ground water

Transboundary Aquifers: A Global Program to Assess, Evaluate, and Develop Policy

by S. Puri[1] and A. Aureli[2]

Abstract

Transboundary aquifers are as important a component of global water resource systems as are transboundary rivers; yet, their recognition in international water policy and legislation is very limited. Existing international conventions and agreements barely address aquifers and their resources. To rectify this deficiency, the International Association of Hydrogeologists and UNESCO's International Hydrological Programme have established the Internationally Shared (transboundary) Aquifer Resource Management (ISARM) Programme. This multi-agency cooperative program has launched a number of global and regional initiatives. These are designed to delineate and analyze transboundary aquifer systems and to encourage riparian states to work cooperatively toward mutually beneficial and sustainable aquifer development. The agencies participating in ISARM include international and regional organizations (e.g., Organization of American States, United Nations Environment Programme, United Nations Economic Commission for Europe, Food and Agriculture Organization, and South African Development Community). Using outputs of case studies, the ISARM Programme is building scientific, legal, environmental, socioeconomic, and institutional guidelines and recommendations to aid sharing nations in the management of their transboundary aquifers. Since its start in 2000, the program has completed inventories of transboundary aquifers in the Americas and Africa, and several ISARM case studies have commenced.

Introduction and Background

Transboundary aquifers have long been recognized (e.g., Bittinger 1972; Hayton and Utton 1989). However, their significance and function in environmental and human development has received scant attention from policy makers, unlike transboundary river basins (Bourne 1992). Consequently, there are neither global policies nor appropriate legal instruments to govern this vital natural resource. In an effort to remedy this gap, following its 1997 Congress in Nottingham, UK, the International Association of Hydrogeologists (IAH) established a Commission on Transboundary Aquifer Resources Management (TARM) to promote their study and joint international cooperation. The IAH initiative coincided with the adoption of the UN Convention on international water courses and the commencement of the UNESCO International Hydrological Programme (IHP), theme 2: Water Interactions: Systems at Risk and Social Challenges. The 14th Session of the Inter Governmental Council of UNESCO (in 2000) approved joint TARM activities of IAH and UNESCO, in cooperation with the Food and Agriculture Organization (FAO) and the United Nations Economic Commission for Europe (UN ECE). The scope of interagency joint action was defined in a Framework Document (Puri 2001) with the acronym ISARM (Internationally Shared (transboundary) Aquifer Resource Management). Collaboration under ISARM draws on the synergy of international agencies that support and promote the sound use of transboundary aquifers. Since its inception, several regional initiatives are under way, for example, the ISARM-Americas Programme (coordinated by the Organization of American States [OAS]); the ISARM-Europe Programme (coordinated by the UN ECE); and ISARM-Balkans (coordinated by UNESCO-INWEB). Studies financed through the Global Environment Facility (GEF) have commenced in Africa and the Caribbean, and significantly, the UN

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International Law Commission has substantially advanced a draft Convention of the Use of Transboundary Aquifers (Yamada 2004).

This volume of *Ground Water* is a timely contribution to the TARM/ISARM Programme. The inventory of European transboundary aquifers (Arnold and Buzás, 2005) provides many valuable lessons for other regions, not least that nomenclature and hydrogeological mapping across international boundaries still requires better coordination. The paper by Eckstein and Eckstein (2005) provides basic topologies of transboundary aquifers so that international law can be better formulated. The paper by Jarvis et al. (2005) investigates the hydropolitical complexities in the management of transboundary aquifers.

This paper traces the development of the ISARM initiative and summarizes planned activities that may merge with global actions such as Water for Life Decade and correspond with the culmination of the Millenium Development Goals (MDGs).

