III TWM

Transboundary Waters Management

Acta of the III International Symposium on Transboundary Waters Management (2006)

Javier González (Editor)

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III TWM - TRANSBOUNDARY WATERS MANAGEMENT

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Foreword

The UNESCO International Hydrological Programme (IHP), established in 1975, is the only global scientific intergovernmental programme of the UN system devoted to water resources, emphasizing the formulation of policy–relevant strategies for its sustainable management. IHP is an evolving programme, continuously adapting to the needs of a changing society, particularly in developing countries. It is a multidisciplinary programme furthering the knowledge–base for water resources management, with a special focus in contributing to the fulfillment of the water–related UN Millennium Development Goals (MDG). The Sixth Phase of IHP (2002-2007) –Water Interactions: Systems at Risk and Social Challenges– is based on the fundamental principle that freshwater is as essential to sustainable development as it is to life, and that water, beyond its geophysical, chemical, and biological functions in the hydrological cycle, also has social, economic and environmental values that are inter–linked and mutually supportive. The Seventh Phase of IHP (2008-2013) –Water Dependencies: Systems under Stress and Societal Responses– will give more focus to social and economic issues in water management, water governance for sustainability, ecohydrology for sustainability, groundwater and urban water management.

Transboundary aquifers are as important a component of global water resource systems as are transboundary rivers; yet, their recognition in international water policy and legislation is very limited. Existing international conventions and agreements barely address aquifers and their resources. To rectify this deficiency, the UNESCO's International Hydrological Programme (IHP) in cooperation with other UN agencies, international organizations and non–governmental organizations such as FAO, UN ECE, UN ESCWA, OAS and IAH has launched the Internationally Shared (transboundary) Aquifer Resources Management (ISARM) Programme. This cooperative program has developed a number of global and regional initiatives. These are designed to delineate and analyze transboundary aquifer systems and to encourage riparian states to work cooperatively toward mutually beneficial and sustainable aquifer development. Using outputs of case studies, the ISARM Programme

is building scientific, legal, environmental, socioeconomic, and institutional guidelines and recommendations to aid sharing nations in the management of their transboundary aquifers. Since its start in 2000, the program has completed inventories of transboundary aquifers in the Americas, Africa and the Balkans, and the inventory of Central and Eastern Asia has been initiated.

Within the framework of a UN–wide initiative, UNESCO has launched the project From Potential Conflict to Co–operation Potential (PCCP) that addresses more specifically the challenge of sharing water resources primarily from the point of view of governments, and develops decision–making and conflict prevention tools for the future.

In this context of international cooperation on shared water resources, UNESCO–IHP has supported the Third International Symposium on "Transboundary Waters Management" held at the University of Castilla la Mancha in Ciudad Real, Spain (30^{th} May to 2^{nd} June 2006) and the preparation of this Acta, which represent a significant contribution to the Groundwater programme of the Sixth Phase of the IHP.

Alice Aureli
Responsible for Groundwater Activities
International Hydrological Programme

Preface

The natural distribution of water resources within a territory is often at odds with local water demands. This implies a need for waters management at a transboundary scale, taking resources outside the natural territories in which they flow or reside, and transcending the limits of subbasins, basins or hydrological systems limits. Besides natural boundaries, water resource managers often face anthropogenic boundaries. Water resources are coupled with the larger reality of a region, including its environmental, social, and economic characteristics. Barriers presented by international borders, regional borders, or just competing uses require dealing with individuals, institutions and entities with various levels of responsibility. These natural and human boundaries are some of the factors to be considered in developing effective strategies for overcoming waters management boundaries.

Resolving disputes related to water management frequently requires the adoption of compromise agreements, setting a relative equilibrium within a sustainable framework. Nowadays, water management requires the accommodation of many interests while pursuing the achievement of such important goals as human development, ecosystem conservation, and social and economical viability. To achieve these goals, the identification of all types of water management boundaries in an interdisciplinary context is fundamental.

The Third International Symposium on "Transboundary Water Management" (TWM) was devoted to identifying, exploring, and analyzing all the boundaries related to water management. The III International Symposium on TWM (2006) was the third edition of a series of international meetings devoted to the analysis of transboundary issues in water management. Two TWM meetings were organizing previously, the fist in Monterrey, Mexico in 2002, and the second in Tucson, USA in 2004. The third symposium has served as an integrating element for the continuous transfer of knowledge on transboundary waters management, through the presentation of new ideas, technologies, and advancements in hydrological and water system modelling, management policies, integration of nonconventional water resources, public participation

processes, water markets, water law, etc., while taking into account technical, environmental, social, and economic realities so that this knowledge could be applied in practice to water management. In this edition, more than 150 water managers, policy makers, academics, consultants, and representatives of international organizations and NGOs from 40 countries have shared their experiences, technical advancements, knowledge, and points of view relating to transboundary waters management.

This book is intended as the Acta of conclusions arriving from the celebration of the III International Symposium on TWM, held at the University of Castilla–La Mancha, in Ciudad Real, Spain, from May 30^{th} to June 2^{nd}, 2006. The book contains twenty one selected papers, which deal with a wide range of issues related to water management in a transboundary context. This Acta has been divided into six parts: *Water Law and TWM*, *Government Mechanic for TWM*, *Resolving Transboundary Waters Conflicts*, *TWM and the EU–Water Framework Directive*, *Transboundary Aquifer Management*, and *Decision Support System for TWM*. This set of papers provides an integral perspective of current water management boundaries in the world, and the way for implementing Transboundary Waters Management strategies. The book is dedicated to experts, policy makers, researches, water managers and any person interested in analyzing the approaches for overcoming the water management boundaries.

JAVIER GONZÁLEZ
EDITOR AND SYMPOSIUM CHAIRMAN

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I

WATER LAW AND TRANSBOUNDARY WATERS MANAGEMENT

NATIONAL REFLECTIONS OF INTERNATIONAL TRANSBOUNDARY WATER LAW

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Introduction

Signature and ratification of multilateral or bilateral agreements on transboundary rivers, lakes or groundwater resources do not bring the course of international undertakings to an end. In fact, these actions trigger the next phase, where parties to the treaty honour commitments and fulfil obligations under the international law tenet of *pacta sunt servanda*. Compliance with international standards generally implies adjustment of the internal water resources legislation, producing an interface between the domestic and international planes. Viewed from the "domestic" perspective, the interface may follow a pattern of conscious and deliberate, or coincidental adaptation of the national legislation, ranging from a tight fit to a loose approximation of internationally agreed requirements. On the other hand, water-sector legislative reform may upon a brief or cursory examination, seem to ignore agreed international standards and obligations. It will be seen that in rare circumstances specific mechanisms are prescribed by agreements –how the objectives are specifically achieved is often left to the discretion of the states, and it is the objective of this paper to highlight the different ways states have (or have not) met these broad objectives, and discusses the manner in which they have done so.

This paper traces the influences of international texts and principles on regional instruments, and will explore the area of interface that occurs between the domestic plane of water resources legislation and international transboundary water-related obligations. The contemporary water sector legislative reforms contained in the primary water codes of a sample of countries will be taken as a starting point with occasional reference to subsidiary legislation, and the extent and manner in which these domestic reforms have responded to the international obligations from shared river treaties will be examined. Recent significant water sector legislative enactments which have occurred in

South Africa and Namibia will be analysed against the mature regional system of binding obligations on watercourse systems in effect in the Southern Africa region. At the opposite end of the spectrum, the contemporary significant water sector legislation of the Kyrgyz Republic will also be reviewed against the system of binding obligations in effect in the Central Asia region. In such a way, it can be seen how the myriad types of water uses are accommodated within a legal context, with internationally recognised, or formally agreed principles and obligations serving as common denominators, but contextualised to correspond to the country setting.

The *UN Convention on the Law of the Non-Navigational Uses of International Watercourses (1997)* forms the primary international instrument containing rules for the sharing of watercourses, and identifies the latter as "the system of surface and groundwaters constituting [. . .] a unitary whole, normally flowing into a common terminus." It has been mirrored and contextualised in regional agreements, such as the *Revised SADC Protocol of Shared Watercourse Systems 2000*, (hereafter the Revised Protocol), and enshrines many of the customary international law principles contained in the UNECE *Convention on the Protection and Use of Transboundary Watercourses and International Lakes 1992* (hereafter the *1992 UNECE Convention*), the *Mekong River Basin Agreement* (hereafter the Mekong Agreement) 1995 and the *Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources (1992)* (hereafter the Almaty Agreement) which will be examined. The 1997 UN Convention ordains rules on water rights and management, fleshing out the fundamental tenets of equitable and reasonable use, the obligation not to cause significant harm, the notions of prior notice and good faith negotiation concerning planned measures which may affect other states, and the protection of the aquatic environment. The duty to co-operate is also embraced, and the emphasis is on the sustainable management and conservation of water.

In turn, the regional treaties are often underpinned by various independent bilateral and multilateral agreements between riparian states which seek to integrate development, management and use of shared water resources. Bearing in mind the fact that states have individual ways of planning, managing and protecting their water resources; diverse definitions of water rights and use; as well as the influence of local institutions, practices and political history, it is useful to asses how far these subjective national needs are shaped by their

international commitments[1]. It is useful to analyse all of the provisions of the national legislation and not solely the items on international relations, due to the inextricable nexus between the use and protection rules of water in one state, and their inevitable effect on that of another state sharing the water body. Effective management of water resources will result not only in sustainable use and development, but environmental and ecological protection for the benefit of all water users.

The geographical areas selected have differing contextual implications, and have been selected to be representative of the generic regional issues, although the internal water policy frameworks, political social and economic influences, and institutions of other states in those regions are by no means analogous. The challenges facing the southern African region centre on the fact that states are approaching water stress and scarcity levels. Tensions in Central Asia are the result of competing uses of hydropower and agricultural irrigation combined with a legacy of overuse and environmental negligence.

It should be noted that while the protection of ground water quality has received greater attention in recent years[2], the legal and management policy challenges are caused in part by the incomplete understanding of the subsurface flow regime within different types of aquifers[3]. Although the international and regional instruments refer to watercourses to mean both groundwater and surface water most of the provisions refer to those above ground, and this discrepancy is certainly more visible in the older Water Acts, although much less so in the recent ones.

Southern Africa

The recent emphasis in Southern Africa on the integrated water management concept as a way of overcoming old challenges has been coupled with reforms in the water sector through far-reaching policies and legislation. Neighbouring countries such as Swaziland, Namibia, and Zimbabwe have issued comprehensive new water legislation after 2003. This region (which includes the territory of the states party to the Southern African Development Community – SADC) is home to twenty shared rivers and eighteen transboundary aquifer

[1] H. Savenije, P van der Zaag: 'Conceptual Framework for the Management of Shared River Basins; with Special Reference to the SADC and EU'
[2] T. Jarvis, M. Giordano, S.Puri, K. Matsumoto, and A.Wolf 'International Borders, Ground Water Flow, and Hydroschizophrenia'
[3] ibid

systems[4], although unpredictable rainfall and uneven distribution of resources often lead to droughts, necessitating prudent legal strategies and the environmentally sustainable utilisation of water.

The Revised SADC Protocol

Whereas the Original SADC Protocol on Shared Watercourse Systems of 1995 was more aligned to the Helsinki Rules on the Uses of the Waters of International Rivers 1966, enshrining customary water law principles such as territorial sovereignty, as well as neglecting the rights and needs of downstream states, the Revised Protocol of 2000 benefited from subsequent developments in the discipline, and is thus more reflective of contemporary principles. It is useful to make this distinction between the two instruments even though the original treaty has been repealed, as well as a summary comparison with the 1997 Convention t.

In its preambulatory paragraph, the Original Protocol identifies the equitable sharing and efficient conservation of water as its main objective. It lays out general principles which are similar to those of the Revised Protocol, establishes River Basin Management institutions and lays out their objectives and functions. The immediate difference is the length and detail of the newer version, its clear separations according to theme and precise obligations of the State Parties. Many of the Revised Protocol's provisions seem to be directly derived from the 1997 Convention. To name a few of the similarly or identically phrased notions would include provisions on shared watercourse agreements, the factors relevant to equitable utilization, and the obligation not to cause significant harm. One of the discrepancies between those two instruments however is the exhaustive arbitration and dispute settlement provisions of the 1997 Convention. Other parts of the Revised Protocol which mirror the 1997 Convention (and absent from the Original Protocol) are the main obligations of the state parties as encapsulated in Article 4 on Specific Measures:

- Planned Measures (the duty to exchange information and consult each other, notify measures with possible adverse effects, and the procedures for doing so);

- Environmental Protection and Preservation (the protection of ecosystems, pollution prevention reduction and control, prevention of intro-

[4]Turton A, Godfrey L, Julien F and Hattingh, H: 'Unpacking Groundwater Governance through the Lens of a Trialogue: A Southern African Case Study' Council for Scientific and Industrial Research (CSIR) Natural Resources and the Environment (NRE) –UNESCO-ISARM 2004 data

ductions of new species into the watercourses, and preservation of the aquatic environment);

- Management of Shared Watercourses;
- Prevention and Mitigation of Harmful Conditions ("such as floods, water-borne diseases, siltation, erosion, salt-water intrusion, drought or desertification"[5]);
- Emergency Situations.

The Revised Protocol lists the Institutional Framework for Implementation in article 5, outlining the structure of the organs and institutions, but not their specific functions which for example in the case of shared watercourse institutions, the treaty notes "shall be determined by the nature of their objectives which must be in conformity with the principles set out in this Protocol". Other aspects of the Revised Protocol which are notably absent from the Original Protocol are watercourse agreement provisions, where guidance is offered regarding bilateral and multilateral agreements, noting in particular that the actions of parties to such agreements must not adversely affect the rights of non-party members who also share that watercourse, "without their express consent"[6].

Bilateral and Multilateral Agreements

Some of the major bilateral and trilateral agreement commitments of South Africa and Namibia are detailed below.

The *Tripartite Interim Agreement Between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-Operation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses* signed in 2002 (Tripartite Agreement) directly mentions that the general principles of the Revised Protocol apply to this instrument, listing them as sustainable, equitable and reasonable utilisation, environment protection and the participation and co-operation principles. The three countries agree to adopt technical legal and administrative measures to "prevent, reduce and control pollution of surface and ground waters", enhance water quality, control transboundary impact, co-ordinate plans and information, promote partnerships, promote infrastructure security, and mitigate flood

[5] Article 4(4)(a)
[6] Article 6(4)

and drought effects *inter alia*. It establishes the institution of the Tripartite Permanent Technical Committee (TPTC), sets out dispute settlement procedures and determines time frames for implementation. This instrument draws very heavily from the Revised Protocol, making its principles relevant to the Incomati and Maputo watercourses.

The purpose of the *Treaty on the Development and Utilisation of the Water Resources of the Komati River Basin between the Kingdom of Swaziland and the Government of the Republic of South Africa, March 1992* (the Komati River Treaty) was to provide "in particular for the design, construction, operation and maintenance of the Project and the establishment of KOBWA" (the Komati River Basin Water Authority), the development and the utilization of the watercourse. This treaty provided for the development of a river basin plan, the implementation of the project comprising the Driekoppies and Maguga Dams, and water allocations between the two countries, as well as the establishment of the Komati River Basin Water Authority. It concerns itself primarily with the operational aspects such as costs of the project and its administrative bodies, and makes note in article 13 of social and environmental considerations.

The *Agreement between the Governments of the Republic of Angola, the Republic of Botswana, and the Republic of Namibia on the Establishment of a Permanent Okavango River Basin Commission (OKACOM) 1994* (hereafter the OKACOM Agreement 1994) makes special reference to the principles of the Helsinki Rules, Agenda 21 and the Rio Summit 1992, which comprise the major soft law instruments shaping the law in this area prior to other agreements of relevance to Namibia, which were formed later. The Commission is established to perform the function of technical advisor on conservation, development and utilization of shared waters; and specifically aspects such as long term yield of the available resources, demand from consumers, criteria to determine sustainable use, matters connected to the construction of water works, pollution prevention, and ways of overcoming water shortages are mentioned as some of its responsibilities. The agreement also sets out the composition and structure of the Commission, its meetings, functions, powers and financial arrangements.

The Agreement between the Government of the Republic Namibia and the Government of the Republic of South Africa on the Establishment of a Permanent Water Commission, (1992) (hereafter the Permanent Water Commission Agreement) is almost identical to the OKACOM Agreement citing in its preamble recognition of the 1966 Helsinki Rules, and also setting out the objectives of the Commission to be technical adviser to the two states on devel-

opment and utilization of water resources, and the composition, procedures, powers and financial arrangements of this body. The responsibilities of the Permanent Water Commission are also almost identical to that of the Okavango Commission (above).

South Africa

Full advantage was taken of the opportunity provided by the transformation of the political landscape in South Africa following the democratic government elected in 1994, and the introduction of the new Constitution, to initiate sweeping reforms in all areas of law including water[7]. The Water Act of 1956, granted exclusive use but not ownership of water, through riparian rights principles, which under apartheid in effect deprived a majority of the black population who were non-land owners from water for both irrigation and adequate domestic use[8].

The *National Water Act No. 36 of 1998* declares the "central guiding principles in the protection, use, development, conservation, management and control of water resources" to be '*sustainability and equity*', recognised in the context of "the need to share some water with other countries" and is deemed necessary to protect water resources for present and future generations. With the identification and distinction of these specific principles, the statute draws parallels between these tenets of national water management and the international customary law principles enshrined in most of South Africa's bilateral and multilateral agreements, and are alluded to when in the rest of the Act, it notes the need to meet its "international obligations" –although it does not list the specific instruments. While in the transboundary context these principles apply inter-state, on the national plane highlighting sustainability and equity noted within the context of its "international obligations" and the need to "share water with other countries", is relevant in the development of national mechanisms or procedures which are relevant to international equitable sharing determinations. It is also interesting to note the prominence given to sustainability and equity in the Act as illustrative of how the country's history and water scarcity realities are remedied through its legal framework.

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[7]Abrams, LJ : 'Water policy development in South Africa' Paper written for the Cranfield International Water Policy Conference, Cranfield University, Bedford UK, September 1996

[8]Kirsten J, Perret S, van Zyl J: 'Land Reform and the New Water Management Context in South Africa: Principles, Progress and Issues' Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, Pretoria, South Africa *http://lnweb18.worldbank.org/ESSD/essdext.nsf/24DocByUnid/59F4C3205FB26FD385256BE600728A18 /$FILE/ southafrica.pdf*

Considering the practical realities of scarcity of water in South Africa, the development of law and policy towards more ecologically sound and internationally advocated principles is best illustrated by the implementation of 'The Reserve' provisions of the National Water Act which comprises two parts: the "basic human needs reserve" and the "ecological reserve", where water is allocated in terms of quality as well as quantity for 'all significant water resources', which would arguably include transboundary watercourse systems. This concept is in line with the general objectives of its international commitments, such as conservation, sustainability and equity although none of its international agreements list this specific mechanism to achieve those goals. Indeed many of the mechanisms found in this and other regions in this paper have been at the discretion of the state in implementing the general goals or framework set out by the international texts, even where such texts are detailed in setting out, for example in this particular case, the environmental protection and preservation provisions as found in article 4(2)(a) of the Revised Protocol. Here the only specifically mandated mechanism is the permit system. Generally, the opposite is true for bilateral agreements which tend to be more specific regarding methods to be followed by states. The important and pioneering Reserve provisions however, cannot be traced back to directly to any of the agreements although it does accurately satisfy the duty of environmental protection and preservation in article 4(2)(a) of the Revised Protocol, and works towards the goals of article 8 of the Tripartite Agreement on water quality and prevention of pollution.

It should be highlighted that the Tripartite Agreement postdates the National Water Act. Therefore, while it is important to assess the degree in which the national framework complies with the former, it is evident that the Tripartite Agreement is not the source of the Act's inclusion of a particular matter. Notwithstanding it shall be seen that the Tripartite Agreement and the National Water Act correspond in a number of areas.

The water protection provisions of the Tripartite Agreement specifically advocate the adoption of 'evolving classification' systems which aim to "classify and state the objectives and criteria in respect of water quality variables to be achieved through the agreed classification system"[9]. The National Water Act contains equivalent rules[10], which require the water resource strategy to inter alia "state the objectives in respect of water quality to be achieved through the classification system for water resources" and to state the water quality variables, objectives and criteria. The Tripartite Agreement frames the

[9] article 8(a)
[10] section 6(1)(i)

development of classification systems, and water quality variable criteria, as the product of resolutions of the Technical Committee and also refers to the co-ordination of management plans which are all within the transboundary context. However, the Act's classification system for national implementation facilitates these transboundary classification objectives. The classification system is further developed in Chapter 3 which is devoted to water resources protection, where guidelines and procedures are set out for determining different classes of water resources in the first part, while the second part enables the Minister to utilize the classification system to establish clear goals relating to the quality of the relevant water resources, which must strike a "balance between the need to protect and sustain water resources on the one hand, and the need to develop and use them on the other." Interestingly, the source of this latter phrase can be found in almost identical form in the Original Protocol[11], and duplicated in Article 3(4) and 3(8)(vi) of the Revised Protocol, which advise state parties to maintain a balance between resource development for higher standards of living and conservation enhancement.

The Tripartite Agreement also encourages the adoption of monitoring programs towards its pollution prevention goals. The national law tallies well with this requirement by authorising its catchment management agencies[12] to carry out monitoring permitted water uses in their areas of competence and empowering authorities to install monitoring devices[13].

One of the most important mechanisms mandated by the Revised Protocol is the use of a "permit, license or authorization" under Article 4(4)(b) regarding the Prevention and Mitigation of Harmful Conditions for any person intending to use the waters of a shared watercourse, or dispose waste, but makes exceptions to needing permits for domestic uses. The *Revision of General Authorisations in Terms of Section 39 of the National Water Act, 1998 (No 399 of March 2004)* contains schedules which "replace the need for a water user to apply for a license in terms of the National Water Act" for certain specified activities, such as domestic uses, on condition that the stipulated authorization criteria are satisfied. The National Water Act provides a tight fit to the Protocol's abstraction and waste disposal licensing obligation through its provisions on detailed uses and situations which require government authorisation under Chapter 4, and legislates on aspects such as the "considerations, conditions and essential requirements of general authorisations and licences,"[14] "existing lawful water

[11] article 1(3)
[12] Schedule 3 on the Powers and Duties of Catchment Management Authorities
[13] ibid
[14] Part 2

uses" where permits may not be required under certain circumstances;[15] "general authorisations to use water;"[16] considerations for individual applications for licenses;[17] and compulsory licenses. Regarding its waste disposal permits, conditions are attached to licenses relating to the disposal of waste by specifying the water body it may be discharged into, articulating the permissible levels, volume and necessary treatment[18]. The Revised Protocol adopts the standard of "no significant harm" for conditions to granting permits, in which interestingly, is also found in the Act where responsible authorities may attach conditions relating to the protection of water sources, the stream flow and other water uses which serve to protect the water source[19]. With respect to permit criteria, section 27(1)(j) requires that South Africa's international obligations regarding water quality must be considered when issuing abstraction and disposal authorizations. Additionally, international obligations have priority call in times of shortage, and conditions of licences can be amended as a result[20].

In several parts of the Act, explicit reference is made to South Africa's 'international obligations' (although specific instruments or watercourses are not listed) which nevertheless provides a direct correlation on the matters to which those provisions relate. The Preamble of Act notes the government's overall responsibility for international water matters, as well as setting out the fundamental principles of the equitable allocation of water, and sustainable use of the nation's resources. One of the purposes of the Act is listed in section 2(i) as meeting its international obligations, and includes international rights and obligations as part of its national water strategy and its catchments management strategy[21]. One of the notable features of the Act is that, international obligations are specifically mentioned when drafting water allocation schedules, and is considered when issuing permits[22]. For example, the Komati River Treaty with Swaziland sets out water allocation for the parties in article 12 and Annex 3, and "from the date to be determined by the Joint Water Commission, be entitled annually to the following Net Consumption: 157.8 cubic hectometres at High Assurance and 381.0 cubic hectometres at Low Assurance." Although the national text intends to provide legitimacy for these types of internationally agreed assurances, obviously the Act provisions do not provide details of specific quantities, but instead simply denote fulfilment "international obliga-

[15]Part 3
[16]section 39
[17]Part 7
[18]section29(1)(c)
[19]section 29(1)(a)
[20]section 49(2)(b)
[21]section 6(b)(ii) and section 9(a)
[22]section 27(1)(j), section 45(2) and section 49(1)(b)

tions". The Act also alludes to these commitments by specifying that in considering water pricing strategies, water use charges may be made on a national or regional basis; and again while not referring specifically to any instrument for further details, it provides a vague allusion to the terms of water allocation, and co-operation found in the Tripartite and Revised Protocol Agreements[23].

A very good fit can be found between the national text provisions concerning activities affecting the stream flow of waters, and those of its obligations contained in article 9 and Annex I on Flow Regimes in the Tripartite Agreement which sets up numeric quantities of volume flows, fleshes out ways of controlling the flow regime, and lists the criteria to be considered when establishing flow regimes. The Act notes specifically state responsibility to render power generation a controlled activity where it alters the flow regime of rivers, and states the duty to protect the stream flow regime as a priority for license authorisation[24]. Most significantly, the Act does establish that activities which reduce the availability of water in a watercourse necessary to meet its allocations at international level, are termed stream flow reduction activities[25]. Additionally, although having no corresponding provisions in the Tripartite Agreement, it itemises what should be considered when declaring such activity such as the extent to which the activity significantly reduces the water availability; the duration of the activity, and the effect on the reduction on the Reserve[26].

Under both the Revised Protocol and the Tripartite Agreement, South Africa is legally bound to prevent, reduce and control pollution. In this area, the South African framework provides a loose approximation with respect to pollution per se, and a good fit to the duty to protect and conserve the environment and water sources in general. The Tripartite Agreement advocates the adoption of,

> "techniques and practices to prevent, reduce and control the pollution and environmental degradation... that may cause significant harm to the other Parties or to their environment, (emphasis added) including human health and safety [...]"[27]

Thus pollution must be prevented within the national sphere as well as addressing transboundary effects of pollution. The Revised Protocol also encourages "individual" as well as "joint" measures to prevent reduce and control pollution[28]. Although noted with reference to "mutually agreeable methods", the types of water protection examples cited by the Protocol, are the setting

[23]section 57(1)(a)(ii)
[24]section 29(1)(a)(ii)
[25]section 36(2)
[26]section 36(3)
[27]Article 8(d)
[28]Article 4(2)(b)(i)

of water quality objectives and criteria (discussed above); addressing pollution from point and non-point sources; and establishing lists of substances to be prohibited, limited, investigated or monitored[29]. The main methods employed by the Act to prevent pollution are control of water-related or land-based activities, and permit requirements for water uses (including waste discharges etc). The Act however fails to mention addressing point and non-point source pollution; and while these particular provisions may be found wanting, the Protocol frames pollution prevention in terms of general environmental protection and the preservation of ecosystems and the aquatic environment. The National Water Act contains several mechanisms to this end such as environmental impact assessments (also encouraged by the Revised Protocol[30]), the Reserve provisions for ecological purposes, prohibiting streamflow reduction activities, the injection of environmental considerations into the planning process, *inter alia* and thus can be seen to be fully congruent with this provision.

Chapter 10 of the legislation specifically deals with international water management, declaring that the Minister may establish bodies to implement regional and international commitments, but notes that they may be given additional responsibilities, and may also perform some of the functions *outside* South Africa. Some of the pre-existing bodies are declared to be legally established under this particular legislation. Some of the bodies that would thus have authority under this provision would be the KOBWA; the Permanent Water Commission[31]; the Joint Water Commission[32], and the Tripartite Permanent Technical Committee[33]. Throughout this section and in the rest of the statute consideration is always given to the "relevant international agreement or commitment".

The Regulations on *Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources (No. 704 of June 1999)* which is a subsidiary instrument of the National Water Act of 1998, comes directly under Article 13 and Annex III on Transboundary Impact in the Tripartite Agreement specifically identifying mining as an activity which may cause significant transboundary impact on the watercourse, and cannot commence before

[29] Article 4(2)(b)(iii)

[30] article 4(1)(b)

[31] Agreement between the Government of the Republic of Namibia and the Government of the Republic of South Africa on the establishment of a permanent Water Commission signed at Noordoewer, 14 September 1992.

[32] Treaty on the Establishment and Functioning of the Joint Water Commission between the Government of the Kingdom of Swaziland and the Government of the Republic of South Africa.

[33] Under the Agreement between the Government of the Republic of South Africa, the Government of the Kingdom of Swaziland and the Government of the People's Republic of Mozambique relative to the establishment of a Tripartite Permanent Technical Committee.

the provisions of Article 4(1) of the Protocol are complied with. This refers to obligations of notification, information exchange and consultation on planned measures between the State Parties. In order to fulfil this obligation the state must receive the requisite information from the relevant national actors. The 1999 Regulations which address water pollution, detail how mining activities and locations can be restricted and controlled, provides penalties for failure to comply with the act, and obliges miners and related parties to observe the duty to provide information. This regulation directly abides by the Tripartite provisions, and is an example of how national states are responsible for translating the broader principles and duties contained in their treaties and agreements, into the exhaustive responsibilities and undertakings to prevent pollution by mining activities. The obligation to provide information to the state in turn facilitates the government's responsibility to furnish Shared Watercourse Institutions with such information, with which the government has a duty to cooperate and exchange data[34]. Article 4(2)(b)(iii)(cc) of the Revised Protocol and Article 8(1)(c) of the Tripartite Agreement, mandating the establishment of lists of substances, the introduction of which, should be "prohibited, limited, investigated or monitored" is also met by provisions 5 and 8 of the Regulation, through the restrictions of materials used and security measures to be considered. No explicit mention, however, is given to international or regional standards.

The *Water Use Notice (2000)* lays down the types of water use that must be registered in the various provinces, one of the notices of which includes the Komati River (Notice No. 536) covered in the Tripartite Agreement. While registration specifically is not mandated by the regional and international instruments, it is necessary for the government to carry out its commitments, and thus it works towards fulfilling the responsibilities in the Tripartite Agreement, even though there are no complementary provisions in the instrument. In fact, the water uses listed in the legislation are covered by the Tripartite Agreement, which in Article 9(2) on flow regimes states that,

> "Any abstraction of waters from the Incomati or Maputo watercourses, regardless of the use or geographic destination of such waters, shall be in conformity with the flow regimes of Annex I and relevant provisions of this Agreement."

This responsibility for regulating the flow of the rivers authorised by the Revised Protocol and the Tripartite Agreement (which also note the duty to cooperate by considering the needs of other riparian state users), is supplemented by the additional responsibility for the prevention of water flow diversion. Wa-

[34] Article 5(3) addresses the institutional framework for implementation.

ter Use Notices additionally require registration for the following uses which directly match South Africa's international commitments:

- *engaging in a stream flow reduction activity.* This includes activities such as afforestation, which mirrors precisely the notion of 'permissible afforestation area' that both parties agree on in the Tripartite Agreement[35]. Registration of such activity will enable the government to remain within its allowed 364 975 ha, and a runoff reduction of 475 million m^3/a.

- *discharging waste from any source and through any conduit.* Registration enables the government to ensure that permits will be sought for any such activity which fits tightly with its responsibilities under the Revised Protocol article 4(1)(b) on notification of planned measures with possible adverse effects. Waste discharge activities cannot commence before the provisions of Article 4(1) of the Protocol are complied with, which mandates notification, information exchange and consultation on planned measures between the state parties. In order to fulfil this obligation the state must receive the requisite information from the relevant national actors.

- *altering the bed, banks, course or characteristics of a watercourse.* This requirement accurately fits the responsibilities of the state's notification duties in the Tripartite Agreement which specifically lists these factors as causing significant transboundary impact under Annex III[36]; and mandates the notification and consultation between parties on undertakings such as "river training and canalisation of river beds with a length exceeding 500 m."

Summary of Observations. The provisions which mandate abiding by South Africa's "international obligations" as well as the establishment of water bodies specifically listed in regional instruments demonstrate the most obvious harmonisation between international and national texts. The National Water Act additionally exhibits a tight fit to international instruments on aspects such as classification systems and abstraction and waste disposal licensing. Its priority on 'protection of the waters' of these mechanisms provides a reasonably good fit to the duty to prevent significant harm to the watercourse. The Act is instrumental to honouring detailed water sharing schemes and water pollution control programmes agreed under a number of its agreements. Interestingly, the act uses very similar phraseology to its corresponding international text,

[35] article 4 of Annex I on Flow Regimes
[36] article 1(e)

such as on the issue of balancing development and conservation. The influence of international commitments is also visible in some of its subsidiary legislation, such as the 1999 Regulations, which directly correspond to South Africa's regional commitments, and significantly fleshes out how its duties can be fulfilled. It is interesting to note in addition that the National Water Act 1998, although promulgated earlier in time, is congruent with the commitments contained in the Tripartite Agreement.

The National Water Act does not contain some of the techniques suggested in the international framework for addressing pollution. It does however, contain significant water protection mechanisms and techniques which does accord with its obligations. Other 'good fit' evaluations can be seen with aspects such as streamflow reduction activities.

Namibia

Although it shares several of the major rivers (the Kunene, Orange (Senqu), Okavango and the Zambezi) in the Southern African region, Namibia's arid climate renders critical to its socio-economic development, the sound management and conservation of water buttressed by a sound legal water framework. Recognizing the importance of these rivers along its borders, Namibia is party to joint commissions pertinent to all the above mentioned rivers, and has recently enacted a comprehensive water law framework.

Namibia's intention to adhere to its international commitments is manifest in the Water Resources Management Act No. 24 of 2004 where it notes among its fundamental principles in section 3(m), the need to meet "Namibia's international obligations". The observance of international obligations is assigned to Part X of the statute, which affirms Namibia's rights and duties both to the agreements to which it is a party, and also customary international law, and further proceeds to specifically name the 1997 Convention and the SADC Protocol.

One such obligation is the duty to regularly exchange data and information under article 9 of the 1997 Convention, and several articles of the Revised Protocol, which includes "in particular that of a hydrological, meteorological, hydrogeological and ecological nature and related to the water quality as well as related forecasts;" and also information concerning planned measures. This duty is precisely replicated in section 55 of the Act entitled "collection of data concerning internationally shared watercourses" where a list of ten items which must be provided to the Minister in furtherance of his or her functions

as regards international water course systems, is mandated. Once this data is collected, it then facilitates the state's duty of exchange with its neighbours. Factors such as volumes of water used, or volumes of waste discharged, the number of persons who rely on such watercourses currently, and the waste load capacity *inter alia* are required by the Minister for collection and analysis, and are sufficiently congruent with the examples given in the 1997 Convention on hydrological, ecological and water quality issues. The Revised Protocol requires states to consult on planned measures, particularly those with adverse effects[37]. In the same way, a link can be drawn between the duty to notify the government on any such activities as directed by the Act, and the duty to collect information on waste discharge or water use and abstraction found in the Revised Protocol.

The Act additionally refers to the duty to "collect and analyse" information "concerning internationally shared water resources"[38] with respect to the role of the Water Resources Management Agency, which receives information from a number of sources including the national Basin Management Committees[39]. This therefore is instrumental to the duty to inform state parties regarding planned measures in the Revised Protocol[40], emergency situations, and other notification requirements committed to by Namibia.

Part X of the statute which contains the powers and functions of the Minster with respect to internationally shared waters in section 54, also forms a tight fit to Namibian international obligations through its authorisation of

> "joint management, planning and development of joint projects with other basin states within the Southern Africa Development Community for the purpose of promoting economic growth, environmental integrity and common understanding."

This therefore provides the statutory backup for interstate projects such as the Gariep Dam which alters the flow regime along the border with South Africa, or the water transfers from Angolan parts of the Kunene River[41]. Section 54(c) of the law refers to the promotion and establishment of institutional relationships between internal river basin organizations and international ones. Article 5 of the Revised Protocol outlines the institutional framework for implementing the Protocol and identifies four different organs to carry out this task. The statute serves as a direct nexus between the types of bodies such

[37] article 4(1)(a) and (b)
[38] Section 7(g)
[39] Section 13(h)
[40] Article 4(1)(a)
[41] http://www.sardc.net/Editorial/NewsFeature/waterprotocol.htm

as the Basin Management Committees in Part IV of the Act, and those organs responsible for implementing the Protocol. Although the latter refers to the Water Ministries of each state party, it does not detail the national entities responsible for basin management, which are presumed to and do fall under the competency of the water Minister; further the requirement of consultation between the Minister and international bodies is unequivocally provided for in the Act[42]. All information, technical exchange and consultation can thus pass to regional level through the water Minister. The Act also empowers the Minister to develop and improve Namibia's participatory and consultative input into these organizations.

Part X[43] of the Act also advocates the establishment of a common database between neighbouring riparian states, which will accumulate information on the descriptions and uses of shared waters. While none of its international agreements specifically sanction the establishment of a database, this stipulation can be sufficiently matched to article 9(3) of the 1997 Convention which calls for states to "process data and information in a manner which facilitates its utilization by the other watercourse States to which it is communicated." The development of a common database would greatly facilitate this end, thus demonstrating a very tight fit to the Convention on this point.

Another clear association of the Namibian Act to its international commitments is demonstrated through section 27(1)(b) on the Reservation of Water Resources, similar to the South African Reserve, which mandates the

> "reserve of part or all of the flow of a watercourse, including any groundwater resource. . . to. . . reasonably protect aquatic and wetland ecosystems, including their biological diversity, and to maintain essential ecosystem functions."

This among other mechanisms such as environmental impact assessments and 'protected areas' directly tally with the duty of environmental protection and preservation cited in article 4(2)(a) of the Revised Protocol which aims towards the protection of ecosystems in shared watercourses. The water protection provisions of Part XII are concerned with the environmental protection of a declared water management area, with consideration given to riverine habitats, wetlands and ecosystems at risk of contamination or distinction, and are a strong match to the Protocol's instructions for states to "protect and preserve the ecosystems of a shared watercourse"[44]. The Act details the methods to achieve this objective, by declaring water management areas, determining its boundaries and prohibiting certain activities therein.

[42] section 54(e)
[43] Section 54(a)
[44] article 4(2)(a)

The statute requires that these reserve provisions under section 27 should be considered when issuing water abstraction licenses and permitting effluent discharges. Among its fundamental principles the statute notes in particular,

> "respect for Namibia's rights with regard to internationally shared water resources and, in particular, to the abstraction of water for beneficial use and the discharge of polluting effluents."

The Revised Protocol mandates that permits should be granted only once it has been determined that the relevant activity will not result in "significant harm on the regime of the watercourse."[45] Like the South African statute, the Act provides a tight fit to the general abstraction licensing and waste discharge permitting requirements of the Revised SADC Protocol, through its article 35 which details seventeen different factors upon which the issuance of permits may be based which in effect aim to protect the water sources. These include inter alia, the reservation of water under article 27, the master plan, the potential impact of the licensed activity on water quality and aquatic ecosystem, the safe yield of the aquifer, and any "additional criteria which the Minister may prescribe". The inclusion of two references to international obligations[46] when assessing licenses: the proposed effect of abstraction on Namibia's international obligations; and the stipulation that licenses for water abstraction and use must be consistent with the principles of the Act which include international obligations, is further indication of the accurate match of the licensing provisions. Additionally an exact parallel can be drawn where abstracting water for domestic purposes is exempted under both the Act and the Revised Protocol. The detailed licensing provisions of the legislation also includes aspects such as terms and conditions, duration, and contents, which are not *per se* mentioned in the Revised Protocol, but meet the obligation to have such permit systems in place. A striking feature of the Act is that it particularizes additional criteria in the pre-grant scrutiny stage if the authorization pertains to a shared watercourse. These additional factors are: the total volumes of water used and abstracted, the nature of the uses, number of persons dependent on the watercourse, abstraction commencement dates, the availability and reliability of alternative sources; and the potential increases in water demand for such shared waters[47].

While the Revised Protocol and the 1997 Convention lay the responsibility of protecting water sources to the state, the Act echoes this notion by encouraging the government and other entities to participate towards this goal, for example the local water user associations are encouraged "to protect the ru-

[45] Article 4(4)(b)
[46] section 35(f)(ii)
[47] section 35(2)

ral water supply scheme concerned against vandalism and other damages"[48]. Such protection of water resources is also an important element of the national water Master Plan[49], which mainly involves planning along the notions of water demand and availability. These specific provisions are not found in any of the regional or international treaties in and of themselves, but can be said to sufficiently match these instruments by working towards the broader goal of protection of water systems through effective management. This nexus is more clearly demonstrated where the Revised Protocol defines "management of a shared watercourse" to mean,

> "(i) planning the sustainable development of a shared watercourse and providing for the implementation of any plans adopted; and (ii) otherwise promoting the rational, equitable and optimal utilization, protection, and control of the watercourse;"

Further protection provisions can be found in Parts XI and XII on Water Pollution Control and Water Resource Protection. The relationship between the Act and Namibia's agreements on the issue of permits for abstraction and use (above) are very similar to the issues on permits for waste discharge. Under the Act most types of effluent discharge require a permit, as mandated by the Revised Protocol in article 4(b) which requires that

> "any person. . . who intends to discharge any type of waste into such waters, to first obtain a permit, licence or other similar authorization from the relevant authority within the State concerned."

This notion is echoed on the Act under most of the provisions of Part XI; however it allows certain exemptions from the permit requirement. Article 57 lists these as (a) those of household wastes (b) those which by reference to volume or composition can be permitted. The domestic waste exception is in line with article 4(4)(b) of the Revised Protocol; whereas the volume and composition criteria forms a closer fit to pre-set water quality objectives in the anti-pollution provisions of article 4(2)(b) of the Protocol. Tightly corresponding to both these water quality objectives, and waste discharge requirements[50], applications for permits must include items such as the location of the discharge site and treatment facility, the proposed volume, rate of the discharge, and chemical composition, *inter alia*[51]. The following section also offers guidance for which criteria should be used to determine granting discharge permits, declaring that a consideration of the impact of such discharges on the environment and existing water uses, but of particular note, explicitly states the effect

[48]section 18(2)(b)
[49]section 23(2)(c)
[50]article 4(4)(b)
[51]section 59(1)

of such discharges on "Namibia's international obligations relating to internationally shared waters"[52]. These pollution control provisions provide a good fit to the Revised Protocol in working towards its goals, in the "prevention, control and reduction" of pollution, while leaving methods to unilateral implementation. The Act further identically matches the requirement to curb potential risks to human safety cited in the Protocol[53], where it notes that proper effluent discharge management requires the protection of public health[54]. The Act also meets the Protocol's objectives through the use of an environmental impact analysis when considering applications for effluent discharge licenses[55] to ensure no negative repercussions are inflicted upon the environment.

Part IX of the Act is devoted to groundwater protection. The Revised Protocol does not make special provisions for groundwater bodies, and instead consistently refers to the generic term of "watercourse", which it defines as a "system of surface and ground waters". Although not cited in any of the treaties to which it is a party, the Act refers to protection of such bodies through the special licensing system of drilling boreholes, mining and the duty to keep records and provide information. This is in line with general international practice in this area, and is visible in a number of contemporary water codes[56].

The Act empowers the Minister, in section 127 on water related emergencies, to "... take necessary measures to deal with the emergency by reducing or eliminating such threat... " which forms a good fit to article 4(4)(a) on mitigating and preventing harmful conditions, and also article 5 on emergency situations of the Revised Protocol, and Part V of the 1997 Convention. The Revised Protocol identifies harmful conditions as those "resulting from natural causes or human conduct, such as floods, water-borne diseases, siltation, erosion, saltwater intrusion, drought or desertification." The Namibian framework enables the Minister to cancel and suspend licenses which would contribute to factors such as drought, desertification or siltation[57]. It further makes provisions for dam safety and flood management outlining five different options to prevent or minimize the risk of flooding such as the construction or demolition of dykes, levees and similar structures, enter consultations to determine the extent of floodplain areas[58]. The law prohibits activities such as watercourse lockage[59]

[52] section 61(g)
[53] article 4(2)(b)(i)
[54] section 63(c)(v)
[55] section 60(2)(e)
[56] For example see Kyrgyzstan below.
[57] section 127(1)(a)
[58] section 127(1)(b), section 84 and Part XIV
[59] section 78

which is a "human conduct" envisaged in the Protocol that would result in harmful conditions.

Summary of Observations. A general observation can be drawn that tight adherence to its international agreements, as reflected in the frequent reference to 'international obligations' and 'shared waters' was intended by the drafters of the Water Management Act. These constant parallels to regional and other treaties ensure that the Act is interpreted in a manner consistent with the responsibilities it has committed to therein. Consequently, numerous tight fit provisions can be found in the Act: deciding factors in abstraction and disposal permits, water quality and pollution provisions, data collection and exchange and the protection of ecosystems, and the prevention and mitigation of harmful conditions.

Central Asia

The communist legacy has left the spirit of co-operation and unity evident in the legal framework amongst the Central Asian states, which is belied by the reality that tension sometimes exists over management and sharing of water resources that are used for irrigation, hydroelectricity and human consumption. Almost ninety percent of the surface water in the Aral Sea Basin comes from the Amu Darya and the Syr Darya rivers; and while Kazakhstan, Turkmenistan, and Uzbekistan receive the lion-share 73% of this figure, upstream Kyrgyzstan and Tajikistan receive 0.4% and 11% respectively, in spite of the fact that they provide 80% of the region's surface water[60]. This tension is only partly overcome through a number of regional agreements on transboundary water resources, with the co-operative approach manifest in the preambulatory phrases of all the bilateral and multi-lateral agreements on shared water resources and related issues. The prevalent theme throughout the agreements reviewed is that water is a valuable commodity with economic value and competitive uses. Some writers have identified obstacles to regional co-operation as being insufficient attention on international water law norms and the lack of harmonization of national water legislation in the region[61]. Another consequence of the transition from Communism to market economies is the need to

[60] Heltzer G, 'Stalemate in the Aral Sea Basin: Will Kyrgyzstan's new water law bring the downstream nations back to the multilateral bargaining table?' Georgetown International Environmental Law Review, Winter 2003 (hereafter, Heltzer (2003))

[61] D. McKinney in D. Burghart and T.Sabonis-Helf (eds.), The Tracks of Tamerlane-Central Asia's Path into the 21st Century 'Cooperative Management of Transboundary Water Resources in Central Asia', National Defense University Press, 2003

rectify the environmental damage resulting from inefficient and unsustainable development policies[62].

Considering the heavy reliance of these states on water for irrigation and power generation[63], following independence an agreement was signed in 1992 on *Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources (1992)* (the Almaty Agreement).

1992 UNECE Convention. Of the regional instruments under current discussion, the 1992 Convention sets out the most detailed provisions of state obligations, and can be contrasted against the framework-type provisions of the Almaty and Mekong Agreements. Despite being one of the older instruments covered in the study, initially for European application only, but later acceded to by Central Asian countries, it still contains principles, techniques and mechanisms which would be very relevant in all regions and contexts, and the reflect current priorities. Recognizing the importance of co-operation, and strong national and international measures, the instrument sets out the guiding principles in the Preamble and general provisions, which include prevention of transboundary pollution and environmental protection, sustainable water management, and conservation of water sources. The instrument authorises that the parties should take "compatible relevant legal, administrative, economic, financial and technical measures, to prevent, control and reduce any transboundary impact"[64]. Some such mechanisms are environmental impact assessments, the 'ecosystems approach' and contingency planning[65]. It details the items on which joint research and technique development can be collaborated on, such as *(inter alia)*

> "(a) Methods for the assessment of the toxicity of hazardous substances and the noxiousness of pollutants; [...] (e) Environmentally sound methods of disposal of hazardous substances; [...] (g) The development of environmentally sound water-construction works and water-regulation techniques; and (h) The physical and financial assessment of damage resulting from transboundary impact."[66]

Other salient features of the Convention include identification of areas for bilateral and multi-lateral co-operation, such as programmes on water qual-

[62]ibid
[63]ibid
[64]Article 2(1)
[65]Ibid.
[66]Article 5

ity and quantity; exchange information on pollution sources; elaborate waste emission limits; and develop warning and alarm procedures[67]. Similarly it lists the specific types of information to be exchanged between riparian states, which include "experience gained in the application and operation of best available technology," (which is further fleshed out in Annex I) research and development results, and, emission and monitoring data, among other aspects –including calling for certain information to be made available to the general public[68]. The agreement also offers guidelines on mutual assistance in critical situations, and highlights the way in which the assistance can be rendered and the procedures to be followed (for subsequent elaboration). The Annexes to the Agreement also elaborate guidelines for states on best environmental practice, and the development of water quality objectives. Additionally, it advocates the application of the 'polluter-pays' and 'precautionary' principles, and also the precepts of 'equality and reciprocity', which can also be found in the Almaty Agreement 1992 (below).

Bilateral and multilateral Agreements

The instruments governing water relations in the area are characterized by their strong economic slant, namely the use of water for energy production. A typical example of this is the *Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the use of water and energy resources of the Syr Darya basin (1998)* (The Syr Darya Agreement). This framework provides compensation for upstream countries such as Kyrgyzstan for its water in exchange for,

> "equivalent amounts of energy resources, such as coal, gas, electricity and fuel oil, and the rendering of other types of products (labour, services), or in monetary terms as agreed upon, for annual and multi-year water irrigation storage in the reservoirs."[69]

It further stipulates that customs duties do not apply for energy, labour or services associated with the agreement, and sets out that responsibilities for construction and maintenance shall be according to the legal right of ownership. The agreement encourages joint consideration on a number of issues, such as

> "ensuring the safe operation of hydrotechnical facilities in the Syr Darya Basin, economic and rational water use with the application of water conser-

[67] Article 9
[68] Article 13 and 16 respectively.
[69] Article iv

> vation technologies, and irrigation equipment, reduction and discontinuation of polluted water discharges in the water sources of the Syr Darya Basin."[70]

Also the *Agreement between the Government of the Republic of Kazakhstan and the Government of the Kyrgyz Republic on utilization of the water facilities of interstate use on the Chu and Talas Rivers (2000)* (Chu and Talas Rivers Agreement) acknowledges the social and economic values of water, listing the facilities owned by Kyrgyzstan allotted for interstate use, which it will be compensated for by states who use them[71]. It also requires that maintenance, repair work and costs shall be undertaken jointly, and Parties shall co-operate in joint research and design for efficient use of the facilities and water resources[72].

However, the main regional framework for interstate water co-operation and management is the *Agreement between the Republic of Kazakhstan, the Republic of Kyrgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources (1992)* (the Almaty Agreement). This agreement notes the historical union of the now separate republics, and encourages joint management and joint problem solving for the rational use and protection of water sources, in furtherance of economic development, but also to mitigate ecological stresses following water depletion[73]. The frustrations with its use are primarily a result of the fact that its water allocations date back to the Soviet arrangement[74]. The parties are obligated to provide for strict observance of the rules within their countries, and the treaty warns that the infringement of riparian rights of one state may lead to the undermining of the rules and benefits thereof for all states. In this regard it incorporates the polluter-pays principle by containing provisions advocating penalty provisions in the form of economic or "other mechanisms"[75]. The agreement encourages joint works regarding environmental protection, scientific and technical information exchange, and joint use of production potential. Finally it establishes the Interstate Co-ordination Water Management Commission, and details its functions and powers. This regional treaty forms an umbrella framework, and outlines general principles to be adhered to without detailing mechanisms to achieve them.

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[70] Article x
[71] Articles 2 and 3
[72] Articles 4 and 10
[73] Preamble
[74] Heltzer (2003) supra note 32
[75] Article 12

Kyrgyzstan

The predecessor to the *2005 Water Code* on water resource use and management was the *Law On Water of the Kyrgyz Republic 1994*. The legal framework under this law suffered criticisms of ambiguity in the role of state bodies, underdevelopment of regulations such as protection of underground waters from drilling, and difficulty in enforcing the rules due to lack of inspection and monitoring mandates for government entities[76].

The recent Water Code of 2005 is a comprehensive overhaul of the previous water framework and aims to regulate the "use, protection and development of water resources" in the country. This Code is similar to the Namibian and South African national laws, containing most of the modern precepts of water law and management with detailed abstraction and water use provisions[77], and requisite terms of any licenses issued; it contains separate groundwater protection and use provisions[78]; and protection zones are established[79]. In line with international and regional commitments it further enumerates water resource protection from pollution and depletion[80]; it provides dam safety mechanisms which are a regional priority[81]; and also establishes a State Water Inspectorate as well as a Single Water Information system[82].

The Code contains several explicit citations of its obligations on the international plane, notably the Water Code specifically lists its bi-lateral and multi-lateral agreements as sources of relevant law in its provision on inter-state co-operation[83]. This 'catch-all' provision stipulates that inter-state use and protection of water resources, and water economy constructions are governed by the Kyrgyz legal framework (the Constitution and laws) and agreements and general provisions of international law. The Code also identifies the minimum elements of a National Water Strategy, one of which is ascertaining "the volume of unused flow of water resources taking into account environmental needs and international agreements concerning water relations"[84]; and

[76] http://www.landreform.kg/en/vestnik/vestnik.cgi?Action=water&Number=12&Article=1 issue 12 August 2002 Uran Tursunaliev Water Rights Newsletter

[77] Chapter IV
[78] Chapter VI
[79] Chapter X
[80] Chapter IX
[81] Chapter XII
[82] Chapters XV and XVII
[83] article 98
[84] article 18(3)

must take into account any "obligations under international law" in the formulation of Basin Plans and the water allocations in such plans.

The analogous management principles in the Code and Kyrgyzstan's agreements are interesting to note. Article 2(5) of the Convention which espouses the doctrines of the precautionary, polluter pays and sustainability principles can also be found in article 6 of the Water Code as principles for the overall management of water resources. Other principles also promulgated in the law are the participatory principle, and the principles of openness and real guarantees. The seventh principle enumerated in the Code is that of the 'Economic Value of Water Resources' which encapsulates the spirit of a majority of its bilateral and multilateral agreements with bordering states.

This tenet is also noted in the preamble of the Chu and Talas Rivers Agreement, where the "social, economic and environmental value of water resources" is acknowledged.

The 1992 UNECE Convention states that parties must take "all appropriate measures"[85] to control, reduce and prevent pollution, which involve "relevant legal, administrative, economic, financial and technical measures"[86] to that end. Kyrgyzstan's regional agreements refer only summarily to pollution control –the Almaty Agreement warns states against transboundary pollution in article 3, while the Syr Darya Agreement mandates the reduction and continuation of polluted discharges. The Water Code significantly matches the 1992 Convention which highlights the importance of pollution control measures – Chapter Nine of the Code (the largest chapter) is concerned with the Protection of Water Resources from Depletion and Pollution. This chapter in particular is illustrative of the tight fit between the Convention text and the Water Code provisions which mirror its pollution control stipulations. One example of compelling parallels between the Convention and the Code is the implementation of best environmental practices and appropriate diffuse source pollution prevention measures, especially where the main sources are from agriculture, as detailed in articles 3(g) and 56 respectively. The Code declares that Basin Water Plans must identify areas that by reason of their topography or use,

> "such as the use of pesticides and fertilizers in agriculture, pose risks of diffuse source pollution to water bodies and water economy constructions and shall propose measures to prevent, reduce or mitigate such pollution".

Annex II of the 1992 Convention elaborates guidelines on the development of best environmental practices, which article 56(1) of the Water Code reflects

[85] section 2
[86] article 3

by listing diffuse source pollution measures as "the preparation and dissemination of technical guidelines and training programs".

Sufficient correlation can be established between the protection of waters under the 1992 Convention through "prior licensing of waste-water discharges by the competent national authorities, and that the authorized discharges are monitored and controlled"[87], and the mandate of several bodies such as the National Water Council and Basin Councils whose functions involve protecting against the pollution of water sources. The Authorized State Environmental Protection Body is mandated to issue or revoke permits for discharging polluted items into water sources, as well as maintaining a register of such activity. The 1992 Convention declares in article 3(c) that set limits for waste-water discharges stated in permits should be based on the "best available technology for discharges of hazardous substances". This obligation is halfway accommodated through article 13 of the Water Code which empowers the authorized State Sanitarian and Epidemiological Body to formulate conditions for such discharge permits, although this provision does not contain the 'best available technology' or similar standard. The 1992 Convention declares that threshold values in permits for hazardous substance discharges into water, should be determined based on the best available technology[88] but goes on in article 3(2) to declare that the "production or use of such substances" may be prohibited altogether. The Code diverges from either of these two options and seems to find an independent solution by banning the discharge of hazardous substances from entering the water supply[89].

The Water Code tallies with the Convention's sanction of "stricter requirements, even leading to prohibition in individual cases, [...] imposed when the quality of the receiving water or the ecosystem so requires"[90], by instructing that adjacent to or within 'water protection zones', specified activities such as the storing, processing or disposal of waste which may pollute or harm the water source, are prohibited[91]. The Code additionally provides a good reflection of the Convention requirement of "at least biological treatment or equivalent processes" as well as the application of "best available technology", through its provisions on state water economy programs reviewable every five years[92] which includes "as minimum construction, rehabilitation and modernization of [...] waste water treatment plants". Water economy constructions are the re-

[87]article 3(b) of the 1992 Convention
[88]article 3(1)(c)
[89]article 12 and 51(1)
[90]article 3(d) of the 1992 Convention
[91]article 69(1)
[92]article 13

sponsibility of the State Environmental Protection Body, which is tasked with developing and describing "processes and standards for the treatment of pollutants and wastes prior to their discharge to water bodies". The Code further provides a tight fit on the issue of environmental impact assessments, as advocated by the Convention as a method of preventing pollution, the results of which must be taken into consideration when granting water use and discharge permissions[93].

The Code demonstrates some match in its compliance with the monitoring aspect of the Convention rule through article 52(2), but this task is given by law to the permission holder, the results of which are then forwarded to the State Environmental Protection Body. While the Convention does not state explicitly that this monitoring and control function be carried out specifically by the state, such an interpretation can be inferred; and although the Code legislates on the monitoring responsibility of several state agencies of water resources generally, this is not mentioned in the context of effluent discharge permission.

Another precise matching of the Water Code to the 1992 Convention is the importance given to "additional specific measures" to prevent groundwater pollution[94] which is given effect through the creation of 'Groundwater Protection Zones'[95], which restrict specified activities within such a zone which has been determined to be especially vulnerable to pollution or overdraft.

The State Water Cadastre under the Single Water Information System (Chapter Nineteen) will contain information on the quantity and quality of surface and groundwater in the state, which has been collected from the monitoring of various bodies mentioned in the Code[96]. The Code emphasizes compliance with quality standards, and does not expressly indicate what criteria shall be considered in formulating those standards. This Information System is a direct fit to the duty to provide information in articles 6 and 16 of the 1992 Convention, insofar as the Information System is intended to provide information on "resources management, the planning of water economy development activities and the rational use and protection of the water fund", which are available to the public save for items that are commercially confidential[97]. This latter exception remains faithful to article 8 of the Convention which protects "in-

[93] articles 26(8) and article 53(3)
[94] article3(k)
[95] article 68
[96] article 17(2)
[97] article 97(2)

formation related to industrial and commercial secrecy, including intellectual property, or national security".

On the related issue of monitoring, the 1992 Convention declares simply that states "shall establish programmes for monitoring the conditions of transboundary waters." The Code is instrumental to meeting this stipulation, by articulating the activities of the National Water Monitoring System and related state agencies which are responsible for monitoring, collecting, and analyzing data pertaining to quantity quality and use of water resources, compliance of standards and objectives for water quality, ecosystem health, atmospheric conditions and flood or drought risks[98]. This data goes towards the Information Cadastre.

The framework of interstate co-operation such as 'mutual assistance',[99] 'joint monitoring and assessment'[100] and co-operation on research and development[101] with a view to reducing transboundary impact in the 1992 Convention, is also endorsed by the Almaty Agreement which encourages information exchange on

> "scientific-technical progress in water economy, complex use and protection of water resources, conducting joint research for scientific-technical support of problems, and expertise in water related projects" (article 5).

The Water Code notes the responsibility of the state to "stimulate and provide research and development of new technologies, [and] the establishment of new tools and equipment" in the context of water use and pollution, which mirrors the elements on research and development contained in the Convention. A parallel may be drawn between the phasing out of substances which may have transboundary impact as noted in the Convention, and the Code's inclusion of deadlines in discharge licenses for the phased reduction for the quantity of pollutants –with the difference being that the former is framed in the context of research initiatives, and the latter a matter of practical application. The Code does not mention other research areas such as development of environmentally sound technologies, production and consumption patterns.

The Code produces a very tight fit to the collaborative spirit of Kyrgyzstan's agreements by providing an accurate application of the calls of the 1992 Convention[102], and the Almaty Agreement to the establish a joint body, in the

[98]article 17(2)
[99]article 27
[100]article 11
[101]article 5
[102]article 9

form of the Interstate Coordination Water Management Commission, geared towards developing interstate water management policy[103] and joint works for solving ecological problems[104].

Under the Chu and Talas Rivers Agreement, the parties are legally bound to take (joint) measures to protect water facilities and territories from floods, mud flow and other natural phenomena. The 1992 Convention also requires states to establish warning and alarm systems[105], to meeting which the Water Code provides the necessary instrument by establishing a National Flood, Mud-flood, and Drought Information and Warning System[106], as well as extensive provisions on flood management in subsequent provisions. The Water Code mentions the duty of the representatives of the Warning System to alert state bodies and members of the public to situations of threat; a mechanism which would be well suited to convey warnings on information acquired, to neighbouring states.

Chapter Four of the Code is dedicated to water use and abstraction, and licensing in particular which details not only the states obligations and functions, but the rights and obligations of individuals; criteria for water use permissions; its duration and contents; and priorities for water use *inter alia.* These detailed provisions thus provide concrete guidance on the state's obligation to regulate use. The 1992 Convention also requires states to exchange information on "permits or regulations for waste-water discharges"[107], and through the framework in place established by the Water Code, the government will be able to furnish other states with information on permit grant criteria, and the types of uses authorized ready, if so required.

