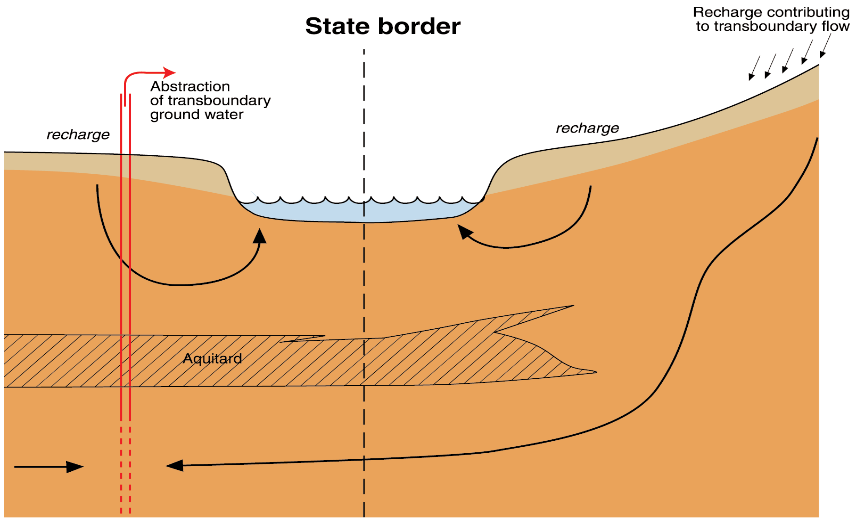
INTERNATIONALLY SHARED (TRANSBOUNDARY) AQUIFER RESOURCES MANAGEMENT

Their significance and sustainable management

A FRAMEWORK DOCUMENT



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A framework document

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Drafts of this document were discussed at international consultation meetings, including the XXX IAH Congress (Cape Town, South Africa, November 2000), ISARM Consultative Meeting (Santa Fe, Argentina, August 2001) and at the UNESCO/WMO Conference on Hydrological Challenges in Transboundary Water Resource Management (Koblenz, Germany, September 2001). The comments and opinions received have been incorporated.

The ISARM Programme is open for participation by interested parties through contacts with the Regional Offices of UNESCO and Regional Vice Chairmen of IAH.

Preface

This framework document presents a multi-annual work programme that responds to the challenges of shared water resources set out in the Declaration of The Hague Ministerial Conference (Ministerial Declaration of the Hague on Water Security in the 21st Century, The Netherlands, March 2000). Since the management of transboundary aquifers is a multidisciplinary and multidimensional issue, the document has been prepared for wide circulation and is addressed to a wide readership, but particularly to scientists, legal specialists, socio-economists, environmentalists and policy makers.

The purpose of this document is to summarise the current understanding of transboundary aquifers, demonstrate their significance in water resource management and to highlight the fact that as yet there is very little international experience in the approaches needed for their shared management. Unlike transboundary surface water and river basins, transboundary aquifers are not well known to policy makers. Present International Law does not adequately address the issues concerning spatial flow of ground waters and has limited application in conditions where impacts from neighbouring countries can be subtle to develop. Scientific correlation of the hydrogeology of such aquifers is often deficient and issues related to shared, sustainable production remain blurred because of poorly developed institutions and a lack of capacity and awareness. The ISARM Programme seeks to address these issues.

The ISARM Programme operates through a co-ordination committee drawn from UNESCO, FAO, UNECE and the International Association of Hydrogeologists (IAH). Each of these organisations provides a specific contribution to this multidisciplinary initiative aiming to improve understanding of scientific, socio-economic, legal, institutional and environmental issues surrounding the management of transboundary aquifers.

The Programme is expected to culminate in 2006 and to publish an inventory of Transboundary Aquifer Systems (TAS). This document illustrates some key issues that arise from case studies of Transboundary Aquifer Systems existing under diverse climatic and socio-economic conditions. The following aquifer systems are currently assessed and studied by national, regional and international organisations:

- the Guaraní Aquifer — South America
- the Nubian Sandstone Aquifers — Northern Africa
- the Karoo Aquifers — Southern Africa
- the Vechte aquifer — Western Europe
- the Slovak Karst-Aggtelek aquifer — Central Europe
- the Praděd aquifer — Central Europe.

Further analysis, reviews and recommendations are necessary. The IAH, FAO, UNESCO and UNECE joint response is the ISARM Programme, which aims at improving co-operation among the international scientific community and supports scientific institutions especially in developing countries.

The ISARM Programme was endorsed by the Intergovernmental Council of the UNESCO International Hydrological Programme (IHP), at its Fourteenth Session held in June 2000. The Sixth Phase of the IHP (2002–2007) entitled 'Water Interactions: Systems at Risk and Social Challenges' directs greater prominence to promote integrated and sustainable management of international river basins and groundwater resources systems (IHP-VI Theme 2, Focal Area 2.2 on International River Basins and Aquifers).

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1 INTRODUCTION

1.1 Why internationally shared aquifers are important?

While debates about the management of transboundary river basins have been taking place for many years (van Dam and Wessel, 1993), the same cannot be stated about transboundary aquifers. In the same way that there are internationally shared river basins, there are also internationally shared, or transboundary, groundwater resources hidden below ground surface, in all parts of the world. Some transboundary aquifers contain huge fresh water resources, enough to provide safe and good quality drinking water for the needs of all humanity for many tens of years. Groundwater, though not visible as surface water, is ubiquitous in the global landmass and is contained in the pore spaces of rock formations (aquifers). Its science, hydrogeology, has rapidly developed over the last 35 years, contributing to the well being and development of the human population in all parts of the globe (Burke and Moench, 2000).

Aquifer systems, due to their partial isolation from surface impacts, on the whole contain excellent quality water. In many countries these systems have been fully 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 waters, based on available international law and hydraulic engineering, is evident in all continents. However the hidden nature of transboundary groundwater and lack of legal frameworks invites 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 (Salman, 1999).

A clear need has been identified for an international initiative on Internationally Shared/ Transboundary Aquifer Resources Management. The International Association of Hydrogeologists (IAH) established a Commission to investigate the issue in 1999. A meeting of experts was held in parallel with the International Conference on Regional Aquifer Systems in Arid Zones – Managing non-renewable resources organised by UNESCO in Tripoli 20–24 November 1999. The results of the consultation indicated the need to create an international network supported by IAH, UNESCO, FAO and UNECE. Therefore with the support of UNESCO and IAH in co-operation with FAO and UNECE a meeting of experts was held at UNESCO in Paris 27–28 March 2000. As a result of the meeting a programme proposal for an international initiative on internationally shared/transboundary aquifer resources management (ISARM/TARM) has been tabled.

One of the drivers of the ISARM Programme is to support co-operation among countries to develop their scientific knowledge and to eliminate potential for conflict, particularly where conceptual differences might create tensions. It aims to train, educate, inform and provide inputs for policies and decision making, based on good technical and scientific understanding.

1.2 Increasing the knowledge of ISARM

While the groundwater component of the hydrological cycle is well understood, international water policy development suffers from inadequate knowledge about it. For example, the 1997 United Nations Convention on International Watercourses only refers to some ground waters, but not all (see later sections on Legal aspects). Consequently, integrated and holistic transboundary water resource management policies are constrained by this gap.

An important contribution to the improvement of knowledge has been made by the UNECE, which has developed guidelines for monitoring of such aquifers (UNECE, 2000). These 'Guidelines on Monitoring and Assessment of Transboundary Groundwaters' were prepared by the ECE Working Group on Monitoring an 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 meting (The Hague, Netherlands, 23–25 March 2000).

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992) includes important provisions on the monitoring and assessment of transboundary waters, the effectiveness of measures taken to prevent, control and reduce transboundary impact, and the exchange of information on water and effluent monitoring. Other relevant aspects deal with the harmonisation of rules for setting up and operating monitoring programmes, which includes measurement systems and devices, analytical techniques, data processing and evaluation techniques. Further needs for monitoring arise, because the Conventions aims to protect ecosystems, which may be closely connected with groundwaters and the protection of sources of drinking-water supply.

Monitoring and assessment 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 co-ordinated systems for surveillance and early-warning systems to identify outbrakes or incidents of water related diseases or significant threats of such outbrakes or incidents (including those resulting from water pollution or extreme weather). It also foresees the development of integrated information systems and databases, the exchange of information and the sharing technical and legal knowledge and experience.

The character of these Guidelines is strategic rather than technical. They are intended to assist EC governments and joint bodies in developing harmonised rules for the setting up and operation of systems for transboundary groundwater monitoring and assessment.

1.3 Selection of terminology

During the formulation of the ISARM Programme several consultations were undertaken with regional experts regarding the use of the terminology. The semantic connotations associated with the English terms 'transboundary' in some regions and 'internationally shared' in others may give cause for concern. Alternative terms such as 'regional aquifers', 'international aquifers' and 'multinational aquifers' were considered. Neither of these, however, provide the important conceptual issue of the dynamics of these aquifers, namely that 3-dimensional groundwater flow can take place from one side of a boundary to another and that this factor is of prime concern when dealing with management of the resources. Consequently 'transboundary' and 'internationally shared' are suggested.

In order to avoid the semantic concerns, the ISARM Programme has used these two terms interchangeably in this document. Further it has been agreed that due to local preferences the regional programme may be referred to using either of these prefixes.

1.4 Issues for multidisciplinary management

By its nature, the beneficial use of groundwater is more particularly subject to socio-economic, institutional, legal, cultural, ethical and policy considerations than surface water. Its national development seems to be hampered by weak social and institutional capacity, and poor legal and policy frameworks. In a transboundary context, this can be even further amplified because of contrasting levels of knowledge, capacities and institutional frameworks on either side of many international boundaries.

Whereas there are good examples of how such issues have been dealt with in managing international rivers, there is no equivalent body of knowledge for the management of internationally shared aquifers, the majority of which have not been inventoried. A recent UNECE survey of Europe (Fig. 1) has indicated that there are over 100 transboundary aquifers in Europe (Almassy and Buzas, 1999). Figure 2 shows the distribution of several major North African internationally shared aquifers underlying regions of acute water shortage. Sometimes knowledge gaps can constrain the beneficial use of these resources. At present, management policies for these shared aquifers systems have not been implemented, though in some transboundary aquifers such as the Guaraní aquifer, shared by Argentina, Brazil, Paraguay and Uruguay, a serious co-operative effort is underway through multilateral support.

The above observations suggest that there is a need to fill the gaps through multi-disciplinary assessment of internationally shared aquifers. In addition to the scientific, socio-economic and institutional and legal knowledge, attention should focus on such critical matters as capacity building, participation, raising awareness, investment and appropriate technology.

1.5 The features of transboundary aquifers

The key features of transboundary aquifers include a natural subsurface path of groundwater flow, intersected by an international boundary, such that water transfers from one side of the boundary to the other (Fig. 3). In many cases the aquifer might receive the majority of its recharge on one side, and the majority of its discharge would occur in the another side. The subsurface flow system at the international boundary itself can be visualised to include regional, as well as the local movement of water.

Very few international boundaries follow natural physical features, and water resources can cross them unhindered. For good management and fair share of these resources, scientists estimate the resources that cross these boundaries. In hydrogeological terms, these crossing resources can only be estimated through good observations and measurements of selected hydraulic parameters, analogous to the estimation process of other transboundary resources such as fisheries and wild-life, each requiring statistically sound observations.

Even where international boundaries may follow such features as rivers, the aquifers underlying them may not reflect the true transfer of groundwater flows from one side to another, as illustrated in Fig. 4.

In any legal agreements to be drawn up for the equitable share of transboundary resource, the initial stage must be the correct identification of flow and movement of water followed by its quantification. In reality, socio-economic pressures may have either already initiated withdrawal of water, or have such a priority that legal agreements cannot keep pace. Institutional weakness and political pressures may fail to address all the relevant issues, potentially leading to severe environmental impacts and unsustainable development.

1.6 The five focus areas of ISARM

The ISARM Programme has identified five key focus areas that require attention for sound development of transboundary aquifers (Fig. 5). These include the scientific-hydrogeological, the legal, the socio-economic, the institutional and the environmental aspects. This ISARM Framework Document is a preliminary overview of each focus area. No doubt there will be other issues, specific to regional conditions e.g. aquifers in arid zones with limited recharge or those in temperate regions with more reliable recharge. These are to be incorporated and developed through detailed case studies, involving multidisciplinary regional working groups.

A project logical framework of the ISARM Programme is shown at the end of this Document (Appendix II). A preliminary questionnaire is also included for completion by interested parties (Appendix III). During the course of this Programme an inventory of transboundary aquifers is to be compiled. Responses to the preliminary questionnaire may form the basis for such an inventory.

Figure 1. UNECE Survey of European transboundary aquifers

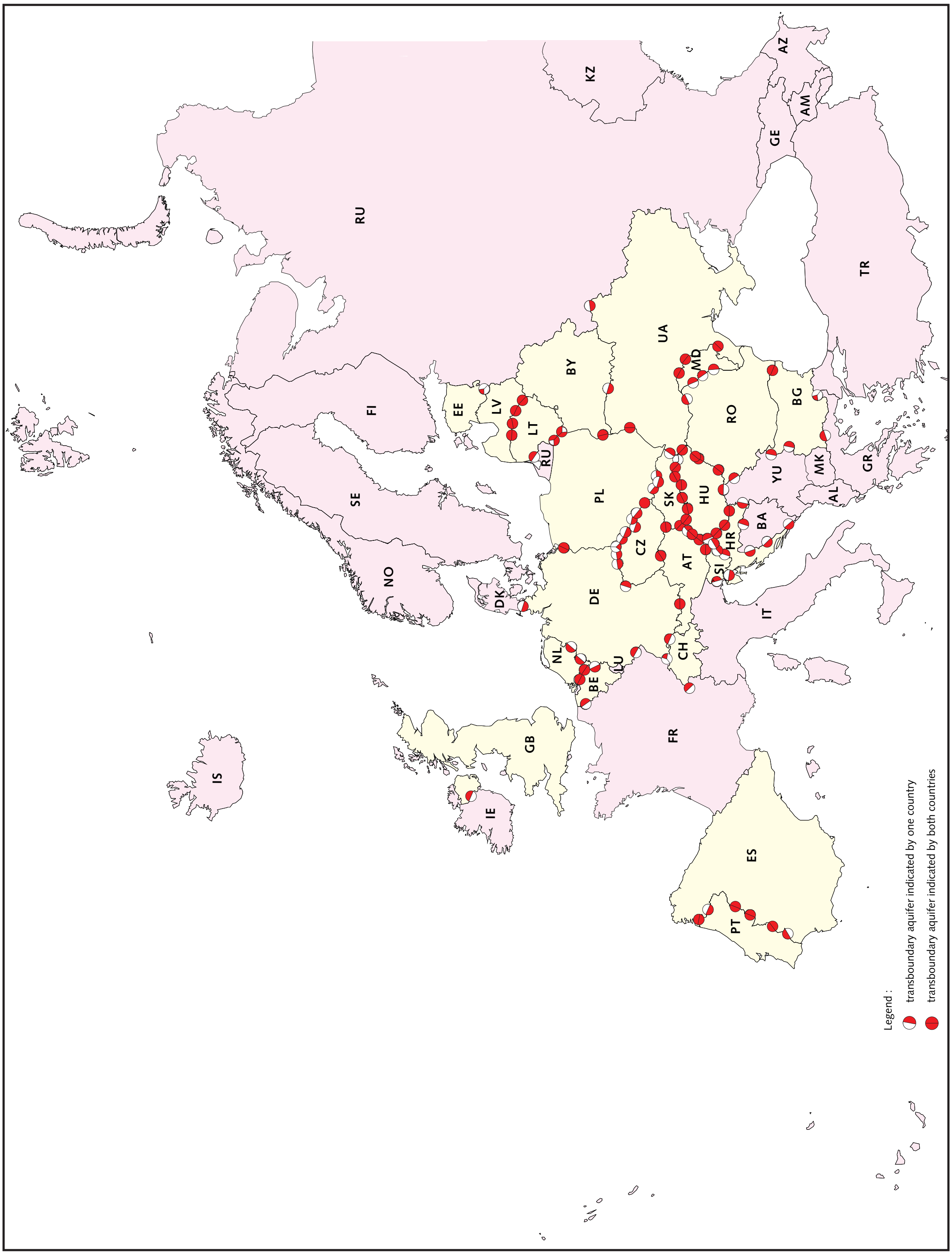


Figure 2. Internationally shared aquifers in northern Africa (redrawn from OSS and UNESCO, 1997)