Overview of Transboundary Aquifers and International Water

Through the mid-1980s and late 1990s, the issues concerning the management of transboundary aquifers were hardly in the forefront of scientific and political discussions, in contrast to those concerning transboundary rivers (Naff and Matson 1984; Bourne 1992; Van Dam and Wessel 1993). Much political and technical discussion, usually associated with the Middle East region, was dedicated to reduction of the potential for conflict. In fact, some of the discussions that then suggested that future wars might be fought over shared water now agree that this is not necessarily the case. Unfortunately, these discussions never took sufficient account of the fact that very large quantities of fresh water resources are held in aquifers—many of the world's largest aquifers (e.g., the Rum-Saq, the Nubian, and the North Sahara Aquifer System) underlie precisely the regions where shortage, indeed absence of surface water, was the driving force for concerns on security.

It would appear that although the earliest serious concern about transboundary aquifers arose in the case of the U.S.-Mexico border regions as far back as 1977, it was in 1987 that the lessons and experiences from this region were somewhat generalized in the so-called Bellagio Draft Treaty. This document was presented to a Special Session of the Sixth Congress of the International Water Resources Association in Ottawa, in May 1988, and resulted in a publication by Hayton and Utton (1989), which contains the model treaty in 20 articles. The preamble paragraphs state, "Noting especially the present unsatisfactory state of protection and control of their transboundary groundwater as well as the prospects of crisis conditions in some areas because of increasing demands upon, and the decreasing quality of, those ground waters." This sets the stage for establishing treaties in transboundary aquifers. Article II in the draft treaty recognizes the common interest and responsibility of the Parties in ensuring reasonable and equitable development and management of ground water in border regions. These two issues probably reflect the specific situation of the U.S.-Mexico shared aquifers and cannot directly be generalized to the huge number of diverse transboundary aquifers in the world.

Ground Water in International Water Law

In recognition of the importance of transboundary water, the UN International Law Commission began work on drafting a convention related to it. After 27 years of work, the 1997 Convention, formally known as the Convention on the Law of Non Navigational Uses of International Watercourse, was adopted by the UN General Assembly. However, it has still not entered into statute in 2005 because the requisite numbers of countries have not ratified it so far. In 1966, the International Law Association (ILA), a nongovernmental organization, included ground water explicitly in their Helsinki Rules that addressed surface and ground water flowing to a common terminus. As these rules did not fully address other ground water flows, in 1986, the ILA developed the Seoul Rules. These demonstrate special concern with transboundary ground water through the provision of specific articles that relate to "hydraulic interdependence," "protection of ground water," and "ground water management and surface waters"; the latter addresses the issue of conjunctive use. One of the difficulties of these attempts to legislate on aquifers is their diverse nature and their astonishing heterogeneity, making rigid legislative classifications undesirable to hydrogeologists (Puri 2003). Consequently, hydrogeologists generally not well versed in international law or in politics have been notoriously reluctant to engage in this debate. As a result, many significant issues in the sound management of transboundary aquifers that did not receive the degree of attention due them (Mechlem 2003) are now being urgently considered through the ISARM initiative, which is assisting the UN International Law Commission's Special Rapporteur in addressing transboundary aquifers (Yamada 2003, 2004).

IAH and UNESCO Actions to Promote International Awareness

In recognition of the need to address transboundary water resources and the fact that significant aquifers of the world are of a transboundary nature, the IAH accepted a proposal put forward following its Nottingham Congress in 1997 to establish a Commission. The Minutes of the IAH Council meeting record item 14 as follows: "The President introduced a proposal initiated by S. Puri (UK), following discussion in Nottingham in 1997, for an IAH Commission on the problems and issues of transboundary aquifers. It was thought that, with the present international political profile of water and the number of current political issues surrounding the sharing of water resources, insufficient attention was being given to the problem of transboundary aquifers and that work by IAH could help to focus this. Council were invited to approve the formation of this Commission under the leadership of Mr. Puri and, with the help of UNESCO, to

launch its work at the UNESCO sponsored meeting in Libya in November 1999." The proposal was approved unanimously, and the work of the IAH TARM began with the mobilization of scientific opinion at the Tripoli Symposium (November 1999) devoted to Regional Aquifer Systems. A further impetus was given to the scope of the work of the TARM Commission following the Hague Ministerial Declaration at the 2nd World Water Forum in March 2000.

