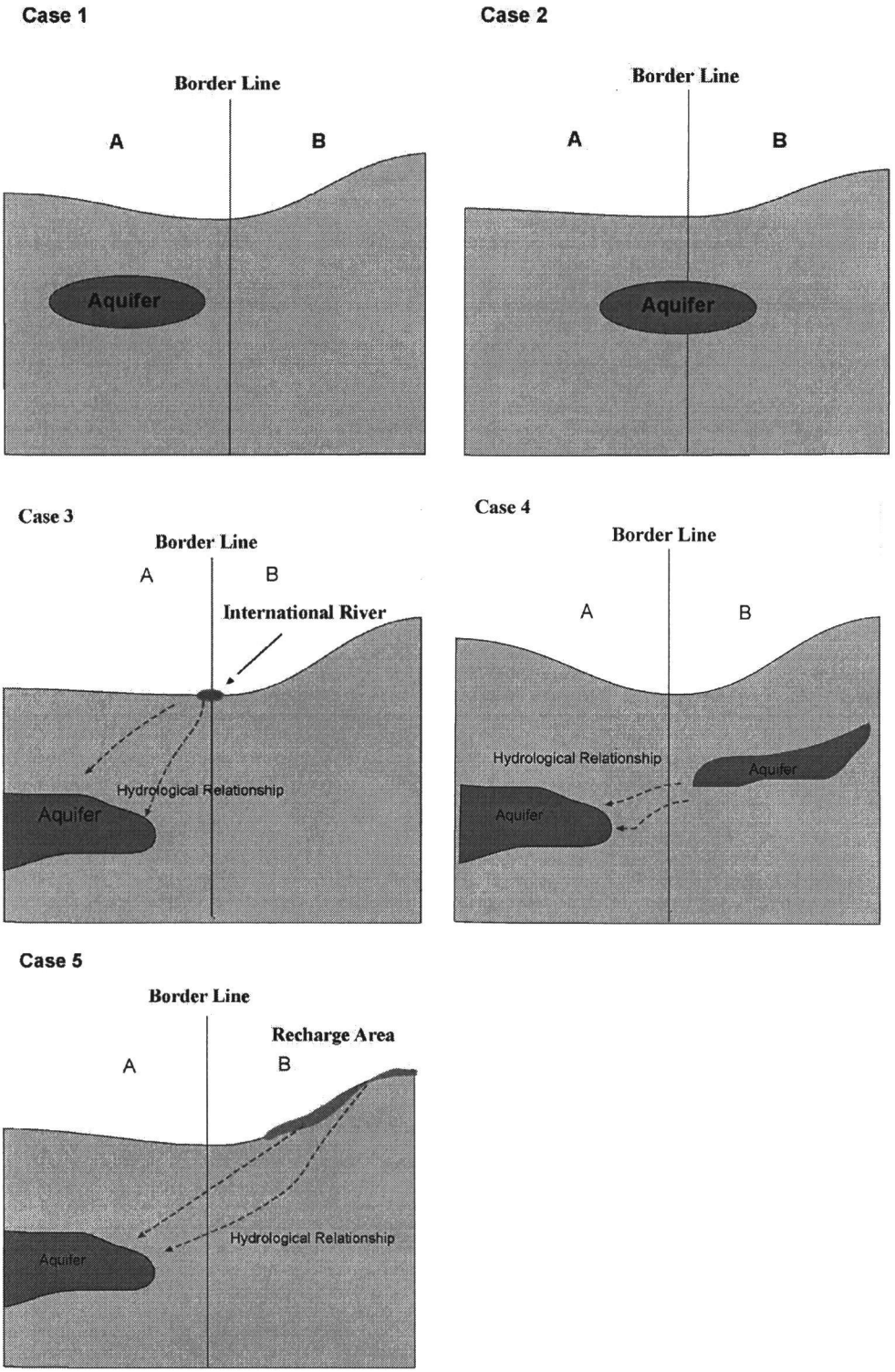

Figure 1. Schematic drawing of aquifer types.

These best describe guidelines for classifying transboundary groundwater. Except for Case 1, these conditions address possible sharing of an aquifer between States. One modification of Case 2 should be noted: if there is a hydrological relationship where intra-State rivers/lakes are linked to an international aquifer, then it is important to be aware of this relationship because the intra-State rivers or lakes may have some influence on the aquifer. Schematic views of these aquifer types are shown in Figure 1.

These guidelines suggest possible conditions that determine the transboundary nature of aquifers, and provide a means by which States can proactively manage transboundary aquifers. In addition, these categories are important not only in defining the nature of the aquifer itself, but also in illustrating the scope of the hydrological relationships between aquifer-sharing States. Management with a transboundary element is extremely difficult because of the challenges of cooperation among neighboring countries. This can be an additional obstacle for transboundary aquifer management.

3. Evolution of International Groundwater Management in Environmental Law

The principles for transboundary groundwater management have not yet been visibly developed. The reasons for the absence of transboundary groundwater law are, as Krishina and Salman (1999, p.163) point out, "the inadequacy of scientific data" and "complexity of the issues of groundwater." In order to allow for uncertainty concerning the physical characteristics of groundwater, principles or laws on transboundary groundwaters are left undefined or ambiguous. These ambiguities will be discussed in real contexts: the Helsinki Rules, Seoul Rules, Bellagio Draft Treaty, Agenda 21, The Law of the Non-Navigational Use of International Watercourses, and the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. In particular, the discussions will be focused on the transboundary elements and physical characteristics of groundwater.

3.1 Helsinki Rules

The International Law Association (ILA), established in 1873, is a non-governmental international organization that works for the development of emerging rules of international law (Krishna and Salman, 1999, p. 170). The earliest works regarding transboundary groundwater regulations are the Helsinki Rules.

The Helsinki Rules, drafted by ILA in 1966, represent an early attempt at codifying customary international law pertaining to transboundary water resources (Eckstein 1998, p. 92). The final version is called, "Helsinki Rules on the Uses of the Waters of International Rivers", and was published in 1967. The concept of a 'drainage basin' in the Helsinki Rules was used for defining the influential geographical area of water system (Article II). As a part of an international drainage basin, underground waters were included as follows:

> "An international drainage basin is 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" (Helsinki Rules: Article II, 1967).

In the commentary section, the underground waters "... constituting a part of the drainage basin are those that contribute to its principal river, a stream or lake or other common terminus"(Helsinki Rules, Chapter 1, Article II, 1967). The Helsinki Rules clearly state that groundwater is, "connected to surface water" (Krishna and Salman, 1999, p. 170). Hayton explains that Article II "encompasses all waters included in the entire system" (Hayton 1982, p. 75). Although Article II declared a connection between surface and groundwater, as Krishna and Salman point out, "confined groundwater, that is groundwater which is not connected to surface water, is not dealt with under the Helsinki Rules" (Krishna and Salman, 1999, p. 170). Even though the importance of groundwater was recognized, the Helsinki Rules excluded confined aquifers—which constitute a large portion of groundwater—because a confined aquifer might exist between States, but not be connected to a particular body of surface water (a principal river, stream, lake, or other common

terminus). The International Law Association addressed this exclusion in the later Seoul Rules.

3.2 Seoul Rules

Twenty years later, the Seoul Rules (1987) were proposed at the Sixty-Second Conference of ILA, which was held in Seoul, Korea. The conference focused on complementing the Helsinki Rules. The Seoul Rules defined groundwater and aquifer by using the terms interchangeably. Also, some specific terms were defined, such as groundwater catchments area and fossil water.

In Article 1: The Waters of International Aquifers, an aquifer is described as

> "All underground water bearing strata capable of yielding water on a practicable, basis, whether these are in other instruments or contexts called by another name such as "groundwater reservoir," "groundwater catchment area," etc. including the waters in fissured or fractured rock formations and the structures containing deep, so called fossil waters" (Seoul Rules, 1986: Article 1).

Article II defined what constitutes an international aquifer, as well as the hydrologic interdependence of surface and ground water:

> "An aquifer that contributes waters to, or receives water from, surface waters of an international basin constitutes part of an international basin for the purpose of the Helsinki Rules. An aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of an international drainage basin constitutes an international drainage basin for the purposes of the Helsinki Rules" (Seoul Rules, 1986: Article 2).

Compared to the Helsinki Rules, the Seoul Rules clearly shows that even aquifers not connected with the surface waters of an international drainage basin, such as a confined aquifer between States, are also considered as in an international drainage basin. The implementation of the Helsinki Rules and the Seoul Rules is the fundamental recognition of the hydrologic relationship between surface and groundwater, and suggests that groundwater management requires an understanding of the mechanisms of the hydrologic cycle.

3.2 Bellagio Draft Treaty

The Bellagio Draft Treaty,[4] proposed by Robert Hayton and Albert Utton in 1989, was a revision of the "Ixtapa Draft,"[5] proposed in 1985 by Ann Berkley Rodgers and Albert Utton. The Ixtapa Draft focused on management of the U.S.-Mexico border region aquifers, while the Bellagio Draft Treaty worked to apply aquifer managements more globally. The idea of drafting the treaty was described in its introduction of the draft treaty:

> "The overriding goal of the draft treaty is to achieve joint, optimum utilization of the available waters, facilitated by procedures for avoidances or resolution of differences over shared groundwaters in the face of the ever increasing pressures on this priceless resources" (Hayton and Utton 1989, p. 665).

While the Bellagio Draft Treaty suggests a framework for comprehensive groundwater management, it has yet to be implemented for practical use in groundwater resources management. The treaty is divided into 20 sections, and each article is followed by a comment section. The treaty also articulates management methods in Article II: General Purpose[6].

Article I includes the definitions of terms, such as aquifer, border region, contaminant, contamination, depletion, drought, groundwater, impairment, interrelated surface water, pollution, recharge, transboundary aquifer, transboundary groundwater

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[4] Hayton and Utton, Transboundary Groundwaters: The Bellagio Draft Treaty, 1989. The draft treaty also described the evolution of transboundary groundwater law in the introduction section.

[5] Rogers and Utton, The Ixtapa Draft Agreement Relating to the Use of Transboundary Groundwaters, 1985.

[6] Article II -1 " The parties recognize their common interest and responsibility in ensuring the reasonable and equitable development and management of groundwaters in border region for the well being of their peoples. 2 – Accordingly, the Parties have entered into this Agreement in order to attain the optimum utilization and conservation of transboundary groundwaters and to protect the underground environment. It is also the purpose of the Parties to develop and maintain reliable data and information concerning transboundary aquifers and their waters in order to use and protect these waters in a rational and informed manner."

conservation area, and transboundary groundwater. Defining these terms prevents the type of confusion caused by lack of accepted definitions. *Aquifer* is defined as, "a subsurface waterbearing geologic formation from which significant quantities of water may be extracted" and *groundwater* is "the water in aquifers" (Hayton and Utton, 1989, p. 678). Note that aquifer is actually defined as a geologic formation, rather than a water storage area under the ground. This definition of aquifer emphasizes its hydrological relation to surface waters. Similarly, the definition of *interrelated surface waters* emphasizes *hydrologic interdependencies* between surface and ground waters. The definition of *transboundary groundwaters* is similar to that adopted in Seoul in 1986.[7] The definition of the term, *conjunctive use*, as "the integrated development and management of surface and groundwater, as a total water supply system" (Hayton and Utton, 1989, p. 678) shows the firm relationship between surface and groundwater, and suggests the need for efficient management. Surface water was recognized as an influence on the quantity and quality of outflows and inflows of transboundary groundwater.

