

# **THE UNESCO PROJECT ON INTERNATIONALLY SHARED AQUIFER RESOURCES MANAGEMENT (UNESCO/ISARM): OVERVIEW AND RECENT DEVELOPMENTS**

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## **ABSTRACT**

UNESCO-ISARM (Internationally Shared Aquifer Resources Management) is a multidisciplinary, international, demonstration project coordinated by UNESCO International Hydrological Programme (IHP), Paris and included in UNESCO's 2004-2007 programme. It was launched in June 2000 at the 14th Session of the Intergovernmental Council of the UNESCO-IHP and is an intergovernmental project involving all national IHP Committees. The Council also invited the Food and Agriculture Organisation of the United Nations (FAO), the International Association of Hydrogeologists (IAH) and the United Nations Economic Commission for Europe (UNECE) to cooperate in order to create the UNESCO-FAO-IAH-UNECE inter-agency ISARM initiative to promote studies concerning transboundary aquifer systems.

In this paper an overview of the UNESCO-ISARM initiative is given followed by a description of the project's recent developments in different parts of the world. The project uses a two-step methodological approach: first an inventory of the existing internationally shared groundwater aquifers located in a given region is developed; then, and taking into consideration the results of this investigation, detailed pilot projects and specific actions are formulated. The current situation of UNESCO-ISARM in Africa, Latin America, the Mediterranean and South Eastern Europe (SEE or the Balkans) is discussed .

## **1. Introduction**

Transboundary aquifer systems are important sources of fresh water in many regions of the world, particularly under arid and semi-arid climatic conditions. Management of transboundary groundwater resources should be based on reliable scientific knowledge and information and avoid potential conflicts between neighbouring countries. In order to facilitate an integrated approach to transboundary groundwater resources management, UNESCO adopted the ISARM initiative.

On a global scale, the importance of fresh groundwater resources is predominant. According to estimations by the United States Geological Survey, 99% of the available fresh water on the planet is stored in the ground. About 69% is stored in glaciers and permanent snow cove and is practically inaccessible for human use. It is interesting to note that while rivers and lakes hold only 0.3% of the total amount of the available fresh water, fresh groundwater represents about 30% of global fresh water, with the remainder being stored as soil moisture.

This groundwater is located in depths up to 4.000 m, and half of this quantity is technically available at depths less than 800 m.

According to the latest UN World Water Development Report (WWDR, 2003) transboundary river water flow is estimated as 42.800 km<sup>3</sup>, while transboundary fresh groundwater resources offer much higher volumes of high-quality water estimated as 23.400.000 km<sup>3</sup>. During the last fifty years, more than 200 international treaties for transboundary watercourses have been agreed and in several river basins international water commissions effectively apply the principles of Integrated Water Resources Management (IWRM). The same does not apply for transboundary groundwater resources, where there is a notable lack of international conventions as well as of bilateral agreements.

From the above considerations it can be seen that while transboundary groundwater resources are three times greater in volume than internationally shared surface waters, great efforts still need to be made to improve the existing situation and reach sustainability in transboundary groundwater resources management. About 75% of the inhabitants of the European Union (EU) member states depend on groundwater aquifers for their water supply. Many of these aquifers are internationally shared. Public water supply requires a reliable source, which means that the quality, as well as the quantity, should be guaranteed in relevant areas. Both groundwater quality and quantity are of essential importance for the diversity of ecosystems. Lower groundwater levels and changes in groundwater quality due to man-induced contamination cause loss of diversity of ecosystems and deterioration of natural reserves.

Essential characteristics of groundwater are endangered due to the deterioration of water quantity and quality and vital functions of groundwater reservoirs are threatened by pollution and overexploitation. Many examples are given in Kohsiek et al. (eds.), 1991. A significant cause of the deterioration of groundwater quality is increasing pollution from diffuse sources, like agricultural activities, groundwater nitrification and salinisation near coastal areas and in many cases near the soil surface. As a consequence of the latter, desertification of millions of hectares of irrigated land around the world has occurred. For example in Australia it has been recognised (Tickell and Humphrys, 1984) that a rise in the groundwater table is one of the main causes of waterlogging and salinity increases near the top layer of the soil. As groundwater moves upward, salinity is increased by the dissolving of salts in the soil. The rising of the groundwater table arises from the effect of intensive actual irrigation combined with the disruption of the natural equilibrium between plants, soil and groundwaters. In fact, intensive removal in the past of deep-rooted vegetation has reduced the natural drainage capacity of basins and destroyed the natural equilibrium between groundwater recharge and drainage. When the water table rises to a depth of less than two meters below soil surface, salt concentrations are further increased by evaporation and damage to vegetation and soils is then likely. Another wide-reaching adverse consequence is that the nutrients and salts are being released and contribute to nitrification and pollution of rivers, lakes and inland seas.