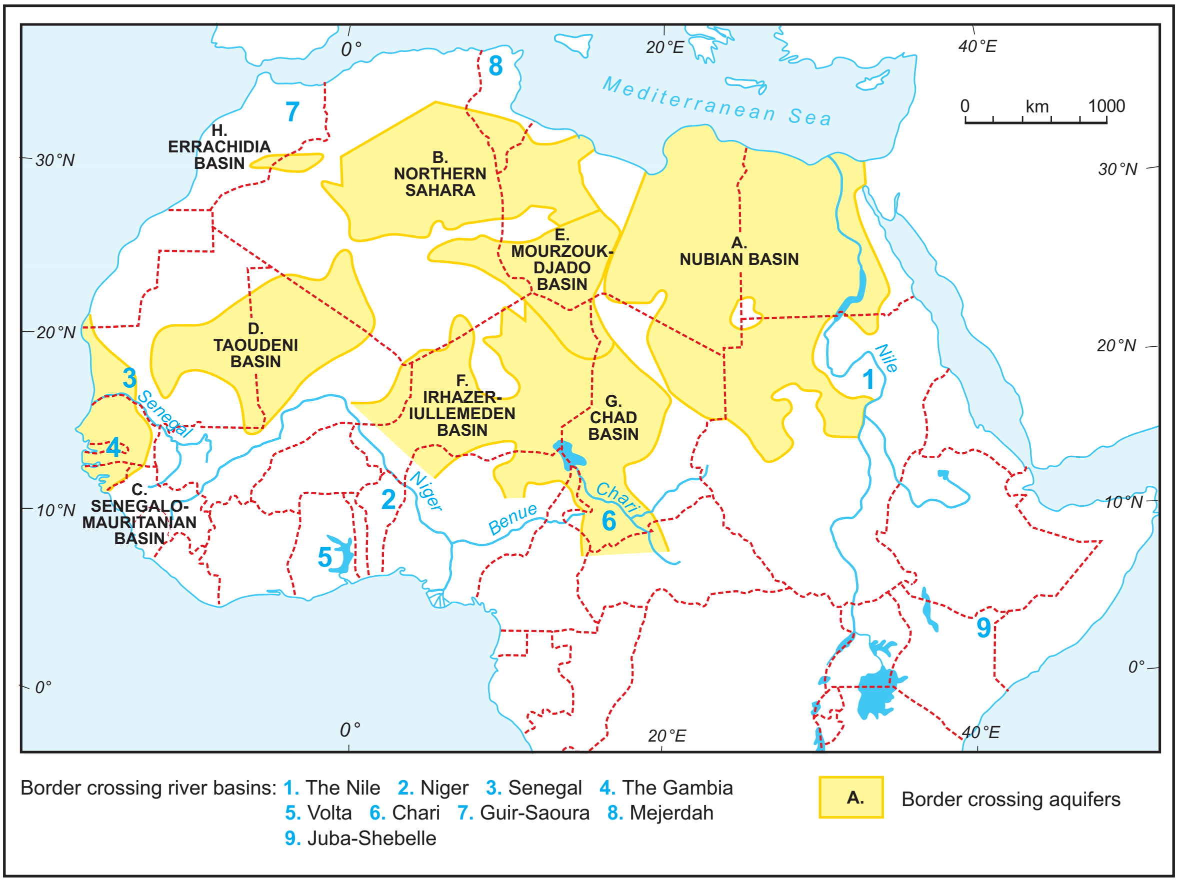


Figure 3. Schematic illustration of a transboundary aquifer

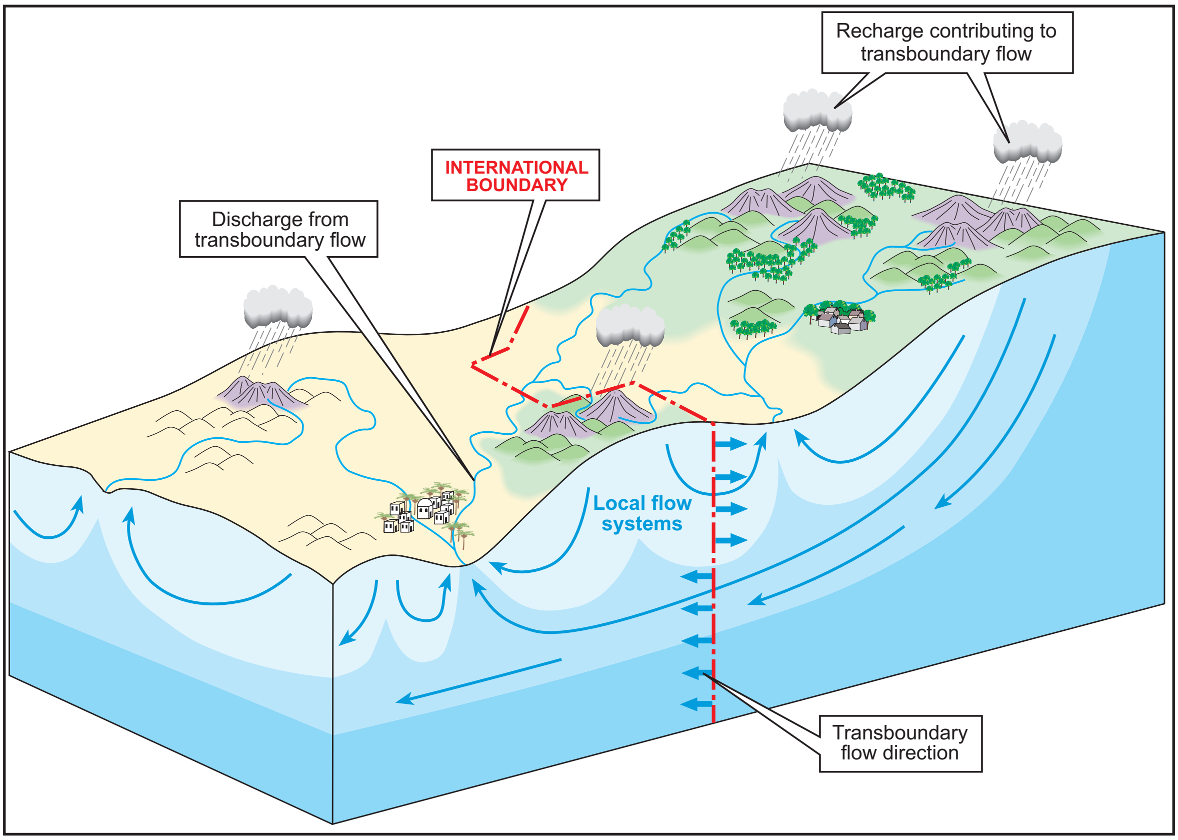


Figure 4. River boundaries over transboundary aquifers

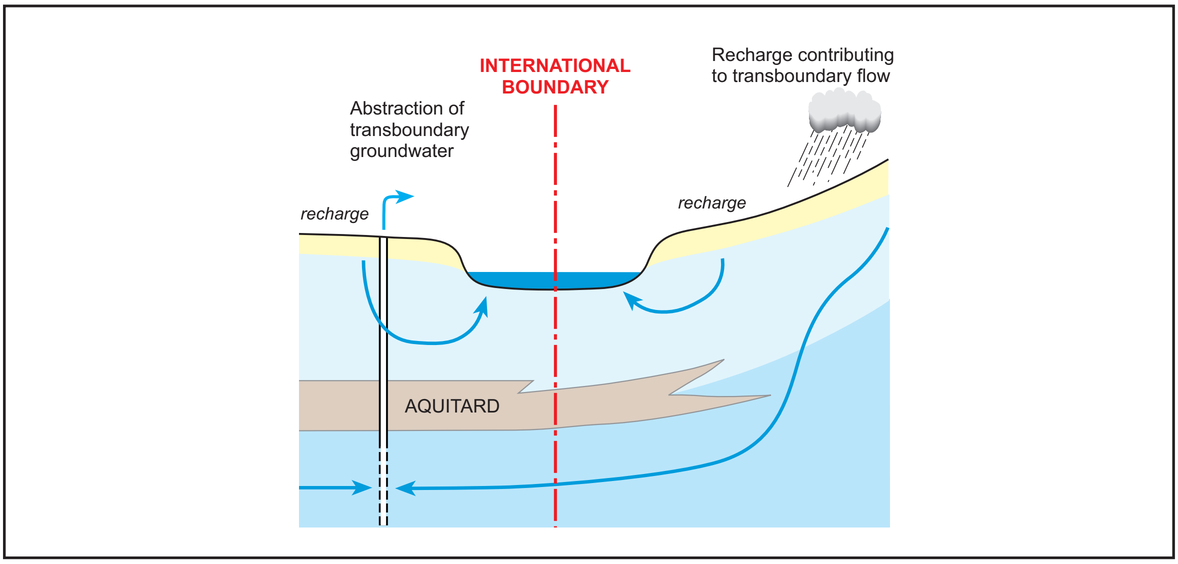
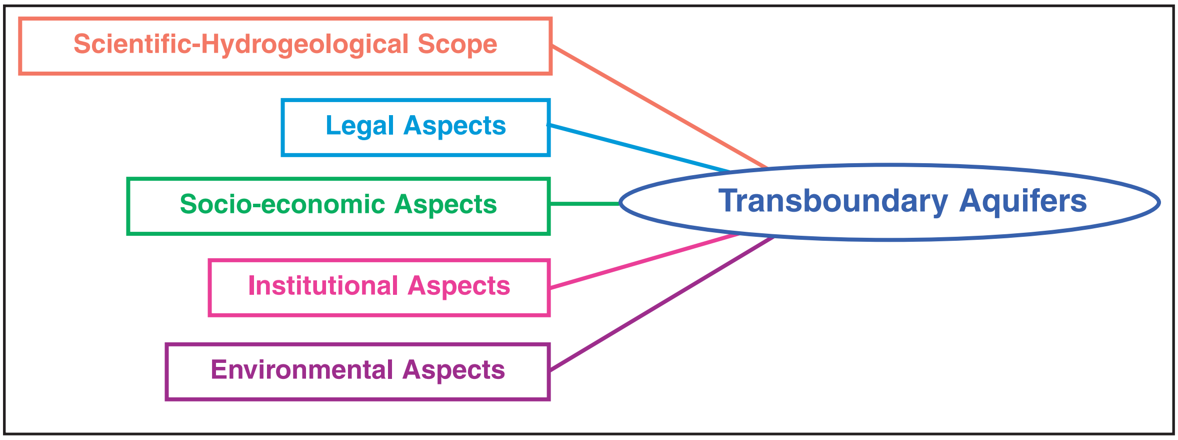


Figure 5. Focus areas of the ISARM Programme

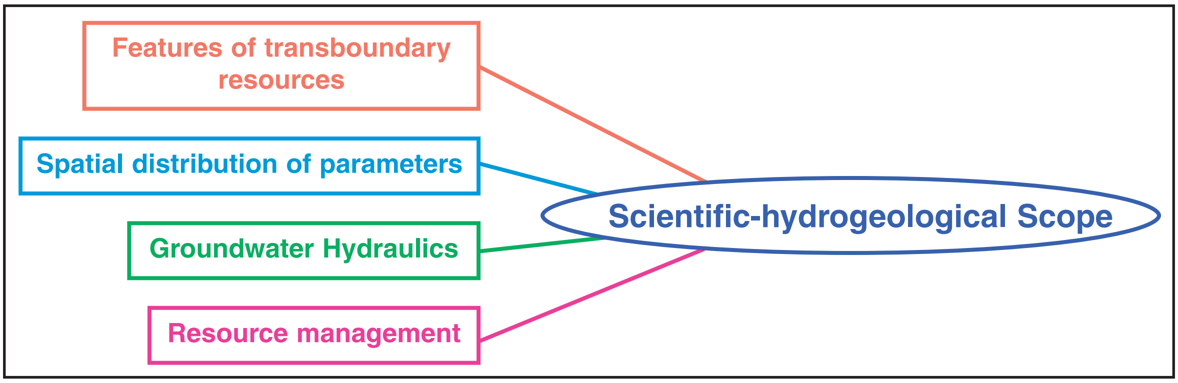


2 SCIENTIFIC-HYDROGEOLOGICAL ISSUES

2.1 Introduction

The scope of key scientific-hydrogeological issues, in considering the management of trans-boundary aquifer resources, is illustrated in Figure 6.

Figure 6. Scope of the scientific – hydrogeological focus



2.2 Identification of transboundary aquifers

The recognition of transboundary aquifers should lead to mutual international acceptance of an effective and equitable management of shared resources. In contrast to surface water, groundwater resource boundaries are often very poorly known and so many transboundary aquifers remain only partly recognised. Nevertheless, it is essential to view the entire aquifer system, including all aquifers that are hydraulically interconnected, directly by lateral or indirectly through vertical contact or through fractures and low permeability formations (aquitards).

2.3 Spatial distribution of parameters

Many factors may affect the behaviour and the development potential of aquifers, including:

- hydraulic parameters;
- rainfall and recharge zones;
- confined and unconfined areas;
- natural discharge zones;
- present and planned groundwater development zones;
- water quality, potential risks of its deterioration; and
- vulnerability to polluting agents.

In transboundary aquifers one or more of these factors may receive a different weighting on either side of a boundary. There are several examples of transboundary aquifers where recharge is received on one side while the natural discharges (and sometime better yields) are across the border. Examples of this condition are found in the Mountain Aquifer extending over Israel and Palestine (W.R.A.P., 1994) and in the Iullemeden aquifer extending over Niger, Nigeria, Mali, Benin and Algeria. The Iullemeden main aquifer consists of Mesozoic continental deposits outcropping along the northern and eastern periphery of the basin. Recharge is almost entirely taking place in the south-eastern outcrops in Nigeria where the rainfall exceeds 500 mm per year. A significant part of the discharge area is in Niger, in humid valley bottoms and in the river Niger itself (UNESCO's IHP Working Group on Iullemeden Aquifer System Project; A. Dodo, 1999). In the Guaraní over 1000 mm of rainfall occurs in the outcrop areas of Brazil, while discharge partly takes place in Uruguay (J. Montaño et al., 2001).

2.4 Groundwater hydraulics that may have international implications

Water abstraction from an aquifer transforms and re-organises the groundwater flow in proportion to the piezometric adjustments induced. This has a number of practical consequences, which are explained below.

2.4.1 Modification of the groundwater flow pattern

Groundwater flow passing an international boundary cannot be measured directly. It is estimated from parameters and calculated through mathematical models. Abstraction on one side of the border may alter the flow through the border. An example from Northern Sahara Aquifer System (UNDP/OPE, 1983) (Fig. 7) illustrates this:

- the underground outflow of the deep aquifer (Continental Intercalaire) is a source of recharge for the coastal aquifer (Jifarah aquifer);
- additional development from the deep aquifer in Algeria only would reduce the outflow to the coastal aquifer by 5%;
- the development scenario was selected to minimise the impact of Algerian development on the Tunisian coastal aquifer.

Siting and pattern of production from wells in transboundary aquifers can be planned to ensure equitable share of the resources.

2.4.2 Modification of the piezometric surface

Groundwater abstraction from wells results in modifications of piezometric heads in the form of a concentric cone of depression. Cones of depression may spread beyond international borders. A model simulation (Fig. 8) of the Nubian Sandstone Aquifer System illustrates the possible long term impact. Modelling foresees that in case of intensive use of the aquifer in the South Western part of Egypt, by the year 2060 the cone of depression might spread in all directions and particularly upstream towards Sudan, into an area where no development is anticipated so far (CEDARE/IFAD, Program for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System).

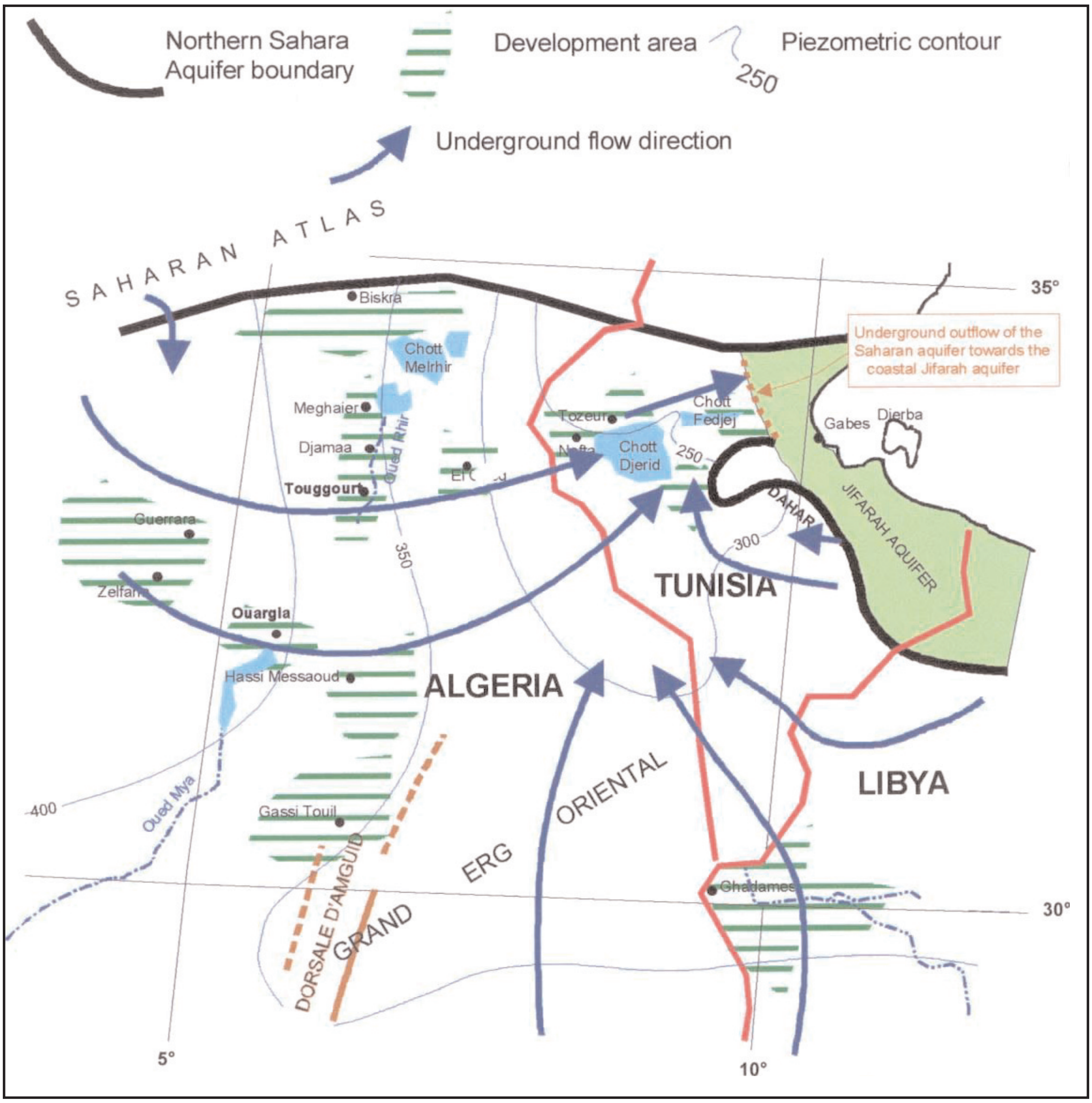
2.4.3 Deterioration of the water quality

Water quality deterioration may take place as a result of development. Poorer quality water from the coastal area or inland saline water bodies can be mobilised, as a result of groundwater abstraction. The impacts could be transmitted from unilateral actions in one of the countries sharing the transboundary resource (Fig. 9).

Vulnerability of aquifer is higher when groundwater moves through formations where large interconnected fractures or cavities are present and encourage rapid flow as in the case of the karstic aquifers (Margat, 1992).

A model simulation, conducted under an IFAD funded project, can illustrate the possibility of mobilisation of poorer quality water. Figure 10 shows a simulation of the possible impact that might be generated in case of additional extraction in Siwa (Egypt) and eventually new development in Jaghbub (Libya). The saline water contained in the aquifer, currently some

Figure 7. Northern Sahara Aquifer System



20–25 km north of Siwa, would probably migrate towards the development areas, essentially towards Siwa.

Quality deterioration from vertical leakage can also occur. In arid regions some topographic depressions favour evaporation of groundwater due to high piezometric levels and create sabkhas containing poor quality water. Production from deeper better quality aquifers will result in reversal of leakage and invasion by poor quality water.