The significant points of the Bellagio Treaty are the clarification of the definition of *aquifer* and the recognition of the connection between groundwater and surface water, which is shown in the idea of creating transboundary groundwater conservation areas. Additionally, the management of aquifers should therefore be conducted with an awareness of the interconnected relationships between surface- and groundwaters.

3.3 Agenda 21

Agenda 21[8] was adopted in June 1992 by the United Nations Conference on Environment and Development (UNCED). It is a comprehensive action plan for

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[7] Seoul Rule in Article I; The waters of International Aquifers states, " The waters of an aquifer that is intersected by the boundary between two or more States are international groundwaters if such an aquifer with its waters forms an international basin or part thereof ".

[8] Rio de Janeiro, June 16, 1992UN Doc. A/Conf.151/26, Vol. III (1992)

environmental management. Chapter 18[9] under Section II: "Conservation and Management of Resources for Development", which deals with water, including groundwater issues. Groundwater is recognized in Agenda 21 as a freshwater source and is given parallel status with surface water. Both surface water and groundwater resources have to be managed interrelatedly, taking into consideration both water quantity and quality (Chapter 18.3). Additionally, this action plan recommends holistic freshwater management (Chapter 18.35). The plan indirectly infers that freshwater resource management should be considered along with the hydrologic cycle. Interestingly, this action plan also points out that the degradation of water quality has been underestimated because of the inaccessibility and physical uncertainties of aquifer systems (Chapter 18.37). It advocates that groundwater protection is a substantial element of water resource management.

Agenda 21 does not include specific provisions of groundwater management, except as a statement of bilateral or multilateral cooperation with the UN system and other world organizations, and the development of technical/institutional capacities. In particular, Agenda 21 neglects the transboundary aspects of freshwater resource management. McCaffrey points out that "it fails to include a *comprehensive* treatment of the international, or transboundary aspects of the protection and management of fresh water" (McCaffrey 1994, p. 158). Section 18.9 explains that integrated water resources management can apply on a "catchment basin or sub-basin" basis, and includes integration of "the land and water related aspects." The holistic concept reflects this statement; however, Section 18.10 limits this integrated approach:

> "In the case of transboundary water resources, there is a need for riparian states to formulate water resources strategies, prepare water resources action programs and

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For the full text of Agenda 21 see http://www.unep.org/Documents/Default.asp?DocumentID=52

[9] Chapter 18: Protection of the quality and supply of freshwater resources: application of integrated approaches to the development, management, and use of water resources. The basic summary of chapter 18 was described in McCaffrey.1994 .The Management of Water resources. In The Environmental after Rio: International law and economics/ edited by Luigi Campiglio et. al.

consider, where *appropriate*, the harmonization of these strategies and action program (18.10)".

The statement is based on the idea that integrated management requires the cooperation of riparian states for transboundary water resources; however, the limitations created by the 'where appropriate' clause does not significantly affect the management of water resource integration.

Overall, even though Agenda 21 does not completely address groundwater issues, it provides positive recommendations that such resources are significant as a part of freshwater bodies, and also for the future demands of water resources.

3.4 The Law of the Non-Navigational Use of International Watercourses

The International Law Commission (ILC) was established in 1947 as the legal arm of the UN general Assembly to promote the progressive development of international law and its codification (International Law Commission: Introduction 2002)[10]. The ILC has worked to develop the Law of the Non-Navigational Uses of International Watercourses since 1970. The commission proposed the Draft Articles on the Non-Navigational Uses of International Watercourses in 1994[11], and the United Nations General Assembly finally adopted the United Nations Convention on the Law of the Non-Navigational Use of International Watercourses in May of 1997.[12] Over all, both positive and negative arguments about water management are present in the convention (Beaumont 2000, Dellapenna 2001, McCaffrey 2001, Wolf 1999*a*). This section focuses on the discussion of groundwater issues.

The draft on the Law of the Non-Navigational Uses of International Watercourses (1994) consists of articles and commentaries. The commentaries provide the details in each

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[10] See International Law Commission http://www.un.org/law/ilc/introfra.htm

[11] For History, See full text at http://www.un.org/law/ilc/texts/nnavfra.htm (UN Document A/CN.4/L492 (1994)

[12] UN Document A/RES/51/229 of 8 July 1997

article. The Convention on the Law of the Non-Navigational Uses of International watercourses in 1997 used the same definition of watercourses as was used in the draft.

In particular, Article II: Use of Terms includes the terms; 'international watercourse', 'watercourse' and 'watercourse State'. A watercourse was defined as, "a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus" (Article II: UN 1994). The ILC rejected the 'drainage basin' approach of the Helsinki Rules. Rather, the ILC defined a watercourse as including only groundwater that flows into a 'common terminus', and "as being overly broad and replaced [drainage basin] with the term the 'watercourse'" (Lazerwitz, 1993). Even though the connection between surface waters and groundwaters, as well as the term 'groundwater' itself are clearly defined, the 'water courses' approach did not include 'confined aquifers' in the Convention. Water that does not flow into a common terminus is, by definition, excluded from the watercourse. The law failed to consider the mechanisms of the hydrologic cycle, in particular, the behavior of groundwater.

The ILC realized that there was a gap in the draft. As a result, in the same year that the draft was launched, the International Law Commission added the Resolution on Confined Transboundary Groundwater[13] as having "completed its consideration of ... The Law of Non-Navigational Uses of International Watercourses" (ILC 1994). The ILC recognized the following:

> "Confined groundwater, that is groundwater not related to an international watercourses, is also a natural resource of vital importance of sustaining life, health and the integrity of ecosystems" (ILC 1994).

This resolution demonstrates the necessity of continuing the effort to elaborate the rules for transboundary groundwater resources. The ILC also considered in the resolution that the rules regarding water management that were presented in the draft of the Law of Non-Navigational Uses of International Watercourses articles may be applicable to transboundary confined groundwater.

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[13] For the text of the Resolution see 2 Yearbook of the International Law Commission 1994 at

Non-Navigational Uses of International Watercourses articles may be applicable to transboundary confined groundwater.

3.5 Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes

A recent example that includes groundwater in the scope is the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes. This protocol was adopted on June 17, 1999, in London. The Convention on the Protection and Use of Transboundary Watercourses and International Lakes was adopted in1992. It did not address groundwater specifically. For example, the definition in the convention (Article 1) did not include groundwater, however, this Protocol includes the definition in the Article 2.

The objective of this protocol is to protect human health and well being (Article 1),[14] and it recognizes that water plays an essential role in doing so. The definitions of 'groundwater' and 'transboundary waters' use language similar to that of definitions in other agreements because this protocol emphasizes the relationship between water and human health.

In terms of groundwater, the scope includes groundwater as well as surface freshwater, estuaries, coastal waters, and other water bodies (Article 3). The article recommends extending the consideration of water resources management to the transboundary, as well as State levels in order to protect human health and well being. It also recommends the spatial coverage of water management, including the protection of water ecosystems.

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[14] Article 1: Objective "The objective of this protocol is to promote at all appropriate levels, nationally as well as in transboundary and international contexts, the protection of human health and well-being, both individual and collective, within a framework of sustainable development, through improving water management, including the protection of water ecosystems, and through preventing, controlling and reducing water-related disease" (Economic and Social Council. MP.WAT/2000/1/EUR/ICP/EHCO 020205/8Fin, 18 October 1999

In conjunction with this scope, Article 6: Targets and Target Dates, 5-(b) specifically mentions the management level of water resources: "transboundary, national and/or local contexts, preferably on the basis of catchment areas or groundwater aquifers" (Article 6). It implies that transboundary aquifers should be managed on an individual aquifer basis, although aquifer is not defined in the context. However, this statement is a significant recognition for transboundary groundwater management, since the transboundary element has been an obstacle to the management structure in groundwater.

This protocol suggests that to achieve the protection of human health and well being requires an integrated approach to the management of water resources, including groundwater.

3.6 Summary

The increasing importance of groundwater management has led to the evolutionary development of rules and resolutions over the last 36 years, from the Helsinki Rules to the Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes, adopted in 1999 (Table 1). The limited drainage basin approach has shifted to the international watercourse approach. Furthermore, recommendations for water resource management now are directed at both transboundary and State levels in order to protect human health and well being, and the environment.

Table 1. Summary of international law related to groundwater

Helsinki Rules (1966)

- Defines a body of underground water as part of an international drainage basin, except confined groundwater

Seoul Rules (1986)

- Defines *international drainage basin,* "An aquifer intersected by the boundary between two or more States that does not contribute water to, or receive water from, surface waters of an international drainage basin constitutes an international drainage basin for the purposes of the Helsinki Rules"

Bellagio Draft Treaty (1989)

- Hydrologic interdependence between surface water and groundwater
- Transboundary aquifer is a part of an *international basin*

Agenda 21 (1992) Chapter 18

- Suggests the comprehensive action plan for environmental management
- Recognizes groundwater as freshwater bodies, and gives parallel status to surface water
- Recommends holistic freshwater management
- Neglects transboundary aspect of freshwater resource management

The Draft of the Law of the Non-Navigational Use of International Watercourses (1994)

- Uses *International Watercourse* approach
- Does not include confined aquifer

Convention on the Law of the Non-Navigational Uses of International Watercourses

- Uses same definition of watercourses as in the draft (1994)

The Resolution of the Law of the Non-Navigational Use of International Watercourses (1994)

- Recognizes that confined aquifer, that is, groundwater not related to an international watercourse, is also substantial
- The Rules regarding water management that are presented in the draft of the Law may be applicable to transboundary confined aquifer

The Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1999)

- Recommends extending the levels of water resource management to transboundary, State's level in order to protect human health and well-being
- Recommends integrated water resources management, including groundwater

The implications of past rules and laws are essential for clarifying the issues surrounding transboundary groundwater resources, as well as the need to face future water scarcity. Although the significance of groundwater in terms of future demands on water resources has been recognized, scientists, lawmakers, and decision makers are still struggling with management questions. Difficulties arise because of uncertainty surrounding groundwater systems and the transboundary element makes it difficult to use definitive terms in environmental laws. Rules and laws have also recognized that groundwater is vital not only for humans, but also for environmental health. Hence, the implementation of transboundary groundwater resource management should include a wide range of spatial and long-term considerations.