The protection of groundwater resources may be based on different methodologies involving either empirical or sophisticated methods. Various traditional strategies for groundwater protection range from the construction of groundwater vulnerability maps and the definition of protection perimeters around pumping wells, to the use of sophisticated optimisation multi-criterion decision-making techniques under risk conditions. A very characteristic example is the definition of adequate waste disposal sites in relation to the risk of groundwater contamination.

This paper presents the UNESCO-ISARM programme and focuses on the recent development of an inventory describing the geological, hydrogeological and institutional status of existing transboundary aquifers in SEE.

## 2. Transboundary geohydrological issues

When interstate borders cross aquifers, the different hydrological and hydrogeological processes that may take place on one side of the border may not be known, or understood or is just not reconcilable with sovereignty consideration within the territory of the country on the other side. As shown schematically in Fig. 1, taken from UNESCO/ISARM Framework Document, 2001, water recharge contributing to transboundary flow may occur in one country and as a consequence a deep aquifer may discharge towards the neighbouring country, whereas the groundwater flow in local shallow aquifers near the border may actually be in the opposite direction.

In internationally shared rivers and lakes much progress has been made on how to determine what type of water resources problems already exist or will likely emerge in order to reach bilateral or multilateral interstate solutions. A large number of international agreements for solving various types of interstate surface water resources problems are available for reference and act as precedents.

The situation is quite different in the case of transboundary groundwater resources. Difficulties arise in scientific and technical matters (groundwater monitoring, data interpretation, modelling, and the close groundwater-land linkages); there may also be a lack of political willingness for cooperation or the institutions involved may be weak. One of the major difficulties in designing groundwater development plans is that groundwater flow and groundwater quality are subject to several types of uncertainties and to a much greater degree than in surface hydrology. These are related to the high variability in space and time of hydrogeological, chemical and biological processes. The principal challenge is to set up a cooperative framework so that institutions from both sides can effectively work together.

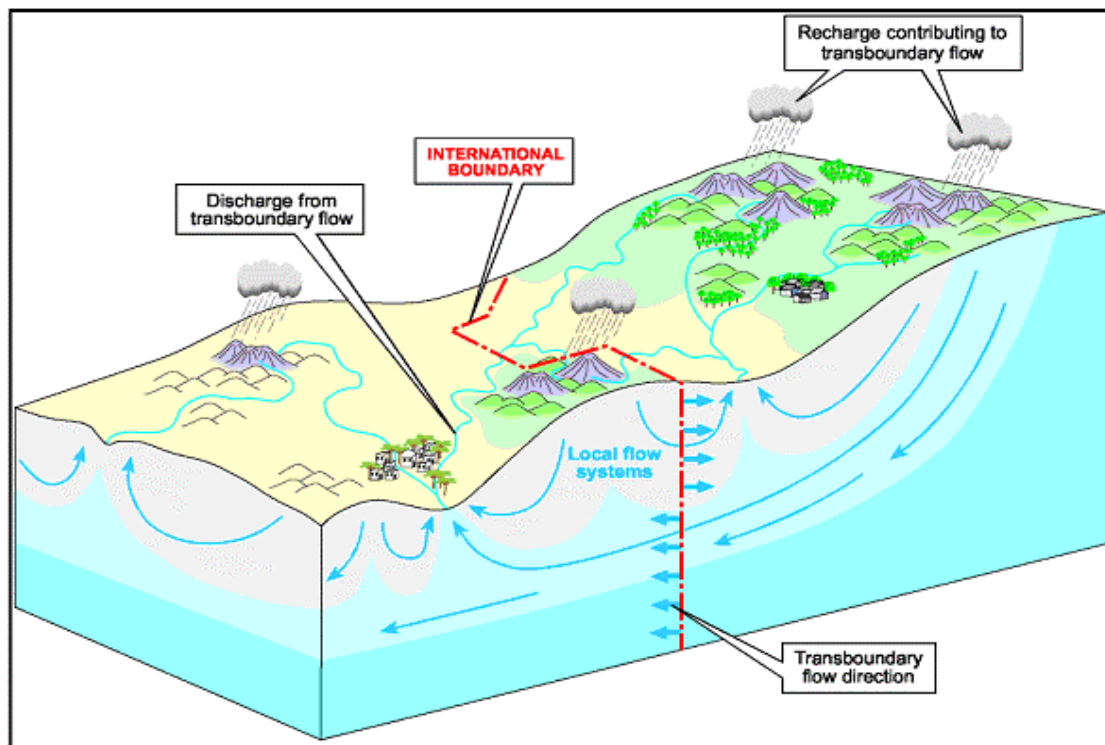


Figure 1 Schematic representation of hydrological and hydrogeological processes in transboundary areas (UNESCO/ISARM, 2001).