Another law instrumental to interstate co-operation is the *Law on Inter-state Use of Water Objects, Water Resources and Water Economy Constructions in the Kyrgyz Republic 2001* post-dating all of the international agreements relevant to Kyrgyzstan. It serves to identify the "main directions of the state policy [...] on interstate use of water objects [...] resources and water economy constructions [...]." In its first article the law recognizes the importance of conserving and protecting Kyrgyzstan's water bodies as part of the nation's wealth, which it also interestingly acknowledges is the main source of supply for other Central Asian countries. Through its second article, the law gives

[103] article 7
[104] article 4
[105] articles 9(g) and14
[106] Article 71
[107] article 13(1)(e)

direct sanction to international rules which are not contained in national laws, but in agreements to which it is a signatory. The law goes on to stipulate principles concerning rivers whose source is in Kyrgyzstan and flows through other states[108], one of which is payment for this water by downstream countries. This is a tight fit to the concept of Kyrgyzstan's compensation by downstream states found in the Syr Darya Agreement, although the latter frames the compensation more in terms of exchange or trades by both sides. The inclusion of the country's right to recovery of costs for objects of international importance, and for the protection and development of the water supply matches accurately the right to compensation associated with "operation and maintenance of the facilities of interstate use"[109] authorized by the Chu and Talas Rivers Agreement. There is an odd ring to the cost recovery provisions of this law, however, due to the fact that national Kyrgyz legislation cannot dictate to other sovereign States. As a result, the enunciation of the principle of payment by downstream countries in the Kyrgyz law has a purely aspirational value as it can be of no effect whatsoever on those countries, which are the real targets of the enunciation. The law recognizes "state property rights for water objects, water resources and water economy constructions within its territory"[110] which is directly sanctioned by the Almaty Agreement which stipulates that "all structures and facilities on the rivers and water services operated by them are the property of the corresponding Republic which owns them"[111].

The Law on Interstate Use of Water Objects aims to offer special protection to constructions of inter-state strategic importance to Kyrgyzstan, with a "share recovery by the states that use those water economy constructions"[112]. This is precisely in accordance with the Chu and Talas Rivers Agreement, where the state owning the facility in use is entitled to compensation from the utilizing state for "costs needed to provide safe and reliable operation"[113].

The law's dispute resolution terms directly reiterate the language of Syr Darya Basin Agreement and the Chu and Talas Rivers Agreements that disputes should be settled by "consultation and negotiation"[114]. There is a slight divergence however where article 7 of the law provides for the heads of gov-

[108] section 3
[109] article 4
[110] article 3
[111] article 9
[112] article 8
[113] article 3
[114] 9 Syr Darya Agreement, article 12 Chu and Talas Rivers Agreement, and article 7 of the Law on Interstate Use of Water Objects, Water Resources and Water Economy Constructions in the Kyrgyz Republic 2001

ernment to decide issues unsettled by negotiations, the Syr Darya Basin Agreement sanctions the establishment of an arbitration court for each case.

An interesting nuance exists in the choice of words between the Almaty Agreement[115] and the Law on Interstate Use of Water Objects and Water Resources[116] on the matter of pollution control. While the Almaty Agreement requires "*each* of the parties. . . to prevent actions on its territory which can infringe on the interests of the other Parties" which leans towards individual responsibility, the Kyrgyz law rephrases this notion by designating "*mutual responsibility* of the parties for protection of water resources from pollution and depletion that cause damage to environment, health and safety of population, economy *of Kyrgyzstan*", thus spreading responsibility to other state parties. Despite the indications that the Almaty Agreement is the source for this provision of the Kyrgyz law, the incongruity is considerable.

The law provides a good fit on the issues of co-ordinating scientific, technical and development matters on water use and mechanisation, as well exchanging information between neighbouring states[117], to the Almaty Agreement's obligation to facilitate wide information exchange on scientific-technical progress in water economy. While the law has a mechanical and technological focus in this regard, the Almaty Agreement centres more on the use and protection of water resources, and technical support in water related projects.

Article 4 of the legislation refers to 'Inter-state bodies on regulation of water relations' which would serve to "prepare proposals on planning, invest[ment] and co-ordination of joint programs and projects in the sphere of water resources." Since the Almaty Agreement gives legal mandate to the establishment of an Interstate Coordinating Water Management Commission (responsible for the determination of water policy in the region as well as water use limits approval); and the Chu and Talas Rivers Agreement authorizes "permanent commissions that set up the operation mode and define amounts of costs needed for operation and maintenance of water facilities", this provision could be interpreted with these Agreements in mind, to provide national legitimacy for such commissions.

Direct mention is again given to international agreements in articles 5 and 6 of the law on inter-state financing of water programs, projects and mutual

[115] article 3
[116] article 3
[117] article 3

settlements. These two brief articles point to the agreements as the source of law in these areas.

Summary of Observations. Much of the Kyrgyz legislation, particularly the more recent Water Code, is highly congruous with the wording of the commitments it has signed up to. The Code directly cites its international obligations as a component of its National Water Strategy and Basin Plans, and also declares its agreements as sources of law. Allusion to its international agreements is also rendered in some of its subsidiary instruments. Further, it demonstrates a tight fit to many features of the 1992 Convention: it precisely duplicates the guiding principles of the 1992 Convention; it demonstrates a tight fit on pollution prevention and control (albeit without the focus on transboundary elements *per se*), and permit issuance for waste-discharge (with the monitoring and control aspect a good fit –resulting from the Code's construction of the state's role in *receiving* monitoring information, and the Convention's inference that monitoring is carried out by the state). Precise matching is demonstrated in the Code's replication of environmental impact assessments as a method of preventing pollution.

Kyrgyzstan's Law on Inter-state Water Use provides a good fit in a number of areas. However, the provisions of this law ring odd insofar as they can be read as being directed at sovereign downstream States. Interestingly, the law also deviates from the standard of individual state responsibility for damage suffered by other states.

Conclusion

The South African text which pre-dates the major regional instrument applicable was found to match a number of its provisions as a result of the similarity of the preceding regional treaty to the current one. The Namibian legislation contains the closest parallels to its international obligations, with the clearest influences of international provisions, even though the Kyrgyz laws also demonstrate many parallels.

The influence of international law is evident for the most part, beyond where "international obligations" are mentioned directly. Many of the 'tight fit' provisions are not always immediately apparent, having been established where the words of the international treaty set out an objective, and the corresponding national law implements a mechanism to achieve this. As elucidated in the South African text, national law may selectively emphasize the principles relevant to its national context. However, it is interesting to note that the more

recent legislation have common features, with similar wording, use of advocating generally recognized international law principles and the methodologies advocated such as the South African, Namibian and Kyrgyzstan water laws, despite the differing geographical and water management contexts.

GROUNDWATER AND INTERNATIONAL LAW: TRANSLATING PRINCIPLES INTO PRACTICE

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Abstract

International law has tended to pay little attention to transboundary groundwater resources. Given the increasing pressure put on these resources, a number of initiatives are now underway to include groundwater in the legal agenda. The UN International Law Commission (ILC) has embarked on a codification of the law of transboundary groundwater resources, which is expected to lead to a groundwater-specific Convention. In parallel with this, programmes are being implemented to devise practical legal and institutional arrangements for some transboundary aquifer systems. It is recognized that, because of the intrinsic nature of groundwater –the hidden treasure– it may take longer to achieve results than in the case of surface water. Moreover, a choice is to be made as to what action should be taken by states, jointly, and what should remain within the powers of the individual states. At the outset, the approach should be preventive, i.e., geared to the setting-up of legal and institutional tools that may be utilized, should problems arise. Finally, for international agreements and other arrangements to be effective it is indispensable that adequate legislation and institutional arrangements be in place at the national level of the states concerned. This paper aims at highlighting some of the issues that should be considered before embarking on agreements on transboundary groundwater resources.

Introduction

According to recent surveys of international state practice and literature (Burchi and Mechlem, 2005), international law has paid little attention to transboundary groundwater resources so far. Therefore, in respect of groundwater it is far less developed than domestic legislation.

Most international water treaties relate to surface water resources. Some of them also deal with groundwater, but only incidentally, either because groundwater comes within the meaning of ‘frontier waters’, or because it is part of a

specific river basin. Very few treaties relate to groundwater as such. Thus, the focus remains on surface water.

This lack of attention is mostly due to lack of a full understanding of the characteristics and behaviour of this 'invisible' resource –the hidden treasure– and to the fact that groundwater has rarely been the subject of disputes in the past. This situation, however, is doomed to change, as growing pressure on the resource calls for action to be taken and for legal and institutional tools to be developed, both at the international level and within national contexts.

Without going into much detail as to developments in international groundwater law and administration since the subject as such is dealt with elsewhere in this book, this paper will pay attention to recent state practice, i.e., to ongoing international cooperation efforts with regard to certain aquifer systems. In particular, it will highlight some of the issues that transboundary aquifer system states are making efforts to address through legal and institutional arrangements, and will indicate the issues and constraints that may be faced when translating principles into practice.

International groundwater law: Present situation and emerging state practice

Present status of transboundary groundwater law

The characteristics and behaviour of groundwater resources are not well understood, even at present. Therefore, groundwater tends to be perceived as something that belongs to the owner of the overlying land –a state, and often persons within a state[1]. Moreover, groundwater has rarely been the subject of disputes in the past. Mainly for these reasons, international law has tended to focus on surface water resources and to deal with groundwater only marginally (Caponera and Alhéritière, 2003; Barberis, 1987).

[1] In India, for instance, although a public resource groundwater is often perceived as the property of the overlying landowner.

The existing international legal instruments on water resources[2] do not consider the specific characteristics of groundwater (GW-MATE, 2002–05; Foster, 1999; Nanni and Foster, 2005)[3]. Hence, they tend to set forth principles and rules for both surface water and groundwater, without providing any guidance as to their implementation in the latter case.

While there are many international agreements on surface water resources, the number of groundwater-specific agreements is limited. The best known are:

- the Agreement (*Arrangement*) between the Canton of Geneva (Switzerland) and the Préfet of Haute-Savoie (France) relating to the protection, utilization and recharge of the Franco-Swiss Geneva Aquifer, which was signed on 9 June 1977 and is in force since January 1978, and
- the interim Agreement on a permanent and definitive solution of the salinity problem of the Colorado River, which was concluded by the United States and Mexico in 1973 (Minute No. 242 under the Treaty between the United States of America and Mexico relating to the utilization of the waters of the Colorado and Tijuana rivers, and of the Rio Grande from Fort Quitnam, Texas, to the Gulf of Mexico, signed at Washington on 3 February 1944).

The Geneva Aquifer Agreement is perhaps the only example of international legal instrument focusing on groundwater resources management as such, in a

[2]Of these legal instruments we may quote the Convention on the Law of Non-Navigational Uses of International Watercourses (UN Watercourses Convention), adopted by the General Assembly of the United Nations on 25 May 1997 (but not in force yet), the 1992 Convention on the Protection and Use of Transboundary Rivers and International Lakes and the 1999 Protocol on Water and Health (both regional), the 2000 Revised SADC Protocol (also regional), and a number of river basin-specific treaties such as the Convention and Statute of the Lake Chad Basin, which was signed by Cameroon, Chad, Niger and Nigeria on 22 May 1964, the 1994 Danube Protection Convention, the 1998 Convention on the Protection of the Rhine and the 2002 Sava River Basin Framework Agreement. In addition, several bilateral treaties on boundary waters or 'water-economy questions' (mostly concluded before 1970) recognize the effects of groundwater use on surface water, and vice-versa. Finally, there are agreements focusing on local issues of relevance to groundwater, such as the Agreement concluded by Egypt and Italy on 6 December 1925 to set the boundary between Cyrenaic and Egypt, which contains provisions on the utilization of the Ramla Well.

[3]Basically, (a) all aquifers are characterized by a flow component and a storage reserve; (b) groundwater moves slowly from the recharge area to discharge areas, and in the time employed the flow and the discharge may be influenced by human activities; (c) many aquifer systems (mostly in arid regions) receive negligible contemporary recharge and become subject to depletion if measures to control groundwater abstraction are not taken; (d) it is important to consider the linkages between aquifer recharge and land use, as urban, agricultural and other activities may modify recharge rates; highly dispersed groundwater abstraction patterns may have significant aggregate impacts with adverse effects showing at a considerable distance; (e) aquifers are more vulnerable to pollution than surface water, as groundwater moves slowly and groundwater flows are complex; because of this complexity and the time lag between the occurrence of pollution and when the effects are felt, it is technically difficult to prove liability for groundwater pollution.

comprehensive manner. It provides for the establishment of a joint Commission to facilitate cooperation in the monitoring of water levels, water abstraction and water quality, to prepare annual water utilization programmes and to provide advice on groundwater protection measures, amongst other things. The Agreement also contains provisions as to the respective rights and obligations of the two parties in relation to the artificial recharge of the aquifer. The Commission keeps an inventory of groundwater abstraction works in both states and, since these works are equipped with meters, is in a position to know how much water is taken by each user (Barberis, 1987).

The USA/Mexico interim Agreement offers another example of cross-border cooperation on groundwater issues, albeit on a smaller scale. Pending the conclusion of a permanent agreement on transboundary groundwater –which has not been arrived at yet– the two states undertook through this Agreement to introduce restrictions to groundwater pumping for a strip of land extending five miles on both sides of the Arizona-Sonora border, and to consult each other before engaging in any new resource development having adverse effects across the boundary (Caponera and Alhéritière, 2003; Barberis, 1987; UNESCO, 2001). It is interesting to note that Minute No. 242 was agreed upon within an institutional mechanism having no specific jurisdiction on transboundary groundwater, i.e., the International Boundary and Water Commission.

The initiatives just mentioned do not constitute the rule. They were taken because the need of the states concerned to solve specific problems so warranted. A high level of cooperation has been indeed attained in the case of the Geneva Aquifer, resulting in a joint institution vested with a wide range of groundwater management functions and powers.

Cooperation is also taking place in the case of the Nubian Sandstone Aquifer System (NSAS), which is of concern to Chad, Egypt, Libya and Sudan. A joint Authority was established by Egypt and Libya in the early 1990s to facilitate the study and development of the NSAS. Sudan and Chad have become members later. The Authority, which is supported by the Center for Environment and Development of the Arab Region and Europe (CEDARE), is in charge of data collection and administration, the conduct of studies, the formulation of water resources development programmes and plans and the implementation of common policies, amongst other things. It has a board of directors, a secretariat and a director. On 5 October 2000 the four states signed two agreements on procedures for data collection and sharing, and on the access to their regional information system, which was developed with the assistance of CEDARE (Burchi and Mechlem, 2005).

Among judicial decisions of relevance to groundwater, we may quote the judgment by the International Court of Justice (ICJ) on 25 September 1997 in the Gabickovo-Nagymaros Case (Hungary v. Slovakia), and the decision of the German *Staatsgerichtshof* (a national court in a federal state) in 1927, in the *Donauversinkung* Case. In its judgment on the Gabcikovo-Nagymaros Case[4] the ICJ stressed that states are under a general obligation to ensure that activities carried out within their national boundaries respect the environment of other states. The Court rejected the 'state of ecological necessity' taken by Hungary as justification of the interruption of the Danube water diversion works agreed upon with Czechoslovakia, on the grounds that it is difficult to assess the effects of slow natural processes[5]. Thus, it implicitly recognized that groundwater behaves differently from surface water (McCaffrey, 1999).

The Donauversinkung Case dealt with interferences in the natural phenomenon by which the water of the Danube at a certain location flows underground and then from the aquifer into the Aach, a tributary of the Rhine. In this case the Staatsgerichtshof, applying international law though the case involved the Länder (states) of the Federal Republic of Germany –Württemberg, Prussia and Baden– asserted that states have the duty in regard of international rivers to abstain from injuring the interests of other states. Thus, Baden –the Land interested in an augmented flow in the Aach river– was to refrain from accelerating the natural sinking of the Danube (but was under no obligation to undertake permanent improvements), while Württemberg was not to impede such sinking (Ibidem).

Further reference to groundwater is to be found in the writings of scholars. In this connection, it is worth mentioning the work of the International Law Association (ILA) starting by the Helsinki Rules on the Uses of Waters of International Rivers of 1966, which may be considered as a precursor of the UN Convention on the Law of Non-Navigational Uses of International Watercourses (UN Watercourses Convention), adopted by the UN General Assembly on 25 May 1997. Through the Helsinki Rules, the ILA brought groundwater, together with surface water, within the notion of 'international drainage basin', defined as 'a geographical area extending over two or more states determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus'. Later on, recog-

[4]The Case was brought before the ICJ due to the fact that Hungary decided in 1989, unilaterally, to interrupt work on a project that had been agreed upon with Czechoslovakia on the basis of a treaty concluded in 1977, consisting of a series of water diversions from the Danube. The reason for this interruption was allegations that the diversions would result in a reduction of the groundwater level and in an impairment of water quality. In this connection, Hungary invoked a 'state of ecological necessity'.

[5]A 'state of ecological necessity' could be justified by imminent danger.

nizing that according to this notion groundwater would fall within the scope of the Rules only when related to surface water, the ILA instructed its 'Committee on International Water Resources Law' to study the subject further, and in 1986 adopted the Rules on International Groundwaters (Seoul Rules). The Seoul Rules expand the scope of the Helsinki Rules by making them applicable to all international groundwater resources, including those not connected to surface water bodies. In addition, they explicitly recognize the interaction between groundwater and other natural resources, and the particular vulnerability of groundwater to pollution (Art. 3) (Manner and Martti Metsalampi, 1988). New Rules adopted by the ILA in 2004 ('Berlin Rules') contain groundwater-specific provisions, but their scope appears to extend to *all* aquifers, including those that are not transboundary.

Eminent bodies such as the Inter-American Bar Association, the Council of Europe (European Water Charter, 1968) and the Asian-African Legal Consultative Committee have also paid attention to groundwater, but the most remarkable result of legal research on transboundary aquifers is perhaps the Bellagio Draft Treaty, which was prepared over an eight-year period by a multidisciplinary group of experts. This 'model treaty' contains 20 articles relating to concrete mechanisms for cooperation in transboundary aquifer management in critical areas. It addresses aquifer contamination, planned depletion ('mining'), drought management and transboundary transfers, in addition to abstraction and recharge issues (Hayton and Utton, 1989). Further, it vests a joint commission with the power to declare 'transboundary groundwater conservation areas', prepare comprehensive management plans for each area and prepare and approve aquifer depletion ('mining') and drought management plans. Water quality protection remains a responsibility of the aquifer states. Although tailored to the situation at the USA-Mexico border, the model treaty may be of interest to aquifer system states elsewhere in the world, particularly in arid regions. Its provisions on planned depletion are particularly relevant in the case of non-renewable resources, where mining should take place over a period of time sufficient for developing an 'exist strategy' involving resort to other water sources or alternative economic production patterns.

Finally, mention should be made of the resolutions and recommendations of international bodies. In this connection, the United Nations Water Conference (Mar del Plata, Argentina, 1977) recommended the use of aquifers as collective and integrated systems and studies to explore the potential of groundwater basins, the use of aquifers as storage and the conjunctive use of groundwater and surface water (Manner and Martti Metsalampi, 1988). The United Nations Conference on Desertification (Nairobi, 1977) placed emphasis on the implementation of transnational projects involving the assessment of surface and

groundwater resources (Caponera and Alhéritière, 2003). Aquifer management is also referred to in the Statement on Water and Sustainable Development, adopted at the International Conference on Water and the Environment, Dublin, in 1992, and in Agenda 21, produced by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 (Mechlem, 2004).

To sum up, with a few exceptions international water law fails to address current transboundary groundwater management needs in an adequate manner, as the principles emerging from it are mainly tailored to surface water and tackle groundwater issues only partially. These principles, as embodied in the UN Watercourses Convention, are as follows:

- the states of an international watercourse have the right, and at the same time the obligation, to use such watercourse or basin in their respective territory in an equitable and reasonable manner;

- they shall refrain from causing significant harm to the other watercourse states;

- they shall regularly exchange data and information relating to the watercourse;

- the state intending to take measures which are likely to have adverse effects on the territory of the other states shall provide these states with advance notification of such measures.

There are, however, strong indications that this situation is changing. On the one hand, the International Law Commission (ILC) of the United Nations has recognized that the UN Watercourses Convention presents some important shortcomings with regard to groundwater (Mechlem, 2004). Hence, in 2002 it included groundwater in its programme of work and is now studying new draft articles on transboundary aquifers which take into account the particular characteristics of this resource. Since the work of the ILC is covered by other contributors to this book, little may be said here on progress in drafting the articles, except that this exercise may lead to a new groundwater-specific convention in a not too distant future.

On the other hand, governments are becoming increasingly aware of the fact that sound transboundary aquifer agreements, domestic legislation and international, inter-state/provincial and national groundwater institutions may greatly facilitate groundwater and aquifer system management. Thus, a number of programmes and projects are being formulated and implemented to assist coun-

tries, upon their request, in devising practical legal and institutional arrangements for the management of transboundary aquifers underlying their territory.

Ongoing initiatives

To be mentioned in the first place is the North-Western Sahara Aquifer System (NWSAS, or SASS in French), involving Algeria, Libya and Tunisia. In the course of implementation of a FAO project (2002), these countries agreed to establish a joint institutional mechanism for cooperation –the NWSAS Cell– consisting of a steering committee, a scientific committee and a secretariat attached to the *Observatoire du Sahara et du Sahel* (OSS), an inter-governmental organization. The secretariat was vested with the task to facilitate data collection and aquifer system modelling in support of resource planning and decision-making by the member states, emphasis being placed on three 'hot spots', namely the Ghadames Basin, the Artesian and Tunisian Outlet Basins, and the *chotts*. The secretariat was also charged with the study of steps forward in the development and refinement of the joint institutional structure, following an evolutionary approach. Recently, the institutional mechanism has expanded its mandate so as to include the identification of hot spots and has been vested with advisory powers with regard to the introduction of aquifer management measures. The new structure will be composed of a Council of Ministers, a Steering Committee, National Committees and working groups, and a Coordination Unit hosted by the OSS (Communication of November 2005).

Another FAO project was formulated as part of a GEF initiative in 2004, to deal with the establishment of an institutional mechanism for tri-partite consultation on the Iullemeden Aquifer System (IAS), which is shared by Mali, Niger and Nigeria. Implementation started in 2005. Studies conducted under the project concluded that the existing regional water agreements focus on river basin management and do not address the main issues facing the IAS, i.e., the vulnerability of the system and the hydrogeological risk deriving from land uses, mining activities and growing resource extraction. A number of institutions have been set-up under these agreements, but none of them is in a position to address the specific IAS management needs, either because their focus is on surface water, or because the participating states do not coincide with the IAS states. Thus, it was concluded that there is a need for an alternative institutional arrangement, to be backed-up by a new agreement for the IAS. The starting point should be an institutional mechanism for consultation that, relying on the existing national institutions and with the support

of a regional institution[6], deals with the enhancement of the common knowledge base, the development of a system for the regular exchange of data and information and the identification of vulnerable zones and of the issues to be addressed. After an interim period this mechanism, which will initially consist of a tripartite steering committee (political level), national scientific/technical committees and a secretary/facilitator, should evolve into a permanent structure equipped with a secretariat, and should be vested with broader functions, such as the definition of risk management measures, the provision of advice on programmes and projects which are likely to create situations of risk, programme coordination and the prevention and settlement of disputes. Given that Benin, and perhaps Algeria[7], also overly the IAS, the agreement could be open to the accession of these states.

Further projects with an important component involving the setting-up of joint institutional mechanisms for transboundary aquifer system management and the development of the relevant international agreements are being formulated in the African continent, the Mediterranean region and elsewhere.

As far as the Americas are concerned, a high-level *ad hoc* group of experts is currently elaborating a draft agreement on the Guaraní Aquifer System (Argentina, Brasil, Paraguay and Uruguay), which would vest coordination of groundwater management functions in a body to be established under the Inter-Governmental Coordinating Committee (ICC) for the Plata Basin. According to the draft agreement, the states must inform each other of any measures that in their understanding are likely to cause a significant damage beyond their boundaries. Furthermore, they undertake to cooperate in the identification of critical areas requiring the introduction of specific management measures. The *ad hoc* group of experts is working in parallel with a GEF project which is mainly focusing on hot spots (pilot areas), but may provide useful food for thought when a decision as to the overall legal framework will be made, resulting in the final version of the agreement. Since the Guaraní Aquifer System, although somehow related to the Plata basin, is largely independent of surface water flows, it would perhaps be convenient to establish an independent institutional mechanism for the System, coordinating with the ICC for policy matters.

[6]More precisely, it was recommended that the mechanism should be hosted by an existing multilateral and neutral institution for regional integration, such as the Economic Community of West African States (ECOWAS).

[7]This is to be verified.

The cases just mentioned show that dialogue and cooperation among states sharing transboundary aquifer systems tend more and more to focus on

- the need to improve the knowledge base with regard to aquifer systems and their vulnerability, the characteristics and behaviour of groundwater and the interaction with other natural resources;
- the need to establish a system for the sustained sharing of data and information;
- the identification of present and potential threats, and of critical areas (or 'hot spots');
- the creation of joint institutional mechanisms for cooperation to facilitate decision-making as regards the measures to be planned and implemented in order to manage the risks to which aquifer systems are subject, and to curb resource depletion and degradation;
- the need to harmonize legislation;
- the strengthening of the capacity of the national institutions to implement the measures agreed upon within national boundaries.

There is a growing awareness of the key role that institutional mechanisms may play, if established, with respect to the control of activities going beyond water utilization. It is now increasingly understood that rather than on water sharing, emphasis is to be placed on the impact that land uses for agricultural, industrial or other purposes may have on an aquifer system. Given that these uses may take place well inside the national territory of the states concerned, a certain caution is exercised when the level of cooperation is to be defined. Therefore, an evolutionary approach is often advocated.

Possible constraints to the implementation of international law

International groundwater law –or the law of transboundary aquifers– is in its infancy, but some progress is slowly being made in its development. It seems to be acknowledged that the prevailing international water law principles –equitable and reasonable water use, no significant harm, the duty to exchange data and information and the duty to provide advance notification of planned measures with possible adverse effects– need to undergo some modifications involving the consideration of the specific characteristics of aquifer systems and the behaviour of groundwater. Efforts are being made in this direction, as was mentioned earlier.

Further, it is being recognized that, when devising a framework for international law implementation legislation and companion institutional arrangements should be designed in such a way as to facilitate the control by a state of activities with potential adverse transboundary impacts and the enhancement of the knowledge base with regard to the shared resources[8]. In the case of groundwater, however, focus should also be placed on land uses and hydrogeological risks. This means that in a number of countries action should be taken to strengthen the existing domestic legal and institutional framework for groundwater management, but that efforts should not be limited to groundwater legislation and institutions. Given the close relationship between *groundwater* and the use and management of other natural resources, the need may arise also to consider changes in the legal and institutional framework for the management of these resources.

Finally, the examples illustrated earlier, show that there is a growing awareness of the importance of setting-up international institutional mechanisms for cooperation in the management of transboundary aquifers, whether autonomous or under the umbrella of existing institutions. Obviously, since each aquifer system has its own characteristics, there is no golden rule.

When making efforts to translate international law principles into practice in respect of transboundary aquifers, states may experience a number of constraints which they should try to overcome. Most of these constraints –some are enumerated herebelow– derive from the way national legal systems work.

- *Private groundwater ownership* – The existence of private groundwater ownership rights may constrain the control of groundwater abstractions and groundwater quality protection by the public administration, and other activities relevant to groundwater management. However, legal reforms to shift from private ownership to a regime of state control have been accomplished in a number of countries, sometimes resisting claims of unconstitutionality (Caponera, 1992; Burchi and Nanni, 2003; Nanni and Foster, 2005).
- *The absence of a proper knowledge base* – Without a proper appreciation of the conditions of an aquifer system states will be reluctant to agree on what action should be taken jointly, as opposed to the measures that should be left to the individual states. This constraint derives from the fact that most states do not possess the tools that would facilitate the acquisition of such knowledge within their own boundaries. Data

[8] To be understood in broad terms, i.e., not limited to quantity or quality aspects, but including the types of pressure to which the resources are exposed, economic and social aspects, etc.

and information are normally in the hands of numerous institutions that tend to function like tight compartments, no form of inter-institutional cooperation and lines of communication being in place. None of these institutions is vested with a coordination role, hence each collects and processes its own data following its own procedures and methods, so that it is difficult to attain at least comparable results if not a reliable picture of the situation of the aquifer system within national boundaries, let alone at the system level.

- *Lack of knowledge as an excuse for inaction* – Lack of knowledge should not be taken as an excuse –as it often happens– for procrastinating action and refraining from setting-up the legal and institutional tools that may become necessary to curb resource depletion and degradation. In other words, all precautions should be taken to prevent the occurrence of damage. Aquifer system states should be prepared to implement the necessary measures, should a threat to the resource turn into actual damage in the future.

- *The type of institutional mechanism for international cooperation opted for* – In the name of Integrated Water Resources Management (IWRM) one may be tempted to state that if a given transboundary aquifer system is linked to a river basin and a joint (surface) water institution is in place for that basin, that institution should be also put in charge of the transboundary aquifer. This matter is being discussed in the case of the IAS, and while according to some IAS management should be vested in the Niger Basin Authority, others assert that since the situation of the IAS differs from that of a surface water basin, a different approach is required. Aquifer system management involves the consideration of the hydrogeological risk deriving from certain activities, hence of land degradation and environment protection aspects. Given the variety of hydrogeological settings and differences as to the location of aquifers vis-à-vis river basins, institutional options for transboundary aquifer management should be considered on a case-by case basis (GW-MATE 2002-2005).

- *Lack of adequate national legal frameworks* – In order to be able to implement international law principles and to meet international legal obligations within their respective territory, the aquifer system states concerned should equip themselves with an adequate national legal framework. National legislation should vest groundwater in the state and contain provisions enabling the public administration at the various territorial levels to, *inter alia*,

  – control and regulate all those human activities that are likely to expose the aquifer system to a risk and to pollution, including well drilling and groundwater extraction, agricultural and industrial activities, mining and other land uses;
  – control wastewater discharges through a permit system and emission limits, amongst other things;
  – identify, define and map critical (vulnerable) areas –'hot spots'– and declare them formally 'control' areas where restrictive measures may be introduced if circumstances so warrant,
  – take measures to protect aquifer recharge areas.

  The legislation should also require the assessment of the environmental impact of certain activities, particularly at the locations where a risk may originate. Finally, provision should be made in the legislation for aquifer planning, either as part of river basin planning or as a self-contained exercise, depending on the hydrogeological settings, and on the relationship between the aquifer system concerned and surface water flows (Burchi and Nanni, 2003; Nanni and Foster, 2005; GW-MATE, 2002–05). It is important that states linked to the same aquifer system harmonize their respective legal framework.

- *Lack of coordination among national institutions and absence of an institution 'in charge'* – Normally many institutions are responsible for various aspects of groundwater (and aquifer) management at the national level. Functions are fragmented and at the same time there are gaps, with the result that it becomes difficult to implement legislation, and impossible to meet international legal obligations. Therefore, aquifer system states should seek to establish inter-institutional coordination within their domestic context. Measures should be taken to make sure that there are no duplications of efforts in data collection and processing, and that there is a regular flow of information. Possibly, one agency should be designated to act as the lead institution, or focal point, for the coordination of data collection and groundwater monitoring programmes, the administration of the 'aquifer system data-bank', the regulation of groundwater abstraction and aquifer planning, amongst other things. However,

it should be kept in mind that there is no golden rule for the development of an institutional framework, as each country has its own political and administrative set-up. In addition, a number of elements are to be taken into consideration before opting for an institutional arrangement rather than for another –a national or regional agency, an aquifer management organization, a river basin authority, etc.– including the size of the country, climate, the characteristics of the aquifer, groundwater behaviour, etc. (GW-MATE, 2002-2005).

- *Lack of public participation in decision-making at the national level* – National legal frameworks do not always facilitate the participation of stakeholders in decision-making with regard to aquifer system management and planning. However, it is now increasingly recognized that this participation is at the root of a better understanding of problems, leading to the acceptance of measures and restrictions that would otherwise be unpopular, such as those relating to land surface zoning through the declaration of groundwater 'control' or 'management' areas and the like, and to the enforceability of legislation particularly at the local level (Burchi and Nanni, 2003). National legal frameworks should promote the participation of stakeholder representatives in the aquifer management institutions.

- *Lack of incentives to comply with the legislation* – The implementation of legal provisions often becomes difficult because those to whom the legislation is directed cannot afford to comply with it. Thus, particular care should be devoted to the introduction of a system of financial incentives, in the form of subsidies, credit or temporary exemption from taxes and other dues, amongst other things.

- *Misunderstanding of technical concepts* – The characteristics and behaviour of groundwater are often misunderstood by non-experts, and this may lead to erroneous interpretations of the legal regimes applicable, unless resource lawyers and groundwater specialists work more closely together and certain concept are clarified. For instance, on some occasions the term 'confined aquifer' has been taken as synonymous with 'non-renewable' resource, which is erroneous because 'confined' refers to the situation in which groundwater becomes pressurized and isolated from the overlying land surface, though being normally subject to recharge via lateral flows originating elsewhere (Nanni and Foster, 2005).

Conclusion

Conflict is often perceived as necessarily inherent to the transboundary character of water resources, whether surface or underground. However, it is pos-

sible in the case of aquifer systems that conflicts do not materialize at all, especially if a system is large and complex. In this case, problems may tend to be localized and solutions may have to be found at the local level.

The agreements for the Geneva Aquifer and the USA/Mexico border area were arrived at because the states concerned were in the presence of problems requiring a swift response, and a high level of cooperation has been indeed attained in the case of the Geneva Aquifer, as was mentioned earlier. In both cases, the conclusion of an agreement was also facilitated by the fact that the negotiating states were two. Conversely, when an aquifer system is large and several states are involved it becomes more complicated to arrive at a decision, and often the minimum common denominator, i.e. what *all* states can afford to do, is to be taken as the starting point.

However, it is increasingly being felt that even in the absence of pressing problems states ought to be prepared to agree on, and implement, given aquifer management measures, should a risk situation turn into actual adverse impact. In the cases of the NWSAS and the IAS the states concerned have felt the need to cooperate through an institutional mechanism. Thus, an evolutionary approach has been advocated, allowing the aquifer system states to start from a simple institutional structure to facilitate the enhancement of the common knowledge base and prepare the ground for more elaborated international consultation mechanisms.

Finally, the translation of international law into practice requires the introduction, by the aquifer system states concerned, of domestic laws and institutional arrangements in support of resource planning and decision-making, possibly with the involvement of stakeholders and water users.

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CODIFICATION AT THE INTERNATIONAL LAW COMMISSION AND EMERGENCE OF STATE PRACTICE: TOWARDS THE DEVELOPMENT OF INTERNATIONAL GROUNDWATER LAW?

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Abstract

Until recently, transboundary aquifers have received little attention in international law. If rules for transboundary surface waters are quite developed, this is not the case for transboundary groundwaters. However, it seems that a change is actually occurring , in two parallel tracks:

1 The UN International Law Commission, which is the UN body in charge of the codification and development of international law, has included in its program of work since 2002 the topic of Shared Natural Resources with three sub-topics:

- "confined" transboundary groundwaters
- oil
- gas natural

Three reports were already submitted and discussed at the ILC. In the last report (2005), a full set of draft articles on the law of transboundary aquifers is proposed. In this process, and with the concern of proposing rules adapted to the specific characteristics of transboundary aquifers, the Special Rapporteur has received, upon his request, scientific and technical advice from an ad-hoc group of experts coordinated by UNESCO-IHP. In 2006, the ILC has adopted at first reading the draft articles on the law of transboundary aquifers.

2 State practice on transboundary aquifers is emerging:

- At the 6th Committee of the UN General Assembly, State delegations are expressing their support to the work of the UN ILC, and encouraging the establishment of rules for transboundary aquifers
- States sharing an aquifer are expressing willingness to establish joint cooperation, and are starting to create simple mechanisms among

themselves which will hopefully lead to a more achieved joint management. The case of the North Western Sahara Aquifer System (Algeria, Libya and Tunisia) is one of the most developed, but other cases are following.

The process leading to the establishment of rules of international law is slow. In the case of transboundary aquifers, it seems that this process is now on, and could be achieved in a near future.

Introduction

Groundwater represents as much as ninety-seven percent of the earth's freshwater fraction in liquid form (excluding water locked in polar ice caps) (Foster, 1999). In arid and semi-arid regions, it is often the only source of water. Most of this groundwater is found in transboundary aquifers. Despite an increased dependency on it leading to over-exploitation, depletion and pollution (World Water Assessment Program, 2003, and Yamada, 2003a), groundwater has received less attention at the international level than for surface water. Until recently, international law has typically considered groundwater only as a subsidiary to surface water (Stephan, 2006). The UN Convention on the Law of Non-Navigational Uses of International Watercourses (1997) (UN Doc. A/RES/51/229, available at *www.un.org/law/cod/watere.htm*, hereinafter UN Watercourse Convention) represents the latest authority in international water law. It includes groundwater in its coverage but in a very limited way. In article 2 on the "Use of terms", the Convention defines a watercourse as "a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole and normally flowing into a common terminus" (article 2 paragraph a). An international watercourse is defined as "a watercourse, parts of which are situated in different States" (article 2 paragraph b). Regarding groundwater, the Watercourse Convention appears limited in its scope. It only considers groundwater when it is related to surface water, and flowing to a common terminus. Groundwater unrelated to surface water is excluded. This leaves out important systems such as the Nubian Sandstone Aquifer System (Chad, Egypt, Libya and Sudan). On the other hand, groundwater and surface water, even when they are related, do not necessarily "share" a common terminus. In reality, surface water and groundwater rarely flow to a common terminus.

In the same way, interstate treaties and agreements concluded on transboundary waters concern in a very large majority international rivers and rarely address transboundary aquifers. One exception is the Agreement on the Franco-Swiss Genevese Aquifer (1978) which is the only example of a treaty

Agreement	Surface water body	Groundwater body
Convention on Cooperation for the Protection and Sustainable Use of the River Danube (Sofia, 29 June 1994)	The Danube River	Groundwater in the catchment area of the river (article 2§1)
Convention on the Protection of the Rhine (Berne, 12 April 1999)	The Rhine	Groundwater interacting with the Rhine (article 2§a)
Agreement between the Federal Republic of Nigeria and the Republic of Niger concerning the equitable sharing in the Development, Conservation and Use of Their Common Water Resources (Maiduguri, 18 July 1990)	The Maggia/Lamido River basin The Gada/Goulbi og Maradi River Basin The Tagwai/El Fadama River basin The lower section of the Komadougou-Yobe River basin (article 1§2)	Groundwater contributing to the flow of surface waters (article 1§3)
Convention on the Sustainable Development of Lake Tanganyka (Dar es Salaam, 12 June 2003)	Lake Tanganika (article 3)	"groundwaters that flow into the Lake" (article 1)
The Protocol for Sustainable Development of Lake Victoria basin (Arusha, 29 November 2003)	Lake Victoria	"underground waters flowing into Lake Victoria" (article 1)

Figure 1. Selection of treaties on transboundary waters, and the surface and ground water bodies they cover.

dealing exclusively with the management of a transboundary aquifer. Most treaties and agreements on transboundary waters view groundwater only in so far as it is related to the surface water body of concern, as illustrated in Figure 1.

As a result, transboundary aquifers receive a limited coverage in international law:

- A great number of transboundary aquifers are excluded and not considered, mainly when they are not related to a surface water body.
- The provisions are tailored for a surface water body and do not cover the specific characteristics of aquifers.

However, this situation is evolving towards a better consideration of transboundary aquifers. The International Law Commission has recently adopted at first reading a full set of draft articles on the law of transboundary aquifers. A State practice on cooperation over transboundary aquifers is emerging.

Codification at the International Law Commission

The International Law Commission (ILC) is the body of the United Nations in charge of the progressive development and codification of international law, in accordance with article 13(1)(a) of the Charter of the United Nations. Its members are elected by the UN General Assembly among persons of recognized competence in international law. In 2002, the Commission decided the inclusion in its programme of work the topic entitled "Shared natural resources", and appointed a Special Rapporteur. The Special Rapporteur indicated his intention to deal with "confined" transboundary groundwaters, oil and natural gas under the topic. It should be noted that the word "confined" is not used here by the ILC in its hydrogeological meaning, but in another meaning adopted by lawyers to refer to groundwaters unrelated to surface water. The Special Rapporteur also proposed to adopt a step-by-step approach, to the study of the topic, first taking up groundwaters.

The role played by UNESCO-IHP

Within the framework of its Internationally Shared Aquifer Resources Management (ISARM) project, the International Hydrological Program (IHP) of UNESCO has set-up and coordinated a multidisciplinary ad-hoc task force of experts to support the Special Rapporteur in his task, upon his request, and to provide him with scientific and technical assistance on the science of hydrogeology. Meetings were held to prepare the reports, and briefings were conducted at the ILC in Geneva to provide guidance on the science of hydrogeology. The ISARM project had been launched in June 2000 when the intergovernmental Council of UNESCO's IHP, representing one hundred and sixty Member States adopted the Resolution XIV-12 to promote studies regarding internationally shared aquifers. The ISARM project is multi-disciplinary. It has identified the following focus areas that require attention in order to promote the sustainable development of transboundary aquifers (Puri, 2001):

- Scientific-hydrogeological
- Legal
- Socio-economic
- Institutional
- Environmental

The process at the ILC

The reports: from "confined transboundary groundwaters" to "transboundary aquifers". The ILC holds an annual session of approximately ten weeks. The Special Rapporteur submitted three reports on the topic of "transboundary groundwaters" to the ILC. The first report (2003) (UN A/CN.4/533) is "a very preliminary one, dealing with the outlines of the topic", and its background at the ILC. He defines the scope of the study he has to undertake on groundwater as covering "water bodies that are shared by more than two States but are not covered by article 2 (a) of the UN Watercourse Convention". In the second report (2004) (UN A/CN.4/539) the Special Rapporteur presents seven draft articles, intended to provoke substantive discussions at the ILC (paragraph 5). However, it is worth noting that in the thinking of the Special Rapporteur an important shift took place. To start with, the Special Rapporteur acknowledges the difference between the meaning of the word "confined" as used by the Commission and its meaning for hydrogeologists (paragraph 13). He thus decides to drop this word. He also decides to discard the concept of "confined", "unrelated" or "not connected", and to reconsider the assumption announced in his first report to cover "only those groundwaters not covered" by the Watercourse Convention. The Special Rapporteur has therefore widened the scope of his study to include all groundwaters. Moreover, he adopts the concept of aquifer, covering not only the waters but also the geological formation, the container and its content. The Special Rapporteur is meeting here the concerns of the hydrogeologists to which the geological formation is as important as the waters it contains. The seven draft articles include provisions on the scope, definitions, the obligation not to cause harm, the general obligation to cooperate, the regular exchange of data and information, and the relationship between different king of uses.

In his third report of 2005 (UN A/CN.4/551), the Special Rapporteur presents a full set of draft articles on the law of transboundary aquifers. The seven previous articles are slightly amended to take into account the comments and suggestions from the debates at the ILC and at the 6^{th} Committee (legal) of the UN General Assembly. The new articles include provisions on the reasonable and equitable utilization with specific factors concerning aquifers and the consideration of non-recharging aquifers, on monitoring, the protection, preservation and management of transboundary aquifers, and on the assistance to developing States. The Commission established then a Working Group to review the draft articles submitted by the Special Rapporteur. In 2005, the Working Group completed the consideration of eight draft articles (UN A/CN.4/L. 681). In 2006 the Working Group was reconvened and completed the revision of the draft articles (UN A/CN.4/L.683). The revised draft articles were deferred to

the Drafting Committee of the ILC and were adopted by the Plenary of the ILC at first reading (on file with author). The ILC has also decided to decided to request States to provide comments and observations by January 31, 2008.

The draft articles. The revised draft articles as adopted by the ILC represent a modified version of the draft articles submitted in the third report. The Working Group had introduced some amendments. For instance, a draft article on sovereignty was added. According to this draft article, an aquifer State has sovereignty over the transboundary aquifer or aquifer system to the extent it is located within its territorial jurisdiction. However, this sovereignty is not absolute. The reference to non-recharging aquifers, as well as their definition had been deleted. Non-recharging aquifers are therefore submitted to the same legal regime as recharging aquifers. The draft article on the Factors relevant to equitable and reasonable utilization, was also amended to give special regard to vital human needs in weighing different utilizations of a transboundary aquifer or aquifer systems. This provision, previously contained in another draft article in the third Report of the Special Rapporteur, was considered more appropriately placed in this draft article , since it sets forth an important principle relevant to determining the appropriate utilization of a transboundary aquifer or aquifer system. Regarding the draft article on the "Prevention, reduction and control of pollution", the Working Group discussions focused on whether more emphasis should be placed on prevention, and in that light, whether the precautionary principle should be placed in an independent article. Given the fragile nature of transboundary aquifers, it was agreed to strengthen the obligation to take a precautionary approach by changing the wording from "are encouraged to take a precautionary approach" to "shall take a precautionary approach". In the draft article on "Management", a last sentence was added mentioning that a joint management mechanism be established wherever appropriate. The Working Group thought that the strengthening of this obligation was particularly important in light of the value placed by groundwater experts on the joint management of transboundary aquifers. However, it also recognized that, in practice, it may not always be possible to establish such a mechanism.

Emerging state practice

While few years ago, State practice over transboundary aquifers was very scarce and almost non-existent, the situation is now showing signs of change. In the 6^{th} Committee of the UN General Assembly, State delegates have been globally following with interest and concern the study of the law of transboundary aquifers by the ILC. On the other hand, States sharing an aquifer are seeking to establish cooperation mechanisms over their common resource, and

are introducing the consideration of a legal component in projects on transboundary aquifers.

A. The reactions at the 6^{th} Committee of the UN General Assembly.
The UN General Assembly has six main committees :

- First Committee – Disarmament and International Security
- Second Committee – Economic and Financial
- Third Committee – Social, Humanitarian and Cultural
- Fourth Committee – Special Political and Decolonization
- Fifth Committee – Administrative and Budgetary
- Six Committee – Legal

The General Assembly is the main deliberative organ of the United Nations. It is composed of representatives of all member states, and so are its committees. Some issues are considered only in plenary meetings, while others are allocated to one of the six main committees.

The work of the International Law Commission is presented, discussed and commented every year at the 6^{th} Committee of the UN General Assembly, where States' delegates have the opportunity to express their States' views.

Since the beginning of the study of the topic of "Shared Natural Resources" and its first item "transboundary aquifers", the reactions at the 6^{th} Committee have expressed a global support of the project, acknowledging the importance of groundwaters in general, and of transboundary aquifers in particular, and have shown their awareness of the need in international law for specific rules for transboundary aquifers. They also expressed their global support to the step by step approach adopted by the Special Rapporteur, and to the continuous consultation he has undertaken with groundwater experts, and their involvement in the elaboration of the draft articles.

At the last session of the 6^{th} Committee in 2005 (Summary 2005), the 60^{th} session, the comments focused on the third report of the Special Rapporteur and are of particular relevance for the rest of the work, as they concerned the full set of draft articles. The main issues that were raised are:

- The importance of the principle of sovereignty of aquifer States on groundwaters, and the relevance of Resolution 1803 (XVII) of the General Assembly on permanent sovereignty over natural resources.

- The flexibility of the rules proposed by the Special Rapporteur allowing the development of bilateral and regional arrangements to address cooperation on transboundary aquifers, which are considered more adapted.
- The necessity of the protection of aquifers and the adoption of the precautionary approach.
- The assistance to developing States.

B. First steps of cooperation over transboundary aquifers: established consultation mechanisms.

a. Two established cases.

- The SASS (Système Aquifer du Sahara Septentrional) (Algeria, Libya and Tunisia)

The SASS (from its French acronym) is a transboundary aquifer system between Algeria, Libya and Tunisia. It contains considerable reserves of non-renewable groundwater. Located in arid and semi-arid areas where surface water is very rare, the three countries rely heavily on their groundwater resources (Mamou et al., 2006). The three countries concerned with the future of the system have decided and agreed to come together and find a way to jointly manage the system. The first necessary step was to improve the scientific knowledge over the system on its geographic extent and the evaluation of the exploitable reserves and their use. Well aware of the potential risks on the SASS, and its importance as a water resource for them, the three countries undertook a joint study of the system under the supervision of the Observatoire du Sahara et du Sahel (OSS) (more information is available at *http://www.unesco.org/oss-sass/vuk/systeme_informationuk.htm*). The achieved results was an improved knowledge of the basin's hydrogeology, which could lead to the establishment of a common data base between the three countries serving as an exchange information tool, and the design of a model simulating the hydrodynamic behaviour of the aquifer system and making it possible to forecast the impact of abstraction. These results were considered as enlightening for the decision-makers of the three countries. For instance, the simulations carried out have highlighted the areas where the system appears to be the most vulnerable. It is the sector of the

Algerian-Tunisian Chotts where the strongest density in population can be found, and where the pressure on water resources is strong.

In the second phase of the SASS project, an institutional mechanism has been established and is currently under signature by the three States. The structure of the mechanism is as follows: a steering committee composed of the national water authorities in the three countries, a coordination unit hosted by the OSS, and an ad hoc scientific committee for scientific evaluation and orientation, of which UNESCO-IHP is a member. The mechanism is in charge of managing the tools developed for the system (a common data base and a model) and the exchange of information, the establishment of monitoring indicators and promoting studies (Mamou, 2004).

- The NSAS (Chad, Egypt, Libya, Sudan)

The Nubian Aquifer Sandstone Aquifer System or NSAS, is one of the largest regional aquifer resources in Africa and in the world. It consists of a number of aquifers laterally and/or vertically connected, extending over more than 2,000,000 km^2 in East Libya, Egypt, North-East Chad and North Sudan. The Nubian aquifer is a strategically crucial regional resource in this arid region, which has only few alternative freshwater resources, a low and irregular rainfall and persistent drought, and is subject to land degradation and desertification. Under current climatic conditions, the Nubian aquifer represents a finite, non-renewable groundwater resource (Bakhbakhi, 2006, Appelgren and Stephan, 2004). Since the early seventies, Egypt Libya and Sudan have expressed their interest in regional cooperation in studying and developing their shared resource. A joined authority was established in July 1992 between Egypt and Libya. Sudan and Chad joined later on. Amongst other things, the Authority is responsible for collecting and updating of data, conducting studies, formulating plans and programs for water resources development and utilization, implementing common groundwater management policies, training technical personnel, rationing the aquifer waters and studying the environmental aspects of water resources development (Appelgren and Stephan, 2004). In the frame of the "Programme for the Development of a Regional Strategy for the Utilization of the Nubian Sandstone Aquifer System", supported by the International Fund for Agricultural Development (IFAD), and executed by the Center for Environment and the Development of the Arab Region and Europe (CEDARE), an integrated regional information system was developed. Within the framework of this Programme, and with the objective of consolidating the existing data and information, and the continuous update of the knowledge

of the aquifer system, the four countries have signed two agreements (Regional Strategy, 2001):

- Agreement number 1: for the monitoring and exchange of groundwater information of the NSAS.
- Agreement number 2: on monitoring and data sharing.

The four countries have now engaged in a project of the Global Environmental Facility (GEF) on the "Formulation of an Action Programme for the Integrated Management of the Shared Nubian Aquifer" which includes an important legal component. The four countries shall undertake to jointly identify, understand and reach agreement on the priority issues, threats and root causes of the NSAS, and to prepare a Strategic Action Programme (SAP) outlining the necessary legal, policy and institutional reforms needed to address the priority threats and their root causes as identified, with a focus on the environmental aspects of aquifer management. The overall expected results of the project would contribute to strengthening the institutional, legal and analytical frameworks for the sustainable management and use of the shared NSAS (available at: *http://www.gefonline.org/projectDetails.cfm?projID=2020*).

b. Consultation mechanisms in projects.

- **The Iullemeden Aquifer System** *(Mali, Niger, Nigeria)*

The Iullemeden Aquifer System (IAS) covers about 500 000 km^2, with an exploitable reserve estimated at 2000 km^3. The system has an important recharge capacity, mainly seasonal, through rivers and ponds. The water is used in majority for irrigation. A GEF funded project on "Managing Hydrogeological Risk in the Iullemeden Aquifer System" (*http://www.gefonline.org/projectDetails.cfm?projID=2041*) will address the threats and risks on the aquifer system through the establishment of joint mechanism and cooperative frameworks for: (a) identification of transboundary risk and uncertainty issues, (b) formulation of joint risk mitigation and sharing policy; and (c) joint policy implementation through a joint IAS legal and institutional cooperative framework.
A first temporal consultation mechanism is suggested, composed of:

- a secretariat
- a steering committee (political level)
- technical national committees

The mechanism would be in charge of improving and maintaining the common database and identifying risks and vulnerable zones. It is expected that the temporal mechanism will develop in a second phase towards a permanent consultation mechanism, which would be in charge of:

- completing the joint identification of the system,
- defining and managing the risks,
- preparing legal and institutional recommendations for the Aquifer States,
- sustainable development of the IAS,

- **The Coastal Aquifer System of the Gulf of Guinea** *(Benin, Cote d'Ivoire, Ghana, Nigeria, Togo)*

The coastal transboundary aquifer system located along the Gulf of Guinea and shared by five countries (Benin, Cote d'Ivoire, Ghana, Nigeria, Togo) are facing severe deteriorations, such as saline water intrusion, due to poor overall management, and declining groundwater discharge.

A preliminary Transboundary Diagnostic Analysis has identified and prioritized significant threats on the aquifer system : groundwater pollution, wrong land use; saline intrusion; degradation of the coastal ecosystems, recharge reduction, groundwater over extraction, and global climate change impacts. Based on these results, a project on the "Joint Management of Coastal Aquifer in the Gulf of Guinea" has recently been submitted for GEF funding. This project includes a legal component, aiming at the eestablishment of a cooperative mechanism of technical assistance between the five countries. This mechanism would be conducted by the Project Steering Committee, in charge of supervising the General Coordinator. The General Coordinator would play the role of an implementing organs and would coordinate the activities of the national committee in each State.

c.Transboundary aquifers in the EU Water Framework Directive. The EU Water Framework Directive (WFD) (2000/60/EC) , which came into force on 22 December 2000 (Official Journal of the European Community 22.12.2000, L 327/1) acts as an umbrella incorporating all water-related elements and topics, based on the concept of integrated river basin management.

The WFD extends to all aquatic systems, including surface waters (rivers and lakes), groundwater and coastal waters. Its objective is to ensure that 'good status' is achieved for all surface and ground water bodies, except for exceptional cases, in 2015.

The WFD is based on the concept of integrated river basin management and can thus offer input for best practices in transboundary (surface and ground) water resources management Its main provisions regarding transboundary waters include the following provisions:

- establishment of protected areas in each river basin district (i.e. including international ones), which include groundwater drinking water protected areas;
- monitoring requirements for transboundary groundwater bodies,
- requirement for coordination of single international river basin management plan in each international river basin district (hence covering transboundary aquifers).
- And the most important one is the request to delineate and characterize international river basin district and transboundary groundwater bodies (review of the impact of human activity on the groundwater status, and an economic value of water use) (article 5);

Member States of the European Union are requested to comply with the provisions of the directive. So far, eleven Member States with international river basins have assessed transboundary groundwater bodies.

d. Legal component in regional projects.

- The regional development of ISARM in the Americas

  The ISARM project was launched in the Americas in 2002, where it is jointly co-ordinated by UNESCO and the Organization of American States (*www.oas.org/dsd/isarm/ISARM_index.htm*).

  In its first phase the programme has focused on the assessment of transboundary aquifers in the continent. One of the most important steps of the programme has been the collection of data on transboundary aquifers. Through preliminary questionnaires sent to the countries, UNESCO and OAS have assessed the prevalence of transboundary aquifers in the American continent in order to identify critical case studies while

creating a comprehensive Inventory of the transboundary aquifers for the Americas.

At its second workshop held in El Paso, Texas in 2004, the legal and institutional issue was identified as one of the most important issues to be developed by the project in the future (UNESCO/OAS ISARM Americas Programe, 2005). The third workshop held in Sao Paulo, Brazil in 2005 discussed the second phase of the ISARM Americas for 2006, and it was decided that the phase will focus on the Diagnostics of Institutional and Legal Framework as well as the socio-economic & environmental aspects. The activities in 2006 will be mainly focused on the identification of the legal and institutional issues related to transboundary aquifers in the American countries (UNESCO/OAS ISARM Americas Programme, 2006).

- Capacity building for sustainable utilization, management and protection of internationally shared groundwater in the Mediterranean region (ESCWA, ECE, ECA, in partnership with UNESCO-IHP (ISARM))

An inter-regional project was formulated on "Capacity building for the sustainable utilization, management and protection of internationally shared groundwater in the Mediterranean region" aiming at strengthening the capacity of water management institutions in the Mediterranean region to implement sustainable forms of utilization, management and protection of internationally shared groundwater resources. ESCWA, ECE, and ECA have forged this inter-regional Mediterranean initiative to address these prevailing issues (project document on file with author).

The shared ground waters represent a natural resource of critical, strategic social, economic, environmental and political importance to current, medium and longer-term development in the water scarce MEDA region. In this sense the shared ground waters are, at a time a potential source of conflict as well as a common strategy for cooperation with mutual benefits for sustainable development and social and environmental security in the region. In the MEDA region the shared aquifer resources dominate and are often the only available water supply to support social and environmental services. The MEDA economies depend largely, directly or indirectly, on the shared coastal aquifers along the Mediterranean to support coastal urban and agricultural development, control land degradation and salinization, and maintain coastal and marine ecosystems in the coastal zone that is of central economical importance to the MEDA.

The Mediterranean partners, comprise originally 10 MEDA countries, Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, and the Palestinian Authority. Since 2006 the MEDA countries1 are partners of the European Neighborhood Policy (ENP), with Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Israel, Jordan, Lebanon, Libya, Moldova, Morocco, Palestinian Authority, Syria, Tunisia, and Ukraine.

Conclusion

According to article 38 of the Statute of the International Court of Justice, the sources of international law are:

- international custom
- the general principles of law
- and judicial decisions.

In international law, a custom is composed of two elements:

1) a repeated practice, or precedent,
2) the conviction that such practice is compulsory because of a rule of law.

The process leading to the elaboration of an international custom, and is the result of a numerous State practice.

Regarding transboundary aquifers, State practice was very scarce, even non existent. In his first report, the Special Rapporteur of the ILC expresses his intention to collect State practices with respect to use and management (§25). In this regard the ILC had prepared a questionnaire sent out to governments and relevant international organizations (UN A/CN.4/555 of 29 April 2005 and Doc. A/CN.4/555/Add.1 of 15 July 2005).

Since then, State practice has been slowly emerging, as developed in part II of the article. The process leading to the establishment of rules of international law is slow. Regarding transboundary aquifers, it seems that this process is now on.

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II

GOVERNMENT MECHANIC FOR TRANSBOUNDARY WATERS MANAGEMENT

CHALLENGES FOR TRANSBOUNDARY WATERSHED MANAGEMENT IN AMERICA

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Abstract

The watershed or river basin approach is a useful vehicle to solve problems related to water resources management of transboundary river basins, and to promote regionally coherent water policies and legislation, which may become increasingly needed given present globalization and integration efforts and trends. Situations in which rivers and lakes border multiple countries, rivers flow from one country to another, and aquifers underlie more than one country are numerous and represent potential sources of conflict. Notwithstanding international efforts such as the Helsinki Rules and the Convention on the Law of the Non-navigational Uses of International Watercourses, there are no clear property rights and universally accepted conflict resolution rules pertaining to transboundary water resources. This has given rise to opposite theoretical doctrines favored by upstream or downstream countries and to several tendencies and proposals, such as using market mechanisms to allocate water among different users in different countries. Another mechanism being proposed by some NGOs is the concerting of water users' interests even if they are in different countries. However, achieving a sense of equity among the countries involved has been a more realistic short-term goal in settling international disputes.

In the Americas more than 78 river basins are shared by two or more countries, and about 71% of the surface water is produced in transboundary basins. Therefore, it is not surprising that transboundary river basins was one of the eight priority session topics selected by the Regional Committee of the Americas for discussion at the Fourth World Water Forum held in Mexico City in March 2006.

In Latin America, solutions have been mostly reached through bilateral agreements that more often than not, reflect the customary legal norms and application of the principle of just and equitable use. One important governance lesson has been, however, that care must be taken to include the participation of the local communities to avoid bias. The region offers some interesting examples of international water commissions that have been created for this purpose, as well as bi-national and even tri-national commissions. Because of the increased com-

plexity and difficulty to reach agreements among large numbers of persons at the multinational level, these basins are sources of conflicts, but the river basin or watershed approach is also a good opportunity for cooperation and integration.

Introduction

The Americas is a diverse region. Its emerged land area of about 40 million km^2 extends from the North Pole to the South Pole with polar, cold, temperate, dry, and tropical climates. It has ice caps and glaciers and snowy peaks. It has areas with four season weather and areas with two-season dry and wet cycles. There are humid rainforests and areas with mean annual precipitation of more than 6,000 mm. It also has arid and semi-arid areas and the driest place on Earth. It is rich in biodiversity. One country alone, Brazil, has from 20 to 30% of all species in the world. And it has water.

More than 55% of the total renewable freshwater of the world makes it the water-richest region. In the Great Lakes area of North America it has the largest concentration of inland non-saline water bodies in the world. It has extensive aquifers in North and South America as well as long and large discharge rivers. It suffers droughts and floods, is ravaged by hurricanes and tropical storms, and affected by phenomena such as El Niño and La Niña. With about 24 thousand km^3 per year of renewable water, it could supply every person in the Caribbean with almost 90 m^3 on an average year, around 700 m^3 to every Central American, almost 15,000 m^3 to every person in North America, and more than 17,000 m^3 to every South American person (García et al., 2006).