The next section explores how groundwater resources were addressed in international freshwater treaties of the past.

4. Past Trends in Groundwater Management

4.1 Methodology

In order to examine past trends in groundwater management, approximately 400 treaties from the Transboundary Freshwater Dispute Database (TFDD) at the Department of Geosciences at Oregon State University (Wolf 1999*b,c*), UN Treaty Collection and other sources of literature (FAO 1986, Teclaff 1981,1985, Utton 1981, 1982) were reviewed. The treaty review combined TFDD with other treaties that specifically mentioned ground water issues in their text. When searching the treaty documents related to groundwater issues, other keywords such as aquifer, groundwater, spring, subsoil, subsurface underground and wells were used. However, references to riverbed, riverbank, or activities at both bed and bank that might indirectly influence the groundwater regime were not considered treaties related to groundwater provisions for this analysis.

For the analysis, treaties were categorized into three levels according to the degree of groundwater resource management (Table 2). Level 1 status was given if the treaty indirectly mentioned groundwater according to the keywords, but did not deal directly with

Table 2. Description of the degree of groundwater resource management.

Level	Description
Level 1	Indirectly mentioned groundwater; no specific provisions of management
Level 2	Briefly mentioned groundwater provisions of management; water rights of groundwater are assigned to a State; clarified the physical relationship of groundwater with surface water.
Level 3	Deals with groundwater regulations specifically, including allocation, quality provisions, and/or protection of land

groundwater, and simply mentioned it in the text. Level 2 status was given if the treaty briefly mentioned groundwater, but there were no specific provisions, implementations, or clarifications of the physical relationships between surface water and groundwater. Although rights for ground, spring, and aquifer waters were assigned to a given State, the specificity of allocation is absent in this level. Level 3 status was given if a treaty specifically dealt with provisions, water allocation, or implementations of groundwater quality.

Treaties that mentioned groundwater were also classified according to subcategories within the primary categories mentioned above: 1) water quality, including pollution; 2) water quantity, which included reference to the allocations of groundwater; 3) territory/ boundary concerns; 4) physical relationship with surface water; 5) water right; 6) water quality and quantity; and 7) others.

A series of preliminary analyses were conducted that

- Consider the spatial and temporal distribution of treaties
- Identify the issues of concern
- Discuss the degree of specificity in how groundwater was addressed and whether physical surface-groundwater relationships were detailed.

4.2. Findings and Discussions

In total, there are approximately 400 treaties related to transboundary freshwater, of which 109 treaties mention groundwater. Only 62 treaties were actually reviewed. The review was limited by a lack of access to the actual texts or to English translations.

In terms of spatial distribution, the majority of groundwater treaties are from Europe, 35 treaties, followed by Africa, 13 treaties, Asia, 10 treaties, and then North America, 4 treaties (Figure 2). None of them are found in the South America region. The regions that have prominent surface water degradation and historical scarcity, such as the Danube, Rhine, the Aral Sea, major river basins in Africa and the Middle East, include some degree of groundwater provisions in the treaties. Seventeen treaties are multilateral, and 47 are bi-lateral agreements. Thirteen of the 17 multilateral treaties are post 1970s, and aim for water agreement in the transboundary context. This trend reflects increasing concerns about global environmental problems.

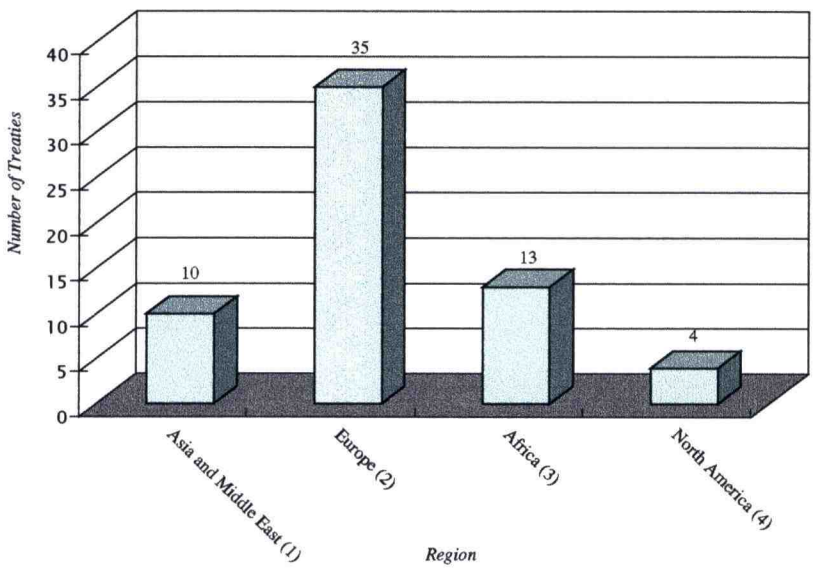

Figure 2. Spatial distribution of treaties.

The oldest of the international water treaties is the Treaty of limits between Portugal and Spain (1864) (Figure 3). It states that both countries share water from springs, if springs are located on their boundary. The most recent is the Revised Protocol on Shared Watercourses in the Southern African Development Community in 2000. The protocol states that groundwater is considered in a watercourse system. It is a broad statement of principles specific to a region, but not to a particular water system.

The number of treaties that address groundwater does not increase over time. However, there are some interesting trends: Previous to and right after World War II, treaties that mention groundwater deal with it as a frontier or border issue. Additionally, they do not use the term 'groundwater' directly; instead, they use 'spring' and 'well'. For example, in a treaty between Germany and Poland for the settlement of frontier questions (1/27/1926), a spring is a landmark between the countries. The treaty states that "Polish nationals having a right of used should be allowed to cross the territory near the spring south of Proschau which has been assigned to Germany."

The term 'spring' is first used in 1864 in the treaty of limits between Portugal and Spain, which is also mentioned as the oldest treaty. The term 'well' was used in 1888, is in the Agreement between the Government of Great Britain and France, with in regard to the Somali Coast. The term 'well' was used for the landmark for territory demarcation and sharing water. The terms 'aquifer' and 'groundwater' were used after 1950, except in one agreement: Convention regarding the Water Supply of Aden between Great Britain and The Sultan of Abdali (4/11/1910). This trend shows the evolution of the increasing recognition of the importance of groundwater, from a landmark to a resource, as provisions regarding groundwater are specified in international treaties concerning water resource management.

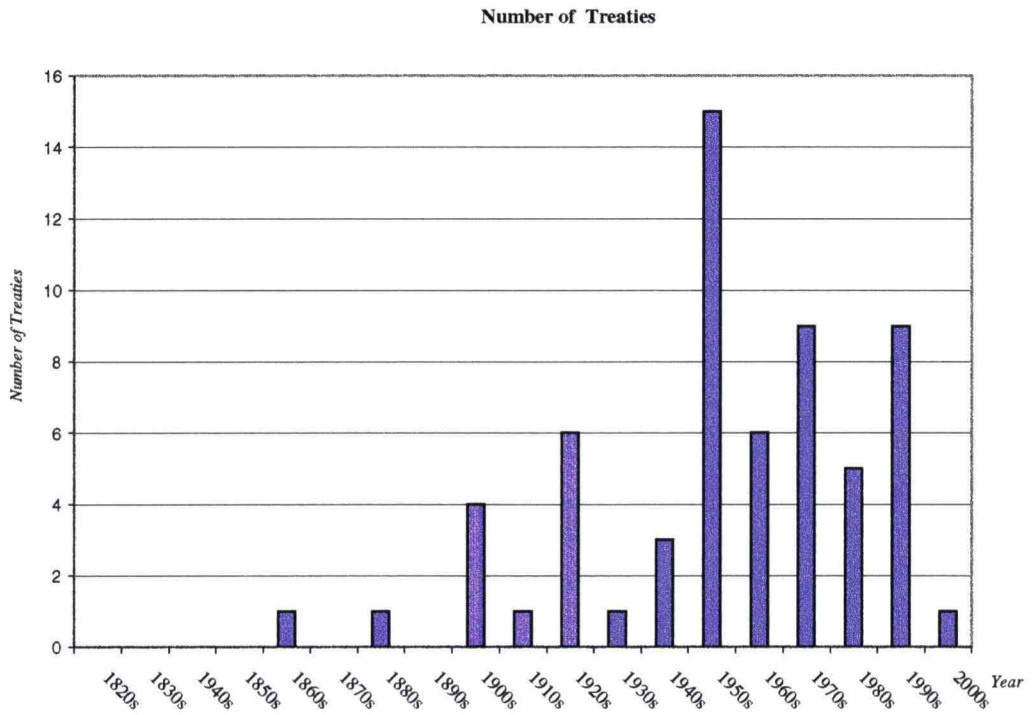

Figure 3. International freshwater agreements by decade.

In the category analysis (Figure 4), 62[15] out of 109 treaties have been categorized so far. Of 62 treaties, only 6 treaties were found to deal with groundwater quality. For example, the protocol amending the 1978 agreement between the United States of America and Canada on Great Lakes water quality in 1987 states that in order to maintain or improve the quality of Great Lakes water, concern should be directed toward the control of groundwater contaminants. This agreement clearly recognizes the physical relationship between surface water and groundwater. Furthermore, only 8 treaties mention quantities. Despite concerns over groundwater quality and quantity, the total number of treaties that mention both quality and quantity is only 14 treaties. In contrast, 17 treaties are mentioned as a border and frontier issue and the physical relationships between surface and groundwater is mentioned in 17 treaties.

[15] Full text is not available for all treaties. Category analysis conducted only on those treaties where the full text is available.

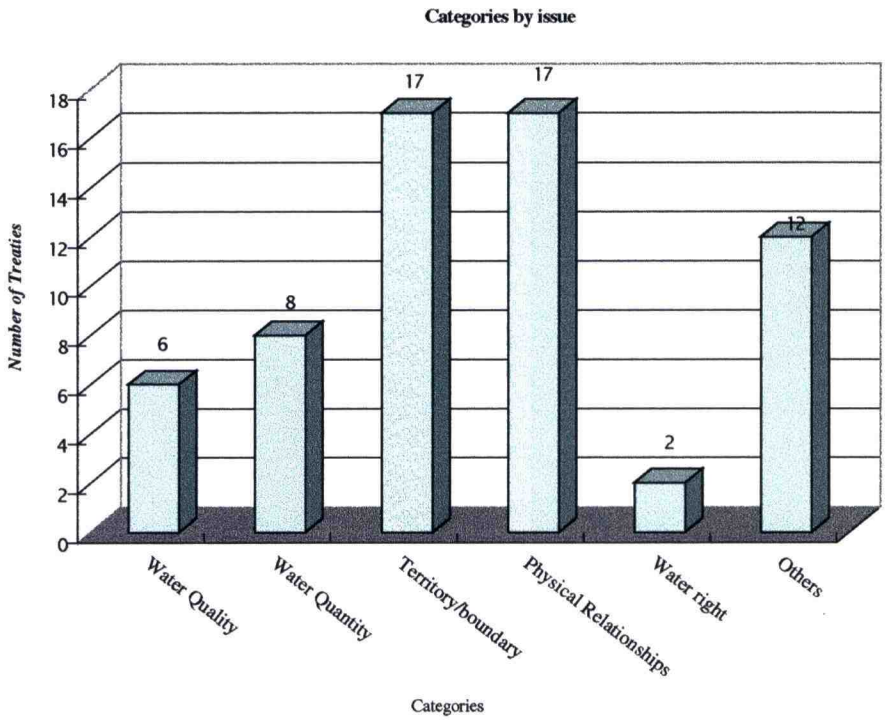

Figure 4. Categories by issue.