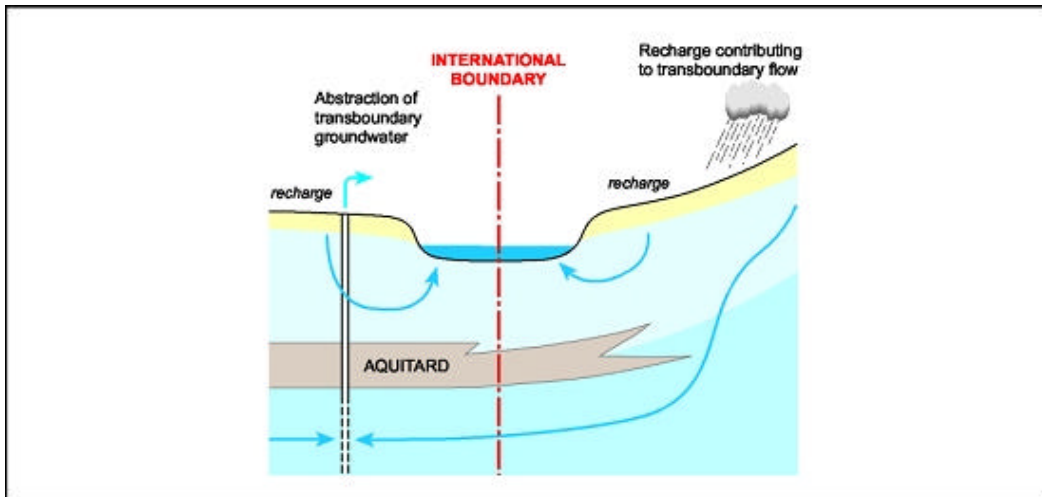


Figure 2 Interaction between surface and groundwater flows near an interstate boundary (UNESCO/ISARM, 2001).

In many cases interactions between surface and groundwaters on both sides of an international border may create international disputes. As shown in Figures 2 and 3 groundwater overpumping on one side of the border may lower the water level of a shared surface lake or river (Fig. 2) or accelerate the sea water intrusion in a coastal zone on the other.

A very characteristic example of groundwater-surface water interdependencies can be found in the Balkans, in the region of Lake Doirani, internationally shared between Greece and the Former Yugoslav Republic of Macedonia (FYROM). Over the last decade, a period which saw many years of drought, extensive groundwater pumping on the Greek side for irrigation purposes may have contributed to substantially lowering the lake's water level with a negative impact on the fishing industry on the FYROM side.

In all these situations cooperation between countries is of primary importance in order to understand problems, to agree about the underlying causes and to try to develop reliable solutions.

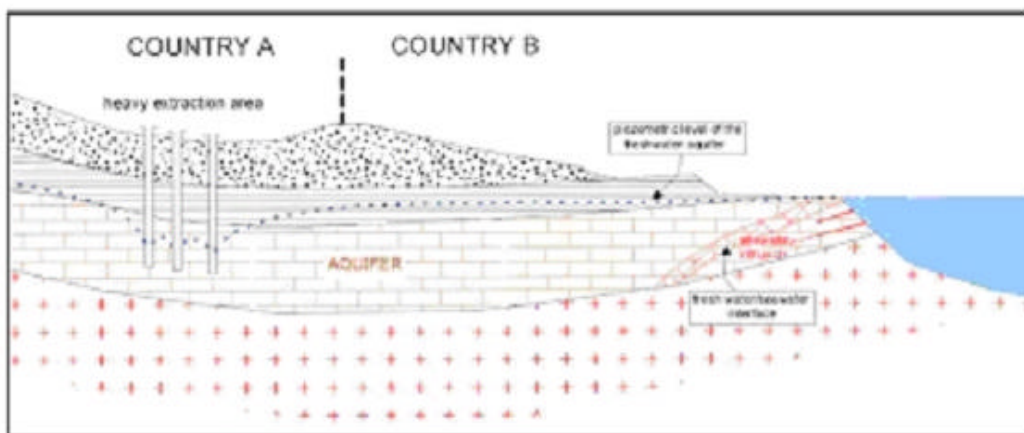


Figure 3 Groundwater salinisation in country B due to overpumping in country A (UNESCO/ISARM, 2001).