2.4.4 Pollution

Human activities at the ground surface, e.g. landfill of waste, can result in aquifer pollution. The polluted groundwater from one side of an international boundary can travel to the other. Once polluted, aquifer cleanup is slow and expensive, the detection of its sub surface distribution can also be expensive.

One of the differences between surface and groundwater resources is the time needed to detect pollution. In the aquifer systems impacts generated by the present generation may be detected by the future generations.

Figure 8. Possible scenario of the spread of the cone of depression (model simulation)

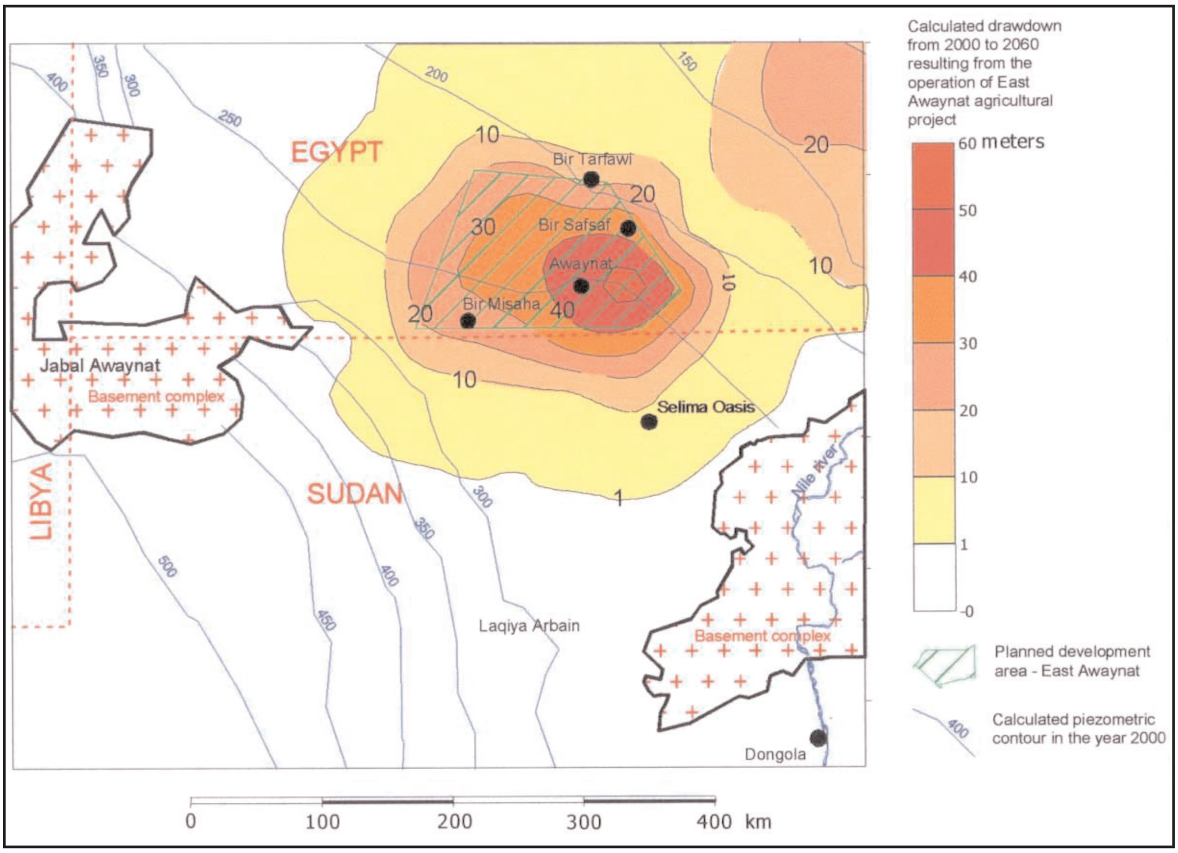
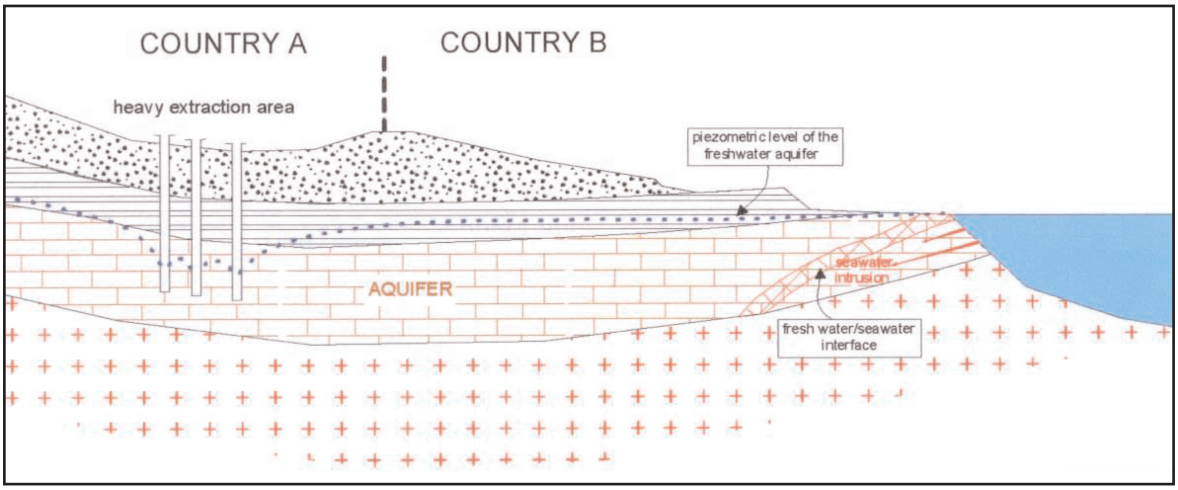


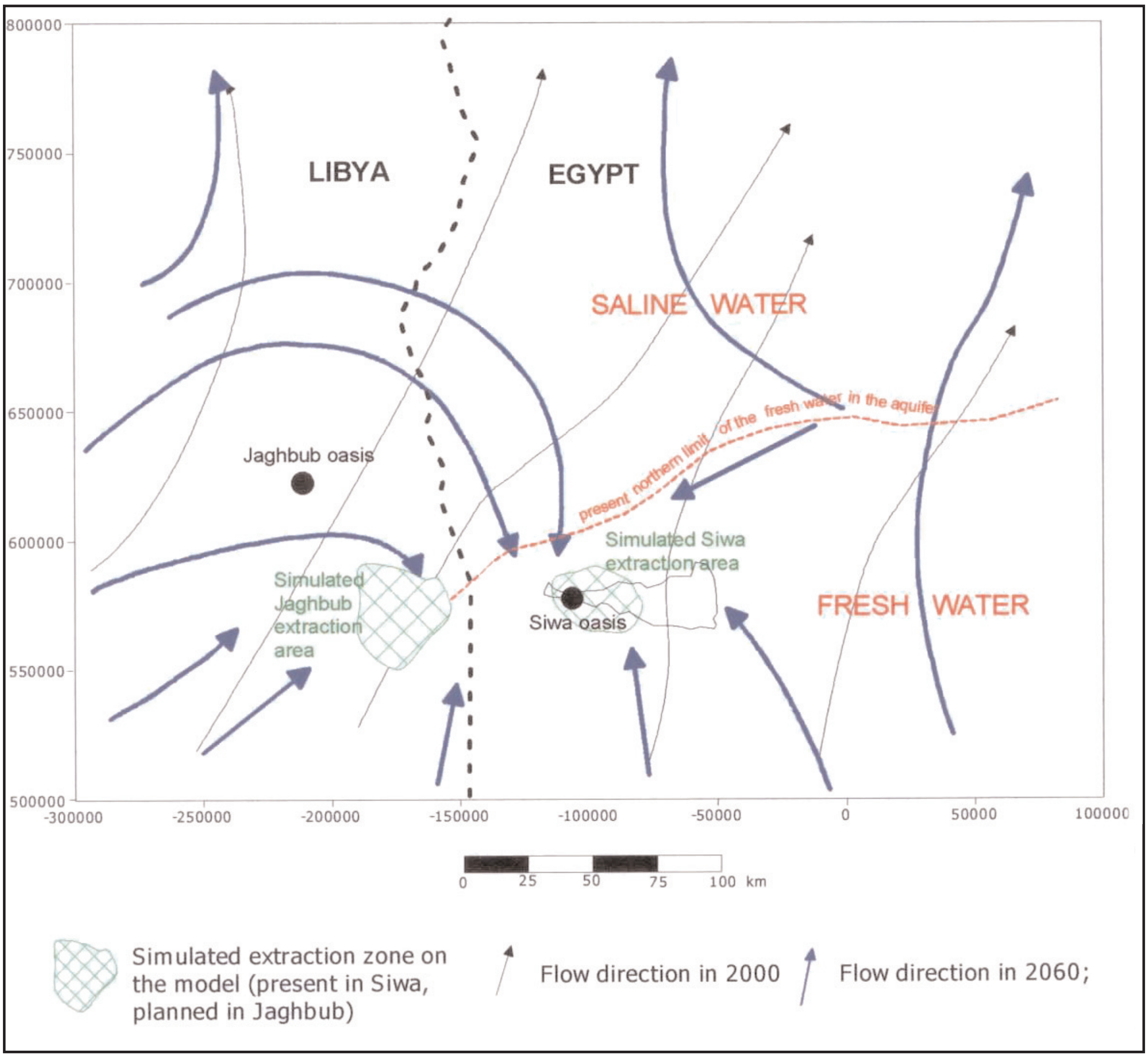
Figure 9. Impact of saline intrusion from transboundary production



2.5 Some transboundary aquifer management issues

The sustainable management of water resources requires a multidisciplinary approach. But level of difficulties considerably increases in the case of the international river basins and aquifers (Kindler, 2001). Currently management of the resources in transboundary aquifers broadly follow the same rules as those for any national aquifer resource, driven by the national priorities. Whereas, for a shared resource the national priorities may have to be adjusted, to ensure equitable distribution.

Figure 10. Simulation of salinisation due to overpumping



2.5.1 Transboundary aquifer with contemporary recharge

In the case where the aquifer receives contemporary recharge, the global strategy consists of preserving natural outflows and of abstracting a volume equivalent to the average annual recharge. Such a strategy can only be achieved through joint management among the countries sharing the resource. Examples of this approach are given by the following ISARM Case Studies: the Vechte aquifer, the Slovak Karst – Aggtelek aquifer, and the Praded aquifer. A similar approach might be applied in the case of the Guaraní aquifer.

The practical application of the concept of sustainable development must be promoted further in the negotiations on transboundary water resources systems (Proceedings of the International Conference on Regional aquifer systems in arid zones – Managing non-renewable resources. UNESCO, 2001).

2.5.2 Transboundary aquifer with minor contemporary recharge

Transboundary aquifers with minor contemporary recharge, but large volume in storage, can be drawn on for limited time periods (UNESCO, 2001). The amount and rate of extraction by each country should be subject to multilateral agreements. The purpose of these agreements would be to ensure that each sharing country accepts the mutual effect – even if slightly detrimental – on its own resource, and of groundwater development in the partner countries.

Examples of transboundary aquifers with minor contemporary recharge are:

- Algeria, Tunisia and Libya sharing the Northern Sahara Aquifer System mostly developed in Algeria and Tunisia;
- Libya, Egypt, Sudan and Chad sharing the Nubian Sandstone Aquifer System developed only in Libya and Egypt;
- Egypt and Israel sharing the Nubian Sandstone aquifer in Sinai and Negev; and
- Saudi Arabia and Jordan sharing the Saq aquifer (Puri et al., 1999).

In all these cases, no substantive formal agreement exists so far, but studies are in progress, sometimes sponsored by international organisations (IFAD) to establish the basis of agreements regulating the groundwater extraction in each of the concerned countries.

The role that the regional United Nations Economic and Social Commissions could play in strengthening regional co-operation is very relevant.

2.6 Prerequisite to sound management of transboundary aquifers

The UNECE survey of transboundary aquifers and other studies have confirmed the need for having a unified and consistent knowledge base as a prerequisite for the management of transboundary aquifers. Ideally this should be developed within a conceptual model of the whole transboundary aquifer, providing a firm foundation that supports sound development through risk based management. Determination that a particular rate of groundwater withdrawal or general management plan is sound depends on in-depth understanding of the groundwater system.

This understanding begins with knowledge of basic hydrological processes. Relating this to specific situations requires understanding of the extent and nature of the aquifer, how it relates to other aquifers and hydrogeologic features, how the recharge and discharge of water takes place within the aquifer, and where potential sources of contamination are located.

Without such understanding the use of a transboundary aquifer cannot be confidently planned. This conceptual model should be augmented by a consistent programme on both sides of a boundary to monitor basic hydrologic parameters, such as precipitation, groundwater levels, stream flow, evaporation, and water use. The monitoring programme will provide the data essential to generate a quantitative perspective on the status of the groundwater system and to validate the conceptual understanding. The data must be consistent with the conceptual model. If not, the conceptual model may need to be revised.

Good and reliable information is crucial to facilitate co-operation among aquifer stakeholders. All stakeholders should have easy access to good, reliable data on abstractions, water quality, aquifer water levels. Current information technology allows information to be made available to an unlimited number of users easily and economically (Ramón Llamas, 2000).

With such an approach it should be possible to establish mutually accepted rules, adopted by all parties, based on a holistic definition of the aquifer system and principles of equivalence of impacts of abstraction.

3 LEGAL ASPECTS

3.1 The need for legal agreements

Current mounting concerns for the quality of groundwater resources and for the sustainability of withdrawal rates of groundwater reserves take on a distinctive political connotation when groundwater flows across an international boundary of States and become, as a result, a ‘shared’ resource. Sensitivities about sovereignty, the diversity of legal and socio-political systems and different national agendas make for a complex scenario. This is compounded by the fact that none of the internal groundwater laws and institutions of the sharing countries, can provide rules of governance acceptable to all. Consequently such rules must be found elsewhere, i.e., in treaties and agreements between or among the concerned sovereign States or, failing such treaties and agreements, in the consistent practice of States.

Agreement on rules of good governance required for the development, management and protection of the shared aquifers has not yet been reached in any of the case studies illustrated by this document. However, it is recognised that an agreement would be the ultimate goal pursued by the countries sharing the Nubian Sandstone Aquifer System (NSAS) (Chad, Egypt, Libya, Sudan), the North-western Sahara Aquifer System (best known by its French acronym as SASS) (Algeria, Libya, Tunisia), and the Guaraní Aquifer (Argentina, Brazil, Paraguay, Uruguay), as they co-operate in intensive, joint data collection (NSAS, SASS, Guaraní) and environmental management (Guaraní) projects underway.

3.2 Existing rules of governance

There are very few treaties and agreements providing rules of governance for the development, management and protection of shared groundwater resources.

The Canton of Geneva in Switzerland and the Department of Upper Savoy in France concluded in 1977 a convention on the protection, utilisation and recharging of the Geneva aquifer they share. The convention provides for a joint commission composed of six members (three Swiss, three French), of who at least four (two of each State) are experts in water matters. The commission prepares an annual plan for the use of the groundwater resource and proposes measures to protect it against pollution. Furthermore, it gives advice and approval on the construction and modification of new and existing abstraction equipment. Since the Geneva aquifer is artificially recharged, the commission also verifies the costs of constructing and operating the artificial recharge station. A complete inventory of all pumping installations is maintained and the amounts of water to be withdrawn are limited and recorded with metering devices. Finally, the quality of the water withdrawn from and recharged into the Geneva aquifer is regularly analysed. Due to this extensive system of control the commission is always informed on the quantity and quality of the groundwater supply and hence it appears that it can plan the withdrawals from and recharges into the aquifer with a considerable accuracy.

The intensity of co-operation reflected in the Geneva/Upper Savoy convention and the far-reaching obligations and arrangements also reflected in it, are the exception.

On a less ambitious scale, Mexico and the United States of America reached agreement in 1973 on specific volumetric limitations annually on groundwater pumping in the territory of both, within eight kilometres of the Arizona-Sonora international boundary. The agreement further requires the two countries to consult each other prior to undertaking any new development or substantial modification of either surface or groundwater resources in its own territory in the border area that might adversely affect the other country. The agreement was facilitated by, and was reached within the framework of, the Mexico–United Statesof America International Boundary and Waters Commission (IBWC). The Commission, consisting of two separate sections located in the twin border cities of Ciudad Juárez, Mexico and El Paso, Texas and each headed by a Commissioner, has been in existence since 1944. The groundwater resources in the border area of the two member countries have been progressively brought within the scope of the Commission's remit. As a result, short of a comprehensive treaty or agreement dealing with the groundwater resources Mexico and the United States of America share along their frontier, a well-tested bilateral institution is available to address authoritatively groundwater problems as they arise on either or both sides of the border.

Other agreements exist, notably in Europe, covering groundwater resources within the larger framework of co-operation in the management and protection of border rivers, or in the development of border rivers. In these agreements, however, groundwater plays a marginal role.

3.3 Rules and principles that apply

The joint data collection projects underway in the NSAS, SASS and Guaraní aquifers bear also evidence of the participating project countries' implied concurrence with, and acceptance of, at least one fundamental obligation of international water law stemming from the practice of States in relation to shared water resources, namely, the obligation to exchange on a regular basis available data and information on the shared water resource. In addition, the behaviour of those same States could arguably bear testimony to the general obligation not to cause significant harm, insofar as the joint data collection projects they are currently engaged in, have sprung from the perception that unilateral development could work harm across the border. These two fundamental State obligations are also borne out of the few agreements in which groundwater plays a marginal role, mentioned earlier.

In addition to these fundamental obligations, the Mexico–United States of America groundwater border pumping restrictions agreement and the Geneva-Upper Savoy convention on the Geneva Aquifer bear out one other fundamental tenet of international water law stemming from the practice of States in relation to shared water resources, namely, that each State has a right to a reasonable and equitable utilisation of the waters of a shared water resource. In addition, the Mexico-United States of America agreement carries an explicit prior consultation clause, which bears out yet another fundamental obligation of international water law stemming from the practice of States, namely, the obligation to notify other States in advance of planned measures.