Seventeen treaties in this category of physical relationship between ground and surface water indicate that groundwater protection is included as a secondary reason for the protection of surface water. However, although the agreements may emphasize the relationships between surface and ground waters, they avoid specific terms that offer direct protections for groundwater.

Out of the 62 treaties reviewed, nine treaties are categorized as Level 3 (Appendix 1 (a)), which has specific groundwater management provisions or allocation issues. These nine treaties can be further divided into groups depending on (1) extraction limits from springs or aquifers; (2) water allocations; and (3) the inclusion of management principles.

Limitations on extractions from springs or aquifers are mentioned in five agreements. For example, the Mexico-U.S. Agreement on the Permanent and Definitive Solution to the

Salinity of the Colorado River Basin (Minute 242) gives limitations on groundwater pumping within the region. The Convention on Environmental Impact Assessment in a Transboundary Context, Espoo (9/10/1997) states that, generally, the extraction of a certain amount of water affects the surrounding environment. The Israeli-Palestinian interim agreement on the West Bank and the Gaza Strip (1995) Article 40, which concerns water and sewage issues, makes broad water management statements. This agreement requires the allocation of groundwater from an aquifer to be shared between the two countries. It includes the specific pump rates from the Eastern, Northeastern, and Western Aquifers, the establishment of a joint water committee, and regulation of committee's roles. The agreement relating to the protection, utilization, and recharging of the Franco-Swiss Geneva Aquifer also specifies limits to the amount of water that may be withdrawn from the aquifer. The treaty between the State of Israel and the Hashemite Kingdom of Jordan (1994) in Article IV: Groundwater in Emek Ha' arava / Wadi Arava, states that the extraction rate from wells can be up to 10 MCM/year, and that this decision will be made by the Joint Water Committee. An interesting observation concerning this treaty is that the treaty primarily aims for peace between States. Water issues may potentially provoke conflict among peoples in the region; consequently, the utilization and rights of groundwater are clearly defined in order to avert conflicts.

One treaty specifically mentions water allocation—the treaty concerning State frontiers and neighborly relations between Iran and Iraq and the protocol (6/13/1975) notes that that the sharing of waters from springs is to be conducted on an hourly basis between two States.

Four agreements mention management principles. The Convention on Cooperation for the Protection and Sustainable Use of the River Danube (6/29/1994) stipulates "groundwater resources subject to a long-term protection as well as protection zones valuable for existing or future drinking water supply purposes" (Article 6). This treaty explicitly mentions the designated use of groundwater. Furthermore, in order to protect the resource, the treaty not only requires long-term management of groundwater, but also

provides for the protection of the land surface, which plays a role in the filtration of water from the atmosphere. This treaty shows that groundwater regulations should consider the hydrologic cycle, both temporally and spatially. The 1910 convention regarding the water supply of Aden (Yemen) between Great Britain and the Sultan of Abdali states that water supply construction by the British should not affect the quantity or quality of water from wells across the border in the territory of the Sultan of Abdali. This agreement is an example of a situation where one State agrees not to cause harm to another. The idea of not causing harm can be seen in one of the principles of international environmental law. Additionally, the Johnston negotiations (12/31/1955), although unratified as a treaty, does attempt to function as an agreement between politics and water resource management among the States of Syria, Israel, Jordan, and Lebanon. A provision of the agreement includes the diversion of waters from saline springs in order to prevent increasing the salinity of Lake Tiberias. However, this provision focuses on the surface water, rather than the groundwater. The Convention on the Geneva Aquifer (1977) is the most elaborate, in terms of particularities of groundwater management. The scope of this agreement begins to explore the joint management scheme for the Geneva Aquifer.

Thirty-three agreements in Level 2 (Appendix 1 (b)) briefly mention groundwater indirectly, as some extension of surface water (which represents 17 treaties of this level). Seven treaties of agreements in this level are related to territory/boundary issues. Interestingly, the agreements often concern pollution, with reference to the water quality of surface water. In order to protect the surface water, groundwater has to be protected, but groundwater is not the primary issue in these agreements. For example, the convention creating the Niger Basin Authority and Protocol (1980) states the need for "the initiating and monitoring of an orderly and rational regional policy for the utilization of the surface and underground waters in the Basin" (Article 4). This agreement notes that surface and underground waters should be rational and cooperatively managed. However, this statement is limited in that it is concerned only with the groundwater in the Niger Basin, since the agreement defines only certain tributaries.

There are 19 treaties in Category 1 (Appendix 1 (c)) that include at least one key word concerning groundwater, such as *aquifer, groundwater, spring, subsoil, subsurface, underground,* or *wells.* In this category, the frontier demarcation-related issues are prominent. They comprise 9 treaties of this level: for example, "Borderline also applies in the subsoil" (Agreement between Poland and the German Democratic Republic 7/6/1950). This statement expresses the State's sovereignty over the subsoil; however, it does not specifically mention resources such as groundwater. Sovereignty could apply to mineral rights as well as to hydrological aspects. The statement also applies to the physical relationship between groundwater and surface water, and indirectly implies that groundwater should be protected.

The agreement between the Federal Republic of Nigeria and the Republic of Niger (7/17/1986)[16] defines groundwater under some limited conditions[17]:

> "Groundwater resources shall not be accounted for the purpose of equitable sharing determination unless: (a) such resources are part of shared river basins within the meaning of Article 1, paragraph (3)18; or (b) such resources lie in whole or only in part within the shared river basins and are bi-sected by the common frontier between the Contracting Parties" (Article 9).[18]

From the perspective of quantity concern, only groundwater that contributes to river basins is discussed in this treaty.

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[16] Agreement between the Federal Republic of Nigeria and the Republic of Niger Concerning the Equitable Sharing in the Development, Conservation and Use of Their Common Water Resources.

[17] Article 1, 2 . "The shared river basins to which this Agreement applies are: a. the Maggia/Lamido River Basin; b the Gada/Goulbi of Maradi River Basin; c.the Tagwai/El Fadama River Basin; and d.the lower section of the Komadougou-Yobe River Basin, and each River Basin shall be defined by reference to the Maps annexed to, and forming an integral part of, this Agreement."

[18] Article 1 Paragraph (3) "Subject to the provisions of Article 9, a reference to the shared river basins shall include a reference to underground waters contributing to the flow of surface waters."

Overall, this study quantitatively shows that the treaties of the past do deal with groundwater. However, groundwater is usually treated as a secondary issue of surface water. Thirty-four of agreements are in the categories of territory/boundary issues or physical relationships between surface and groundwater. Nine agreements out of 62 have specific provisions for groundwater management.

If the best way to manage the groundwater resource is on an aquifer-by-aquifer basis, specific agreements for groundwater should become more widespread. However, at present, the provisions for groundwater have been left behind in the management of surface water, for example, treaties address groundwater in only one sentence or one word, such as *groundwater*; *spring*, or *well*, or use ambiguous words in the text. Additionally, the locations of transboundary groundwaters have not been concretely identified, in contrast to transboundary surface waters. The first step of transboundary groundwater management might be to identify the location and properties of aquifers.

Recent treaties reflect the concept of basin-wide surface water resource management. Use of the basin-wide approach and the expansion of its scope to include groundwater have been gradually increasing. This trend has resulted from increasing environmental problems and, in particular, concerns over aquatic ecosystems and human health. These analyses demonstrate a growing awareness of the need to manage groundwater resources conjointly with surface water resources, since the hydrological relationship between groundwater and surface water cannot be separated. However, in order to develop concrete structure for the management of individual aquifers, institutional guidelines must first be elaborated. If, in so doing, the hydrologic cycle is ignored, transboundary groundwater management will not succeed in bringing about the sustainable development of groundwater.

5. Practice of International Groundwater Management

5.1. Dealing with Uncertainty of Transboundary Groundwater Resources

The uncertainty in science is not irreconcilable with the realities of politics. Making a compact of international environmental law usually takes a long time, and the delay in action may result in serious environmental degradations in the meantime. According to

Lawrence Susskind, "There will always be uncertainty hovering over global environmental treaty negotiations" (Susskind 1994). Without highly credible data, involved States may well be reluctant to sign an agreement because they have to take the risk of uncertainty; they may also put themselves at a disadvantage by doing so.

Without exception, there are enormous physical uncertainty involved in the study and management of groundwater: for instance, determining the flow of aquifers, quantities of water available, surface land area and time necessary for recharge, as well as the location of aquifers, including the boundary conditions. Additionally, there are administrative and political considerations as well, as the transboundary element of groundwater often creates ambiguities over States' sovereignty and responsibilities.

Transboundary groundwater resources in treaties referred to in the previous section show that there are not many treaties that address the specific details of groundwater properties. Uncertainty surrounding the physical properties of groundwater in fact represents the main hindrance to the establishment of rules concerning this resource. The absence of specific regulations currently results in fewer obligations for groundwater management; consequently, decision makers are likely to ignore the management of transboundary groundwater until it becomes a problem.

The next section will demonstrate a relevant framework for the negotiation process, as well as suggest a practical approach for addressing transboundary issues. However, this section of the paper will first discuss how uncertainty in science is handled in the international environmental negotiation arena, using the process of negotiation and elaborated practical framework of the Kyoto Protocol as an example. The Kyoto Protocol addresses the reduction of greenhouse emissions, which requires transboundary cooperation and regulations; therefore, the Kyoto Protocol provides a model for dealing with uncertainty regarding transboundary elements that can apply to groundwater management. Second, a relevant "precautionary principle" for addressing uncertainty of transboundary groundwater management will be discussed.

5.1.1 Uncertainty in Environmental Problems

Many issues dealing with high levels of uncertainty have been discussed in the international environmental policy arena. For instance, the agreement about ozone-layer depletion in the Montreal Protocol resulted from mitigating uncertainty in the negotiation processes. The most well-known example is the Kyoto Protocol, which was enacted in 1997. It was an effort to reduce greenhouse gases emissions with multi-country cooperation (186 countries signed up for ratification by December 2001). An inevitable, significant number of uncertainty were dealt with: how much greenhouse gas emissions impact climate change, the sources and sink of greenhouses gases, and so on. The main issue in the negotiations was identifying target CO_2 reduction levels; the resulting document included quantitative targets, called "Quantified Emission Limitation and Reduction Objectives (QELROs)" (Oberthür and Ott 1999, p. 115).