### 3. ISARM's methodology for transboundary aquifer management

The UNESCO/ISARM Programme has identified the following five key focus areas for the sound management of transboundary aquifer water resources.

- scientific-hydrogeological approaches,
- legal aspects,
- socio-economic issues,
- institutional considerations, and
- environmental protection.

#### *Scientific-hydrogeological approaches*

The management of groundwater quantity and quality is a complicated multidisciplinary scientific field requiring good cooperation between various disciplines, such as:

- *Hydrogeology*: geophysical and geological prospecting, drilling techniques, mapping
- *Groundwater hydrodynamics*: quantitative aspects of flows, mathematical modelling, calibration, and prediction scenarios
- *Groundwater management*: systems analysis, optimisation techniques, risk analysis and multiobjective decision-making methods
- *Hydrochemistry*: chemical composition of the soil and water
- *Hydrobiology*: biological properties of groundwater systems

Modern tools for groundwater development extensively use new information technologies, development of databases, computer software, mathematical modelling and remote sensing.

#### *Legal aspects*

International conventions on transboundary waters should include provisions for the monitoring and assessment of transboundary waters, including measurement systems and devices and analytical techniques for data processing and evaluation. Guidelines on how to effectively exchange information and monitoring data and undertake measures to reduce impacts from transboundary water pollution are also very important. As surface and groundwaters are interconnected, measures to protect ecosystems and drinking water supply should also include the monitoring and assessment of transboundary groundwaters.

For the monitoring and assessment of transboundary rivers and lakes under an international convention has already been agreed upon (UNECE, 2000). No such international treaty yet exists for transboundary aquifers. The monitoring and assessment of surface waters are also part of the 1999 Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. This Protocol contains provisions regarding the establishment of joint or coordinated systems for surveillance and early-warning systems to identify issues related to water pollution and public health, including extreme weather conditions. It also includes the development of integrated information systems and databases, the exchange of information and the sharing of technical and legal knowledge and experience.

The complexities of groundwater law have been described by many authors in the technical literature. Overpumping can cause groundwater quality to deteriorate through salinity problems, either by seawater intrusion or evaporation-deposition. Overpumping of groundwater in one

country can endanger the future freshwater supplies of another country. The Bellagio Draft Treaty, developed in 1989, attempts to provide a legal framework for groundwater negotiations. The treaty describes principles based on mutual respect, good neighbourliness and reciprocity, which requires joint management of shared aquifers (Hayton and Utton, 1989). The Draft is only a model treaty and not a result of accommodating actual state practice, and accepts that collecting groundwater data may be difficult and expensive, and should rely on cooperation; it does provide a general framework for groundwater negotiations.

Only three bilateral agreements are known to deal with groundwater supply (the 1910 convention between Great Britain and the Sultan of Abdali, the 1994 Jordan-Israel peace treaty and the Palestinian-Israeli accords (Oslo II). In addition, the 1977 Geneva Aquifer Convention is also an important reference for internationalization of shared aquifer management and regulation by intra-State authorities for transboundary cooperation. Treaties that focus on pollution usually mention groundwater, but do not quantitatively address the issue. In August 2005 the third report on shared groundwater resources was presented in Geneva to the United Nations International Law Commission (UN-ILC, 2005). In this report a set of articles for a draft international convention on the law of transboundary aquifers is proposed.

### ***Socio-economic issues***

It is widely accepted today that use of water resources, protection of the environment and economic development are not separate challenges. Development cannot subsist when water and environmental resources are deteriorating, and similarly the environment cannot be protected and enhanced when growth plans consistently fail to consider the costs of environmental destruction. Nowadays it is clear that most environmental problems arise as 'negative externalities' of an economic system that takes for granted - and thus undervalues - many aspects of the environment. The integration of environmental and economic issues is a key requirement in the concept of sustainability, not only for the protection of the environment, but also for the promotion of sustainable long-term economic development, especially in water scarce areas.