These fundamental rights and obligations of international water law, which stem from the consistent practice of State giving them the force of law, can be found stated – or 'codified' – in the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses, adopted by an overwhelming majority of votes at a specially convened session of the United Nations General Assembly on May 21, 1997. It should be noted that the United Nations Convention has not entered into force yet, for lack of the required number of ratifications. Another well-known and authoritative 'statement' of the rules of international water law is the so-called Helsinki Rules adopted by the non-governmental International Law Association (ILA) in 1966, as subsequently complemented by specific Groundwater Rules adopted by the Association in 1986.

3.4 Gaps in existing legal regime for transboundary aquifers

There is some controversy as to whether the fundamental right to a reasonable and equitable utilisation and the fundamental obligations not to cause significant harm, to exchange on a regular basis available data and information, and to notify other States in advance of planned measures are equally applicable to deep, confined or 'fossil' shared groundwater resources which are cut off from any significant recharge and to groundwaters which, being interconnected to a surface water system, show appreciable recharge. Whereas 'fossil' groundwaters do not come within the scope of the United Nations Convention, the drafters of the Helsinki Rules and of the subsequent Groundwater Rules thought otherwise and brought them within the fold of both sets of Rules. Again, in this regard too the practice of the States sharing the NSAS and the SASS aquifers – both of which are deep, 'fossil' groundwater resources cut off from any significant recharge – is significant. For arguably, the joint data collection projects underway bear out, and are evidence of, the co-operating States' perception of the fundamental obligations to exchange on a regular basis available data and not to cause significant harm as surely applying to the 'fossil' groundwater resources they share across their respective international boundaries.

3.5 Further development under the ISARM Programme

Since the behaviour of extensive regional aquifers in contrast to that of regional river systems is dominated by time and space, there is a need to review the available legal and customary rules and principles. There are also significant differences among aquifers (recharged – non recharged, confined – unconfined, quality affected by saline intrusion – vertical leakage, etc) requiring the legal rules to be coincident with the principles of scientific hydrogeology. Development of rules that may apply should be through further careful analysis of evolving state practice. Drafting of treaties and international agreements cannot be completed without a careful assessment of among other factors, the domestic, legal and institutional practices and rules of their long term impacts. Under the ISARM Programme legal specialists will work within the multidisciplinary teams to give guidance and advice on these important issues.

4 SOCIO-ECONOMIC ASPECTS

4.1 The state of groundwater development – competition for resources

Declining water levels in unconfined aquifers, loss of formation pressure in confined aquifers, changing leakage and boundary conditions and migration of poor quality water are signs of growing competition for groundwater. Together with increased pumping costs, these effects are impacting domestic economies such that physical, social and economic consequences are being pushed beyond national boundaries.

The hydrogeological settings where such impacts become apparent are zones of existing or planned intensive agro-industrial development, often focused on the same product. With aquifers straddling international boundaries, or where alluvial aquifers along the course of a shared watercourse are exploited, downstream resources may be impacted. Groundwater pollution externalities form agricultural, industrial and municipal development, including waste disposal, that spread across international boundaries are another symptom of these intensifying patterns of groundwater and aquifer use.

The core of the issue is that groundwater presents many opportunities and advantages for national development and, in many regions of the world, groundwater represents a reliable and flexible source of freshwater, upon which people have become increasingly dependent. The development of groundwater has significantly enhanced local productivity by making the resource accessible to a wide range of individual users. Mechanised boreholes have allowed this access to be on demand and just-in-time. However, the social, economic and environmental systems dependent on groundwater are under threat from over-abstraction and pollution. It is important to recognise that this has been a recent but rapidly expanding phenomenon. Cheap and reliable mechanised borehole pumps were only introduced in post-Second World War period and the scale and intensity of the abstraction and pollution have only been apparent in the last quarter of the 20th century. Prior to this, groundwater was seen as a ubiquitous and reliable source of high quality water. As groundwater abstractions from increasingly deep aquifers grow, the 'footprint' of the associated drawdown externalities is now extending beyond national boundaries.

4.2 Driving forces

Population growth, concentration in urban areas, combined with economic transition and international trade liberalisation represent recent and rapidly emerging driving patterns of natural resource use. Most economies, which have moved towards market orientated means of natural resource allocation, have seen rapid economic growth. In many cases higher water productivity associated with groundwater use has been instrumental in sustaining economic development and national food security, but often also at high social and environmental cost.

As a result, the patterns of use and consumption of groundwater are changing and intensifying to the extent that countries sharing common aquifers are effectively competing for these systems (their water, hydraulic status and quality of the aquifer material). However, at the same time as the productivity improves, pressures on the prime (and usually strategically important) aquifer systems grow with the attendant risks of unplanned depletion and environmental degradation.

4.3 Nature of competition

The points of competition over internationally shared groundwater and aquifers are not always obvious and may only become apparent when exploitable groundwater has been exhausted or damaged beyond economic 'repair', limiting the capacity to support current and future social and economic use. Equally, where there is considerable economic asymmetry between or difference in development opportunities in neighbouring countries, the ability of one country to capture a common property resource from another by virtue of its financial and technological strength may result in a more or less deliberate 'race to the pump house'.

In many instances these patterns of groundwater and aquifer use are driven by domestic development policies and uses that do not recognise the physical and environmental limits of shared aquifer systems. This is particularly the case where agricultural and land-use policies have short-term distributional or economic objectives. However, the political realities of maintaining rural employment and food production for export earnings may block attempts to introduce progressive groundwater management reforms. Equally the impacts of development take time to become apparent or are not easily predicted making it difficult to justify mitigating measures in purely economic terms.

4.4 Governance issues

In the current situation of lack of international legislative framework or well defined property rights, riparian states may have to rely on voluntary actions, or limited bi- or multilateral agreements or 'soft' institutional arrangements where internationally shared aquifers are an issue. Given the insistent high level of input subsidy and price support mechanisms for many staple food crops still practised in many developed and developing countries, there are few incentives to curb use of energy, fertilisers and pesticides. Therefore, for this type of co-operation to work it is important to adopt a broad approach with co-operative frameworks that recognise, harmonise and take necessary precautionary steps, and secure efficient management of social risk, on the social, economic and food security policies and the needs of the individual economies and of the region as a whole. However, these types of multi-objective 'agreements' are difficult to implement with any degree of certitude. Shifting and less co-ordinated socio-economic policies and priorities make effective groundwater management an elusive target and the risk of inappropriate groundwater development is never far away when imperatives and incentives to produce are so entrenched.

On a more positive note, the profile of regional governance is raising and is focusing on 'good' aspects like development, economic security and stability. There are new problems emerging that can only be solved collectively drawing on common cultural backgrounds of the countries in a region. Also the perceptions of international management are enhanced and new thinking is emerging on how to approach global issues. There are also gaps, such as: the jurisdictional gap, the participation gap and the incentive gap (ODI, 1999).

4.5 Conclusions – opportunities for joint management

As drawdown externalities (in all their aspects) become more and more apparent at national and international level it is important to go beyond simple national water balance considerations and address complete transboundary systems. The role of macro-economic policies, particularly those related to food security, in driving patterns of groundwater use bear careful examination and point to the need to harmonise natural resource management approaches across shared aquifers. These may require methods of implementation that are substantially different from those deployed for shared surface waters since they will involve engagement with a diffuse array of groundwater users on either side of the international boundary. In addition the precise quality of local groundwater dynamics do not present easily understood and quantified limits to use.

Recharge calculations may vary by orders of magnitude and leakage conditions through an aquifer system can change rapidly as soon as water is taken out of storage rather than out of flow.
Reconciling this with broader macro-economic linkages – including total water balance at international levels (including virtual or traded water, for quantity and quality) – will take a degree of sensitisation from the politicians and the technicians to the socio-economists, but it will also need flexible application. A co-operative framework could for effectiveness sometimes be focused on joint risk management rather than on a more far-fetched precautionary approach, and it will need to be tolerant to national priority policies to enable well monitored development of the joint resources for economic security and civil stability of individual countries and regions.

5 INSTITUTIONAL ISSUES

5.1 Introduction

A comprehensive institutional response to acknowledged transboundary aquifer management problems has not yet emerged. There are no institutions that can equate to such bodies as the Rhine Commission or the Chad Basin Commission. Multilateral finance agencies have barely started to include ground water in basin wide projects (e.g. the Nile Basin, the Limpopo basin and the Aral Sea basin). Shared groundwater tends to be flagged as part of a river basin commission mandate – however, groundwater cannot be subject to the same type of strict input-output controls that govern flows in shared watercourses, as demonstrated in earlier sections of this document. Given that groundwater management is subject to a range of generally 'soft' regulatory measures, the hard question in situations of regional water scarcity where countries need to develop and benefit from the international water resources, is whether critical international water issues, including water allocation, can continue to be delayed and left to insecure and lengthy processes of negotiation, voluntary actions and collective decisions. What is the alternative if any? Are the only management approaches 'soft' or is invoking the precautionary principle (i.e. no development) the only option in some cases? The framework and accountability of the institutional mechanisms to reconcile these matters can be pivotal in sound, equitable management of resources.

5.2 From domestic to international management

Domestic management arrangements for implementation of international agreements may be severely handicapped for managing shared aquifers. Closely related to the valuation and competition issues, the distribution of groundwater resources and its use creates major challenges for management and the institutional arrangements for implementation. Extraction points are generally dispersed and groundwater conditions often depend on the decisions of numerous individual land and well owners. Large aquifers can, however, extend across multiple geographic, administrative and political regions. In this situation, local agencies generally have little hope of influencing regional groundwater conditions through isolated actions under their direct control. While, inter-country dialogue may be primarily driven by regional development and the role of regional markets, the local patterns of use and opportunities for effective management are more likely to be a function of local needs and solidarity. The institutional mechanisms that will deal with transboundary aquifers issues therefore need to differentiate between the domestic management regime and that required for international management.

In this overall context, some form of regulatory management, whether imposed by the government, user based organisations or through informal social mechanisms is essential to maintain public control and implement international commitments at the domestic level. The role regulation can play is, however, specifically conditioned by socio-economic and cultural circumstances and the configuration and status of the aquifers being used. In some transboundary aquifers individual users may be widely dispersed, or belong to different local administrations. Direct regulation of individual users by government is often politically and practically impossible. Furthermore, management will need to vary at local to regional scales in order to reflect both social and hydrogeological factors. In many cases, much more adaptive approaches to local resource management involving a high level of participation are essential based on enhanced economic and cultural co-operation at bilateral and regional level and in related border areas.

It is important to recognise, however, that many types of management (such as the control of pollution from concentrated urban or industrial sources or management to address localised pumping depressions) can be effective even without co-ordination at a larger scales. This points to the need for institutions charged with groundwater management to work in concert with legal and regulatory frameworks that both enable local populations to develop management approaches suited to regional conditions and provide avenues for higher level interventions to address the actions of large individual consumers or polluters. This may need to be emphasised and pursued as a priority co-operation issue at the regional level and include transboundary impacts for which joint management of a shared aquifer becomes essential.

Practical examples of management

The Kansas State (United States of America) Groundwater Management Districts Act is the enabling legislation for all groundwater management districts in Kansas. This act stipulates the process required to form a Groundwater Management District (GMD), funding and operational authorities and both specific and general direction for all activities either required or eligible to be undertaken. It is important to note that this act makes it a policy of Kansas that local land owners and water users be allowed to determine their own destiny in regard to groundwater management issues as long as they do so from within a legally formed and operated GMD.

5.3 Legal and ethical dimensions

Ethical issues affect management and influence the way in which transboundary management can be achieved. In some societies groundwater is or has been linked to land ownership, while in others it is viewed as a 'common heritage' permitting everyone to equal access, for at least basic needs (FAO, 2001). These conflicting positions may be enshrined in religious doctrines such as the Shari'a (where the 'right to quench thirst' is a basic principle) and in western legal concepts rooted in the early Roman idea of groundwater ownership following land ownership.

Regional ethical concepts are critical for management of shared resources. In the Arab region water is a free natural resource that should be made available not only for basic needs but to farmers to meet the social and development demand for each country, to guarantee cultivation of agricultural products. All steps towards 'commercialisation' of water resources are considered as unethical (AOAD, 1997). At the same time, rights of access to groundwater have generally been linked to land ownership. There is, thus, often an unclear distinction between the 'private' nature of groundwater rights and 'public' ownership of the resource itself. This contradiction is brought to the fore by increased recognition of the need for water to be used more efficiently. How efficient management is to be achieved, the sets of social objectives against which efficiency is measured (including maintenance of supplies for the poor and the environment), what sections of society play a role in decision making and what management mechanisms are used, all touch deep ethical roots and can become points of tension. This type of issue – as with many issues in society – may have no fundamentally correct answer but may be more apparent across international boundaries than the technical problems of agreeing how to share a common property resource. Such debates are, however, central to developing the social consensus on which political decisions regarding groundwater depend. This is why water law systems tend not to adhere to philosophical neatness but devise pragmatic balances between the investment needs related to the economic features of water and the need for public regulation associated to the social and environmental dimensions of the resource.

Considerations on ethical issues in relation to groundwater development and/or mining
M. Ramón Llamas

Some arid regions have very small amounts of renewable water resources but huge amounts of fresh groundwater reserves, like for example the existing reserves under most of the Sahara desert. In such situations, groundwater mining may be a reasonable action if various conditions are met: 1) the amount of groundwater reserves can be estimated with acceptable accuracy; 2) the rate of reserves depletion can be guaranteed for a long period, e.g. from fifty to one hundred years; and 3) the environmental impacts of such groundwater withdrawals are properly assessed and considered clearly less significant that the socio-economic benefits from groundwater mining.

(Paper published in the Proceedings of the International Conference on Regional aquifer systems in arid zones – Managing non-renewable resources, Tripoli - Libya, 20–24 November 1999. UNESCO TDH 42, 2001.)

5.4 Conclusions

Institutional, cultural and ethical dimensions are likely to be as important as technical and macro-economic dimensions in the evolution of approaches to address existing and emerging international groundwater problems. Sharing basic data and information on internationally shared aquifer systems and the projected demands are clearly important, but so too is the joint promotion of effective management.

International water issues are too important to be left to local participation and the market. An important institutional issue for management of internationally shared aquifer systems is therefore the scope of regional co-operative frameworks, broadly scoped social and economic communities, versus basin and aquifer commissions. Regional economic bodies could be mandated and have capacity to:

- act from the authority of political economy;
- set policy and guidelines for water management in the region;
- integrate water and economic issues into the regional economy;
- mitigate and compensate for externalities and negative impacts of regional policy on individual member states as well as the environment; and
- monitor effectiveness and compliance with water management and environmental standards at regional and national level.

Individual governments and the economies in a region do not form single entities but are collective in nature, and decisions represent balanced negotiated outcomes acceptable to sectors and executive, legislative and judicial powers. These facts call for introduction of alternative approaches to economic analysis in international water management, to maximise the positions of individual states and then use the agglomerated result for well-informed negotiations.

6 ENVIRONMENTAL ISSUES

6.1 Introduction

The environmental issues that affect transboundary aquifers are wide ranging and can be viewed both from a local and a global perspective. The main concerns addressed here will be developed further in the context of the ISARM case studies.

6.2 Sustainable development of transboundary aquifer resources

If the conventional definition of sustainable development, i.e. 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' can be applied to aquifers within a nation, then there is no reason why the same cannot be applied to transboundary aquifers.

However the broader socio-economic notions of sustainability and 'sustainable development' remain relative across nations, despite the wealth of thought and publications on the subject. The Commission for Sustainable Development uses a framework for defining acceptable withdrawal of groundwater. The framework, which is on 'driving force-state-response' indicators (UN DPCSD, 1996), suggests that withdrawal quantity should be relative to either 'available water', or to 'groundwater reserves'. In some situations this steady state mass balance approach is too restrictive. Recently work on the 'vulnerability' of aquifer systems to pollution and other impacts points to the appropriateness of source vulnerability indicators rather than state-response indicators (Robins, 1998; WWAP, 2001).

The World Water Assessment Programme (WWAP) of the United Nations system has undertaken the task to develop groundwater resources indicators. A first presentation of the elaboration of the indicators will be contained in the World Water Development Report (WWDR) that will be presented at the Third World Water Forum in Kyoto in March 2003.

In sustainable management of transboundary aquifers, problems such as groundwater overdraft will often emerge gradually. If they are identified and actions initiated to address them early, joint action may cause little social disruption. If, on the other hand, joint responses are delayed until major problems arise, massive social disruption may be unavoidable. In a scenario where to return groundwater use to sustainable levels, extraction needs to be drastically reduced, the resulting social disruption will be politically difficult and socially unacceptable.

Sustainable development of transboundary aquifers requires making predictive analyses involving the use of computer modelling techniques, to define the life of the resources. A holistic conceptual understanding of the groundwater system is the basis for the proper construction of a computer model. Real and relevant hydrologic features of the groundwater system must be correctly incorporated into the model. Furthermore, all models need to be calibrated using real and consistent data. The results of the monitoring program provide this validation check. The more sophisticated tools and methods of analysis that can indicate sustainability are built on a foundation of conceptual understanding and monitoring.

Determining the sustainability of a transboundary aquifer with any degree of confidence can only be conducted in a resource planning context having detailed information and understanding. Ultimately, though, resource development policy involves tradeoffs. Most aquifer systems have ecosystems, landscape elements, or pre-existing water users that are dependent on current discharge or recharge patterns. Further development may require trading off these dependencies in favour of new plans or policy. If dependencies are not well understood or considered, management changes may have major unanticipated impacts. The best approach to minimise negative outcomes is to follow the progression of investigation outlined above.

6.3 Biodiversity

Examples of ecosystems that depend partly or totally on groundwater are numerous. There is often no inherent conflict between preservation of these ecosystems and withdrawals from transboundary aquifers for socio-economic development.

Since an aquifer system is essentially below ground, biodiversity issues generally relate to the regions where aquifers discharge through rivers, lakes or swamps. Such water bodies frequently have specific characteristics, related to the physical and hydrochemical features of the aquifer that create special ecosystems (Gilbert et al., 1997).

In many regions, but especially arid regions, discharging groundwater fed water bodies can be absolutely critical to the maintenance of biodiversity. Even in temperate climates, the discharge region of a transboundary aquifer can provide specific conditions of quality, temperature and nutrients that rare species will be reliant upon.