To address the uncertainty of CO_2 emissions, the Kyoto Protocol utilizes so-called "flexible mechanisms" and a "process-oriented" approach for procedures and institutions (Oberthür and Ott 1999:37). The flexible mechanisms and process-oriented approach allow negotiation to move forward with many countries' interests and incentives represented. The flexible mechanisms of the framework are as follows (Oberthür and Ott 1999, p. 117):

- Multi-year targets
- Banking (transfer of unused emissions into the next budget period) and borrowing (transfer from the next budget period) over several budget periods
- A comprehensive approach for six gases
- Emissions trading
- Joint implementation.

One example of a flexible mechanism is that the original proposal included target CO_2 reductions of 20% by the year 2005. In the final agreement, however, target reductions

were differentiated for Parties in the commitment period. Furthermore, reduction targets for six gases (CO_2, CH_4, N_2O, SF_6, and two fluorinated gasses) were based on the "basket approach." The basket approach involves an overall reduction strategy for the six gases together, rather than targeted restrictions for each gas individually.

The "process-oriented approach" (Oberthür and Ott 1999, p. 37) is a basic guideline of the flexible mechanism that addresses the uncertainty of science, rather than a separate idea. In 1992, the Framework Convention on Climate Change (FCCC)[19] was " a milestone because it established the institutional framework and some, although rudimentary, procedures that can be used by Parties to further elaborate provisions of the Convention" (37). Article 4.2 (d) of FCCC states, "... in the light of the best available scientific information and assessment on climate change and its impacts, as well as relevant technical, social and economic information" (Article 4.2 (d) FCCC). This article suggests that the process-oriented approach uses the *best available* scientific information and assessment, which allows decision makers some leeway to take action, rather than postponing decisions on the climate change problem.

In particular, the process-oriented approach affects the process of the most controversial issue: CO_2 sinks.[20] Some of the questions surrounding CO_2 sinks include how to measure CO_2 sinks for determining target reductions and how changing land use alters CO_2 sinks. Article 3-4 [21] specifically addresses these uncertainties. The article states that the

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[19] United Nations Framework Convention on Climate Change (1992). Legal basis of Kyoto Process adopted in 1992. http://unfccc.int/resource/docs/convkp/conveng.pdf

[20] To maintain the CO_2 level in system, the carbon cycle in nature have to be in equilibrium. However, human-induced additional carbon dioxide, such as fossil fuels, changes this cycle. A CO_2 sink can be defined as "a system that stores more carbon that it emits" (Oberthür and Ott 1999:131)

[21] Article 3-4 "Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice, data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human- induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land –use change and forestry categories shall be added to, or subtracted from, the assigned amounts for parties included in Annex I,

levels of carbon stocks in 1990 are to be used to determine estimates of CO_2 change in subsequent years, rather than carbon sinks. Carbon sinks provide uncertain scientific data and there is much opposition to their use in baseline calculations. Furthermore, sources created by additional human activities and sinks created by changing land use and forestry management would necessitate later adjustments in baseline calculations. Article 3.4 shows that the procedure for determining the target levels helps to form a consensus for addressing the reduction of CO_2.

The Kyoto Protocol succeeded in mitigating uncertainty in science through the flexible mechanism and process-oriented approach during negotiations. As a result, the involved parties were to cooperate in order to work toward remission of greenhouse gases. Susskind states, "Uncertainty, however, provided an incentive to negotiate" (Susskind 1994, p. 67). He claims that if there is no uncertainty, negotiation is not necessary; in other words, global environmental agreements always evolve through a sequence of negotiations that allow each party to acquire their own interests. Consequently, the flexible mechanism and process-oriented approach in the negotiation process enabled the parties to address the uncertainty of sciences. The flexible mechanism "assists to meet [parties] commitment" (The World Bank)[22]. The negotiation process of the Kyoto Protocol demonstrates that the existence of uncertainty is no excuse for failure to solve transboundary problems.

The idea of flexible mechanisms as applied to transboundary groundwater management between Israel and Palestine has been explored by Feitelson and Haddad (1997). They called it, "Sequential Institution Building Approach" (Feitelson and Haddad 1997). As a cooperative research project, The Palestine Consultancy Group, The Harry S

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taking into account uncertainty, transparency in reporting, verifiability, the methodological work of the Intergovernmental on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A party may choose to apply such a decision on these additional human- induced activities for its first commitment period, provided that these activities have taken place since 1990" (Kyoto Protocol to the United Nations Framework Convention on Climate Change).

[22] International Environmental Law: Concept and Issues
http:www4.worldbank.org/legal/legen/legen _iel.html

Truman Research Institute for the Advancement of Peace, and scholars from the Hebrew University of Jerusalem compiled a final report regarding the joint management of shared aquifers in 1995. They described four basic structures on which the joint management operation was built: Resource Protection, Crisis Management, Economically Based, and Comprehensive integrative structures (Feitelson and Haddad 1997) There are twenty-two activities contained under these four main structures. These activities, such as monitoring of water resources, are conducted in appropriately different stages. They note that the Joint Water Committee (JWC) allowed for considerable uncertainty in the process of joint management, particularly when decision makers are unsure of the most desirable action. This example may not work for aquifers under multiple jurisdictions; however, it does provide some insights for future transboundary groundwater management.

In summary, the flexible mechanism and process-oriented approach are useful for mitigating uncertainty surrounding transboundary groundwater management because (1) decision makers must be able to utilize the best available data and assessment tools on a given date; (2) the flexible mechanism can be used for the implementation of management plans: for example, a multi-targeted approach for improving monitoring schemes, establishing an institutional framework, and evaluating achievements; and (3) the process of negotiating agreements must be flexible in order to gain most parties' interests and cooperation. Both approaches are highly recommended for transboundary groundwater management.

5.1.2 Precautionary Principle for Transboundary Groundwater Management

As mentioned, there are not many treaties covering transboundary groundwater resources, compared with surface water. Most treaties mentioning groundwater are secondary issues to the primary issue of surface water provisions. To address the absence of agreements, the1977 United Nations Water Conference recommends, "In the absence of bilateral or multilateral agreements, Member States continue to apply generally accepted

principles of international law in the use, development and management of shared water resources" (Report of the United Nations Water Conference, Mar del Plata 1977). This statement suggests that the general principles are valid for the management of transboundary groundwater as well, and they can also lead to the development of specific regulations.

Scholars (Baberis 1991, Freestone 1999, Krishira and Salman 1991) have proposed general principles in relation to freshwater resources that have been widely used in environmental law: *the precautionary principle*; *the obligation not to cause appreciable harm*; *equitable and reasonable use*; *prior notice obligation and the duty to negotiate*; *polluter pays*; and *sustainable development*. In particular, the importance of equitable and reasonable use has often been argued in the area of water allocation concerns, since equity in water-sharing is a key issue of water conflict resolutions (Solanes1992, Wolf 1999*a*). However, other than equitable and reasonable use, there are not many principles found in the agreements comprising the Transboundary Freshwater Dispute Database (TFDD). The principles that apply to provisions governing quality, such as the obligation not to cause appreciable harm and polluter pays, are found far less than the equitable and reasonable use principle in the TFDD. This reflects Giordano' s analysis of quality provisions in agreements concerning surface water management in TFDD: "Treaties with water quality provisions remain a significant minority" (Giordano 2001). The application of principles likely depends upon the problems with which a particular agreement is primarily concerned.

Among these principles, the precautionary principle[23] should play a main role in enhancing the regulation of both quality and quantity of groundwater because the principle embraces the characteristics of how a decision maker deals with the uncertainty of the sciences. The principle from a policy perspective "... can be characterized as addressing the manner in which policy maker, for purposes of protecting the environment, apply science, technology and economics" (Freestone and Hey 1996, p. 12). The precautionary principle is

[23] There is still a debate about whether or not the precautionary principle is a principle of customary international law. This discussion is found in "The Status of the Precautionary Principle in International Law," by James Cameron and Juli Abouchar, 1996.

a code that policy makers are obliged to apply to the comprehensive approaches to protect the environment.

The precautionary principle originated in German environmental policy.[24] It was described by the German Federal Government in 1976 under the name of the *Vorsorgeprinzip* [25] (Cameron and Abouchar 1996, p. 31). *Vorsorgeprinzip* emerged on the international level, such as in the Declaration of the Second International North Sea Conference on the Protection of the North Sea (London Declaration). There are a number of different ways to define or describe the precautionary principle (Kiss 1996,p.27). The Rio Declaration is the most prominent recognition of the principle (Freestone and Hey 1996, p. 5). Principle 15 states:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". (Rio de Janeiro, June 14, 1992)[26]

As Principle 15 explains, the precautionary principle states that uncertainty is not a reason for not protecting natural resources. The precautionary principle means moving forward with decisions despite uncertainty. In the case of transboundary groundwater, the resource in many places has been degraded because uncertainty over physical properties caused delays in regulatory action. The application of the precautionary principle would positively affect action by regulation by reducing delays caused by uncertainty.

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[24] Further descriptions are found in "Origins and Development of the Precautionary Principle," by David Freestone and Ellen Hey, 1996.

[25] Vorsorgeprinzip is "Environmental policy is not fully accomplished by warding off imminent hazards and the elimination of damage which has occurred. Precautionary environmental policy requires furthermore that natural resources are protected and demands on them made with care."

[26] Rio de Janeiro, June 14 1992 31 *ILM* 874.

The precautionary principle has "become intrinsic to international environmental policy" (Freestone and Hey 1996, p. 3). In fact, the principle has already been invoked with respect to marine pollution, hazardous wastes, climate change, ozone depletion, biodiversity, fisheries management, and general environmental management (Gullett 1997, p. 55). Yet the application of the precautionary principle to situations involving transboundary groundwater resources is found in only two agreements (2 multilateral) in the TFDD; two agreements include an actual precautionary principle.

The previous examples suggest that policy makers should begin to apply the precautionary principle to prevent further degradation of transboundary groundwater; however, the concept of precaution itself has already been considered in the management of transboundary groundwater resources. Nolkaemper mentioned that "[most environmental treaties] include a principle embodying the objective of precaution" (Nollkaemper 1996, p. 79). The idea of precaution and the precautionary principle differ in that the precautionary principle is, according to Cameron and Aboutchar, a "*guiding* principle" (Cameron and Aboutchar 1996, p. 30). As a guiding principle, the precautionary principle can lead to more inclusive actions against environmental degradation. For example, the Bellagio Draft treaty (1966) includes the idea of precaution in regard to the degradation of both quantity and quality, although it does not precisely mentions the precautionary principle as a concept. The Bellagio Draft Treaty mentions the significance of the hydrologic cycle in a comprehensive approach to groundwater management that involves protecting both surface and underground water. To protect the hydrologic cycle, the Draft also extends protection to the surface area: "Transboundary Groundwater Conservation Areas" (Article 7) is delineated in order to conserve the quality and quantity of groundwater management concerns. This delineation is based on the idea of precaution. The term *conservation* remains a question of uncertainty, such as how influential is the conservation area of a transboundary groundwater resource and how much area must be conserved. Even though there is no specific evidence for the extent to which land use impacts the quantity of groundwater, the idea of precaution leads to protecting against possible degradation. The precautionary principle melds the idea

of precaution with comprehensive and specific approaches by science, technology, and economics.