The ISARM Framework Document makes a preliminary overview of different socio-economic aspects of transboundary aquifer management. The main driving forces behind the over-exploitation of groundwater resources resulting in negative impacts are: population growth, concentration of people in big cities and inefficient use of water for agricultural irrigation. The agricultural sector is most often mainly responsible for groundwater over exploitation. The situation becomes particularly difficult when neighbouring countries share common transboundary groundwater resources, as a number of differences arise in

- socio-economic level
- political, social, and institutional structures, including strict region-specific positions on national sovereignty
- objectives, benefits, and economic instruments
- international relations, national legislation and regulation.

Competition for use of groundwater for different purposes on one or both sides of the border may generate potential conflicts. Effective governance should consider specific hydrogeological conditions, aquifer recharge rates and multiobjective use of renewable groundwater resources involving multidisciplinary regional working groups.

### ***Institutional considerations***

For transboundary water courses and lakes, international commissions have proved to be the most effective institutional settings for transboundary surface water resources management. No

such common institutions exist for transboundary groundwaters. Whether transboundary groundwater management should be a specific task of one or more specialised committees belonging to the same international river or lake committee, or whether a separate common institutional body should be created for this purpose, remains a question unanswered. In view of the physical interactions between surface and groundwaters, coordination between different specialised institutions is necessary for the overall sustainable management of water resources.

In the present situation national institutions dealing with groundwater are not sufficiently or effectively prepared to be able to undertake the joint management of transboundary groundwaters. Groundwater management units, when they exist, are often side-lined and non-visible in surface-water dominated water administrations and groundwater is not explicitly addressed in national water legislations. Capacity building, especially on developing joint enabling capacity and consultation mechanisms at decision-maker level, including harmonization of domestic groundwater law, supported by common monitoring systems and sharing information and data, is essential. The role of regional partnerships between different decision makers, scientists from different disciplines, and other water stakeholders is also important for preventing conflicts and enhancing cooperation. It is important to link and reconcile transboundary aquifer management with land management, and with regional political and social and economic regional cooperation and development policy.

### ***Environmental issues***

Preservation of groundwater quality and ecosystem biodiversity should be an important objective for sustainability. Environmental protection should be realistically based on Environmental Risk Analysis (ERA) rather than on some precautionary principles which may not lead to any action. ERA is a general and very useful approach for studying risks related to over-use or pollution of water in sensitive areas. The application of ERA consists of two main phases

- (1) the assessment of risk, and
- (2) risk management.

The assessment of risk is mainly based on modelling of the physical system, including forecasting of its evolution under risk. The main objective of risk analysis is the management of the system, however this is not possible if risk has not first been quantified.

The risk assessment phase involves the following steps

- Step 1: Identification of risk or hazard
- Step 2: Assessment of loads and resistances
- Step 3: Uncertainty analysis
- Step 4: Risk quantification

When it is possible to assess the risk under a given set of assumptions, then the process of risk management may begin. The various steps of the risk management phase are

- Step 1: Identification of alternatives and associated risks
- Step 2: Assessment of costs in various risk levels
- Step 3: Technical feasibility of alternative solutions
- Step 4: Selection of acceptable options according to the public perception of risk, government policy and social factors
- Step 5: Implementation of the best choice.

When applying ERA different scenario of socio-economic development, including possible climate change, should be taken into consideration. This is important in view of the vulnerability of transboundary groundwater resources.

#### 4. Overview of ISARM's programme

The UNESCO/ISARM programme aims at improving the understanding of scientific, socio-economic, legal, institutional and environmental issues related to the management of transboundary aquifers. The programme operates through a joint coordination committee of experts from UNESCO-IHP, IAH, FAO and UNECE.

An important contribution to the improvement of knowledge has been made by UNECE, which has developed guidelines for monitoring such aquifers (UNECE, 2000). These 'Guidelines on Monitoring and Assessment of Transboundary Groundwaters' were prepared by the UNECE Working Group on Monitoring and Assessment and adopted as part of the 1996–1999 work plan under the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992). These Guidelines were endorsed by the Parties to the Conventions at their second meeting (The Hague, Netherlands, 23–25 March, 2000).

A framework document presenting the different social, economical, legal and environmental aspects of ISARM was published in November 2001 (UNESCO/ISARM, 2001). As a first step the programme has initiated the inventory of Transboundary Aquifers of the World. The international conference on "Hydrological Challenges in Transboundary Water Resources Management" was organised in Koblenz, Germany, 25-27 September, 2001 by the IHP National Committee of Germany under the auspices of the World Meteorological Organisation (WMO) and UNESCO.

##### *ISARM Africa*

The first phase of the UNESCO/ISARM programme was initiated in Africa in 2002 (Figs.4 and 5).