There are 35 countries and among them, some of the richest and some of the poorest in the world. More than 800 million persons, 78% of which live in cities, speak Spanish, Portuguese, English, French, and more than 400 indigenous languages. Although in general water is considered to be good, its great water richness is sparsely used: 32% to meet the increasing socioeconomic demands of its society, with some perceived as winners and some perceived as losers depending on the way it is used.

As in many other parts of the world, hydrology and the political, administrative and legal set up in the Americas do not match.

According to UNEP (2002), the Americas with 78 river basins shared by two or more countries is the region of the world with more international river

basins, against 35 in Europe, 30 in Africa and 28 in Asia. Forty of those are in North and Central America and 38 in South America. About 71% of the surface water is produced in these transboundary basins (Douroheanni and Jouravlev, 2002). About 55% of the Latin American and Caribbean territory belongs to transboundary river basins and in one country, Guatemala, it reaches 75%. The use of water in many interior areas of several countries depends on the use of the common resource among two and even three bordering countries, and more cases can be found considering States within Federal Countries like the United States, Mexico, Brazil and Argentina.

There are at least 67 transboundary aquifers shared between neighboring countries or federal states: 27 located in South America, 19 in North America (Canada, United States, and Mexico), 12 in Central America and 4 in the Caribbean (Dominican Republic – Haiti). About one third of these are in arid and semi-arid zones; 20 are already intensively mined, and 16 located in areas of intensive agriculture or industry show high rates of salinization (IGRAC, 2005). One noteworthy example is the Guaraní Aquifer in Argentina, Brazil, Paraguay and Uruguay, one of the largest groundwater reservoirs in the world, with current water storage of approximately 37,000 km^3 and a natural recharge of 166 km^3 per year.

Most of its largest rivers are in the East, like the St. Lawrence, Mississippi, Rio Grande/Bravo, Usumacinta, San Juan, Magdalena, Orinoco, São Francisco, Paraná, Paraguay, Plata, and Amazon, whose more than 6 million km^2 basin spans eight countries: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Surinam and Venezuela, and whose annual volume discharge of 6,700 km^3 is five times that of the second largest river in the world, the Congo River. Other noteworthy examples of transboundary river basins (Revenga et al., 1998) are the Rio Grande/Bravo in the United States and Mexico, Usumacinta in Mexico and Guatemala, San Juan in Nicaragua and Costa Rica, Orinoco in Colombia and Venezuela, and La Plata in Argentina, Brazil, Bolivia, Paraguay and Uruguay, the fifth largest basin in the world and second only to the Amazon Basin in South America.

It is not surprising then, that transboundary river basins was one of the eight priority session topics selected by the Regional Committee of the Americas for discussion at the Fourth World Water Forum held in Mexico City in March 2006.

Challenges

The use of the shared water resources poses several challenges to neighboring countries and States (Salman, 2006). Among these, the major deal with the following:

- Different political maturity of neighboring countries, which may make it difficult to reach agreements about the use of the waters when different modalities of solving conflicts are prevalent.
- Different political orientation in neighboring countries, which may introduce questions about the ulterior motives for the proposals being made.
- Different degree of development, which may increase the need of one country to use the shared waters, while the neighbor may want to save that use for later stages of development.
- Different population density, especially in the transboundary watershed, that may assign asymmetric priorities to the use of the shared resource.
- Conflicts between users of the same resource on both sides of the national or state boundary.
- Difficulties in applying the integrated water resources management (IWRM) approach to the transboundary river basin or watershed.
- Sovereignty-type conflicts between the bordering nations.
- A changing world trade and rules.

One or more of the above factors, when present, may give way to disputes between the neighboring countries or states sharing a common river basin or watershed. These disputes may be of the following nature (Salman, 2006):

- Border disputes. Historically, countries tended to resolve the disputes and set their borders –either peacefully or as a result of an act of war– at natural easily identified geographical features like mountain ridges and, especially, rivers and lakes. Sometimes borders were agreed on each opposite margin or lakeshore, making the water bodies a condominium or a de-facto no-man's land. In other cases, the whole lake or stretch of river belonged to one country and the border was set at one of the margins or lakeshore. Sometimes the border was set by a line joining the middle points of the surface of the lake or river, and sometimes it was set at the thalweg, or line joining the deepest points of the river. Sometimes this solved the dispute and sometimes it only made it latent.

- Water volume disputes. River basins generally are not distributed evenly between neighboring countries. Those having the lesser portion generally tend to favor a fifty-fifty distribution of the river flow and those having the larger portion, generally favor a distribution proportional to the contributing basin area.

- Water-use right disputes. Sometimes there is agreement about the border or the volume distribution issues, but disputes arise about the right to make non-consumptive use of the water body by one country, like navigation or fishing, even if the border lies in its margin or shoreline and the lake or river lies entirely within the neighboring country.

- Water quality disputes. At times, disputes arise because one country feels that the use of the water in the tributaries lying entirely within the borders of the neighboring country, are changing the water quality of the water that flows into its part of the transboundary river basin. This may also happen in a shared river or lake.

- Benefit disputes. Lately, the theme of economic development of countries with transboundary watersheds has internationally raised the importance of water-related activity and is seen as the basis for an adequate practice of benefit sharing from an IWRM perspective (Sadoff and Grey; Manakalo, 2006). Nevertheless, an optimal IWRM scheme implies the maximization of benefits for the whole –in this case the entire transboundary river basin– and not for any of its parts –those lying in each of the neighboring countries. Although countries now seldom experience open conflict over the development of international rivers (Mirumachi, 2006), negotiations often end in stalemate when development schemes where all transboundary basin countries reap the desired benefits, are not adopted.

Facing the challenges

International efforts notwithstanding, there are no clear property rights and universally accepted conflict resolution rules pertaining to transboundary water resources (García et al., 1998). The International Law Association's Helsinki Rules dating from the mid sixties was a serious attempt. The United Nations Convention on the Law of the Non-navigational Uses of International Watercourses was approved in May 1997 by 103 votes in favor, 3 against, and 27 abstentions. It needs 35 ratifications to enter into force, but 9 years later, only 14 have done so.

Frederick (1996) identified two opposite theoretical doctrines: i) unlimited territorial sovereignty, which would give a country exclusive rights to the uses of water within its territory, favored by upstream countries; and ii) unlimited territorial integrity, in which one country cannot alter the quantity and quality available to another, favored by downstream countries.

Between these two extremes and although they are not part of any United Nations sanctioned rules, there are some substantive principles governing the utilization of international watercourses that reflect the customary legal norms (Querol, 2003): i) the prohibition to cause appreciable damage; ii) the equitable and reasonable use of water; and iii) the requirement of previous consultation. In practice, a great number of agreements are reached through bilateral negotiations and bi-national treaties, some reflecting the above mentioned principles and some not. However, when a hegemonic hydropolitical configuration exists in a transboundary river basin, the benefits from water management are not shared equitably across countries, or within the countries of the basin (Cascao, 2006).

Lately, disputes over water are increasingly being taken to the courts, national, and regional as well as the International Court of Justice (ICJ). Also because of trade agreements, water disputes are being taken to the International Centre for Settlement of Investment Disputes (ICSID) (Salman, 2006). It has been posed that if a dispute arises between sovereign states regarding the regulation or use of shared waters, if all attempts to resolve it by negotiation or conciliation have failed, it should be taken to arbitration or adjudication by a tribunal applying international law. Also, if the protesting country is willing to submit the dispute to arbitration or adjudication, the countries in the dispute are to refrain from taking action on the situation that has been the subject of the protest. The pros and cons of such approach has been the subject of discussion for many years. Clagett (1961) had pointed out that although at the time the United States Department of State, the Seventh Conference of American States and the river committee of the American Branch of the International Law Association have favored this position, some authors have argued that resolution by an impartial body on the basis of law is not a suitable means of settling water disputes, and that the mere existence of a commitment to arbitrate would hinder rather than facilitate resolution by agreement.

In Latin America and the Caribbean, the regulation of transboundary water systems and bodies is mostly reached through bilateral agreements and treaties, such as those signed between the United States and Mexico for the Rio Grande/Bravo and the Colorado river, and between Costa Rica and Nicaragua for the San Juan river. UNEP (2002) reports 23 agreements in force in North

America, Central America and the Caribbean, and 6 in South America, although many of these deal more with the protection and improvement of the environment in the border areas than with shared use of the waters. Most of the treaties about the shared use of water reflect customary legal norms and principles, such as the prohibition to cause appreciable damage, reflected in the large number of bi-national environmental and sustainable development projects; the equitable and reasonable use of water, reflected in the agreements for hydroelectric projects such as Itaipu and Corpus Christi, as well as in the willingness to negotiate the use of irrigation water in the Rio Grande/Bravo; and the requirement of previous consultation, reflected in the reserve of right made by Argentina in Itaipu and the information exchange in the case of the Rio Grande/Bravo (Querol, 2003). In some cases, countries have also reached agreements on navigation and on bi-national regional development programs, such as between Peru and Ecuador regarding the Amazon River basin.

To resolve, but more to prevent conflicts, the region has also made good use of instruments like International Joint Boundary Waters Commissions (IJC), such as those in operation between Canada and the United States, between the United States and Mexico, between Mexico and Guatemala, and between Guatemala and El Salvador. It has also resorted to the creation of bi-national, tri-national and multinational commissions such as those for the Sixaola river basin between Costa Rica and Panama; and the upper Rio Lempa, Rio Motagua, and Rio Ulúa Trifinio region between El Salvador, Guatemala, and Honduras. In the La Plata river basin in South America, 9 bi-national commissions have been created, along with one tri-national commission (between Argentina, Bolivia, and Paraguay), and two pentad-national commissions between Argentina, Bolivia, Brazil, Paraguay, and Uruguay, one for the Paraná river, and one for the La Plata river basin as a whole.

As previously mentioned, the application of market-based mechanisms has been suggested as the most efficient way for benefit allocation in a river basin. However, this approach has not been fully accepted or applied in the region, even in river basins lying entirely within the same country and its application may face considerable difficulties in transboundary situations. Several NGOs and universities in Central America have suggested working with the communities living within these territories in order to reach agreements in a new concept of national sovereignty (López, 2002). Lately, a more participative decision-making process, taking into consideration the opinions of local populations is being attempted. The cases of Corpus Christi in the Misiones province of Argentina, the Rio San Juan in Nicaragua and Costa Rica, and the upper Rio Lempa basin, between Guatemala, Honduras, and El Salvador are given as examples of this approach (Querol, 2003; García and Quiroga, 2002).

In general terms, it can be said that the great number of transboundary river basins existing in the region, the great dependency on their resources for national development of bordering countries, and the many challenges and hurdles involved in reaching agreements, the region has been remarkably free of serious conflicts involving these resources. Conflicts have existed and continue to exist, but the mechanisms in place have, for the most part, been able to face and deal successfully with them. The following section briefly describes some examples. These are by no means the only ones or the most remarkable ones, but simply those with which the author has some familiarity and chosen to illustrate existing or new emerging situations.

Examples of conflicts and conflict resolution in the region

The examples described in this section involve conflicts related to border demarcation between Mexico and Guatemala in the Suchiate river and between Guatemala and El Salvador in the Paz river; to downstream-upstream uses between Mexico and Guatemala in the Usumacinta river basin and between Guatemala and El Salvador in Güija lake; to navigation between Costa Rica and Nicaragua in the San Juan river; to trade between Mexico and the United States in the Rio Grande/Bravo; to ground water between Mexico and the United States in the Colorado river; and to water quality between Argentina and Uruguay in the Uruguay river.

Suchiate River between Mexico and Guatemala

Along the stretch of the river that flows between the countries (Figure 1), the border is the thalweg. The river has a very steep slope before coming down to the coastal plain and flowing between the two countries, both of which have agriculture in their margins. This area is prone to frequent flooding and the river frequently strayed off course, incursioning into Mexico or into Guatemala. Farmers at both sides considered then that, since the national boundary had moved, they had gained (or lost) land for their farms. At one point, farmers on one side (there is no agreement as to which side) decided to build break-waters and dikes to "defend" their property against the river. Farmers on the opposite bank build even higher, stronger, and longer break-waters and dikes, thus starting a "break-water and dike war" at the border. Both countries, through the Mexico-Guatemala IJC agreed on a joint integrated river bank protection program whose execution was financed by both. A moving-bed river model was built in hydraulic laboratories in Mexico City and the bank protection structures and their sequence was carefully designed accordingly. The program was successfully executed through the IJC and the erratic

behavior of the river, along with the associated problems between users on both sides, were greatly minimized. This case is an example of how established mechanisms such as the IJC were able to contribute to the solution of conflicts between users and also to prevent possible border conflicts.

Paz River between Guatemala and El Salvador

A problem similar to the one described for the Suchiate River was confronted in the Paz River, between Guatemala and El Salvador (Figure 1). Contrary to the Suchiate, the border is neither the thalweg nor the river itself, but it has been demarked geodetically and indicated in the field by concrete pylons in accordance with the 1938 frontier agreement between both countries. The border is fixed but, unfortunately, the river is not. Farmers on both banks, however, live under the impression that the river is the border, and "gain" or "lose" territory as the river moves, originating conflicts between users of both sides. In this case, the solution adopted has been one of conflict resolution by the Guatemala-El Salvador IJC working with the farmers and now the situation is better understood by all involved and conflicts have been reduced. Although no potential border conflict existed here, this case is another example of how established mechanisms such as the IJC were able to contribute to the solution of conflicts between users.

Usumacinta River between Mexico and Guatemala

The Usumacinta River has its origins in the Guatemalan mountains, flows between Guatemala and Mexico in a border stretch, and goes into Mexico lowlands, flooding agricultural lands (Figure 1). For a long time, Mexico has developed plans and designs to build a large dam within its territory for hydroelectric generation and flood control purposes. Guatemala has feared that flooding would be transferred from the Mexican lowlands upstream into Guatemala, flooding natural protected areas and Mayan archeological sites, as well as large areas inhabited by settlers. Over time, this has become a very sensitive issue among local border populations and has also met strong opposition from environmentalists. Joint studies have been carried out by both countries sponsored by the IJC, but Mexico's attempts to reach an agreement have not progressed and it remains an on-going issue. This is an example where no Treaty exists between both countries for the use of the Usumacinta and the IJC has been unable to reach an agreement due to the sensitive nature of the situation. Conflict has been avoided only because of the maturity and level-headedness of successive governments in Mexico and Guatemala. Also lately, a movement to involve the local population and local governments on both

Figure 1. Paz River between Guatemala and El Salvador

sides in cooperative actions and projects has been initiated fostered by NGOs and local organizations.

Güija Lake between Guatemala and El Salvador

The area of the lake, the largest in El Salvador, is 42 km^2 and by virtue of the 1938 frontier agreement between Guatemala and El Salvador, the boundary-line places about seven tenths of its area in El Salvador and about three tenths in Guatemala (Figure 1). The drainage basin of the lake is 2,560 km^2 of which 80% are in Guatemala, and El Salvador controlled the outlet. This, as the Usumacinta case described above, is also an upstream-downstream use case. On the Guatemalan side, use of the land at its margins, which is flat, is basically for agriculture. In El Salvador, it drains into Desagüe, a tributary of the Lempa River, the major river in the country from which it generates most of its power in a series of dams and reservoirs. A power generation plant (Guajoyo) was proposed at the outflow of Güija when this integrated system was in its initial stages, in Salvadoran territory. Maximizing the benefits for hydropower meant drawing more water and lowering the water level of the lake and thus affecting agricultural lands in Guatemala. Limiting the withdrawals prevented this to happen, but restrained the power generation. After lengthy discussions, negotiations between the countries were brought to a successful conclusion about withdrawals and water level, with El Salvador agreeing to supply a certain amount of electric power to Guatemala, and Guatemala agreeing to take necessary protective measures to prevent any silting up of the lake as a result of erosion in the surrounding mountains. This is a case where a potential conflict was averted by negotiations and agreement.

San Juan River between Costa Rica and Nicaragua

As a result of a Treaty signed by both countries in 1858, ownership of the river belongs to Nicaragua (Figure 2). Costa Rica does not dispute such ownership, but claims navigational rights based on its interpretation of the Treaty. Based on its own interpretation of the Treaty, Nicaragua claims the right to impose a number of restrictions on such navigational rights. After some discussions and negotiations that did not advance towards a solution, Costa Rica took the case to the International Court of Justice, where a resolution is pending (Salman, 2006). The interest of this case is that it is a dispute about a non-consumptive use and, despite having a Treaty, there is disagreement in its interpretation.

Figure 2. San Juan River between Costa Rica and Nicaragua

Figure 3. Rio Grande and Bravo River between Mexico and the United States

Rio Grande/Bravo River between Mexico and the United States

Water sharing of the Rio Grande/Bravo between the two countries is regulated by 15 Treaties, the oldest signed in 1889. By the 1944 Treaty which relates to the waters of the Colorado and Tijuana Rivers, as well as the Rio Grande (Rio Bravo) from Fort Quitman, Texas to the Gulf of Mexico, this country was allowed two third of the flows from 6 Mexican tributaries, and the United States one third of the flows from the 6 Mexican tributaries and all flows form the United States tributaries (Figure 3). Water delivered to the United States by the Mexican tributaries must average 350,000 acre-feet/year (432 million $m^3/year$) measured in 5 year cycles.

A drought in the early nineties prevented Mexico to comply with this in the 1992–1997 cycle, accumulating a water debt of one million acre-feet, which the country started repaying in the 1997–2002 cycle but was unable to finish. The water debt is now repaid but farmers in Texas claimed arbitration under

the North American Free Trade Agreement (NAFTA) against the Mexico government, arguing that Mexico preferred its own investors over the other party investors and claimed US$ 320 million to US$ 668 million in damages, plus interest and costs. What makes this case interesting (Salman, 2006) is that it is not a conflict or disagreement between countries under the jurisdiction of the Mexico-United States IJC, but a case of private farmers in one country demanding the government of another country, not under the rules of the 1944 treaty, but under the rules of the NAFTA agreement. Resolution is pending.

Colorado River between United States and Mexico

In 1942 the United States built the All American Canal to carry water from the Colorado River to the Imperial Irrigation District in California. The Rio Colorado is shared by the United States and Mexico and its use regulated by 15 Treaties, the earliest dating from 1944 (Figure 3) which deals only with surface waters and does not include groundwater. Since the canal was unlined, seepage provided recharge to the Mexicali aquifer in Mexico. Due to high seepage losses, the United States planned to build a concrete-lined canal in order to reduce them and take more of the water delivered from the Colorado River to California. Farmers in Mexicali felt damaged and protested as well as environmentalists, but the United States claimed that it is simply reclaiming water from the Colorado River that was allotted by the 1944 Treaty which deals only with surface waters. NGOs in Mexicali and in the United States have filed a class action suit against the United States Government in a court in Las Vegas. Again, this case is interesting (Salman, 2006) because it reflects a controversy of NGOs inside one country against the government of that country on behalf of farmers in another country in courts of the demanded country. Resolution is pending.

Uruguay River between Argentina and Uruguay

To solve and help prevent conflicts in the Uruguay River (Figure 4), Argentina and Uruguay formed a bi-national commission (CARU). They also signed a bilateral Treaty on the uses of the river. Against Argentina's objections, Uruguay authorized the construction of a paper mill project by Europe's largest pulp producers –a US$ 1.7 billion project, the largest foreign investment in Uruguay and a key source of employment for Uruguay that would become the world's largest cellulose project (Bekker and Pieter, 2006). Argentina's objections stem from concerns about toxic air and liquid emissions, material damage to fisheries and serious damage to ecosystems. Protesting a unilateral decision and claiming a breach in the Treaty, sought reparations.

Figure 4. Uruguay River between Argentina and Uruguay.

Uruguay stated that the necessary environmental impact analyses were made which showed the impact did not warranted notification under the CARU. In May 2006, Argentina failed claim at the International Court of Justice. The Court failed in favor of Uruguay. This case is interesting because it shows that, despite having treaties and the necessary mechanism in CARU to prevent this type of dispute, conflict still thrived.

Non-Transboundary water subject to international conflict?

Salman (2006) points that other international water disputes are emerging, where the parties are no longer riparian states. By virtue of trade agreements, multinational corporations are also emerging as parties of such disputes against the governments of other states, not only confined to water quantity but also to water quality, right of use and monetary compensation, and not only related to transboundary waters but to all waters within a country. This is causing concern in Latin America and the Caribbean, to the extent of being one of the priority issues selected by the Regional Committee of the Americas for discussion at the Mexico 2006 Fourth World Water Forum. One of the concerns deals with the possibility of trade laws compelling trade in water resources (Mann, 2004). The answer of government experts is no, but also refuse to ban it because of trade law. Another concern relates to the possibility of rescinding a practice once started, for example bottling and canning water, bulk water removals, and domestic "sales" for privatized public services. Other concerns

are about environmental conditionalities and whether domestic use can be a legislated priority. This involves for example, allowing limits to withdrawals for trade if you allow withdrawals for any other domestic purpose and setting limits for bottled or canned water, bulk withdrawals or privatized public services. There is much uncertainty regarding these issues, compounded by the risk of invoking foreign investor rights (Mann, 2004).

Conclusions

The following conclusions can be drawn from the above discussion:

- For being the region with more transboundary river basins in the world (78), where 71% of its waters are produced, the Americas are remarkably free of serious water disputes and conflicts. Conflicts have existed and continue to exist, but the mechanisms in place have, for the most part, been able to prevent them. These mechanisms include the great number of agreements presently in force (29), as well as the creation of bodies such as International Joint Commissions and Bi-national, Tri-national, and Multi-national Commissions.

- Countries have preferred to solve disagreements by bilateral negotiations and bi-national treaties, more often than not, reflecting the principles of avoiding appreciable damage, equitable and reasonable use of water, and previous consultation. Hegemonic hydropolitical situations are not the norm. Lately, however, disputes over water are increasingly being taken to the courts, national, and regional as well as the International Court of Justice.

- The application of market-based mechanisms has been suggested to solve water disputes, but this approach has not been fully accepted or applied in the region, even in river basins lying entirely within the same country, and its application may face considerable difficulties in transboundary situations. Several NGOs and universities in Central America have also suggested working with the communities living within these territories in order to reach agreements in a new concept of national sovereignty. Whether this approach will be successful is still to be seen.

- Lately, a more participative decision-making process, taking into consideration the opinions of local populations is being attempted. It is being recognized that governance is important and care must be taken to include the participation of local communities, not only on both sides of the border but also between upper and lower basins.

- New areas are emerging due to the international laws of trade and trade agreements. Cases of private entities in one riparian country suing the government of the neighboring riparian country have begun to appear. Also, cases of private organizations in one country, suing the government of that country in courts of that same country, in favor of users in the neighboring riparian country. Although still rare, the possibility of multinational corporations suing for monetary compensation or rights to use any waters –not necessarily transboundary– in another country is an increasing cause of concern in Latin America and the Caribbean.

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LESSONS LEARNED IN DESIGN AND FINANCING OF TRANSBOUNDARY RIVER BASIN PROGRAMS. THE CASE OF THE SIXAOLA RIVER BASIN, COSTA RICA-PANAMÁ

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Abstract

The Sixaola River Basin has a surface area of 2,848.3 km^2, located in the Limon Province in Costa Rica (81%) and the Bocas del Toro Province in Panama (19%). The watershed is classified as among the poorest regions of both countries and its social indicators reflect significant lags with respect to the national averages of both countries. This is particularly true for the upper and middle zones of the watershed. Both the middle and lower portions are prone to annual flooding. Although long neglected, it received special attention some ten years ago due to flood events, increasing poverty indexes and social demands of the population on both sides of the border. Thus, a bi-national agreement was signed by both countries in 1994 and ratified in 1995 to develop a bi-national vision for development.

In order to implement the designed Program, several challenges had to be faced and solved. These were related to financing, devising a workable participative bi-national Program execution arrangement, and devising a workable economic evaluation method. To agree on a financial arrangement for sustainable development programs for bi-national watersheds which include productive and/or infrastructure investments, is difficult. In this case, a financial scheme in-

volving two separate loans –one for each country– complemented by a GEF donation was arranged. A bi-national arrangement for the execution of the project was devised making use of the existing institutional infrastructure and providing means for the local stakeholders to participate in the decision-making process. This arrangement was mirrored in both countries and coordinated bi-nationally by the existing Bi-national Commission. The difficulties in estimating the benefits basin-wide in a watershed context were avoided by analyzing the different activities (soil conservation, water quality, forest management, tourism, etc) from an economic point of view as stand-alone projects.

The development of the project was a rewarding participatory experience, not only regarding the bi-national agreements reached at the highest government level in both countries for a Regional Sustainable Development Strategy and investment plan, but also regarding the agreements that were reached at the local level among border communities, organizations and local governments, which guarantees even more the sustainability of the Program.

Only the first phase of the Panamanian side of the project has been executed so far. From the evaluation made, it was concluded that community participation and empowerment is critical in this type of projects. Also, regional government institutions should participate more directly in the execution of projects.

Introduction

The use of water –be it surface or groundwater– from a given source or location is dependent on many factors. From a hydrological point of view and allowing for over-simplification, these factors can be grouped in two categories: the first one, related to climate and meteorology and the second, of physical and geomorphologic nature, related to the “catchment”, be it a watershed or river basin. The interaction between the precipitation “input” to the system is transformed by the system operator (the catchment) into an “output” of streamflow or groundwater flow, following gravity. In any point in the watershed there is a natural hydrological balance, which is altered by human activity, sometimes with unforeseeable hydrologic and environmental consequences. Any modification of the “operator” will produce a change in the “output”, even if the “input” remains unchanged and the cause-effect relationships are complex and often difficult to quantify, measure and predict.

If the hydrologic and environmental scene were not complex enough, any human use of the water also causes social, economic and financial impacts, some of which may be the objectives of the water use, positive for the intended beneficiaries, and some may be detrimental and undesirable to other groups or stakeholders. Some gain and some lose.

The above-mentioned complexities increase as the size of the watershed increases and as the location and extension of the watershed or river basin expands from the realm of local governments to that of the provinces or states into the national level. These complexities also increase in Federal forms of government when the scope comprises more than one state and even more, when the scope comprises more than one country.

This paper draws on documents of the Inter-American Development Bank (IADB, 2003b; IADB, 2004; IADB, 2006) to present the experiences of the Bank in financing sustainable development programs in transboundary watersheds and river basins, illustrated with the case of the Bi national Sixaola river basin between Costa Rica and Panama, reviewing the road covered for the design and financing of that operation, the hurdles which had to be overcome and the lessons learned along the way.

The Sixaola Bi-National River Basin

The drainage area of the Sixaola River Basin is 2,848.3 km^2, of which 531.5 km^2 are in the Republic of Panama and 2,316.8 km^2 are in the Republic of Costa Rica (19% and 81% of the watershed, respectively; see Figure 1). It covers areas with elevations ranging from 3,800 meters above sea level in the Talamanca Mountains in Costa Rica to the flat flood plains of the Atlantic coast.

For analysis purposes, taking into account both the geomorphology characteristics of the basin and the existing physical and socio-economic links with other neighboring zones, the area has been divided into three sub-zones with strong interrelations:

The *upper watershed.* With an extension of 2,038 km^2, it includes the most elevated zone of the Sixaola River basin, from 700 masl, up to 3,280 masl on the Chirripó Grande Mountain, the highest in Costa Rica. This area is scarcely populated by disperse indigenous communities, practically isolated from the rest of the country due to the lack of roads and which, from the socio-economic standpoint presents the worst indicators (in terms of health, infant mortality, life expectancy at birth, education, etc.). The total population in this region is 848 people, mostly Indians of the Bri Bri (30%) and Cabécar (70%) ethnic groups, all living in Costa Rican territory. Therefore, the population density is very low (0.42 inhabitants/km^2). The main productive activity is subsistence agriculture, centered almost exclusively on the production of maize and beans, although some farms report production of cacao and bananas. Cattle rising,

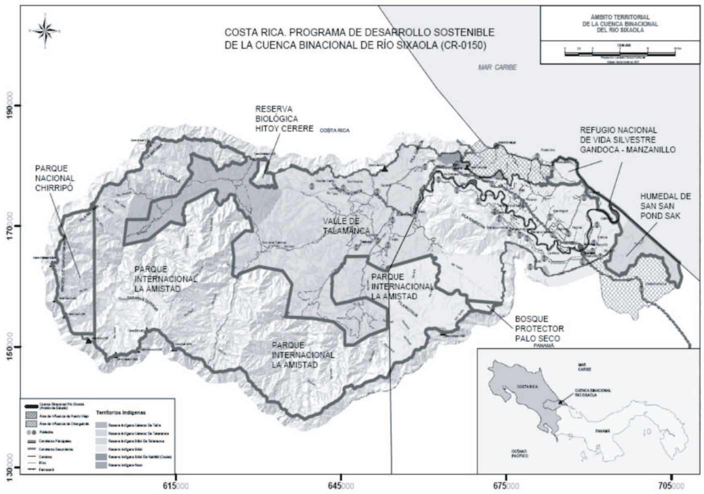

Figure 1. Sixaola Bi-National River Basin

hunting and fishing are also carried out. From the physical point of view, this is an area characterized by the dominance of primary rainforest. Most of the territory is also part of a large bi-national protected area (Parque Internacional de La Amistad).

From the environmental point of view, the main issue is the illegal logging occurring in the protected areas, threatening the rain forest's biodiversity. The extreme poverty of the indigenous population living in this area and its subsistence practices are causing a significant reduction of the biodiversity resources. The loss of forest and vegetation may increase the instability of a geomorphological phenomenon known as "Mass Movement" which is located between the Sacabico and Dagabri Rivers. This formation is 17 km long and 2.5 km wide. It is very unstable and the loss of vegetation is causing erosion and excessive transportation of sediments to the Telire and Sixaola Rivers, increasing the river bed elevation in the lower reaches and thus, the risk of flooding.

The *middle basin.* It extends from 60 masl up to 700 masl, over a 512.4 km^2, distributed between the two countries. It has a population of 8,375 inhabitants (7,256 in Costa Rica and 1,119 in Panama), largely indigenous people (95%), who belong to the Bri Bri and Cábecar ethnic groups in Costa Rica, and Bri Bri and Naso Teribe ethnic groups in Panama. Population density is 16.36 inhabitants/km^2. The area is mainly Indigenous Territories where the use of the land has a communal nature and private land ownership is non-existent. The main crops produced in these areas are linked to agro-ecological produc-

tion, basically banana and cacao, which have progressively been displacing annual crops. Due to demographic pressures, the rate of deforestation in this area is high (during the 1997–2000 period it reached 16% in the three indigenous territories of Talamanca). There is also overexploitation of fisheries resources and of animals used primarily for subsistence. From the physical point of view, this is a transition zone with predominance, in the rain forest, of species such as bay and bitter cedar trees. Some of the forest area has been substituted by crops, mainly cacao, plantain, and banana. The use of agrochemicals in this area has been increasing.

Environmentally, the mid section of the watershed is the most vulnerable area. This is considered a transition zone, where the indigenous communities and small producers are progressively substituting the primary forest for subsistence agriculture. The expansion of the agricultural frontier is impacting the existing ecosystems. Deforestation is increasing erosion rates and sedimentation, which also affects the frequency and severity of floods. The expansion of the agricultural frontier is causing an increase in the use of agrochemicals. On the other hand, the lack of adequate domestic and municipal waste water conveyance and treatment systems increases point source pollution, with its subsequent health impacts.

The *lower basin* extends from sea level up to 60 masl with an extension of 336.8 km^2. The majority of the basin population is concentrated in this area (24,358 inhabitants: 11,550 in Costa Rica and 12,808 in Panama). The population density is substantially higher, 72.49 inhabitants/km^2 and the population growth rates are extremely high (11.5% per year). Only 28% of the population is indigenous and another 6% is of Afro-Caribbean descent. The region is located in the strategic Limón-Almirante axis, and accommodates one of the existing border crossings between the two countries: the bridge that communicates the municipalities of Sixaola and Guabito.

One unique characteristic of this area is that it is driven by the production of bananas under the ownership (almost entirely) of a multinational company. In the last years, some national companies and small producers have emerged primarily in Costa Rica. In Changuinola (Panama), 10,000 ha are farmed by two multinational companies, generating 3,500 jobs. In addition, there are six independent producers who farm 2,000 ha and generate 1,600 employments. The production of plantain, although of lesser importance in the region, also holds an important position: half of the production is from national producers, grouped in three associations.

This highly marked dependence on one product and one large producer, generating most of the employment, most of the income to the municipality, and having developed most of the infrastructure, creates a highly vulnerable social system. From the physical point of view the area is characterized by the presence of large human settlements (urban nucleus at Sixaola and Guabito) and large areas dedicated to the production of bananas. The area is characterized by constant flooding that cause significant losses in terms of agricultural productivity and physical infrastructure. Two distinct areas can be distinguished in the coast. The first one is the Puerto Viejo Manzanillo corridor in Costa Rica and the second one is Changuinola in Panama, both of these with their associated *hinterlands*.

The main active vectors of environmental degradation are those that originate from the intensive use of agrochemicals in the upstream reaches of the river as well as in the banana plantations in the lower basin, which is polluting the river and contributing streams and impacting the health of the local population. The intense application of pesticides and fertilizers is impacting the coral population in Gandoca-Manzanillo and San San Pond Sak. The disposal of untreated sewage and solid waste from the urbanized centers in the coastal zone also has a negative effect on these ecosystems. The excessive use of agrochemicals is also affecting the quality of the coastal aquifer. This aquifer is used by a large proportion of the population of Bocas del Toro in Panama, as a domestic water supply source. The deforestation of the river banks (mainly along the bi-national Sixaola River) caused by farming and human settlements, increases the vulnerability of the area to natural hazards.

Regional sustainable development strategy

Both countries signed an agreement on Costa Rica-Panama border cooperation, which was ratified in 1994 and 1995 by the legislative assemblies of the two countries. Under this agreement, the Bi-national Standing Commission for the agreement was created, with an Executive Secretariat in each country, attached to Ministry of Planning and Economic Policy (MIDEPLAN) in Costa Rica and the Ministry of Economic Affairs and Finance (MEF) in Panama. The secretariats are in charge of coordinating with the other national entities that are active in the watershed in their respective country. With the support of three technical cooperation donations[1] (IADB 2002, IADB 2003a, IADB/GEF 2006), an indicative plan for functional land-use management (PIOTF) was

[1]ATN/JF-7577-PN (Bocas del Toro, panama, 2002–2003:IADB US$ 450,000; Local US$ 150,000: Total US$ 600,000); ATN/SI-8060-RS (Sixaola, Costa Rica, 2003–2004: IADB US$ 400,000; Local US$60,000; Total US$ 460,000); and RS-X1006 (Costa Rica-Panama, 2006: GEF PDF-B US$ 300,000).

developed and both secretariats started working on possible watershed development scenarios in a participative way with local stakeholders and local governments. Several donor organizations, civil society organizations, communities, NGOs, productive organizations, municipalities, regional offices of central government institutions participated in this process. At ministry-level meetings in Costa Rica and Panama, agreements were reached on the most probable scenario, taking into account the likelihood of its occurrence and its potential impact on the watershed. This scenario included the present trend with the addition of an improved transportation corridor between the ports of Limon in Costa Rica and Almirante in Panama, and an increased tourism development in the coastal area. After three years, it was assumed that the region would need to be prepared to address the challenge that a banana sector crisis developed in the coastal area, with the corresponding effects in unemployment and family income.

On that basis and using the PIOTF as a reference, a common regional sustainable development strategy (RSDS) for the entire bi-national watershed was developed. The purpose of this Strategy is to guarantee economic and social development of the region, improving the well-being and livelihoods of the population, safeguarding the ecosystems and biodiversity unique to the region. A series of interventions are proposed by the RSDS that will: reduce the dependency on one single product (bananas) and one single producer, reduce the vulnerability of the population and the local economy to natural disasters, and conserve and protect the ecosystems and biodiversity. To achieve the first objective, the RSDS promotes the diversification of production and fostering new income generation opportunities. To reduce vulnerabilities the RSDS seeks to reduce the effects of flooding via a comprehensive and coherent plan of actions. These are aimed to involve the communities of both neighboring countries in a wide spectrum of interrelated prevention, mitigation, ecosystem protection and better management of natural resources activities.

During the formulation of this strategy, a Bi-national Technical Commission was established, with representatives from the major national entities in each country with sector responsibilities in the watershed. The process followed in developing the RSDS is schematically shown in Figures 2 and 3.

Sustainable Development Program

In accordance with the adopted RSDS, an investment program was designed for the bi-national watershed. The program's main objective is to improve the living conditions of the population, through interventions in the economic, so-

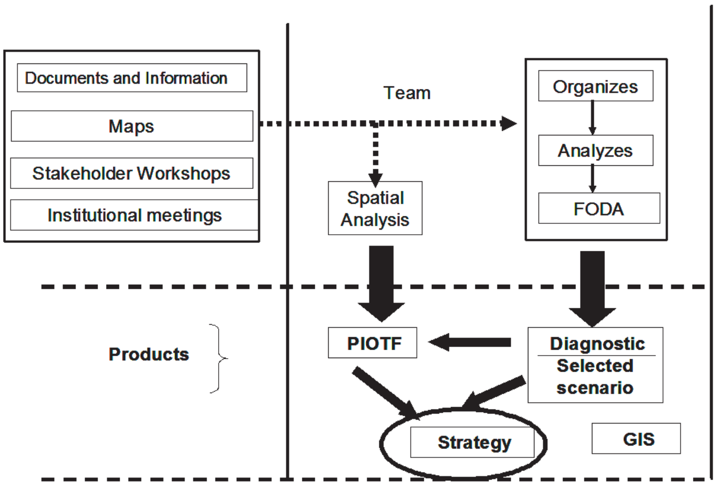

Figure 2. Process for developing the RSDS.

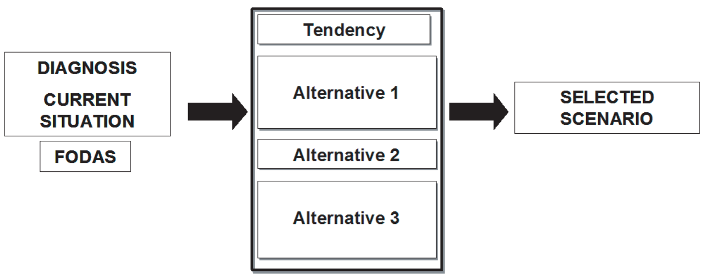

Figure 3. Scenario analisys.

cial, environmental, and local management areas that will help to implement a sustainable development model for the watershed. To achieve the proposed objective, the program will focus on: (i) preserving the natural resources and reducing vulnerability; (ii) introducing a change in the existing natural resource development and production models, to ensure sustainability while preserving biological diversity and productivity; (iii) steering public investment in infrastructure and basic services to increase coverage levels and improve access for the population; and (iv) enhancing the capacity and coordination of national institutions responsible for resource administration and strengthening local governments financially and administratively with effective community participation.

Therefore, the Program was designed with four components: (1) environmental management, natural resource management, and vulnerability reduction, to implement effective measures in support of environmental protection, sustainable resource management, and vulnerability reduction in the watershed, with community participation, based on the regional sustainable development strategy (RSDS) and its indicative plan for functional land-use management (PIOTF); two subcomponents make up the structure of this component: environmental and natural resource management, and vulnerability reduction to mitigate to the extent possible, the effects of the recurring floods and landslides in the lower watershed of the Sixaola River emphasizing the harmonious coexistence of the population and economic activities with the aforementioned natural phenomena; (2) production diversification to tap the economic development potential of the watershed, by identifying alternatives for production diversification and opportunities to create permanent jobs through demand-driven initiatives; (3) public services and basic infrastructure to increase the coverage and the population's access, promoting community and private-sector management; and (4) strengthening of management capacity of the various actors with responsibilities in the watershed, in order to establish a management structure that contributes to implementation of the strategy formulated at the local, watershed-wide, and bi-national levels.

In order to implement the designed Program, several challenges had to be faced and solved. These were related to financing, devising a workable participative bi-national Program execution arrangement, and devising a workable economic evaluation method.

Financing arrangements

From the countries point of view, the main challenge related to financing was to secure it, and it was decided to request a loan from the IADB. For a multilateral financing institution such as the IADB, however, the main financing problem in a bi-national watershed is that there is no regional lending as such, since no country is willing to pay the debt of the other. Since both countries were in agreement as to what needed to be done in the watershed, a solution was to give individual loans to each country, so that each one could execute that portion that corresponded within its national borders.

This would solve the problem only partially, due to the bi-national nature of some of the more important needed environmental actions and interventions, such as preparation of a bi-national Master Plan for the implementation of bi-national actions in both countries, execution of a comprehensive margin protection and bank restoration bi-national project along both margins of the Sixaola river, preparation of a bi-national water quality diagnostic and baseline, including identification and characterization of the principal point and non-point pollution sources along the bi-national reach of the river, affecting population health and lower basin ecosystems, execution of a bi-national water quality monitoring and control project, and installation of a bi-national early warning network and system to provide timely and accurate information to locally organized committees, for the prevention and mitigation of natural risks related to hydrometeorological phenomena. The Costa Rica-Panama environmental management plans of several bi-national wildlife reserves and wetlands also needed to be harmonized.

Since donations do not present the same problems as loans when more than one country is involved, the support of the Global Environmental Facility (GEF) was sought to complement the individual loans to Costa Rica and Panama. The final financial arrangement negotiated for the sustainable development program for the Sixaola River bi-national watershed is shown in Figure 4.

The Panama loan covered a much larger area than that within the Sixaola watershed, as its purpose was the sustainable development of the whole Bocas del Toro region. This loan was negotiated and initiated first and included two phases. In order to go to the second phase, certain values of a series of trigger indicators had to be met. These indicators were concerted in a participative approach and at present they have been met. The Republic of Panama is ready to request financing for the second phase. The Costa Rica loan was prepared

Project Name	Sustainable Development of the Sixaola River Bi-national Watershed	Sustainable Development of the Bocas del Toro Province		Integrated Ecosystem Management of the Rio Sixaola Bi-national Watershed
Type of Instrument	Loan	Loan		Technical Cooperation
Borrower-Beneficiary	Republic of Costa Rica	Republic of Panama		Republics of Costa Rica and Panama
Executing Agency	Ministry of Planning and Economic Policy (MIDEPLAN)	Ministry of Economy and Finance (MEF)		Ministry of Planning and Economic Policy (MIDEPLAN) in Costa Rica and Ministry of Economy and Finance (MEF) in Panama
Status	Approved in 2004; to be submitted to Congress in 2006	In execution since 2003		In preparation
Description	• Natural resource and environmental management; vulnerability reduction • Diversification • Basic services and infrastructure • Institutional capacity building	• Capacity building (municipal, local) • Productive development and sustainable management of natural resources • Basic services and transportation infrastructure		• Bi-national environmental management and vulnerability reduction • Economic valuation of the bi-national ecosystem services of the basin • Bi-national monitoring and water quality control • Comprehensive bio-restoration of the stability of both river banks in critical areas • Bi-national early warning system with community participation
Amount and Source	IADB: US$ 9,220,000 Local: US$ 2,780,000 Total: US$ 12,000,000	Phase I IADB: US$ 15,200,000 Local: US$ 1,700,000 Total: US$ 16,900,000	Phase II IADB: US$ 27,000,000 Local: US$ 3,000,000 Total: US$ 30,000,000	GEF: US$ 3,500,000

Figure 4. Financial Arrangement for the Sixaola Bi-national River Basin.

in 2004 and is presently waiting approval from Congress. The GEF donation was negotiated and prepared in 2006 and is ready to be started.

It must be pointed out that to obtain financing for studies and drafting of plans and strategies for sustainable development of bi-national watersheds do not present the degree of difficulty and complexity illustrated in this example. To agree on a financial arrangement for sustainable development programs which include productive and/or infrastructure investments is more difficult, as this example demonstrates.

Participative Bi-National Program Execution Arrangement

The execution of this type of program requires of mirror institutional arrangements in both countries at the local, regional, national, and bi-national levels. Fortunately, the bi-national arrangement already existed when the Bi-national Standing Commission for the Costa Rica-Panama bi-national agree-

ment was created, and had only to be strengthened by the creation of the Bi-national Technical Commission. This strategy of using the existing organizational infrastructure in each country and strengthening it when needed for the objectives of the Program was also followed in each country at the national, regional, and local levels.

It must be pointed out that both countries had the required basic administrative institutional infrastructure at the three levels mentioned. Both also had civil society organizations at the local level capable of participate in the Program. What was needed was to provide means for both types of organizational infrastructures to work together. Although this was finally achieved, at the beginning some resistance was encountered, as central governments tend to be conservative about decentralization of decision making powers, and local civil society –and even regional offices of the national government at times– do not feel comfortable with decisions coming from the capital city. In fact, that was one of the challenges that had to be worked out in order to achieve the required local and regional managerial capability needed for the Program.

The organizational arrangement, similar in both countries, consisted of the flowing: (a) civic, community, environmental, and productive local associations, which were recognized through a field "scan" process to identify the key actors; (b) representatives from these organizations integrated District Committees in each district; (c) representatives from the District Committees integrated Development Councils at the regional or provincial level; (d) these were supported by a Program Executing Unit belonging to the Government Executing Organization. This structure is illustrated in Figure 5.

The mirror structures in both countries were coordinated at the bi-national level by the Bi-national Executive Secretariat and advised by the Technical Bi-national Commission. The civic, community, environmental, and productive associations (OCCAPs) already existed, same as the Provincial or Regional Councils formed by national, regional and local government representatives, as well as the Bi-national institutional structure. What the Program did was to provide a supplementary structure represented by the District Committees so that the OCCAPs could also take part in the decision-making process at the appropriate level applying the principle of subsidiarity.

The manner in which this participative execution arrangement was designed to function is illustrated in Figure 6, which depicts the project cycle: i) the Project Executing Unit contracts technical assistance to aid the OCCAPs and local governments in the preparation of their projects; ii) the project profiles or final projects are sent to the District Committees to integrate the District An-

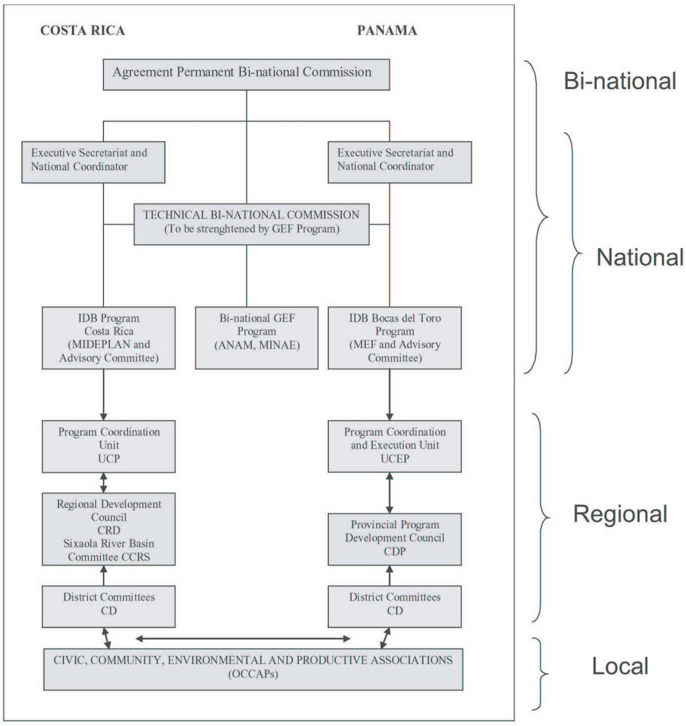

Figure 5. Participative Bi-national Program execution arrangement.

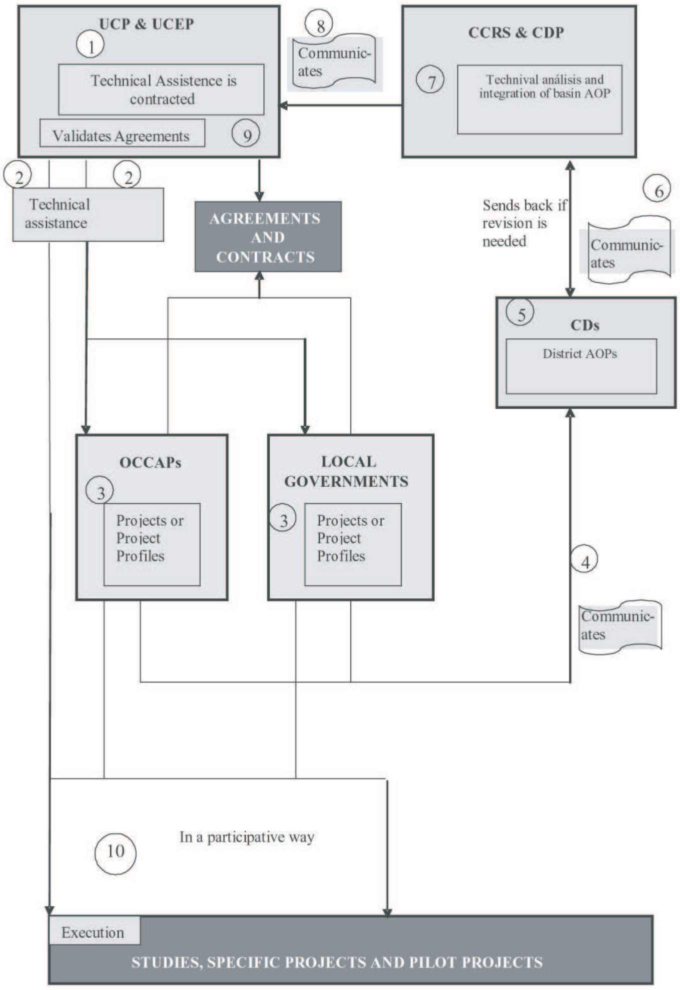

Figure 6. Project cycle.

nual Operation Plan (AOP); iii) the District AOPs are sent to the Provincial or Regional Development Councils to coordinate and integrate the Provincial or Regional AOP, which is communicated to the Project Executing Unit. Agreements and contracts are then drafted by the Project Executing Unit with the OCCAPs and local governments for the execution of the projects and technical assistance is provided.

Economic evaluation

The real basin-wide economic effect that a program of this type will have is very difficult to evaluate. There are costs, which generally are easier to quantify and there are benefits, which in some cases may be difficult to estimate. Sometimes some stakeholders gain all the financial benefits and accrue few of the costs and sometimes other stakeholders accrue the lion share of the financial costs and very few benefits. But even if in any case, the costs are paid one way or another, there may not be the same assurance about receiving the benefits.

The difficulties in estimating the benefits are further exacerbated by the fact that watershed management projects entail the execution of an array of activities covering different areas (soil conservation, water quality, forest management, tourism, etc). Trying to analyze the economic impacts at the aggregate level is extremely complex (Russell et al 2001). The information required to be able to conduct a multi-objective analysis may be such that it becomes an impossible task. However, these activities can be analyzed from an economic point of view as stand-alone projects. The economic analysis in most cases was done by type of activities and by analyzing a sample of projects with similar attributes. An indicative sample of high-priority projects (pilot, specific, and indicative projects) requested by the communities and local governments were identified and analyzed in consultation workshops during program preparation.

The feasibility analysis of some components were based on a cost-effectiveness justification of program activities, with a view to ensuring that the proposed management and strengthening tools are the best suited for creating a minimal framework of governance and management capacity, as well as guaranteeing the protection and sustainable management of the natural resources and the protection and appreciation of its protected areas and biodiversity. A benefit-cost analysis was performed on certain productive and infrastructure projects to ensure that these must had a social and economic return, measured as the internal rate of return (IRR) of over 12%.

Conclusion

In order to implement the designed Program, several challenges had to be faced and solved. These were related to financing, devising a workable participative bi-national Program execution arrangement, and devising a workable economic evaluation method. To agree on a financial arrangement for sustainable development programs for bi-national watersheds which include productive and/or infrastructure investments, is difficult. In this case, a financial

scheme involving two separate loans –one for each country– complemented by a GEF donation was arranged. A bi-national arrangement for the execution of the project was devised making use of the existing institutional infrastructure and providing means for the local stakeholders to participate in the decision-making process. This arrangement was mirrored in both countries and coordinated bi-nationally by the existing Bi-national Commission. The difficulties in estimating the benefits basin-wide in a watershed context were avoided by analyzing the different activities (soil conservation, water quality, forest management, tourism, etc) from an economic point of view as stand-alone projects.

The experience was rewarding. There are many important aspects that merit to be highlighted as a consequence of the experience in the preparation of this Bi-national Program. First, the participative methodology used during the preparation of the Program made it possible to reach important bi-national agreements, such as the definition of common issues that needed to be faced simultaneously by both countries in a coordinated manner, like the reduction of vulnerability to flooding, river margin reforestation, protection of important bi-national reserves and others, which gave way to the fruitful discussions and the adoption of the common RSDS and its action plan. The existence of the Bi-national Agreement and its mandates, such as the creation of the Bi-national Secretariat and the Technical Bi-national Commission, resulted in a pragmatic action plan, whose execution will bring real benefits to the population of both countries. It is not common to find two important national economic and financial planning Ministries like MIDEPLAN and MEF, prioritizing and focusing their attention on investments in a bi-national region and working towards a common goal, but respectful of the sovereignty of each country.

Another no less valuable experience relates to the agreements that were reached at the local level among border communities, organizations and local governments, which guarantees even more the sustainability of the Program. The successful development of coordinated investment programs in each country, with a bi-national vision and mutual agreement allowed also the participation of other donors, like the GEF, to build upon them and solidify the necessary complementarities.

Only the first phase of the Panamanian side of the project has been executed so far. From the evaluation made, it was concluded that the collaboration and participation of regional government institutions and the local governments is fundamental for the success of this type of project. It was also felt that regional government institutions should not be mere spectators but should participate more directly in the execution of projects, under the supervision of the Program Executing Unit. It cannot be overemphasized the importance of com-

munity participation and empowerment, as it is critical for the success of this type of project. To achieve that goal, however, ample information and technical assistance must be provided, especially in relation to productive projects to be executed directly by the beneficiaries. In this regard, the assurance of the existence of adequate marketing channels and opportunities is crucial. The existence and application of clear Operational Rules is basic for the successful execution of this type of Programs.

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GENERAL DIAGNOSTIC AND COMMUNITARIAN PARTICIPATION IN THE INTERNATIONAL USAMACINTA RIVER BASIN

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Abstract The present work constitutes a documentary investigation work and fundamentally the information searching by consultation processes with different communities that live in the middle Usumacinta River Basin located between Guatemala and Mexico.

This work complements with the results of the first binational factory on threats to the natural and cultural resources in the Average River basin of the Usumacinta River celebrated in Santa Elena Peten the 4^{th} and 5^{th} of May of the 2006, and in the work of field and coexistence with communities of Guatemala and Mexico in a territory where it is possible to emphasize the following particular characteristics:

1 It is developed in a zone where the Maya's civilization flourished, which knowledge allow the consolidation, in this region, to one of the richest cultures of the Western Hemisphere, whose vestiges tell us about a civilization with deep knowledge in nature y science.

2 As a bio-region it constitutes one of the most significant germoplasta banks of the world, the presence of unique species and the amount of the same ones, deserve special attention, because they constitute part of the universal human patrimony.

3 The zone because of its innumerable archaeological vestiges, added to the wonderful nature, is one of the zones with greater eco-tourist potential.

4 The presence of innumerable water bodies constitutes this area one of the most important water zone of Latin America

5 The resources of the subsoil like petroleum are object of controversy between the communities and the governments, by the little benefits for the local population.

6 It constitutes one of the areas with greater incidence in the forest fire subject.

7 It is one of the zones with more elevated population increase in the last 5 years.

8 It is a zone of potential conflict by the development of mega-projects of infrastructure and in particular by the opening of new highways and initiatives of projects of hydroelectric energy generation.

9 The whole region works as the last valve of escape for the demand of land in the country and still of other countries of the Central American region.

So particular characteristics make of the region a so important zone for land farmers destitutes of the bordering areas as for the big corporations whose interests go farther than the simple Earth occupation for the subsistence. In this frame and hope to find and to add valuable data, that allow us to have a nearer vision of the social and environmental dynamics which is developed in this surroundings, the work group, whose more important characteristic is that was conformed to personnel of the zone, they with their own limitations, has made a work of insertion in the communities which has allowed us to mainly make our work with much acceptance on the part of the inhabitants and an ample participation since in these places a feeling to the works of investigation exists by ricochet.

Antecedents of a diagnosis

The shortage of resources had not allowed to initiate the process of an wide diagnosis but with participation of communities of the zone and that serves us like a true tool that give us the guidelines to follow a plan of work designed from the perspective of the communities effect to obtain a greater incidence in the political and the international cooperation and with a valuable tool to wake up a better future in the zone.

Geographic location of the Usumacinta River Basin

The Usumacinta River is located to the south of the territory of Mexico, and to the north of the Guatemala territory, in the zone the west of the Yucatan Peninsula, the longest river of Meso America and the sixth long one of Latin America. The river basin constitutes 106.000 kilometers of territory located between the States of Chiapas, Tabasco and Campeche in Mexico representing this country the 42% of the total territory of the river basin and the departments of Huehuetenango, Quiché, Cobán and Petén in Guatemala that as a whole represent the 58% of the river basin in mention. And their waters run from south to north, ending at the Mexico Gulf an approximated load of 105.200 million annual cubic meters of water. Bordering communitarian reserves of Corozal: The Coal, the Cross, Lacandonia Flower.

Is in this socio-geographic location where is the great Usumacinta River, located in the northern department of Petén, in Guatemala, the Eastern part of the States of Chiapas and Tabasco in the Mexican territory. Their waters are

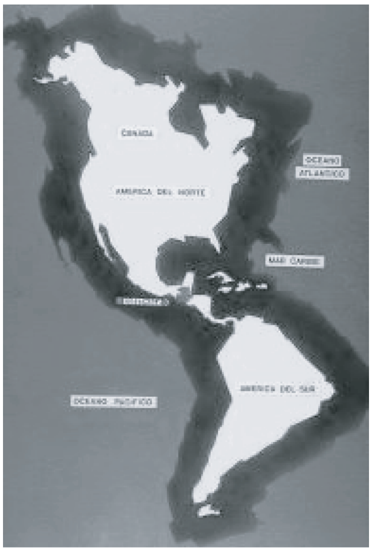

Figure 1. Location of the Usumacinta River Basin.

product of the union between the rivers Pasión and Chixoy in the vertex known as Altar the Sacrifices, Mayan Fluvial port and archaeological place, just here begins to denominate Usumacinta, that in Nahuatl language means “place of many monkeys”.

If we measured its length by segments, the part covered by the common border Guatemala-Mexico, it reaches the 198,5 kilometers. In this point the Usumacinta was known by Mayan like the Great Yochoa or “Father of Waters” and was used like the commercial route to arrive at other routes like the route from the Jade and Obsidian, products that were the bastions of the Mayan commercial interchange.

Little-known witnesses are the Mayan fluvial ports like Piedras Negras, Yaxchilan, Bethel, El Porvenir and La Felicidad and if we go the river La Pasion back, we found the strategic commercial cities of Ceibal and Cancuen, this last one was recently presented by the archaeologists.

Biophysics Aspects

Soils Because of the varied conformation of the river basin, an analysis of all grounds will not be made, but to mention that the richest grounds of the river basin are the denominated alluvial plains soils and among them the se-

Figure 2. Alluvial zone soils.

Figure 3. Savannahs soils, La Libertad Peten.

Figure 4. Usumacinta river and its affluent rivers.

Figure 5. Chixoy or Salinas river. Aerial view.

ries Petexbatún and Usumacinta and/or Quinil according to the ground map of Simons, Táramo and Pinto, and they are classified like fluvisoles, and gleyisoles eútricos right for the agricultural development, according to the drainage degree, they belong to cambisoles vértico, or to gleyisoles and fluvisoles, they are fertile grounds but the lack of drainage and adhesiveness limit their agricultural use, then we found the Savannahs soils, conformed grounds on schistose hills, the soils of the low ones that are only taken advantage of some periods of the year; taking in river basin the Classification from grounds from the FAO/UNESCO.

Hydrology The river basin forms what is called the slope of Mexico Gulf and collet in its course the following rivers and streams: Chixoy or Salinas,

Figure 6. Classic house in rural populations.

La Pasión River, Lacantún River, San Pedro River, and Candlemas River; and streams: El Chorro Yaxchilan and Macabilero.

The Karstics formation in most of the territory, determines that exists few superficial drainage, is considerable the presence of lakes and lagoons, without superficial contributions nor water-drainages, in almost all lakes and lagoons exist high fluctuations in the level of these water bodies.

If we take as information the volumen of the river Usumacinta in the Boca del Cerro Station, we would have the data:

Average annual volume	1.771,5 m^3/s
Minimum average annual volume	943,9 m^3/s
Maximum average annual volume	2.239,9 m^3/s

Although in the last years the rain regime has varied sensibly, there is no registry of these variations, only the observation of the farmers. The rain regime has changed too much and also the volumes of the rivers has lowered. We know the waters of the Petén as hard waters, by the high levels of alkalinity varying between 500 mg/liter and 170–200 mg/liter, like it is said at the beginning of this chapter. The annual volume and the affluents have here no mention.

Territory We will describe what correspond to the High and what to the Average River Basin. Here is locates the object of our study: the transboundary river basin.

In the high river basin inhabit indigenous populations like the Aguatecas, Quichés, Sacapultekas, Achíes, Qeqchies, Ixiles, Mames, which are positioned there from centuries reason why it attends the consuetidinario right the Possession of their land. Nevertheless as result of the 36 years war recently culminated in Guatemala, this geography is drastically modified and more than 250.000 originally poor farmers of Huehuetenango, Quiche and Alta Verapaz had to leave their land and to take refuge in Mexico. The majority have not return to their place of origin.