The IAH initiative on TARM coincided with developments in the UNESCO IHP's VIth Phase (2002 to 2007), entitled Water Interactions: Systems at Risk and Social Challenges. Five themes were established, with theme 2 devoted to integrated watershed and aquifer dynamics. One focal area of this theme was devoted to international river basins and aquifers. The rationale for developing it was: "The basin scale is appropriate for comparing water resources (precipitation, groundwater, surface water) and water use or water demand (domestic, industrial, agricultural). It is the natural scale for hydrological processes but it is also a relevant approach for landscape and land use mapping because of the topographically-driven organization of the watershed. The evaluation of water resources at the basin scale needs to combine data from various sources. However, the problem is more complicated for the water demand which is often evaluated at administrative scales. Mechanisms that govern water demand are not well outlined and relevant parameters are yet to be suggested." Taking note of the rationale of this focal area and recognizing the wider value of transboundary aquifers, UNESCO's Scientific Panel concluded that a major international initiative was justified.

Launch of the ISARM Programme

Additional preparatory work was done by UNESCO and IAH through consultation and partnership with other agencies such as FAO, the Economic and Social Commission for Western Asia (ESCWA), and UN ECE. These resulted in a Resolution to the 14th Session of the Inter Governmental Council of UNESCO IHP (June 2000), presented by the Government of Argentina as shown in Table 1.

The aforementioned resolution, adopted by a vote of 143 countries, authorized UNESCO IHP's component on ISARM.

Accelerating Global Interest in ISARM

Between the 14th and the 15th Sessions of UNESCO's Inter Governmental Council (June 2002), work activities of the ISARM/TARM Programme have accelerated.

ISARM Africa

A workshop was organized in cooperation with IAH in Cape Town, South Africa, November 20 to December 1, 2000, with the aim of setting up a network in the Southern African Development Community (SADC) countries for enhancing the study and assessment of the Southern African regional aquifers. An International Workshop was organized, June 2 to 4, 2002, in Tripoli, Libya, by the General Water Authority of Libya with the aim to improve the existing knowledge on African Shared Aquifer Systems and to prepare an inventory of case studies. A proposal for the study of the Iullemeden Aquifer was prepared and submitted to the GEF for financing through the support of UNEP; GEF approval was confirmed in July 2003. A continent-wide inventory is substantially advanced.

ISARM Latin America

A seminar was organized by the National Committee of Argentina for IHP and the University of Santa Fe (Argentina), August 29 to 31, 2001, with the aim of launching the inventory of transboundary aquifer systems in Latin America. The XXII Brazilian Congress on Groundwater held in Florianópolis from September 10 to 13, 2002, requested the participation of ISARM experts. The IAH Congress at Mar de Plata, Argentina, in October 2002, established the ISARM-Americas Programme with the OAS as the lead agency, working with

Table 1
Resolution Supporting a Transboundary Aquifer Initiative, Submitted by Argentina to the UNESCO IHP Inter Governmental Council

Recognizing	that transboundary aquifer systems are an important source of fresh water in some regions of the world, particularly under arid and semiarid climatic conditions
Also recognizing	that due to a lack of reliable scientific knowledge and information, conflicts may arise
Recalling	that at the Fifth UNESCO/WMO International Conference on Hydrology (Geneva 1999), concern was raised on the lack of monitoring and assessment of the key aquifer resources
Noting	that the Tripoli Statement of November 1999 and the Ministerial Declaration of the Hague (March 2000) drew attention to the problems of managing shared water resources
Endorses	the recommendations of the experts meeting organized by UNESCO and IAH in cooperation with FAO and UN ECE (UNESCO, Paris, March 27 to 28, 2000)
Decides	to launch an interagency initiative to promote studies in regard to transboundary aquifers (TARM)
Requests	the director-general of UNESCO to take necessary actions to conclude a Memorandum of Understanding with UN ECE and FAO
Invites	Member states to facilitate regional cooperation and provide their support to this initiative
Encourages	UN agencies to provide their support and funding institutions to contribute financially to this initiative

the UNESCO IHP. A continent-wide inventory is in the process of publication.