In Tunisia, in the Ichkeul National Park, the Ichkeul Lake and related swamps rely partly on groundwater discharge to provide seasonal fluctuations in salinity, which ranges from low levels in winter up to 30–40 g/l in summer. The conditions are essential for maintaining potamogeton-bird, swamp-bullrush-geese, fish and fishing ecological compartments and their relationships. The Azraq lakes in Jordan are another example of a surface water body supported by the transboundary flow in aquifers. These lakes are an important stopover and watering point for annually migrating birds. In recent years with the strong abstraction of ground water, the lakes size has reduced drastically thus having a serious impact on the transmigratory routes for birds.

Discharge of transboundary groundwater into inland seas e.g. the Caspian and the Aral, supports important marine ecosystems. In Azerbaijan, discharge from the alluvial aquifers of the river Kura, which rises in Georgia and flows to Armenia, maintains an important sturgeon fishery. Aquifer over abstraction and excessive fertiliser application in the irrigation areas of these countries have had negative impacts on the quality of groundwater flowing to the coastal areas, where natural feeding areas for sturgeon have been impacted.

6.4 Climate change

The impact of climate change on transboundary aquifers of the world is yet to be fully evaluated in the same way as it has been for agriculture and land use. In some regions climate change will result in increasing recharge and in others reducing. The consequences of either of these impacts on abstraction, maintenance of wetlands, discharge to water bodies could be very serious, especially where well developed infrastructure has been established. Global sea level changes, may impact marine saline intrusion – the hydraulic reference point change could mean that many aquifers may extend inland intrusions, thus affecting groundwater quality.

As stated earlier, aquifer response to stimuli such as climate change will be even more gradual than those resulting from human intervention. The detection of these impacts will require a very careful analysis of data. For transboundary aquifers, the need for consistent data and a comprehensive conceptual understanding is essential.

The earlier discussion about aquifers with and without contemporary recharge is relevant to climate change. The approaches that have been developed for managing non recharging aquifers may need to be revised in the context of climate change. Conversely, aquifers currently being recharged, may suffer 'surcharges' due to increased recharge. This could have an impact on existing infrastructure such a building with deep foundations. Swamps, wetlands and lakes that are supported by aquifer recharge may extend in area, possibly flooding surrounding infrastructure, such as roads and highways, etc. These impacts could be gradual and problems may not be noticeable until damage has occurred.

6.5 Poverty alleviation, water and health

The role of transboundary aquifers in poverty alleviation and health is linked to socio-economic development. In under developed economies, low levels of awareness of this linkage seems to hinder the provision of aquifer resources to alleviate water shortages to the under privileged, especially the rural populations. Since water, sanitation and health go hand in hand, provision of drinking water to rural populations could relieve them of the worst incidences of drought and the related deprivation. The current development of national Poverty Reduction Strategy Papers being developed under World Bank and other Development Agencies, need to stress this issue, where large shared resources are available but unused. Transboundary aquifers that are subject to pollution through excess application of agro-chemicals, e.g. in many regions of the Former Soviet Union, and other impacts such as industrial waste, lock the poor into a cycle of poverty and ill health, related to their use of poor quality water for drinking or irrigation.

6.6 Conflict prevention

The United Nations has initiated a major programme devoted to prevention of water related conflicts. This has been embodied in the World Water Assessment Programme (WWAP), which responds to the challenges formulated at the The Hague Ministerial Conference of March 2000 (Appendix IV). The UNESCO IHP VI also incorporates two themes related to conflict resolution and prevention especially in shared water resources. By their very nature transboundary aquifers have to be at the centre of conflict prevention and resolution. Some estimates have suggested that nearly 300 water bodies cross international borders and 47% of the worlds land area overlaps with an international freshwater basin (Samson and Charrier, 1997). While at present there are few known conflicts concerning transboundary aquifers, there are many signs of discord regarding them, particularly in areas where resources are limited. The WWAP project titled 'From Potential Conflict to Co-operation Potential' (PC-CP), which has recently been initiated will have a significant linkage with the ISARM Programme.

Conflicts, relative to transboundary aquifers may be couched in terms of competition, confrontation or disputes. A scale of interrelationships in competition for natural resources may be presented as shown in Table 1.

Conflict resolution and prevention can take several routes, among them:

- Awareness building;
- Multi-sectoral partnerships;
- Integrated assessment and management;
- Implementation of sustainable strategies.

One of the aquifers most known as a case of conflict is the Mountain Aquifer system shared by Palestine and Israel. Other aquifers over which some conflicts have arisen include the Guaraní in South America.

The ISARM Programme aims to provide scientific inputs to assist in the process of resolution and prevention mentioned above.

Table 1. Scale of interrelationships in competition for natural resources

Harmony	An ideal state, achieved in sparsely populated regions with ample resources per capita
Institutional mechanism	Very few of these can be found for transboundary aquifers, the exception being the Geneva - Upper Savoy Agreement
Informal mechanism	Various forms of co-operation such as personal contacts among governmental officials, academia, etc
Tension	Movement towards formal conflict, low level government profile
Diplomatic action	Formal act, or protest concerning specific issues
Open dispute	Diplomatic acts supported by open heated debate. Linkage to other issues
Armed conflict	Violent though isolated conflict
War	Highest level of potential conflict strongly correlated to water

6.7 Ethical development of transboundary aquifers

An UNESCO Working Group on the ethics of freshwater use reported on its activities in June 2000 (Llamas et al., 2000). A major output of the working group was a declaration of ethical principles for water management. Although this declaration concerns all waters, it can be made specific to transboundary waters as well. The key underlying statement is drawn from the universal Declaration of Human Rights and it states that 'every human being has the right to life sustaining resources, including water for drinking, food, industry and well being'. Access to safe drinking water and sanitation, as well as, water for economic development is essential for alleviating poverty and sustaining peace and stability.

In the application of these principles to transboundary aquifers, it is clear that water resources that pass through a country are to be utilised and developed ethically – they should not be knowingly abused such that human beings, be they in the country of the development or outside of it, may suffer.

Ethical principles should be adopted when transboundary resources are devoted to multiple use of water, in the situation of natural and humanitarian disasters such as droughts, irrigation, and agriculture, industrial and municipal use. The links between water and ecology need to be directly maintained.

Groundwater withdrawals from paleowater bodies, or very slow recharging aquifers, can be considered under specific conditions, given that no other resources can be mobilised to respond to the need of the present generation (UNESCO, 2001).

6.8 'Exotic' uses: CO_2 sequestration, disposal of waste, thermal artificial storage and recovery (ASR)

In addition to transboundary aquifers that hold fresh water resources, there are also similar aquifers that contain water, which may not be suitable for consumption, containing saline water. Several such aquifers occur in the world, some in coastal regions and some in marine conditions. Utilisation of these 'aquifers' for several exotic purposes is possible, though still on an experimental basis (Puri and Edworthy, 1986). The best known example of trials are in the North Sea, where Statoil, the Norwegian oil company is testing the disposal of liquefied CO_2 in deep aquifers (Saline Aquifer CO_2 Storage project). To date 2 million tons of CO_2 has been injected into the Utsira Sand reservoir, at Sleipner. The capacity of the submarine aquifer is enough to retain the annual liquefied CO_2 emissions from 2,340 gas fired power stations, each of a magnitude of 500 MW (Chadwick et al., 2001). Disposal of other naturally biodegrading wastes can take place in certain transboundary aquifers, provided joint management and monitoring takes place.

Some transboundary aquifers could also be utilised for artificial storage and recovery of water (e.g. the Geneva–Upper Savoy aquifer). This can be extended to other uses such as thermal energy (Roth et al., 2001) as exemplified in the German Austrian co-operation for the Regensburg – Linz region, in which thermal energy is used by both sides equitably. A jointly developed mathematical model could help in ensuring adequate recharge. Although the travel and recovery times of these systems is bound to be 'long', in terms of long term global sustainability, these approaches need the serious attention of the international community.

7 MAJOR OUTCOMES OF THE ISARM PROGRAMME

7.1 International inventory of shared aquifers

Following on from the experience of the UNECE, the ISARM Programme will facilitate a network of specialists and experts, who will compile an international inventory of transboundary aquifers also mobilising contributions from UNESCO's IHP National Committees. A good start has been made, as exemplified by the case studies included in this document.

An example of preliminary questionnaire is included at the end of this document (Appendix III). This questionnaire should preferable be completed in co-ordination by representative of the countries sharing the aquifer system and returned to the IHP National Committees (http://www.unesco.org/ihp_db/nat_committees/search_free.asp) or to Regional IAH Vice Chairmen (http://www.iah.org). Further guidance for its completion and electronic versions, can also be requested from the contact addresses given there.

7.2 Development of a toolkit

This Framework Document has stressed in several places the lack of experience in the management of transboundary aquifers in contrast to surface resources. The document has also emphasised the considerably more complicated nature of aquifers, compared to surface waters, due to their 'hidden' nature. It would therefore be of considerable value to develop a 'toolkit' that might consolidate the best practices, guidance and information on transboundary resource management. The toolkit might provide indications for a management approach of transboundary aquifers. It will present lessons learnt from case studies, wise practices and guidelines. While it is too early for a detailed design of such a toolkit, Table 2 presents what could be its main components.

Table 2. Main components of the toolkit package

Toolkit package	*Main components*
Scientific	Guidance for the development of reliable conceptual models
Legal	Guidance on legal frameworks for negotiation of agreements
Institutional	Guidance on responsibility and powers of institutions engaged in joint management
Socio-economic	Guidance on the current and forecast needs for population, industry, agriculture and environment
Environmental	Guidance on development of an EIA, covering biodiversity, climate change, ethical use

The objective is to set out each package within the toolkit so as to consider the multidisciplinary aspects related to transboundary aquifer systems. It would provide valuable suggestions to support the 'joint – owners' of the resources in the achievement of a common platform for each of the focus areas of transboundary aquifers.

8 CASE STUDIES: SUMMARY PROFILES

EUROREGION PRADĚD, CZECH – POLAND SHARED AQUIFERS

Prepared by Z. Boukalova and R. Roszkowski

Background

The alluvial aquifer system is shared by the Czech Republic and Poland in catchments draining northward to the Baltic Sea that belongs to the Odra River basin. There are two hydrogeological units:

- Crystalline complex with fissure permeability;
- Intergranular glacial-fluvial sediments (sands, gravel sands, gravels and clays).

The area represents one of the most attractive and valuable natural reserves of both countries. However, it is also characterised by the impacts of quite inappropriate human interventions into the hydrogeological regime.

Significant issues

Wide deforestation and intensive agriculture and industry on the Czech side of the locality is causing erosion and consequently an increase of surface runoff, especially to the Polish lowland area and creating potential floods.

Water quality

Groundwater flow direction is from SW to NE, i.e. from the Czech to the Polish side. Contamination of the ground and surface water has serious risks for the wells drawing on the aquifer in the Polish side. The majority of the potable water for the Polish side is from the aquifer.

Potential sources of pollution from the Czech territory

- Illegal waste disposal;
- Lack of sewerage system for waste water discharge of the towns into the land.

Beneficial uses of the aquifer

In case that the contamination of groundwater occurs, the Polish water supply sources would be irrecoverably damaged and a completely new system will have to be established, which would require a large amount of finances.

Anticipated focus of the case study

Integrated land and water management

In 1998 a Secretariat of the Euroregion Praděd began activities to deal with the common land and water management of the area and make sure that all legislative, historical, ecological and human aspects of the area development are respected and all possible conflicts of interest of the Czech–Polish border area will be solved. Euroregion Praděd includes approximately 60 municipalities on the Czech side and 13 on the Polish side. The total area of the Euroregion Praděd is 3,300 km^2. The Czech part comprises 1,600 km^2 and the Polish part 1,700 km^2.

THE NUBIAN SANDSTONE AQUIFER SYSTEM (NSAS)

Prepared by O. Salem and P. Pallas

Background

The NSAS consists of a series of aquifers laterally and/or vertically interconnected, extending over more than 2,000,000 km^2 in East Libya, Egypt, Northeast Chad and North Sudan (Fig. 11). The main components of the NSAS (Fig. 12) include:

- Palaeozoic continental deposits;
- Mesozoic continental deposits, pre-Upper-Cenomanian;
- Post-Eocene continental deposits in hydraulic continuity with the underlying low permeability formations.

The aquifer system extends over the whole Nubian Basin, although becoming very saline in the northern part. South of the 26th parallel the aquifer is unconfined. Here the yields are the best and drawdowns from wellfields are not extensive.

Major recharge took place in the last pluvial period and at present there is slow discharge from the aquifer system, while it responds to the current climatic conditions.

Water resources and beneficial uses

Data collected in the framework of the IFAD funded programme on the NSAS made it possible to estimate the amount of fresh water stored in the two aquifer systems. Following the results of this study it is possible to envisage different scenarios considering different options of the water resources development. The main results of this fresh water resources assessment are shown on Table 3.

Most of the present water extracted from the NSAS is used for agriculture, either for large development projects in Libya or for private farms located in old traditional oasis in Egypt (New Valley). However, an important project designed for transporting water to the coast from the NSAS is under development in Libya and is already supplying some 70 Mm^3/yr of water to Benghazi and to the major coastal cities west of Ajdabyia. From the figures displayed on Table 3 it appears that the present extraction represents only some 0.01 % of the estimated total recoverable freshwater volume stored in the NSAS.

Significant issues concerning the NSAS

The large groundwater development projects planned in the southern part of Egypt and Libya within the Nubian basin are not expected to induce any significant effect beyond the common border between the two countries. The different options of water resources development can influence the amplitude of the cone of depression, such as the cone of depression that may be extended beyond the Egyptian-Sudanese border over some 50–70 km that could be expected to be generated if particularly intensive water extraction is realised in the South-western part of Egypt.

In the North, the groundwater development in Siwa oasis from the deep aquifer (Nubian) is close to the fresh water/salt water interface and increasing the present abstraction may draw saline water into the fresh water aquifer. The development of a well field in Jaghbub area, located in Libya in a symmetric position of Siwa referred to the border line, would probably augment the risk of deterioration of the water quality in the Nubian aquifer.

An IFAD funded project is assessing the regional implications of various groundwater development scenarios based on the NSAS and will propose consultation mechanisms for a joint management of the water resources including the systematic data exchange on groundwater extraction and on water level and water quality fluctuations.

Table 3. Essential data of the Nubian Sandstone Aquifer System

	Nubian system (Palaeozoic and Mesozoic sandstone aquifers)		*Post Nubian system (Miocene aquifers)*						
Country	*Area (km^2)*	*Fresh water volume in storage (km^3)*	*Area (km^2)*	*Fresh water volume in storage (km^3)*	*Total volume of fresh water in storage (km^3) 1*	*Total recoverable groun-dwater volume (km^3) 2*	*Present extraction from the Post-Nubian system (km^3)*	*Present extraction from the Nubian system (km^3)*	*Total present extraction from the NSAS (km^3)*
Egypt	815,670	154,720	426,480	97,490	252,210	5,180	0.306	0.200	0.506
Libya	754,088	136,550	494,040	71,730	208,280	5,920	0.264	0.567	0.831
Chad	232,980	47,810	–	–	47,810	1,630	–	0.000	0.000
Sudan	373,100	33,880	–	–	33,880	2,610	–	0.840 3	0.833
Total	2,175,838	372,960	920,520	169,220	542,180	15,340	0.570	1.607	2.170

– Not applicable
1. Assuming a storativity of 10^{-4} for the confined part of the aquifers and 7% effective porosity for the unconfined part.
2. Assuming a maximum allowed water level decline of 100 m in the unconfined aquifer areas and 200 m in the confined aquifer areas.
3. Most of this water is extracted in the Nile Nubian Basin (833 Mm^3/yr) which is not considered to be part of the Nubian Basin.

Source: CEDARE/IFAD (Programme for the development of a Regional Strategy for the Utilisation of the Nubian Sandstone Aquifer System).