In the average river basin, where are located the Qeqchies, Ladinos, Choles, Lacandones Tzetzales, Quichés and a non defined mixture of all the native cultures, the situation is very varied. In the case of Guatemala, the cooperatives count with Land title, but not the zones of Sayaxché and rest of the municipality of La Libertad. Most of them have been positionings or as it is known them here, "AGARRADAS", that with time are left or transferred other farmers. Intimately related to the "agarradas" is the agricultural system of "roza tumba"and burns practiced by the migratory agriculture of the farmers and natives due to the following reasons:

- Not to have legally constituted territories to the edaphic conditions of grounds.
- The pressures on their populations to continue advancing on the forest.

In the case of Mexico, recently the territories so much to the Choles as to the Lacandones granted have been delimited. From l940 the government instituted the Law of Agrarian Reformation "Most of low territories of Chiapas and most of the tropical forest Lacandón was opened for its colonization under a policy similar to the one of U: S: Homesteading act", from this point begins immigration to the forest from multitudes of farmers in demand of land, but this action, the invasion to the forest Lacandón, was suddenly braked for the native groups that were not Lacandones.

In l971 a presidential decree granted legal title for 614.321 hectares of land for the Lacandones in name of the environmental protection and leaving without land hundreds of farmers, Choles, Tzetzales, and others, who had been moved to these areas. This situation degenerated in conflicts, which motivated the relocation of the displaced people, therefore the human establishment known as Benemérito were originated, Corozal previously Echeverria and the present dimensions to the establishments of Metzabock, Najá Lacanjá

Chansayab were limited to 2500 hectares each one. What is point out of these actions are three aspects.

- Fast colonization to create open spaces in the forest.
- Use of settlers for the operation of the resources.
- Marginalization of the majority groups or its respective relocation.

Facilitating in this way the access to the wood and oil resources in the zone.

A similar process took place in Guatemala in the 60s, 70s and 80s and until now we are knowing its results in the zone called Zona Reina, very near to Chiapas, where the Guatemalan Catholic Church and some congregations even played an important role when supporting to the groups of emigrants towards these zones in search of land and later when they were sent out because of the internal war.

The deficiency in legal certainty on the land property has created an extractive, opportunistic and non responsible culture in the management of land. An agricultural development plan for a parcel cannot be formulated without having access to credit and to the technology nor without being proprietors. A state land registry does not exist and therefore it does not perceive taxes, although lately the goverment of Petén have begun to receive a tax for renting.

Forest The wooded cover of the river basin is one of the richest in species, considered like one of the last banks of germoplasma in the planet, reason why we will take into account the predominant species and basing to us on the previously done classification where the river basin were divided in high river basin, average river basin and low river basin.

Comparing the images from 1980 to those from 2001, the change of wooded cover has been considerable, supposing the deforestation one of the most dramatic threats, turning the future of the States which share the forest in danger. It can be observed in the Mexican side that the deforestation process has been stopped while the pressure is increasing on the forests of Guatemala.

The wealth of the Underbrush is here impressive where are very coveted species of Xate, Nance, Capulín, Sunsa, variety of eatable fungi, Wild Palm, Opisandra Maya and the palm of botán, Sabal morrisima whose leaves are used as roofing and to make brooms. The manaca or corozo, or cohume, Orbignya cohume, etc.

Biodiversity. Different studies in the zone, report a natural biological wealth without precedents, some of the most genuine species of the zone which somehow have presence in all the river basin object of our Study will be enumerated.

Figure 7. Usumacinta River and the forest.

Figure 8. Biodiversity in the Usumacinta River.

According to the investigations of Lundell, the number of vegetal species in the zone can be high than 3.000 species properly identified with base, in units of landscape and microclimates.

The creek of the lakes, rivers and other water bodies has several hidrofíticas associations called "sibal". And other calls reedbed these last ones denominated by "zapote" of water to Zapatón, plant which the villagers attribute medicinal properties to.

The down part of the vegetal population is occupied by the tintal formation, dominated by palo de tinte, and is here where botán grows and other palms too.

In well drained humid soils appears the "corozal" formation characterized by the palm of corozo, associated with Mahogany tree, Chicozapote and species of ficus.

In the well drained plains of the north of the Petén and the North part of Chiapas, it is developed what Lundell considers the climax association of the region. A latifoliado closed forest which is classified almost pluvial forest, whose dominant species can reach the 50 meters of height.

Fauna. The main animal species can be enumerated in the following way:

Mamals: Jaguar, Puma, Onza, Wild Cat, Ocelote, Tapir o Danto, White Tail Deer, Cabrito o Huitzizil, Pecarí Coche de Monte o Pecaría de collar, Tepezcuintle, Mouse of Mount, Armadillos, Cotuza, Hare, Rabbit, Tacuazín, Pizote, Micoleón o Kinkajou, Raccoon, Gray Squirrel.

Monkeys: Mico or Spider monkey and Suraguate or black Howler Monkey.

Birds: They are 114 birds species, between them the most important are parrots, budgie, guacayama, eagle, toucan, oropéndolas, petenero turkey, etc.

Snakes: Most dangerous are the "yellow barba", rattlesnake, "cantiles de agua", mazacuata, coral snake, etc

Anphibians: Crocodile, Iguanas, Lizard, Cocodrillus Morelletti.

Fish: Bull, Róbalo, Sardine, Mojarra, "White Fish", Aletón, Sábalo, etc

Butterflies, Insects, etc.

Figure 9. Fauna in the Usumacinta River.

Social aspects

Population. In effects of the work we will use the official data from CILA in the case of the States of Chiapas, Tabasco and Campeche in Mexico and the data of the MINUGUA 2001, which are the most recent with official report of data by Municipalities prepared by the ANAM National Association of Municipalities in the case of Guatemala.

Place	Rural	Urban	Total
State of Chiapas	582.888	296.595	879.483
Tabasco	49.806	25.592	75.398
Campeche	78.366	107.400	185.766
Huehuetenango	ND	ND	879.988
Quiche	ND	ND	588.832
Alta Verapaz	ND	ND	814.301
Baja Verapaz	ND	ND	203.431
Petén	ND	ND	333.390
TOTAL			3.960.589

According to these data the river basin is inhabited by almost four million people, nevertheless the data of Mexico belong to years 80 and those of Guatemala to 1997. In case of Guatemala and Petén the reported data are specially minors to the real number of inhabitants, in this zones diverse population projections have been made, taking like valid the made one by APESA in l990 which use as base the number of 247000 inhabitants on the year of l990 and an annual growth rate of 9,5%, the projections done by this company for the year l997 were of 622.628 inhabitants, it's a number very near to the present estimations of 850.000 inhabitants in Petén in 2001, taking into account these variables it is recommended to the corresponding instances to observe the facts

like migrations and other activities which have done violence to the process of the population growth in the river basin. This population has a varied ethnic and linguistic composition, since by the side of Mexico are easily idenificable by the following groups:

The North Lacandones	The South Lacandones	The Choles
The Tzetzales	The Tojolobales	The Tzotziles
The Cabil	The Nahuatl	The Zoquez
The Coxoh	The non indigenous	

In Peten the Ladinos and Qeqchíes are the majority, and

The Itzáes	The Mopanes	Quichés
Cakchiqueles	Mames	

And in the other departments which conform the river basin inhabit Aguacatecas, Sacapultekas, Kanjobales, Mames, Ixiles, Achíes, Cakchiqueles, Pocomchíes, Qeqchíes and ladinos.

Health. Between the diseases with highest incidence in the zone of the Usumacinta are the malaria, in the 99% of the communities, the flu in 80%, the infections specially intestinal gastric in the infantile population, respiratory infections, skin diseases, intestinal parasitism, pneumonias and bronchopneumonias, anaemia, undernourishment, peptic disease, urinary infection, and conjunctivitis (IDIES l,995, The PNUD l,999).

What is also related with the health is that the life expectancy is an average of 68 years and Infantile mortality rate is 5,6% in the regions of Mexico and Guatemala, which is catalogued as one of those of greater social refuge (Plan Puebla Panama). These health indexes are not in our disposition, but based again on our observations in the high river basin, the health in the zone is precarious and there is not enough hospitals, health centers or primary health attention in the moved away populations from the urban centers, like the located ones in the Riverside of the Chixoy, Pasión Lacantún and Usumacinta, where a high deficiency in medical attention is observed and where the diet is basically beans and omelette.

Figure 10. Education in the Usumacinta River.

Education. Before analyzing the traditional considerations on the education heading, in the high river basin, given its ethnographic wealth and the special presence of indigenous groups who claim to be Mayan's descending and the their historical processes, is complex to make differences in this matter, as soon as, if it is taken into account that the native cultures contain in their own an educative baggage, if not written, traditional, allowing them to survive with ancestral knowledge. Maintaining the structure of an alive and functional language which have remained for thousands of years. Because of that reason when speaking of education and schooling we will basing on their Spanish language domination which is the official language in Central America. We will differentiate the deficiencies from the point of view of the Spanish reading and writing lack. In both routes would be necessary a deeper study.

Communications. Because of the terrain conditions, which make difficult the access and the characteristic on the inhabiting population, which is dedicated to the primary activity, and it count on very few paved ways, most of normal ways are passable the whole years and some of them only in dry periods.

1) the big transboundary road between Tabasco, Ciudad Flores and Belice, which connect Petén, by a paved way with the road C.A.9, to the rest of Central America. This way cross the whole Laguna del Tigre region and was recently build, 1997–1999.

2) The inter-American way which connects the towns of Ococingo, Altamirano, Chanal, San Cristóbal de las Casas, Palenque and Tuxtla Gutiérrez with interconnections to each other in both countries and interconnects in Ciudad Cuaucthemoc in Chiapas, Mexico and La Mesilla in Huehue-

tenango, Guatemala. Connecting all the river basin to the rest of Central America.

3) The asphalted road that leaves from Palenque via the Lacandonía Mexicana, Meritorious, Reserve of Montes Azules, Comitán San Cristóbal and Tuxtla, the state capital. Perhaps this is the most important one in the river basin.

4) Road in construction connecting Flores, Bethel and La Técnica. This road would interconnect with a bridge on the Usumacinta River towards Corozal and from there to the rest of the river basin's cities.

In addition the towns with more than 1.000 inhabitants count on an interconnection road with the main commercial lines.

About telephones, the service at the moment is deficient although already exist satelite telephones in diverse communities as much on the Guatemalan side as on the Mexican side, places that traditionally did not count on this service.

On the other parts of the river basin exist in the Petén an airport with international category and several private and municipal runways that facilitate the access by air in addition to other land and aquatic transport connections.

Poverty. According to the POVERTY INDEX of the PNUD publications, since there is no a specific study of the river basin that would be worth that would be very important to create with the participation of sectors related with the subject and combine it with another criteria that involve all the poverty markers for the future; since either on this subject there is much clarity, because the PNUD relates health and cleaning, the FIS or Social Investment Fund extends nutrition residential and social access to health, education, house, relations and rent, forgetting access to drinking water, electrical energy, computer, science technology or telecommunications.

Political and social organization. The administrative and political organization corresponds to the states, and the organization of the population corresponds to themselves under legal figures established by the countries, therefore in Mexico the correlation from top to bottom is:

- Federal government
- State government

- Municipal President
- Municipal Commissioners

In the case of Guatemala the government structure is the Democratic Republican in this way:

- Republic Constitutional President and his Advisors
- Departmental Governor and Departmental Advisor of Development
- Municipal Mayor
- Auxiliary Mayors, they are the mayor's representation in each village and small village all over the country.
- Municipal Advisors for Development (COMUDES)
- Communitarian Advisors for Development (COCODES)

In addition to this legal and constitutional structure, exists the traditional own organization of each community in the case of the indigenous populations which have ancestral communal organization structures keeping jealously a group of norms, ancestral laws and rites, without constitute a parallel organization to the formal authority to whom they respect, also they keep in this way his old wisdom.

This organization has allowed the cooperatives in the case of Guatemala to surviving in so inhospitable regions where they were transferred without a development plan, "roads and communications remaining during almost twenty years marginalized and in total abandonment".

Economic aspects

Production. The zone counts on extensive forest areas, at the present time basic foods are cultivate here, small and big cattle and extractive not wood resources activities in addition to the already known wood extractions with commercial aims. Basing on the soil's potencial we can classify the agricultural production in this order: Maize, Beans, Rice, Pepitoria, Chile, Others.

These cultures are intimately related to the burns and deforestation system that is one of the main causes of the advance of the agricultural border. The soil in not the appropriate for the agricultural and the system of migratory agriculture has been used from before the colonization, at the moment it is very used by the farmers of the region too.

In the zone of Chiapas people begin to cultivate organic coffee in small parcels with the typical disadvantages as lack of capital to work with significant volumes for the market or that the region does not produce all necessary vegetable and fruit, because of what produced previously was chicle, xate, honey and they were destined to the outer markets. So it seems that a policy of incentives for these products did not exist since at the moment they have fallen.

All the activity is oriented to the primary sector, except for the industrialization of the wood that at its better moments opened a gigantic sawmill in Tenosique, very famous by the way, and of the numerous ones and small sawmills which worked in Guatemala, at the moment are superliving hardly two.

The production of chicle has fallen enormously because of the introduction of synthetic chicle. It becomes necessary to make an ample study on the individual, since the white gold that meant in first half of the last century, there are not more than memories of this production system in most of the places that before were known like “chiclerias”.

The production of honey which although we did not obtain numbers in the region of the Usumacinta, we know the product existence in the zones of Chiapas, that in small scale is being impelled for its commercialization.

In the Usumacinta river and its affluents did never exist a control of the economic activities, as the fishing and the hunting of the lizard just to get its skin, in the bodies of water, rivers or lagoons. As well collet snails or giant shrimp, the Pigua at begin of the winter and because of in the case of Guatemala, these activities are furtive, by the CONAP control. By verbal indications of the fishermen of the river, the average rent of a fisherman is not lower than 7.84 USD per day, the double of laborer that is 3.26 USD per day.

Conflicts identification in the river basin

In this chapter we will rely on three sources:

- The purely bibliographical investigation.
- Our field work
- The meetings with the communities.

With this simple base we have made a table of problems with its respective classifications adding commentaries to the ones considered more dangerous from the perspective of the communities.

List of the environmental problems in priority order:

Description	Typology	It affects...
Forest fires	RED	more to Guatemala than to Mexico
Deforestation and forest destruction	RED	at the moment both countries
Invasions	RED	more to Guatemala than to Mexico
River water pollution	RED	more to Mexico than to Guatemala
Lack of drinking water	RED	both countries
Air pollution	RED	both countries
Exploration and oil operation	RED	to Guatemala
Change on the ground use	RED	both countries
Ungovernability and insecurity	RED	both countries
Hurricanes	GREEN	both countries
Floods	GREEN	more to Guatemala
Drought	GREEN	both countries
Land possession	GREEN	both countries
Internal migrations and in transit	GREEN	both countries
Animals and vegetables species traffic	GREEN	more to Guatemala
Presence of strong social movements	GREEN	to Mexico
Lack of attendance to agricultural technical and credit for small producers	GREEN	both countries
Illiteracy	GREEN	both countries
Low cover of security service	GREEN	both countries
Lack of employment	GREEN	both countries
Increase of plagues	GREEN	to Guatemala
Suspension of the natural movement of marine species	YELLOW	to Guatemala
Lack of enviromental policies	YELLOW	both countries
Generalized poverty	YELLOW	both countries

Figure 11. Factors and effects in the Usamacinta River.

It is important to make notice that the communities also indicated like main problems, the following ones:

Forest fires

The 84% of the groups indicate to forest fires like the first conflict and burden for their survival. There are several classifications of fires.

The fires caused by agricultural fires, activity based on the system of tree cutting and fire, generally handled by negligence without fire-resistant barriers and the highly individualistic system of the impoverished farmer, who does not

Figure 12. Fires in the Usumacinta River.

have money to pay manual labor so that they help him nor uses the ancestral resource of the communal work that some qeqchíes populations still practicing.

In addition forced by the familiar subsistence it burns an average of 2 to 4 new earth apples per year of Guamil or forest. And if we took into account that between the present 850.000 emigrants, a 50% are farmers (preservative numbers). Every year the requirements of extension by each farmer are of 2 apples of forest that will be burned for maize fields. In this way the magnitude of disaster is of 425.000 farmers and 2 apples each one making a total of 850.000 apples, which turned into hectares represent an amount of 571.093,75 hectares per year; more of the produced by fires in l998.

Big fires like the one of 1998 agravated by the intense drought caused by the phenomena of "El Niño" and the deliberate fires. The images of the Landsat Thematic Mapper satellite, and the presented ones in the Plan of Tourist Development about the vegetal cover and the magnitude of fires really demonstrate, by means of computerized projections, the accelerated depredation and that it

will not arrive at year 2010, base of the predictions, and not so long the Mayan forest will become a desert like Namibia and many other parts of Africa.

River pollution

High river basin	Zone of higher Guatemala and Chiapa
Middle river basin	Zone of Coban, Petén, Chiapas and Tabasco
Low river basin	Tabasco and Campache Mexico

The geomorphologic conformation of the zone, the population and the deficiencies of basic services of water and cleaning typical in the populated rural

regions of the river basin and the lack of treatment of the remainders of the urban centers, which drain in the river basin, make of the Usumacinta their natural garbage dump with the most serious consequences for the inhabitants of the middle and low zones. Even though was not a recent study about the quality of the water, the indications given by the settler who continue using the water of the river to drink, "now are greater the problems causes by drinking this water".

The zones more densely populated correspond to the high river basin, with populations which exceed 1.639.000 inhabitants although there is not an official census. Data of Colegio de la Frontera Sur in Chiapas and the National Institute of Statistic in Guatemala, have projected these approximated numbers, because there is to the date no a trustworthy count neither of the population growth nor of the migration, two phenomena in the last increased 5 years.

When the farmers spoke about the water contamination, it is to take into account most of them dependent on the river water for drinking and bathing, there are no toilet, no drainpipes in most of the towns mainly in the high river basin, an example is a very visited archaeological place that did not have any toilet. Although in this last trip we have verified with extreme affability that the conditions have improved in this tourist place with world-wide reputation. In the high river basin and in the three greater towns of the middle river basin the systems of drainages fall directly to the river. As example the case of the Mexican city of Benemérito, where the waters of the city and the hospital fall directly to the river and the currents drag the contamination towards laurel forest a Guatemalan locality, the same river where the last ones must take the water to drink.

It has been detected that chemical agents used for the maintenance of the pasture has contributed enormously to the contamination of the water bodies.

Air pollution

During fires the life's conditions were strongly threatened by respiratory disease as well as in the feeding, in addition to the elevation of the temperature to 44 Celsius degrees, in Petén where the greater fires were registered, the data of the hospital report the increase in 40% of patients with respiratory diseases in relation to normal times.

Although the air pollution by petroleum has not been quantified nor will become, the adjacent populations to the oil concessions and the ways where the

trucks and the pipe line journey, suffer the strong gas emanations and it has not been anticipated what kind of damages will cause to the human nature, in addition to the danger represented by the fuel transport from distant places.

The problems of the air pollution derived from forest fires and agricultural fires affect the visibility in the access of airships and in the case of Honduras, problems of transboundary contamination as the Honduran authorities commented with fires of season 2005.

Lack of drinking water

The dramatic potable water deficiency was undergone by the 100% of the participant communities in the factory and is the common case for all the small localities which live in the middle river basin. In the high river basin even though most of urban centers count on some drinking water service, the deficiencies are greater in the rural areas for being these populations very dispersed and conformed by poor farmers who cannot, in many of the cases, managing a drinking water project. Another one of the determining factors in the absence of this service is the uncertainty on the land property which does not allow obtaining the basic services.

Most of the inhabitants obtain the water during the summer, of pool or opened deposits, rustically made, all the water they and their animals need, they bathe there and drink.

Hurricanes, floods and droughts

These phenomena have been magnified in the recent years. At first the phenomenon of "El Niño", then the presence of the Mitch Hurricane which knocked down many regions in Central America and the constant floods have left without house hundreds of farmers. The most affected were the inhabitants of the Salinas River side and who lived in the shores of the Usumacinta river,

the new settlers and the emigrants. The phenomena associated to the droughts and floods are the exhaustive deforestation of the shores of the rivers and the fires which devastate all vegetation until the same borders of the great river.

Land property

One of the greatest disputes in the history of the river basin:

At first Spaniards dispute the land to the Mayans, and under the concessions of the real certificates by conquest right they are appropriated territories pertaining to the American natives. At this moment begun a not well known history of defence and invasions of territories that at the present time mark bloody periods in the history of both countries.

The production systems of both countries are protected in the obligatory manual labor of the conquered ones, creating particularly difficult social relations, which have been one of the significant brakes for the development of the area. At the contemporary time, the land property was the ground reason of the war of the 36 years in Guatemala. Weapons for the powerful ones and disarmed for the farmers. The land appears again in the actual massacre the Zapatista revolution.

Efforts have existed to declare National Parks, Reserved zones and the greater effort: The declaration of the Reserve of the Maya Biosphere Reserve "RBM", in the case of Guatemala, from parallel 17.10. upwards, where supposedly land for the establishment of towns would not be adjudged, the case is that in the own Mayan Biosphere Reserve. There are whole towns there living and all over the places the agricultural border advances, and the strategy to adjudge communitarian forest concessions is more than a brake, an outpost for many farmers eager for land.

As the history of the river basin was previously described, it is full of conflicts and confrontations. Recent history demonstrates us that the reason of one of the most serious conflicts has been the land possession and the operation of the resources without regulation nor control from the governments who apparently favor the operations of the wood and oil resources to obtain quickly economic resources and others presents.

Actions to mitigate threats

- Legislation and policies.
- Revision of laws and agreements.
- Interpretation of fulfillment of laws and agreements relative to the Middle River basin.
- Renewal of previous proposals on possible solutions.
- Complementacion of proposals of precise actions in the different subjects.
- Communitarian Participation in the diagnosis, elaboration and management of concrete proposals.
- Sustainable development plan for the Middle River Basin to a 5 years term.
- Plan of alliance fortification for 5 years.

Alternatives

- Employment generation.
- Qualification and automation.
- Regulation of the land property.
- Sustainable agriculture, the experience in the handling of the cross parcel.
- Demonstrative projects of sustainable cattle ranch, dairy and cheese.
- Communitarian projects of echo tourism.
- Demonstrative parcels of agriculture.
- Technical attendance in commercialization.
- Other support alternatives in organization and credits for the creation of services for the tourism (terrestrial and aquatic transport etc)

The constant presence of the Guatemalan government, in addition to the army support Institutions like the National Council of Protected Areas (CONAP); Institute of Investigation on Volcanology, Meteorology and hydrology (INSIVUMEH), Migration, Ministry Of Agriculture, National Advice of Reduction of Disasters (CONRED) and the respective Municipalities.

Referring to nongovernmental organizations are Centro Maya, Defensores de la naturaleza, Fundatep, Fundación Guillermo Toriello, Consejo Nacional de Organizaciones Campesinas (CENOC), Consejo Indígena Qeqchí de peten, (CIQP), Asociación de Comunidades Forestales de Petén (ACOFOP), Qanan K'aax, Organización Civil, Conservación Internacional (CI), CARE, Selva 2001 de Sayaxché Asociación Civil, etc...

By the Mexican side we found cooperatives, communal organizations like those of the Choles and the Lacandones and the Zapatistas, there are also companies of Mexican millionaires supporting the oil concessions and the construction of Hydroelectric.

Between this wide range of actors a shock of interests takes place creating constant conflicts, that because of the magnitude of the geographic area is hard to perceive in its true dimension. Neither Guatemala, nor Mexico have an environmental policy defined to protect the zone.

The potential of this region is really high, in individual with respect to ecotourism, forest handling and organic agricultural production in some regions.

The present tendencies which are not very encouraging, continue reporting elevated deterioration indexes of the atmosphere and the natural resources, which added to the precarious levels of human development in the zone and the high indexes of population growth, presents a situation that will require urgent and concrete interventions to change the present predominant patterns as the natural resources handling of this vast region equipped by the nature and the history with two fundamental elements for its sustainable development.

Transboundary Cooperation

Considering the river basin as a bioregion culturally and ecologically inhabited for thousand of years by Mayans, now with a truely multiethnic population and micro-region so dissimilar, variable but simultaneously common regions for its settlers, where the communication has always existed between families and communities like the first way of exchange, for those who the concept "Transboundary" arises as a result of the present political and administrative limits from the countries, they know by ethnichistory in the river basin different towns were based and evolved.

Thus in high river basin, we can mention the natives Quichés, Mames, Aguacatecas, Kanjobales, Rabinaleros, Qeqchíes, and the Mayans who from

pre-Columbian times maintain an intensive commercial exchange and intercultural cooperation using the main rivers Salinas or Chixoy and Lacantún and their slopes, like the river Chajul and the river La Pasión.

At the moment we can mention like Cooperation actions the following ones.

Local Level

The increasing communication, that exists between the indigenous communities of Mayan ancestry, as much at level of priests and chamanes, like a forest and cultural level of educative interchanges, health, aspects that have taken them to know themselves mutually. Although on these aspects there are no formal registries consists us that it is had been giving the level of communities.

a) In 1975 the Internal Commission of Borders and Water (CILA) is created, by agreement of the governments of Guatemala and Mexico and it is subscribe like the agreement of Tuxtla. The basic objective of the CILA is to foment the maintained development of the bordering resource, to unify the cartographic information and to look for the right use of the bordering resources through the development of joint projects which will benefit both countries. Integrated by the Secretariat of Programming and Budget of Mexico, the main directorate of Geography of the National Institute of Statistical, Geography and Computer Science and the Ministry of Communications and Civil Engineering by the part of Guatemala. The most relevant work has been the elaboration of a Physical Atlas of the international rivers basins between Mexico and Guatemala obtaining valuable cartographic information. One of its limitations has been the lack of publication of its works, that in general, is by lack of budget that is limited in this aspect.

b) We also collect valuable information with respect to previous treaties which have been made within conjunctural marks whose reaches in many of the cases did not extend by lack of political will or resources, but all in all there is only a brief effort in this case.

c) The cooperation relations existed between the CEAR, Special Commission of Attention to Refugees on the part of Guatemala and the COMAR Mexican Commission of Attention to Refugees. In order to take care of the 250.000 Guatemalans fled to the forests from the war during the years of 1980 to 1985 and that were repatriated from the campings of Campeche and Yucatan and were transferred again under the auspices of ACNUR.

d) We have knowledge that in the years 1997, 1998 and 1999 joint meetings between Petén and Tabasco were impelled, for getting a regional development whose more concrete project was the road's construction from Tenosique to Flores. Totality fulfilled by the Mexicans but not at all by Guatemala.

e) The American Biological Corridor is born under the agreement of the governments to protect the biodiversity of the Central American region and start the creation of an ambitious project which integrate five Central American nations in addition to Belize, Mexico and Nicaragua.

f) Binational agreements of the Usumacinta.

g) Most recent it is the initiative "Plan Puebla Panamá" presented by the president of Mexico Vicente Fox and ratified in San Salvador by the Presidents of Central America and Mexico the 15^{th} June 2001, whose objectives is possible to be emphasized:

   - To promote the conservation and sustainable handling of the natural resources and participative mechanisms, specially, by the local communities in the environmental management.
   - Reduce the poverty, facilitate the access to the basic social services of the vulnerable population and contribute to the total development of the Central American towns.
   - Promote the prevention and the mitigation of natural disasters and incorporate the consideration of the management of risk in all sectors projects.
   - Promote the development of the cultural and historical ecological tourism by means of regional actions that emphasize the complementariness, the economies of scale and the productive linkings of the tourism.
   - Foment the commercial interchange in the region by means of a reduction of the transaction costs in the commerce between the countries and of promoting the participation of small and medium companies in the regional exports.
   - Promote the physical integration of the region to facilitate the transit of people and merchandize and in this way to reduce the transport costs.
   - Unify and interconnect the electrical markets with a view to promoting an increase of the investments in the sector and a reduction of the price of the electricity.
   - Develop the infrastructure of computer science interconnection on the region.

At the level of non-governmental organisms

- At level of nongovernmental organisms, intimately related to the river basin of the Usumacinta River, it is the organizational process of “La Alianza de la Selva Maya”, being formulated between Guatemala, Mexico and Belize, whose objective is to work by the sustainable development of the Mayan Forest.
- Also is being developed the project “Guacamayas sin Fronteras”.
- The Institute of Environmental Right and Sustainable Development promotes several actions of cooperation in matter of qualification between Guatemala and Mexico.
- Nature Defenders have begun the debate when speaking with the Mexicans about environmental subjects and specific natural resources.
- “Conservación International” works in equipment in the border of Ceibo searching environmental problems caused by the population.

Problems

The barriers to obtain the transboundary cooperation are more virtual than real. The same villagers that during years, in the cases in that the neighborhoods between the localities are relatively short, maintain almost always informal or commercial relations and bonds that can be reinforced through concrete actions to allow improving the conditions for both sides. An imbalance in this sense would mean to increase the differences and not to favor the cooperation.

At level of the governments it is urgent to take into account to the local villagers of the river basin for any act or program related to them and to look for consensuses before elaborating state commitments which would be later restrained by lack of intentions understanding, that in fact will not be able realize.

For NGOs with presence in the area is very advisable to arrived at the communities with clear terms in the benefits and responsibilities would have actions entails and to leave on the one hand the paternalism.

Opportunities

There are a lot of opportunities of cooperation in the area. All we would have to insist now like countries, world-wide organizations, local or national authorities and villagers, it is the salvation of the forest altogether with the man, later we will not have much to write about this river basin.

The decontamination of the rivers, is another one of the crucial subjects in the immediate future, we cannot continue throwing our sweepings to the river basin.

To learn and to teach the suitable and technified use of the natural resources can generate a vast program of true sustainable development that to the date has only been a dream. The particular conditions of the zone allow it. This area instead of being the zone of the pariahs, had to be the barn of Central America and Mexico.

The definition of land possession, "nobody takes care of what not belong to". When creating a zone of land proprietors we think that the investments will increase. Farmers say they cannot build formal constructions in the case of the house, because they fear to be expelled.

Generation of alternating sources of employment and development. The case of the Mexican government stimulates by different routes the alternative sowing like cacao, organic coffee, rubber trees, etc.

These are some of the subjects that we can mention to be able to visualize the opportunities of cooperation with the basic objective of creating a sustainable alliance between the man and the nature, to survive in harmony.

Ecological tourism: The ecological tourism can be one of the immediate and viable alternatives to protect and to take rationally advantage of the zone because of Mexico and Guatemala count on:

a) Native cultures of an historical wealth very related to the Mayan culture.

b) Natural and scenic beauties with high tourist value, rivers, lakes, mountains, forests.

c) Extraordinary biodiversity.

Being this bio region the cradle of the Mayan civilization, where the kings of the forest accumulated important knowledge about how to handle the natural resources and developed the Mayan agriculture, we can infer that the rescue of these practices could palliate the crisis in our present production systems and the necessity to guarantee the nourishing security of ours more and more increasing populations.

From the development of the project for the sustainable advantage of the middle Usumacinta's river basin, April 2005, that under the auspices of the Agency the International for the Development (AID) of the United States of

America, the Coordination of the Foundation Defending of the Nature, the Kukulkan Foundation of Guatemala and the Foundation Pro Natura Chiapas Mexico and the consolidation of the Communitarian Alliance of the Binational Usumacinta River basin we added to this diagnosis the following ones.

WHAT KIND OF OPPORTUNITIES OFFER THE COMMUNITARIAN PARTICIPATION BY MEANS OF THE CONFORMED ALLIANCE

- An organization decided to work in a coordinated way at level of both countries.
- All we live in the same river basin, and we are decided to improve it and us.
- We know what we want to do, but never there was a direct support to the communities, it is always made by means of intermediate organisms.
- If the project in the middle river basin is a mid and long term project, we are decided to work.
- The authorities should take us in serious, because our personal and communitarian relations come from very long in the time and it is nothing new for being border points.
- We want to have a joint plan with our authorities.

RECOMMENDATIONS FOR THE ALLIANCE

- Fortify the Alliance's organization.
- Look for influential policies to find the improvement, more than everything so that the government worries in this subject.
- Facilitate the legalization process of the Alliance in both countries.
- Develop projects that would involve people to work and not to wait for everything given. Tourism case.
- Develop a work plan that we would consider possible to fulfill.
- Elaborate development proposals for its management at level of national and federal governments.

AWAITED RESULTS

- RESULT 1: Reduce the non compatible development activities with the conservation through the implementation of bilateral policies.
- RESULT 2: Promote activities of sustainable development in the region of the binational Usumacinta middle river basin.
- RESULT 3: Fortify bilateral and regional cooperation for the sustainable development of the region.

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III

RESOLVING TRANSBOUNDARY WATERS CONFLICTS

INTERNATIONAL WATER PROBLEMS AND SUSTAINABLE CO-DEVELOPMENT. A CENTRAL ASIAN EXAMPLE

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Abstract Research on the conception and implementation of sustainable development policies by international cooperation, or sustainable co-development, studies the historical and cultural dimensions of the regions and populations involved in such cooperation. It shows that the knowledge of history, culture, traditions and behaviors is necessary to better understand environmentally related development questions and have a better insight of the real needs and priorities of the populations concerned.

Restricting this paper to the history of the environment of a given region, Bukhara in Central Asia, we show that a thorough study of historical and geographical evolutions, taking us across "time and culture boundaries" from an independent emirate to a Russian territory, to a Soviet republic and, finally, to an independent state, could enable the policy-makers and the practitioners to make the difference between natural and man-made causes of a problem and, therefore, to better address its remediation, especially if external political constraints can be overcome.

Introduction

We are familiar with physical, administrative or political boundaries and many of the water management questions are related to the consistency of these boundaries. We propose to explore other types of boundaries, which could be called "time and cultural boundaries", related to the history of a given region, its evolution with time politically and culturally, and the influence of these factors on the approaches to solve water problems in a sustainable way. This is part of our research on the conception and implementation of sustainable development policies by international cooperation or **sustainable co-development**, whose objective is to systematically introduce and study the historical and cul-

tural dimensions of an economic cooperation question and their interactions with the three classical pillars of sustainable development, the environment, the economy and society (Fried, 2001).

The example, which follows and concerns water in the oasis of Bukhara, Uzbekistan, is intended to show how history, geography and culture interact across time with hydrology and environmental sciences in general and illustrate how studies of these various aspects are needed to correctly identify the actions necessary to solve an international water problem in a sustainable way (Fried, 1997).

Water in Bukhara: The Emirate

The Bukhara region has a semi-arid climate with a very large arid trend and receives weak rains only, unevenly distributed and almost non-existent during the vegetation season; the only usable waters come from the Zeravchan, a stream which crosses the Bukhara valley, and from groundwater; this means that agricultural development is impossible without irrigation.

Irrigation is an ancient practice and its organization is part of the cultural and social heritage of the region. Actually, since the middle Ages, Bukhara had established a rather comprehensive irrigation system which, among others, regulated the access to water, the operation and maintenance of the canals and the allocation of water. Furthermore this system had created specific functions linked to water distribution: for instance, the **aryk aksakal** or the head of the canals elected and paid by the peasants of the village; like the magistrate of water of Valencia, Spain, he had the responsibilities of a referee and could take some decisions in the allocation of water.

Water in Bukhara: Russia and the Soviet Union

The Russians did not fundamentally change the water management system, mainly using the local experience and know-how, but brought some technical improvements. It is during the Soviet era that significant changes occurred: important public works were then started because irrigation had been placed at the same rank as electrification in the priorities of the USSR. Besides, the decision of considerably increasing the cotton production and to practically make it the only culture of the region implied an enormous intensification of irrigation; therefore, dams were built, the canal network was rationalized, drainage structures were set, new canals and collectors created, groundwater resources heavily pumped.

Cotton monoculture had been decided in an authoritarian way at the central level of the USSR, without taking into account the geographic and socio-cultural realities. Works were done too quickly, without taking the local hydraulic capacities into account, without efficient drainage systems and without any preoccupation of the run-off and, in general, without any global vision. Very quickly this resulted into a significant water shortage and, consequently, a considerable salinity increase.

Various solutions were then tried, often inefficient or worse: for instance the planned modification of the beds of the Amou-Darya and the Syr-Darya, the two rivers which flow into the Aral Sea, furthermore increased the regression of the Aral Sea and its salinity, resulting in the emergence of the sea bottom and favoring its erosion. The salt thus exposed could then be carried away by the winds all over the region, as far as the mountains of Pamir, polluting the very reservoir of the Aral Sea basin waters and creating respiratory illnesses and detrimental local climate changes towards desertification. Furthermore, as the intensive monoculture of cotton implies a heavy use of fertilizers, pesticides and herbicides, this resulted in a significant pollution with disastrous health effects on the populations of the region, which has been nicknamed "a slow Chernobyl"!

While most pollution aspects of the Aral sea disaster are doubtless of human origin, the whole desertification process has classically been attributed to human decisions and policies and became a political argument for the new independent State of Uzbekistan in the negociations for financial compensations from Russia, considered as the most direct successor of the Soviet Union.

Water in Bukhara: Human or natural causes of a disaster? Lessons of history

Yet thorough explorations of the existing documents show that world known geographers, and among them the French geographer Elysée Reclus, identify a general natural desertification process of the Aral Sea basin. In his "Nouvelle Géographie Universelle" edited in 1877, Elysée Reclus mentions a significant decrease of the level of the Aral Sea and the disappearance of many lakes of the region. Reclus relates this phenomenon to the variations of the flow rates in the two major rivers going to the Aral Sea, the Syr-Darya and the Amou-Darya. But, having analyzed the diaries of several travelers (it should not be forgotten that the region is crossed by the famous Silk Road and merchants, ambassadors and other western travelers have used it from the Middle Ages on), Reclus underlines the very probable complete disappearance of the Aral

Sea during some periods, which he relates to variations in the paths of the rivers mentioned above, e.g. the Amou-Darya directly flowing to the Caspian Sea. Of course, besides this natural desertification process, Reclus also insists on the influence of intensive irrigation, the aging of the irrigation system, its inefficiency to cope with a growing population resulting in water and food shortages and the general lack of water safety resulting in various water diseases, all phenomena which add to desertification but do not create it (Reclus, 1881).

Therefore, although cotton monoculture, decided by the Soviet government, clearly is a major actor in the desertification and pollution processes of the region, recurrent climate changes and ancient uncontrolled irrigation practices are at the origin of the region desertification which cannot therefore be fully attributed to the Soviet regime or even the Russian presence. Although intensive and inconsiderate use of the water resources have certainly largely increased desertification and modern agricultural practices through chemical pollution by fertilizers and pesticides have reinforced its ill-effects, they have not created this desertification.

Since 1992, a short time after the creation of the New Independent States, the Central Asian Republics have reacted and started to look for sustainable solutions. In particular they have established the International Fund for Saving the Aral Sea (IFAS), the Interstate Coordination Water Commission, and the Sustainable Development Commission, which stimulate donors such as the European Commission, European Union member states, the USAID and the World Bank.

Conclusion

In conclusion, my objective in this paper is not to propose solutions or to provide arguments to any political discussion on the respective responsibilities concerning the disaster of the Aral Sea basin. I just hope to show that, to be efficient and sustainable, the solutions of an environmental question, and moreover an environmental disaster, will require a thorough study of the region concerned, its history, its culture, its traditions, including its traditional know-how in the various sectoral economic policies (on this example, agriculture), and a reassessment of both political and scientific evaluations in an integrated science-policy approach (Baktiari et al., 2005). In particular, it should be a top priority of international cooperation for sustainable development or sustainable co-development, whose guidelines and principles are given in Appendix 1.

Appendix 1

From sustainable development to sustainable co-development

For almost twenty years now, the United Nations has defined sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Many interpretations have been made of this rather fuzzy definition and the objectives set at Rio have not been achieved. Yet Johannesburg has reinforced many of the ideas derived from that definition over the years, such as the integration of the long-term evolution of the environment into the sectoral economic policies to prevent irreversible damages to the environment, or the prevention of wasteful use of natural resources. And the multiplication of local initiatives has contributed to better understand how to identify the economical, social, and environmental and, as presented above, historical and cultural dimensions of development and to achieve their necessary integration in a philosophy of the long term, based on:

- A **Political will**, expressing the necessity and the common desire of evolution of the populations towards political stability and social balance through a better definition of the relationships between civil society and the public authorities, the research of adequate institutional, legal, administrative and financial structures, the participation of the citizen to development through public debate and active citizenship.
- **Financial resources** in the framework of an economic policy aiming at a market economy regulated by public action and the search for balance between liberalization and planning and balance between public and private.
- **Human resources** expressed as work force, competences, and capacities for innovation, access to scientific and technical progress, knowledge and use of the cultural and historical heritage.
- **Preservation of natural resources** through careful use without wasting them, reduction of losses, wastes and nuisances, without irreversible damages to the environment.

Most generally, international cooperation will play a significant role as, on the one hand, economic and environmental interdependence is the rule and, on the other hand, many countries are unable to mobilize the adequate financial means on the long term all alone and, often, do not have the necessary scientific and technical knowledge and know-how. Furthermore, experience shows

that most countries, developed or developing, have know-how, craftsmanship, experience of methods and solutions adapted to specific environmental problems, which they can share with their partners in the cooperation, giving its real sense to the word “cooperation”.

A domain of full application of the principles of sustainable development is water, essential to life in the present and in the future, hence a vital and strategic resource. Therefore, and especially in its international dimensions, water cannot be managed according to classical business rules and purely commercial interests. Water resources management should follow a logic of solidarity and mutual trust, nationally and internationally. International cooperation in the domain of water should be based on genuine partnership, in a perspective of shared responsibilities and mutual benefits.

To fully express these ideas of partnership based on bidirectional exchanges of knowledge and know-how, and the responsible participation of each partner in the cooperation, we have introduced the concept of “**sustainable co-development**”, which, when applied to water, becomes “**sustainable water co-development**”, and whose operational principles are the following:

a) Know and take into account the history, culture and physical environment of the partner to better understand its institutional, political, social and geographic characteristics, aiming at identifying the real needs and priorities of the partner and establishing mutual trust.

b) Identify the competences, experience and know-how of the partner which could benefit the cooperation.

c) Give actual responsibility to each partner through the use of their own financial, natural and human resources, especially aiming at the disappearance of the mentality “assistant-assisted”.

d) Ensure the cooperation in the long term, making use of sustainable political, economic, financial, technical, scientific and human means, completed by a systematic follow-up and a regular evaluation to dynamically adapt the cooperation to possible evolutions with time.

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WATER AND PEACE FOR PEOPLE. POSSIBLE SOLUTIONS TO WATER DISPUTES IN THE MIDDLE EAST

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Abstract Over the recent months, I have had a privilege of take a step aside –from a hectic daily life of operational work– to complete a book with the headline of this speech. Carving out such a time for reflection and contemplation has been extraordinary rewarding in term of enhancing my understanding of how to act more effectively. The book deals with dispute resolution of water courses that involve seven countries in the Middle East, I would very briefly like to share some of my lessons learnt.

Possible solutions to water disputes in the Middle East

First of all, let me express my sincere appreciation for being invited among such a distinguish group – to learn and to share learned lessons of experience. A special thanks to the Universidad de Castilla-La Mancha for hosting the Symposium and to UNESCO for its perseverance in promoting this topic.

The book, "Water and Peace for People – Possible Solutions to Water Disputes in the Middle East" deals with:

- The Euphrates and the Tigris Rivers, involving Turkey, Iraq, and Syria.
- The Golan Heights between Syria and Israel – The Wazzani Spring between Lebanon and Israel.
- Contested Water between the Israeli and the Palestinians.

*Disclaimer: All the statements set forth in this Paper are those of the author and should not be assumed to reflect the views of any particular organization.

Let me clarify my perspective as an *External Observer* to the region: I am cautious in suggesting panaceas in preventing and resolving international water conflicts, especially in the Middle East. There are a number of outstanding diplomats, high-level decision-makers, and technical experts in the countries involved. Instead of competing with their excellence, I have tried to reflect their experience and guidance that they have conveyed to me.

There is a constant increased demand for water in the region because of the combination of rapid population growth and a steady social and economic development, which is incommensurable with existing natural water resources. This may eventually create greater suffering and instability than today. Therefore, it is easy to overexploit and pollute the waters at the expense of the coming generations. The water disputes in the region are hindering effective water use as well as fuelling political flames that already have bit lit.

Some may say that the political circumstances should first be settled, and then the water disputes should be addressed, but the problem with that is that conciliation and cooperation between the countries on how to manage international water resources are prerequisites for sustainable development of the region.

Water is such a valuable and basic human need that the countries have an intergeneration duty to find ways of solving the water problems. Such an obligation is also rooted in all the three monotheistic religions – in Islam, in Christianity, and in Judaism.

Solutions to the water disputes in the Middle East are such a long-term imperative due to a course that is far more significant than entrenched short-term political schisms, namely **provide water and peace to the people, and especially for the poorest.**

The outlined proposals to the above-mentioned disputes aim to incorporate the hard facts on the ground:

> "Half of the urban population in the larger cites in the region do not have adequate drinking water facilities, pollution of surface and underground water is rapidly developing, to which the Governments do not have proper remedies. Lack of agreements between the countries hinders effective and fair use of the resources, which is leading to short-term and temporary solutions."

Lessons learnt from deliberations with the countries (Trondalen, 2004) have shown that creating a gap between the *reality at the negotiation table* between

leaders and the *reality on the ground* –even among the enlightened public– has been as mistake in many of the past efforts.

The experience has shown that in the course of the political rhetoric, the public sometimes has not been given a picture of what might be realistic and what might even be factually incorrect information.

I am attempting to promoting moderate positions in situations where every contester wants a larger "*piece of the pie than what might be physically feasible*". The key-problem appears however, to be how to *enlarge the pie* rather than try to *enlarge one of the pieces at the expense of another party.*

Any special water arrangements for the Middle East?

Contrary to some observers dealing with international water management, the I am arguing that "sustainable governance" of most water resources is a matter of complex political sensitivities, especially in the Middle East, and therefore *ready-made* regional co-operative models of water managements *are not directly applicable* to every geographical, political, economic and social setting.

Therefore, special arrangements should be developed, and there are several reasons for this: Each country has its own history in utilising a particular international water resource; quite often, the internal political situation is such that the water utilisation may change. In addition, strained, and other inflexible relationships with neighbouring countries call for a constant search for applicable principles, so called "yardsticks" that can be used in developing common understanding. Finally, every existing water agreement in the region is tailored to the specific physical and political conditions.

There are some "yardsticks" that may be applied in sustainable governance of international watercourses in the Middle East.

In some cases, countries *share* and *allocate* international water resources in the spirit of "good neighbournes" and "equitable utilisation", and even "non-appreciable harm". The academic literature records several success stories, especially in Europe and even in more complex areas such as in the Mekong Basin in Indo-China, and in the Indus Basin. Therefore, it seems wise to look at some experience from other parts of the world which may give some clues to how things may work out in the region. A key-lesson is the old cliché, thus equally important notion of *sustainable water management*.

Sustainable management of international watercourses can be discussed from various perspectives. Traditionally, water disputes are often analyzed from either an *upstream* or a *downstream perspective*. In practice, however, an *interest-based perspective* is quite different from the conventional upstream-downstream doctrine. This more pragmatic –and possibly more contemporary– viewpoint overweighs the earlier approach, and is based on the concept of *sustainable development* (Trondalen and Munasinghe, 1999). It relies on a balanced application of three of the most important principles in dealing with international resources:

- Social Equity.
- Economic Efficiency.
- Environmental Protection.

In most case, countries legitimise their "water rights" by referring to national "sovereignty" of water resources.

An obvious consequence of the country's sovereignty is to claim the right to *own*, *access*, *control* and *use* the resource. Since the concept of *sovereignty* and *water rights* are frequently used in the public and professional debate as well in the legal terminology, a translation of these terms into concepts that might be applied in operational negotiations seems relevant. Despite the vagueness of the terms, following principles are derived from the concepts of "water rights" and "sovereignty":

The notion of "water rights" implies that a country has "rights" to a resource in terms of following attributes: *Ownership*, *access*, *control*, and/or *use* of a particular water resource. Internationally as well as in the Middle East, there are several examples of water rights attributed to all four "rights", one of them alone, or in various combinations. However, "water rights usually is a right to use", whilst "ownership does normally means a *usufructuray* power, and not ownership of the *corpus* of water itself".

The question is whether experience from other regions in managing these water "rights" are bringing the countries in the Middle East closer to a solution. What this illustrates is that water "rights" are interpreted differently in various parts of the world.

I am arguing that the concept of sovereignty, which is closely linked to the concept of "rights", might be an appropriate term to translate in a negotiation

arrangement. According to international law, the notion of **sovereignty** over any natural resource comprises of two important legal principles:

- Sovereign rights, i.e., "rights" of water to either of the attributes mentioned above.
- Sovereign obligations, i.e., "obligations" to use the water in a certain way such as *sustainable use, environmental protection, and economic efficiency* (cf. national and international obligations as discussed earlier).

Rights. One may argue that any water solution between countries should include an interpretation of the four attributes of **water rights** such as:

- *Ownership* of which part of the water resource (and even recycled water).
- *Access* to which part of the water resources (e.g., part so aquifers). However, this concept is mostly applied in a geographically defined area, like access to a territory, and is therefore not such a useful concept in this context. Thus, the two others seem relevant:
- Control of which part of the water resource (and even recycled water).
- Use of which parts of the aquifers and recycled water.

Obligations. Another meaning of *sovereignty* is **obligation**: Every state or state-like entity that has *rights* over specific water resources are *obliged* to manage them according to national laws, but also to international recognised obligations (EU-WFD, 2000), or even to religious law (such as *Sharia law*). Protecting a semi– or renewable water resource from depletion both in terms of quantity and quality, is one of the most important obligations that any country have. In this context, these obligations apply specifically to protection against pollution and over-pumping (of aquifers).

Therefore, the politically temptation of a one-sided emphasis on its water "rights" is a twin "edged-sword" for any country since the notion of "obligations" is equally strong.

This reality is acknowledged by most countries in the region, and the questions would rather be:

- How can an agreement between the Adversaries include incremental steps that would incorporate transfer of water "rights" and water "obligations" in a sustainable and agreeable manner?
- How can implementation of these steps be enforced in a realistic and structured way?

Anyone who claims that there are quick-fixed answers to these questions suffers either ignorance or limited real-life experience in the region. Therefore, the proposals for resolution of the four water disputes have several reservations, especially political ones, but they should not prevent an *External Observer* to offer a proposal. The countries will anyway carry the burden of both successes and failures.

> Quite a few of the water disputes could have been handled in a different manner that of the situation of today if the countries had focussed on preventive measures rather than resolution of conflicts after they have escalated.

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TOWARD REGIONAL MECHANISMS FOR SHARED GROUNDWATER RESOURCES MANAGEMENT (SGRM)

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Introduction

Integration and multi-disciplinarity

A constraint and facilitator assessment of transboundary water resources management (TWM) practices, requires participation to share the views of water resources management practitioners of different disciplines, backgrounds and with experience from different regional and country environments. The cases-based assessment could focus on initial identification of limiting factors to clarify why TWM has worked in some situations, basins and aquifers, while the outcomes have been more mixed in others. A synthesis, review and continued dialogue based on practical empirical experience by independent multidisciplinary and inter-regional teams could contribute to predict, and setting directions for the future in transboundary groundwater management, and its role as an integrated part of regional cooperation for development and environmental sustainability. The dialogue should stay flexible and geared towards realities and change for effectiveness, and implies motivation and thrust to involve in multi-disciplinary and intersectoral perspectives built on human behavior and social and economic realities. In this way synergies for common benefits and reduction in risk from conjunctive and integrated management can be fully achieved. International environmental management, under the Rio Conventions, CBD, CCC, CCD, and other global and regional instruments gives recognition to the needs and provides for integration to work together towards the common focus and develop synergies between the conventions for multi-benefits in concrete projects at the national and local level. One significant and water resources related example is joint land and groundwater management for increased total risk reduction benefits (Figure 1) that could be drawn upon and expanded in TWM.

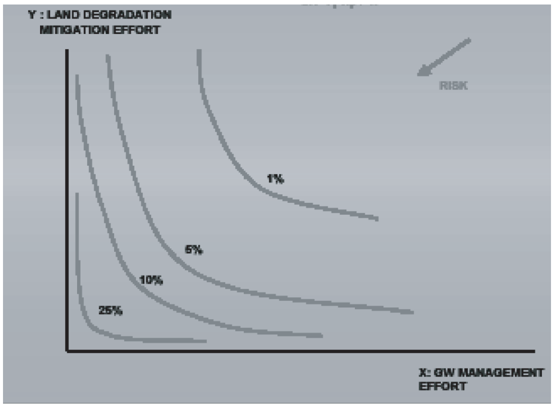

Figure 1. Joint land and groundwater management; synergies for reduced risk.

Recognition of political and social realities

In all systems for adjustment and action, including non-intervention and laissez-faire approaches, political decisions are judged for political sustainability, minimum political and social risk and uncertainty, and less for vague and longer term objectives of sustainable development. The realistic attitude is of aversion to policy changes, especially in relation to other countries. Imperatives of socio-economic development and public investments are not consistent with priority concerns of cautiousness and low political risk.

As a consequence the objective of utilitarian optimisation expressed in economic terms, built on technical and scientific truth that is often superseded by real life priorities with political currency within domestic jurisdictions that point at social equity and distributional objectives. Political attitudes to decision-making as the central drivers in the political economy could on one hand restrict the scope for transformation of established social systems, and on the other provide openings and opportunities for evolution and change. Change could not always be secured at the domestic level and need to be referred to the regional level with more distance to immediate bi-lateral water allocation and hydro-political issues. The political and behavioural conditions, with the institutional conditions for effective acceptance and implementation of TWM issues often referred to allocation issues and demand/supply balance within the scope of operational issues at the hydrological basin, and immediate and short term bi-lateral relations (Box 1). In conclusion the drivers and opportunities to progress depend on the level of risk and uncertainty as perceived by the decision makers, with the need for a wider regional approach to secure the necessary level of authority, distance and confidence.

Towards a regional cooperation approach to TBAM

The growing aspirations and the trust of regional cooperation in transboundary environmental management in the development patterns in most regions could facilitate TWM. Regional initiatives at regional level in environmental governance and development cooperation at the level of public policy, investments and distribution are emerging under global initiatives on environmental governances[1] and expanding in the regions, not only in Europe and the Americas, but above all in Africa and also in the Middle East. As a result of inter-regional cooperation initiatives, the countries aim to move away from national mono-sector and especially agricultural development programs, where the development economies are focused on and competing for the same markets with limited inter-regional exchange and trade and absence of common regional institutions and mechanisms for regional political and socio-economic cooperation, based on common political imperatives of security with sustainability and environmental protection needs and objectives. The (10) MEDA group of countries, along the process of region-wide structural change, is getting closer to and cooperating with Europe and other regions in political and socio-economic development and the trade, energy the environmental and natural resources conservation sectors. The cooperation is organized under defined frameworks such as the EU Neighbourhood policy and partnership programme, (ENP)[2] (Figure 2), from in 2006 succeeding the EU-MEDA partnership.

The ENP, is focused on regional and global environmental protection the environment, where priorities are identified and driven in key areas through the projects for introduction and approximation of the EU-WFD, the 1992 Helsinki Water Convention and other European frameworks, to supplement and fill the gaps in existing regional instruments. The integrated cooperation expansion process, focused on water resources and TWM with "water and environment for cooperation", where the evolution towards regional fora and institutions with support from the inter-regional initiatives brings water into inter-regional main-stream with new opportunities to move out of and effectively deal with the critical transboundary water issues. A regional approach carries a number of convincing advantages as the necessary capacity and authority to handle

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[1]One example is the UN-ILC codification initiative for a global groundwater framework convention that has adopted and supports regional approaches on transboundary groundwater management, and notably in the form of regional plans.

[2]The Mediterranean partners, comprised the 10 MEDA countries, Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, Turkey and the Palestinian Authority. Since 2006 the MEDA countries are partners of the wider **European Neighbourhood Policy** (ENP), with **Algeria**, Armenia, Azerbaijan, Belarus, **Egypt**, Georgia, Israel, **Jordan**, **Lebanon**, **Libya**, Moldova, **Morocco**, **Palestinian Authority**, **Syria**, **Tunisia**, and Ukraine (Figure 1.).

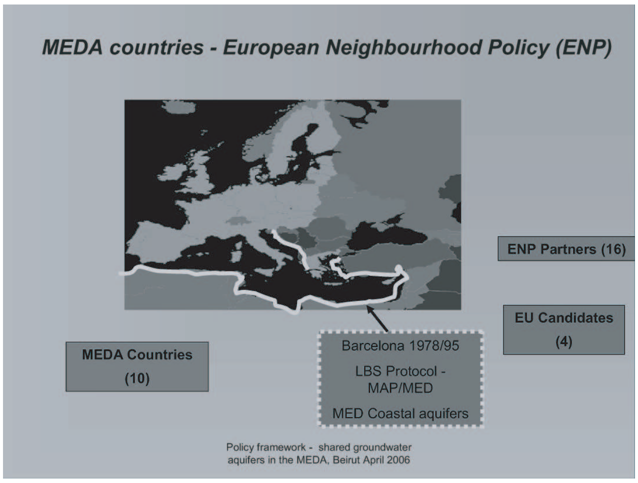

Figure 2. The EU and its neighbours.

long-term bi-lateral conflicts over water allocation issues, establish and support sustainable regional policy frameworks and TWM institutions and reduce the risk of overlaps and repetitions in individual aquifers and basins.

This is of particular relevance in a region that has a long tradition of national sovereignty. In this perspective a change to open-minded multidisciplinary thinking based on political and social realities and regional commonalities focused on confidence and cooperation and solidarity in region rather than on bilateral allocation issues, with evolution towards regional cooperation and governance opens main opportunities for effective and successful TWM and SGRM in the MEDA. Moreover a regional approach based on regional consultation mechanisms will add capacity and synergies for environmental integration and cooperation on other transboundary environmental issues, beyond water resources. As in case of the MEDA the countries have recognized the benefits to review, draw upon and apply and approximate existing instruments on SGRM in other regions. This induces the priority subject for inter-governmental assistance in public transboundary environmental governance with the immediate scope for introducing references and actual cases of success and failure, of existing approaches and frameworks to SGRM in other regions.

Transboundary groundwater management

With few exceptions the water scarce arid and semi-arid regions in the world have limited surface water resources and rely heavily on groundwater. As a consequence, the hydrological, and related socio-economic, environmental and legal and institutional aspects are different from those in humid regions with a wider scope and alternative requirements for management mechanisms than in transboundary surface flow based watercourses. Groundwater is mainly a storage resource that is vulnerable to over-use and contamination that could have long-term far-reaching consequences often with irreversible environmental consequences. As demonstrated by a scarcity of international judicial judgements, and often directed towards wider environmental impacts and risks rather than to water allocation water issues[3], the transboundary impacts in aquifer systems are generally less visible and uncertain and difficult to demonstrate and prove at the decision-making level. Groundwater is used by a multitude of local users[4], which limits public intervention and control and complicates implementation of imperatives for internationally shared[5] aquifers resources management already at the national level. In this situation a common regional approach to groundwater, based on common groundwater guidelines, represents a necessary step, with clear advantages and without alternatives to secure sustainable governance to address region-wide risk, hampered by uncertainty and local political intervention, to cross the interface between international and domestic law and to harmonize and stimulate regional standards. TWM through the regional frameworks and an important target for regional environmental cooperation and a common regional factor for social development[6] and environmental integration. A consequent approach throughout the region can be expected to support efficiency, with reduced overlaps and repe-

[3]reference to the often quoted judicial decisions as: The German inter-state decision on the Donauversinkung (1927), and the Gabcikovo-Nagymaros (1997) decision between then Czechoslovakia and Hungary.

[4]The often stated example is the Indian, and southern Asia "juggernaut, or social groundwater revolution". The number of wells in India grew from 1 to 30 million in the last three decades, resulting in region-wide threat of resource depletion, with wide social and environmental consequences.

[5]UNESCO, 2004b. Margat, J. communication. The English term "shared", in French "partage", to define cross-border aquifers and the related water resources is debated. It is has been argued that the meaning "shared" is as "the result of sharing" and (Margat, 2004) that applies only when a distribution has been made become effective under an agreement or a treaty.

[6]The countries in the ESCWA region have recently joined in the process to formulate common regional groundwater capacity building guidelines representative for the climatic, political, and socio-economic characteristics of the region. The guidelines provide for a consistent approach to groundwater and related land and environmental management throughout the region.

titions at country and aquifer basin levels initiatives to develop regional strategies on SGRM [7].

Global environmental governance (GEG)[8] relies on the ability to manage, and benefit from emerging changes in social systems, and secure the provisions for, (a) participation of civil society, and (b) management and identification of issues from conflict. Programmes, to be attractive to decision making, need to attend to desired rather than pre-set objectives that minimize the conflict from the decision.[9] Conflict management, in a broader scope, is not only a means to resolve disputes, but the opportunity to use conflicting relationships to identify inequities and also solutions that have been concealed by the conflict. For example the definition of an environmental issue requires two or more parties and is no effective case for governance until there is a potential claim from the loser(s) to the winner(s). However behaviours remain the same and political decisions are similar to other social decisions and normally based on prospect of least conflict for the decision maker. In this context the often quoted "lack of political will", as explanation to failure of success, seems to be losing in meaningfulness and seen as a kind "useless function". Generic terms, for example "ecosystem restoration", can be hard to understand, and is only meaningful in the perspective of set conservation goals, building on socio-economic needs, ethical-cultural values, aesthetic definitions and outcomes of political-economic processes. The considerations seem to focus on the behaviour and the problem of mutual understanding between defined communities, such as people of different disciplines. The languages of specialists are often difficult to understand not only by decision-makers and in between different disciplines and legislators and could result in fatal communication gaps. There is therefore a call for enhanced understanding and the use of a common language between generalists and specialists in different disciplines. This suggests that the language of socio-economics, when adapted to human behaviour and social realities in the political economy and close to the driving forces for change and improvement could help to bridge the communication gaps and even out disciplinary positions and misunderstandings.