ISARM Arab States

A project proposal on the Sustainable Management and Protection of Internationally Shared Groundwater Resources in the Mediterranean Region was prepared by UN ECE-ESCWA-ECA (Economic Commission for Africa) and UNESCO for submission to the European Union's Euro-Med Water Programme. Within this framework, ESCWA has commissioned a desk survey of the shared aquifers within the Mediterranean region. A seminar was organized in cooperation with ESCWA in Beirut from February 27 to 28, 2002, setting out the key components of the ISARM Programme and establishing the expert network for the region.

Defining the Agenda for Transboundary Aquifers

A Framework Document (Puri 2001) on ISARM addresses the principal issues concerning transboundary aquifers. It summarizes the current understanding, demonstrates their significance in water resource management, and highlights the fact that as yet there is very little international experience for their shared management. Unlike transboundary surface water, transboundary aquifers are not well known to policy makers. Available international law does not adequately address the three-dimensional spatial flow and storage in ground water and has limited application in conditions where impacts from neighboring countries can take decades, given that ground water response is slow compared to surface water (Yamada 2003). Scientific correlation of transboundary hydrogeology is often deficient, and shared, sustainable production rates remain uncertain because of weak institutions and a lack of capacity.

The global prevalence of transboundary aquifers has been further underlined through the publication of the World Hydrogeological Map (IAH 2003). An analysis of the number of transboundary aquifers is awaited—however, by analogy to the 261 transboundary river basins of the world, it would seem that a similar, if not greater, number are shared by nations. Almost 40% of the world's population lives in one or another transboundary water resources region. In Europe alone, 89 transboundary aquifers have been identified (Almássy and Busás 1999).

Aquifer systems, due to their partial isolation from surface impacts, on the whole contain good-quality water. In many countries, these systems have been evaluated and extensively used for municipal and other demands. Such resources represent a substantial hidden global capital that still needs prudent management. Competition for visible transboundary surface water, based on available international law and hydraulic engineering, is evident in all continents. However, the hidden nature of transboundary ground water and lack of legal frameworks invite misunderstandings by many policy makers. Not surprisingly, therefore, transboundary aquifer management is still in its infancy, since its evaluation is difficult, suffering from a lack of institutional will and finance to collect the necessary information. Although there are fairly reliable estimates of the resources of rivers shared by two or more countries, no such estimates exist for transboundary aquifers. A key driver of the ISARM Programme is to support cooperation among countries to develop their scientific knowledge and to eliminate potential for conflict, particularly where conceptual differences might create tensions. It also aims to contribute to scientific knowledge including risk-based management, for regional scientific cooperation.

Regional Initiatives: The UN ECE Environmental Conventions

A regional initiative in the management and monitoring of transboundary aquifers arose from the significant developments achieved by the UN ECE through the promotion and adoption of the guidelines and recommendations relating to Europe's environment. With the geopolitical changes that took place in Europe between 1990 and 1995, the membership of the UN ECE increased from 34 to 55 countries. The environmental legacies of past actions (or inactions) in the former Soviet Union and Eastern Europe were the driving forces behind the interest of states to improve their environment. As many of the environmental issues are closely related to transboundary water, a Convention on Protection and Use of Transboundary Water Courses and Inland Lakes was signed in 1992 and has been in force since October 1996. Arising out of these concerns, the UN ECE also issued guidelines on water quality monitoring and assessment of transboundary rivers in 1996. Again, the focus of attention was on surface water until the year 2000, when following an agreed work plan, monitoring guidelines related to ground water were also prepared. In the course of this work, a pioneering inventory of European transboundary aquifers was completed (Almássy and Busás 1999), which also includes volumes on "Problem Oriented Approach and the Use of Indicators," "Application of Models," and "State of the Art on Monitoring and Assessment of Groundwaters." These four volumes provide a good basis to extend the lessons learned to other regions in the world. Consequently, other economic commissions, notably ESCWA and ECA, are developing regional approaches to transboundary aquifers.