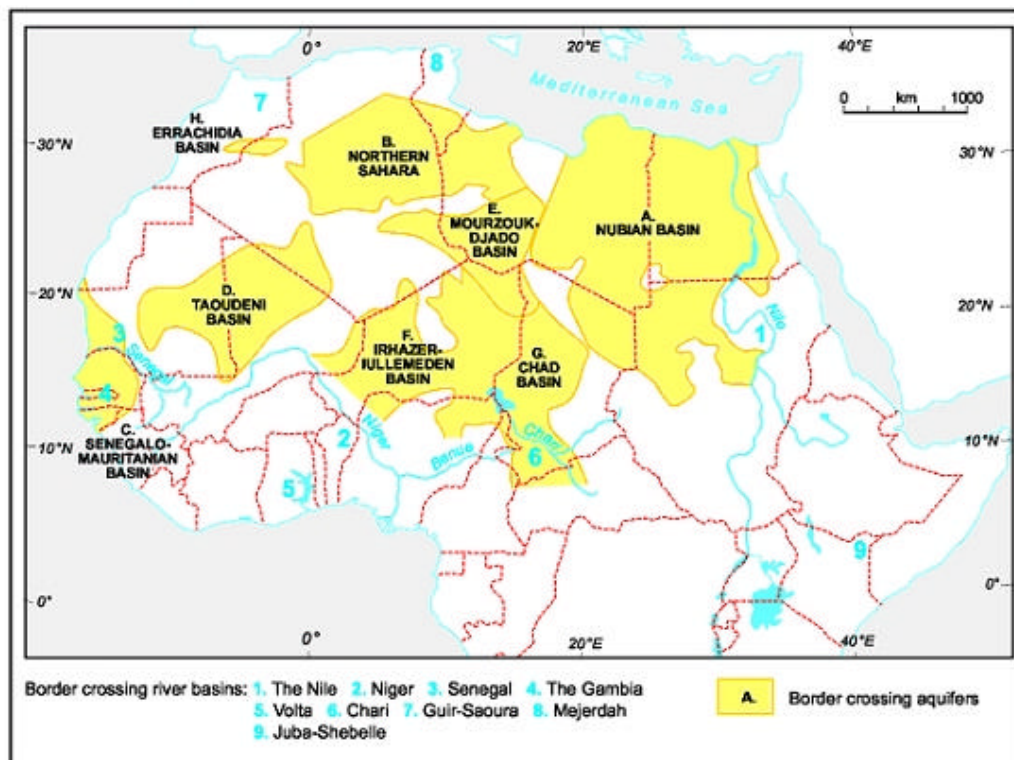


Figure 4 Transboundary aquifers in Northern Africa (OSS/UNESCO, 1997; UNESCO/ISARM, 2001).