[7] For the GEF's groundwater portfolio, initiated as a series of unrelated but similar aquifer systems the scope to link the ensemble of large sedimentary aquifers in the Sahara/Sahel and in other semi-arid sub-regions and groups of sedimentary aquifers in Africa and the Near East together under a coherent national strategy is currently being considered.

Regional SGRM. The Meda Region case[11]

The shared ground waters represent a natural resource of critical, strategic social, economic, environmental and political importance to current, medium and longer-term development and security in the water scarce MEDA region. In this sense the shared ground waters represent a common strategy for cooperation with mutual benefits for sustainable development and social and environmental security in the region and also an issue of water security and water conflict. The shared aquifer resources also dominate the supplies and are often the only available water to support social and environmental services. The shared ground waters are in general unrelated to the sparse and localised surface waters[12] in the region. The MEDA economies depend largely, directly or indirectly, on the shared coastal aquifers along the Mediterranean as water supply to support coastal urban and agricultural development, control land degradation and salinization, and maintain coastal and marine ecosystems in the coastal zone that is of central socio-economical importance to the MEDA countries[13]. Management intervention and protection of the Mediterranean coastal aquifers represent yet another example of wider integrated environmental approach to transboundary aquifer management supported by long established frameworks and current initiatives for the Mediterranean cooperation[14].

TWM experience in the MEDA.

Bilateral cooperation on TWM has so far been focused on the domestic needs and allocation of the principal shared surface watercourses in the region, including the Jordan, the Euphrates-Tigris, and the Nile basins, and the shared aquifer systems in the sub-region. As a result scientific and political mechanisms and institutions as joint and technical committees have been established, sometimes with mixed success. As water demands have increased, by population rise, higher expectations and demands, and growing recognition of ecological water demands, the riparian countries are working and competing under water stress and increasingly critical supply/demand ratios. With international water competition and without regulation or incentives at the domestic level

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[11]The case is drawing from the ongoing (2005–2007) interregional project on *"Capacity building for the sustainable utilization, management and protection of internationally shared groundwater in the Mediterranean"*, jointly executed by ECA, ECE, ESCWA, UNESCO and UN-DESA.
[12]with exception of large river systems that flow into the MEDA from outside.
[13]several of the coastal aquifers cross the boundaries between the MEDA countries. Moreover the coastal aquifers are transboundary, with seepage outflows that support the common resources, in the coastal zone, at the fresh-marine water interface along the coast, and in the coastal and marine water bodies along the Mediterranean sea.
[14]Under the Barcelona Convention and process, including the LBS Protocol, the MAP/MED and The GEF Strategic Partnership for the Mediterranean Large Marine Ecosystems.

for limiting the growing apprehension of national shares of resource, the cooperation on surface water has traditionally been focused on allocation issues, underpinned by technical and regulatory and standard-driven approaches. At a certain level of stress and hydropolitical pressures the water conflicts have exceed resolution capacities at bi-lateral level with a decline in transboundary management effectiveness and with need to adjusted and brought to the regional level.

International water allocation, normally seen as an ultimate scope of shared water resources management, is generally linked to political and socio-economic issues originating from sovereignty and unilateral considerations at domestic level often beyond the objectives of transboundary water resources management. In this sense an approach, where the ambitions on water allocation are lowered could be more effective and prudent to provide for the building of confidence and basin awareness and build regional and domestic capacity as part of the process, and is more likely to succeed and to reduce main risks of delay or failure. The challenges are to initiate and widen the scope of joint activities, and enhance the awareness of common socio-economic and environmental benefits of groundwater services and management benefits, and of the joint threats with related social and economic risk, of degradation and loss of strategic aquifer resources. As a result regional cooperation on shared ground waters can be expected to emerge as priority area and strategy to address environmental risk and climatic change in the region. In the wider perspective of sustainable regional development the MEDA countries are likely to support regional cooperation for security to sustain the common groundwater and environmental systems on which the MEDA countries and economies depend. This may also represent a change from unilateral allocation-focused attitudes towards integrated natural resources management for regional socio-economic development based on an eco-system approach for sound management of the common regional natural resources. Specifically, rational development and utilization of the shared ground waters support productivity enhancement of strategic importance to the current process of structural economic change in the region. The regional option is also more central to the common regional priority process towards development, growth and environmental sustainability as common nominators for the expanding EU-MEDA cooperation.

Regional risk sharing

A regional approach, based on joint multiple policy and social risk and uncertainty management and implemented through effective consultation mecha-

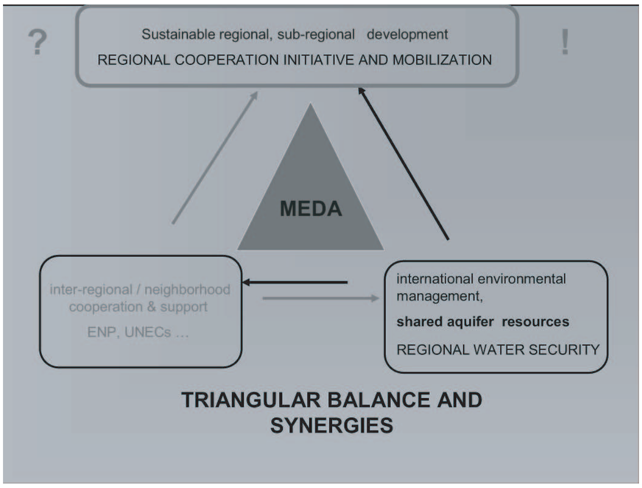

Figure 3. Institutional balance and synergies in inter-regional cooperation.

nisms, can be expected to induce change in a region with a traditional attitude of territorial sovereignty and integrity. The TWM schemes provided as supplements to geo-political package deals were flawed by hydro-political considerations have shown mixed success.

In this sense regional risk sharing provides for an alternative or supplementary approach to often conflictive and competitive allocation and benefit sharing in a region. With a widened joint scope and increasing the joint awareness of common socio-economic and environmental benefits of the groundwater services and management benefits, but also of joint security threats with related regional social and economic risk, of degradation and loss of strategic aquifer resources, regional cooperation on shared ground waters is converted into a priority area and regional cooperation strategy to jointly address environmental risk and climatic change in the region. A major constraint, specific for the MEDA, is the lack of existing integrated regional institutions with the capacity to host and assume the responsibility for the regional consultation mechanism with capacity to interact with and match the inter-regional initiatives and the EU-MEDA Neighbourhood partnership programme (Figure 3).

Developing instruments for transboundary groundwater management in the MEDA

The identified opportunities and requirements to progress are based on an adopted vision with defined scopes and objectives for assessments of the shared

groundwaters, exchange with other regions, involvement of the regional and sub-regional institutions and projects with the need to provide for confidence –and consensus– building and address the central factors, and establishment of a strategic partnership that includes external development partner.

The inter-governmental policy involves quality management with regular reviews of adherence to agreed objectives with indicators for effectiveness, efficiency, traceability, documentation in protocols, based on standards and common typology, and activities harmonized to avoid duplication in the region.

Joint coordinated action – institutional arrangements

The development and implementation of a regional policy framework, with policies, strategies and methodologies for international cooperation on shared groundwater management depend on defined and adopted institutional development, based on a regional instrument as an initial regular protocol for a consultation mechanism followed by a regional enabling framework. The regional instrument will lay down the social, economic and environmental conditions in the region and the countries, and the requirements including responsibilities, functions, structures and specific arrangements for cooperation to be considered in the institutional arrangements, including regional consultation mechanisms and other bi-lateral and multilateral joint bodies. The countries will develop an agree on management targets under a common action plan, including, land and groundwater uses, with impacts and restrictions of economic activities, and groundwater abstraction and pollution and the impacts on groundwater dependent ecosystems and wetlands, and also considering selective joint monitoring of ground water levels and quality. A regular regional and country reporting process will be built on indicators for legal system performance, focused on the legal system at regional and domestic level.

Scenarios

Identification and review of regional scenarios, for extreme groupings of socio-economic water demand and climatic change represent an opportunity for common assessments as the basis for cooperation –and consensus– building in the MEDA. The scenario for substantial change in water stress is for high regional economic growth, growing agricultural and urban water demands, com-

bined with growing needs for adaptation to the maximum/medium scenario for climatic change[15].

The need to meet growing water demands for socio-economic development, especially in the rapidly growing urban and coastal zones and for agricultural production, but also to compensate for increasing evaporation and to mitigate frequent droughts will lead to accelerated exploitation of shared aquifers, including the coastal Mediterranean aquifers and the non-renewable aquifer systems within, and shared with countries outside the MEDA. The threats of aquifer depletion and salinization, and water and land degradation will have cross-boundary impacts with consequent inter-country pressures and potential conflicts.

Country commonalities and differences and regional inclusiveness

The uniform cultural characteristics in the MEDA supports a regional approach. However the capacity to handle increased water stress varies between the middle-income, service and urban-based economies, and the lower-income agricultural countries are different, and the scope for socially sustainable development in the MEDA countries with high dependence on transboundary non-renewable shared ground waters is disputed region-wide issue. Inclusiveness represents the rationale for regional approach to be implemented on the assumption that the MEDA countries (and possibly also other non-MEDA, Middle Eastern Countries) will eventually participate and cooperate under the regional policy framework. The ultimate effectiveness and success of the regional policy framework will benefit from political momentum and solid political base for regional cooperation and solidarity and irrespective of bi-lateral differences, if any.

Socio-economic drivers and opportunities for policy intervention

The socio-economic characteristics for the countries and for the MEDA region as a whole are summarized in Table 1. The data in the Table point at agriculture using 70–90 % of the scarce water resources, mainly as groundwater and contributes only 3–15 % in a majority of the MEDA economies.

[15]Climate Change: The MEDA countries coincide with the highest category , as: “Stressed countries with increase in stress”, for change in water stress building from climatic change (re: The Met Office Hadley Centre for Climate Prediction and Research).

	Population million	Poverty %	GDP* $ billion	GDP US $/cap.yr	Agric % of DGP
ALGERIA	32.5	23	212.0	6600	10.3
EGYPT	77.5	16.7	316.0	4200	17.2
JORDAN	5.8	30	25.5	4500	2.4
LEBANON	3.8	28	18.8	5000	12.0
LIBYA	5.7	–	37.5	6700	8.7
MOROCCO	32.7	19	134.6	4200	21.2
SYRIA	18.5	20	60.5	3400	25.0
TUNISIA	10.1	7.6	71.0	7100	13.8
TURKEY	69.7	20	508.0	7400	11.7
Total MEDA	256.3 $ million	47.8 $ million (av. 19%)	1383 $ billion		

Table 1. MEDA Countries: economic indicators

The imbalance should however be seen in the perspective of social policies at national level of food security and rural welfare and employment.

Key socio-economic issues-opportunities for policy intervention

The regional instruments on shared groundwater management are focused on and lay down the socio-economic factors together with the areas for policy interventions. The following list, presents examples of key socio-economic issues in relation to joint shared aquifer management in the MEDA region,

- urban growth with strong rural to urban migration,
- rapid irrigation expansion with increased agricultural water demands and pressure on the groundwater resources,
- action to improve the water economy and to mobilize alternative supplies – reuse of treated sewage water, use of saline, marginal groundwater etc.
- rapid growth in the tourism and industry sectors with resulting increased water demands, especially coastal resort areas with concentrated tourism development.
- increased water demands, as the consequence of inappropriate development models with no consideration of the water economy,

- dominant, growing and agricultural use and increase in irrigated area for intensified cash crop production of central importance for the socio-economic development of the society, and...
- growth and reallocation of the industrial sector without consideration of the environment and the growing water values in the region.

The identified opportunities for regional policy intervention, decision support and technical cooperation include:

1) Diversification of the regional economy: alternative tourism (eco-, desert-, and archaeological tourism; local handicraft industry, valuation of local resources and skill; services; and industrialisation adapted to the environment and the natural resources.
2) Reorientation of urban development, into a natural resources-based and low water-consuming approach.
3) Promotion of balanced sectoral water allocation, together with improved water economy in the agricultural sectorÿ and increased recourse to alternative supplies;
4) Emphasizing technical and socio-economic efficiency in water allocation.
5) Promote implementation of an integrated management of different (conventional and non-conventional – reuse, artificial groundwater recharge, desalinisation of marginal waters, etc.) supplies, and diversified exploitation of alternative aquifer resources;
6) Promote research on irrigation technology, soil and plant relations, irrigation efficiency and expanded agricultural waste water reuse and managed aquifer recharge,
7) Initiate and support the integration of research into the development of agro-pastoral, oasis, quanats and other threatened traditional social and water management systems,
8) Policy and strategic studies on intersectoral allocation, balancing supply/demand, as regionalized strategic studies implemented at national level.
9) Economic evaluation of an ensemble of alternatives, including valuation of the non-conventional supplies and groundwater abstraction, compared with water transfer between sub-zones within, and outside the shared aquifer systems.

National water policies, a starting point for TWM in the MEDA

Regional cooperation depend on domestic policy[16] and the National water policies in the MEDA countries represents a starting point for common action.

The MEDA countries are faced with two basic common water problems, summarized as: (a) Increasing demands, (b) limited resources, (c) inappropriate water usage. Behind these lie policy, socio-economic, and technical policy issues that vary for the conditions in the countries and that need to be recognized and considered in the regional perspective. The regional consensus on the objective of water policy intervention and reform is the achievement of sustained growth in the context of sound natural resources management. The issues and requirements for domestic policy actions coincide and there are opportunities for regional cooperation on common priorities.

Policy reform, for integrated macro-economic, agricultural and water resources policy to achieve socio-economic development and proper natural resources management on which sustainable development is dependant. In addition the population development policy represents a priority for action in most of the MEDA countries.

Social factors:

- The need to promote the conservation of water and its values,
- Development of awareness and skills to improve farming productivity and water efficiency, and
- Accelerated structural reform towards a service based urban economies.

Economic factors: To reconsider current economic incentives employed in some of the countries that give economic signals and continue to promote over-use and inefficient use of water.

Institutional framework: Rationalization of public water institutions including decentralization and devolution of authority.

Legislation: Water legislation is in need of review and strengthening, in particular in relation to the conservation and protection of water resources and related land and eco-systems.

[16]Which is contrary to international law that supersedes domestic legislation. (author's observation)

Technical factors: Alternative design and improved operation and maintenance to reduce water losses and protect actual investments, and a practical approach for improving the quality of database and enhancing its exchange.

Financial matters: Mobilization of financial resources through enhanced engagement of the private sector.

Agricultural groundwater use: The key factor in shared aquifer management and use in the MEDA.

Agricultural trade and exports: A critical driver for development and use, and a potential threat to shared groundwaters.

Structural change out of agriculture: Towards urban, industrial and service economies, managed sustainable groundwater use integrated with managed aquifer recharge and reuse, if driven at the regional level, could provide a unique option to induce change towards sustainable development and economic growth.

Towards a common regional vision in the MEDA

The group of MEDA countries, early in the longer process in moving towards the formulation and implementation of a regional policy framework with institutional mechanisms for inter-State cooperation on SGRM, started with identification of common opportunities, and of the risks and uncertainties for joint action:

Opportunities for defining and establishing a regional mechanism for inter-State cooperation

- An initial "low ambition" approach involving data exchange, joint identification and understanding of shared aquifer systems and issues related to shared aquifers management, confidence building, raising awareness, and capacity building,
- Focus on mutual benefits from a regional policy framework
- Take stock of existing cases for the implementation of such mechanism and build on existing experience on inter-state and sub-regional cooperation
- Capitalize on the interest of partners and stakeholders in implementing the policy framework either as observers or advisors

- Capitalize on the interest of donors and regional/international and UN agencies in supporting the sustainable management of shared groundwater resources

- Involve politicians and decision makers together with scientists and civil society groups, on as political, socio-economic, environmental and technical issues.

Risks and uncertainties

The regional policy framework need to adapt to the realities of water sectors in MEDA countries and regional specificities, with the specific cultural, socio-economical, and geo-political conditions posing risk and uncertainties in implementing the proposed policy framework:

- Prevalence of political instability in the region

- Lack of political commitment and/or good governance

- Inadequate technical capacity particularly in relation to monitoring networks

- Inadequate financial resources and water-related investment

- Lack of proper and affective institutional set up

- Inadequate and/or outdated legislations

- Weak enforcement capacities at both national and regional levels

- Lack of sensitivity to aquifer conditions and environmental issues

- Lack of sensitivity to impacts of international agricultural trade on groundwater-irrigated products

- Sensitivity of the issue of culturally-rooted concept of water as a non-commercial commodity and resistance to water pricing

- Lack of the concept of sharing external costs like environmental degradation from use of shared groundwater aquifer resources

- Lack of harmony and/or trust between riparians

Identified items for action

To progress and benefit from the opportunities for change, at minimum level of political and social risk and maximum flexibility to high political, policy and scientific uncertainties in the region it will be important to maintain good progress and momentum through a visible and diversified joint action programme. The following key activities are envisaged under the joint action programme:

- Jointly define a common draft risk management policy for shared groundwater management in the MEDA,
- Establish and manage joint on-line communication system on shared aquifer management,
- Establish a joint data base, including knowledge mapping on shared aquifer systems,
- Establish a common baseline assessment together with monitoring criteria and schedules on shared groundwater management, and
- Jointly develop and adopt common regional policy and technical guidance on key scientific, socio-economic, environmental and legal and institutional issues, including the following themes and issues:

1) *International groundwater water law*
   - Unilateral attitudes and positions on principles of customary international law,
   - Enhanced awareness and recognition of international law
   - Monitoring and indicators on legal performance at regional and domestic level

2) *Regional socio-economic cooperation*
   - Agricultural water use: Common/harmonized domestic agricultural and food security policies,
   - Sustainability and groundwater dependent ecosystems
   - Regional approaches to drought and other groundwater related emergencies

3) *Integrated Groundwater resources and environmental management*

- Shared groundwater quality and quality management
- Sustainability and groundwater dependent ecosystems
- Regional approaches to drought and other hydrological emergencies
- Inter-regional and intra-regional exchange and cooperation
- Common regional climatic change adaptation strategies
- Regional approach to sustainable development of non-renewable groundwaters
- Regional approach to management and protection of specific common aquifer systems (e.g. karst aquifer systems, and Mediterranean coastal aquifer)
- Regional strategy and programmes on non-traditional water supplies: managed aquifer recharge, waste water reuse.

Options for a regional policy framework and a consultation mechanism

A major challenge on shared groundwater in the MEDA is high agricultural groundwater use, linked to national agricultural, food security and rural development policies, especially for the current situation of structural change with the rapidly growing service and urban sectors. There are also systematic issues of the legal order common to the countries in the region conflicting sectoral policies, laws and institutions that are likely to affect implementation of shared groundwater management. The other group of challenge is growing recognition of ecological degradation of the groundwaters and the groundwater related land resources and groundwater dependent ecosystems.

Core proposal for a draft regional policy framework in the MEDA

The policy framework for transboundary groundwater management in the MEDA aims at a regional structure that organizes and coordinates existing capacity, experience and initiatives under one common regional framework. A common concerted effort is required, for effectiveness to secure necessary political foundation to mobilize inclusive cooperation and secure institutional and financial sustainability. There is also the prerequisite for consistency and efficiency.

A major challenge is to make the policy framework institutionally and financially sustainable based on contributions from the MEDA countries. Therefore the suggested approach is cautious building on two steps for setting up of the consultation mechanisms and the joint body, of (a) a minimal temporary structure for a transitional regional consultation mechanism; and (b) a permanent consultation mechanism based on a regional protocol.

Conclusion

Transboundary groundwater management has its focus at the domestic and local level and at regional land and environmental systems, involving a joint approach to common environmental risk and uncertainty, rather than allocation of transboundary water resources.

As a consequence when demands and competition for finite stored volumes of groundwater are growing, and the countries develop unilateral stands, built on wider security aspects beyond water allocation, a regional approach could be a powerful alternative to basin or aquifer based cooperation on TWM.

Recognizing the potentials for wider cooperation and development benefits of a regional approach the MEDA group of (10) highly groundwater dependent countries has initiated a dialogue for the development of a regional policy framework adapted to and with capacity to handle the specific political, and socio-economic aspects for transboundary groundwater management in the region.

It is suggested that a common regional concept could help in bridging bilateral issues and unilateral action and foster regional cooperation and secure effective and sustainable implementation and institutions in transboundary groundwater management. The region has the wider capacity to support and sustain an all-inclusive dialogue for confidence, participation and transparency though harmonized and equal capacity in transboundary water resources governance. A regional approach would also establish enabling capacity for an integrated regional environmental programme, beyond the water sector addressing priority transboundary issues in the region.

The wider benefits, and drivers are linked to the prospects of regional, and interregional development. From this aspect a regional initiative on SGRM, building on wider inter-regional exchange and assistance, is consistent with and will add to “water and environment for cooperation” for sustainable growth, stability and security.

IV

TRANSBOUNDARY WATERS MANAGEMENT AND THE EU-WATER FRAMEWORK DIRECTIVE

TOWARD A NEW INTEGRATED MANAGEMENT OF TRANSBOUNDARY RIVER BASINS EXAMPLE IN EUROPE. IMPLEMENTATION OF THE FRAMEWORK DIRECTIVE 2000–2015

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Abstract

For the first time in history, twenty-nine Countries are committed to jointly manage all their freshwater resources on a basin scale. The European Water Framework Directive sets "*a transparent, effective and consistent legislative framework*" for the community water policy. Its main challenge is achieving "good status" for surface and ground water before 2015. For such a purpose it relies on various key principles: the need for integrated water policy, the principles of precaution and preventive action, the "polluter-pays" principle, the recovery of costs linked to water use, a river basin approach and the involvement of the public in the decision-making process. As Europe is the continent where there are the greatest number of transboundary river basins shared between at least two countries or more, the Directive strengthens transboundary basin management and introduces the concept of "International Districts", for which the riparian Member States will have to comply with the same obligations as for the strictly national basins. The European Water Framework Directive cannot be "exported" as such in all developing countries, but its key elements can, such as securing public participation, creating basin councils, drawing up basin plans, establishing appropriate monitoring and enforcement, introducing cost recovery mechanisms. The important thing to "export" is the *process* of establishing an IWRM framework – the final shape varying from country to country.

Introduction

There are two hundred and sixty three rivers or lakes and hundreds of aquifers over the world, the basins of which are shared by at least two or more (up to eighteen) riparian countries.

Their specific situation should be better taken into account in the debates and bi-national and multilateral agreements on a new governance of water resources.

Many agreements were signed in the past centuries between riparian countries of transboundary rivers to ensure:

- free navigation
- more rarely the share of river flows or the prevention of floods,
- and, since the end of the nineteen century, the building of hydropower dams.

But, today, there are still too few agreements, conventions or treaties dealing with pollution control, aquifer management and a fortiori the integrated management of shared river basins.

However, in cooperation with international organizations and programs, several countries have already established, for a long time for some of them, a real basin organization and a large number are considering doing so.

The United Nations Convention on uses other than navigation in international river basins will take more than a decade to be ratified.

This is the reason why the International Network of Basin Organizations has had, for twelve years, the objective of strengthening and developing effective basin organizations over the world, especially for transboundary rivers, lakes and aquifers.

Indeed, river basins are the relevant territories in which water runs on the soil or in the sub-soil, whatever are the national administrative limits or international boundaries crossed!.

Integrated water resources management must be organized at the level of the basins, to ensure the sustainable development of our societies.

The European Water Framework Directive

In such a context, **the European Water Framework Directive of 23 October 2000**, especially demand that, from now on, the twenty five Member States and the four candidates countries to accession to the European Union delimit «International Districts», in which a «good ecological status» will have to be achieved before 2015 and lead to a harmonization of practices and to the improvement of management tools between the riparian countries of Transboundary waters, including with the neighboring countries of our new borders, in the Balkans and in Eastern Europe!

For the first time in history, twenty-nine Countries are committed to jointly manage all their freshwater resources on a basin scale.

The Directive of 23 October 2000 sets «*a transparent, effective and consistent legislative framework*» for the community water policy.

In Europe, the Community Directives are imposed to the Member States, which must not only transcribe them into their national law, but also apply them within prescribed times, unless they will face the risk of being prosecuted by the European Commission at the Court of Justice of the Union for lack of conformity and be condemned to very heavy financial obligations.

At the same time, the European Union passed to 25 Member States Member States in 2004, and maybe 29 later, with the accession of new Eastern European and Mediterranean Countries.

Very ambitious objectives

The Framework Directive objective for 2015 is the long term protection of the aquatic environments and water resources, to secure drinking water supply for the population and meet the economic needs in a sustainable manner.

Therefore, the objectives are both simple and very ambitious:

- stopping the deterioration of water resources,
- reducing the discharges of substances,
- and achieving a «good status» for water and aquatic environments.

But as everything is related at the basin level, the Directive cannot limit itself to the only issues of quality and conservation of the environments and must

take simultaneously all the aspects of water and land management into account, navigation, flood and drought prevention, water transfers or hydropower production in particular. . .

Basin management policy is not only water policy!.

The linkage to other policy areas becomes even more important as concepts such as "living with rivers" or "giving space to rivers" get greater weight.

A common method and principles for action

The preamble of the Directive proposes several main principles to the Member States:

- the need for integrated water policy,
- a river basin approach,
- the principles of precaution and preventive action,
- the principle of remedial measures at the source of the threats to the environment,
- the polluter-pays principle and the principle of the recovery of costs linked to water use «including environmental and resource costs»,
- decision making «at a level as close as possible to the sites of water use and degradation»,
- a «combined approach setting emission limit values and environmental quality standards»,
- involvement of the public as a condition for success.

The Directive proposes an overall approach, with a precise timetable, common methods and a progressive development of new tools.

The relevant scale is the river Basin

The Framework Directive plans for the establishment of hydrological districts in large basins.

It introduces new territorial concepts such as:

- «**sub-basins**», in which particular issues can be dealt with,
- the «**water bodies**», which are entities corresponding to homogeneous ecosystems where the obtained results will be evaluated and compared,
- «**heavily modified water bodies**», for which exemptions could be obtained by the Member States, by reasons of disproportionate cost, by too long delays in the building of infrastructures or pollutant migration or by existing uses, which cannot be suppressed.

Europe is the continent where there are the greatest number of transboundary basins shared between at least two countries or more.

The Directive strengthens transboundary basin management.

It introduces the concept of «**International Districts**», for which the riparian Member States will have to comply with the same obligations as for the strictly national basins.

The existing International commissions will be consolidated, new ones will be created.

In Europe, most of these International Commissions have a similar organization which is based on the plenary assembly of the international commission itself which makes the decisions committing the Member States, its permanent secretariat, and on many official geographical, sectoral or technical Working Groups which are the places where the decisions are prepared, the plans and programs developed or the common tools designed for observation, monitoring or warning in particular.

Here are some examples of International Commissions on various cases of European transboundary basins.

In each of these International Districts, a common characterization has already been established, and the following will have to be prepared: a master plan for the monitoring of the basin, an overall management plan and a program of measures to achieve the objectives of the Directive.

The new directive has significant innovations

- **It concerns all the environments:** rivers, lakes, groundwater, coastal water, are interdependent and must achieve the good status objectives.

- **The Directive introduces a socioeconomic approach and firstly requires the identification of water uses** and the assessment of the economic impact of these uses.
- **The Directive requires the establishment of a common frame of references for assessment**, allowing real analyses of the situations and strategies of the Member States. It is also a guarantee for transparency.

Today, the systems for assessing water quality and for formulating the objectives to achieve vary considerably from one country to another within the European Union.

Quality indicators and reference values will then be defined for each type of «water body» allowing, for example, exchanges of data and comparisons between countries.

The development of this European frame of references will take place up to 2006.

Inter-calibration procedures are also planned for to calibrate the data provided by the Member States.

- **The Directives requires a report on the recovery of the costs of services linked to water uses,**

It introduces into the economic calculation not only the traditional investment and operating costs, but also newer approaches, such as the calculation of opportunity costs between various uses of the resources and of the costs of the damage caused to the environment.

A demanding planning

For each District, «**management plans**», defining the objectives to be achieved, and «**programs of measures**», defining the necessary actions, must be formulated before 2009 at the latest.

The Directive provides an interesting methodology for developing these management tools: characterization of the current situation in the basins, an assessment of the pressures and their impacts and the identification of significant sensitive areas have been just carried out and will be used as a basis for the establishment of different baseline scenarios before 2015.

An iterative approach of the programs of measures will permit assessing:

- if the mere continuation of the current actions is sufficient to achieve the objectives, or
- if additional actions must be considered and if their financial or social cost is acceptable, or in the negative option,
- if exemptions are appropriate, whose justification will have to be made public and subjected to possible discussion.

Public consultation: A participative working method!

The Directive clearly stipulates that the water stakeholders must actively participate in all the steps of the management plan formulation.
The reference documents will be available to the public, the latter being consulted during the formulation of the management plan.
The methods for information, consultation, the gathering and processing of the comments of the public will be based on a concern for transparency of the costs, the assigned objectives and granted derogation, the evaluation and publication of results.
Consultations of the general public are required at the different steps of the process.

An obligation of result

The Directive imposes to the Member States to achieve the «good status» objective for water bodies before 2015, for all those which will not have benefited from of an exemption, because too heavily modified.

The obtained results will be evaluated and made public.

A precise timetable for implementation

The Directive sets out a precise timetable for its implementation:

- **2003: laws for transposition** of the Directive into the national legislations
- **December 2004:** characterization of **the situation** in the basins
- **December 2006:** setting up of networks for monitoring water quality

- **December 2009:**
  - definition of the objectives and justification for derogation, the district management plans;
  - formulation of the first action plans, the **programs of measures**;
- **December 2015:** Reporting on the achievement of objectives
  - new updating of the management plans
  - second action plans

We are thus committed from now on to carry out **the process with the obligation to succeed!**

Conclusion

The European experiment shows that, if water has no boundaries indeed, a suitable and constraining integrated management of the resources in the basins of rivers, lakes or aquifers shared by several riparian countries, is today necessary and can be considered with real ambitions.

The first results obtained are positive and stimulating.

Clearly, nowhere else in the world, we may see, officially and for twenty nine countries, a so high care of water resources management.

This does not mean that the European Water Framework Directive can be "exported" as an all to developing countries. The Directive itself is not universal. But its key elements are, such as securing public participation, forming basin councils, making basin plans, setting time-bound, measurable targets, establishing appropriate monitoring and enforcement, introducing cost recovery mechanismsĚ The important thing to "export" is the *process* of establishing an IWRM framework – the final shape varies from country to country.

Thus, obviously, the implementation of the *European Water Framework Directive* in the 25 countries of the enlarged European Union, and in the Countries applying for accession, seems a major fact for the dissemination of the good governance principles recommended by the International Network of Basin Organizations, which makes it a priority topic for the mobilization of its members, not only in Europe, but in all the Countries which would be interested.

TRANSBOUNDARY RIVER BASIN MANAGEMENT PLANNING (RBMP) AS SEEN BY THE WATER FRAMEWORK AND THE PROPOSED FLOOD DIRECTIVES OF THE EUROPEAN UNION

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Abstract

The natural and human boundaries that impose several conditions on water resources management are of special importance in the international river basins where water supply, water demand and water use have always some transboundary effects. Although the international river basin states are often party to international agreements on water protection and management, common framework is needed to coordinate RBMP efforts across the entire basin. Establishment of such a framework is the main purpose of the European Union Water Framework Directive 2000/60/EC of 23 October 2000. But the WFD introducing the principle of cross-border coordination within river basins, with the objective of achieving good quality for all waters, sets no objectives on flood risk management. This is why in January 2006 the European Commission presented to the European Parliament and the Council a proposal for a new directive on the assessment and management of floods. At the background of some comments on water management cooperation in international river basins, the paper examines transboundary issues in the EU Water Framework Directive and in the newly proposed Flood Directive. Complementarity of two directives is discussed and it is argued that their joint and coordinated implementation will be a good example of practical application of the Integrated Water Resources Management (IWRM) principles.

Introduction

The Integrated Water Resources Management (IWRM) is a process promoting an integrated –as contrasted with fragmented– approach to water management. According to the Global Water Partnership (GWP) IWRM is defined as:

> "...a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".

The IWRM principles are based on the recognition that each single water management intervention has consequences for the river basin as a whole. In other words, integrated management should be recognizing that multiple benefits may be achieved from each single intervention. These benefits include full spectrum of water management purposes, including water supply, nature protection, and protection against water related disasters such as floods and droughts.

The Integrated Flood Management (IFM) is essentially a subset of IWRM. Its objective is not only to minimize the potential human and economic losses from floods but also to maximize the efficient use of floodplains and protect ecosystems depending on periodical innundations. At the core of all that integration is effective communication across institutional, disciplinary, natural and human *boundaries*, which can take place only if there is a perception of common interest. Indeed, in order to resolve well known in water management disputes, all stakeholders have must do their best to appreciate and understand differing viewpoints in a rational and objective manner (WMO/GWP, 2005).

The level of difficulties in implementation of IWRM and IFM considerably increases in case of transboundary river basins. Although the contexts and circumstances differ widely across the world, about 260 major river basins and groundwater aquifers cross national boundaries. They cover about 50% of the land surface of the globe affecting 40% of its population (Wolf et al., 1999). As the demand for water increases, water quality deteriorates and flood phenomena intensify, there is an increasing need to manage water resources shared by two or more countries, which cannot be managed in an sustainable and integrated fashion because of inherent political and legal complexities. States located in the transboundary river basins usually pursue their national self-interests according to their own development objectives. But they often are constrained in their ability to act unilaterally because of water resources limitations or excess. In such cases, development of appropriate linkages between laws of nature and laws of man is imperative, ensuring that these laws are compatible and mutually reinforcing each other.

At the background of some comments on cooperation in the international river basins, the purpose of this paper is to examine some transboundary water resources management issues in the Water Framework Directive and in the newly proposed Directive on the Assessment and Management of Floods of the European Parliament and of the Council. According to these directives, a single and coordinated programme of water management measures is to be developed for each transboundary river basin. These programmes should satisfy in an integrating fashion the objectives of both documents. The objectives are on one hand to achieve "good" ecological status for all European waters and protected areas by 2015, and on the other, to reduce risk to human health, the environment and economic activities associated with floods in the Community. It is argued that integration of two directives and development of an integrated programme of water management measures is an important step towards practical implementation of IWRM principles in the European river basins which almost all cover the territory of more than one country.

Some comments on water cooperation in International River Basins

The economic, social and environmental aspects of transboundary water problems are difficult to solve, since planning of shared water resources development and protection cannot be regarded as a generally accepted obligation of sovereign states. It must be recognized, that the political feasibility of plan implementation is of the overriding importance in international basins. Depending on political circumstances, some alternatives may simply be impossible to implement. There is a need for international *cooperation* between riparian states. But if we define cooperation as behavior intentionally coordinated by two or more actors (Brown, 1992), there are many established mechanisms inducing cooperation: tradition, regulations, courts, markets (through the laws of supply and demand) and negotiations. In fact none of these mechanisms work in its pure form and the best results are achieved by their combination which suits best a given context.

Although the contemporary international relations theorists have not been able to devise any operational general model of cooperation, there are many examples of bilateral and multilateral cooperation that proceed from mutual calculation of benefits that would otherwise be unattainable. This is especially true in case of the so called *functional schemes*, for instance, the international transport system. Functional neutrality is often possible, whereas political neutrality is not. For example, political neutrality of water issues in the Middle East is rather a non-existent concept, but still functional arrangements in that

field have the virtue of technical self-determination which makes them more readily acceptable.

As far as regulations are concerned, the fundamental principles and procedural rulesof cooperation are codified in the *1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses*. Although the Convention does not provide a complete solution to all pending problems concerning the use of international rivers, its leading principles are of significant importance. Above all, they are firmly related to the concept of the *international watercourse* that is understood as "a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole". This provision is an application of the *principle of coherence*, based upon the hydrological unity of the river basin. As underlined by Manner (1987): "coherence does not imply territorial unity; on the contrary, it presupposes that the basin is divided into areas under separate territorial jurisdictions".

The Convention prescribe that each basin state is entitled to the *equitable and reasonable* share in the beneficial uses of basin's water resources, what many regard as the cornerstone of the law of transboundary watercourses. To be "equitable and reasonable", water use must also be consistent with adequate protection of the watercourse against pollution and other forms of degradation, including negative consequences of flood processes. Indeed, Part V of the Convention refers to prevention and mitigation of harmful conditions and emergency situations resulting, among others from natural causes, such as flood or ice conditions, siltation or erosion. Prevention and mitigation measures shall shall be taken individually and, where appropriate, jointly, by the watercourse states. In addition the Convention stresses the need of early notification of the potentially affected neighbouring states and encourages joint development of contingency plans for responding to flood emergencies.

It should be recognized that the concept of "equitable and reasonable sharing" is difficult to operationalize. First, water projects are capital intensive and allocation of their costs and benefits to individual states is usually subject to difficult negotiations that often extend far beyond water resources management. Second, the national water laws differ from one country to another. Third, the international water law is still far from being fully developed. The 1997 Convention undoubtedly constitute a major advance in international water law, but still they do not resolve some of the problems, among others, water quality aspects are not treated adequately.

In Europe, most of these aspects are considered also by the *1992 Convention on the Protection and Use of Transboundary Watercourses and International*

Lakes of the UN Economic Commission for Europe. This Convention entered into force in 1996. The aims of the Convention can be summarized as follows (Bosnjakovic, 1998):

- protection of transboundary waters (including surface and groundwater) by preventing, controlling, and reducing pollution;
- ecologically sound and rational management of transboundary waters;
- reasonable and equitable use of transboundary waters; and
- conservation/restoration of ecosystems.

The Convention defines *transboundary waters* as any "surface or groundwaters which mark, cross or are located *on boundaries* between two or more States", therefore, the 1997 Convention concerning *international watercourses* seem to be more in tune with the river basin approach of both EU Water Framework and the proposed Flood directives discussed in this paper.

Although the importance of territorial jurisdiction is not questioned by either of the two Conventions, the notion of *equity* in the division of jointly owned goods, such as water resources, is operationally difficult to define. The grand term itself has animated political philosophers since antiquity and it is of the utmost importance as one of the corner stones of the theories of social justice. There are no clear-cut rules, however, for translation of a notion of equitable share of the basin's water resources into a system of national property rights. In order to come to an agreement, the riparian States must negotiate in order to reconcile their often conflicting interests.

The importance of negotiations as the most common and *effective* procedure for establishing co-operation is generally acknowledged. The aim of negotiations is usually to design a *procedure* for managing water resources that the riparian States consider to be fair. How do we know that coperation is fair? One answer, proposed by Young (1994) is, that no advantage accrues from playing one role instead of another. In a way, it is analogous to saying, that the game playing field is level: "the players can expect to do as well no matter which end of the field they have to play on". Irrespective of definitional difficulties, indeed equity and fairness, even more than efficiency, are key values associated with transboundary water management.

The cooperative arrangements for water management in the transboundary river basins generally fall into one of two categories (Lonetgan and Brooks, 1993):"those aimed at an *equitable apportionment of water supplies* (e.g. the 1959 agreement between the then United Arab Republic and the Republic of

Sudan, and the Indus Water Treaty of 1960) and those which promote *joint management and exploitation of a river basin* (e,g. The Colombia River treaty of 1961 between the US and Canada". The worldwide experience shows that the second of these categories, is much more promissing. This is confirmed also by the 1992 UN/ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, mentioned earlier. The first meeting of the Parties to this Convention held in Helsinki in July 1997 decided among others, that one of the main programme areas is assistance in setting up joint river and lake commissions (e.g. International Commission for the Protection of the Danube River).

To summarize, there is no clear-cut answer to the question what circumstances favor the emergence of cooperation that is vital for water management in international river basins. There are no general hyphoteses apart from the tautological conclusion that cooperation will take place when the riparian States each calculate that the benefits of coordinated action exceed the benefits of unilateral uncoordinated action. But assessment of such benefits is a difficult task and usually is centered around a cluster of political, economic, and social issues going far beyond water resources management.

Transboundary issues in the EU Water Framework Directive

The Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 (in short Water Framework Directive, WFD) establishes a framework for Community action in the field of water policy. Following the WFD preamble, "within a river basin where use of water may have *transboundary effects*, the requirements for the achievement of the environmental objectives established under this Directive, and in particular all programmes of measures, should be coordinated for the whole of the river basin district. . . This Directive is to contribute to the implementation of Community obligations under international conventions on water protection and management, notably the United Nations Convention on the Protection and Use of Transboundary Watercourses and International Lakes, approved by Council Decision 95/308/EC and any succeeding agreements on its application". From the following text of the WFD it is clear, however, that the term "transboundary waters" is being used in the Directive in its wider sense of "international waters", as proposed in the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses.

According to the WFD "Member States shall ensure that a river basin covering the territory of more than one Member State is assigned to an international

river basin district. . . Each Member State shall ensure the appropriate administrative arrangements...for the application of the Directive within the portion of any international river basin district lying within its teritory. . . Where a river basin district extends beyond the territory of the European Community, the Member State or Member States concerned shall endeavour to establish appropriate coordination with the relevant non-Member States. . . ".

The WFD introduced the principle of transboundary coordination within river basins with the objective of achieving "good" status for all waters by 2015, but concerning flood management only contribution "to mitigating the effects of floods" is mentioned.

To define "good" status of surface waters the WFD uses two criteria: (i) "good ecological status", which is defined by Annex V and has to be assessed using *biological*, *hydromorphological*, and *physico-chemical elements of quality*, and (ii) "good chemical status" that means the chemical status achieved by a water body under which concentration of pollutants do not exceed the environmental quality standards established in Annex IX, under Art. 16, par. 7, and under other relevant Community legislation.

Regarding the *hydromorphological* elements of water quality, which are of special importance for all hydraulic engineering measures, including also those built for flood management, "good" status requires that:

- the quantity and dynamics of flow, and the resultant connection to groundwaters, should reflect totally, or nearly totally, *undisturbed conditions*,
- the continuity of the river should not be disturbed by anthropogenic activities allowing for *undisturbed migration* of aquatic organisms and sediment transport,
- the channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zones should correspond totally or nearly totally to *undisturbed conditions*.

Although this sounds as a total rejection of almost all hydraulic engineering structures built in the river channels, among others dams and storage reservoirs which are so important for flood management, the WFD provides that Member States may designate some water bodies as "artificial". The water body may be designated "artificial" when changes of its current hydromorphological characteristics necessary for achieving "good" ecological status, would

have significant adverse effect on other purposes of water management, for example protection against floods.

The WFD criteria of "good" status are the same for both national and transboundary river basins, but designating specific water body in one Member State "artificial" may have some implications for water bodies located in the downstream neighbouring states.

Transbounday issues in the proposed EU Directive on the Assessment and Management of Floods

The Explanatory Memorandum to the proposal for a Directive of the European Parliament and of the Council on the Assessment and Management of Floods of January 18, 2006, identifies two trends pointing to an increased flood risk and to greater economic damage from floods in Europe.

> "First, the scale and frequency of floods are likely to increase in the future as a result of climate change, inappropriate river management and construction in flood risk areas. Second, there has been a marked increase in vulnerability due to the number of people and economic assets located in flood risk zones".

The objective of the proposed Directive is to reduce and manage flood-related risks to human health, the environment, infrastructure and property. The Explanatory Memorandum points out that the WFD introduced the principle of cross-border coordination within river basins, with the objective of achieving good quality for all rivers, "but it set no objective on flood risk management". This is why, once the proposed Floods Directive is adopted, implementation of the two Directives which have complementary objectives will have to be closely co-ordinated.

The proposed Directive points out that a purely national approach to flood management is neither technically nor economically feasible, since most river basins are shared by between various countries. Coordinated planning and action must take into consideration the interests of all countries involved and the best use of resources. Such cooperation between countries has already commenced under the auspices of international river commissions such as those for the Danube, Odra/Oder, Elbe, Rhine, Maas/Meuse and Scheldt/Escaut basins. But the Directive will establish only a common framework to address shared challenges and will establish common approaches to flood management. "Detailed objectives for protection against floods, measures best suited to achieve the objectives and deadlines will be defined at the country level and not at EU level".

The Directive proposes the three-step procedure: (i) risk assessment, to identify "risk" and "no significant risk" areas, (ii) elaboration of flood-risk maps, and (iii) development and implementation of flood risk management programmes.

According to Article 12 of the proposed Directive:

> "In the case of an international river basin district falling entirely within the Community, Member States shall ensure coordination with the aim of producing one single international flood risk management plan... In the case of an international river basin district extending beyond the boundaries of the Community, where one single international flood risk management plan including any third country concerned is not produced, Member States shall produce flood risk management plans covering at least the parts of the international river basin district laying within the territory of the Member State concerned".

All national and transboundary flood risk management plans should include description of structural and nonstructural measures required to achieve the appropriate levels of flood protection, and this programme of measures should be fully coordinated with the programme of measures developed under the WFD.

Concluding Remarks

The development of river basin management plans under the WFD and of flood risk management plans under the proposed Flood Directive are elements of basin-wide integrated water resourcs management (IWRM). Similar to WFD, the proposed Flood Directive also provides that in the case of international (transboundary) river basins, Member States shall ensure that one single flood risk management plan is produced. To ensure efficiency and wise use of resources, implementation of the WFD and the proposed Flood Directive obviously needs to be closely coordinated. The WFD recognizes that in case some water bodies are used for different forms of sustainable human activities (e.g. flood risk management, nature protection, inland navigation or hydropower) they often impact adversely the natural hydrological regime, river continuity and morphological conditions. Such impacts should always be reduced to the largest extent possible but at the same time the WFD provides a clear and transparent process for addressing unavoidable impacts, including possible exemptions from the objectives of "good status" and/or of "non-deterioration" in its Article 4(7).

According to the proposed Flood Directive, Member States shall establish appropriate levels of flood protection specific to each river basin, focusing on the reduction of the probability of flooding and of potential consequences of flooding to human health, the environment and economic activity. The flood

risk management plans shall identify measures that aim at achieving the appropriate levels of flood protection. Those measures implemented in one Member State cannot increase flood risk in other neighbouring countries.

Although at the core of all river basin management planning is effective communication across institutional, disciplinary, natural and human boundaries, in case of international river basins special attention must be paid to integration of the objectives set up in different documents relating separately to different aspects of water resources management. In Europe, coordinated implementation of the EU Water Framework Directive and the recently proposed EU Directive on the Assessment and Management of Floods provide a good example in this respect. The overlapping "borders" of two directives should be carefully looked at.

The close links of the proposed Flood Directive with the Water Framework Directive should ensure that the coordinated plan and the programme of water management measures, both structural and nonstructural, will simultaneously contribute to the objectives of both documents. It will be ensured that the flood-related protective measures have no negative effect on the "good" ecological status of river basins and their waters, and *vice versa* – the WFD programme of measures will take into account the flood management objectives. Coordination of the "borders" of different legal documents referring to water resources management in the international river basins is of special importance for practical implementation of the IWRM principles.

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INTERNATIONAL WATER MANAGEMENT CO-OPERATION IN THE DANUBE BASIN

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Abstract

New challenge in Europe is the Water Framework Directive - 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. This EC Directive has to be implemented not only by the present EU Member States but also by all countries that are applicants for EU membership and if it is possibility for other countries in international river basins. The Directive is the ruling piece of legislation concerning the river basin management –in case of Hungary the Danube River basin– in a major part of Europe. In the Danube River basin District there are six EU Member States but all the other countries on the entire watershed agreed on to implement the Water Framework Directive jointly. The appropriate co-operation and co-ordination of all water-related institutions and experts can help this process, from regional through transboundary to international level. The list of the existing water related co-operations on different levels presented in this paper is not complete at all but even in such a phase can show that how many different co-operations exist in the Danube Basin. A loose network of these co-operations could help the implementation of the EU Water Framework Directive. Most of the listed co-operation got observer status to the Convention on Co-operation for the Protection and Sustainable Use of the River Danube. In such a network every form of co-operations should hold own independence avoiding its overlapping at the same time.

The different levels of the Co-Operations

The Danube River basin is the second largest river basin of Europe covering 801.463 km^2 and territories of 18 states including EU Member States, Accession Countries and other states that have not applied for EU membership. There are 13 countries sharing more 2.000 km^2 - Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech republic, Germany, Hungary, Moldova, Romania, Serbia and Montenegro, Slovak republic, Slovenia and Ukraine. Coun-

tries sharing less 2.000 km^2 are Switzerland, Italy, Poland, Albania and Macedonia. The Danube River basin has a rich history with strong cultural heritage. This is also reflected in the large number of ethnic groups in the basin and the large number of languages spoken. The keen and many-sided water related co-operation has also long and rich history.

New challenge in Europe is the Water Framework Directive - 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. This EC Directive has to be implemented not only by the present EU Member States but also by all countries that are applicants for EU membership and if it is possibility for other countries in international river basins. The Directive is the ruling piece of legislation concerning the river basin management –in case of Hungary the Danube River basin– in a major part of Europe. In the Danube River basin District there are six EU Member States but all the other countries on the entire watershed agreed on to implement the Water Framework Directive jointly. The appropriate co-operation and co-ordination of all water-related institutions and experts can help this process, from regional through transboundary to international level. The appropriate co-operation and co-ordination of all water-related institutions and experts can help this process, from regional through transboundary to international level.

In the water management of a country with shared watersheds beyond the regional and national level usually the transboundary level of the co-operation is the basic one. The next is the catchment level (in case of large catchments like Danube sub-catchment level as well) and then those international co-operations and organisations that can give common basis for the adequate and comparable water management practice.

The list of the existing water related co-operations on different levels presented in this paper is not complete at all but even in such a phase can show that how many different co-operations exist in the Danube Basin.

The list of different levels of the Hungarian-related co-operations in the Danube Basin:

- **National level**
  - transboundary commissions
- **Catchment level**
  - Convention on Co-operation for the Protection and Sustainable Use of the Danube River (DRPC)

- International Association for Danube Research (IAD)
- International Association of Water Supply Companies in the Danube Catchment Area (IAWD)
- Danube Commission
- Forum of the Danubian Hydrological Services
- International Hydrological programme of UNESCO
- Regional co-operation of the Danube countries

- **EU level**
  - 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the filed of water policy

- **International level**
  - Convention on the protection and use of transboundary watercourses and international lakes
    World Meteorological Organisation

Transboundary level

Hungary with its 93.030 km^2 territory 100% belongs to the Danube River Basin and situated in the middle of the catchment.

In Hungary 96% of the surface water resources originate from the neighbouring countries. It explains that in the water management have such an important role the joint commissions on transboundary waters between Hungary and the neighbouring countries.

Before the East-European political exchanges at the end 1980s Hungary had five neighbouring countries (Austria, Czechoslovakia, Soviet Union, Romania and Yugoslavia) and had with all of them agreements on the transboundary water related questions. Nowadays Hungary has seven countries around (Austria, Slovakia, Ukraine, Romania, Serbia and Montenegro, Croatia and Slovenia). Only one of them did not change the official name (Austria) and two of them have the same territory even now (Austria and Romania).

Today Hungary has seven transboundary agreements in force and accordingly seven joint commissions on transboundary waters (later joint body). With Croatia and Slovenia Hungary signed the new agreements on joint body in

1994, while with Ukraine in 1998 and with Romania in 2003. The new, updated Agreement with Slovakia has been elaborated and like the new agreement with Romania, will be based on the EU Water Framework Directive and Convention on Cooperation for the Protection and Sustainable Use of the Danube River (DRPC), taking into account the Helsinki (Convention on the protection and use of transboundary watercourses and international lakes) Convention as well.

The general feature is that each joint body consists of Hungarian Delegation and Delegation of the other Contracting Party. Each head of delegation, the plenipotential has one or two deputies, all authorised by their governments. The head of these joint bodies in Hungary are nominated from the Ministry of Environment and Water. In the neighbouring countries the head of joint body is nominated also from the water or environment related ministry. The committees have one session per year led by heads of delegations and another by the deputies as a rule. In certain cases can be organised extra sessions. The sub-committees/expert groups/working groups are organised under the joint bodies according to rivers and/or functions. Numbers and competencies of the sub-committees are different from relation to relation. For certain tasks the Committees establish ad hoc sub-committees.

All the Agreements and joint bodies have a relatively long story, started with the Peace Treaty after the World War I, when new frontiers were established crossing the catchment areas of the watercourses coming from the new states around Hungary. Coming from the nature of problems prevailing that time main items of the agreements were (and in certain cases are) the security against floods, the drainage of excess waters, financial questions, etc. New agreements were signed after the World War II. The first opportunity of placing the agreements upon a common basis is just the situation when the Helsinki and the Sofia Conventions have been already entered into force in 1996 and 1998; however one has to count with some differences even among the new and/or updated agreements. The EU Water Framework Directive has a certain effect on all transboundary cooperation. Nowadays all of them are dealing with the implementation of EU WFD in frame of either new expert groups or as new topic in the already existing sub-committees.

At the first stage the Agreements covered mainly the flood control questions, at the second stage the surface water management problem too, later the water quality questions and the problem of water resources management were included while the next stage will be the groundwater related issues. In the beginning the agreements were valid only for several kilometres from both sides of the frontiers, but today we are going into the directions of the whole catch-

ment area, as it is required by the implementation of the EU Water Framework Directive as well.

Catchment level

Convention on Co-operation for the Protection and Sustainable Use of the River Danube

On 29 June 1994, in Sofia, Bulgaria, eleven of the Danube Riparian States (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Romania, Slovak Republic, Slovenia, Ukraine) and the European Union signed the Convention on Co-operation for the Protection and Sustainable Use of the River Danube (short title: Danube River Protection Convention-DRPC).

The main objectives of the Convention:

- sustainable and equitable water management
- conservation, improvement and the rational use of surface and groundwater in the Danube catchment area
- to control the hazards originating from accidents involving
- damage-free floods
- to reduce pollution loads of the black Sea from sources in the Danube catchment area

In May 1998 the ninth signatory of the DRPC ratified the Convention. According to its Article 27 the Convention could therefore enter into force on October 22, 1998. The first meeting of the Steering Committee (Heads of Delegation) took place in Vienna in October 1998. Then was established the International Commission for the Protection of the Danube River (ICPDR). ICPDR is a transnational body that is formally comprised by the Delegations of all Contracting Parties to the Convention, but has also established frameworks for other organisations join.

The main bodies established under the Danube River Protection Convention are: Conference of the Parties; ICPDR; Permanent Secretariat; Expert Groups; Ad-Hoc Groups and Sub-Basin groups. The Conference of the Parties is the highest level body under the Convention. The different bodies of the ICPDR are the Ordinary Meeting Group that takes the political decisions; Standing Working Group that provides political guidance and the technical expert groups that prepare the technical background documents. The Permanent Secretariat located in Vienna, Austria.

The permanent and ad hoc expert groups nowadays under the Convention are:

- Expert Group on River Basin Management
- Monitoring and Assessment Expert Group
- Pressures and Measures Expert Group
- Expert Group on Flood Protection
- ad hoc Information Management and Geographical Information System Expert Group
- ad hoc Public Participation Expert Group
- ad hoc Strategic Expert Group

The Danube River Basin is the second largest river basin in Europe covering 801.463 km^2 and territories of 18 states including EU Member States, Accession Countries and other states. The largest tributaries to the Danube are the Tisza River 157.186 km^2 and Sava River 95.719 km^2. It explains that the sub-basin approach is important. In December 2004 was signed MoU towards River Basin Management Plan including flood defence for the Tisza River supporting sustainable development of the region by the 5 Tisza countries (Slovakia, Ukraine, Romania, Hungary, Serbia and Montenegro). There was established the Tisza Group to implement the tasks. With the support of the Stability Pact for South Eastern Europe Bosnia and Herzegovina, Croatia, Serbia and Montenegro and Slovenia signed The Framework Agreement on the Sava River Basin in December 2002. The Agreement entered into force in December 2004. One of the objectives of this agreement is also preparation of river basin management plan. There is sub-basin approach for River Prut and Danube Delta as well.

On the joint proposal of Austria and Germany in 2000, that time the only Danubian countries being members to the European Union, the Contracting Parties confirmed their political commitment to support to elaborate a coordinated river basin management plan for the entire Danube River Basin in line with the requirements of the EU Water Framework Directive using the ICPDR as the common platform for it. The River Basin Management Expert Group was established in 2000 for the implementation of the EC Water Framework Directive. This group coordinated the following two reports sent to the EU:

- Information required according to Article 3 (8) and Annex I of the EU Water Frame-work Directive (reporting deadline: 22 June, 2004)

- The Danube River Basin District – River basin characteristics, impact of human activities and economic analysis required under Article 5, Annex II and Annex III, and inventory of protected areas required under Article 6, Annex IV of the EU Water Framework Directive (2000/60/EC) (reporting deadline: 22 March 2005)

Preparation of these reports was partly supported by the UNDP/GEF Danube Regional Project and can be downloaded from the ICPDR website.

International Association for Danube Research(IAD)

The International Association for Danube Research (IAD) was founded in 1956 with the goal of promoting and co-ordinating activities in the fields of limnology, water management and water protection in the Danube River basin. The Association is incorporated into the Societies Internationalis Limnologiae (SIL). 11 countries are IAD members: Germany, Switzerland, Austria, Slovakia, Hungary, Croatia, Bosnia and Herzegovina, Yugoslavia, Bulgaria, Romania and Ukraine. The official languages are German and English. Conferences are held annually except for the SIL Congress years.

The main research areas of the IAD are:

- development of ecological river concepts and models
- eco-morphological mapping of the River Danube and its tributaries to identify areas needing restoration
- preservation or promotion of biodiversity by ecological improvements of the habitats of threatened and rare species
- studies of fish-ecology to ensure sustainable fishery practices
- interactions between river system, floodplains and wetland areas
- development and standardisation of additional chemical parameters for water quality monitoring
- quality management in data acquisition for improved comparability and evaluation of research
- mapping of the biological quality of waters according to the saprobic system
- long-term studies on the development of invertebrate stocks of Danube ecosystem

- microbiological and hygienic assessment of the river
- investigation and mathematical modelling of biological transformations of material and interactions between river structures, water quality and biocenoses
- definition of quality targets for local uses of river water on the Middle and Lower Danube
- nutrient content and trophic state of the Danube with special reference to the delta and the adjacent part of the Black Sea
- inventory of aquatic vegetation in the delta, in the main channel, and in the floodplain waters of the Danube
- concentrations and ecotoxicity of contaminants in sediments and suspended solids
- application of ecological short-term and long-term tests for monitoring contaminant concentrations and investigation of the lethal and chronic impacts on organisms (bio-accumulation)
- implementation of automatic bioassay systems for the protection of biocenoses and early recognition of pollution pills

International Association of Water Supply Companies in the Danube River Catchment Area (IAWD)

The International Association of Supply Companies in the Danube River Catchment Area (IAWD) was founded in Vienna in 1993 with the aim of improving and safeguarding the water quality of the Danube and its tributaries. Members are public water services and water supply companies from Germany, Switzerland, Austria, Slovakia, Czech Republic, Hungary, Croatia, Slovenia, Serbia and Montenegro, and Romania.

IAWD encourages all measures and attempts directed at avoiding and eliminating the contamination of and hazards to the raw water quality in order to ensure reliable drinking water supply.

With a view to achieving these goals, every effort is made to unite the water companies of all countries in the Danube catchment area in the IAWD to encourage concerted action towards on the following objectives:

- representing the interests of all drinking water supply companies in the Danube catchment area

- developing a uniform, internationally agreed monitoring and investigation programme to safeguard water quality as well as evaluating and publishing the results obtained
- making the results of this work available to national and international institutions public relations
- maintaining a regular and continuous exchange of experience between members cooperating closely with other organisations, which pursue similar objectives

IAWD is an independent technical organisation set up as a non-commercial, non-profit organisation that serves only public and scientific goals. Today's water-related problems can only be solved by joining forces in cross-border cooperation. The particular circumstances of the water companies in the eastern European Danube catchment area are given special consideration.

Danube Commission

The Convention regarding the regime of navigation on the Danube signed in Belgrade on 18 August 1948. The Danube Commission, which consists of the representatives of the Member States, has been established to supervise the implementation of the so-called Belgrade Convention. First the Commission's headquarters were located in Belgrade, than in 1954 it was transferred to Budapest. Twice a year, the Danube Commission holds its ordinary sessions and if necessary, the Commission may hold extraordinary meetings. The Commission regularly convenes groups of experts of the Danube countries for the consideration of items provided for the working plan. Members are to the Convention: Germany, Austria, Slovakia, Serbia and Montenegro, Bulgaria, Romania, Ukraine, Russia, Croatia and Moldova. The official languages of the Commission are the German, French and Russian.

The Convention of Belgrade regulates the unrestricted navigation on the Danube up to Ulm as well as individual tasks and legal status of the Danube Commission. To ensure and to improve the conditions for navigation on the River with respect to technical, nautical and administrative issues the Commission also deals with hydrometeorological, hydrological, hydraulic and legal topics. Due to regulation works affecting the flow regime and the limnological behaviour the Commission established a working group on hydrology, concerned particularly with the acquisition and exchange of hydrological data, data on water resources as well as discharge forecasting. Since 1953 is published the hydrological yearbook.

Forum of the Danubian Hydrological Services

The first meeting of Forum of the Danubian Hydrological Services had accepted the following guiding principles of the co-operation:

- The Forum is an unofficial body of representatives of National Hydrological Services (NHS) in the Danube River Basin having as an objective to discuss professional, managerial, financial etc. Issues of operating NHSs to gain mutual information on the relevant problems and their solutions. The Forum would not deal with the hydrological programmes under the aegis of UNESCO/WMO and other international organisations.
- The participants cover the cost of the travel and accommodation
- The working language is English

The organizing country sends the invitation letter to Hydrological Services of Albania, Austria, Bosnia and Herzegovina, Bulgaria, Czech Republic, Croatia Germany, Hungary, Italy, Poland, Romania, Slovenia, Slovakia, Switzerland, Yugoslavia and Ukraine, and as to observers to the Danube Commission and to the ICPDR.