Transboundary Aquifers Linkage to Social Development

The presumed linkage between water resources of transboundary aquifers and social development is widely accepted. Recent international fora devoted to international water resources, e.g., the World Summit on Sustainable Development in Johannesburg, the World Water Forum in Kyoto, and the Dushanbe Fresh Water Forum, have stressed that human survival depends not only on national but also on international water. It follows that the role of transboundary aquifers in society and its security cannot be separated from any considerations of the natural and built environments.

In this context, "aquifers and rivers" interdependency should be better appreciated—the dry-season base

flow of many rivers may be derived from transboundary aquifers. Large numbers of poor people in Africa, South America, and Asia rely directly on dry-season transboundary water resources for their subsistence. The "water poor" in the transboundary aquifers context are those impacted by

- Persistent threat to their natural livelihood base from hydrologic extremes
- Dependence of livelihood on cultivation of food or gathering of natural products that rely on transboundary waters
- Excess pumping resulting in greater drawdowns, and increased costs to the poor in terms of energy
- Contamination of transboundary water resources, and inability to use, or have no access to, an alternative source
- Vulnerable people who spend several hours a day collecting potable water, and whose security, education, productivity, and nutritional status is thereby put at risk
- Those living in areas with high levels of water-associated diseases (bilharzia, guinea worm, malaria, trachoma, cholera, typhoid, etc.) without means of protection

To date, social assessments for poverty alleviation taking account of transboundary water resources are rare. The interrelationship between integrated water resource management and poverty has not yet been generally recognized, as might be noted from the lack of reference to "water poverty" in many Poverty Reduction Strategy Papers.

Programs Related to ISARM

Several programs associated with ISARM have started, and an important initiative has been offered by the Government of Libya, which has proposed the establishment of an African Centre for the Management of Shared Groundwater Resources in Tripoli, under the auspices of UNESCO and the World Meteorological Organisation (WMO).

Another important related project is the International Groundwater Resources Assessment Centre (IGRAC) established with support from the Dutch Government. IGRAC forms part of several global data and information centers devoted to worldwide ground water assessment and provides a service facility ensuring the free flow of ground water data and information at no cost. In an exchange of letters, ISARM and IGRAC have agreed to collaborate in several aspects. IGRAC is hosting the ISARM digital working environments for networks of experts developing ISARM case studies; it is also hosting the ISARM Web site and provides the quality assurance facilities for the storage and exchange of worldwide data on transboundary aquifers. As the case studies produce their outputs, the bank of information within IGRAC would be used to develop the toolkit mentioned subsequently.

Case Studies

A number of case studies have been proposed under the ISARM Programme. These are activated through the participation of national expert teams working together to formulate the concepts, develop technical proposals, and submit them for financing to appropriate agencies. The current list of potential case studies is given in Table 2, though the list is not yet comprehensive.

Development of the ISARM Guidance Package

The experience gained from ISARM activities in several regions confirms that there remains a lack of experience in the management of transboundary aquifers, which is in contrast to surface water resources. The reviews and analyses conducted by ISARM experts have also demonstrated that the considerably more complicated nature of aquifers, compared to surface water, requires a multidisciplinary approach. It has been concluded therefore that there would be considerable value in developing a multidisciplinary toolkit, or a guidance package, that might consolidate the best practices, guidance, and information on transboundary resource management. The multidisciplinary toolkit might form the basis of a management approach that could apply to most transboundary aquifers. A flowchart representing the approach to development of the toolkit is shown in Figure 1 (Puri and El Naser 2003).

While it is too early for a detailed design of such a toolkit in advance of the completion of the ISARM case studies, it would be worthwhile to set out its main components, as shown in Table 3.