Figure 11. Areal distribution of the Nubian Sandstone

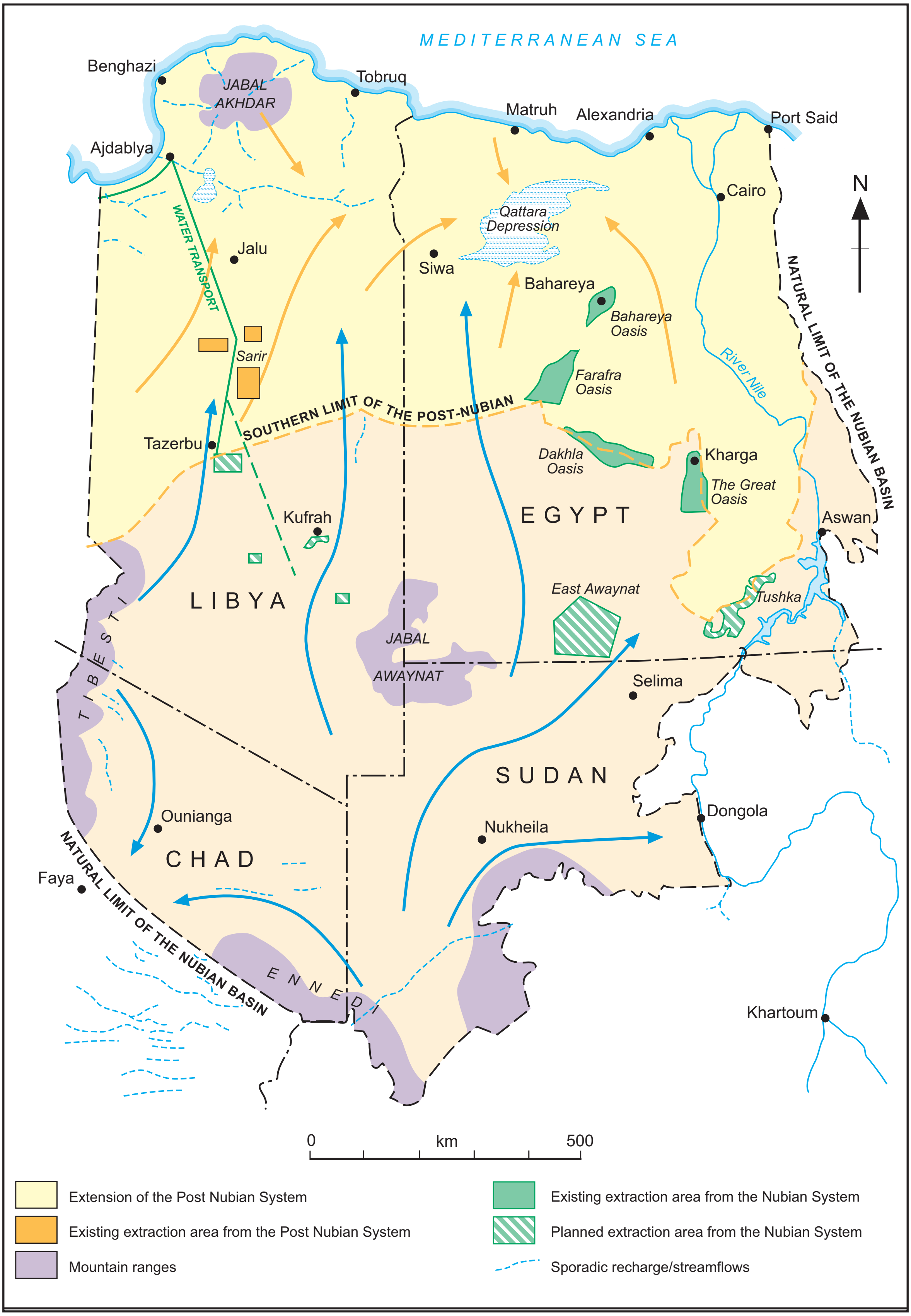
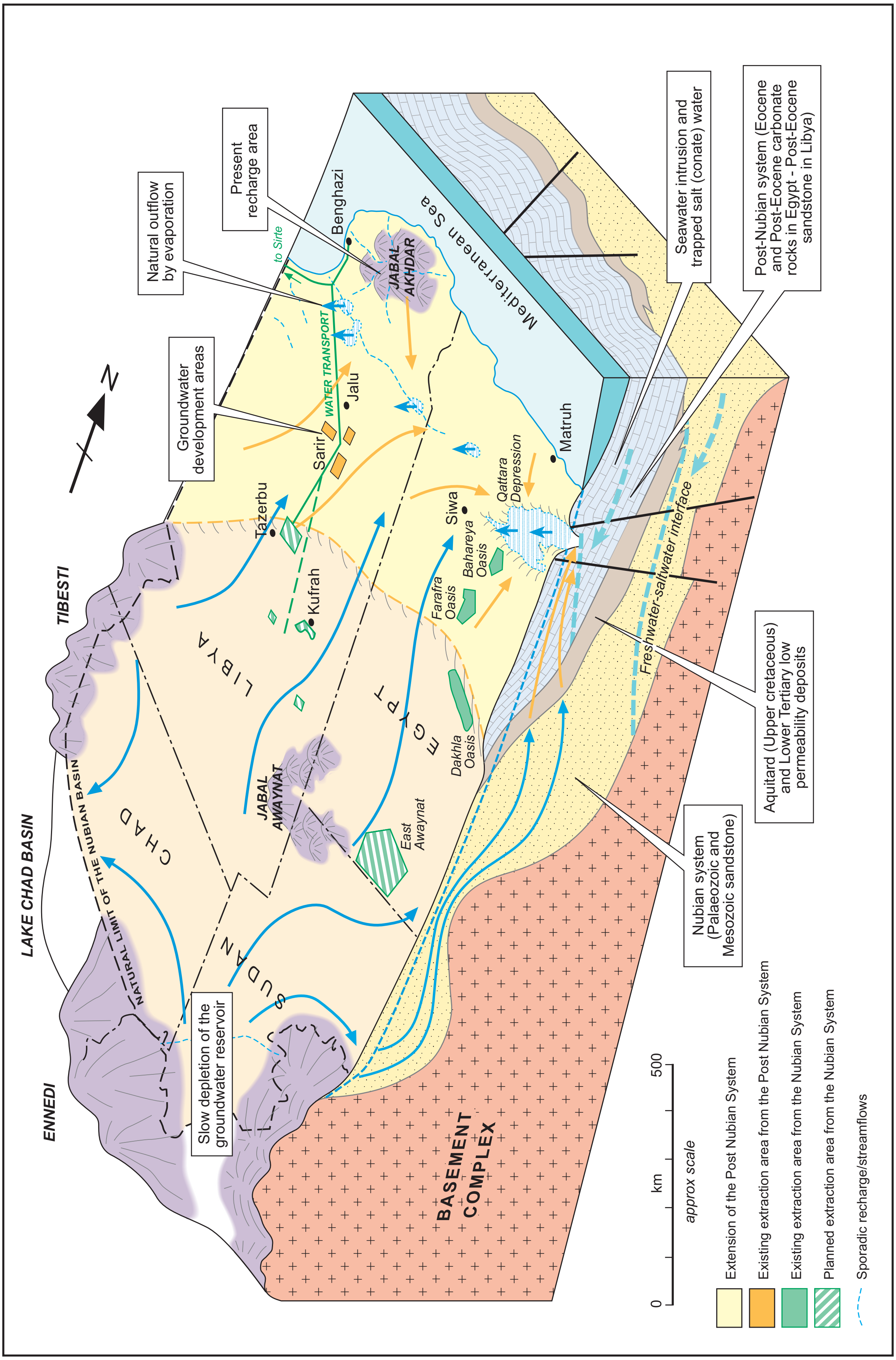


Figure 12. Blockdiagram of the Nubian Sandstone Aquifer System



THE GUARANÍ AQUIFER SYSTEM

General description, beneficial uses and GEF support

The Guaraní Aquifer System includes areas of Brazil, Uruguay, Paraguay and Argentina. It is named 'Guaraní' after the Amerindian tribe which inhabited the southern South America, and 'Mercosur' as a reflection of the new economic trading zone these countries make up. Water of very good quality is exploited for urban supply, industry, irrigation and for thermal, mineral and tourist purposes. This aquifer is one of the most important underground fresh water reservoirs in the world, due to its extension, about 1,200,000 km^2 with a volume of 40,000 km^3. This storage volume could supply a total population of 5,500 million people for 200 years at a rate of 100 liters per day per person. This aquifer outcrops in dense populated areas like São Paulo State (Brazil).

A Project for the Environmental Protection and Integrated Sustainable Management of the Guaraní Aquifer is being elaborated with the support of the GEF, World Bank, OAS and the universities of the four countries.

Hydrogeological features

This giant aquifer is located in the Paraná and Chaco-Paraná Basins of southern South America (Figs. 13 and 14). It is contained in aeolian and fluvial sands from the Triassic-Jurassic, usually covered by thick basalt flows (Serra Geral Fm) from the Cretaceous, which provide a high confinement degree. Its thickness ranges from a few meters to 800 m (Fili et al., 1998 and Araújo et al., 1999).

The hydrogeological map (1:2,500,000) includes type of aquifers, hydro-stratigraphy, lithology and hydraulic and hydrogeochemical characteristics (Campos, 2000).

Mathematical model and data base

The development of mathematical models would assist to introduce improvements in the conceptual model and to better identify the uncertainties. Data needs to be consistent and comparable. It would be necessary to create, to arrange and to disseminate a full data base, to be shared by all stakeholders of the Guaraní Aquifer System.

A Consejo Superior drawn from the member countries has been established, and it co-ordinates all the work programme to be conducted on the management of study of the aquifer resources.

Final comments

The current and future MERCOSUR region development depends on this large fresh water resource, so it is necessary to guarantee its sustainable management, yet at present, no national or international guidelines exist which could help attain this goal.

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- OAS (http://www.oas.org)

Figure 13. Guaraní Aquifer outcrop map

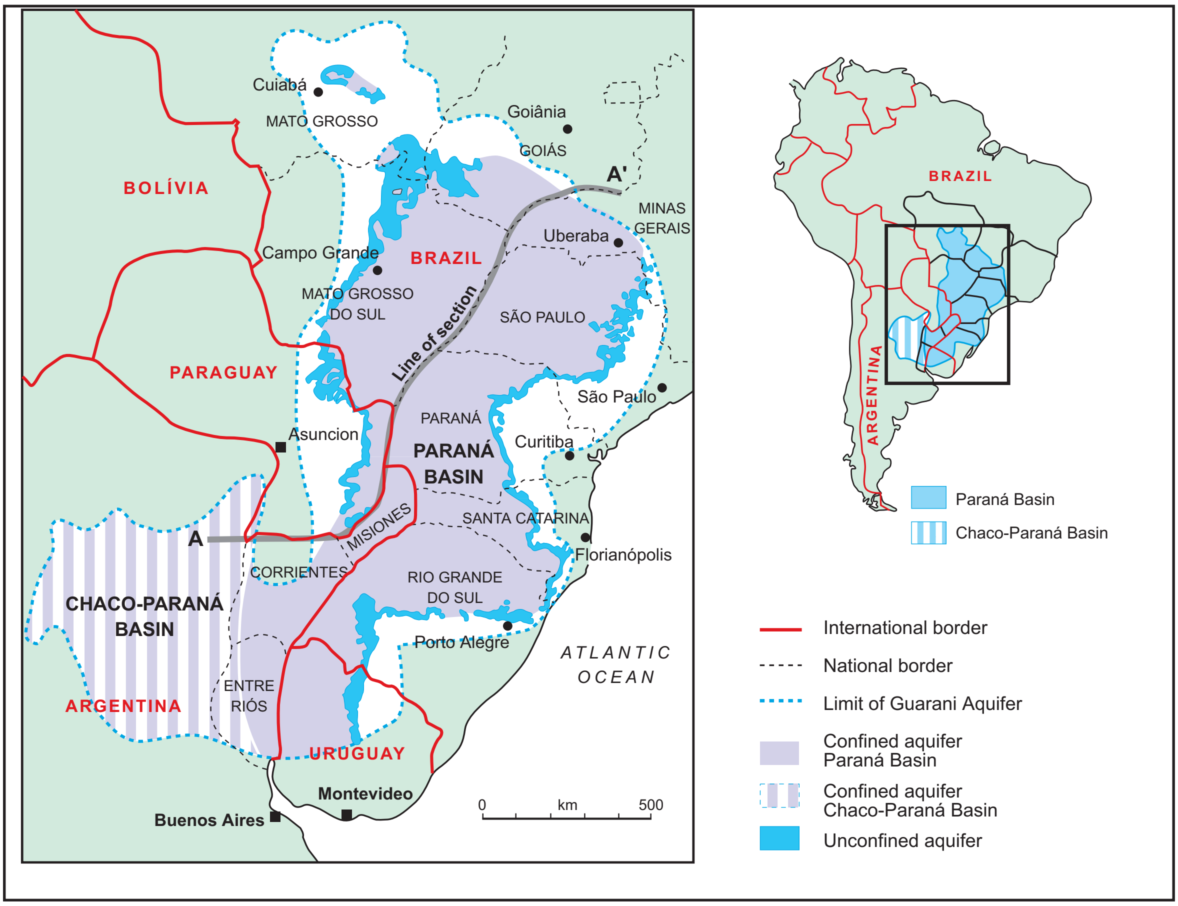
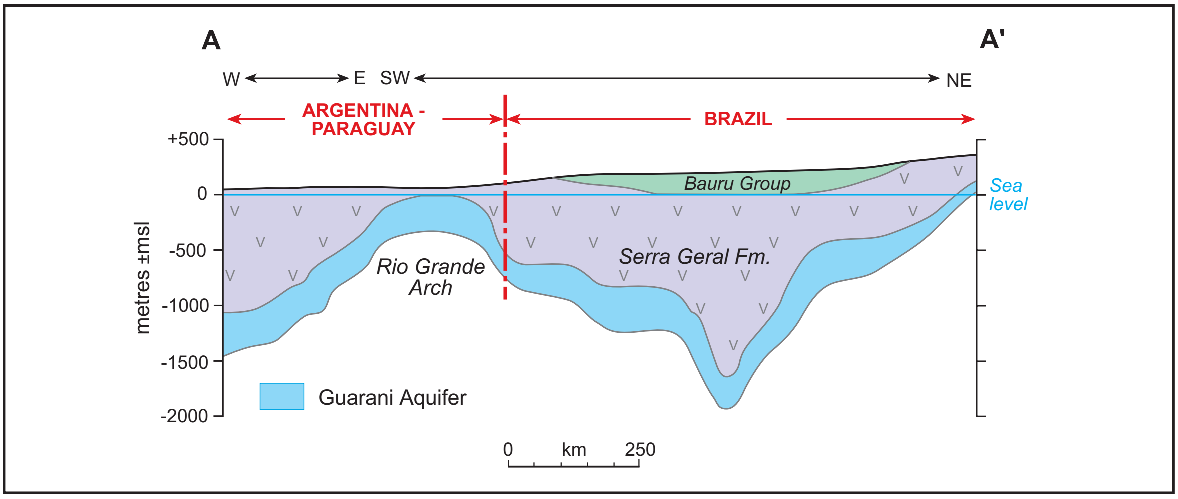


Figure 14. Cross section through the Guaraní aquifer



DIGITAL WATERWAY VECHTE

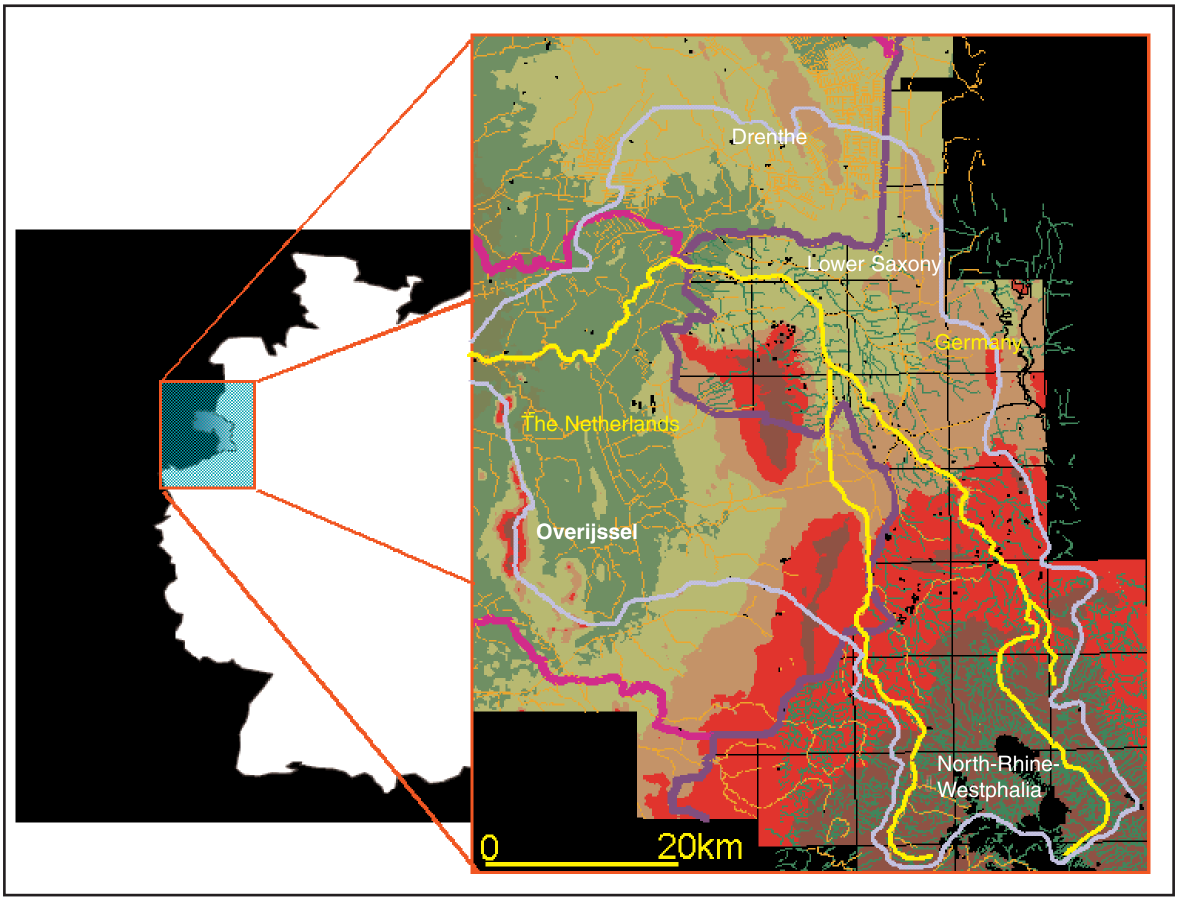
Prepared by Geo Arnold

Background of the shared aquifer system

The aquifer system of the Vechte catchment is shared by Germany and the Netherlands. The Netherlands is situated downstream of the German federal states Lower Saxony and North-Rhine-Westphalia. Basically, all surface water and groundwater in the catchment area of the Vechte flows from Germany into the Netherlands. Consequently, the Dutch side is most interested in transboundary water management. Groundwater is abstracted at both sides of the border, which might have transboundary impact. Formulating appropriate water management plans requires correct and useful data, recorded and processed according to standards. Therefore an appropriate transboundary information system will be helpful.

Thirty to forty different parties from local to national level were involved in the preparation of the project. This had considerable logistical, organisational and financial consequences for the preparation of the project. The project area (Fig. 15, Table 4) includes parts of the provinces Drenthe, Overijssel in the Netherlands and two federal German states, Niedersachsen (Lower Saxony) and Nordrhein-Westfalen (North-Rhine-Westphalia). The two federal German states can almost be considered as two separate countries. The differences between these federal states as regards their official administrative structure and policy set-up have their impact on the project. In Germany different authorities and organisations collect data just for their own purpose. Integration of data collection hardly exists.

Figure 15. Project area Vechte



Beneficial uses of the water resources in the shared aquifer

Generally, the slope of the ground surface is to the west. In the eastern area the mean level is 35 metres above MSL and in the western part at MSL. Characteristic in this area are the ice pushed ridges that run from the north to the south with maximum heights from 60 to 100 metres above MSL.

The water courses (Vechte and Dinkel) flow more or less north and later to the west. Some tributaries have been largely canalised. In this area with relatively shallow groundwater levels the surface waters act as a drainage system. Most rivers and brooks have been stated (1995) as considerably contaminated, partly related to the intensive agriculture in the border area. The poor water quality will have a negative impact on the nature reserves in the area.

Geologically the research area can be subdivided into two different parts. In the southern part (south of Nordhorn) the older pre-Tertiary deposits are both geologically and geohydrologically most important for the groundwater transport in the subsoil. In the rest of the area the Quaternary and Tertiary deposits are of importance (Fig. 16).

With regard to cross-border groundwater, there are two areas which are of importance. In one area the groundwater crosses the border via a fractured, cemented rock formation. The accumulation is a matter of artesian water that reaches well from faults in the deep rock. This groundwater is of good quality but only used to water livestock.