Regional co-operation of the Danube countries in the frame of the International Hydrological Programme (IHP) of UNESCO

The co-operation of IHP National Committees of the Danubian countries –Germany, Austria, Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Yugoslavia, Bosnia and Herzegovina, Moldova, Romania, Ukraine, Albania, UNESCO and from 2001 ICPDR– in the framework of the International Hydrological Programme of the UNESCO divides into *two fields*

- organisation conferences on hydrological forecasting and the hydrological basis of water management (XXI. - September 2002. Bucharest, Romania)
- hydrological co-operation on expert level

Referring to the Principle of this regional co-operation the working languages are Russian and German, and in the last years is used as third one the English. The overall co-ordination is performed by an IHP Committee of one of the participating countries, in turns.

From 1965 till 1974 the co-operation took part in the framework of the International Hydrological Decade of UNESCO, later on in the International Hydrological Program of UNESCO. The co-operation aims to contribute by common efforts of all Danubian countries to the solution of current hydrological and water management issues of the whole River basin. This hydrological co-operation is basically a financially self-sustaining venture.

The countries took the co-ordination in the following order:

1974 – 1986	Slovakia and Yugoslavia
1987 – 1992	Germany
1993 – 1998	Austria
1999 – 2003	Slovakia
2003 – 2005	Hungary
2006 –	Serbia-Montenegro

As the main result of the first period was published in 1986 the Hydrological Monograph of the Danube basin (Hydrology of the River Danube)

- **Part 1.**
  - *Chapter I.* Physical-geographical and water management characteristics of the Basin
  - *Chapter II.* Hydrological regime of the Danube and the most important affluent
  - *Chapter III.* Water balance of the Danube
- **Part 2.** Tables of water levels and flows of 48 representative gauges
- **Part 3.** Maps

List of the printed reports issued from 1993 till 2006 (in brackets the year of publication and the project coordinator country):

- Sediment regime of the Danube (1993 – Hungary)
- Thermal and ice conditions of the Danube and its major tributaries (1993 – Czechoslovakia)
- The fords of the Danube (1996 – Hungary)
- Palaegeography of the Danube and its catchment (1999 – Hungary)
- Coincidence of the flood waves of the Danube and its tributaries (1999 – Yugoslavia)
- Danube River Basin Coding (2000 – Slovenia)

- Regional analysis of the annual peak discharges in the Danube Catchment (2004 – Romania)
- Flow regime of the River Danube and its catchment (2005 – Germany, Hungary)
- Basin-wide water balance in the Danube River basin (Slovakia)

European Union Level

As the EU Water Framework Directive (later on WFD) has to be implemented not only by the present EU Member States but also by all countries that are applicants for EU membership, the Directive will be the ruling piece of legislation concerning the river basin management in a major part of the UNECE region. The WFD underlines the necessity of transboundary co-ordination. The requirement to produce coordinated river basin management plans for entire river basin districts until 2015 will compel States to evaluate whether the capacities, structures, mandates and legal basis of existing joint bodies are sufficient to meet the challenge of the WFD or whether there is a need to adapt them or to establish new ones.

The WFD comprises some important new concepts as:

- the concept of river basin district, the area of the whole river catchment with their associated groundwaters and coastal waters as main unit for the management of river basins,
- the assessment of the status of water bodies on the basis of ecological status defined by biological, hydro-morphological, and physico-chemical quality elements,
- the establishment of type-specific reference conditions,
- the combined approach using control of pollution at source through the setting of emission limit values and of environmental quality standards,
- the integration of economics into water policy and planning via the economic analysis of
- water uses and the use of pricing to encourage better water uses and to recover costs

The Common Implementation Strategy for the WFD (known as the CIS) was agreed in May 2001. The main aim of the CIS is to provide support in

the implementation of the WFD, by developing a common understanding and guidance on key elements of this Directive.

Following the achievements of the 2001/2002 Work Programme the priorities and organisational structure of the CIS was reviewed by the Water Directors in November 2002. The new focus has led to the review and reduction of the number of the working groups into four key groups:

- Ecological status
- Integrated River Basin Management
- Groundwater
- Reporting

A Strategic Co-ordination Group oversees these working groups and reports to the Water Directors of the European Union, Norway, Switzerland, The Candidate Countries and Commissions, the "driving force" of the CIS.

International level

UN/ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes under the UN/ECE auspices came into force on 6^{th} October 1996. It has been ratified by 32 countries – Albania. Austria, Azerbaijan, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Kazakhstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Moldova, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine and the European Community.

The Riparian Countries to the same watercourse or lake under the Convention meet to harmonise their approaches and to define their rights and obligations. As many countries depend on transboundary water resources the Convention bringing the Riparian Countries together can help to prevent disputes over the use of transboundary waters.

The first Meeting of the Parties was held in June 1997, in Helsinki, the second one in March 2000, in The Hague. *Referring to the work plan 2004–2006 the following programme areas were accepted:*

- Programme area I: Promotion of the Convention and its activities and advisory service
- Programme area II: Integrated management of water and related ecosystems
  - flood prevention and protection
  - ecosystem approach in water management
  - implementation of the water Framework Directive
  - integrated management of transboundary waters in Eastern Europe, the Caucasus and central Asia
  - water and industrial accidents
  - management of transboundary waters in the UNECE region
  - interim implementation of the Protocol on Civil Liability
  - review of achievements, policies and strategies regarding the protection and use of transboundary waters
- Programme area III: Monitoring and assessment
  - strategies for monitoring and assessing transboundary waters – strategic and technical guidance
  - pilot programmes on monitoring and assessment
  - assessment and reporting
- Programme area IV: Water and human health
  - Protocol on water and health: interim implementation
  - preparation for the first meeting of Parties to the Protocol

The following working groups undertake the tasks under these programme areas

- Working group on integrated water resources management
- Working group on monitoring and assessment
- Working group on water and health

World Meteorological Organisation – Commission for Hydrology

Hydrology and Water Resources Programme (HWRP). The activities under the HWRP concentrate on operational hydrology and on water resources assessment in general. They include the measurements of the basic hydrological elements from networks of hydrological and meteorological stations; the collection, processing, storage, retrieval and publication of hydrological data; the provision of such data and related information for use in planning and operating water resources projects; and the installation and operation of hydrological forecasting systems. Hydrological data are taken to include those on the quantity and quality of both surface and groundwater.

Regional Association VI. (RA-VI) Working Group on Hydrology. The HWRP incorporates and supports a wide range of activities related to education and training in operational hydrology. Regional aspects covered by the six regional associations (RAs) of WMO through their Working Groups on Hydrology.
The RA-VI. (Europe) Working Group on Hydrology its working plan for 2006–2009 deals with the following topics:

- Public Relations and Visibility of Hydrological Services
- Networking for contributions to regional initiatives related to water
- in particular to the Water Framework Directive
- Water Monitoring and assessment (technical aspects)
- Climate and Water
- Potential Extreme Floods
- Drought and Forecasting
- Subgroup on Flood Forecasting and Warning

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THE ALBUFEIRA AGREEMENT FOR THE SUSTAINABLE USE OF SHARED RIVER BASINS BETWEEN SPAIN AND PORTUGAL

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Historical Background

Spain and Portugal share the territory of the Iberian peninsular, whose geomorphological characteristics are such that most of the territory drains towards the Atlantic Coast. In fact, both countries have several river basins in common such as the Miño, Limia, Douro, Tagus and Guadiana, whose main characteristics and relative importance as regards surface area covered and water yield within the boundaries of the two countries can be seen in Table 1.

The history of Spanish-Portuguese relations where the subject of water is concerned, dates from the Treaty of Limits of *29th September 1864 and of the Supplement* to it incorporated by means of an Exchange of Notes in September 1912, subsequently the agreement to regulate the hydroelectric use of the International stretch of the River Douro, dating back to 11th August 1927 and, more recently, the Agreements of 16th July 1964 and 29th May 1968. The agreement of 1927 was superseded by the Agreement of 1964, whereas, until the time of signing the new agreement that is the subject of this communication, the annex to the treaty of 1912 was subsidiary in nature, the agreements of 1964 and 1968 remaining fully in force.

The *Treaty of Limits* of 1864 was the first one to consider the boundary rivers, albeit by way of accepting that they serve to mark the frontier between the two countries, going no further than pointing out that the resources existing in these stretches must be used for mutual benefit and that neither country

	Area (Km^2)			Average annual draining ($Km^3/year$)		
River Basin	Spain*	Portugal**	Total	Spain*	Portugal**	Total
Cantábricas	24.642	0	24.642	19,6	0	19,6
Atlánticas gallegas	11.827	0	11.827	11,1	0	11,8
Miño/Minho	16.230	850	17.080	11,1	1	12,1
Limia/Limia	1.300	1.180	2.480	1,2	1,5	2,7
Entre Niño & Duero	0	3.780	3.780	1,2	3,5	4,7
Duero/Douro	79.000	18.600	97.600	13,7	9,2	22,9
Entre Duero & Tajo	0	14.000	14.000	0	5,9	5,9
Tajo/Tejo	55.800	24.800	80.600	12,2	6,2	18,4
Sado, Mira & Algarve	0	13.900	13.900	0	1,5	1,5
Guadiana	55.300	11.500	66.800	5,5	1,9	7,4
Atlántico Sur	4.612	0	4.612	1,1	0	1,1
Guadalquivir	54.970	0	54.970	6,9	0	6,9
A té Gibraltar	7.792	0	7.792	0,9	0	0,9
Entre Gibraltar & Ebro	79.827	0	79.827	7,5	0	7,5
Ebro	84.552	0	84.552	18,2	0	18,2
Entre Ebro and France	16.493	0	16.493	2,7	0	2,7
TOTAL	492.345 (207.630)	88.610 (56.930)	580.955 (264.560)	113,6 (43,7)	30,7 (19,8)	144,3 (63,5)

Table 1. Characteristics of the Peninsular Basins.
* Source: Water in Spain White Paper, 2000
** Source: National Water Plan of Portugal, 2001.

must lose out. The *Addition* to this treaty, which, following its publication in the State Gazette on 17^{th} September 1912, acquired the status of an annex to that Treaty, was a short set of rules for the industrial use of the water along the boundary stretches of the rivers that we are considering. The same rights and half of the flow were assigned to each country, and it established the requirement of presenting a technical project for any industrial use that was planned and that this project be subjected to an international commission whose decisions in this respect would have to be adhered to, and that the aforementioned commission would have the right to inspect and monitor the works and the licence that was granted.

However, the *Agreement of 16^{th} July 1964 between Spain and Portugal to regulate the hydroelectric use of the international stretches of the River Douro and its tributaries and the agreement and protocol between Spain and Portugal signed on 29^{th} May 1968 to regulate the hydraulic use of the international stretches of the rivers Miño, Limia, Tagus, Guadiana, and Chanza and their tributaries* has, without doubt, allowed for a greater development of the water resources in these frontier areas of the rivers and has consequently created wealth for both countries, but it has gone no further than that: a framework to promote mere industrial or, more precisely , hydroelectric development. The agreement of 1964, through its 25 articles and an additional protocol, together with the 1968 Agreement, with its 26 articles and another additional protocol make a detailed sharing of all the frontier stretches between both nations, establishing a principle of allocating 50% of the hydropower generation capacity to each country by earmarking particular sub-stretches and height difference for hydropower use, the following aspects of distribution being highlighted:

- The use of the international stretch of the River Douro was shared between the two countries.
- The frontier stretch of the River Tagus was assigned completely to Spain.
- The upper frontier stretches of the River Guadiana were assigned to Portugal, as it would be affected by the Portuguese Alqueva Hydraulic Scheme; the lower international stretch was not assigned, as it is of no hydroelectrical interest.
- The River Chanza, a tributary of the Guadiana, was assigned to Spain.
- Spain was allowed to transfer water from the River Tua, a tributary of the Douro, to the River Miño basin.

In contrast to what we could call the 1912 Agreement, those of 1964 and 1968 include in far greater detail those aspects relating to licences, bound-

ary rights, compulsory purchase, temporary occupation, declarations of public interest, dealing with and giving approval to projects etc. However, most importantly, both agreements give a naturalisation charter to "*The Spanish-Portuguese commission to regulate the use of the international rivers in their frontier areas*" that for all this time has been the framework where actions, works and licenses have been approved, and problems concerning boundary rights, compulsory purchases, adverse effects of uses on the other party, and incidents have been overcome. They have carried out policing work of the waters, inspection of work, their exploitation control etc. As a significant aspect, the agreement of 1968 also included some references to certain matters other than hydroelectricity, such as the need to guarantee minimum flows during drought or those relative to fish conservation, invariably in accordance with the national legislation concerned.

The need for a new Co-operation Framework

There were three kinds of reasons that led the parties to consider the need for a new agreement at the beginning of the 90's: objective, basic and the current situation.

Objectively, as has been stated earlier, these agreements have allowed for great development of hydroelectric use along all the frontier stretches, leading to a very positive balance for the two countries, as nearly all the actions foreseen in them have been carried out. All that remains to be finished is the use of the Alqueva on the Portuguese Guadiana, near to completion, that of the Tua and the joint use of the Sela on the Miño. Although these agreements fulfilled the purpose for which they were intended, the model itself has become obsolete. Its legal framework was insufficient and it became necessary to review or update it.

As a basic reason, during the last third of the 20^{th} century Spain and Portugal have undergone far-reaching changes from political, economic and social perspectives. This situation has involved an increase in water use, with the consequent modifications to the river regimen. As well as an increase in inter-sector, and even inter-territorial competition with regard to the use and availability of water and a progressive deterioration of its quality. These trends, typical of societies with a mature water economy, are reinforced by the change in attitude to water resources that is taking place on an international and even a world scale. Water is no longer considered to be just one more economic factor in industry, energy, agriculture or supply but also a resource of major importance from a health and hygiene viewpoint. It is now accepted that it is a

scarce and precious natural resource that needs protection, bearing in mind the important role that water plays in the environment in general, so the resource must be managed within a framework of sustainable development. Furthermore, Spain and Portugal joined the European Community (now Union) on 1^{st} January 1986. This meant a new standards framework in the environmental field and, in particular, with respect to water, not only regarding the fulfilment of regulations but also to the necessary co-ordination between both countries.

However, without any doubt, the political situation in Spain and Portugal was what finally created the moment for the beginning of negotiations, as well as their development and final outcome. Ever since the Water Act 29/85 dated 29^{th} August came into force, the hydrological planning process required by the law was initiated in Spain as one of the main bases for the new water control policy. The Basic Documentation and the Directive Projects affecting the different basins began to be formulated and, in April 1993, the Spanish Government presented a proposal for a National Water Plan. This was received in a very negative light by Portuguese public opinion, very sensitive to water-related topics with Spain, as a policy of *fait accompli* that ignored Portugal, since the policies of Spanish water planning, basically in the expectations of new irrigation areas that were foreseen in the water plans for the Douro, Tagus and Guadiana basins and the plans for new schemes to transfer water from the Douro and Tagus towards the south-west, because Portuguese opinion believed that this could lead to a blocking of that country's water policy. The situation was further complicated because the effects of the serious drought that had been affecting Spain for several years were being felt in Portugal at the same time.

Negotiation process

Since the summit meeting between the Portuguese and Spanish governments that took place in Palma de Majorca in the autumn of 1993, the formal negotiation process began to widen the scope of the agreements then in force, with a view to regulating the sustainable use and the protection of water resources of the shared river basins. The Porto summit of November 1994 added a further impetus to the negotiation process, focussed on a new Agreement in a broader framework, in technical, legal and political terms. The Declaration of Porto was signed on 19^{th} November 1994. This declaration gave a new emphasis to the negotiations on the basis of:

- Creating the appropriate conditions for the optimum use of the shared river basins within the framework of environmental protection and water quality.

- Co-operation between the two countries in defence of their respective interests by means of a systematic exchange of information.
- Prior evaluation of the effects in Spain and Portugal of any significant actions in the other country.
- Co-ordinating the planning and management of water resources in the shared basins from the point of view of their sustainable use by both countries.
- Finishing in the shortest possible time an agreement between Spain and Portugal on water resources based on,
  - The principles of international and European Community law.
  - The recognition of an equal and reasonable right of both countries to the water resources of the shared basins.
  - A co-operation mechanism that ensures the regular and systematic exchange of information.
  - A bilateral institutional model that allows the evaluation of water situations of mutual interest.

Both countries recognised the new environmental awareness that had taken root in their societies and transferred it to their mutual water policy, for which they decided to leave a purely technical/economic framework for the use of the frontier rivers to pass definitively to a much wider framework that covered all the area of the shared basins rather than just the parts of the rivers forming the frontier between both countries. They agreed to pay special attention to the balance between environmental protection and the use of water resources necessary for sustainable development in both countries, to prevent the risks that could affect the water or be caused by them and to protect the aquatic and land ecosystems that depend on these.

The pace of the negotiations was at first rather slow as, combined with the supposed major differences in the initial negotiation positions and the difficulty in establishing negotiation methods, there had to be added the increasing effects of the aforementioned drought that heightened the polarisation and the governmental changes in 1995 and 1996 occurring respectively in Portugal and Spain.

The start of the formulation in 1995 of the new Water Framework Directive in the heart of the European Commission also affected the pace of the negotiations and made the new Spanish Portuguese agreement, the majority of whose negotiations took place in 1997 and 1998, have an interactive composition with the above-mentioned directive to incorporate its general philosophy,

as differences in the text between the bilateral agreement and the European Community framework, to which both countries were soon going to be subject, were not acceptable. After ten formal negotiation meetings as well as many other technical and legal meetings, in which the Ministries of the Environment and Foreign Affairs of both countries took part, the agreement was signed during the Spanish Portuguese summit in Albufeira on 30^{th} November 1998 and came into force on 17^{th} January 2000, the date of the final exchange of communications between both parties informing about the fulfilment of the respective internal procedures, in accordance with the condition established in Article 35.

Principles lying the agreement

As mentioned above, the principles lying behind the agreement were fixed, in the declaration of the Porto summit and can be summarised as follows:

Widening of the reference framework of previous agreements. This widening comprises several points: on the one hand, the purely geographical and hydrological aspects, covering all the area of the shared river basins in accordance with current tendencies that consider this to be the reference unit for studying hydrological material. It therefore covers surface water, groundwater water and ecosystems related to the water environment. This also amounts to a widening in material terms, as all activities related to the use of water resources, including those that concern the safeguarding of water quality, must be dealt with, which went further than the merely sectorial approach of the previous agreements.

Co-operation between the parties. The management of water resources in each country, taking the word "management" in its most all-encompassing sense, can only be fully carried out by co-operating taking into account the transboundary character of these resources.

This co-operation revolves around three fundamental elements:

- Exchanging information on a regular and systematic basis.
- The enquiries and joint activities to be developed internally by the bodies created as a result of the agreement, but which, logically, are not confined to this area.

- Taking measures to guarantee the effectiveness of the agreement, including those that allow for the homologation of the administrative and legal systems of both countries, which must have a preferential position.

Co-ordination of the planning and management of the water resources in the river basins. It is a topic of singular relevance. The solution adopted is compatible with the concept of the indivisibility of a river basin and follows the guidelines of what is established in the Water Framework Directive. The aim is that the environmental goals to be reached are co-ordinated, there being national independence to establish and carry out measures, infrastructures operation included, that facilitate the achieving of these targets. Obviously, this way of acting does not mean that specific actions can be jointly undertaken when these are desirable and feasible.

With the subject planted in this way, it appears that co-ordination could be seen as an unambitious measure. Currently, to aim for a shared and global management system is not possible. On the one hand, because both countries have, in administrative terms, relatively different management methods, which would result in malfunctions, at least in the short term, during a period that is particularly sensitive for measuring the effectiveness of the agreement On the other hand, it is not foreseeable for this harmonisation to take place and become effective immediately. Secondly, it must not be overlooked that for the resources of the rivers to become usable, both in Spain and Portugal, it has been necessary to regulate them, which has been undertaken from different and strictly national interest, viewpoint and finance perspectives. To propose joint management would require an in-depth debate to be initiated concerning the purpose of the regulation, both now and in the future, on the ways of financing its structure, how it is to be repaid and how it operates, as well as its decision-making machinery. This debate involves not only the Administrations, but the users and society in general. In a distant future this may be necessary, but it will be of greater benefit if it is developed at the same time as the institutions envisaged in the agreement are established, and preferably with these operating.

Respect for and compatibility with existing situations arising from previous agreements. A set of requirements in international law and in particular, European Community Law must be borne in mind and adapted to the specific hydrological and social conditions of the Spanish-Portuguese river basins.

Experience has shown the International Rivers Commission to be an effective instrument for agreements and it is therefore necessary to maintain the essence of its functional principles, adapting them to the new responsibilities that the Agreement has designed, in particular, separating questions of a political nature, which are to be dealt with by a new body, the Conference of the Parties, from those of a technical legal and organisational nature that are the responsibility of an updated Commission that, in contrast to other existing cases in an international context, stresses its bilateral nature.

Finally, it is necessary to review the current situation arising from the agreements of 1964 and 1968. In this sense, what has to be defined are: the situation of envisaged but incomplete actions, the points of preferential interest for both countries, the water transfers schemes that have already been carried out or those situations arising from an imprecise interpretation of the earlier agreements, yet completely compatible with the framework that the agreements established.

Contents of the agreement

The contents of the agreement are not going to be analysed point by point as it would take too long to do so. On the contrary, we shall consider those topics that comprise its backbone and which, for obvious reasons, constituted the subject matter of most of the discussions during the negotiations.

The formal layout of the Agreement comprises an introduction, six functional parts with a total of 35 articles, two annexes and an additional protocol with its annex.

Two sentences are worth highlighting from the introduction that summarises the political intentions of the document, because they capture its essence and synthesise the basis of the agreement:

- Search for a balance between protecting the environment and the use of the water resources necessary for the sustainable development of both countries.
- The need to co-ordinate respective efforts for a better understanding of the management of the Spanish-Portuguese river basins.

Institutional regimen (Articles 20 to 23). The Agreement sets up two peer bodies on which the co-operation process is based: the Conference of the Parties on a high political level and the Commission for the Application and De-

velopment of the Agreement, hereinafter referred to as the Commission. Both bodies, especially the second one, comprise the framework for monitoring and controlling the process, as well as being privileged bodies for resolving conflicts that may arise in the bilateral relationship.

No specific organisational formula for the Commission is specified, except its peer nature. In as far as reference is made to the Commission, from the itemising of some of the purposes that it has, it can be deduced that it has a marked technical-legal function. However, without detracting from this function, it is primarily a decision-making body on a large number of topics. There are, on the other hand, in the Agreement itself, mechanisms that allow for a more in-depth treatment of topics of a more specifically technical or legal nature or of any other kind, through the creation of sub-commissions or working groups in which specialists on the topic can take part.

Information exchange (Articles 5, 6 and 7 and Annex I). It should not be forgotten that, above all, the Agreement is an instrument for co-operation between two countries, for which reason the availability of sound information on the material that it regulates is a pre-requisite for this co-operation to be effective. At present, the information between the technical bodies in charge of the water management in both countries is free flowing. However, it is necessary to go deeper into the institutionalisation of this exchange, creating in each country the necessary structures for it to be gathered and transmitted to the empowered body promptly and in a suitable form and with the right quality.

Three different levels should be considered in the information exchange concept:

a) The level that involves meeting the objective obligations arising from the Agreement, especially those that refer to the flow regimes.

b) The one dealing with the legislation, organisational structures and administrative practices, in such a way that these aspects are performed in a harmonious way.

c) That which covers international initiatives concerning matters associated with the Agreement, in such a way that if the ideal of presenting mutual initiatives in international fora is not achieved, at least a certain prior enquiry regime is established for these initiatives.

The Agreement institutionalises the rights of access to information of each country's citizens, along the lines envisaged in Directive 90/313/EEC on the freedom of access to information concerning environmental matters in the

Aarhus[1] agreement signed on 24^{th} June 1998 on citizens' access to information participation in environmental matters.

The Commission must not only receive from the Parties all the information necessary to fulfil its functions, but it must also have powers to require from the Parties whatever it considers necessary, in particular that referring to the manner in which each country carries out the actions envisaged in the agreement, which entails control over its fulfilment, by means of a programme of measures concerning the mutual objectives that have already been agreed upon.

Those elements for which information must be exchanged are contained in Annex I to the Agreement:

a) Management monitoring over cross-frontier water; rights of use (licenses, authorisations, etc.), hydrological, infrastructure data, etc.

b) Activities liable to have transboundary impact; discharges, water allocated for future human consumption, sensitive areas, vulnerable areas, activities leading to erosion etc.

c) Methodology, studies and data on the ecological conditions of the water and better environmental practices.

This information, which is relevant to the resource management or for the evaluation of a possible transboundary impact, must be obtained in accordance with the procedures envisaged in the applicable Community Directives. However, the information must be homogenous and compatible, which requires an effort to be made in the short term to ensure that the networks of both countries are adequate.

Annex I itself lists pollutant materials that must be the subject of special surveillance and which is similar to that appearing in Annex VIII of directive 2000/60/EEC, which established a European Community action framework in the area of water policy (Water Framework Directive).

Transboundary impacts (Articles 8 and 9 and Annex II). It is a particularly sensitive aspect, in which the solution found is based on the European directives relating to environmental impact and international legislation subscribed to by both countries, in particular the Espoo[2] Agreement on environmental impact evaluation in a transboundary context, of 25^{th} February 1991.

[1] Signed by Spain in 1998. Parliament approved its ratification in May 2001.
[2] Ratified by Spain 1^{st} September 1992

If mechanism is to function correctly, it must be based on the principle of good will, i.e. trying not to cause significant damage and to act diligently to prevent its effects when they arise, as well as not using the enquiry mechanisms to obstruct any action taken by the other party.

The system envisaged does not cause any imbalance in the relations between both countries, precisely due to its bilateral nature. In the first place, because it defines the river basin as the unit in which transboundary impact may arise as a result of a project or activity, although this is qualified in Annex II by the consideration of the distance from the frontier to the action being considered.

Secondly, because the evaluation procedures must be expressly fixed by the applicable European legislation. Finally, because the consultations, i.e. whether or not a project or activity is defined as being potentially likely to cause a transboundary impact, is carried out in the heart of the Commission, which is responsible for determining, *a priori*, projects or activities that must be submitted to environmental impact evaluation.

The distinction that the Agreement makes between projects and activities is particularly interesting, as the possible application of a suspension clause would only occur in the former case. However the ambiguity of the definition means that care should be taken in applying it to particular cases.

The system envisaged in the Agreement is completed with safeguard clauses for reasons of public interest, as well as the repair of responsibilities in accordance with the applicable international law and which, logically, acts in both directions.

Annex II provisionally defines the types of projects as well as the conditions to be applied in these for their transboundary environmental impact to be evaluated, an evaluation that must, in any event be made in accordance with European directives.

Water quality and flow regimes (Articles 13 to 16 and Additional Protocol and Annex). As far as water protection is concerned, the Parties undertake to inventory, evaluate and classify transboundary waters, on the basis of its quality and current and potential uses and to define objectives or standards of quality in the terms of the applicable European directives, even considering the possibility of applying a special protection statute in cases where this is applicable. The Parties also undertake to co-ordinate the pollution prevention and control procedures in accordance with European Community Law.

The flow regime established in the Agreement must be understood from the perspective that it has been intended to guarantee the existence of certain flow rates in such a way that hydrological and environmental functions of the rivers can be achieved and, at the same time, for it to be possible to lay a firm foundation for both the current and future use of water resources in the two countries.

Infrastructure management must be carried out in such a way as to guarantee that these minimum flow rates are met, this demand preferably being satisfied by the upstream country, although consecutively, it can freely carry out the allocation of resources that it wishes and considers to be most appropriate as long as the flow rates established in the Agreement are not jeopardised. This condition means that new actions in both countries are undoubtedly going to be subjected to installation and working restrictions, which will limit some of these or impose restrictions on them. Future actions, which may also include temporary resource transfers, must, in applicable cases, be subject to the environmental impact assessment procedure. The upstream country must accept the guaranteed flow rates as a datum for its future planning, whose possible transboundary projects or activities will also be conditioned by their potential transboundary impact. On the other hand, the downstream country must condition its development by the guaranteed flow.

In any event, it must be borne in mind that the flow regime is not an isolated element but that it is one that takes into account the fact that a system exists in both countries whereby in both countries one uses water through licensing and therefore, with established and consolidated legal obligations, a system of which the regime arising from the 1964 and 1968 agreements forms a very special part. It is therefore logical to suppose that the flow rates in the frontier stretches are not going to vary greatly over the year from those at present, although they can be re-examined in order to satisfy the assigned hydrological and environmental functions.

It cannot be overlooked that the hydrological regime of Spanish-Portuguese rivers is very irregular, increasing from North to South in such a way that there are years in which the guaranteed flows are not reached, either naturally or even with the support of the regulation system established. Therefore, faced with these natural scarcity situations, it is absolutely necessary to establish exceptions to the general flow regime.

To define these situations objectively, indicators based on a standard rainfall for each basin have been established, calculated on the basis of the measured rainfall occurring in two or three selected gauging stations (Figure 1). The intended purpose is to have a simple, easily accessible indicator for the interested

BASINS	GAUGING STATIONS	WEIGHTING
Miño	Lugo Orense Ponferrada	30% 47% 23%
Douro	Salamanca (Matacán) León (Virgen del Camino) Soria (Observatory)	33,3% 33,3% 33,3%
Tagus	Cáceres Madrid (Retiro Park)	50% 50%
Guadiana	Alcalá la Real (Air Base) Ciudad Real	80% 20%

Table 2. Flow Regime (Reference Rainfall).
The mean values are understood to be calculated in accordance with the registers of the period 1945/46 to 1996/97 and will be updated every 5 years.

BASIN	GAUGING STATION	Minimum Flow (mcm/year)	START of exception period	END of exception period
Miño	Frieira dam	3,700	$P^{(R)}$ up to 1st July<70 % $P^{(M)}$	following month to December if $P^{(R)} > P^{(M)}$
Douro	Miranda dam Saucelle dam+Águeda G.S. Crestuma dam	3,500 3,800 5,000	$P^{(R)}$ up to 1st June<65 % $P^{(M)}$	following month to December if $P^{(R)} > P^{(M)}$
Tagus	Cedillo dam Ponte de Muge G.S.	2,700 4,000	$P^{(R)}$ up to 1st April<60% $P^{(M)}$, or $P^{(R)}$ up to 1st April<70% $P^{(M)}$ and $P^{(R)}$ previous year < 80 % $P^{(M)}$	following month to December if $P^{(R)} > P^{(M)}$
Guadiana	Badajoz dam Pomarao G.S.	600-300 2 m³/s daily	According to rainfall and state of reference reservoirs	fllw'ng month to Dec.if volume in ref. reservoirs >3.150 mcm

Figure 1. Flow regime (Minimum flow).
$P^{(R)}$ is the accumulated reference rainfall in the basin from the beginning of the hydrological year to the date indicated.
$P^{(M)}$ is the mean accumulated rainfall in the basin in the same period.

parties and one that makes it possible to clearly define these situations. In the case of the Guadiana, due to its greater irregularity and the gauging station network that it has been equipped with, the criterion has been completed with the situation in several reservoirs.

The thresholds, both those that refer to the declaration of a period of exception as well as when this situation no longer exists, were determined in such a way that the periods of exception will affect a limited number of years and be

Total annual flow in Badajoz dam (mcm/year)		
Volume in refence reservoirs (mcm)	% Accumulated rainfall above the mean	
	$> 65\%$	$< 65\%$
>4000	600	400
between 3150 and 4000	500	300
between 2650 and 3150	400	Exception
<2650	Exception	Exception

Table 3. Flow Regime: Detail of minimum flow in the Guadiana River. Accumulated rainfall is evaluated on 1^{st} March.
* This regime will not be applied until the Alqueva reservoir begins to be filled.

Mean daily flow in Badajoz dam and in Pomarao Considering $2m^3/sec$ in all cases.			
La Serena	3219 mcm	García Sola	554 mcm
Zújar	309 mcm	Orellana	808 mcm
Cíjara	1505 mcm	Alange	852 mcm

Table 4. Flow Regime: Mean daily flow in Badajoz dam and in Pomarao.

compatible with the real situation. It is also important to establish the moment when this decision must be taken and this will occur depending on the climatic situation and the ways in which water resources are used in the basins, in such a way that it will be possible to carry out management changes to include demand during periods of exception, without which this would be senseless. In all cases, supply to the population and for social uses as well as maintaining environmental conditions in the river must be attended to, although of course, bearing in mind the natural regime that will have arisen from the hydrometeorological situation.

Exceptional situations (Articles 17, 18 and 19). It is advisable to deal with this situation separately from the flow regime for two reasons. Firstly because it does not only deal with quantitative aspects, but also it also covers the co-operation in accidental pollution incidents that must be handled with the required diligence, information and collaboration. Secondly, because in the aforementioned articles, instructions are given on how to act during flood and drought situations that are much more important from a practical viewpoint

than the mere declaration of exception, which is no more than an isolated circumstance.

The flood alarm situation is not only activated automatically at the request of one of the parties, but either of the parties can take action if it understands that a situation has arisen that could lead to flooding.

During flood alarms, it is very important to have reliable information. In such cases information must be passed on in real time or as closely as possible to this and be transferred as directly as possible between the person who generates the information and the one who must use it. This means having these points of reference identified beforehand, together with the type of information required and the operational measures that can be taken as an alternative. Experience in recent years as regards the modus operandi in Spanish reservoirs, which has helped to facilitate flood management in Portugal, is a good starting point in how these topics should be approached. It must be completed with joint studies on floods and management rules of reservoirs in these situations. The Commission will carry out a subsequent evaluation of the action taken and may propose measures for improving the efficiency of the co-operation procedure.

As far as droughts are concerned, the obligation of the parties to adopt measures begins as soon as the exceptional situation is confirmed. These measures are aimed at a more rigorous management of available water resources and include, among other things, infrastructure management, water savings and consumption reductions. Furthermore, it will be necessary to carry out stricter control of discharges of wastewater in order to be able to maintain acceptable quality levels despite the states of water stress in the environment and prevent, to the extent that this is possible, cases of accidental pollution.

All exceptional measures that are adopted must be communicated to the Commission as soon as possible, so that this body can evaluate their effectiveness and any possible collateral effects, even during the period of exception itself.

The guarantee regime (Articles 24 to 26 and 31 to 33). The main guarantees for the correct functioning of the co-operation regulated by the Agreement are the bodies created by it, the Conference of the Parties and the Commission already described.

The guarantee regime is completed with a conflict resolution system for disputes that it has not been possible to solve specifically by negotiation between the parties or in the heart of the Commission or the Conference of the Parties. It has been attempted to make this system in agreement with the most modern forms of international law accepted by both countries. In particular, the procedural norms are based on those established in the Espoo Agreement and, reinforcing the bilateral nature of the relationship, with no interference from other international organizations except the International Court of Justice, as was the case with the 1964 and 1968 agreements.

The Agreement is in force for seven years, which are automatically extendable for further periods of three years unless this right is expressly waived by one of the parties no later than ten months before the each period has elapsed. Amendments may be made by mutual agreement at any time.

It is important to mention that the Agreement is not the end of a process, rather a starting point and a reference framework in which questions relating to water in the shared river basins of Spain and Portugal must be adjusted, questions that because of their own nature, change with time. Hence the need to have a flexible instrument that allows it to be adapted. Its development and perfection must provide fora for realizing mutual problems and needs and for the two peoples to get to know each other. Water must never be a barrier that separates, but a vehicle for cohesion. This agreement may help in achieving that goal.

V

TRANSBOUNDARY AQUIFER MANAGEMENT

TRANSBOUNDARY AQUIFERS AND THEIR MANAGEMENT IN THE CONTEXT OF GLOBALISATION

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Abstract

It is widely accepted that current globalisation is exerting unprecedented driving forces in all endeavours of human society, including its use of natural resources such as groundwater. These driving forces can be considered to provide measurably significant benefits, though at the same time also less obvious negative impacts. The positive benefits include economic gains to some sectors, while the negative impacts include rapid over exploitation of natural resources. Transboundary aquifers are found all over the world and their use and exploitation is largely a local concern, since groundwater governance still seems to lag well behind surface water resource management. Where there are transboundary aquifers shared by two countries, each with significantly different socio-economic status, the differing requirements and priorities have to be addressed, to ensure that equitable and sustainable development can take place without degradation of the common aquifer system. Globalisation is also having another transboundary impact – that of creating pressures on national natural resources from decisions made through multi national organisations and corporations. Recognition of this impact is already is already taking place, and some solutions are being adopted. Where this recognition is lacking, and decision making is left too late, the result in environmental resources losses, with serious impacts on human wellbeing may be irreversible. This paper explores these issues with regard to the direct impact of globalisation and the indirect impact on natural resources, in particular aquifer resources.

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Overview

This short paper considers to what extent aquifers and their management, or barriers to their management, may be influenced by forces of globalisation. The paper reviews a subject that is of increasing interest to natural science experts, working towards sustainability of their national resources that appear to be subjected to external forces, over which local managers find themselves powerless to intervene. The review draws on several studies and concepts that have introduced interesting terminology into hydrology such as 'the silent revolution' of Llamas (2006) and the 'trade in virtual water' of Allan (1988). It is partly motivated by several discussions that relate water and global relations, such as Gleick (2005), who considers freshwater & foreign policy in the context of the role of the United States, and the Session on "Water & Free Trade" held at the 4^{th} World Water Forum, Mexico (2006). It also relates to terms that Global Environmental Facility financed projects have introduced into the literature, such as 'transboundary diagnostic analysis', 'hydrogeological risk' and 'causal chain analysis'. To many groundwater specialists such ideas and terms are not in common usage in their national resource management practices, and the paper argues that hydrologists should also need to engage in this important debate.

The concern about globalisation and its relationship to water resources is not a new issue; it has been raised as far back as 1999 by Casano and Gustafsson (2000). They considered the perceived impacts of multinational corporations' decisions regarding their investments on the water resources of third countries to which production had been shifted for cost reduction and economic efficiency. In this paper we ask, are aquifers subject to some new forces of globalisation? This rhetorical question cannot be answered through the study of the hydrogeology of aquifers alone, but if the study of aquifers is expanded to include the associated socio-ecological systems, or the more commonly understood 'ecosystems approach', then a framework can be developed that also includes transboundary aquifers, the subject of this short paper.

Globalisation & Global Change

The effect of climate change on available water resources in most regions, assessed from a series of analyses, including the general circulation models, are expected to be small compared with demands generated by population growth, industrialization, urbanization, land-use changes and improved standards of living (Beran, 1986). In considering the drivers that affect transboundary aquifers most researchers and groundwater practitioners are of the opinion that apart from the impacts of climate variability, they are instead sub-

jected to easily discernible local changes such as land use change, urbanisation and associated with these changes a bewildering input of substances that enter the groundwater flow systems. They also accept that such change is global, ie worldwide, and it is now proceeding at an unprecedented pace, & in geographic scope, affecting river basins & aquifers, impacting their quantity and quality. Various assessments such as the Millennium Ecosystem Assessment have shown that ecosystem degradation, involving loss of ecological capital is intense – in 2002, humanity's global ecological footprint, was exceeded by 23%. Ecological-footprint accounting measures the extent to which the ecological demand of human economies stays within or exceeds the capacity of the biosphere, which also includes the water resources in aquifers, to supply goods and services. (www.footprintnetwork.org).

It is claimed that if this trend continues, the globalised human economy is projected to be in ecological overshoot from the impacts of global interdependence on goods and services (see e.g Simms et al 2006). Current globalisation is driven by an unprecedented flow of capital, being $491 Bn in 2005 (World Bank, Global Development Finance) the impact of which includes to some extent a worldwide change in landscape, its vegetation, local land characteristics, as well as soil & sub soil properties. For the water resource planner such global change can be more readily perceived in terms of urgently needed investments in infrastructure, such as dams and irrigation canals, and the on going drainage of wetlands for cultivation & food production.

In this paper the term 'globalisation' follows Young et al. (2006) view that globalisation is a central feature of coupled human-environment systems, or as socio ecologists call them socio-ecological systems, and natural science experts, ecosystems. It is suggested by researchers that the key analytical dimensions of globalisation, include rising connectedness, increased speed, spatial stretching, and declining diversity. These phenomena can cut both ways in terms of impacts on the resilience and vulnerability of socio-environmental systems. Some researchers specifically considering groundwater (Villholth, 2006) suggest that globalization provides novel opportunities for facilitating the process of acquiring and applying the necessary knowledge since the likely benefits of this are an increase in convergence of understanding and approaches to the sound management of aquifers.

These types of observations are being made not only in the natural science and the socio-ecological circles. In a workshop held by the World Business Council in Beijing (June 2005), aimed at how Business & Water, should be navigating a sustainable course, the participants while working on a scenario planning exercise listed a series of drivers of change that will affect water is-

sues in China in the near future – interestingly, in addition to the national economic policies, they also listed international trade & globalisation as one of the drivers that must be taken into account.

The connection between globalisation as mentioned above, and the global change, is the rapidly accelerating worldwide mobilisation of natural land for agriculture, transformation of rural land to urban – with significant impact on local socio-environmental conditions. While there is no unique measure of the rate of increase of globalistion, quantification of the global change indicates that more land was converted to cropland since 1945 than in the 18^{th} and 19^{th} centuries combined; 25% of the world's coral reefs were badly degraded or destroyed in the last several decades, due to such factors as discharge of untreated waste water in coastal areas; 35% of mangrove area has been lost in this time and the amount of water in reservoirs quadrupled since 1960, despite loss of storage capacity due to sedimentation. Withdrawals from rivers and lakes doubled since 1960 & from aquifers considerably more. More people have moved from rural areas to cities in the last 20 years than in the last century. Studies are showing that if all the impacts that affect a river basin can be summed, then 80% of the 'change' arises from globalisation, as defined above, and 20% from impact of 'climate change'.

One important insight, flowing from these considerations seems to be that there is a reversal of the usual conditions of change in the biological-physical world, in which changes in large-scale systems (eg global hydrological patterns) are slow and durable, while changes in small-scale systems are fast and ephemeral (eg a local watershed). This type of reversal is though to have an uncertain, but degradational effect on resilience, vulnerability and adaptability of the human-environmental system.

Drivers to global change in aquifer systems

A global change is also taking place in aquifers. In seeking to translate the impact of globalisation into aquifers, the start point is widely reported observation that aquifers are being overdrawn –ie the groundwater resource is being pumped beyond the rate at which it is recharged– consequently, in the majority of such aquifers, water is being drawn from storage, of which globally there is a significant amount, a concept still elusive to many water engineers and policy makers. As yet there are no agreed figures of the global total of withdrawal from storage, although steady progress in its evaluation is being made, indicating it to be about 750–800 $km^3/year$ (IWMI & Others).

Among the driving forces behind this withdrawal from storage several have been variously termed as 'trade in virtual water' (Allan, 1998) or 'the silent revolution' (Llamas, 2006). It is argued here that both these analyses are flawed when taken in isolation from the forces of globalisation. While the former is intuitively close to inter connectedness or interdependence as used by Simms et al. (2006), the latter is simply the final link in a chain that arises from globalisation. The so called revolution, which has been characterized as also being chaotic, is in fact a change in behaviour resulting from such factors as the inflow of informal capital (remittances from overseas[1]), trade liberalisation with greater access to reliable drilling & pump technology (Barker and Molle, 2002). This enables land users to make investments in private sources of water, usually groundwater, and its use as an unlimited free good, over which local resource managers seem powerless to intervene, as noted above. It is such powerlessness of the resource managers that is leading to the so called chaos in the management of global aquifer systems. Increasingly the informal inflow of capital is being augmented by accelerating global financial flows, through new trade policies supported by the WTO and liberalisations of investment policies (Cesano and Gustafsson, 2000; ÈCLAC, 2006). As a result multi national corporations are able to make investments involving the use of local water resources and a consequent increase in competition for it. An example is the well documented case involving Coca Cola and its bottling plant in Kerala, India (see eg www.navdanya.org), where it has sought groundwater in competition with local farming needs.

While trade in virtual water, and its impact on water resources remains unrecognised by those involved in such trade, some multi national corporations, that are taking part in the silent revolution, are starting to recognise their trans national impacts on water resources. For example, Coca Cola, with operations in 200 countries, utilises about 3.1 litres of water for 1 litre of product, though their plants that make teas and coffees have higher water-use ratios, and even higher In countries where under local legislation, the bottles are recycled. In its global operations the corporation, which withdraws a total of 297 Bn litres of raw water, has adopted mitigation measures in arid regions, such as India and the American Southwest. In India, this mitigation includes rainwater harvesting in response to the vacillation between monsoons and droughts, ie climate variability, and the local overdraft of aquifer storage. As noted before, the globalisation led changes can cut both ways in their impacts on aquifers - while many impacts are leading to severe depletion of aquifer resources, in

[1]There are approximately 120 million migrant workers worldwide with many of them travelling between developing countries in Asia and Latin America.According to the World Bank, developing countries' income from remittances was $160 billion in 2004,

some seemingly very limited pockets, depleted storage is being replenished for preventing economic losses. Less obviously but of equally significant impact relates to associated activities that arise from the globalisation. An example has been reported in an article by Harvard College, in which the success of Pepsi-Cola over its rival Coca-Cola on the Indian market was attributed partly to the offers made to the government by the company to bring new food technologies and facilities into the country while, at the same time, offering support for exports of local products and enhancement of rural areas (see e.g, Discussion paper, Stefania Masari, "Current food consumption patterns and global sustainability", prepared for Bank CARIME, also Kotler, 1986). Each component of these offers has its own interaction with water, both at the local village level, as well as nationally. In the former, in connection with changing demands on water from wells and other sources, and in the latter from new demands made by consumers of the products being marketed.

Depletion of global aquifer storage

Alley et al. (2002) indicate that during the past 50 years, withdrawal from storage in aquifers has led to depletion that has spread from isolated pockets to large areas in many countries throughout the world. Prominent examples include the High Plains of the central United States, where more than half the groundwater in storage has been depleted in some areas, and the North China Plain, where depletion of shallow aquifers is forcing development of deep, slowly replenished aquifers with wells now reaching more than 1000 m. These authors state that groundwater depletion may be the "single largest threat to irrigated agriculture, exceeding even the buildup of salts in soil". In many arid regions of the world, much of the aquifer storage removed contemporaneously was recharged during humid periods of the last Pluvial (7,000 to 10,000 years ago). Summing up all the global groundwater depletion would be appreciable enough to contribute to sea-level rise during the past century, if as a result of water pumped from wells, returns to the sea either by runoff or by evapotranspiration followed by precipitation. Konikov and Kendy (2005) note that the total volume depleted from the High Plains aquifer equates to about 0.75 mm, or about 0.5%, of the observed sea-level rise during the 20^{th} century. They also observe that assuming that the volume of groundwater depleted during the past 100 years is much greater than can be accounted for by storage in the terrestrial and atmospheric components of the hydrological cycle, then the ultimate sink for the "missing" groundwater is the oceans. This may be so large as to constitute a measurable contributor to sea-level rise.

Why does loss of global aquifer storage require urgent quantification? If the scale of the global depletion of water in aquifers is as large as that suggested by Konikov and Kendy (2005), then ecosystem degradation and the ecological overshoot of the globalised human economy may be subject to even greater threat than is conventionally recognised. Aquifer resources often play a central, but 'hidden' role in the sustainability of socio-ecological systems, as will be apparent from the previous discussion. The chaos of the silent revolution is the unplanned but short term economic gain that arises from the withdrawal of large amount of natural resource, or ecological capital. When placed in the context of the contribution of aquifers to river & lake baseflows, which range from 30% to 60% of annual flows in the worlds rivers, the cumulative economic losses have a direct bearing on human livelihoods as well as the aquatic habitats that provide food & fibre. As is quite obvious to groundwater practitioners, replenishment of lost aquifer storage is difficult to reverse; non reversal will lead to the accelerating decline in the resilience of ecosystems that depend on aquifers. If some of the ecosystems that are so impacted till they reach their tipping point, it may not be possible to revive them, leading to a permanent loss of environmental and ecological capital.

Global groundwater withdrawal & natural resources consumption

A simple analysis of the conventional hydrological cycle shows that natural processes can keep up with the demands of the human economic activity they support, with all the associated consumptive uses of resources and discharge of waste, but only as long as the demands stay within the regenerative capacity of the coupled hydrosphere- biosphere, the latter being the living part of the planet. In the case of aquifers, it is the access to and the availability of resources, and the bio degradation capacity of the porous medium.

Analyses have shown that the Earth's biologically productive area (areas of grassland, cropland, forests, fisheris and wetlands –all requiring an appropriate quantity and quality of water) is approximately 11.2 billion hectares, or 1.8 global hectares per person in 2002 (assuming that no capacity is set aside for wild species). Global hectares are hectares of biologically productive area with world average productivity. This standardised measurement unit, or 'ecological currency', makes comparisons of demand and supply possible across the world.

The idea of an ecological foortprint, introduced into the literature in the last decade, is a measure of the amount of area required to sustainably produce a

flow of products required by the socio-ecological systems. Such a footprint may be larger than the area actually used to produce the product. For example, products from a forest being harvested at twice the replenishment rate would be calculated as having a footprint twice the area actually used. CO_2 emitted in the production of goods for export is added to the energy footprint of the importing nation. Production from aquifers can be related directly to the area of the cone of depression, and abstraction exceeding the annual rate of recharge can be related to the additional area needed for the extra recharge.

In 2002, humanity's demand on the biosphere, its global ecological footprint, was 13.7 billion global hectares, or 2.2 global hectares per person. Thus in 2002, humanity's ecological footprint exceeded global biocapacity by 0.4 global hectares per person, or 23 per cent. This finding indicates that the human economy is in ecological overshoot: the planet's ecological stocks are being depleted faster than nature can regenerate them. This means that it is eroding the future supply of ecological resources and operating at the risk of environmental collapse.

Global economic issues & linkages to aquifers

Understanding patterns of trade in ecological resources (through, for example, the flow of virtual water) is important for several reasons. Trade may mask a nation's abuse of the global commons. This holds true today for resources such as fossil fuels, open sea fisheries and the storage in in aquifers. Using ecological accounting makes it possible to search out the unclear boundaries of the global commons, and makes them visible on the otherwise ambiguous outcomes of the market economy. It can also help reveal how ecologically unequal exchange may be neither socially nor economically sustainable. In extreme cases, substantial reliance on ecological imports can undermine a country's economic viability and sovereignty, leaving it politically fragile, and even resented by the other nations who supply it. Fossil fuels and water are the two obvious cases in point. This interesting assessment has been carried out by the New Economics Foundation *(Simms et al 2006)* Simms, 2006, on which some of the arguments presented in this paper are based.

Global trade, of course, has many benefits and is voluntarily and enthusiastically pursued. Allan (1988) observes that the US Dept of Agriculture & the EU export 40 M tones of grain to the water short regions of the Middle East & North Africa (MENA), in which there is 'embedded' $40Km^3$ of virtual water, which is supposed to reduce the demand from local aquifer sources, many of which are transboundary aquifer systems (eg the Rum-Saq Aquifers and the

Nubian Sandstone Aquifers). In fact it is not actually the water that is embedded, but water that was consumed in the production of the grain where it was cultivated. There is no evidence that as a result of this virtual water, the demand in MENA has decreased. According to the WWC (2006) MENA is also among top 20 countries receiving the highest Overseas Development Aid (ODA), $8.8 Bn for water related support. Much of the grain that is exported is grown in the US Mid West, drawing on irrigation water from the High Plains Aquifers that have been so significantly depleted, see Konikov ans Kendy (2005). These aquifers also nationally transboundary in nature.

All nations today are increasingly interdependent on traded goods, many of which require local water resources, including that contained in aquifers. But ecologically imbalanced trade is risky. Just as nations closely monitor their financial balance of trade and debt to keep healthy and stave off the threat of economic collapse, so, too, they will benefit by measuring their ecological balance of trade to prevent their state of ecological self-sufficiency, based on their ecological capital falling to critically low levels. Traditional measures such as gross domestic product (GDP) are short changing current and future generations according to Professor Sir Partha Dasgupta of Cambridge University. This is because they fail to value the goods and services generated by the natural world and instead treat them as free to use and limitless in their abundance and ability to withstand damage and decay. Such services include the carbon soaking power of forests, the fisheries and coastal defense activities of coral reefs, the pollution filtering-potential of wetlands and the nutrient recycling processes of the earth's soils. Currently neighbouring countries who overdraw their shared aquifers, fell their forests for timber exports, dynamite reefs for fish, pollute their land for intensive agriculture and contaminate their waterways with farm and factory run off can appear to be getting richer in the short term. In reality, they are likely to be sliding into poverty or, at the very best, buying time, because they are plundering their natural capital-a key pillar of medium and long term wealth.

Negative externalities

Many of the issues and their impacts discussed above result in what economists call negative externalities. To understand these negative externalities and the unplanned consequences of how they connect to the use of water, consider one ecologically significant product that is invisible to most consumers: palm oil (Simms, 2006). The UK imported over 700,000 tonnes of it in 2004. It is grown to earn foreign currency, traded internationally, and needs energy throughout its production cycle. Palm oil is a key ingredient in inexpensive

chocolate, and oil and wax from the palm kernel tree are used to add bulk and shelf-life to a variety of products from food to cosmetics. Replacing forests by palm-tree plantations make good economic sense in Southeast Asia where the tree grows quickly, irrigated by local aquifers. However this economic good sense is fuelled by increasing demand from abroad which results in these plantations expanding rapidly. Quick expansion and a monoculture approach is creating serious unsustainable land use problems, including destruction of the rainforest, the modification of the hydrological cycle and other unique ecosystems, local pollution, and social conflicts rooted in the increasing power of agribusiness. In addition to palm oil, a similar situation can be applied to the production of soya bean in Latin America, which eventually ends up in chicken nuggets markted in Europe and elsewhere (see eg Greenpeace Reports on 14,000 hectares in the Santarem / Belterra region, in Brazil that produce 34,000 tonnes of soya a year in connection with the MacDonalds food chain).

Understanding the impact of such ecological externalities (or ecological footprints) sometimes means having to visualise long and complex supply chains, possibly through a comprehensive transboundary diagnostic analysis. In the example above, a thread connects chocolate to palm trees to shrinking rainforests in Southeast Asia, but it is not easy to see, and it would be difficult to connect through the causal chain analysis that has been forward under the Global International Water Assessment. Just as difficult is visualising the links between chicken nuggets and soya bean production, a shrimp salad served in London and the loss of groundwater supported mangrove forests in Bangladesh, which once provided valuable buffers against storms and floods. But these, and many other environmental connections like them, are growing in size, number and complexity as the world becomes ever more interdependent or globalised.

In concluding this section, the author notes that we are lacking sound methodologies for taking these observations from science to policy in water management. It would seem that so far the Integrated Water Resources Management (IWRM) paradigm may have failed to address many of these rather convoluted and intricate issues, specifically as regards aquifers & their dependent ecosystems. Values of ecosystem goods and services can be introduced as a policy tool to realise the IWRM. This means that, based on ecosystem goods and services that can be utilised for human welfare and productive activities, river basin management schemes can be established so as to utilise identified ecosystem goods and services in the manner to most effectively achieve the basin management objectives. The ecosystem goods and services that may be used for river basin management purposes are associated with: flood control (floodwater storage, flood peak reduction, flood retardation), water supply

(maintenance of streamflow, groundwater recharge, prevention of saline water intrusion), water quality maintenance and purification (removal of agricultural pollutants, treatment of wastewater), erosion prevention, reduction of net Green House Gas Emission or enhancement of absorptive capacity, transport, recreation and eco-tourism, provision of natural resources (timber, medicinal plants, fishes, agricultural products), maintenance of biodiveristy and cultural and heritage significance For groundwater dependent ecosystems, one would need to consider the services they can provide due to the presence of groundwater: ie nutrient removal, retention of toxics and maintenance of biodiversity.

Prognosis through the valuation of aquifers

Despite all the pro's and con's of the globalisation, there is a commitment from the world community to address these weighty issues, through, for example, the worldwide adoption of the Millennium Development Goals. To the meet the MDG Goal 7, on environmental sustainability Target 10 has specifically been mentioned with regard to the provision of drinking water to half the proportion of people without sustainable access to safe water, at a cost that might be between $9 to $30 billions per annum upto the year 2015; This cost estimate simply focuses on 'water after the tap'. As water resources, and also aquifer resources, are treated as natural resources, then Target 9 on conservation of natural resources needs to be revisited by the engaged community of water & environmental specialists. Since majority of the ODA in the water sector is provided for WSS (70%) and only about 25% is allocated to water resource management, and a much smaller amount to training & education, this is also an issue for serious consideration.

Looking ahead from purely the 'water' perspective, the current levels of ecological degradation, vast inequalities in economic opportunities both within and across societies, and a fractured set of institutional arrangements for global environmental governance all represent seemingly insurmountable obstacles to a move towards sustainability. While these obstacles are significant, Senddon et al. (2006) suggest that they might be overcome through a reinvigorated set of notions and practices associated with sustainable development, one that explicitly examines the linkages between sustainability policies and sustainability politics. (Sneddon et al., 2006) Embracing pluralism provides a way out of the ideological and epistemological straightjackets that deter more cohesive and politically effective interpretations of Sustainable Development.

The pluralism and removal of epistemological straightjackets could be introduced through the valuation of aquifers and the services that the resources in

them provide to ecosystems. Although aquifers are untraded goods and therefore there is no general international market for groundwater, assigning a value is ofcourse counched in difficulties within conventional economics. Nevertheless, some services of groundwater can be valued eg for drinking, or for the production of irrigation water - even though this grossly undervalue the full scale of services provided, as it ignores a multitude of linked services eg as contributors to baseflow to transboundary streams, inflow to lakes, salt concentration modifiers in mangroves, etc. In addition there is no market price for public good function of aquifers eg as support to ground water dependent ecosystems or as buffer storage in drought. Analogies can be used, for example by valueing the services provided by groundwater dependent wetlands. Several studies from Europe indicate wetland values ranging from \$34 to \$1300 per ha - but there is no clear link to the value of the input of critical water resources from aquifers. An alternative would be to value the sound functioning of aquifers in stressed areas that would build up local ecosystem resilience (through the replenishment of the depleted storage) and to pressures from climate variability.

Prospects

The challenge of reversing the degradation of ecosystems and the aquifers that are a part of them, while meeting increasing demands for their services, can be met under some scenarios. These will require significant policy and institutional changes, but these changes will be large, and they are not currently under way. However, many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs, or that provide positive synergies with other ecosystem services. Studies have indicated that investing in nature can provide an excellent rate of return, for example 1\$ invested in fighting land degradation and desertification may conservatively generate over 3\$ in economic benefits and 1\$ spent clean water and sanitation could give impressive rates of return of up to \$14. The difficulty is in convincing governments and in particular the responsible bodies in the financial ministries of the value of these types of investments.

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TRANSBOUNDARY AQUIFER RESOURCES MANAGEMENT: A TOPIC IN DEVELOPMENT

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Abstract

Groundwater specialists and water resources planners only recently have become aware that transboundary aquifer resources may be a potential source of problems or conflicts and therefore deserve proper management. Growing awareness on transboundary aquifers has resulted in a number of recent initiatives. These include the establishment of TARM/ISARM, which has the overall objective to promote transboundary aquifer resources management; regional inventories of transboundary aquifers, so far conducted for Europe, the Americas, Southern Africa and the Balkans; a recent World Map of Transboundary Aquifers; and the initiative of the International Law Commission to prepare an international convention on shared groundwater resources. At a more aquifer-specific level, there are several pilot projects on transboundary aquifers in different parts of the world. In spite of the results of all these initiatives, many questions still need to be answered. A crucial one is how to prioritize the aquifers or aquifer zones upon which transboundary aquifer management efforts should focus. A methodology using appropriate criteria or indicators will have to be developed to identify and underpin the needs for transboundary aquifer management, and to define priorities.

Why bothering about transboundary aquifers

Aquifers are the main reservoirs for subsurface storage of water and the ‘highways’ for groundwater flow. Groundwater is moving extremely slowly. Typical flow rates in ordinary aquifers are between one meter and a few tens of meters per year, which implies that fluxes are only small compared to those of surface waters. Therefore, if fluxes of groundwater across administrative borders tend to be so small: why should we bother about transboundary aquifers?

Before answering this question, we have to realize in the first place that even low fluxes may cause large volumes of groundwater to pass the boundaries. This is because the vertical cross-sectional area along the border tends to be large, due to the usually considerable lateral and vertical extent of aquifers. Secondly, flow rates in some special types of aquifers, especially in karstic aquifers, may be substantially higher than the typical groundwater flow rates mentioned above. Thirdly, not only the movement of water and associated dissolved substances does matter, but also pressure changes and other effects that may propagate through a groundwater system under minimal displacement of water. In practice, significant cross-boundary interferences may be produced in transboundary aquifers. This means that activities at one side of the border may be reflected at the other side by changes in groundwater level, in rates and direction of groundwater flow, in groundwater storage, in subsurface pressures and in groundwater quality. Early identification of the risks and proper joint management of the transboundary aquifer may eliminate potential sources of conflict and improve the overall benefits obtained from the aquifers.

The next sections will review first of all the state of affairs on transboundary aquifer activities around the world. After that, attention is called for a few aspects that deserve further attention.

Emerging awareness on the importance of transboundary aquifers resources management

Most groundwater in the upper few hundred meters below ground surface is continuously moving –although very slowly– under the influence of physical driving forces and physical boundary conditions. The aquifers through which groundwater is flowing do not respect any administrative boundaries, hence these boundaries are being crossed by flows of groundwater and its dissolved solids.