Each package within the toolkit would ensure consistency and equivalence, as relevant to any given transboundary aquifer system. It would enable the joint owners of the resource to achieve a common platform for each of the focus areas of transboundary aquifers.

Suggestions for New ISARM Initiatives

The world hydrogeological community is invited to propose new regional ISARM initiatives. As guidance for such new initiatives, some suggestions are made, based on the experience from programs that are under way. The programs should be phased and based on case studies, which should selected adopting specific strategies.

Phased Development of the Program

Any ISARM Program should be phased in several stages. While the scope of work of each stage will require discussion and agreement among the collaborators, some suggestions can be made, as follows.

Stage I: Inventory and Preliminary Documentation

A good start can be made with the circulation of a preliminary questionnaire. An example is given in the ISARM Framework Document. This should be completed as fully as possible during Stage I of the program. Additional elements of this could include development of criteria that will define the degree of national significance of the aquifer system. The methodology should be based on a system of weighted scores, with the weightings applied in the context of each country participating in the program. Some possible criteria to consider, listed in no particular order of importance, include

Table 2
Proposed ISARM Case Studies

Proposed Case Study	Comments	Timetable of Commencement
Management of hydrogeological risks in the Mediterranean wetlands	Project proposal in preparation	End 2003
Management of hydrological risk in the Chad Aquifer System (Cameroon, Libya, Niger, Nigeria, Chad, Sudan)	Requested by the Lake Chad Commission	End 2003
Kalahari Aquifer System (Botswana, Namibia, Angola, Zaire)	Draft MSP has been prepared by SADC and submitted[1]	
Managing hydrogeological risk in the Iullemeden Aquifer System (Algeria, Mali, Niger, Nigeria)	With participation by OSS	Approved 2003
Management of the Rum-Saq Aquifer System (Jordan, Saudi Arabia)	Under consideration	By 2005
Management of the Chuy Aquifer (Uruguay, Brazil)	To be prepared during meeting with OAS in Peru	Mid-2004
Joint management of the Nubian Aquifer System (Egypt, Libya, Sudan, Chad)	Cooperation with IAEA proposal	Late 2003
Management and risk evaluation of the Great Oriental Erg Aquifer System (Algeria, Tunisia)	Under consideration	2005
Al-Kabeer Al-Janoubi System (Lebanon, Syria)	Under consideration	End 2005
Regional assessment and strategy of development for the management of the shared aquifers in Latin America—several offers on the table	Under discussion OAS, high priority	Aim for 2003 and 2004
European aquifers—Basin of the River Bug—Poland, Belarus, Ukraine—UN ECE	Intergovernmental MOU completed——under consideration	End of 2003
Joint management of shared Awash Valley sedimentary aquifer resources (Ethiopia, Djibouti)	Under discussion	Mid-2004
Joint management of shared West African coastal aquifer resources (Benin, Ghana, Ivory Coast, Togo)	Under discussion	2005
Joint management of aquifer resources shared between Kenya and Somalia (Kenya, Somalia)	Under discussion	2004
Regional assessment of transboundary aquifer systems a. Africa region b. Near East and North Africa region c. South Asia region d. Far East region e. Latin America region	Awaiting evaluation	2004

[1]Funded through support from the GEF.
IAEA, International Atomic Energy Agency; MOU, memorandum of understanding; MSP, medium-sized projects; OSS, Organisation for Sahara & Sahel.

- Available water resources vs. population served, including industrial, agricultural, and other demands
- Contribution from the aquifer discharge to base flows and support to aquatic or other communities
- Contribution of aquifer water resource to poverty alleviation
- Cost benefit of development in terms of contribution to economic development.

Additional criteria based on the aforementioned can be developed as appropriate.