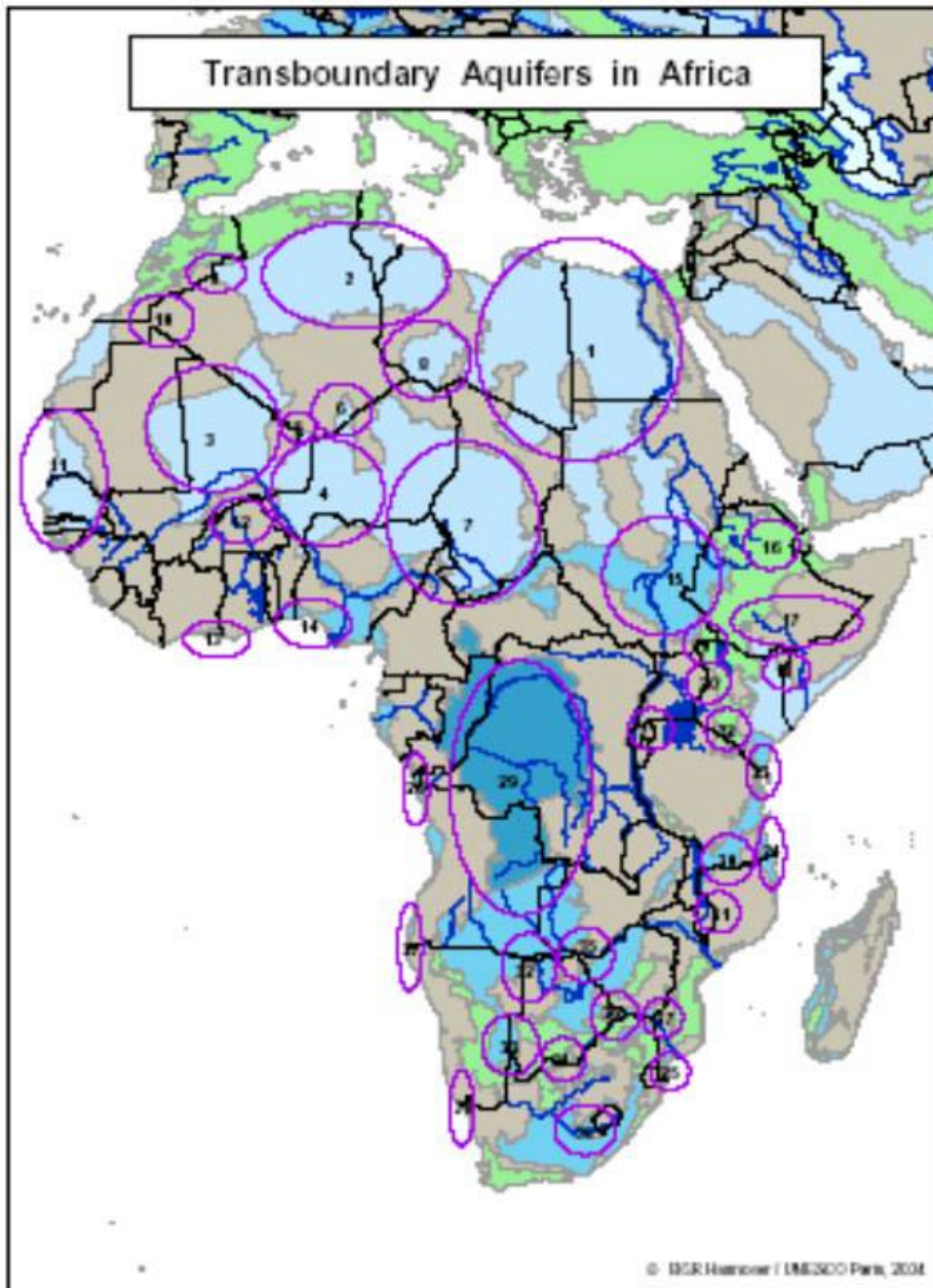


Figure 5 Transboundary aquifers in Africa (UNESCO/ISARM, 2004).

- A workshop was organised in cooperation with IAH in Cape Town, South Africa, from 20 November–1 December, 2000, with the aim of setting up a network in the South African Development Community (SADC) countries for enhancing the study and assessment of Southern African regional aquifers.
- A project proposal for the study and management of the Iullemeden Aquifer (Mali, Niger, Nigeria) was prepared for submission to the Global Environment Facility (GEF).
- An international workshop was organised, from 24 June, 2002, in Tripoli, Libya, by the General Water Authority of Libya with the aim of improving existing knowledge on African shared aquifer systems and preparing an inventory of case studies. As a result an inventory of about 40 principal African transboundary aquifer systems was published in 2004 (UNESCO/ISARM, 2004).

#### ***ISARM Americas***

- This part of the ISARM programme started in 2003. The first UNESCO/OAS ISARM-Americas Workshop was held in Montevideo, Uruguay from 24-25 September, 2003. Participation at the workshop was strong: twenty countries were represented, including Haiti and the Dominican Republic. A seminar was organised by the National Committee of Argentina for IHP and the University of Santa Fe (Argentina) from 29-31 August, 2001, on the transboundary aquifer systems in Latin America; particular focus was given to the Guarani Aquifer.
- XXII Brazilian Congress on Groundwater held in Florianópolis, Brazil, from 10-13 September, 2002.
- International Symposium on Transboundary Water Management held in Monterey Mexico from 18-22, November, 2002.
- The second UNESCO/OAS ISARM-Americas Workshop was held in El Paso, Texas USA in November 2004.
- Close cooperation has been established with the Organization of American States (OAS). A Letter of Agreement was signed with the OAS in September 2004 and a letter of agreement was signed with the UN Economic and Social Commission for Western Asia (UNESCWA) for the compilation of the transboundary aquifers of Western Asia.
- The compilation of an inventory for Asia is expected to start soon.

#### ***ISARM Mediterranean***

A project proposal on the "Sustainable Management and Protection of Internationally Shared Groundwater Resources in the Mediterranean Regions" has been prepared by UNECE-ESCWA and UNESCO for submission to the EU'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 organised in cooperation with UN-ESCWA in Beirut from 27-28 Feb., 2002. UNESCWA, with UNECE and UNECA and UNESCO/ISARM are currently cooperating on building capacity for transboundary aquifer management in the 10 MEDA countries.