Although the notion of groundwater crossing municipal, provincial, state and national boundaries is rather old, it is not yet reflected in the way people is dealing with groundwater. World-wide it can be observed that information systems and activities related to groundwater tend to be organized within limits of jurisdiction rather than within physical limits of aquifer systems.

What are the consequences of this somewhat narrow view? In the first place, it often is the cause of insufficient understanding of the entire groundwater system concerned. By focusing on part of a groundwater system only and neglecting those parts that are located in a different administrative zone, one develops

an incomplete view on the aquifer and its behaviour. This adds uncertainty to any groundwater system analysis, and it even distorts the views if people fail to make a distinction between 'absence of information' and 'absence of a groundwater system'. A second consequence is that understanding poorly what happens at the other side of the boundary leads to lack of any action needed for harmonizing human interferences with the groundwater systems at both sides. It even impedes stakeholders to be prepared for dealing with groundwater system interactions across the administrative boundaries and to anticipate on the propagation of groundwater level declines or modified groundwater quality due to activities across the border. There is a growing consensus among the water resources community that physical units such as water basins or aquifers rather than administrative areas should be selected as appropriate spatial units for water resources management.

Everybody can observe rivers and other streams crossing international borders, and conclude that downstream countries may enjoy large inflows of water, but at the same time are exposed to risks of flooding and pollution originating elsewhere. Therefore, transboundary issues in surface water since long are receiving ample attention and have triggered numerous transboundary water projects, programmes, commissions and treaties around the world. The situation is quite different for the invisible and slowly moving groundwater. Groundwater specialists and water resources planners only recently have become aware that transboundary aquifer resources management is a relevant topic that deserves attention. Neglecting it would put significant groundwater related interests at risk and is a potential cause of conflicts.

Overview of important international initiatives

Growing awareness on transboundary aquifer resources issues and on the need for incorporating the transboundary dimension in groundwater resources management has prompted a series of recent activities and initiatives on transboundary aquifers.

TARM/ISARM

One of these initiatives is the establishment in 1997 of *TARM/ISARM*, a programme under the umbrella of UNESCO-IHP and IAH. TARM and ISARM are the acronyms for Transboundary Aquifer Resources Management and for Internationally Shared Aquifer Resources Management, respectively. TARM/ISARM –usually called ISARM– has the overall objective to promote transboundary aquifer resources management. ISARM's multidisciplinary ori-

entation is illustrated by the five focal areas identified in its framework document: the scientific-hydrogeological scope, legal aspects, socio-economic aspects, institutional aspects and environmental aspects of transboundary aquifers. ISARM is a catalyst for and a partner in several transboundary aquifer projects in different parts of the world. An ISARM portal is hosted and maintained at IGRAC's website and can be accessed either through IGRAC (www.igrac.nl) or directly at www.isarm.net. The portal allows the mentioned framework document (UNESCO, 2001) to be downloaded and gives access to other interesting information on transboundary aquifer in different parts of the world.

Regional and global inventories

In several parts of the world, *regional inventories of transboundary aquifers* have been conducted or are in progress – some of them with active involvement of ISARM. These constitute the first steps towards transboundary aquifer resources management at the area-specific level, by identifying and characterizing the aquifer systems concerned and discussing them in international groups of professionals.

The first regional inventory focused on Europe and was carried out by the Task Force on Monitoring and Assessment of the United Nations Economic Commission for Europe (UN/ECE). It developed a methodology for regional inventories and reported in 1999 on 89 transboundary aquifers in 37 European countries (UN/ECE, 1999). A similar inventory was started a few years ago by OAS and UNESCO for the western hemisphere (ISARM of the Americas) and is scheduled to produce in 2006 a publication showing and documenting almost 80 transboundary aquifer systems in that region (UNESCO&OAS, in preparation). Other transboundary aquifer inventories have been initiated for Southern Africa and the Balkans. Common goals of all these regional inventories (see Figure 1) are:

- Identification and delineation of transboundary aquifers.
- Defining main properties of these aquifers.
- Forging international co-operation on transboundary aquifers.

A World Map of Transboundary Aquifer Systems, presented by WHYMAP in March 2006, gives a preliminary impression of the global distribution of important transboundary aquifers (WHYMAP, 2006; includes 98 aquifers). Figure 2 shows a fragment of this map.

Legal and regulatory frameworks

Good governance of transboundary water resources –and in particular the implementation of harmonizing measures– should be facilitated by recognized legal and regulatory frameworks.

The most important legal documents to date on international waters are the United Nations Convention on the Law of Non-Navigational Uses of International Watercourses (1997) and the so-called Helsinki Rules adopted by the International Law Association (1966; complemented by specific Groundwater Rules in 1986 –the so-called 'Seoul Rules'). Even combined do these legal documents not yet constitute an adequate regulatory framework on transboundary groundwater. Therefore, UN's International Law Commission recently has taken the initiative to develop a *convention on the law of transboundary aquifer systems.* Leading principles of the latest version of the draft convention are:

- Equitable and reasonable uses of aquifer systems.
- The obligation not to cause harm.
- The general obligation of neighbouring countries to co-operate.

It still takes some time to finalize the convention, but after that it will require quite some years before a sufficient number of countries will have endorsed the convention.

Pilot projects and case studies

At a more aquifer-specific level, there are several *pilot projects and case studies on transboundary aquifers*, such as the Guaraní aquifer in South America and the Iullemeden aquifer in Northern Africa.

These projects try to develop practical approaches to the multidisciplinary and very complex subject of transboundary aquifer management in the field.

Other activities

Finally, there are many other projects contributing in one way or another to transboundary groundwater resources management, e.g. the harmonization of information systems under the *European Water Framework Directive and the IW:LEARN* projects on International waters initiated by the Global Environmental Facility (GEF).

Figure 1. Location maps produced in the framework of regional transboundary aquifer inventories

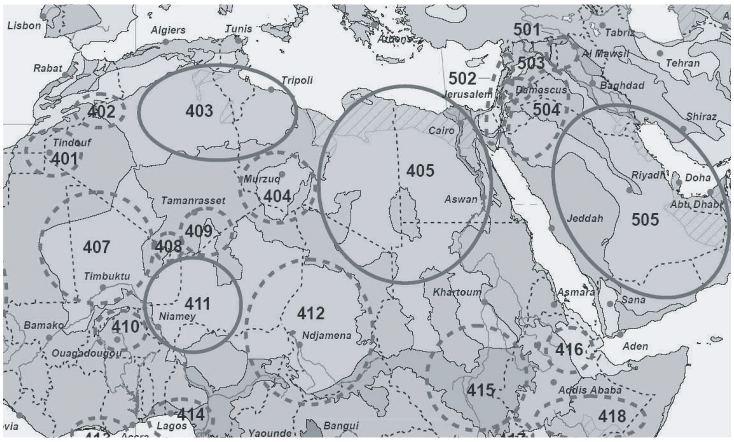

Figure 2. Fragment of WHYMAP's World Map of TBA (WHYMAP, 2006)

Questions and challenges

All these ongoing activities and initiatives are producing valuable results, but the subject of transboundary groundwater is still in its infancy, which means that there are many aspects still to be explored and questions to be answered. A few of these will be addressed below.

What is a transboundary aquifer?

A transboundary aquifer can be defined as a relatively permeable hydraulically continuous subsurface unit (classical concept of 'aquifer') that extends across an administrative boundary and thus is located in at least two administrative territories (countries, states, provinces, etc.). Although this is an interpretation shared by many groundwater professionals, one should be aware that quite a number of spatial units in the world labelled as 'transboundary aquifers' in reality are no aquifers in the classical sense at all. In some cases one refers to transboundary hydrological basins (catchment areas) in which permeable groundwater zones are embedded, in other cases to a permeable geological formation occurring at both sides of a national boundary.

Evidently, one has to know which concept is in the mind of those speaking about specific transboundary aquifers or of those presenting a transboundary aquifer map. Furthermore, it is preferable to use the term 'transboundary aquifer' only for the case of a 'true aquifer' and to introduce a more general term like 'transboundary groundwater system' to encompass all types of geographical units where groundwater is assumed to be able to cross an adminis-

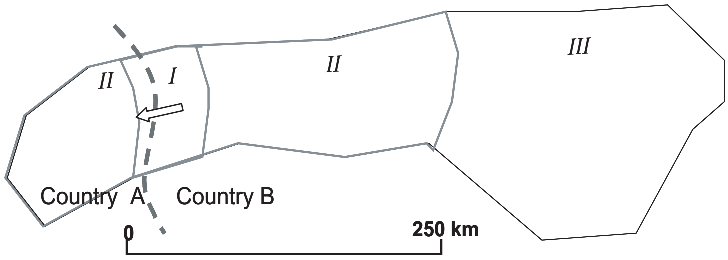

Figure 3. Aquifer zoning according to the hazard of transboundary aquifer interactions

trative boundary. Classifying the transboundary groundwater systems according to the type of unit (aquifer, hydrological basin, geological formation, etc.) may help making the exchanged information more transparent and understanding mapped transboundary systems properly.

Aquifers crossing boundaries inside a country

Internal boundaries inside a national territory –e.g. state or provincial boundaries– are offering similar problems as international boundaries. There still much work to be done to raise motivation for addressing this type of transboundary settings and to remove institutional obstacles for cross-boundary cooperation.

The role of flow direction and distance to the border

Mapped large transboundary aquifers sometimes are extending for hundreds of kilometres from a boundary, but is their entire extent equally relevant from the point of view of potential transboundary impacts?

A first observation to be made is that most types of impacts (e.g. cross-boundary pollution) tend to be produced mainly in downflow direction. This means that the 'downflow' territory has the characteristic of a 'target area' that needs to be protected, because it is more vulnerable than the 'upflow' territory ('source area'), where risk prevention should be a priority. Secondly, cross-boundary impacts in a transboundary aquifer (or any other transboundary groundwater system) are likely to be more retarded and less pronounced if the cause of the impacts is located at greater distance to the boundary. In addition, the more extensive aquifer systems are, the more probable that they are not entirely hydraulically continuous.

These observations suggest that different parts of a single transboundary aquifer are likely to be different with respect to hazards of producing or being affected by transboundary impacts. It follows that zoning the aquifer on the basis of an adequate methodology for expressing this hazard could help developing effective and efficiently targeted transboundary aquifer management approaches (see Figure 3).

Which transboundary aquifers require action?

There are many transboundary aquifers around the world. Obviously, transboundary management has not the same urgency for all of them. For some of these aquifers, transboundary problems are unlikely to develop, but others may be very much exposed to such risks and present a potential source of conflict. Therefore, a methodology is required –using appropriate criteria or indicators– for easily prioritizing those transboundary aquifers where transboundary aquifer resources management is most in need and expectedly most worthwhile. Once such a methodology has been developed, maps showing 'hot-spots' from the point of view of transboundary groundwater hazard could be prepared to catch the attention of decision-makers and the general public and to raise their awareness.

How to motivate decision makers to take proper action?

An important challenge is how to move from the initial stages of inventory and analysis to the stage of real action. Do decision makers at both sides of the boundary agree on what is at stake? Do they adhere to the same set of management principles and rules-of-the-game? Are they able to identify appropriate measures? Can they develop the regulatory frameworks and institutional capacities required for the implementation of measures? Can they resolve cross-boundary conflicts? Should they opt for 'shared management' of the aquifers, or rather for harmonization of management?

On the longer term, it still has to be demonstrated that transboundary aquifer resources management really is going to work at the operational level and will produce the benefits expected from it. The scientific community will have to support the decision makers by developing proper concepts and methodologies, and by presenting information to them in a digestible way.

Conclusions

- Transboundary aquifers form a *relatively new field of interest*. They need to be addressed in order to prevent cross-border conflicts and to maximize the benefits that can be obtained from the groundwater resources.
- During the last decade, many initiatives related to transboundary aquifers have started. So far, they have yielded an impressive amount of information.
- However, the subject of transboundary aquifers is still in its infancy: many aspects still need to be explored and dedicated methodologies for prioritizing and management are still missing.
- Action in transboundary aquifer management will only take place after the professional community will have clear answers on the main *'what – where – how'* questions. Here lies a major challenge for today's groundwater professionals.

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TRANSBOUNDARY AQUIFERS OF THE UNESCO/OAS ISARM AMERICAS PROGRAMME

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Introduction

The UNESCO/OAS ISARM-Americas Programme is the regional initiative for the American hemisphere of the worldwide ISARM Programme and is jointly coordinated by the UNESCO International Hydrological Programme (IHP) and the Department of Sustainable Development – of the Organization of American States (DSD/OAS).

The global "Internationally Shared Aquifer Resources Management – ISARM Programme" was launched at the 14th Session of UNESCO IHP Intergovernmental Council in June 2000, in cooperation with several other international organizations, notably the Food and Agriculture Organization (FAO), the United Nations Economic Commission for Europe (UNECE), the United Nations Economic and Social Commission for Western Asia (UNESCWA) and the International Association of Hydrogeologists (IAH). It aims to promote the recognition and understanding of transboundary groundwater resources, and foster collaboration among the countries sharing the same resource to achieve consensus on legal, institutional, socio-economic, scientific, and environmental aspects. Another objective of the ISARM Americas Programme is the identification of case-studies of particular interest.

The most important objectives of the ISARM Americas Programme is to create a comprehensive Inventory of Transboundary Aquifers of the Americas, a collection of data regarding the hydro-geological characteristics, the actual use of the shared groundwaters and the legal and institutional aspects.

From the start of the activities in 2003 up to January 2006, the Programme has assessed the prevalence of transboundary aquifers in the Western Hemi-

sphere, with the contributions of a network of National Coordinators, which represent 24 countries of the American hemisphere.

Three Coordination Workshops[1] have been held, the first was held in Montevideo, Uruguay, on September 24^{th}–25^{th}, 2003, and the second in El Paso, Texas on November 10^{th}–12^{th}, 2004, the third in San Paulo, Brazil on December, 2005.

According to the Inventory, as of January 2006, 68 transboundary aquifers were identified: 29 located in South America, 18 in Central America, 17 in North America, and 4 in the Caribbean.

Since the First Coordination Workshop in Montevideo, the countries proposed a number of transboundary aquifers as possible case-studies for project implementation, using the ISARM approach. They are located in areas of particular concern in the Americas: arid and semi-arid regions; areas extremely vulnerable to natural hazards and to climatic variability due to climate change; areas with severe land/water degradation due to increased urbanization and industrialization, extensive agriculture and deforestation, which heavily impact entire ecosystems; and areas of potential water use conflict, with high levels of poverty and health uncertainty.

Transboundary aquifers: An opportunity for regional collaboration among water skateholders

Recognizing the multi-facet value of transboundary aquifers also implies to recognize the necessity of establishing a joint management among countries which, in general, neither have adequate legal and institutional frameworks for groundwater management, nor a support by international bi- or multilateral agreements or by integrated administrative policies for environmental protection. The implementation of ISARM Americas has provided a unique platform to promote energies and interest for the development of transboundary aquifer projects.

During the Programme, the countries proposed a priority list of transboundary aquifers for project implementation. The Artibonite and Masacre aquifers in the Hispaniola Island (Haiti – Dominican Rep.) as an example of inter-mountainous and coastal transboundary aquifers in Small Islands De-

[1] Workshop Reports of the events are available in PDF. files at the OAS web-site: *http://www.oas.org/dsd/isarm/ISARM_index.htm*

veloping States (SIDS); the Yrenda-Toba-Tarijeno aquifer system in the Gran Chaco Americano (Argentina-Bolivia-Paraguay), representing transboundary aquifers in semi-arid zones of South America:; and the Hueco Bolson aquifer (Mexico-USA), as a striking example of transboundary aquifers in urban area.

In 2005, another transboundary aquifer has been identified as a priority case-study by the ISARM Americas Programme. Bolivia, Brazil and Paraguay called for international support to implement a project for the protection of the Pantanal transboundary aquifer, which partially underlain the Pantanal wetlands, one of the most unique natural setting in the world, and contributes to the health of the rich and diverse wetland-related ecosystem. In Central America, El Salvador and Guatemala identified the Ostua-Metapan transboundary aquifer, a potential under-utilized resource which, if strategically managed, could solve the water-scarcity problems of the area during the periods of drought.

Transboundary aquifer of the Americas-Regional assessment

A book will summarize the information of the transboundary aquifers of the Americas. This book is a regional assessment of the water-environment-geographic interactions of groundwater resources crossing geographical boundaries in the Americas. It is developed in consideration of the audience: high-level national decision-makers in the countries that have transboundary aquifers; regional agencies that are parties to multilateral agreements and other involved agencies concerned with sustainable development.

This is the first attempt to synthesize the current knowledge of the transboundary aquifers of the Americas, their location, environment, and the status of the management, or lack of, of the groundwater resources shared by two or more countries in the region. The descriptions are preliminary.

The book attempts to provide a science-based overview and a collective understanding of the groundwater resources found in transboundary aquifers, and to settle the ground to help support sustainable use and protection. It presents the state of knowledge of the groundwater transboundary resources of the Americas at the regional scale and the knowledge gaps.

Transboundary groundwater management in the Americas is truly dynamic, a range of national, regional, and global institutions are generally established to consider surface water, but few of them have been adapted to consider groundwater. In some cases, governmental and/or research institutions have attempted

to manage transboundary aquifers through cooperation amongst the countries involved. The regional overviews briefly describe these attempts.

The significance of the transboundary aquifer systems in the Americas is quite dissimilar. While in some cases, those resources are the main source of water supply, USA-Mexico, in others they are virtually untouched eg. Amazon aquifer. The level of cooperation varies from none to full developed strategies where three levels of society: science, government and social elements cooperate to assess and manage their transboundary aquifers.

Rather than presenting a detailed and thorough hydro geological description of the transboundary aquifers of the Americas, this book is intended as a reference inventory book with the objective of future resources management. In particular, this inventory as of January 2006, seeks to establish a framework for cooperation among countries in the Americas and as a pool of knowledge to be used for integrated management of water resources and a sustainable used of these aquifers in the region.

In preparing the book, a clear will to cooperate in transboundary issues was perceived among the participants of the American countries with the support of UNESCO and the Organization of American States – OAS.

NORTH AMERICA		
1N	Abbostford-Sumas	Canada-United States
2N	Okanagan-Osoyoos	Canada-United States
3N	Grand Forks	Canada-United States
4N	Poplar	Canada-United States
5N	Estevan	Canada-United States
6N	Cambrian-Ordovician	Canada-United States
7N	Chateauguay	Canada-United States
8N	Tijuana-San Diego	Mexico-United States
9N	Cuenca Baja del Rio Colorado	Mexico-United States
10N	Sonoyta-Papagos	Mexico-United States
11N	Nogales	Mexico-United States
12N	Santa Cruz	Mexico-United States
13N	San Pedro	Mexico-United States
14N	Conejos Medanos-Bolsón de la Mesilla	Mexico-United States
15N	Bolsón del Hueco-Valle de Juárez	Mexico-United States
16N	Edwards-Trinity-El burro	Mexico-United States
17N	Cuenca Baja del Río Bravo/Grande	Mexico-United States

Table 1. North America Transboundary Aquifers at 1/1/06

CENTRAL AMERICA		
1C	Soconusco-Suchiate-Coatan	Guatemala-Mexico
2C	Chicomuselo-Cuilco-Selegua	Guatemala-Mexico
3C	Ocosingo-Usamacinta-Pojom-Ixcan	Guatemala-Mexico
4C	Marques de Comillas-Chixoy-Xaclbal	Guatemala-Mexico
5C	Boca del Cerro-San Pedro	Guatemala-Mexico
6C	La Trinitaria-Nenton	Guatemala-Mexico
7C	Peninsula de Yucatan-Candelaria-Hondo	Guatemala-Mexico-Belice
8C	Mopan-Belice	Guatemala-Belice
9C	Pucila-Moho	Guatemala-Belice
10C	Sarstun	Guatemala-Belice
11C	Temash	Guatemala-Belice
12C	Motagua	Guatemala-Honduras
13C	Chiquimula-Copan Ruinas	Guatemala-Honduras
14C	Esquipulas-Ocotepeque-Citala	Guatemala-Honduras-El Salvador
15C	Ostua-Metapan	El Salvador-Guatemala
16C	Rio Paz	El Salvador-Guatemala
17C	Estero Real-Rio Negro	Honduras-Nicaragua
18C	Sixaola	Costa Rica-Panamá

Table 2. Central America Transboundary Aquifers at 1/1/06

CARIBBEAN		
1CB	Masacre	Haiti-Rep. Dominicana
2CB	Antibonito	Haiti-Rep. Dominicana
3CB	Los Lagos	Haiti-Rep. Dominicana
4CB	Pedernales	Haiti-Rep. Dominicana

Table 3. Caribbean Transboundary Aquifers at 1/1/06

SOUTH AMERICA		
1S	El Choco-Darien	Colombia-Panama
2S	Tachira-Pamplonita	Colombia-Venezuela
3S	Guajira	Colombia-Venezuela
4S	Grupo Roraima	Brasil-Guayana-Venezuela
5S	Boa Vista-Serra do Tucano-North Savanna	Brasil-Guayana
6S	Zanderji	Guayana-Surinam
7S	Coesewijne	Guayana-Surinam
8S	A-sand	Guayana-Surinam
9S	Costeiro	Brasil-Guayana Francesa
10S	Tulcan-Ipiales	Colombia-Ecuador
11S	Zarumilla	Ecuador-Peru
12S	Puyango-Tumbes-Chira-Catamayo	Ecuador-Peru
13S	Amazonas	Bolivia-Brasil-Colombia-Ecuador-Peru-Venezuela
14S	Titicaca	Bolivia-Peru
15S	Pantanal	Bolivia-Brasil-Paraguay
16S	Agua Dulce	Bolivia-Paraguay
17S	Ollague-Pastos Grandes	Bolivia-Chile
18S	Concordia - Escritos-Caplina	Chile-Peru
19S	Aquidauana-Aquidaban	Brasil-Paraguay
20S	Caiua-Bauru-Acaray	Brasil-Paraguay
21S	Guarani	Argentina-Brasil-Paraguay-Uruguay
22S	Serra Geral	Argentina-Brasil-Paraguay-Uruguay
23S	Litoraneo-Chuy	Brasil-Uruguay
24S	Permo-carbonifero	Brasil-Uruguay
25S	Litoral-cretácico	Argentina-Uruguay
26S	Salto-Salto Chico	Argentina-Uruguay
27S	Puneños	Argentina-Bolivia
28S	Yrenda-Toba -Tarijeno	Argentina-Bolivia-Paraguay
29S	El Cóndor-Cañadon del Cóndor	Argentina-Chile

Table 4. South America Transboundary Aquifers at 1/1/06

WATER MANAGEMENT AND FLATLAND HYDROLOGY

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Abstract

Water management along flatland regions must deal with special hydrology, characterized by a higher degree of uncertainty and ignorance about the hydrological processes and flows. This has caused misunderstandings in water management polices implemented in these areas along the history, all over the world, causing water conflicts. Many cases keep on now a day, even when the level of knowledge has improved. The present work analyzes the main issues for water management in flatland regions. The case of the Upper Guadiana River Basin is used to illustrate the analysis.

The water cycle misunderstanding

Traditionally, hydrologists have been obliged to take a pragmatic approach in order to serve society with the background information needed to decide on various environmental enhancement measures and structures, which form the backbone of modern civilization. Hydrologists have therefore concentrated their interest on the runoff generation part of the water cycle, i.e. what can be called the horizontal or long branch of the terrestrial water cycle. Less attention has been paid to soil water, which provides the water flow consumed in the biomass production process of photosynthesis and returns to the atmosphere as evapotranspiration, in other words the vertical or short branch of the cycle.

Thus, hydrologists in the past have been mainly concerned with the runoff component of the water resource, since it is this component which can be managed (at least to some extent) to provide stable supplies for irrigation, industry and domestic consumption. Of these uses irrigation accounts overall for 70% of the total, and roughly a third of the world's harvest comes from the 17% of the world's cropland that is irrigated (Postel, 1984). Irrigation is a very visible example of alteration of the water balance of an area, and its obvious benefits have been mitigated in many areas by mismanagement leading to waterlogging and salinization of land.

In flatland hydrology plays an important role the vertical hydrology, whereas the horizontal hydrology is unappreciated from the surface, and sometime misunderstood. In a flatland region, some local areas may produce catchment hydrology response at a macro scale from land areas which slope locally. More generally, flatlands are characterized by a macro-scale response which is far from the conventional one in a sloping catchment, and is evidenced by a degeneration of the surface drainage network (Rodier, 1964, 1985).

In warm arid areas, stream flow is infrequent and sediment concentrations are very high, for endogenous streams influenced only by the local climate. In these conditions, small watercourses with a slope between 1 and $3m/km$ usually disappear after a few kilometers.

For exogenous rivers entering arid plains from humid areas, the degeneration of the drainage network begins at slopes of the order of magnitude of 0.1m/km. These two sets of limits, with intermediate situations, define an upper slope limit for flatlands in dry warm areas (Colombani and Rodier, 1989).

The spatial scale of topography is important in the hydrological definition of flatlands. Most flatlands have micro depressions at areal scales of some cm^2 or dm^2. At the meso scale, very shallow depressions may cover 500 m^2 up to 1 km^2. At the macro scale, in playas, salt lakes and some plainlands, the depressions may cover many km^2.

For permeable soils, rainfall enters the plant root zone and is later transpired by the vegetation or evaporated from the soil surface. It remains in the plant root zone for a period related to the depth of the rainfall event, the aridity of the climate, and the season. A small part of a high rainfall may penetrate beyond the plant root zone and continue to move slowly downwards until it reaches the water-table. In the case of impermeable soils, most of the rainfall is stored in micro depressions. If the rainfall is sufficient, these small depressions overflow and water moves slowly towards the larger depressions. At the meso scale

there is no overland flow to streams or lakes, but a small increase in the slope may induce overland flow and streamflow in the poorly organized channel network.

Groundwater is a very important component of the water resources of dry warm areas (Jacobson and Lau, 1983). Except in the sub-humid zone, direct groundwater recharge from rainfall is infrequent, but important inputs to aquifers come from the intermittent rivers of areas with catchment response and exogenous rivers originating in the humid zone. Such inputs may also be significant to the equilibrium of fossil aquifers, which can be very extensive.

Endogenous interactions can be considered the influence of adjacent sloping areas on the hydrology of flatlands in the dry warm regions. On flatlands not subject to external influences, the accumulation of sufficient water will cause flow between surface depressions, first at the micro scale, then at the meso and macro scales if the water supply is sufficient.

When watercourses on sloping land, with a well defined channel network, flow on to flatlands with these characteristics, an intermediate situation develops between a fully organized drainage network and the flatland situation described above. This phenomenon has been termed "hydrographic degeneration" by Rodier (1964, 1985). There, the continuity of runoff is no longer obvious, nor the continuity of the channel itself, and losses of water from the main channel are very important. When a stream from sloping land enters a flatland, it develops a channel which results in some runoff from the flatland as well as the runoff from the sloping land. The resulting runoff however has little relation to catchment area, and values of specific discharge, measured in $m^3/s/km^2$, are meaningless. Often the flow stops completely after a distance related to the magnitude of the discharge reaching the flatland area, and does not reach a drainage terminus in a lake or the sea. This is typical of the arid and particularly the hyper-arid zones (Colombani and Rodier, 1989).

The two main problem of water use in these areas are lack of water (low flow on dry period), and excess of water (disastrous flood, water lodging). The absence of catchment response may produce an apparent excess of water, which occupies vast surfaces with slow movement, during flood event, which may become almost permanent. In other regions, or situations, no water is available from the surface because higher soil permeability, lower annual precipitation, or water-table level depth form the surface.

In order to manage the water resources in flatland areas it is essential to understand the operation of the complex hydrological system of rivers, channels

with or without flow, lakes, reservoirs and swamps; the fluxes between components of this system under various conditions; and possible evolution of the system and its flows. In addition, consideration must be given to the possibilities of water supply from aquifers, taking account of aquifer depth, recharge rates and groundwater quality.

There is a wide range in the physical conditions in flatlands. In areas such as the lower Nile, the Tigris-Euphrates and the Indus, conditions were found to be extremely favourable for agriculture several thousand years ago, with flat fertile soils, ample water and the possibility of controlling it, easy water transport, and the possibility of establishing cities protected by water bodies and swamps. At the other end of the scale of land use are areas such as the lowest part of the Chad, a flat depression with brackish water near the surface, in which a few wisps of grass at intervals of 50m constitute a good pasture for camels.

The complexity of the hydrological process in flatland areas, and their misunderstand by policy makers, has taken to important management errors which have caused mainly major environmental impacts, in addition to economical and social consequences, where the initially considered expectations were unreachable.

Water and land use

Many flatland areas which some centuries ago were swamps of low economic value are now areas with a high agricultural yield, after development and proper management of a good network of drainage channels. Some also make use of old irrigation schemes based on surface or groundwater resources.

Unfortunately, if the principles of soil and water conservation are not respected, the influence of these human activities may be disastrous. Particularly in warm areas, many flatlands which were good pastures have been overgrazed, resulting in a change in the floristic composition towards less palatable and often less nutritious plants. In more arid areas this has resulted in the onset of desertification, with changes in the hydrology at the micro scale, usually involving less infiltration, more surface runoff and, in sloping areas, more erosion.

The human influence on land-use is partly controlling the water balance. If humans change the natural vegetation, those changes will control the state of the ground (bare or covered by vegetation), the size of the interception stor-

age in the vegetation canopy, and the amount of water that is evapotranspired back to the atmosphere. In addition to changing the natural vegetation, there other land-use activities that result in significant effects on the infiltration and storage of water such as urban cover, soil compaction by grazing animals, drainage, ploughing, and logging. If the natural vegetation is changed, the water demand will change, both seasonally and considering water availability at different depths in the soil horizon. In addition, infiltration and water holding characteristics will change. The impact of human actions on water quantity and quality depends also on climate, which defines the temporal variability of water flows.

Water management faces several goals, which compatibility is hard to find:

- Health, depending on access to safe house-hold water and sanitation;
- Food production, depending on the merging of water from the soil and carbon dioxide from the air through the photosynthesis process to form plant biomass;
- Socio-economic production, depending on easy access to water for industry, urban activities and energy generation; and
- Protection of valued ecosystems that are threatened when the quality of the surrounding water is degraded, or the quantity modified.

Conservation's goals and modification's goals are many time opposite and equally necessary for regional development. This is similar for flatland and catchment response regions. However, whereas the impact of actions in catchment response regions is predictable, and easy to check, the same is not true for flatland regions. The complexity of interactions make difficult to analyze the consequences of land-use alterations. Two of the major land-use modifications that flatland regions deal with are drainage channel construction, and irrigation. Drainage operations are a current operation for land-use transformation in flat regions. Drainage may introduce two consequences: ground water recharge reduction, because of time for infiltration is shorted; and water table depletion, when drainage channels are below natural water table and surface water flow is enhancement. Irrigation in flatland regions produces groundwater exploitation by private farmers, sometimes uncontrolled. Over-exploitation caused a significant lowering of water tables and deterioration of groundwater quality. Water table depletion may produce in these areas drastic and fast changes in water flows. Special sensitivity has semi-arid and arid regions, where precipitation is below potential evapotranspiration, and water balance limits the irrigated surface able to be maintenance without over-exploitation. Additionally land-use activity may become a diffuse pollution source. Agricultural fertilisers and

chemicals cause considerable problems. Furthermore, main nitrate sources are animal waste and synthetic fertilisers used for filed and crop production.

Upstream/Downstream hydrosolidarity

A river basin approach with focus on upstream/downstream conflicts of interest has to involve attention not only to water itself and the services that it provides to society, but also to water related ecosystem services, terrestrial as well as aquatic. Besides the blue water, i e liquid water flows in rivers and aquifers, attention has to be paid to the green water flows, i e the water vapour flow involved in a plant production. What basically has to be shared between those upstream and those downstream in a river basin is the rainfall over the basin. To satisfy societal needs, humans have to manipulate various landscape elements. These manipulations –due to fundamental water functions– tend to produce side effects ("environmental impacts"). In an integrated basin approach, side effects of water-impacting land use conversions upstream on water-dependent activities and on ecosystem health downstream have to be considered. A fundamental challenge is therefore to find ways and mechanisms by which reconciliation can be developed between upstream and downstream activities.

In flatland region the concept of upstream/downstream hydrosolidarity becomes more complex. Water flow may be rapidly modify and redirected to the areas with larger demands because of main flow is groundwater flows. The impact of any action may extend not only downstream, but also upstream. When pumping techniques are used, any area in at the flat region may hold all the demand, and use most of the resources. This products a major concern about hydrosolidarity when dealing with flatland response regions. The first affection when exploiting water in flatlands are the aquatic ecosystems, which are maintained in a weak equilibrium, especially when water is scarce. Small demands may produce sort water level depletion, which may be enough to erase water from surface. The great difficulties for controlling pumped water, and the possibility of getting huge amount of water in large aquifers, make solidarity control a difficult task.

Additionally, hydrosolidarity in an aquifer must be view not only from the space, but also from time perspective. The flexibility of an aquifer to offer resources beyond the naturally recharge introduces the possibility of arriving conflict between current and future generations. Therefore, the issue of sharing resources in flatland regions become highly vulnerable for aquatic ecosystems,

and more complex that in catchment response regions, because of the larger management flexibility, being water available in a larger region.

Ecosystems resilience

Ecosystem resilience is the capacity of an ecosystem to cope with changes and perturbations. Loss of resilience leads to more vulnerable systems, and possible ecosystems shifts to undesired states that provide fewer ecosystem goods (like fish and crops) and services (like flood control and water purification). Resilience may be viewed as the "immune system" of ecosystems. Studies of rangeland, forest and ocean ecosystems show that human-induced stress and overexploitation of species reduce their resilience to storms, fires or other events which they coped with before. When resilience is lowered, even minor disturbances can cause a shift to a state that is difficult, expensive or even impossible to reverse.

Social resilience is a measure of a community's ability to cope with change without losing its core function as a community, including its economic and management possibilities. Notably, social resilience differs fundamentally from ecosystem resilience by having the added capacity of human to anticipate and plan for the future. Water is a key resource for social, economic and cultural development. This is illustrated by the fact that must of the world's poorest countries are those where coping with water scarcity will be a key component in agricultural development. Green water refers to the water that supports plant production in forests, grassland, rain-fed croplands and wetlands and is responsible for much of the production of wealth. On the other side, blue water play a major role in holding aquatic ecosystems, and this is the concern for must of environmental issues. In flatland, green water flow gains importance against blue water.

Human changes on flatland hydrology produce large impacts on the aquatic ecosystems, because water depletion produces surface water removal. Resilience of these ecosystems is low, and the capacity to recover the original situation depends much more on the hydrogeological resilience. Non-aquatic vegetation is also affected by ground water depletion, especially when original water table is close to the surface. Here resilience is also regulated by the hydrogeology response to changes.

Some changes in the soil are irreversible, like the related with water dryness and the soil water-storage capacity and permeability. After water table decreases, soil structure may change because of the dryness effect. The soil

pore distribution may adjust though more closed structure, and water-storage capacity, and sometimes permeability, decreases. This is called the soil subsidence effect. Soil subsidence produces a resilience decrement, because the smaller soil water-storage capacity.

In relation to quality alterations, the long time of residence of water in flatland, which mainly escapes in form of green water flow, produce that contaminants, high nutrient concentrations or salts remain on field during long time. Usually, these impacts reach ground water, with long time to recover the original water quality for the natural flow. Thus, vulnerability of flatland ecosystems is generally larger than in catchment response regions. The capacity of the ecosystem to get adapted to changes is reduced.

Furthermore, in arid and semiarid regions, modifications may lead to notably changes, losing original vegetations and animal species associated to aquatic environments. Land-use mismanagement when water scarcity is noted has a risk of land transformation to dessert, with difficult reversibility.

A case of study: the upper Guadiana River Basin

The Spanish Iberian Peninsula contains seven major river basins: Duero, Tajo, Guadiana, Guadalquivir, Segura, Júcar, and Ebro. The case of study here presented is situated in the Guadiana river basin. The upper catchment of the basin is closed to the central part of Spain. Its interior localization produces that rainfall front coming form the Mediterranean Sea and Atlantic Ocean reach the basin with small humidity content. Mean annual precipitation depth is around 400 mm per year, with a semiarid climate. The region occupies a total area of 15,500 km^2, and it is limited by the Tajo, Jucar, Segura and Guadalquivir Basins (Figure 1). The Upper Guadiana River Basin distinguishes from the rest of Guadiana River because of its flatland hydrological response.

The landscape is characterized by reduced slopes, with multiples endorheic basins, typical for a flatland region. Geological and orographical configuration produces a rich and complex hydrological system. Two major flatland regions are situated in the basing at different elevation, which are designed mainly by the “Campo de Montiel” and “Mancha Occidental” aquifers (“Acuifero 24” and “Acuifero 23”, respectively). These two flatland regions are interconnected by subsurface flows, which locally become surface flows, like the case of the ”Ruidera” pools system. Ruidera system is a cascade of pools, receiving flows from the surface and ground water, which produce a surface flow connection

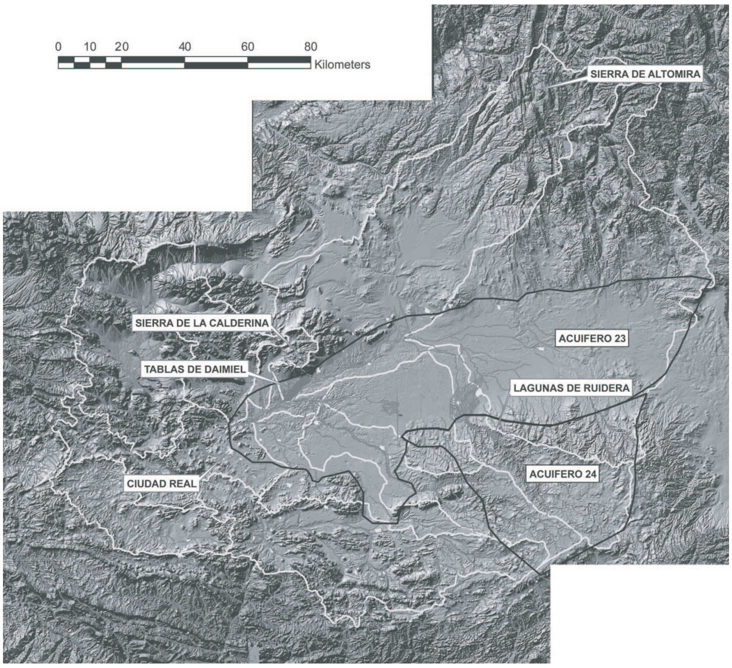

Figure 1. Upper Guadiana River Basin orography. Subcatchments are plotted in white polygons, and major aquifers in black polygons.

between these flatlands given by the sequence of spilled water between consecutive pools. Ruidera is considered a Natural Park by the valuable scene provided and the ecosystem which holds.

The set of endorheic basins also produces a rich variety of aquatic ecosystems, with permanent or seasonal lagoons. The surface waters in the flatland regions loss their continuity; however major rivers can be identified from the surface. Streamflow are coming mainly by the ground water contribution, when water table level reaches the surface in this surface water courses. The morphology of these courses is characterized by a weak depth and high width. These surface flows get low depth and flood vast areas, with slow water movement. Within the surface course of the Guadiana River the major ecosystem is the called "Tablas de Daimiel", which has the degree of National Park. The lower flatland region in the Upper Guadiana River Basin is receiving flows form two areas with catchment response: "Sierra de Altomira" and "Sierra de Calderina". These catchment response areas produce two tributary rivers of the Guadiana, which superficial flow disappear after reaching the flatland areas.

The hydrological complexity of the system that form the Upper Guadiana River Basin has suffer hard modification during the history, many of then coming form a erroneous interpretation of the hydrological system and the its high interdependence and low resilience.

Historical misunderstanding

In her book, Almagro (2006) presents the sequence of historical item that have produced a drastic transformation of the landscape, hydrology and ecosystems in the Upper Guadiana River Basin. The fist item is found in the year 1781 a.c., when the architected Juan de Villanueva (Madrid, 1739–1811) presented two projects related to the transformation of the Upper Guadiana River Basin. The objective of these projects was to build channels, which was a usual action in Europe during XVIII century. These channels had the intention to provide fluvial communication with other Spanish Regions, the irrigation of vast areas in the region and the energy supply to new water mills. The amount of water required to feed the projected channel were expected to be given by the natural flows coming from the "Lagunas de Ruidera" and the leakage flow obtained form drainage channels. One major issue at this moment was the sanitary risk that vast extensions of permanent flooded areas produced for population. Drainage channels were recurrently requested to reduce flooded areas and its transformation for the agricultural use, canalizing this water and delivering it in the region.

The projects had a reference in the french channels constructed before, which become a fluvial communication between the Mediterranean Sea and the Atlantic Ocean. Other channel projects were being constructed at this time, like the "Castilla Channel", with frustrated ending years after. One major difference is given in the case of Upper Guadiana, the climate. Low average precipitation was noted in this area then; however this was not found reason to declare unfeasible the Juan de Villanueva projects. Nobody noticed the slow movement of such huge amount of water in the region.

The Juan de Villanueva projects were not constructed before he died. During XIX century the concepts used for Villanueva were used in many new projects, some of then constructed during second half XIX century and first half XX century. The construction of channels, "ríos", was requested in many areas. It was expected that these channel would bring more water. The idea of land use transformation to irrigated land for agriculture was spread in the country. Simultaneously, the technical and scientific knowledge was continuously improving from the Villanueva period. However, it is in 1956 when was publicized a law which initiated the construction of a project in the Upper Guadiana River Basin similar to the Villanueva one.

The ideas of Villanueva were adopted by the local population, and requested for centuries. Even when hydrological knowledge was enough in 1956 to explain the consequences of such actions, the project was executed. A total of 1,100 km of channel were constructed, which produced the direct dryness of a flood area of $310km^2$. However the expectation was frustrated, the "new rivers" did not transport enough water. The expected irrigation area was too much for the water available. Additionally the water level decreased because of the drainage network.

The lesson given by the water was not enough in the region to understand that water available could not support the expected agricultural transformation. Progressively numerous wells were constructed in order to supply of water the projected irrigated areas. The progressive increases in wells construction and water pumping produces nowadays a total transformation of the landscape, hydrologic regime and ecosystems in the region. Many ecological habitats have disappeared, and the main aquifers are claimed over-exploited.

The original sanitary problem has suffered a rapid transformation to an environmental and socio-economic problem, where an important population depends on the supply of water that can not be achieved in the area without over-exploiting the aquifers. The reduced resilience of the flatland region has produced drastic changes. However, now the social resilience has become a major

issue. Modifying the actual tendency toward a sustainable solution requires introducing new economical activities, and transforming the agriculture improving its efficiency.

The misunderstanding of water behaviour in flatland regions has produced in the world many examples similar to the Upper Guadiana. The vulnerability of these systems produces rapid changes, which make an issue water management in flatland regions with arid and semiarid climates.

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VI

DECISION SUPPORT SYSTEM FOR TRANSBOUNDARY WATERS MANAGEMENT

DECISION SUPPORT MODELING IN TRANSBOUNDARY WATER RESOURCES MANAGEMENT: THE CASE OF THE MESTA/NESTOS RIVER IN THE BALKANS

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Abstract Transboundary water resources management may lead to potential conflicts and political tensions between riparian countries. The reasons for such tensions may be of a domestic or international nature. Integrated transboundary water resources management involves *alternative options* for water storage and use, wastewater treatment and disposal, *different states of nature* (climatic conditions and socio-economic environments) and *various preferences or objectives* (economic, social and environmental). In this paper, three alternative methods based on Multicriterion Decision Analysis (MCDA) are proposed in order to facilitate negotiations on sharing international waters. According to the first method, each country proceeds separately and evaluates alternatives according to its own objectives. In the second approach both countries' particular objectives are first traded-off and then alternatives are ranked according to the common composite objectives. The third method is based on the aggregation of the countries' different alternatives in order to obtain a consensus between the partners. The case of the River Nestos/Mesta, flowing between Bulgaria and Greece, provides an illustration of this methodology in practice.

Keywords: Transboundary Water Management, Multicriterion Decision Analysis, Modelling, Nestos/Mesta River.

Introduction

Big rivers and lakes have been used in the past as natural frontiers between countries and as such they have been the sites of many armed conflicts throughout history (e.g. the Rhine between France and Germany, the Rio Grande

*INWEB: International Network of Water/Environment Centres for the Balkans.

between the USA and Mexico, the Odder and Neisse between Germany and Poland, and the Amur and Ussuri between Russia and China). In most cases however, river basin boundaries do not determine national political borders and sharing common water resources may induce tensions and conflicts. One main reason is the dissymmetry between the situation of countries occupying the upstream part of the river basin, where they can control and even divert the water, in comparison with the less favourable case of countries located in the downstream part of the river catchment. Characteristic examples of such situations are the Nile River, shared between the Sudan upstream and Egypt downstream, the Jordan River in the Middle East shared between Israel upstream and Palestine and Jordan downstream and the Mesta/Nestos River between Bulgaria upstream and Greece downstream.

Basic questions are how, and through what kind of processes, water in transborder regions may unify rather than divide the riparian countries, and how stakeholders in international water catchments may increase their benefits without causing losses to others? The issue is complex, because political issues of domestic and foreign policy are involved and affect technical, economic and ecological considerations.

This paper first reviews the complexity of transboundary water resources management and different strategies for regional negotiations. Then, the technical and institutional approaches, which may lead to agreements on sharing waters, are analyzed. Effective implementation of such treaties may be realized following a bottom-up approach, based on “regional partnerships”. There is a need for such regional exchanges and partnerships to be coordinated, and this makes the creation of the UNESCO Chair/INWEB (International Network of Water – Environment Centres for the Balkans) extremely important.

UNESCO-INWEB activities on international waters in the Balkans

UNESCO-INWEB has developed and continues to work on major international programmes for transboundary water resources management at a regional level. UNESCO-INWEB’s first priority lies in South Eastern Europe (SEE) or the Balkans. The Balkan Peninsula extends from the Bay of Trieste west to the Danube River Delta in the eastern Black Sea. The northern geographical boundary of the Balkan region is traditionally considered to be the

Figure 1. Countries in the Balkan region.

Danube River, although Romania also belongs to the Balkans. The 10 Balkan countries[1] are shown in Figure 1.

The Balkan Peninsula covers an area of around 520,000 km^2 and has about 45 million inhabitants. Almost all the main rivers in the Balkans, except those of Central and South Greece, are internationally shared. This means that the majority of the land that extends up to 90% belongs to transboundary river catchments (Figure 2).

Three main programmes are presently under development. The first, entitled UNESCO-TRANSRISKBA, is coordinated by the UNESCO Regional Office for Science and Culture in Europe (UNESCO-ROSTE) and has as its main goal the development of an inventory of transboundary surface waters and lakes in the SEE. The second programme, entitled UNESCO-ISARM /Balkans (Internationally Shared Aquifer Resources Management), deals with technical, institutional, economic and social considerations of transboundary groundwa-

[1]Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Former Yugoslave Republic of Macedonia, Greece, Serbia & Montenegro, Slovenia, Turkey, Romania.

Figure 2. Area covered by internationally shared rivers in the Balkan region.

Figure 3. Geographical location of the Nestos/Mesta River.

ter management in the region. The third is the PCCP/SEE programme (from Potential Conflict to Cooperation Potential), which focuses on various methodologies, including training and capacity building, in order to prevent and alleviate potential conflicts in sharing transboundary water resources.

After the collapse of the Former Yugoslav Federation in SEE, the number of internationally shared river basins in the region more than doubled. In fact, before 1990, there were six sub-Danubian international river catchments[2] shared between Albania, the Former Yugoslav Federation, Greece, Bulgaria and Turkey. Today, seven new transboundary catchments should also be considered[3], which are shared by Slovenia, Croatia, Bosnia & Herzegovina, Serbia & Montenegro and FYR Macedonia. To the above international basins, four transboundary lake basins should also be added[4]. The Nestos/Mesta River Basin, shown in Figure 3, shared between Greece and Bulgaria, is one of the major challenges in the region.

Despite earlier agreements, Bulgaria has in the past withheld water for increased agricultural and industrial needs. Since 1975 the Nestos flow has declined from 1500 million m^3 to 600 million m^3 resulting in repeated Greek

[2]Transboundary Rivers: Aoos/Vjosa, Drim, Axios/Vardar, Strymon/Struma, Nestos/Mesta, and Evros/Maritza/Meric
[3]Transboundary Rivers: Sava, Kupa/Colpa, Cetina, Una, Drina, Neretva, Trebisnjica
[4]Transboundary Lakes: Skutari/Shkotar, Ohrid, Prespa, Dojran/Doirani

protests. Despite a series of negotiations no agreement has been reached; and failure to resolve the situation has resulted in conflicts between the two countries. **Recently** an agreement has been reached, but noticeable pollution from the Bulgarian part has raised the level of tension in a region of Greece highly dependent on irrigated agriculture and hydropower. There is a major need for cooperation and application of European Union (EU) guidelines for Integrated Water Resources Management (IWRM) in transboundary river basins in the Balkans.

Potential conflicts of riparian states in water resources development

Disputes over shared water resources among nations have a long history. According to Gleick (1991, 1992), when water resources are considered as strategic goals, three classes of water-related disputes may be distinguished, i.e.

1) targets during war
2) tools or weapons of conflict, and
3) roots of conflict.

Conflict situations in transboundary water resources management occur on at least two levels:

1) conflict among goals, objectives and attributes, in particular economic, environmental and social criteria and
2) conflicts of interest between countries and among groups of actors involved.

Goals. Broadly speaking, every state has social, economic and political goals linked to water resources development, conservation, and control and protection of the river basin. Economic goals may be to obtain new water resources in order to increase food production, conservation goals may be to control water pollution, and control and protection goals may concern defence from floods or drought control. These goals may be achievable by jointly building water reservoirs. This would entail the states involved cooperating together and solving possible areas of conflict.

Purposes in accomplishing goals. Goals are accomplished by various water resources developments, transfers of water from the water-surplus adjacent river basins, water conservation, control and protection. Each particular goal means satisfying some particular purpose, which may have to do with irrigation, drainage, hydropower production, navigation, water supply, water pollution control, flood defence, drought control, or other.

Objectives and attributes in accomplishing purposes and goals. Finally, to satisfy the purposes of state goals in water resources development one must define and then maximize or minimize the economic, social, monetary and political objectives. The particular goals, purposes, objectives and interests in water resources development of the river basin should be strictly taken into consideration in any future cooperation on conflict resolution between the states.

MultiCriterion Decision Analysis (MCDA)

MCDA techniques are gaining importance as potential tools for solving complex real world problems, because of their inherent ability to consider different alternative scenarios, the best of which may then be analyzed in depth before being finally implemented (Goicoechea et al., 1982; Szidarovszky et al., 1986; Pomerol and Romero, 2000).

In order to apply MCDA techniques, it is important to specify the following:

- **The objectives**, which indicate the directions of state change of the system under examination, and which need to be maximized, minimized or maintained in the same position.
- **The attributes**, which refer to the characteristics, factors and indices of the alternative management scenarios. An attribute should provide the means for evaluating the attainment level of an objective.
- **The constraints**, which are restrictions on attributes and decision variables that can or cannot be expressed mathematically.
- **The criteria**, which can be expressed either as attributes or objectives.

As shown in Figure 4, the three pillars of sustainability, i.e. the economic, social and environmental criteria can be defined hierarchically, starting from basic indicators, which are then aggregated into second and third level indicators.

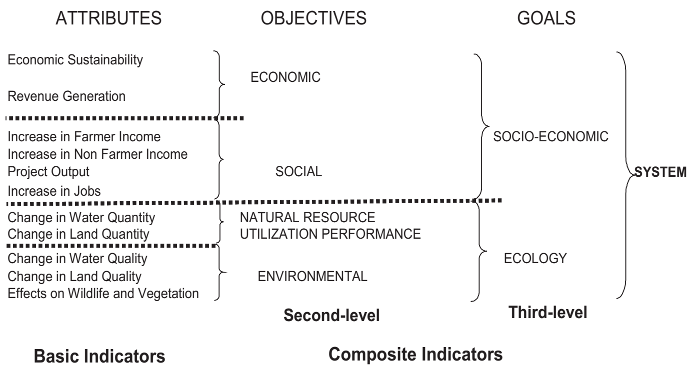

Figure 4. Social, economic, and environmental attributes, objectives, and goals.

In MCDA the aim is not to obtain an optimal solution, as would be the case with only one objective, but a "non-inferior" or "non-dominated" solution. This is a solution that improves all objective functions. Other solutions cannot improve a single objective without causing a degradation of at least one other objective.

MultiCriterion Decision Analysis (MCDA) is adapted in this paper as a decision support methodology for managing transboundary risks related to different criteria and objectives set by different countries. For this purpose, three alternative methods are proposed in order to facilitate negotiations and reach final decisions. All are based on the combined use of modeling, experts' opinions and a decision support method called *Composite Programming* (CP). This is a distance-based technique, which defines the "best" solution as the one in the set of efficient solutions, whose point is at the least distance from an ideal point (Zeleny, 1982). The aim is to obtain a solution that is as "close" as possible to some ideal. The distance measure used in CP is the family of L_p – metrics and given as

$$L_p(a) = \left[\sum_{j=1}^{J} w_j \left| \frac{f_j^* - f_j(a)}{M_j - m_j} \right|^p \right]^{\frac{1}{p}} \quad (1)$$

where

$L_p(a)$	L_p metric for alternative a.
$f_j(a)$	Value of criterion j for alternative a.
M_j	Maximum (ideal) value of criterion j in set A.
m_j	Minimum (anti ideal) value of criterion j in set A.
f_j^*	Ideal value of criterion j.
w_j	Weight of the criterion j.
p	Parameter reflecting the attitude of the decision maker with respect to compensation between deviations.

For $p = 1$, all deviations from f_j^* are taken into account in direct proportion to their magnitudes, meaning that there is full (weighted) compensation between deviations. For $2 \leq p \leq \infty$ the largest deviation has the greatest influence, so that compensation is only partial (large deviations are penalized). For $p = \infty$, the largest deviation is the only one taken into account (min-max criterion) corresponding to zero compensation between deviations (perfect equity).

The methodology proposed addresses two fundamental issues in transboundary water management, which are conflict situations at two levels:

a) conflict among objectives and criteria, in particular, economic, environmental and social criteria

b) conflict among strategic goals between countries

As an extension of the present methodology, two different types of uncertainties will be taken into consideration, i.e. uncertainties

a) in criterion values

b) in the preference functions of the actors or interest groups.

Three different approaches are used for conflict resolution. In the *first approach*, each country proceeds separately and evaluates alternatives according to its own objectives. In the *second approach* the different objectives used by the two countries are first traded-off and then alternatives are ranked according to the composite objectives. The *third method* is based on the aggregation of the countries' different alternatives in order to obtain a consensus between them.

The case of the international river Nestos/Mesta, flowing between Greece and Bulgaria, provides an illustration of this methodology in practice.

The Mesta / Nestos case study

Identification of problems and options for water management

a) in the Greek part of the basin:

Main problems:

Water availability problems: The river flow in the area is controlled by 3 dams for energy production, which come under the jurisdiction of the Public Power Corporation. Downstream of the dams there is significant agricultural activity. The river's delta is protected by the Ramsar treaty. Intensive use of fertilisers, overexploitation of groundwater and the intensive use of drills have created water quantity (and quality) problems. As irrigation is the main source of development in the region, it is important to maintain a level of involvement through a long-term programme and a level of interference. The water from the river also covers urban needs and provides the opportunity for recreational activities.

Water quality problems: The delta area consists mainly of agricultural fields and settlements. Farmers' intensive use of pesticides and fertilisers, the lack of landfills and wastewater treatment facilities, the unsystematic breeding of cattle and the use of groundwater resources for drinking water may cause salinisation of coastal areas, health problems from unsuitable drinking water and negative impacts to the delta's ecosystem.

Environmental problems. Impact on fauna and flora: In compliance with the Ramsar treaty in the delta area, many different authorities are responsible for different aspects of water resources management, which makes an integrated approach in management difficult to apply.

Development problems: Poor infrastructure and lack of facilities mean that there is a very low level of tourism in the area, despite its unique environmental beauty.

Management alternatives:

OPTION 1 (GR)

Project Name:	Strengthening Agricultural Practices and Crop Redistribution.
Location:	Basin wide.
Objectives:	Increase agricultural production and productivity.
Project Purpose:	To provide effective, credible and farmer-oriented support services, such as providing farmers with information on research and demonstrating and providing information on new crops/varieties and farming systems, thus improving farming practices.

OPTION 2 (GR)

Project Name:	Review and Reappraisal of Irrigation Development Projects.
Location:	Downstream part of the basin.
Objectives:	To improve agricultural production and productivity of high value crops.
Project Purpose:	Irrigation of 15,000 ha of land to enable crops to be grown all year round.

OPTION 3 (GR)

Project Name:	Medium/Long Term International Wildlife Tourism Development.
Location:	Delta region, reservoirs and other wildlife areas.
Objectives:	To improve economic gains from wildlife tourism.
Project Purpose:	Medium and long term investment in tourism.

OPTION 4 (GR)

Project Name:	Inland Fisheries Resource Development Project.
Location:	Delta Region.
Objectives:	To increase fish production.
Project Purpose:	To establish a controlled and profitable exploitation of fisheries in the basin.

b) in the Bulgarian part of the basin:

Main problems:

* *Water quality problems:* Problems are caused by the direct outflow of the waste waters from living needs in the populated areas; industrial waters mouthing at the river, either directly or from the sewer systems of the populated areas; hard waste materials from living needs; waste materials from the wood industry and wood treatment; waste materials from cattle breeding; and pollution from the uranium mine near the village of Eleshnitsa.
* *Development problems:* The lack of waste water treatment plants (WWTP) and significant shortcomings in infrastructure create unfavourable conditions for water use. Tourism is negatively affected by the underdeveloped road infrastructure, and agriculture by the limited availability of land for the development of intensive farming.
* *Different socio-economic conditions:* Due to political reasons, development in the area is very slow. Bulgaria has a new political status, and the transition to free market-economy conditions is still incomplete.

Management alternatives:

OPTION 5 (BG)

Project Name:	Water Supply Distribution Project.
Location:	Basin wide (Bulgarian part).
Objectives:	Exploitation of the remaining flow of the river (after the 29% flowing to Greece).
Project Purpose:	To improve unfavourable conditions for water use.

OPTION 6 (BG)

Project Name:	Construction of New Reservoirs for Multiple Water Uses.
Location:	Basin wide (Bulgarian part).
Objectives:	Exploitation of the reminder flow of the river.
Project Purpose:	To enhance the development of the area.

OPTION 7 (BG)

Project Name:	Construction of WWTP.
Location:	Basin wide (Bulgarian part).
Objectives:	Water pollution management.
Project Purpose:	To enhance the development of the area by improving internal infrastructure.

OPTION 8 (BG)

Project Name:	Development of Local.
Location:	Upper part of the basin (Bulgarian part).
Objectives:	Economic gains, integrated planning approach.
Project Purpose:	Tourism development in the area, based on indigenous resources such as areas of natural beauty, thermal spas, local crafts and historical heritage.

In order to evaluate performances of the above projects, the following indicators were supposed to be set by agreement between the two countries:

Indicators

1) Economic Sustainability.
2) Revenue Generation.
3) Increase in Farmer Income.
4) Increase in non farmer income.
5) Increase in Jobs.
6) Change in Water Quantity.
7) Change in Land Quantity.

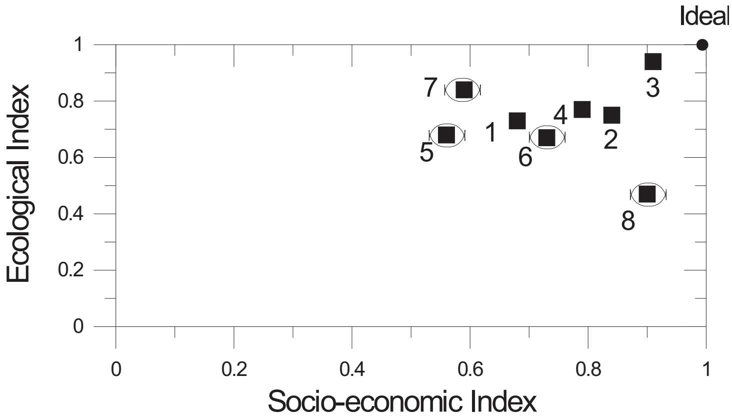

Figure 5. Ranking of alternatives for Greece's assessment.

8) Change in Water Quality.
9) Change in Land Quality.
10) Effects on Wildlife and Vegetation

For each alternative option of water resources management, the evaluation of indicator values is the major problem, which may be resolved either by running different models or by asking experts judgement.

In the present hypothetical case study, we first suppose that two groups of national experts evaluate separately the alternative options 1–10, which are described above. Values of indicators 1–10 are converted in a scale from 0 (worst) to 1 (ideal).

By use of formula (1) with equal weights, indicators 1–5 are grouped in one *socio-economic index* and from 6 to 10 in one *ecological index*. Results obtained by the two separate hypothetical national groups are shown in Figures 5 (for Greece) and 6 (for Bulgaria).

Ranking of alternatives is obtained by comparing the distances of each option from the ideal point (1,1). From the Figures 5 and 6 the following rankings are obtained:

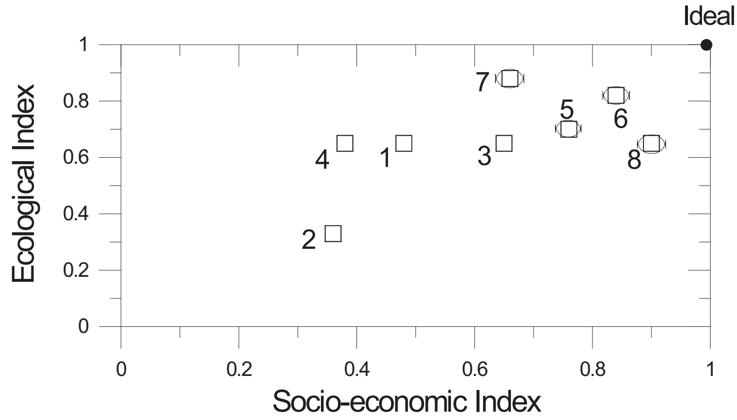

Figure 6. Ranking of alternatives for Bulgaria's assessment.