The other area is located at the side of the ice pushed ridges and consists of a deep channel with sandy deposits with a depth of more than 100 metres. In this aquifer large groundwater pumping stations have been installed at both sides of the border. Insufficient collaboration and data have resulted in an excessive decrease of the groundwater level.

Water will generally flow from Germany into the Netherlands through the thin Quaternary layer and via the trenches and brooks. In the future, the qualitative aspect of this groundwater might cause problems.

Significant issues concerning the shared aquifer

Consultations between German and Dutch water works on the extractable amounts of water have already been started, whereas the Dutch water board Regge and Dinkel and its main German partners have regular meetings on the surface water for years.

Formally, contacts between the Dutch and German officials occur within the Border Waters Committee and its sub-committees. From the protocols it can be derived that no matters concerning contents are discussed and that the consultations mainly consist of an official exchange of information on special subjects.

The anticipated focus of this case study

The main objective of the project was to make all existing relevant data on the catchment area of the Vechte digitally available to the interested parties on both sides of the border and in an integrated transboundary manner to facilitate the transboundary assessments that are needed for appropriate cross border water management.

For this project most agreements have been recorded in the protocols. This includes an annual updating of data as well as agreements with regard to support of German specialists in the defining of concepts and the interpretation of data.

The information system REGIS-Vechte that is now operational within the water management institutions on both sides of the border is a first important step towards a sustainable groundwater data exchange between Germany and the Netherlands. The available data of the entire transboundary basin are comparable and can be accessed, evaluated and presented in an integrated manner. The institutions have now access to the available groundwater data, the

Figure 16. Cross-section through the border: comparison of the mapping results of a transboundary aquitard

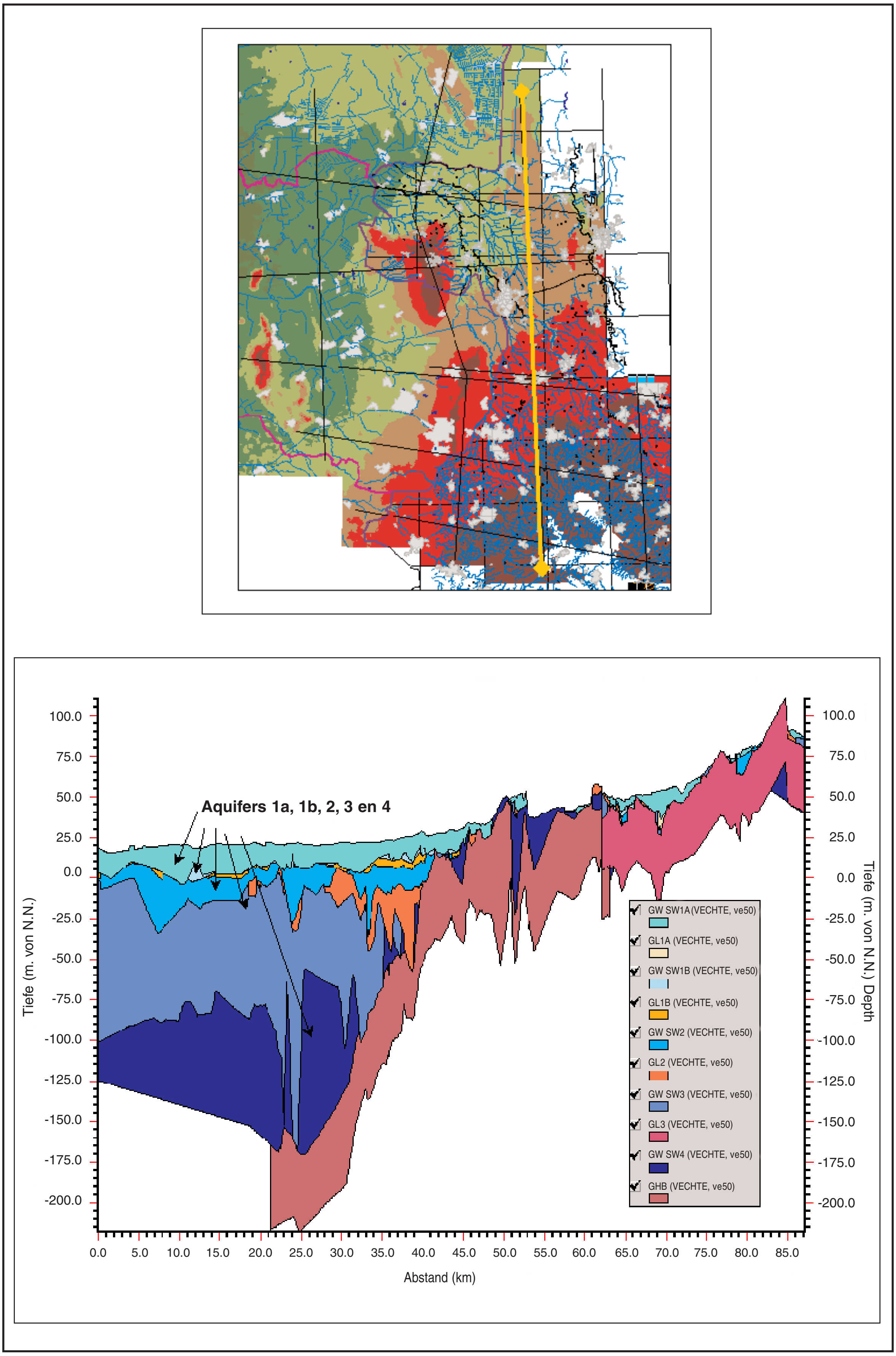
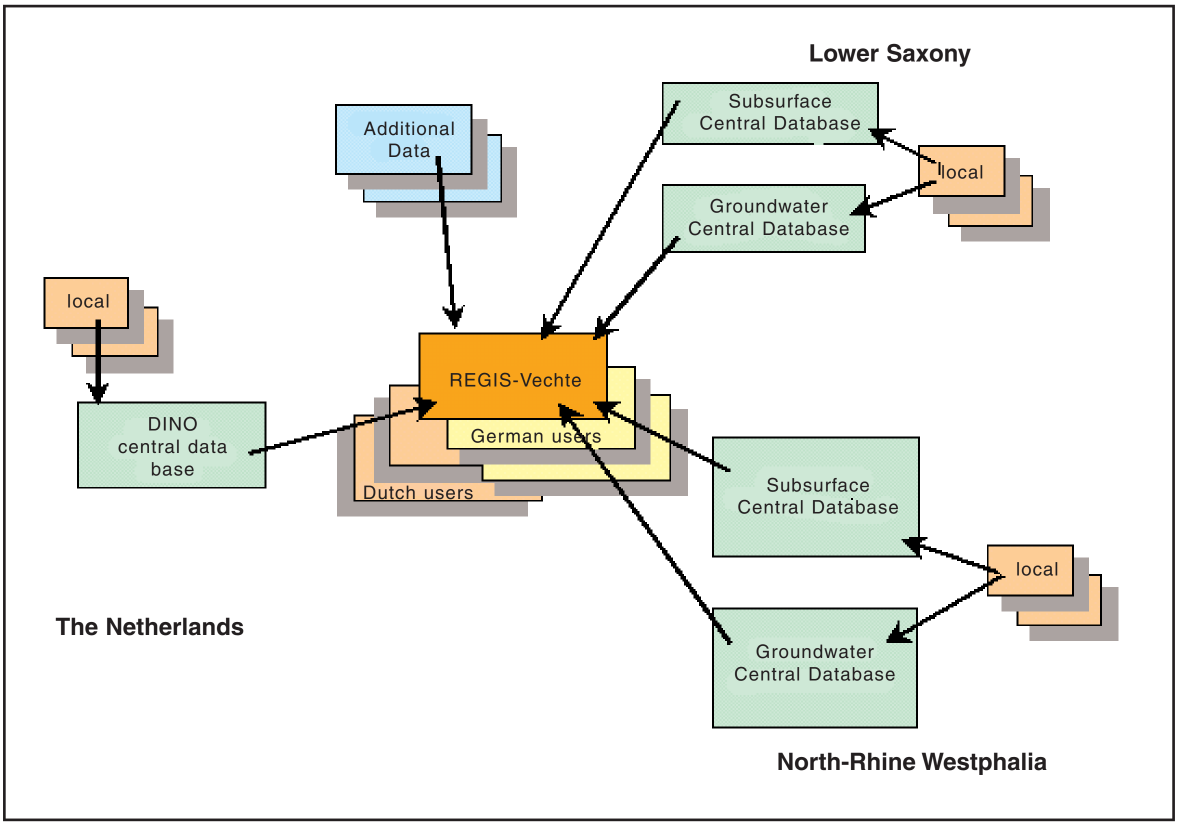


Figure 17. Proposed data flow for the transboundary information system Vechte



subsurface data and the geohydrological subsurface models. The recommended data flow is shown in Figure 17.

The basin wide approach and the cross border collection, compilation and evaluation of data is considered to be in accordance with the European Water Framework Directive. The information system can provide the, by the Directive required, information on groundwater characteristics, monitoring programs, the compliance testing of the environmental objectives and on the anthropogenic impact on groundwater. The available information can be compared with the requirements of the Directive; missing information can easily be identified.

At this moment a proposal will be discussed to use the Vechte catchment as a pilot for the implementation of UNECE guidelines on Monitoring and Assessment of both Transboundary Groundwaters and Rivers. Moreover the possible interaction between the implementation of the European Water Framework Directive and the application of the ECE guidelines is considered.

Table 4. Essential data for the Vechte catchment

	Lower Saxony	*North Rhein Westphalia*	*Netherlands*	*Total*
Surface area (km^2)	1790		1980	3770
Population density* (per km^2)	114	220	286	229
Total annual precipitation (mm)	745			

* Accounting for the total Euregio area from which the Vechte catchment forms a part.

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KALAHARI/KAROO MULTI-LAYERED AQUIFER

Shared by Namibia (Stampriet Artesian Basin), Botswana (South Western Karoo Basin) and South Africa (Western Kalahari aquifer)

Background of the shared aquifer system

The Kalahari/Karoo multi-layered aquifer is shared by Botswana, Namibia and South Africa although it is predominantly used in Namibia where most recharge probably occurs. The aquifer is a key component of future human and economic development in the arid environment of the Kalahari.

Botswana

Lebung and Ecca Groups, located within the Karoo Supergroup host the main significant water bearing layers of the Botswana South Western Karoo Basin. Studies carried out in Botswana indicate that the aquifers are primarily recharged in Namibia. General Groundwater Flow is eastwards. Recent exploration data is available, but a lot is still to be done in terms of resource evaluation. The source of high nitrate concentrations in some boreholes has not yet been established.

Namibia

There is a comparatively good understanding of the geology and hydrogeology of the aquifer in the Stampriet Artesian Basin in Namibia (Fig. 18). Water occurs in the Auob and Nossob sandstones of the Ecca Group (lower Karoo Sequence), as well as in the overlying Kalahari. The dip of the formations is slightly (about 3 degrees) towards the south-east and in general the water quality deteriorates also in that direction. The current study in Namibia is in the process of constructing a numerical model of the system where after it is anticipated that a management plan will be in place. The water quality of the Karoo aquifers appear to be locally very poor, in the so-called Salt block in the south-eastern part of the Artesian Basin in Namibia.

South Africa

In the South African part of the basin, mainly along the Nossob and Molopo Rivers, the known productive and potable water aquifers are in the Kalahari Group, but the underlying bedrock, which may consist of Karoo sediments, quartzite's from the Matsap and Dolomites from the Ghaap Plateau Group play an important role in the sustainability, quality and cross border interaction. Differentiation of aquifer groups is one of the prerequisites of the project. Point source information is available in the national groundwater database. Existing hydrogeological maps also provide information, but water use, main recharge areas and general flow patterns are poorly known in that part of the aquifer.

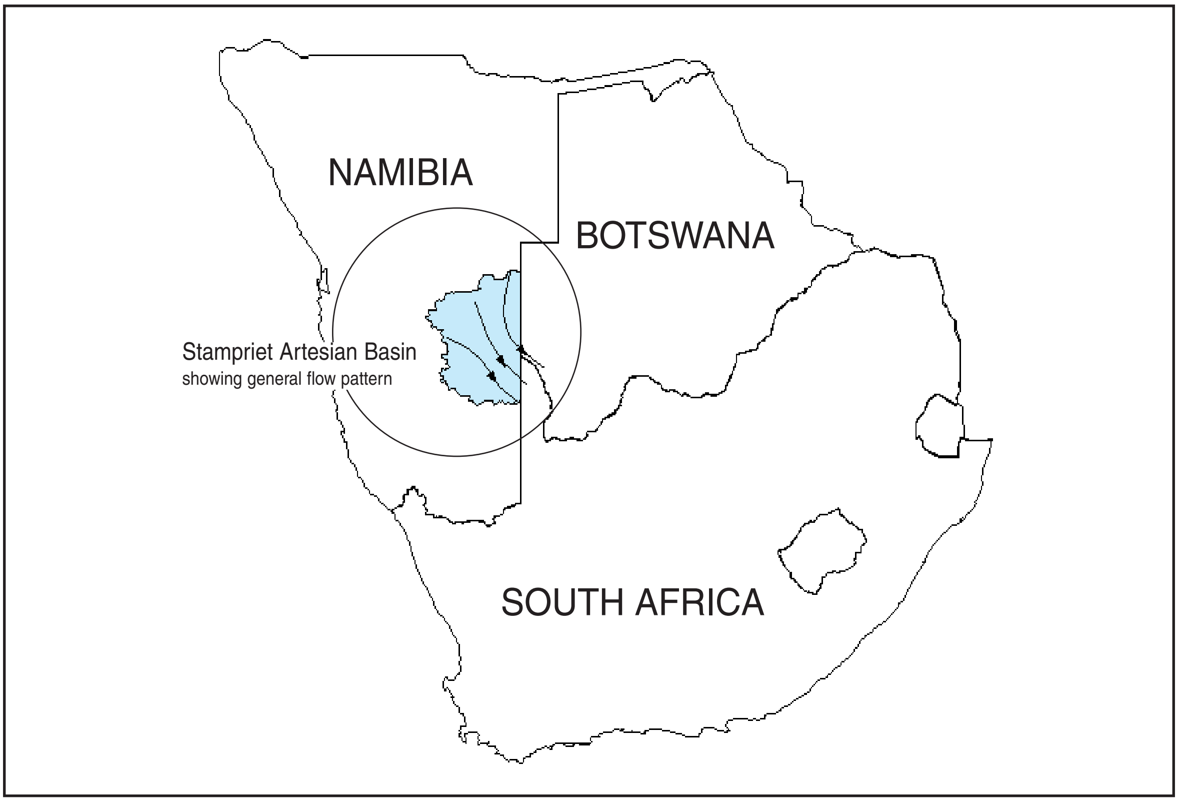
Beneficial uses of the water resources in the shared aquifer

At present water is used in Botswana and South Africa by local communities for drinking water and stock water supplies. Deeper confined aquifers may provide a more reliable source to existing water supplies which often encounter problems of salinity and low yielding boreholes. Groundwater abstraction for irrigation, which highly depends on recharge from flash floods in the river systems, is a matter of concern in the upper Molopo River, in South Africa. Water is used in Namibia for stock watering and increasingly for irrigation purposes. The system also supplies five smaller towns with water. The largest portion of the aquifer falls within Namibia, which is expected to have the largest demand from the system and where needs are expected to rise in the future. Although the system is large, because of the uncertainty of recharge at this stage it is uncertain that the resource can sustain large irrigation schemes, so a conflict between irrigation and sustainability is currently envisaged.

Significant issues concerning the shared aquifer

The special value of the aquifer is the presence of fresh water in this very arid environment, where brackish and saline groundwater is frequent, and where the availability of water resources exerts a strong pressure on potential developments. The major recharge area is likely to be located in Namibia. Activities carried out in one part of the basin may have an impact on other parts of the aquifer. Surface water developments, such as dams built in the Upper Molopo River, may cause a negative long-term impact on the groundwater recharge mechanism in the lower reaches of the river valley. The major issue at this stage is for all three countries to obtain a proper understanding of all aspects of the aquifer, for joint assessment, monitoring and management of the resource. The countries can then work out a legal framework as to a common abstraction policy. This could be done through the existing international river commissions, bilateral technical committees and institutions of the Southern African Development Community (SADC).

Figure 18. Karoo Aquifer in Namibia and generalised flow directions

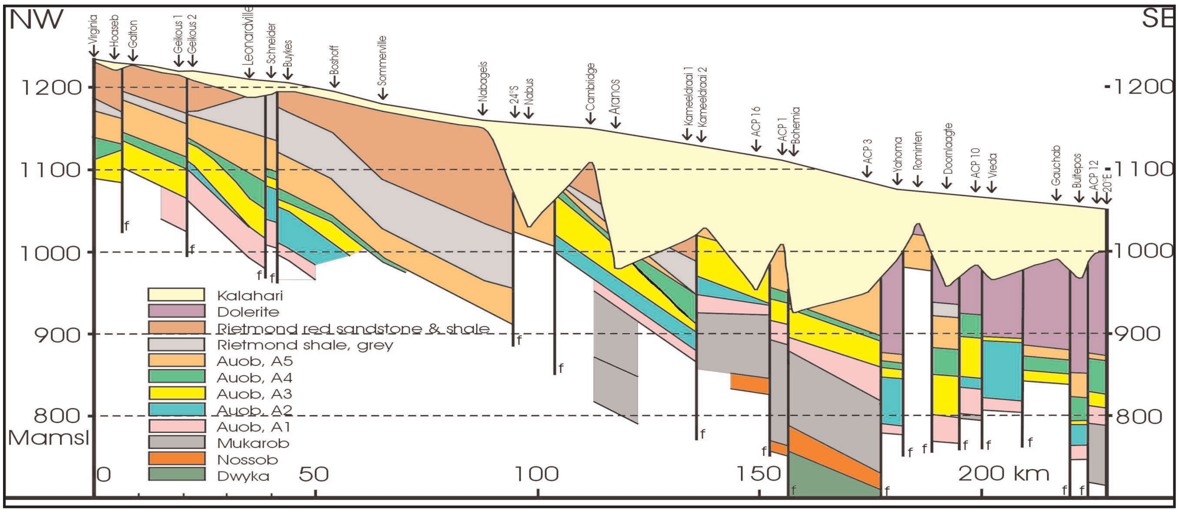


The anticipated focus of this case study

So far, promising detailed exploration took place in Namibia (Fig. 19), and, to a lesser extent, in Botswana. A comprehensive groundwater resources assessment is needed. The case study will contribute to the following objectives:

- A proper understanding of the resource, including a clear definition of aquifer's boundaries, and recharge assessment;
- The emplacement of institutional interaction between the countries;
- The outlining of a legal framework for joint management of the resource, and;
- The development of a 'groundwater treaty/agreement'.