In addition, I recommend the inclusion of the precautionary principle as a way of addressing future issues in the management and protection of groundwater. The reason can be explained by differences between prevention and precaution. According to Kiss, the difference is "in the evaluation of the risk threatening the environment" (Kiss 1996, p. 27). Kiss states that precaution will apply "when risk is high", while prevention implies that environmental degradation has occurred and that preventive action will be taken against further degradation. Because transboundary groundwater management is still in its infancy, there is a strong possibility that sooner or later water resources will face serious degradation. By taking into account the possibility of degradation under current situations, the concept of precaution has been integrated with various factors, the precautionary principle as a guiding principle provides the opportunity for acting positively with regard to future generations.

The precautionary principle must be implemented with some conditions in order to apply it to transboundary groundwater management. First, the definition should include the kinds of activities that may impact a specific object. Although uncertaintymay exist regarding potential impacts and in forecasting damages, policy makers should nevertheless mention them clearly in the definition. Second, the precautionary principle should treat the object inclusively. The precautionary principle in the context of water agreements has not been considered in relation to the quantity of groundwater. The influences of hazardous substances, water-related disease and/or transboundary impacts on the environment are discussed in the other water-related agreements, such as the Convention on the Protection and Use of Transboundary Watercourses and International Lake (1992) and The Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1999). These agreements only deal with water quality concerns, and still do not specifically address quantity provisions.

In summary, the precautionary principle is a notable principle for transboundary groundwater management for the following reasons: (1) The regulation of transboundary

groundwater resources has not yet been fully developed. Thus, regulation of both quality and quantity should have a risk-hedge element, which prevents the further degradation of groundwater. (2) The precautionary principle can be applied not only to quality provisions, but also to quantity provisions, which are influenced by negative conditions in land-surface activities. (3) The precautionary principle can enhance timely actions to prevent the degradation of transboundary groundwater. (4) For future generations, the precautionary principle supports sustainable development of natural resources. The precautionary principle will serve not only for the provision of uncertainty, but also for enhancing research on transboundary groundwater in order to bring more attention to this resource.

6. Future Implementations

The direction in which transboundary groundwater management should proceed is not easy to answer. It is difficult to delineate the optimal geographical unit for management of a resource, and, even if the unit can be determined, there is no guarantee of obtaining consensus from involved States. Furthermore, decision makers must respond to pressing population issues and a changing environment more quickly than in the past. Hence, it is all the more important for decision makers to act in a rational, multi-perspective manner regarding transboundary groundwater management.

As noted above, a framework for transboundary groundwater management has not yet been created. A concrete and explicit management framework is necessary for the sustainable management of this water resource. Such a management framework must be a balance of *regime*, *organization*, and *institution*. Each has a unique function within the framework, but all are dynamic, which maximizes their ability to evolve if necessary. Consequently, each has the potential to interact with the others to serve the common interest—better management of groundwater.

A *regime* would provide a structure for environmental protection drawn from various aspects, such as politics, economics, and socioeconomics. Furthermore, in the absence of

definite transboundary groundwater regulations, the regime can demonstrate awareness of the urgency of groundwater management. A *regime* is defined as, "sets of implicit or explicit principles, norms, rules and decision-making procedures around which actors' expectation converge in a given area of international relations" (Krasner1983, p 2). Yong (1989) gives another definition of regimes, as "social institutions governing the actions of those involved in specifiable activities or set of activities." The regimes act as voluntary constraints, using sets of principles, norms, rules, and decision-making procedures, but with no obligation to follow them.

Additionally, regimes do not stay permanently in the same form; they are continuously evolving in response to economic, socioeconomic, and political factors. In transboundary groundwater management, particularly, principles[27] function as guidelines. As noted in the previous section, principles, such as the precautionary principle, the obligation not to cause appreciable harm, equitable and reasonable use, prior notice obligation and the duty to negotiate, polluter pays, and sustainable development, are all regimes that have been used in international environmental law related to water resource management. These principles continuously serve the development of water resource management. With respect to transboundary groundwater, these regimes are necessary for groundwater management to grow out of its infancy and show definite progress.

Contrary to the clear definition of regime, *organizations* and *institutions* are used interchangeably in literature.[28] To use Mantzavinos' words, an *organization* consists of "corporate actors' groups of individuals bound by some rules designed to achieve a common objective (or to solve a common problem)" (Mantzavinos 2001, p. 83). North explains this concept more specifically. He defines *organizations* as "players of the game", while an *institution* is "the rules of the game in a society" (North 1990, p. 3). These rules differ

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[27] According to Krasner, the principles are "belief of fact, causation, and rectitude" (Krasner 1983).

[28] There are various definitions of both institutions and organizations. These discussions are found in, for example, Yong, Oran (1989). *International Cooperation*, North, D (1990). *Institutions, Institutional Change and Economic Performance.*

somewhat from the rules used in regimes, since these rules work for only a particular situation. In contrast, rules for regimes are overarching, comprising individual sets of rules for various issues. Another definition of institution, according to Aoki, is " [an] equilibrium phenomena"; however, this does not mean, "institutions are rigidly frozen" (Aoki 2001, p. 2). In addition, the institutional role primarily is "to reduce uncertainty by establishing a stable (but not necessarily efficient) structure to human interaction" (North 1990, p. 6). In this sense, organizations are freestanding clusters of groups in a broad area[29] to pursue a common objective. Institutions are purposefully created at some point, and they are established in a specific area. In this study, the term *institutions* applies to agreement between States. Institutions directly act on a specific situation and reduce uncertaintyuncertain. Thus, utilizing institutions for transboundary groundwater management is tremendously influential, since groundwater issues are likely to be localized. On the other hand, the term *organizations* applies to entities such as the United Nations, World Bank groups, regional investment banks, and NGOs (depending on the specificity of the NGO). As a facilitator, financial supporter, and technical advisor, an organization can enhance cooperation to attain sustainable transboundary groundwater management.

The institutional approach for transboundary surface water resource management has been established within a certain geographical setting in order to pursue equity, efficiency, and sustainability of water resources. A joint management structure is often part of an institutional arrangement. The joint management scheme often consists of a multi-faceted approach, focusing not only on the methods of the water resource management scheme, but also on the improvement of human resources by addressing issues such as human rights, health, education, and environment in the region. Establishing a similar management scheme might be beneficial for transboundary groundwater management, since we cannot separate social, environmental, political, socioeconomic, and economic issues from water management. In particular, cost sharing of monitoring is essential. In order to

[29] The term *area* can apply to both a geographical and an interdisciplinary field.

bridge the gap between surface and groundwater management, Feitelson and Haddad suggest, "One applicable lesson that can be gleaned from the extensive experiences regarding management of international surface water is that successful cross-boundary institutions[30] evolve over time, as experience and confidence builds up" (Feitelson and Haddad 1997). The institutional management scheme for transboundary surface water is likely to be effective, although there are some constraints for the institutional mechanism.

One of the institutional approaches that has been discussed for transboundary surface water management is "integrated water resource management" This basin-wide approach has been studied for transboundary surface water resource management (Chenoweth et al. 2001, Kliot et al. 2001). However, according to Tortajada, "there is no clear consensus among the water experts as to what issues are to be integrated" (Tortajada 2001, p.229). Integrated water resource management stipulates, "in managing the resource, both the physical and non-physical aspects are considered simultaneously, while taking a long-term perspective" (Savenije 2000). Integrated water resource management is a complex institutional form. Thus, many scholars have debated the specific conditions for applying the integrated water resources approach to surface water (Chenoweth et al. 2001, Kliot et al. 2001, Nakayama 1997, Tortajada 2001, Van der Zaag et al. 2000). Basically, this approach must facilitate consensus among all riparian countries and requires institutional stability to manage multiple issues. An institutional arrangement is rarely out of accord with the involved basin States; however riparian States that have been left out of existing agreements are naturally less receptive to integrated water management initiatives. This is the largest obstacle to this approach. For example, in the study of treaties related to surface water quality, Giordano (2002) found that "the absence of all-inclusive basin memberships is prominent for surface water" (Giordano 2002). For example, the Mekong Committee (MC) is one of the prominent transboundary joint management schemes, as a result of the agreement between the governments of Cambodia, Laos, Thailand, and Vietnam in 1975.

[30] It is assumed that this *institution* is used in the as same sense as organization, since the authors did not define this term.

This agreement was an initiative by the United Nations Economic Commission for Asia and Far East (ECAFE) (Nakayama 1997); however, the committee has been struggling to obtain all riparian countries' commitment. The specific conditions of integrated water resource management depend on political, economic, and socioeconomic factors, which are different in each basin. Therefore, it would be equally difficult to apply this approach to transboundary groundwater.

In considering the difficulties of integrated water resource management, what kinds of criteria and considerations should decision makers include for transboundary groundwater management? First, transboundary groundwater management has to be specific to each aquifer, with respect to local institutions, since each aquifer has unique physical characteristics, socioeconomic considerations, and political conditions. An institution must originate from a particular situation. In addition, transboundary groundwater management requires not only cooperation among involved States, but also extends to the three-dimensional management of surface- and groundwater interactions, as discussed in Section 2. If these hydrological relationships are present, then transboundary groundwater management must be coordinated with surface water management. Second, institutions must evolve over time, and they must have a flexible mechanism in order to accommodate the uncertainty of groundwater physical characteristics. Feitelson and Haddad state, "institutional flexibility and adaptability may be a requisite for the sustainability of management structure" (Feitelson and Haddad 1998). Third, institutional arrangements have to operate from both centralized and decentralized perspectives, but not from a hierarchical approach. In other words, these arrangements must avoid detachment from other institutions related to water resource. Institutional frameworks have to be well networked. Last, in order to assist institutions' stability, organizations must take the initiative to provide technical, financial, and advisory support in the development of institutions.