Stage II: Detailed Analysis and Development

Once the transboundary aquifers have been prioritized in some manner, as suggested previously, a more detailed evaluation should be conducted. Stage II of the ISARM Programme suggests a multidisciplinary approach for the detailed analysis of transboundary aquifers. A flowchart representing this is shown in Figure 1 for general guidance. The hydrogeological analysis that is needed for the management of transboundary aquifers should run in parallel with and close relationship to the socioeconomic, legal, and institutional analyses. Unless these components of the activities are closely linked, the interrelationships may not be fully established and the final outcome may be weak. One of the objectives of this stage of development is to evaluate the extent to which interregional harmonization is needed. In certain regions where the shared aquifer underlies communities with different cultural, linguistic, and ethnic origins, there could be a substantial variation in the legal and institutional regimes. Work will be required to ensure that these different regimes have common baselines for moving toward compatibility. Stage II does not seek to change national approaches, rather to seek synergies and equivalences.

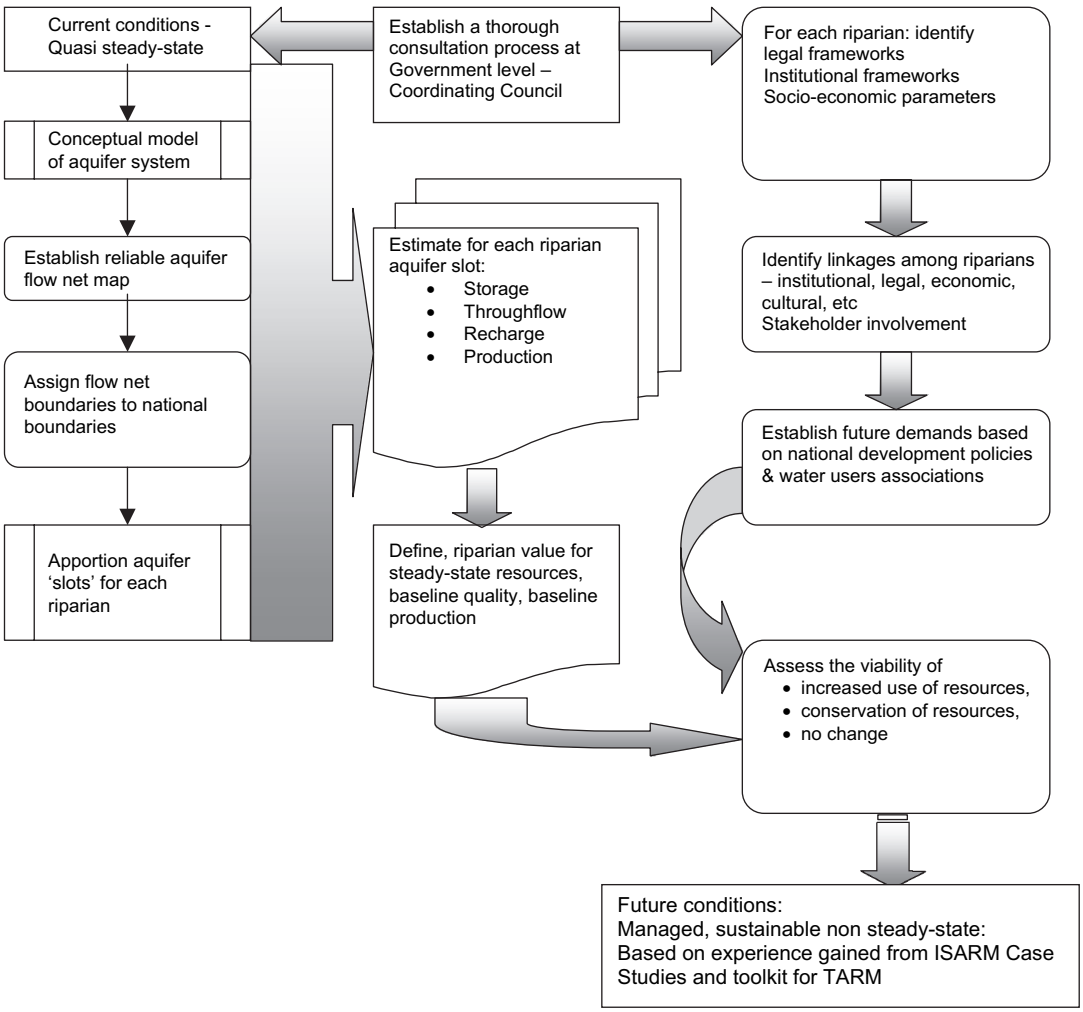

Figure 1. Suggested development strategy for ISARM case studies—toward a toolkit.