Figure 19. Cross section from NW to SE of the Karoo within Namibia



Namibia	
Surface area:	65,000 km^2
Population in the area:	Approx. 35,000
Resources in storage:	In the process of being determined
Current Annual Production:	Approx. 5 million m^3/annum
Potential development resource:	In the process of being established
Mitigation of negative impacts:	None at this stage.

Botswana	
Surface area:	70,000 km^2
Population in the area:	Approx. 42,000
Resources in storage:	To be determined
Current Annual Production:	Approx. 0.8 million m^3/annum
Potential development resource:	Not determined
Mitigation of negative impacts:	None at this stage. Saline water intrusion may occur.

South Africa

Surface area:	To be determined
Population in the area:	N/A
Resources in storage:	Not determined
Current Annual Production:	N/A
Potential development resource:	Not determined
Mitigation of negative impacts:	Assessment of recharge mechanism to be conducted.

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SLOVAK KARST – AGGTELEK AQUIFER

Prepared by P. Caucik

Background

The Slovak Karst – Aggtelek aquifer is shared by the Slovak Republic and Hungary. This common aquifer provides groundwater resources of good quality in both countries.

There is relatively large amount of information about Slovak side of the area; an extensive hydrogeological survey was made in 1972. According to this survey, significant amount of groundwater resources was approved by the Commission for Classification of the Resources (KKZ). The former large monitoring system, operated by SHMI (Slovak Hydrometeorological Ins.), was due to financial matters nowadays reduced to 9 monitoring points (wells, springs) in the area.

The pilot project area on the Hungarian side served earlier as experimental research area, with performed detailed measurements on several points of the aquifer. In full developed state it concerned regular measurements of 15 karstic springs, extended meteorological network and the observation of several other parameters on the surface and in the caves. This observation network is unserviceable today, measurements were abandoned, most of them for financial reasons.

Another source of information are records of data-collection (Results of the Karsthydrological Research on the Aggtelek Mountains) published in 2000.

Beneficial uses of the water resources in the shared aquifer

On both sides of the state border karstic water is used for drinking water purposes. In general, the intake of groundwater is higher on the Slovak than on the Hungarian side. The purpose of extraction is mostly water supply for population in wider region, minor amount is used for agriculture.

Observations taken on karstic objects in this area are used in Hungary as undisturbed standards for scientific purposes.

While the co-operation on expert level has a long history between the Hungarian and Slovak scientific institutions, a well-based water resource management in both countries requires liable data from the aquifer as one unit.

Significant issues concerning the shared aquifer

In September 2000, on the session of the Slovak–Hungarian Joint Commission, both sides agreed to participate in a common pilot project in the Slovak Karst–Aggtelek aquifer.

It should be mentioned also professional contacts between relevant organisations, Ministries, VITUKI, SHMI and Geological Surveys.

The anticipated focus of this case study

This project should help for the development of the functioning monitoring and assessment system in order to help decision-makers and water resource managers to provide sustainable water resources and protect water from harmful impacts in this area. One of the results of the project will be also improvement of co-operation between relevant institutions in both countries.

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Selected notes, references and further reading

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Appendix I

List of acronyms

BRGM	Bureau de recherches géologiques et minières (France)
FAO	Food and Agricultural Organization
GEF	Global Environmental Facility
IAH	International Association of Hydrogeologists
IBWC	International Boundaries and Water Commission, Mexico–United States of America
IFAD	International Fund for Agricultural Development
ILA	International Law Association
NSAS	Nubian Sandstone Aquifer System
OAS	Organization of American States
ODI	Overseas Development Institute, UK
OSS	Observatoire du Sahara et du Sahel
SASS	NW Sahara Aquifer Systems
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
WMO	World Meteorological Organization

Appendix II

Logical Framework of the ISARM Programme

Wider objectives

- To contribute to the multifaceted efforts in global co-operation through providing for the planets needs in sustainable environments, economy, social and political security, based on integrated water resource management, including internationally shared aquifers.

Specific project objectives

- To establish a network of experts from different disciplines for identification and definition of internationally shared aquifers.
- To promote scientific, legal, socio-economic, institutional and environmental assessment of internationally shared aquifer resources.
- To identify several Case Studies of internationally shared aquifers and support multidiciplinary experts teams to conduct detailed investigations.
- To learn, from Case Studies, the issues relevant to good management of internationally shared aquifers resources.
- To raise the awareness of policy and decision makers of the significant and importance of transboundary aquifer resources, forming a critical component of the world freshwater resources.
- To disseminate the lessons learnt from Case Studies and encourage policy and decision makers to incorporate appropriate internationally shared aquifer management.
- To promote co-operation among experts from the different countries that share transboundary aquifers, through making available scientific tools, water resource management options and methodologies that apply to such aquifers.

Tasks and activities

Preparatory Phase (March 2000–September 2001)

- Preparatory meetings and experts consultations.
- Set up of the ISARM initiative and endorsement by the 14th Session of the UNESCO IHP Intergovernmental Council in June 2000.

Short term (One year: September 2001–September 2002)

- Preparation and wide distribution of an illustrated framework document promoting the concept of co-operation for optimal and sustainable management of internationally shared aquifers.
- Dissemination of existing information on internationally shared aquifers, including the scientific, legal and other arrangements in FAO and other databases.
- IHP/OHP Conference entitled ‘Hydrological Challenges in Internationally shared Water Resources Management’ Sept 2001, Koblenz.
- Circulate and process a questionnaire to identify the significant internationally shared aquifers of the world with the contribution of the UNESCO IHP National Committees.

- FAO, IAH and UNESCO co-operation with United Nations Economic Commissions, in particular with UNECE, for the implementation of the UNECE guidelines on monitoring and assessment of transboundary groundwaters and the setting up of training and exchange of information with the other regions.
- Tripoli Seminar on 'Managing Shared Aquifers Resources in Africa' in 2002.

Medium term (Two years: September 2002–September 2004)

- Compilation of existing literature and preparation of detailed Case Studies of selected internationally shared aquifers.
- Report progress at the IAH-ALHSUD Congress on 'Groundwater and human development', 21–25 October 2002, Mar del Plata, Argentina.
- Preparation of a bibliography and database of internationally shared aquifers.
- Contributions for the improvement of standard monitoring procedures.
- Contributions for the preparation of maps that consider potential risk and groundwater vulnerability.
- Publication of national and regional studies.
- Organisation of several regional consultations, to ensure consensus and participation at regional level and to disseminate and debate the results of the Case Studies.

Long term (six years: September 2006)

- Preparation of a 'ISARM toolkit'.
- Capacity building and training based on the implementation of the toolkit, facilitated by regional workshops.
- International Conference on transboundary aquifer systems to evaluate the results obtained and the experience achieved in different regions.
- Publication of the inventory of internationally shared aquifers.

Programme outputs

- Illustrated framework document on the issues involved in the sustainable management of internationally shared aquifer resources.
- Case study reports in Europe, Africa, Asia and Latin America.
- Bibliography and data of internationally shared aquifers.
- Development of an 'ISARM toolkit' comprising technical guidelines, examples of legal and institutional frameworks and a database of findings of the Case Studies.
- Inventory of internationally shared aquifers.

Appendix III

Preliminary questionnaire on transboundary aquifers

Transboundary aquifer data	*Country A*	*Country B*
Aquifer type Shared international boundary length (km) Flow across boundary (MCM/yr) Gradient across boundary		
Areal extent (km^2) Geological symbols on map Abstractions (MCM/yr) Other impacts: quantity Other impacts: quality Level changes (m/yr) Main utilisation Quality trends		
Monitoring data: Quantity		
No. of monitoring stations Frequency of measurements Specific distributions		
Monitoring data: Quality		
No. of monitoring sites Frequency of measurements Specific distributions Determinants: Major ions Heavy metals Pesticides Nitrogen compounds Industrial organic compounds		
Formal Agreements ratified? Informal agreements/conventions? Key institutions		

Questionnaire completed by	Country A	Name …………………………………….. ……………………………………..	Institution and Contact details …………………………………….. ……………………………………..
	Country B	Name …………………………………….. ……………………………………..	Institution and Contact details …………………………………….. ……………………………………..

Please send completed questionnaire to:	• Regional IAH Vice Chairman (http://www.iah.org) • Regional Hydrologist of UNESCO offices (http://www.unesco.org/general/eng/about/office/) • IHP National Committees of the related countries (http://www.unesco.org/ihp_db/nat_committees/search_free.asp)

Appendix IV

The Challenges set out at the Ministerial Conference 'Water Security in the Twenty-first Century' at The Hague, March 2000

Meeting basic needs: to recognise that access to safe and sufficient water and sanitations are basic human needs and are essential to health and well being, and to empower people, especially women, through a participatory process of water management.

Securing the food supply: to enhance food security, particularly of the poor and vulnerable, through the more efficient mobilisation and use, and the more equitable allocation of water for food production.

Protecting ecosystems: to ensure the integrity of ecosystems through sustainable water resources management.

Sharing water resources: to promote peaceful co-operation and develop synergies between different uses of water at all levels, whenever possible, within and, in the case of boundary and transboundary water resources, between states concerned, through sustainable river basin management or other appropriate approaches.

Managing risks: to provide security from floods, droughts, pollution and other water-related hazards.

Valuing water: to manage water in a way that reflects its economic, social, environmental and cultural values for all its uses, and to move towards pricing water services to reflect the cost of their provision. This approach should take account of the need for equity and the basic needs of the poor and the vulnerable.

Governing water wisely: to ensure good governance, so that the involvement of the public and the interests of all stakeholders are included in the management of water resources.

Appendix V

IHP OHP
GERMANY

International Conference on Hydrological Challenges in Transboundary Water Resources Management

Koblenz, Federal Republic of Germany
25–27 September 2001

The global situation is characterised by the fact that about 50% of the world's land surface belongs to transboundary water systems forming half of the overall fresh water resources. These resources determine the living conditions of about half of mankind.

Increasing demands and declining water quality, growing vulnerability from floods and droughts, alarming water-borne health and eco-hydrological problems confront water resources management with challenges that need comprehensive strategies for providing water of adequate quantity and quality and protecting man and nature from adverse impacts. Sustainable solutions for transboundary water systems are therefore of high priority.

The German IHP/OHP National Committee decided to contribute to the development of transboundary activities with special emphasis on the hydrological fundamentals and challenges. The main topics of the conference were hot spot analysis of hydrological problems, integrated hydrological networks and information systems, methodologies for analysing hydrological processes in large-scale water systems, institutional and legal challenges of transboundary hydrological cooperation, and experiences and challenges for sustainable development in transboundary water systems.

Findings

The participants came from 34 countries and the organisations, UNESCO, WMO, UNECE, UN-World Water Assessment Programme, FAO, International Commission for the Protection of the Rhine, International Commission for the Protection of the Danube River, the Mekong River Commission and the Permanent Joint Technical Commission for Nile Waters were represented. The conference supported IHP-V project 4.1 'International Water Systems'. At the end of the conference the participants agreed to summarise their conclusions and recommendations as follows:

- ➤ The conference demonstrated that there is an increasing trend to adopt sustainable policies to water resources development and to apply integrated water resources management (IWRM) practices in transboundary water resources systems (including rivers, lakes, aquifers and coastal seas) to implement these policies.

- ➤ There was a consensus among the participants of the conference that an integrated approach to water resources management practices and institutions at the national level will facilitate and improve transboundary cooperation.

- A number of examples were presented which demonstrated that valuable scientific methodologies and good practices for transboundary water resources systems, that are worth disseminating, exist in some parts of the world.

- The participants expressed the necessity of improving the exchange and access to comparable hydrological data and information, and strengthening institutional facilities and capacity-building in transboundary water resources systems.

- The participants stressed that assessment of water resources based on good quality data is a key prerequisite for the establishment and functioning of collaboration in transboundary water systems.

- The participants recognised that monitoring systems in many parts of the world largely need to be improved to supply valuable data and information for decision-making. Assessment of long-term variations in river runoff, sediment yield and pollutants under the effect of man's impact and climate change should be given recognition. It is urged to strengthen joint monitoring of transboundary water systems.

- Several case studies were presented which showed the importance of confidence-building measures to improve the culture of collaboration, cooperation and joint decision-making in transboundary water resources management. At the same time, the cases presented demonstrated the importance of economic incentives to be provided by the international community to facilitate the mediation processes.

- The participants called upon the United Nations system to continue their efforts to effectively facilitate collaboration in transboundary water systems management. The UN-wide World Water Assessment Programme projects and initiatives, e.g. International Shared Aquifer Resources Management (ISARM), HYCOS components and Potential Conflict to Cooperation Potential and the United Nations worldwide and regional (UNECE) conventions were welcomed. IGOs, governments, scientific/technical NGOs are called upon to support and to contribute to these initiatives.

- The participants expressed the wish that as many countries as possible should participate in and implement regional and global agreements on the utilisation and protection of transboundary water resources systems with a view to achieving a sustainable international water order.

The papers and posters of the conference have been published in the series IHP/OHP-Berichte, Sonderheft 12. The publication is obtainable from Bundesanstalt für Gewässerkunde, IHP/OHP-Sekretariat, Koblenz, Germany, Fax: (+49) 261 1306-5422, email: hofius@bafg.de.

Appendix VI

Tripoli Statement

More than 600 hundred participants from more than 20 countries and regional and international organizations and associations attended the International Conference on

'Regional Aquifer Systems in Arid Zones – Managing Non-Renewable Resources'

Tripoli, 20–24 of November 1999

We the Participants of the Conference recognize that:

1. In most arid countries the scarcity of renewable water supplies implies a serious threat to sustainable coupled and balanced socio-economic growth and environmental protection. This threat is clearly more pronounced in the less wealthy countries.
2. In many arid countries, however, the mining of non-renewable groundwater resources could provide an opportunity and a challenge, and allow water supply sustainability within foreseeable time-frames that can be progressively modified as water related technology advances.
3. The Conference marks a milestone in the discussion of the emerging concept of planned groundwater mining.

We the Participants consider that:

1. Adoption of this concept at national level could have international repercussions;
2. A national integrated water policy is essential with, where feasible, priority given to renewable resources, and the use of treated water, including desalinated water.

We recommend that:

a. Groundwater mining time-frames should account for both quantity and quality with criteria set for use priorities, and maximum use efficiency, particularly in agriculture;
b. Care should be exercised to minimize the detrimental impact to existing communities;
c. Consideration should be given to the creation of economical low water consuming activities.

We the participants further consider that in situ development, or development based upon transferred mined groundwater, depend upon many non-hydrogeological factors outside the scope of this Conference. Nevertheless, hydrogeological constraints need to be defined for both planners and the end users.

We recommend the participation of the end users in the decision making process and the enhancement of their responsibility through water use education and public awareness. We believe that for efficient water-use, cost recovery could eventually be necessary.

In recognition of the fact that:

a. some countries share aquifer systems;
b. international law does not provide comprehensive rules for the management of such systems as yet, and
c. clearly groundwater mining could have implications for shared water bodies;

We the participants draw the attention of Governments and International Organizations to the need for:

a. rules on equitable utilization of shared groundwater resources,
b. prevention of harm to such resources and the environment,
c. exchange of information and data.

We also encourage concerned countries to enter into negotiations with a view of reaching agreements on the development, management, and protection of shared groundwater resources.

For further information concerning this initiative and existing literature on ISARM/TARM the following may be contacted:

◆ IAH	P.O. Box 9 Kenilworth CV8 1JG United Kingdom	Mr Andrew Skinner Secretary General Fax: (+44) 1926 856561 Email: askinner@iah.org http://www.iah.org Mr Shammy Puri Chairman Commission on TARM Fax: (44) 1235 553203 Email: shammypuri@aol.com http://www.iah.org
◆ FAO	Land and Water Department Viale delle Terme di Caracalla 00100 Rome Italy	Mr Jacob Burke Senior Water Policy Officer Fax: (+39) 06 57056275 Email: jacob.burke@fao.org http://www.fao.org
◆ FAO	Legal Department Viale delle Terme di Caracalla 00100 Rome Italy	Mr Stefano Burchi Senior Legal Officer Fax: (+39) 06 57054408 Email: stefano.burchi@fao.org http://www.fao.org/landandwater
◆ UNECE	Palais des Nations 8-14 Avenue de la Paix CH-1211 Geneva Switzerland	Mr Rainer Enderlein Secretary of the Meeting of the Parties Fax: (+41) 22 907 0107 Email: rainer.enderlein@unece.org http://www.unece.org
◆ UNESCO IHP	1 rue Miollis 75015 Paris France	Mr A. Szöllösi-Nagy Secretary International Hydrological Programme Fax: (+33) 1 45 68 58 11 Email: ihp@unesco.org http://www.unesco.org/water/ihp
iwac	IWAC Secretariat P.O. Box 17 8200 AA Lelystad The Netherlands	The International Water Assessment Center (IWAC) has been established in 2000 under the UNECE Convention on Protection and Use of Transboundary Watercourses and International Lakes Fax: (+31) (0) 320 298894 Email: info@iwac-riza.orf http://www.iwac-riza.org/IWAC/iwacsite.nsf?Open

Groundwater in the UNESCO International Hydrological Programme (IHP)

The UNESCO engagement on Water Resources started as the International Hydrological Decade (IHD, 1965–1974) and was followed by the International Hydrological Programme (IHP) in 1975. The IHP is an Intergovernmental Programme. Since its inception particular focus was given to Groundwater Resources. Much progress has been achieved regarding methodologies for hydrogeological studies and training and education in groundwater resources.

In the development of its various phases, IHP has gone through a profound transformation from a single discipline to a multi-disciplinary programme. Recently, with the increased presence of the social science component, IHP has become a truly inter-disciplinary programme, capitalizing on the recognition that the solution of the world water problems is not just a technical issue.

The sixth phase of IHP, covering the period 2002–2007, is planned to be devoted to 'Water Interactions: Systems at Risk and Social Challenges'. The IHP VI Groundwater Component will centre on 'Groundwater Resources Sustainability and Conservation'.

UNESCO through its Division of Water Sciences provides the Secretariat for the IHP Intergovernmental Council/Programme.

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