#### ***ISARM South East Europe (SEE)***

A third phase was launched in the Balkans in 2003 by UNESCO/ISARM and the UNESCO Chair/International Network of Water-Environment Centres in the Balkans (INWEB). In close cooperation with the IAH/Transboundary Aquifer Resource Management (TARM) Commission, INWEB held a workshop in Thessaloniki in October 2004 to present and assess its results. INWEB also cooperated closely with UNECE: Working Group on Monitoring & Assessment, Switzerland to follow up the European inventory previously compiled by UNECE, as well as with UNESCWA, and the Observatoire du Sahara et du Sahel (OSS), for the Mediterranean inventory. The inventory of transboundary aquifer resources in the Balkans (Fig. 6) is available in a draft form on INWEB's web site ([www.inweb.gr](http://www.inweb.gr)) and will be published soon.



No	Name of shared aquifers	Countries involved
1	Dragonja	Slovenia & Croatia
2	Kupa	Slovenia & Croatia
3	Kupa	Croatia & Bosnia Herzegovina
4	Una	Croatia & Bosnia Herzegovina
5	Cetina	Croatia & Bosnia Herzegovina
6	Neretva	Croatia & Bosnia Herzegovina
7,8	Sava	Croatia, Bosnia Herzegovina & Serbia Montenegro
9	Backa & Banat	Croatia, Hungary & Serbia Montenegro
10	Srenj, Macva & Posava-Tamnava	Croatia, Bosnia Herzegovina & Serbia Montenegro
11,13	West Serbia	Bosnia Herzegovina, Serbia Montenegro & Former Yugoslav Republic of Macedonia
12	SW Serbia	Bosnia Herzegovina, Serbia Montenegro, Albania & Former Yugoslav Republic of Macedonia
14,20	Central Serbia	Serbia Montenegro, Former Yugoslav Republic of Macedonia & Romania
15	Zemen	Serbia Montenegro & Bulgaria
16,17,18	Gaver-Neska, Zhepole, Tran	Serbia Montenegro & Bulgaria
19	East Serbia	Serbia Montenegro, Bulgaria & Romania
21	Upper Pannonian/Lower Pleistocene	Serbia Montenegro & Romania
22	Middle Samatian/Pontian GWB	Romania & Moldova
23,24	Samatian, Upper Jurassic/Lower Cretaceous GWB	Bulgaria & Romania
25	Vjosa/Pogoni	Albania & Greece
26	Mourgana	Albania & Greece
27	Presepes	Albania, Greece & Former Yugoslav Republic of Macedonia
28	Galkica	Albania & Greece
29	Pelagonija/Florina catchment	Former Yugoslav Republic of Macedonia & Greece
30	Gevgelija	Former Yugoslav Republic of Macedonia & Greece
31	Lake Dojran	Former Yugoslav Republic of Macedonia & Greece
32	Sandansky-Pelitch	Bulgaria, Greece & Former Yugoslav Republic of Macedonia
33	Golze Delchev/Agistro-Onalos	Bulgaria & Greece
34,35	Nastan-Trigrad, Smolyan	Bulgaria & Greece
36,37	Rudozem, Erma Reka	Bulgaria & Greece
38	Sulengrad/Orestada/Edirne Alluvion	Bulgaria, Greece & Turkey
39	Meric/Evros Alluvion	Turkey & Greece

Figure 6 Location and names of internationally shared aquifers in the Balkans. (INWEB, 2004).

## 5. Conclusions

The importance of transboundary groundwater resources becomes most apparent when there is increased pressure for economic development and water related activities on either side of the border. Joint management of internationally shared aquifer resources is not only a scientific or technical problem. It should also involve joint institutions, common monitoring networks, information and data sharing and a common vision for sustainable development of the entire river catchment. The political linkages in transboundary aquifer management are important and involves wider regional aspects as “water for cooperation”.

Regional partnerships and networks involving decision makers, different scientific disciplines, stakeholders are important driving forces behind the promotion of innovative approaches and the development of effective action plans. In this sense UNESCO’s ISARM worldwide programme is important in order to demonstrate methodological approaches and how multidisciplinary can contribute to sustainable transboundary groundwater management. UNESCO ISARM plans to produce a tool-kit showing the best practices for achieving good results in the field.

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