Stage III: Implementation, Operation, Management, and Monitoring

The sequence of activities in Stage III should be considered in the longer term. There are many reasons for this; mainly, that seeking finances and stakeholder support is generally a process that must not be hurried. Apart from this, a fundamental reason for this stage to extend to the long term is that aquifers respond more slowly than surface water systems. Consequently, the management and monitoring of transboundary aquifers are closely linked and have to be viewed in that perspective.

The Need for a Case Study–Based Approach

The immense diversity of aquifer types and their configurations suggest that no one uniform approach is likely to apply to all transboundary aquifers. It is clear therefore that case studies under different conditions will be needed. As stated previously, case studies in different parts of the world have been proposed and are expected to be conducted, with each making a contribution to the package of approaches that can then be transposed. Case studies should be so selected that each makes a contribution to the overall understanding to the management of transboundary aquifers. While the hydrogeological

Table 3
ISARM Toolkit Components

Toolkit Package	Main Components
Scientific	Guidance for the development of reliable transboundary conceptual models
Legal	Guidance on legal frameworks for negotiation of agreements, based on country practice
Institutional	Guidance on responsibility and powers of institutions engaged in joint management
Socioeconomic	Guidance on the current and future needs for population, industry, agriculture, and environment
Environmental	Guidance on development of an environmental impact assessment, covering biodiversity, climate change, and ethical use

drivers for the full understanding will be important, more important will be the socioeconomics, i.e., the users of the resources, including the demands placed on the aquifers for a sustainable environment, especially where aquifer discharge maintains important habitats.

Strategy for the Selection of Case Studies

The suggestions made in this section should be discussed and refined during workshops. In selecting case studies, the factors that may be used to identify priority transboundary aquifers will include the following aspects.

Persistent transboundary aquifer resource management problems including

- Poor prediction of aquifer yields on one or either side of the national boundary
- High variability in transboundary aquifer properties and therefore high uncertainties
- Presence of unused or underused ground water resources on or other side of the national boundary
- Conflicting demands for the transboundary aquifer resource—such as between irrigation and industrial uses
- Significant environmental concerns arising from current water management practices
- High likelihood that current transboundary aquifer management practices are depleting the resource, either through overexploitation or by pollution.

There could be several other criteria applied in selecting the case studies, some of which could be focused on ensuring the study is not unnecessarily complicated. The characteristics that will make a transboundary aquifer suitable as a case study could include

- The aquifer is well defined and is hydrologically distinct—ideally excluding major interbasin transfer arrangements
- Strong national and local support can be developed for the case study aims
- Good history of surface and ground water hydrometric data collection in at least some of the key sites
- Broadly comparable socioeconomic situations (If, for example, there is significant industrialization on one side, this could complicate analysis including demand forecasts. As a consequence, the details of dealing with such changes may be given greater prominence than the overall approach to improving the transboundary aquifer resource management.)
- On the whole, there is only one international boundary crossing the aquifer system, as bilateral evaluations are thought to be more effective, at least during the case study stage.

Concluding Remarks

The ISARM initiative, a joint program of the IAH and UNESCO IHP, has been in existence for barely 5 years, yet has proven its worth in promoting the cooperative study and management of transboundary aquifers throughout the world. It has promoted a number of regional case study–based initiatives and is encouraging the development of additional initiatives. Active programs are under way or have been completed in Latin America, Europe, and Africa. It provides expertise to nations seeking assistance in understanding and analyzing transboundary ground water resources. The program is developing a guidance package toolkit that will consolidate the best practices, guidance, and information on transboundary resource management.

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