Taking into the consideration the above criteria, I recommended what I term the "Interactive Coordinated Approach (ICA)" for transboundary aquifer management if the

involved States cannot otherwise reach accord on a particular agreement. The idea of a coordinated approach for surface water management would surmount the issues of sovereignty contained within the integrated approach (Medzini and Wolf 2001, p. 113). The coordinated approach takes into account quality, quantity, and timing for water allocation at the point of intersection of boundaries. The rationale of the coordinated approach, first, is that each State can continue to pursue its own institutions of water resource management. In other words, a State is responsible for the efficiency of water usage within its own borders A riparian country would not need to intervene in other countries' management because this approach, by agreement, guarantees appropriate levels of quality, quantity, and timing for water allocation. Although setting these fundamental levels maybe be difficult for groundwater, the involved States would be commited to working within the framework. This approach is advantageous under circumstances where there is already a history of political interactions among the involved States. The largest obstacles to realizing this approach are how to reduce differences in water system infrastructures within each State and how to establish credibility among involved States.

Therefore, to some extent, the joint and coordinated management approaches must be juxtaposed. Since joint management means that activities are jointly organized within the involved States, the development of a joint management scheme should involve the sharing of technical and economic costs; however, joint management does not deal with political negotiations. Working with physical data monitoring and data analyses can help to reduce some of the difficulties involved in creating trusting political relationships.

The fundamental transparency of physical data is important when used in the scheme of the coordinated approach. Secondly, this approach gives an incentive for a State to negotiate to achieve its own interests. Additionally, States have an incentive to negotiate with others if climate changes or increasing demand for water forces a change in the terms of the institutions. Finally, the institutional approach can evolve over time, based on the cooperating States' relationships.

When applied to transboundary groundwater, the coordinated approach would primarily consider the physical characteristics of groundwater. Therefore, the term *interactive* modifies the concept of the coordinated approach. The concept of interaction relates to three aspects regarding the previous criteria for transboundary groundwater institutions. First, interaction refers to the hydrological cycle between surface and groundwater. Second, it applies to the level of coordination of institutional management frameworks, from local users to regional, national, and transnational levels. In order to reduce monitoring costs and physical data analysis, a joint management scheme is required. Since a given aquifer is indigenous to the local user, the framework has to be present at the local level. Compared with surface water, groundwater flows slowly through the belowground geologic structure; consequently, once groundwater is contaminated by chemical substances, the problem is likely to be localized. Therefore, management at the local level is necessary. After some time, the problem potentially expands to the geographic regional level. The inclusion of the regional level takes into account various aspects of water resources. At this level of management, the considerations should include the agricultural or development sectors for economical and sustainable water usage, waste/sewage water sectors, surface water management sectors, and public participation. At the national level, delegates should be sent from each region. The transnational level functions for political negotiation with other States.

Finally, interactions with external organizations—international organizations, such as such as the United Nations, World Bank group, the regional investment banks, and NGOs—are essential in the beginning for financial support and mediation between States. The interactions with external organizations may encourage the more rapid embodiment of an institutional approach. Furthermore, when conflicts or crises occur in relation to groundwater, these interactions can surely assist States to act positively.

The concept of the Interactive Coordinated Approach is still an abstraction, and the application of this approach may depend on the level of infrastructure capacity between States. If there is a huge discrepancy between infrastructure levels in an institutional

arrangement for water resource management between States, the initial approach may be to establish a joint management scheme for the purpose of physical data collections, either informally or formally, rather than the coordinated approach. The purpose for creating an Interactive Coordinated Approach is to enhance the understanding of fundamental principles of transboundary aquifer management. To establish this approach and to see its effects will take a long time; however, a long-term perspective for transboundary groundwater management is a necessity.

Institutional approaches with organizational assistance can mitigate tensions over water stress and reduce uncertainty in a society, since the framework of institutions and organizations evolves interactively (North 1990, p. 5). The disposition of institutional approaches conforms to society. Despite their rigidity, institutions have to adapt and be flexible to the current situations, since the issues surrounding water resources are varied and complex. Up until the present, States have been likely to cooperate over water (Wolf 1998); for the future, however, researchers Wolf, Yoffe, and Giordano (forthcoming) have proposed a question: "Why might the future look nothing like the past?" Since water sources have begun to shift from surface- to groundwater, the stability of water quality and quantity is in danger. Furthermore, the global environment is changing very quickly. Decision makers and scientists should respond swiftly and effectively since the world population is growing, and food production depends upon water availability. Population growth places additional stress on the environment and adds to soil degradation, contamination and scarcity of water, air pollution, and extreme natural disasters. Consequently, many people become environmental refugees, living their everyday lives under pressure.

Since the Cold War, scholars have been aware of a link between national security and environmental degradation. Mathews suggested the necessity of redefining national security in 1989. In her words, there is "the need for another analogous, broadening definition of national security to include resource, environmental and demographic issues" (Mathews 1989). Environmental security is a contentious idea, however, because the fundamental definition of the security concept itself has often been debated (Dalby 1992, Deudney 1991,

Lowi 1999, Ullman 1983). Many researchers make different assumptions about what security means and how it can be linked to the environment. Based on the various assumptions about the term *security*, a country's security issues should not be linked to environmental problems.

Even though in the past water scarcity and degradation have not been linked with national security issues, in the future, they may be connected. Wolf et al. (forthcoming) states, "The combination of changes, in water resources and in conflict, suggest that tomorrow' s disputes may look very different from today's." Although we cannot predict what will happen with water issues, we can definitely see that the problems of groundwater are becoming even more serious issues. The urgency of these problems is evident in the parts of the world that heavily depend on groundwater for their water supply. In particular, the most serious concern is the usage of fossil groundwater. Once the water is gone, it will not replenish itself. The increasing human population also spurs heavier groundwater usage. However, we also seem to have an increasing awareness of the importance of groundwater resource management—how to maintain and improve the quantity and quality of groundwater.

7. Conclusion

This inquiry has found that three components of international groundwater management—environmental law, past trends in groundwater management, and institutional framework—are changing in order to meet demands and to address issues of transboundary groundwater resource over time.

International law promotes the recognition of groundwater status at the global scale. Examining the past treaties concludes that groundwater management must be specific in order to be effective, since the hydrological relationships between surface and groundwater have to be taken into account for management. Thus, past practices for surface and groundwater managements have been often conjunctively operated. In order to address

uncertainties of physical characteristics of groundwater and transboundary elements, an institutional arrangement based on each aquifer basins or a basin-wide approach with surface water is adequate for transboundary groundwater management. In addition, the various level of institutional arrangements are required.

Water issues are a focal point in order to maintain environmental and human health. In consideration of the significant amount of groundwater in the world, groundwater resource management has become more critical for human and environmental communities. Nevertheless, this study shows that 62 of the more than 400 transboundary freshwater treaties reviewed mentioned groundwater. Of these, the majority used ambiguous language and did not mention specific frameworks for groundwater resource management, such as allocations, management principles, and surface and groundwater interactions. Only nine treaties addressed a specific groundwater resource provision. Despite the urgency of groundwater management concerns, the international law arena has not yet fully recognized the need. This analysis of treaties reveals the lack of concrete institutional arrangements for transboundary groundwater resource management.

Surface water regulation, as is, should not be adopted for groundwater resource management because, as yet, we do not know enough about groundwater. Increased knowledge of the physical interactions between the land surface area and below ground is especially desireable, since quality and quantity of groundwater are highly influenced by land use development on the surface. In order to mitigate uncertainty originating from groundwater's physical characteristics, the precautionary principle may be used as a tool for building awareness and enhancing actions for transboundary groundwater management.

In addition, better-defined transboundary groundwater regulations are needed. The Interactive Coordinated Approach might be one suggestion for transboundary groundwater management. The effectiveness of the institutional approach for transboundary groundwater should also be recognized. In particular, institutional arrangements with organizational assistance should be substantial in this beginning stage of transboundary groundwater management. The conditions for institutional approaches must take into account

consideration of political, economic, socioeconomic, and environmental factors for each aquifer. The customized institutional approach consists of all levels, from local users to transnational entities.

Transboundary groundwater management urgently requires guidelines to enhance awareness of this finite resource. Unfortunately, most transboundary aquifers fall into a transitional stage; only a few transboundary aquifers have been studied intensively, such as the Mountain Aquifer between Palestine and Israel, and the Nubian Sandstone Aquifer, Guaraní Aquifer, and others being examined by UNESCO (United Nations Educational, Scientific and Cultural Organization), IAH (International Hydrological Programme), FAO (Food and Agriculture Organization of the United States), and UNECE (United Nations Economic Commission for Europe). Although these studies are still in progress, they will help to establish institutional stability. Finally, the subject of transboundary aquifer management should be widely discussed. This discussion should lead to the establishment of concrete frameworks and long-term commitments for the protection of groundwater, not only in order to address the degradation of this resource, but also to plan for the high demand for water in the future.

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Appendices

Appendix 1 (A) : Level 3

Treaty name	Category2	Date	# of Parties	Countries	GW Reference
Treaty of peace between the state of Israel and the Hashemite Kingdom of Jordan, done at Arava/Araba crossing point	Quantity (quality)	10/26/1994	Bilateral	Israel, Jordan	Article IV
Johnston Negotiations	Quality	12/31/1955	Multilateral	Israel, Jordan, Syria, Lebanon	3. Division of Water
Convention regarding the Water Supply of Aden between Great Britain and the Sultan of Abdali	Quantity	4/11/1910	Bilateral	Great Britain, Aden (Yemen)	Entire agreement
Treaty concerning the state frontier and neighbourly relations between Iran and Iraq and protocol	Quantity	6/13/1975	Bilateral	Iran, Iraq	Article 4
Convention on cooperation for the protection and sustainable use of the River Danube	Quality	6/29/1994	Multilateral	Austria, Bulgaria, Croatia, Germany, Hungary, Republic of Moldova, Romania, Slovakia, Ukraine, European Economic Community	Article 2 (1)
Mexico-US agreement on the permanent and definitive solution to the salinity of the Colorado River Basin (International Boundary and Water Commission Minute No. 242)	Quantity	8/30/1973	Bilateral	Mexico, United States	Article 5

The Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip: Protocol Concerning Civil Affairs	Quantity	9/28/1995	Bilateral	Israel, Palestine Autonomy	Annex III Article 40. Schedule 8,10
Convention on environmental impact assessment in a transboundary context, Espoo	Quantity	9/10/1997	Multilateral	Albania, Austria, Byelarus, Belgium, Bulgaria, Canada, Croatia, Czechoslovakia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Moldova (Republic of), Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States	Appendix I
Convention on the protection, utilization and recharging of the Geneva Aquifer between Canton of Geneva in Switzerland and the department of Haute-Savoie in France	Quantity (quality)	9/6/1977	Bilateral	Swiss, France	Chapter 1-Article 1, Ch 4, Article 9

Appendix 1 (B) : Level 2

Treaty name	Category2	Date	# of Parties	Countries	GW Reference
Agreement between Persia and Turkey concerning the fixing of the frontier line	Territory/ boundary	1/23/1932	Bilateral	Persia, Turkey	Exchange of Notes
Joint declaration of principles for utilization of the waters of the lower Mekong basin, signed by the representatives of the Governments of Cambodia, Laos, Thailand, and Vietnam to the committee for coordination of investigations of the lower Mekong basin	Quantity	1/31/2975	Multilateral	Cambodia, Laos, Thailand, Vietnam	Article XXIII
Statute of the Committee for Co-Ordination of Investigations of the Lower Mekong Basin Established by the Governments of Cambodia, Laos, Thailand, and the Republic of Viet-Nam in Response to the Decision Taken by the United Nations Economic Commission for Asia and the Far East	Quantity	10/31/1957	Multilateral	Kampuchea, Laos, Thailand, Vietnam	Article XXIII
Draft agreement on water quality management of Zapadnaya Dvina/Daugava River basin	Physical relationships	11/12/1997	Multilateral	Byelarus, Latvia, Russian Federation	Introduction
Treaty Between the United States of America and Mexico Relating to the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande	Others	11/14/1944	Bilateral	United States, Mexico	Article 4

Protocol Amending the 1978 Agreement Between the United States of American and Canada on Great Lakes Water Quality, as Amended on16.10.1983	Physical relationships	11/18/1987	Bilateral	Canada, United States	Annex 16
Convention creating the Niger Basin Authority & Protocol	Others	11/21/1980	Multilateral	Benin, Cameroon, Chad, Côte D'Ivoire, Guinea, Mali, Niger, Nigeria, Upper Volta	Article 4 (d)
Agreement between The Federal Republic of Germany and the EEC, on the one hand, and , the Republic of Austria, on the other, on cooperation and management of water resources in the Danube Basin	Quality	12/1/1987	Multilateral	Germany (GFR), Austria, EEC	Article2
Provisions relating to the Belgian-German frontier established by a six-nation delimitation commission in execution of the Versailles Treaty	Physical relationships	11/6/1922	Bilateral	Belgium, German	Subsection 1 and 3
Arrangement between Germany and Belgium concerning the common frontier	Territory/boundary	11/7/1929	Bilateral	Belgium, German	Article 65
Agreement Between Finland and Sweden Concerning Frontier Waters	Physical relationships	12/15/1971	Bilateral	Finland, Sweden	Article 2
Convention on the Protection of the Rhine against chemical pollution	Physical relationships	12/3/1976	Multilateral	Germany (GFR), France, Luxembourg, Netherlands, Switzerland, European Economic Community	Article 7-2
France-Federal Republic of Germany-Luxembourg-Netherlands-Switzerland: Convention on the protection of the Rhine against pollution by Chlorides	Physical relationships	12/3/1976	Multilateral	Germany, Luxembourg, Netherlands, Switzerland	Article 7

Treaty of Peace with Italy, Signed at Paris, on 10 February 1947	Territory/ boundary	2/10/1947	Multilateral	Italy, France (primarily), and the Allied Powers	Annex 5
Agreement between the governments of Great Britain and France with regard to the Somali Coast	Territory/ boundary	2/2/1888	Bilateral	UK, France	Article 1
Exchanges of notes between the United Kingdom and France constituting an agreement relating to the Boundary between the Gold Coast and the French Sudan	Territory/ boundary	3/18/1904	Bilateral	UK, France	Aticle III
Agreement on joint activities in addressing the Aral Sea and the zone around the Sea crisis, improving the environment, and enduring the social and economic development of the Aral Sea region	Quality	3/26/1993	Multilateral	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan	Article 1
Convention between Switzerland and Italy concerning the protection of Italo-Swiss Waters against pollution	Quality	4/20/1972	Bilateral	Switzerland, Italy	Article 1
State Treaty between the Grand Duchy of Luxembourg and the land Rhineland-Palatinate in the Federal Republic of Geramny concerning the construction of a hydro-electric power-plant on Sauer at Rosport/Ralingen	Physical relationships	4/25/1950	Bilateral	Luxembourg, Germany (GFR)	Article 6,10
Agreement concerning water-economy questions between the government of the Federal People's Republic of Yugoslavia and the Government of the People's Republic of Bulgaria	Others	4/4/1958	Bilateral	Yugoslavia, Bulgaria	Article1

Convention and Statutes relating to the development of the Chad Basin	Others	5/22/1964	Multilateral	Cameroon, Chad, Niger, Nigeria	Article 4
Agreement between the Republic of Syria and the Hashemite Kingdom of Jordan concerning the utilization of the Yarmuk waters.	Water right	6/4/1953	Bilateral	Jordan, Syria	Article 8
State treaty between the Grand Duchy of Luxembourg and the Land Rhineland-Palatinate in the Federal Republic of Germany concerning the construction of hydroelectric power-installations on the Our (with annexes)	Physical relationships	7/10/1958	Bilateral	Luxembourg, Germany(FRG)	Annex II
Agreement between the Government of the Polish People's Republic and the Government of the Union of Soviet Socialist Republics concerning the use of water resources in frontier waters	Territory/ boundary	7/17/1964	Bilateral	USSR, Poland	Article 2(3)
Exchange of notes between France and Great Britain relative to the boundary between the Gold Coast and French Sudan	Territory/boundary	7/19/1906	Bilateral	Great Britain, France	Article 41 (3)
Process-Verbal from the meeting of Yugoslav and Greek delegations at Stari Dojran, to determine the manner and plan of collaboration concerning hydroeconomic studies of the drainage basin of Lake Dojran	Physical relationships	9/1/1957	Bilateral	Yugoslav, Greek	Section A ii(d), Section B (d)

Agreement between the Government of the Fededal People's Republic of Yugoslavia and the Government of the Hungarian People's Republic Together with the Statute of the Yugoslav-Hungarian Water Economy Commission	Others	8/8/1955	Bilateral	Hungary, Yugoslavia	Article 1
African Convention on the conservation of nature and natural resources	Others	9/15/1968	Multilateral	Algeria, Cameroon, Central African Republic, Congo, Cote D'Ivoire, Djibouti, Egypt, Ghana, Kenya Liberia, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sudan, Swaziland, Togo, Tunisia, Uganda, Tanzania, Zaire	Article V water
Franco-Italian convention concerning the supply of water to the Commune of Menton	Physical relationships	9/28/1967	Bilateral	France, Italy	Article I
Convention between the French Republic and the Federal Republic of Germany concerning development of the Rhine between Strasbourg/Kehl and Lauterbourg/Neuburgweier	Physical relationships	7/4/1969	Bilateral	France, Germany	Article 2
Exchange of Notes between the United Kingdom and Italy respecting the regulation of the utilisation of the waters of the river Gash	Physical relationships	6/15/1925	Bilateral	United Kingdom, Italy	Question 4.5

UN/ECE protocol on water and health to the 1992 convention on the protection and use of transboundary watercourses and international lakes	Others	6/17/1999	Multilateral	Albania, Armenia, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom	Article 2,3,5,6-5(b)
Statute of the River Uruguay	Physical relationships	2/26/1975	Bilateral	Argentina, Uruguay	Chapter IX

Appendix 1 (C) : Level 1

Treaty name	Category2	Date	# of Parties	Countries	GW Reference
Treaty between Germany and Poland for the Settlement of Frontier Questions	Territory/ boundary	1/27/1926	Bilateral	Germany, Poland	9.23.6.1922
Agreement between the USSR and Afghanistan	Territory/ boundary	1/18/1958	Bilateral	USSR, Afghanistan	Article 1
Agreement between France and Great Britain relative to the Frontier between French and British possessions from the Gulf of Guinea to the Niger	Water right	10/19/1906	Bilateral	Great Britain, France	Annex III
Convention between the French Republic and the Federal Republic of Germany on the development of the upper course of the Rhine between Basel and Strasbourg	Physical relationships	10/27/1956	Bilateral	France, Germany	Article 4
Convention between the government of the French Republic and the Swiss Federal Council Concerning protection of the waters of Lake Geneva against pollution	Physical relationships	11/16/1962	Bilateral	France, Switzerland	Article 1
Areement between the USSR and Czechoslobakia	Territory/ boundary	11/30/1956	Bilateral	USSR, Czechoslovakia	Article 1, Paragraph 2
Austria-Czechoslovakia treaty regarding the settlement of frontier legal questions	Territory/ boundary	12/13/1928	Bilateral	Austria, Czechoslovakia	Article 4

Agreement between the Government of the Federal People's Republic of Yugoslavia and the Government of the People's Republic of Albania concerning water economy questions, together with the statue of the Yugoslav-Albanian Water economic commission and with the protocol concerning fishing in frontier lakes and rivers	Others	12/5/1956	Bilateral	Albania, Yugoslavia	Article1
Agreement between Egypt and Italy concerning the establishment of frontiers between Cyrenaica and Egypt	Territory/ boundary	12/6/1925	Bilateral	Egypt, Italy	Article 5, 6
Exchange of notes constituting an agreement between the United Kingdom of Great Britain and Northern Ireland and Egypt regarding the utilisation of profits from the 1940 British government cotton buying commission and the 1941 joint Anglo-Egyptian cotton buying commission to finance schemes for village water supplies	Physical relationships	12/7/1946	Bilateral	Great Britain, Egypt	Enclosure

Convention on the protection and use of transboundary watercourses and international lakes, Helsinki	Quality	3/18/1992	Multilateral	Albania, Austria, Belgium, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Spain, Sweden, Switzerland, United Kingdom	Article 1,Annex III (d)
Agreement between the Government of the Czechoslovak Republic and the Government of the Polish People's Republic concerning the use of water resources in frontier waters	Territory/ boundary	3/21/1958	Bilateral	Czechoslovakia, Poland	Article 2
Treaty between France and Switzerland , regulating fishing in Lake Geneva	Others	3/9/1904	Bilateral	France, Switzerland	Article 6
Treaty between the government of the Union of Soviet Socialist Republics and the imperial government of Iran concerning the Regime of the Soviet- Iranian Frontier and the procedure for the settlement of frontier disputes and incidents	Territory/ boundary	5/14/1957	Bilateral	USSR, Iran	Article 1
Agreement Between The Federal Republic Of Nigeria And The Republic Of Niger Concerning The Equitable Sharing In The Development, Conservation And Use Of Their	Physical relationships	7/17/1986	Bilateral	Niger, Nigeria	Article 9

Common Water Resources					
Agreement between Poland and the German Democratic Republic	Territory/ boundary	7/6/1950	Bilateral	Poland, German Democratic Republic	Article 2
Protocol on Shared Watercourse systems in the Southern African Development community (SADC) region	Others	8/28/1995	Multilateral	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe	Article 1
Revised Protocol on Shared Water Courses in the Southern African Development Community	Others	8/7/2000	Multilateral	Angola, Botswana, Republic of the Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe	Article 1
Treaty of limits between Portugal and Spain	Territory/ boundary	9/29/1864	Bilateral	Spain, Portugal	Article XXVIII.
Agreement of cooperation between the United States of America and the United Mexican States regarding pollution of the environment along the inland international boundary by discharges of Hazardous Substances	Others	7/18/1985	Bilateral	Mexico, U.S.A	Article 1