1	Pr 3	Wildlife Tourism Development (GR)
2	Pr 2	Irrigation Development Projects (GR)
3	Pr 4	Inland Fisheries Resource Development (GR)
4	Pr 8	Tourism Development (BG)

Table 1. Ranking of alternatives for Country 1 (GR):

1	Pr 6	Construction of new Reservoirs (BG)
2	Pr 8	Tourism Development (BG)
3	Pr 5	Water Supply Distribution (BG)
4	Pr 7	Construction of WWTP (BG)

Table 2. Ranking of alternatives for Country 2 (BG):

We may realize that no consensus is reached and that priorities are different for the two countries. Obviously, Greek experts give preference to options having higher positive impact to the Greek part of the basin and the same applies with the respective options in the Bulgarian part. The two different classifications by the two countries may produce tensions and potential conflicts.

Let us now apply the two methodologies for conflict resolution.

1) According to the first approach, country's indicators that are different for the same option are traded-off by using the formula 1 with the same weights. The common values of individual indicators may be reached by negotiations. The results are shown Figure 7.

1	Pr 3	Wildlife Tourism Development (GR)
2	Pr 6	Construction of new Reservoirs (BG)
3	Pr 8	Tourism Development (BG)
4	Pr 4	Inland Fisheries Resource Development (GR)

Table 3. Conflict Resolution 1

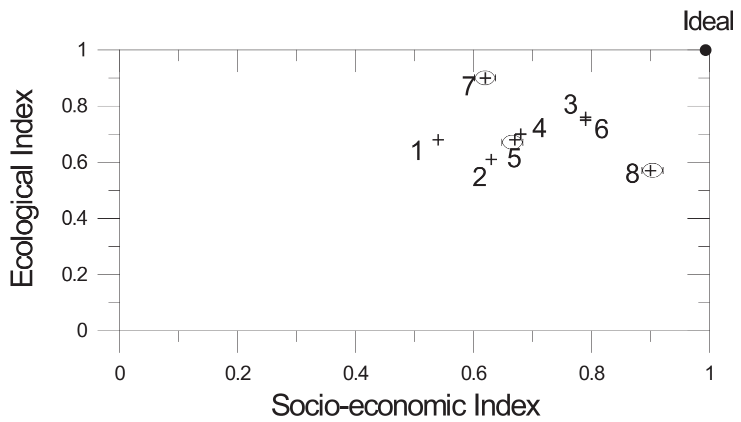

Figure 7. Conflict resolution (1) by trading off countries' different assessment of indicators.

2) In the second approach, instead of looking at individual indicators, trade off are imposed to different global socio-economic and ecological values corresponding to the two countries. The results are shown Figure 8.

1	Pr 3	Wildlife Tourism Development (GR)
2	Pr 6	Construction of new Reservoirs (BG)
3	Pr 8,7	Tourism Development/ Construction of WWTP (BG)
4	Pr 4	Inland Fisheries Resource Development (GR)

Table 4. Conflict Resolution 2

It is worth noticing that the proposed conflict resolution rankings are consistent for the two different methodologies and also fair and well equilibrated between the two countries. Such proposals may help decision makers attain a sustainable agreement between the two countries.

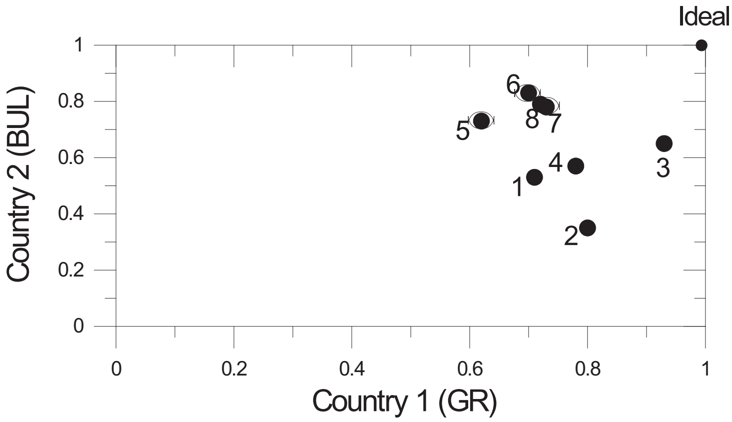

Figure 8. Conflict resolution (2) by trading off countries' different assessment of goals.

Conclusions

Although several hundred international conventions on sharing transboundary waters are theoretically operational around the world, their effectiveness in achieving the goals they have established is questionable. The main reasons for this unfortunate situation are:

1) Centralized institutional decision making structures fail to reflect the interests of local water stakeholders.

2) The technocratic character of water resources management encourages structural solutions and means that it is more likely for engineering works to be built than water management practices be applied.

3) Absence of an integrated water resources management approach, which should reflect not only technical but also environmental, economic and social needs.

The methodology proposed is based on a combination of MCDA and CP techniques adapted to conflict resolution. Trade-offs are made either at the level of countries' different appreciation or understanding of individual criteria, or at the level of countries' different goals.

The methodology is easy to use and the results obtained are fair, transparent and simple to communicate to decision makers.

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WATER BANKING AND LEASING: INSTITUTIONAL DESIGN AND INTEGRATED MODELLING.*

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Abstract

Since 1950, the demand for water has more than doubled in the United States. Virtually all water supplies are allocated, leading to the question of where will water come from? The concept of water leasing/banking has gained considerable attention as a volunteer, market-mediated system for transferring water between competing uses. For a water leasing/banking system to be truly effective, detailed knowledge of the available water supply and the factors that affect water

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demand is critical. Improving understating of the factors that determine residential, industrial, and agricultural demand for water using experimental economics and then integrating into a model will allow for better understanding of the potential of market-based mechanisms to allocate water resources effectively is the focus of this research. The developed model utilizes an open market trading system known as a double oral auction, where buyers and sellers declare their bids and offers to the market. Participants in the experiment represent the interests of specific users, including agricultural users, Native Americans interests, urban interests, and environmental interests. Participants in the experiments are motived by a utility function specific to each water user's needs. Currently fourteen experiments have been run in four different climatic scenarios (decreasing, increasing, normal and dry water scenarios.) The results have shown the market is robust, with multiple trades occurring in each trading year. The trading process is efficient and participants effectively take on the assigned role of their user group.

Introduction

Since 1950, the demand for water has more than doubled in the United States. Historically, growing demands have been met by increasing reservoir capacity and groundwater mining, often at the expense of environmental and cultural concerns. The future is expected to hold much of the same. Demand for water will continue to increase, particularly in response to the expanding urban sector, while growing concerns about the environment are prompting interest in allocating more water for in-stream uses, and cultural issues will remain at the fore. So, where will this water come from? Virtually all water supplies are allocated. Providing for new users requires a reduction in the amount of water dedicated to existing users and a mechanism for transferring water between users.

Markets typically are formed to facilitate the efficient allocation of goods and services. Under simple conditions buyers and sellers pursuing their own self-interest willingly agree upon a single price that fully compensates sellers and provides the commodity to those who value it highest[1]. The general concepts of water rights marketing (here taken to mean a permanent transfer of a water right) and water leasing/banking (a temporary transfer) have been used as a volunteer, market-mediated system for transferring water between competing uses. Water market rights transfers are also often slow, and do not necessarily increase the flexibility of water users to trade quickly in response to

[1] It cannot be emphasized enough that any transfer of water within a market-based system is a voluntary transfer.

near term shortages and thus they do not directly address the need for a trading mechanism that can rapidly respond to climatic induced needs.

A sampling of investigations into water marketing where the focus is upon the formal trading of rights (as against leasing) can be found in Howe (1986), Burness and Quirk (1980), Simpson (1994), Saliba (1987), Easter et al. (1999), Colby (1993, 2000), Howe and Goemans (2003), and Brookshire et al. (2005).

Often water marketing is viewed as movement from agricultural use to urban uses, which are typically viewed as permanent. Rosen and Sexton (1993) state that farmers are price takers in the market for crops and in order to achieve equilibrium they must face decreasing marginal products for variable inputs and increasing marginal costs in the short run. Tradable water rights in a district allow for farmers to negotiate a sale on a variable input. Hamilton et al. (1989) studied a water market in Idaho where water was transferred from agricultural to power generation in times of drought. Instituting a water market allowed for power generation to be higher then current generation in a low flow year. This also increased economic profit as water has its lowest marginal value product in agricultural in this region. Colby (2000) studied three different water markets **1)** SO2 allowances, **2)** fishery quotas, **3)** water rights. The finding was that as economic gains became compellingly large, resistance to transactions receded and an active market eventually developed. There are also questions surrounding how to develop a market (i.e. what are the 3^{rd} party effects, transaction costs, well defined property right and the length of a transfer). Griffin and Hsu (1993) found that the transfer of diversion rights do not have third party effects where the transfer of consumptive rights do. Here collaborative market participation by instream users is necessary to have a successful market, with price differences representing instream values of the affected third parties.

Water Banking/leasing approaches have been set forth as one possibility for addressing the increasing needs and the possibility of reallocation within and across current uses, in a timely fashion. The Water 2025: *Preventing Crises and Conflict in the West (2005)* calls for consideration of market-based principles in the context of existing institutional structures[2]. The New Mexico State Water plan also calls for an efficient water transfer plan (Office of the State

[2]The 2025 report sets forth some guiding principles for water transfers. These include in part, that recognition and respect must be made for state, tribal, and federal water rights, contracts, and interstate compacts or decrees of the United States Supreme Court that allocate the right to use water, that methods should include efforts to enhance water conservation, use efficiency and resource monitoring to allow existing water supplies to be used more effectively and that collaborative approaches go hand in hand with market based transfers in order to minimize conflicts.

Engineer, 2003). The New Mexico plan specifically supports water transfers as a strategic management tool for efficient water transfers inclusive of water banks[3] . Specifically, the State Engineer is responsible for implementation and encourages the creations of water banks in areas that are experiencing shortages.

Illustrations of water leasing/banking include Carey and Sunding (2002) who studied the Colorado Big Thompson project and the Central Valley Project in California and found that consolidation within a district can lead to a decrease in the transaction costs. Similarly, Weinberg et al. (1993) found that a water market price represents the opportunity costs of using water but only in crop production. This means that water markets create an incentive to reduce water use while policies such as effluent or input taxes motivate conservation of only the quantity of water applied in excess of crop needs.

A recent report details the limited nature of water leasing/banking in the Western U.S. (West Water Research, 2004). The report provides an analysis of water banking legislation policies and programs in 12 Western states. There are 23 active water banks of which seven are market based pricing, meaning that the price is negotiated between the buyer and the seller with one bank having online negotiations. The other 16 banks are fixed pricing or administrative pricing schemes that are set annually. Length of transaction varies and the number of transactions is limited annually.

In this research we explore the role of water leasing/banking in allocating resources among competing demands. In particular, we develop a stylized template for temporary voluntary transfers amongst competing uses (agriculture, Native American farming, environmental interests, urban interests) on the Middle Rio Grande in New Mexico, USA. There are many issues (engineering, physical, legal, and institutional) to be addressed in allowing for water transfers within a basin. In our initial framework, we represent one physical component by tracking evaporation associated with trades up and down the river. Our stylized template allows for future exploration of different physical, hydrological, engineering, spatial resolutions, market systems, legal institutions and priority frameworks, option trading through time, various representations of uncertainty, and different frameworks for third-party effects. The model design allows behavioral experiments to be conducted with sub-

[3]The New Mexico plan state: “Consider water rights transfer policies that balance the need to protect the customs, culture, environment and economics health and stability of the states diverse communities while providing for timely and efficient transfers of water between uses to meet both short-term shortages and long-term economic development needs”.

jects from key water use sectors to test how a voluntary water banking/leasing exchange process might operate. Central to our effort is linking of a hydrological/engineering/institutional model that allows for water transfers to be evaluated within the various frameworks.

Water rights

In developing a leasing market structure it is important to understand the structure of water rights found in the region to ensure that the market functions within the existing legal framework. Along the Middle Rio Grande there are various types of water rights, prior appropriations, and Native American and Spanish acequias.

The Bureau of Land Management (2006) recognizes Prior appropriation doctrine as "first in time – first in right", where those with the earliest priority dates have the right to the use of that amount of water over other users with later priority dates. There are four essential elements of prior appropriations doctrine: intent, diversion, beneficial use and priority. Historically intent has been determined by acts such as land clearing, preparation of diversion points and or posting of notice. Today intent is generally indicated by the application for a permit to divert. A permit is necessary for a diversion of water. Beneficial use definitions are used to determine whether a certain use of water will be recognized and protected by law against later appropriations. The last feature of prior appropriations is the priority of a water right. The first appropriator on a water source has the right to use the water in the system necessary to fulfill their water right; a junior appropriator cannot use water to satisfy their water right if it will injure the senior appropriator.

From the New Mexico State Engineer (2006) an acequia is defined in a physical, political and legal context. In a physical sense an acequia is a community ditch that is typically man made, open, unlined channel that conveys water to individual tracts of land, with the right being held in common. In a political sense an acequia is a public entity that functions to allocate and distribute irrigation water to landowners that are the members. In a legal sense an acequia is a ditch, which is not private or incorporated under the laws of the state and is owned by three or more persons as tenants. The area that defines an Acequia represents a cultural boundary or a physical boundary.

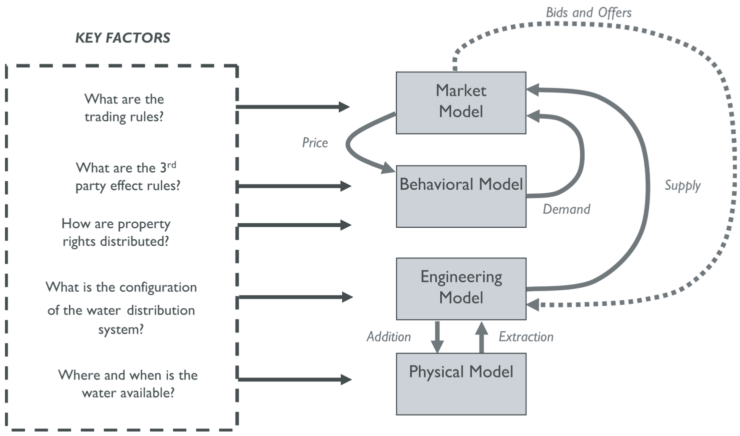

Figure 1. Schematic of integrated model architecture and feedback structure

Physical setting

The model addresses the Middle Rio Grande basin in New Mexico, USA, which is bounded by Cochiti Reservoir to the north and Elephant Butte Reservoir to the south. The model (Figure 1) integrates a physical/engineering model (e.g., climate, surface water, groundwater, and riparian habitat) with a behavioral/economic model (e.g., lease trading system, water demand). Within this region are many different users, including farmers, Indian pueblos, and urban users. The model allows a series of players representing agricultural/Native American farming, municipalities and environmental interests to trade water under high, average, and low water supply years. A relative newcomer to the user group is the river itself and the riparian ecosystem. Specifically, the silvery minnow (Hybognathus amarus) has been federally listed as endangered under the Endangered Species Act. As a result, critical habitat designation for the silvery minnow was established in 2003, extending from Cochiti Dam downstream to the utility line crossing the river in Socorro County. Flow requirements have also been established for various sections of the river and times of the year (U.S. Fish and Wildlife Service, 2003).

The intermittency of flow in lower reaches would be aggravated if not for the waters of the San Juan-Chama Project. Authorized by Congress in 1962, the San Juan-Chama Project is a trans-mountain diversion project that takes water from the upper tributaries of the San Juan River in the Colorado River Basin and transfers it to the Rio Grande Basin. A volume of 110,000 acre-feet is added to the Rio Grande stream flow (via the Rio Chama). 96,200 acre-feet are definitively allocated among various entities along the Rio Grande, although not all entities currently use their allocation. Primary among these is

the city of Albuquerque, New Mexico, USA. Its unused allocation of 48,200 acre-feet has helped keep the river wet and the minnow alive in previous years. However, Albuquerque has plans to being using its allocation in the near future to alleviate the drawdown on the aquifer, which has been the primary source of water for the city (U.S. Fish and Wildlife Service, 2003).

The Middle Rio Grande of central New Mexico (Figure 2) is characterized by basin and range topography with mountains along the east, and arid valleys and mesas to the central and west. The principle drainage for the basin is the Rio Grande, which is the primary source of irrigation water for the region's farmers. Municipal demands are met though pumping of deep alluvial aquifers that are directly connected with the Rio Grande River. Vegetation classes found within the region range from riparian along the Rio Grande to desert grassland, pinyon-juniper woodlands and mixed coniferous forest at higher mountain elevations. The planning region includes Albuquerque, the principal urban center of New Mexico, and several smaller communities including Rio Rancho, Belen, Los Lunas, Socorro and Bernalillo. These communities are located along the Rio Grande, while sparse rural populations characterizing the outlying areas. From 1900 to 2000 the population of this region grew from about 51,000 to about 713,000 (a 1298% increase), according to the U.S. Census Bureau. The most recent doubling of population occurred from about 1970 to 2000.

Physical Model Structure

The water leasing/banking model is formulated within a system dynamics context. System dynamics provides a unique mathematical framework for integrating the natural and social processes important to managing natural resources, while providing an interactive interface for engaging the public in the decision process. System dynamics is formulated on a spatially aggregated, temporally dynamic basis (i.e., lumped parameter model). Simply put, these models track the temporal trends in key system commodities (e.g., surface/groundwater) resulting from variable inflows and outflows (see Figure 3). These "flows" are modeled by way of historic data, empirical relations, analytical models, or from the output of spatially disaggregated models. Stocks and flows rarely operate independently but rather in a system of feedback and time delays.

The physical/engineering model is developed within the commercial system dynamics software package, Powersim Studio 2003. The model is designed to operate on a yearly time step. The model is structured according to 6 interacting reaches, as delineated by the major gages on the Rio Grande. Rio Grande

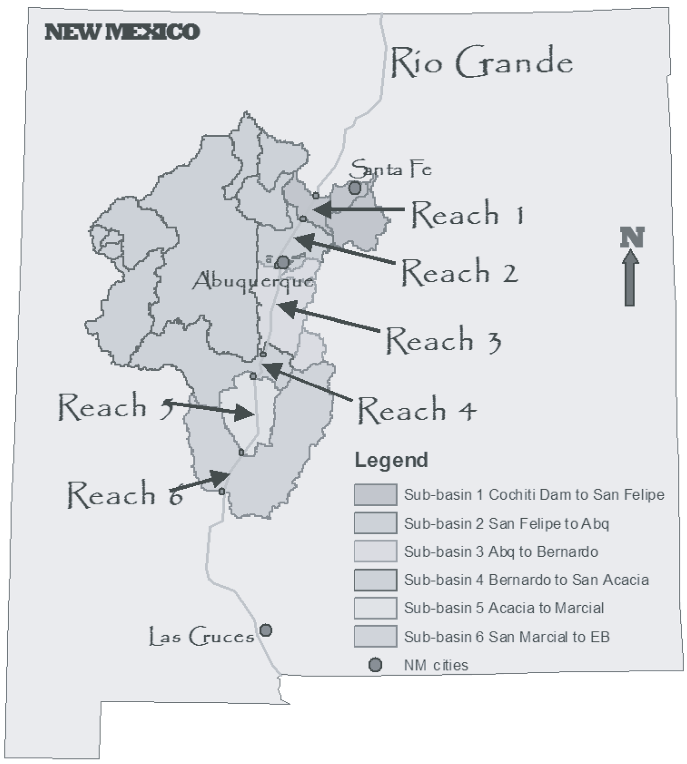

Figure 2. Map of the middle Rio Grande basin along with the 6 primary reaches/watersheds.

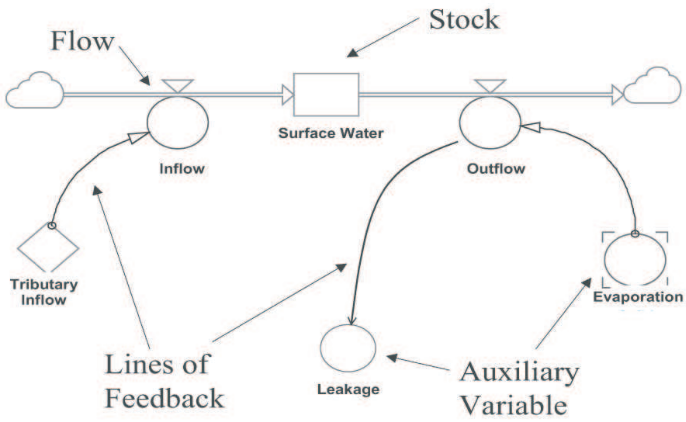

Figure 3. Schematic of simple system dynamics stock and flow diagram.

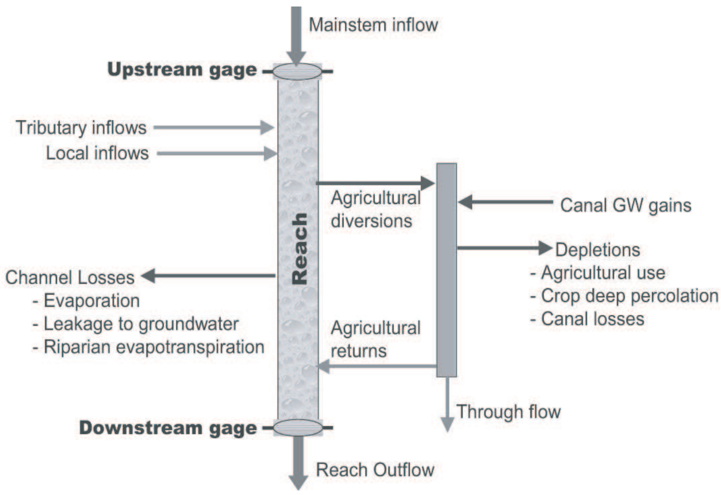

Figure 4. Schematic of generic reach showing the key water budget terms calculated by the hydrologic/engineering model.

inflows, tributary inflows and climatic conditions taken from historical records define the external forcing applied to the model. In this way, simulations can be run for dry, average, or wet years with either high or low reservoir storage. The model then calculates the basic water balance components for each reach of the model. The basic water balance terms are given in Figure 4. These terms are calculated by way of empirical models, analytical models, or through mass balance calculations.

For each time step, two model runs are performed. During the first run the model calculates river flows, conveyance losses, and available irrigation water. This information is supplied to the leasing/behavioral model. When a trading period ends, the water balance is re-calculated with the physical/engineering model. The second run of the model then calculates impacts of the trades on the hydraulic system. The model uses variables to represent the flows, the underlying determination of the flow values, as well as the interaction between the flows, is controlled by equations representing these physical relationships.

Market/behavioral model: Water leasing/banking exchange design

We utilize an open market trading system similar to the system used to trade other commodities such as wheat, corn, pork bellies and metals. Specifically, we employ a system known as a double oral auction. Buyers and sellers declare their bids and offers to the market. Contracts are established when a buyer and a seller agree on a standing price. The market is open for a fixed amount of time. Time in the experiment consists of a series of years, during which the market for water occurs during the six months of the growing season. There are four classes of participants in a leasing experiment. The participants (subjects in the experiments) represent the interests of specific users, including agricultural, Native Americans, urban interests, and environmental interests. Each agent represents the interests of one of these four user groups in a single reach of the model. Trades are allowed between reaches and within reaches. Subjects are motivated by monetary reward in the experiments and are paid based on profits earned through the leasing of water or by obtaining their yearly payoff based on their water use. We are not conducting simulations rather we are assuming the participants in the experiments maximize profits based on their underlying payoff functions. The experiment is based on the engineering model with a stylized river. The river flows from reach 1 to reach 6 (Figure 5). Using Powersim Studio 2003 water reduction factors are calculated for the four different classes of experiments.

Each water user group is motivated by a utility function unique to their needs. Agricultural/Native American users require three acre-feet of water during the growing season for their crops. Failure to obtain this minimum amount of water results in complete failure of their crop for the season. Excess amounts do not increase the crop payoffs but can be leased out for monetary gain. Players have the option of leasing their water instead of growing a crop, or if they are unable to obtain sufficient quantities of water for a crop. The urban region within the model represents Albuquerque. For the urban user, it

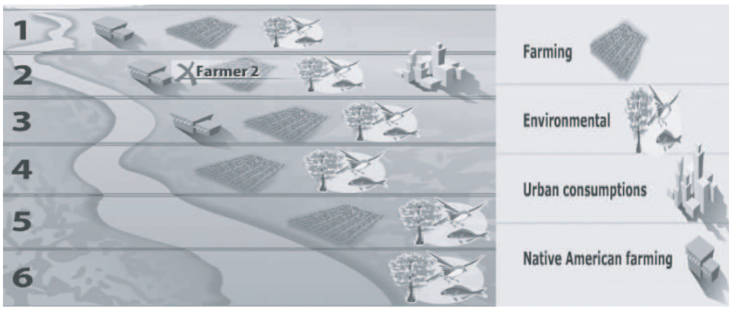

Figure 5. Depiction of stylized river.

is assumed that water produces value in ever increasing amounts but is subject to the law of diminishing marginal utility. For this reason, we model the urban payoff to water using a quadratic specification. Environmental uses of water are assumed to be for minnow protection and riparian restoration. These demands are modeled by a set of preferences that depend upon maintaining a minimum of two acre-feet of water in the river. Below this minimum, environmental losses occur. Above the minimum, positive environmental outcomes are forthcoming.

Figure 6 shows the demand functions for the three user groups. The demand functions for agricultural/Native American farming and environmental interests are a step demand function while the urban user has a downward sloping demand curve. Agricultural/Native American users seeking to maximize monetary payout will be willing to pay up to (b/a) to obtain (a) units of water. The environmental user's demand function is also a step function. The environmental user is willing to pay up to (c/b) to obtain (b) units of water. However, the environmental user receives a negative payoff if they allow water in the river to drop below a threshold of (b) units. This effectively models environmental concerns such as silvery minnow protection in the Middle Rio Grande. The urban user faces a downward sloping demand curve to model the idea of diminishing marginal returns.

Multiplying the agricultural/Native American demand function by the number of players (n), environmental by the number of players (n) and the urban by the number of players (n), then summing creates a market demand curve, the diagram on the far right of Figure 6. Using the experimentally set market supply and the market demand that comes from the aggregation of the three demand functions, an equilibrium or efficiency price can be calculated as the intersection of the market supply and the market demand. This allows the ob-

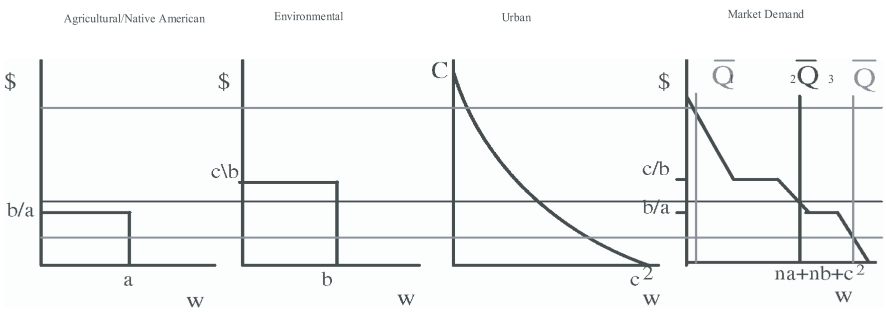

Figure 6. The three different water user groups are summed to create a market demand in order to develop the efficiency price. Red Q_1 represents a dry water scenario, black Q_2 a normal water scenario and blue Q_3 a wet water scenario.

served experimental prices to be compared to the efficiency price in order to determine if the market is efficient.

Three different climatic scenarios are also represented in Figure 6 with red (Q_1) representing a dry climatic scenario, black (Q_2) representing a normal climatic scenario and blue (Q_3) representing a wet climatic scenario. The different climatic scenarios are the market supply of water, with the intersection of the aggregate demand curve being the efficiency price for the market.

Experiments and results

The market experiments are conducted through a series of bidding sessions. In these sessions information from the physical/engineering model is passed to participants via a web interface. Water users may enter bid quantities and prices to sell or buy a unit of water, or they may accept specific offers at one-unit increments. The web interface checks to make sure both the buyer and seller each have sufficient amounts of money and water, and then determines if the transfer is possible using loss estimates from the physical/engineering model. Other potential constraints on a trade include water availability, Rio Grande Compact compliance, and/or Minimum River flow requirements. When a trade is made, the accepted bid or offer disappears from the bid/offer sheet. Buyers and sellers are free to update their bids and offers throughout the duration of the trading year. At the end of the year, the compact balance is checked and the hydrological model is recalibrated based upon the contracts impact on water flows. Bidding is concluded when all bidders have bought or sold as needed, some set number of transfers have been refused, or a fixed time limit is exceeded. All trades are voluntary. As with Smith (1982)

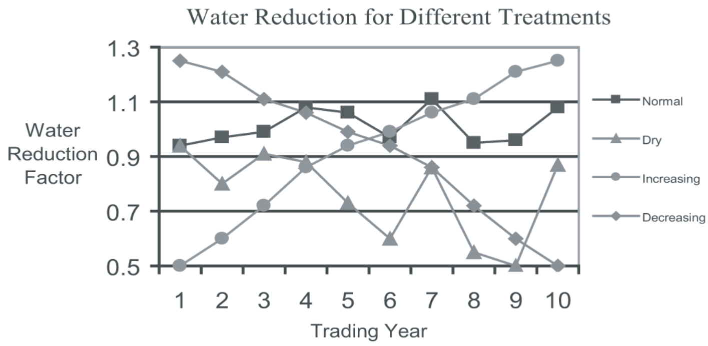

Figure 7. Four different climatic scenarios.

these are not simulations; rather participants received real dollars for participating.

Fourteen experiments were conducted over the summer of 2005; 3 decreasing scenarios, 3 increasing scenarios, 3 dry scenarios, 3 normal scenarios, 1 above normal scenario and 1 below normal scenario. Scenarios were developed by coupling the physical (hydrological) model with the engineering model. The water reduction factors for the experiments are shown in Figure 7. For example, in the decreasing water scenario the agricultural/Native American user begins trading year 1 with 3.75 acre feet of water which is above the 3 acre feet required to grow a crop for the trading year. Over the course of the trading years, water becomes scarce. In year 10 the user begins the trading year with 1.45 acre-feet of water. The water reduction factor was used to calculate the allocation for each user. Results show that the weighted average price obtained in the experiment is above the efficiency price calculated from the demand functions (Figure 8). The model also proved to be robust as all users engaged in multiple trades during each trading year.

Trading of water was observed both between reaches and within reaches. The current model only has one representative per user type on a reach (i.e. only one environmental user per reach). Even with a single representative, the results have shown that trading occurs amongst the user groups and within the user groups. Figure 9 shows how water was traded for the agricultural/Native American user during one decreasing water scenario (experiment 1). As can be seen, most of the trading occurs between the user group itself, with very few trades occurring with the urban user. As water became scarce, the number of trades engaged in by the agricultural/Native American group declined.

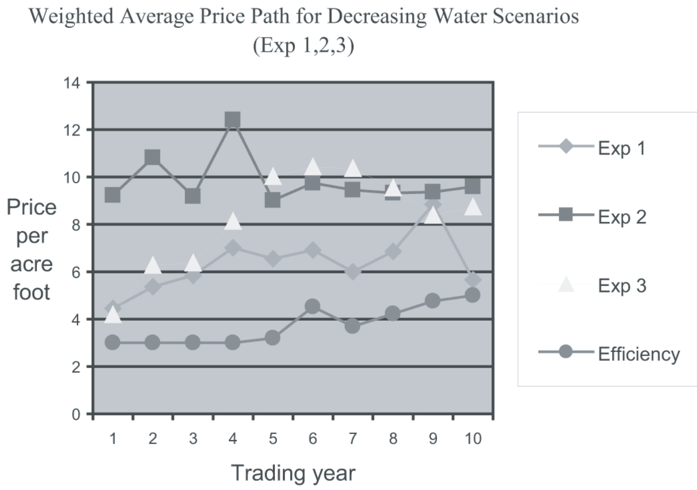

Figure 8. Weighted average price in relation to efficiency price.

Figure 10 shows that although the number of trades declined for this user group the amount of water traded increased as water became scarce. Results show that agricultural/Native American users leased water in dry years to obtain monetary benefits rather than grow a crop. The initial allocation of water for this user group is the point zero in Figure 10. The negative percentage means that farmers are net sellers of water.

Environmental users benefited the most in a decreasing water scenario, as they became net purchasers of water. The market system is able to meet environmental concerns such as protecting the silvery minnow and farmers were able to make a positive monetary reward by selling water to these users. The model is also able to track water movement between reaches and user groups. A priori expectations are that water would be traded upstream due to the effect of evaporation. Thus, water that would have been lost to evaporation can be saved through the trading of water from the lower reaches to the upper reaches. Results from the experiments have shown this to be true.

Figure 11 is a representation of the stylized river before a trading year (left side) and after a trading year (right side). The result shows the 7th round of a decreasing water scenario. To determine water movement by reach it was necessary to aggregate total water in each reach. Summing each user's water allotment by each reach did this. Since the environmental user's initial water allotment is below the minimum flow requirement needed to protect riparian

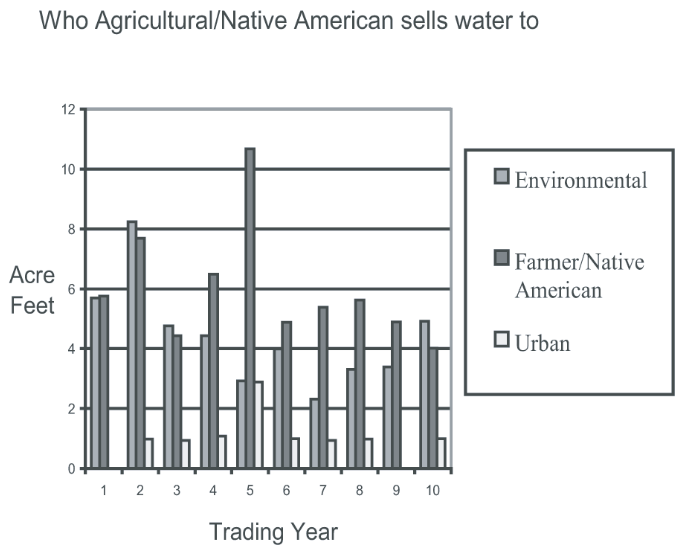

Figure 9. Agricultural/Native American trading of water.

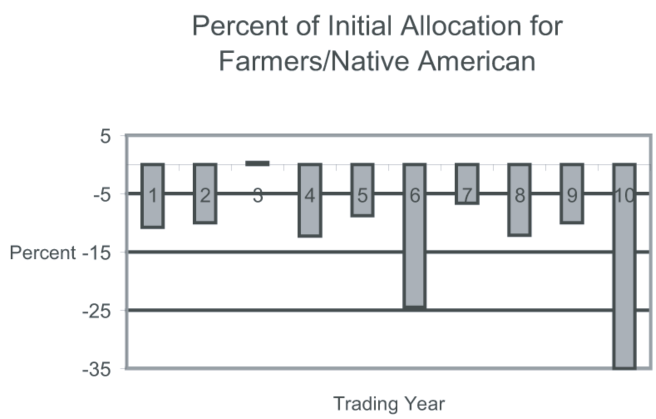

Figure 10. Agricultural/Native Americans percentage of initial allocation.

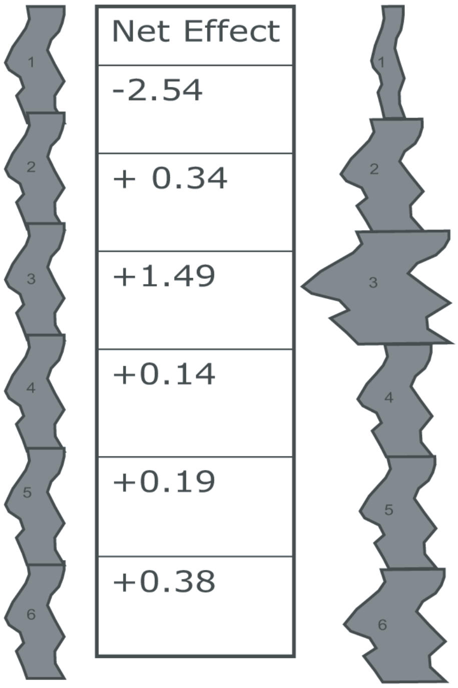

Figure 11. Representation of the stylized river before and after trading with the net effect for each reach.

interest and the silvery minnow, they purchase water since they are facing a monetary punishment if they allow the river to fall below this threshold. This explains why the results show a positive gain in the lower reaches of the river in figure 11, as there is only an agricultural and environmental user in reaches 4 and 5 with only an environmental user in reach 6. The environmental users in the lower reaches are purchasers of water because of the demand functions they face as shown in figure 6.

Not only were these outcomes realized from the experiment, it was also observed that participants are able to handle the cognitive complexity of trading in a complex water market subject to exogenous hydrological forces. Multiple trading was observed in each experiment run showing that participants comprehend the cognitive complexity of the model and that the model is robust.

Extensions

This model is merely a starting point, where any possibly climatic scenario and its affect upon behavior can be modeled. Further research to be conducted

will have real farmers play the role of the agricultural agent, along with Native Americans, environmentalists, and urban consumers playing their respective role. This will allow for water and its role in the culture of acequias to be more accurately modeled and included in later experiments. Currently third party effects are not included in the model; including such effects will introduce solution concepts for these situations. The current economic model is a double oral auction; other models will be examined as a way of conducting trades. Examination of intertemporal trading-both within years and between years will be incorporated into the model. The inclusion of transaction costs; modeling laterals, and the use of a central planner in the model will also be explored as extensions or variations to the current economic model.

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CLIMATE CHANGE: HYDROLOGIC IMPACTS IN THE TRANSBOUNDARY SAN PEDRO BASIN

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Abstract The US Southwest is an arid and semi-arid area where temporal and spatial variability have important impacts on water resources availability and management. Integrating this uncertainty into planning and decision making is a key issue, both for operation optimization and risk management strategies. A study in the San Pedro Basin, combining climatic data series analysis with climate change projection from global circulation models, aims at providing a basis for the inclusion of climatic scenarios into the Basin's decision and policy-making process. Changes in precipitation result in changes in mountain-front recharge. Long-term changes in the basin's water budget are assessed using existing hydrological models for the San Pedro Basin. An effort is made to clearly present a broad range of results corresponding to different scenarios for water managers and policy makers. This analysis will benefit the inclusion of a climatic component into the Decision Support System (DSS) model of the Upper San Pedro Basin.

Introduction

Allocating water resources within a basin is a complex problem. Population growth, industrial development, and agriculture have brought major societies to the edge of water resources availability. Furthermore, human development is affecting global climate patterns. In the last century, massive industrialization has lead to a great increase in the atmospheric concentrations of greenhouse gases.

Assessing the impacts of climate change on water resources and planning for future management strategies requires holistic and interdisciplinary approaches, merging physical sciences and policy making. While climatic and hydrological models serve as the physical basis for estimating hydrologic futures, decision support systems provide a common arena for stakeholder involvement and consensual science-based decision and policy making.

Work is under way aiming to assess the climate change impacts on the water resources of different river basins in Arizona (USA) and Sonora (Mexico), which share similar climatic patterns, regional environments and water resources management challenges. Distinct rivers with different hydrological regimes have been chosen, including the transboundary San Pedro River Basin, where the current work started. Evaluating climate change impacts in basins with different hydrologic regimes will provide powerful insights on the degree of vulnerability of Arizona and Sonora watersheds to such changes. The emissions scenarios defined by the Intergovernmental Panel on Climate Change (IPCC) have been used as reference inputs for the climate change estimations.

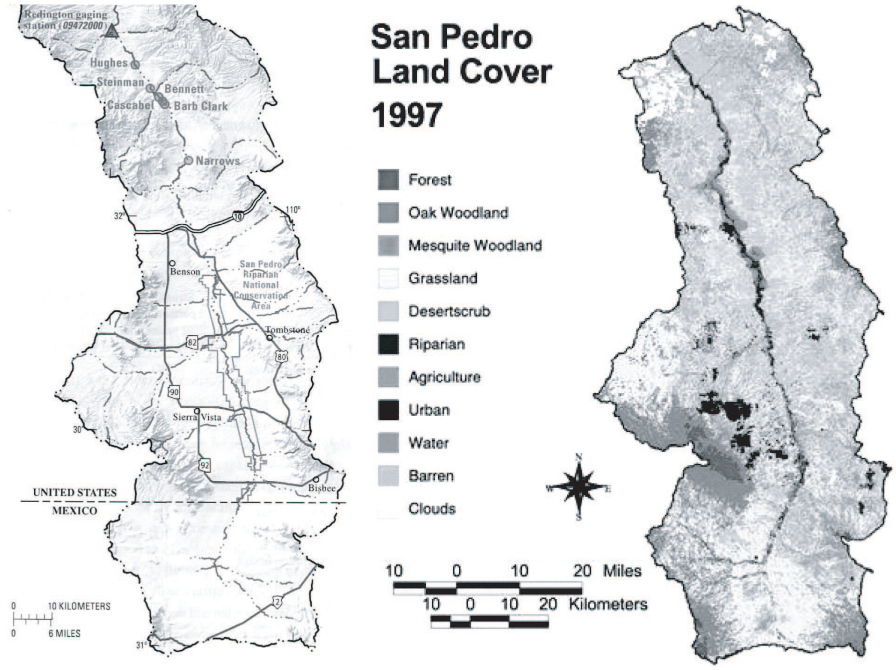

Figure 1. The San Pedro River Basin, location and land cover maps (adapted from USGS, 2005, and EPA-USDA, 2003).

This paper is focused on the Upper San Pedro Basin and presents preliminary results of this work. The potential climate change impacts on the hydrology of the San Pedro Basin will be included in the Decision Support System (DSS) model of the basin, developed by the department of Civil Engineering of the University of Arizona in collaboration with other entities. This will allow the Upper San Pedro Partnership (USPP), a stakeholder consortium in the basin, to evaluate strategies to meet safe yield and cope with a changing water balance under future scenarios.

The San Pedro River Basin

The San Pedro River Basin is a transboundary watershed located in Southeastern Arizona and Northern Sonora, as seen in Figure 1. Home of the *San Pedro Riparian Natural Conservation Area* (SPRNCA), it constitutes a unique riparian river corridor with mostly perennial flows in a desert environment.

The geographic and human setting

The San Pedro River has its first 40 km in Mexico, its watershed starting in Cananea (Sonora), and flows north-northwest in Arizona (US) for another 200 km until it joins the Gila River. A constriction known as "The Narrows" divides the watershed in the transboundary Upper San Pedro Basin (upstream) and the Lower Basin (downstream). The study area for the current work includes the Upper Basin and a portion of the Lower Basin from The Narrows to the Redington gaging station, covering 7560 km^2, slightly more than $3/4$ of the San Pedro watershed.

Following hunter-gatherer populations, agriculture first appeared in the basin the first century AD. Later benefiting from advanced techniques brought by The Hohokam, irrigation and trade took place and population grew. When Spanish explorers such as Fray Marcos de Niza (1539) and Francisco Vásquez de Coronado (1540) arrived at the San Pedro Basin, the population had significantly declined. When Jesuit Father Eusebio Kino visited the region (1690s), twelve to fifteen villages made up to population of 2000 Pimas. Using irrigation, they grew corn, beans, squash and cotton. Kino also introduced European crops, livestock and tools. During the 1700s and early 1800s, Apache raids frustrated Spanish attempts to occupy the valley and forced the Pimas to leave the missions and relocate. Large cattle ranches that appeared with Mexican land grants were also abandoned due to the apache raids. In 1858, 4403 km^2 of the San Pedro watershed were transferred to the United States during the Gadsden Purchase. In 1858, mining in Cananea, which had started in 1686, increased production, and the mines in Tombstone and Bisbee opened. Mormon farmers began settling in the valley in 1877, digging wells, canals and practicing irrigated agriculture. With the completion of the Southern Pacific Railroad in 1881, mining operations increased significantly and the grazing ranges in the valley were fully occupied in the next four years (Goode, 2000, adapted).

While the Cananea mine is still a large active operation in the headwaters of the San Pedro, large ranching tracts in the Mexican side have been subdivided into ejidos for seven new population centers. In the US, population had been booming since the end of WWII, along with an increase in agriculture, which has decreased lately due to conservation efforts. Grazing lands have also turned into housing subdivisions for population ranging from military and border patrol staff to services sector workers and an increasing number of retirees (Goode, 2000, adapted).

In regards to water, the introduction of large centrifugal pumps dramatically increased groundwater use for agriculture while the widespread use of air con-

ditioning allowed great population growth. Since then, impacts on the riparian environment and conflicts on water allocation have only increased. In November 1988 the US Congress designated the San Pedro Riparian Natural Conservation Area, along approximately 70 km of the River in order to "*protect and enhance the desert riparian ecosystem, a rare remnant of what was once an extensive network of similar riparian systems throughout the Southwest*" (BLM, 2006). The water needs to ensure and protect the conservation area came with a congressional mandate to attain sustainable yield by 2011. As defined in the legislation "Sustainable yield implies that yearly groundwater withdrawals in the basin must not exceed average annual recharge values". The achievement of this definition of sustainable yield is the responsibility of a consortium of 21 agencies and stakeholders known as the Upper San Pedro Partnership (USPP). To help the USPP achieve this goal through conservation strategies, a Decision Support System model of the Upper San Pedro Basin has been developed by the *Civil Engineering and Engineering Mechanics Department* of the University of Arizona in collaboration with *Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA)* and the *US Geological Survey*. This DSS model is a technical tool to support decision making in the basin by evaluating different water conservation measures and policy strategies to reduce water withdrawals to annual recharge values.

Regional hydro-climatology

Climate in South-eastern Arizona is characterized by a bimodal precipitation regime: winter rains and summer rains. Around January and February, regional frontal storms originating in the Pacific provide low intensity rainfall of a longer duration. Because of these features and the lower seasonal evapotranspiration rates, winter rains are generally regarded to be the main contribution to groundwater recharge. Summer rains, commonly named the monsoons, start in early July and last until September. They bring convective thunderstorms with high intensity and short duration precipitation. Moisture from dissipating tropical cyclones can eventually contribute precipitation in the months of September and October (Webb and Betancourt, 1992).

Comrie and Glenn, 1998 present a principal components analysis where they delimitate the influence of various precipitation regimes in the US southwest and northern Mexico. As seen in Figure 2, the San Pedro Basin is located under the influence of components 1 (monsoon) and 2 (desert). Region 1, "*the monsoon region*" is characterized by important summer precipitation from June to October. On the other side, region 2 of the principal components analysis, presents very low precipitation values year round with a

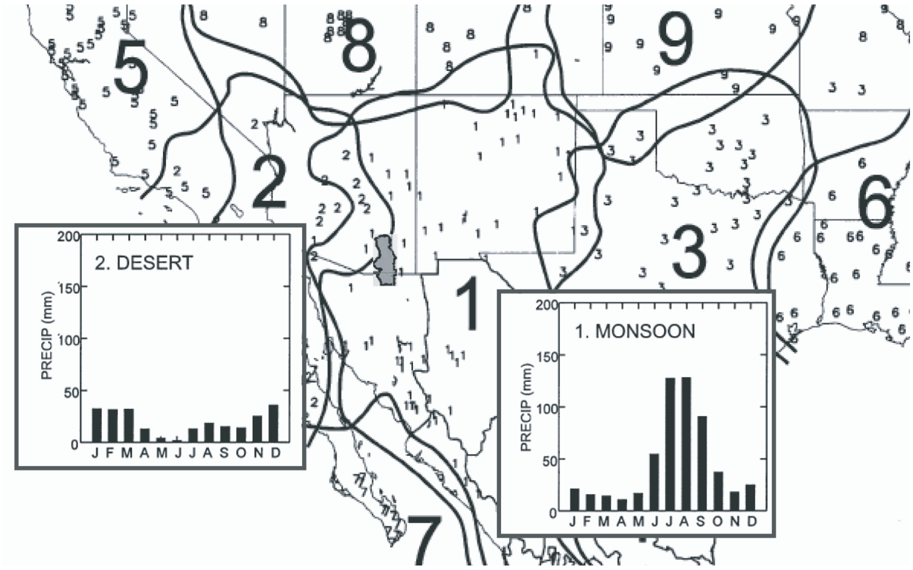

Figure 2. Regional precipitation regimes in the US Southwest and Northern Mexico (adapted Comrie and Glenn, 1998).

slight increase in winter and the lowest rainfall in early summer (Comrie and Glenn, 1998).

Since the San Pedro river watershed is influenced by both precipitation regimes, different types of precipitation events yield recharge processes of different importance and nature through the seasons. Four types of recharge mechanisms have been historically considered in the Southwestern United States: mountain front recharge, mountain block recharge, diffuse recharge, and ephemeral channel recharge (Hogan et al., 2004). Mountain front recharge is the process by which streamflow from crystalline areas reaches the basin and infiltrates into the aquifer. Mountain block recharge is known as the water that infiltrates through fracture systems in crystalline materials in mountain ranges. Diffuse recharge, which is not very common in arid and semi-arid regions, represents the portion of rainfall in the basin that directly infiltrates into the aquifer. Ephemeral channel recharge may occur along drainages and ephemeral channels during streamflow events and floods. Although winter rains are less than half the annual precipitation, which usually ranges between 228 and 635 mm (Goode, 2000), they are responsible for a major portion of the annual recharge (Pool and Coes, 1999; Eastoe et al., 2004). This is due to the longer duration of winter precipitation and the lower evapotranspiration rates during the winter season. In contrast, summer storms are short, local-

ized, and evapotranspiration rates are high. (Pool, 2005) states that ephemeral channel recharge during streamflow and flood events is the main contributing mechanism to alluvial groundwater recharge. During summer, mountain front recharge is thought to be more significant than ephemeral channel recharge, due to higher summer precipitation in high elevations (Pool, 2005). While mountain block recharge is assumed to be of very little if any significance (Anderson et al., 1992), diffuse recharge is susceptible to occur, remaining a minor process (Walvoord et al., 2002; Scalon et al., 2003) in limestone areas in the San Pedro.

Research Objectives

The overall long-term objective is to provide a multi-disciplinary approach and tools to enable adaptive capacity in the management of Arizona and Sonora watersheds in the face of climate change. For this, it is necessary to bridge the gap between physical hydrology knowledge and the management challenges. To achieve this objective, many goals have been set. These range from the physical quantification of climate impacts on the water resources to potential water policy measures to be applied in the basins. A key issue in bridging these goals is the presentation of technical findings to policy and decision makers. The goals are defined in detail following:

The first goal is to quantify the impact of different climate change scenarios on the water resources of different basins throughout Arizona, namely the San Pedro River, the Salt River and the Verde River basins. All of these watersheds support important human developments and environmental areas, and are characteristic of different hydrologic regimes within the state. Work is under way in the San Pedro Basin, where changes in temperature and precipitation –thus in groundwater recharge– are being evaluated with hydrological models to assess potential changes in the basin's water budget. As mentioned before, the US Congressional mandate in the San Pedro Basin requires the users to attain safe yield, that is, annual withdrawals must not exceed the average annual natural recharge.

The second goal is to present a representative range of potential climate change impacts in a manner understandable to stakeholders and decision makers. In the case of the San Pedro, the objective is to include these climate change scenarios and their hydrological impact in the Decision Support System model (DSS) that is being developed to help the Upper San Pedro Partnership achieve its sustainability goals.

Methodology

The methodology followed for this work can be divided in three parts: (1) obtaining the regional precipitation and temperature change estimates for the study period; (2) deriving the recharge estimates for the San Pedro Basin; and (3) the hydrological modelling of the San Pedro Basin to assess the climate change impacts on water resources and their supporting populations and ecosystems.

Regional Climate Change Estimates

Data from 17 global circulation models run under different green-house gas induced climate change scenarios is used to derive estimates of precipitation and temperature change in $5^\circ \times 5^\circ$ cells on the earth surface for years from 2000 to 2100.

The Scenarios:

These change estimates are obtained for different global emission scenarios, developed by the IPCC, representing future distributions of economic and population growth, and different uses of fossil fuels and alternative energies. The scenarios are described in the Special Report on Emissions Scenarios (IPCC, 2000). A total of four scenarios –A1-MES, A2-MES, B1-MES, B2-MES– have been chosen for this study, representing average projections of different future developments. The chosen scenarios belong to 4 different storylines, or scenario families, for world development. These cover a wide range of driving forces from demographic to social and economic developments, encompassing numerous possibilities of future greenhouse gas emissions. The summary for policy makers (IPCC, 2000) of the Special Report on Emissions Scenarios (SRES, 2000) describes the storylines as follows:

1 "*The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B, equivalent to A1 MES used in the present work)*".

2 "*The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self– reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines*".

3 "*The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives*".

4 "*The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels*".

The choice of MES scenarios, standing for MESSAGE, for each scenario marker, responds to the significant uncertainties on future technological trends in terms of innovation and diffusion of energy technologies, both in the supply and end-use sides. Assumptions in the MESSAGE scenarios follow two principles: (1) Exclusion of technologies not functioning currently on a prototype scale; and (2) Future technology distribution estimations are empirically based on currently available technology and costs information. These derived distributions have guided the technology assumptions for each particular storyline scenario.

Table 1 shows global change projections at year 2100 for the different scenarios. It includes CO_2 concentrations in parts per million volumes; global temperature increase in degrees Celsius; and sea level rise in centimeters. Note the different energy source use scenarios within scenario marker A1 and our choice of scenario A1 MES as a representative middle term in the present work.

Scenarios	A1 MES			A2 MES	B1 MES	B2 MES
	A1T MES	A1 MES	A1FI MI			
Energy sources	*Alternative energies*	*Balanced sources*	*Fossil intensive*			
CO_2 ppmv	570	730	970	810	505	615
Temp Δ ($^\circ C$)	2.3	3	4.1	3.3	2.1	2.5
Sea Level Δ (cm)	36	40	48	40	32.5	35

Table 1. Global change projections for year 2100 using different emissions scenarios.

The Models. Yearly data from 17 different global circulation models (GCMs) provides precipitation and temperature change estimates for the region under each scenario. In order to select a tractable number of models and datasets to work with, a screening was done. Ultimately, four models and the model ensemble average have been chosen, for each of the four scenarios. The model ensemble average corresponds to the averaged projections from all the 17 models, in each of the four emission scenarios. Then, four individual models are selected and used separately. These four chosen GCMs are the ones that provide the extremes of the precipitation and temperature change estimates in year 2050, as a criterion. Indeed, the *wettest, driest, coldest* and *warmest* models are chosen. It is important to note that each model dataset provides (1) percentage changes of precipitation and (2) value increments of temperature, for each year along the study period, both with respect to a 1998 reference base precipitation and base temperature values, particular of each model. The selected models to yield the extreme climate change projections are the ones that present the greatest percentage changes for precipitation and the greatest increments for temperature. These change estimates are later applied to the reference base values of the San Pedro Basin. The selected models are CERF 98 as the wettest, CCSR 96 as the driest, WM 95 as the coldest and ECH395 as the hottest.

Future estimates of precipitation have been calculated for the San Pedro Basin by applying the percentage changes predicted by each model on the reference base value of yearly precipitation in the San Pedro. Estimates of temperature have similarly been obtained by adding the model predicted increments to the reference base temperature value of the San Pedro. Each model

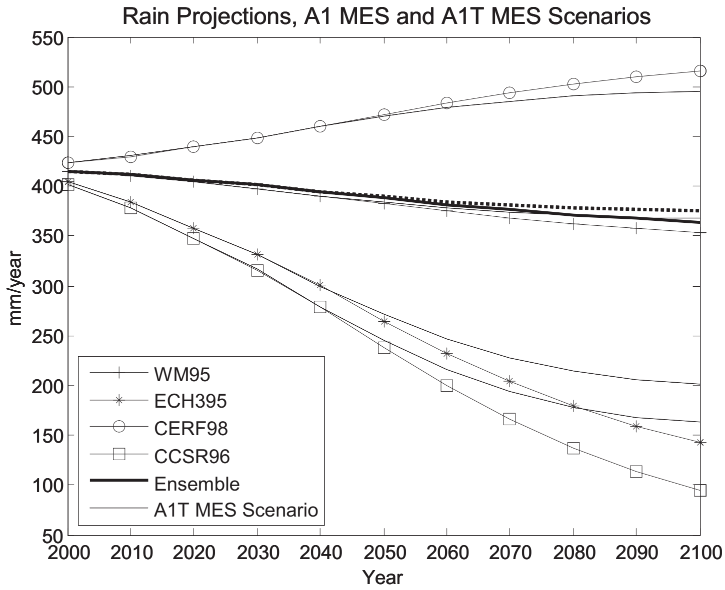

Figure 3. Rain projections for Scenarios A1 MES and A1T MES, using the coldest, hottest, wettest, and driest models and the 17 model ensemble average.

dataset also provides the standard deviation change of yearly precipitation and temperature with respect to a base value of 1998.

With the use of the four extremes models and the 17 model ensemble, it is possible to have an average as well as a range of model projections while at the same time providing and insight on the uncertainty in the model range.

Figure 3 shows rain projections from the four chosen models and the average of the 17 model ensemble for both Scenario A1 MES (solid lines) and A1T MES (dotted lines). The difference between estimates for each scenario reflects the different assumptions regarding the use of energy sources. While A1 considers a balanced use across all types of sources, A1T considers use of non-fossil sources, hence, its smaller decrease in precipitation.

From precipitation to recharge estimates

In order to assess the climate change impact in the basins' hydrology new time series of precipitation and temperature can be produced, using change estimates from the different future scenarios, and used as input for hydrologic models of the basins. In the case of the San Pedro Basin, where this research

started, changes in annual mean precipitation result in significant changes in mountain-front recharge. In riparian basins of the American southwest, mountain front recharge has been assumed to be the primary contribution to aquifer recharge. Precipitation from winter frontal storms and leftover moisture from tropical cyclones during early fall, are assumed to contribute the most significant amounts of precipitation suitable for recharge. Precipitation in mountain ranges runs off through streams that infiltrate when reaching the basin sedimentary fill. There are several regression models to represent recharge. In this study the *Anderson* (Anderson et al., 1992) model, which relates average mountain-front recharge and total annual precipitation in the watershed is used:

$$\log(Qrech) = -1.40 + 0.98 \cdot \log(P - 8) \quad (1)$$

where P is annual precipitation in inches, and $Qrech$ is annual mountain-front recharge, also in inches. It is important to note that only the precipitation in excess of 8 inches yields recharge values in the calculation. This precipitation threshold accounts for evapotranspiration and soil moisture losses. Here, Anderson's equation has been used to see how changes in precipitation would translate into changes in recharge. Precipitation change estimates from the previously described global circulation models for years 2000 to 2100 were applied to the San Pedro historical annual mean precipitation. The obtained precipitation estimates were then used to calculate mountain-front recharge projections along the study period.

As previously mentioned, recent research points out that infiltration into alluvial aquifers from stream-flood events may contribute up to 20% of total recharge in riparian southwestern streams (Pool, 2005). This alluvial recharge happens mostly during the summer monsoon and fall rains.

The hydrological modelling of the San Pedro Basin

The long term changes in the basin's water budget have been assessed using a modified version of an existing hydrological model of the San Pedro Basin (Goode, 2000). It is a three dimensional finite difference model of the study area developed using GMS, a GIS based pre and post processor that employs MODFLOW. The numerical model is based on a conceptual representation of geologic formations by means of layers and boundaries, and of the hydrological processes by means of groundwater flow, mountain front recharge, evapotranspiration, stream flow and interactions between stream and aquifer water. Human induced processes such as well pumping, agricultural recharge and stream diversions and returns are also represented in the model.

Mountain-front recharge is simulated through recharge cells at the perimeter of the sedimentary basin fill. Current model recharge in each of these cells was estimated based on precipitation data and contributing drainage area. Multipliers for annual recharge estimates for each of the scenarios were calculated by comparing the future recharge estimates derived from Anderson's equation with previous model recharge rates. By adjusting the previous recharge rates with these multipliers, new recharge estimates are implemented in the model for the simulation period 2000 to 2100. Simulations were completed with the new inputs to assess overall impacts on the basin's hydrology, namely aquifer levels, evapotranspiration and interactions between the river and groundwater.

A similar procedure will be followed for the Verde River and the Salt River basins in Arizona and for other basins in Sonora, accounting for their different hydrologic regimes.

An effort will be made to clearly present a broad range of results corresponding to different scenarios to water managers and policy makers. In the case of the San Pedro, the different climate change scenarios will be included in the DSS model of the basin. The impact of groundwater pumping in different climate affected water budget scenarios will be reflected in the DSS model using response functions derived from the hydrologic model runs described above. Because the development of DSS models in the Verde and Salt River basins is less mature than in the San Pedro, the presentation of initial research results to stakeholders and decision makers will likely be through reports, talks, meetings and workshops.

Preliminary Results

Precipitation and recharge estimates for the San Pedro Basin

Climate change estimates have been derived for the four previously described scenarios using a model ensemble average and four models corresponding to extreme precipitation and temperature projections: CERF 98 (*wettest*), CCSR 96 (*driest*), WM 95 (*coldest*) and ECH395 (*hottest*). Using *Anderson's* equation (Anderson et al., 1992), recharge estimates have been derived from the precipitation projections in each case. Figure 4 shows the projections of annual precipitation and corresponding recharge rates for scenarios A1 MES and A2 MES. Figure 5 shows the same projections for scenarios B1 MES and B2 MES.

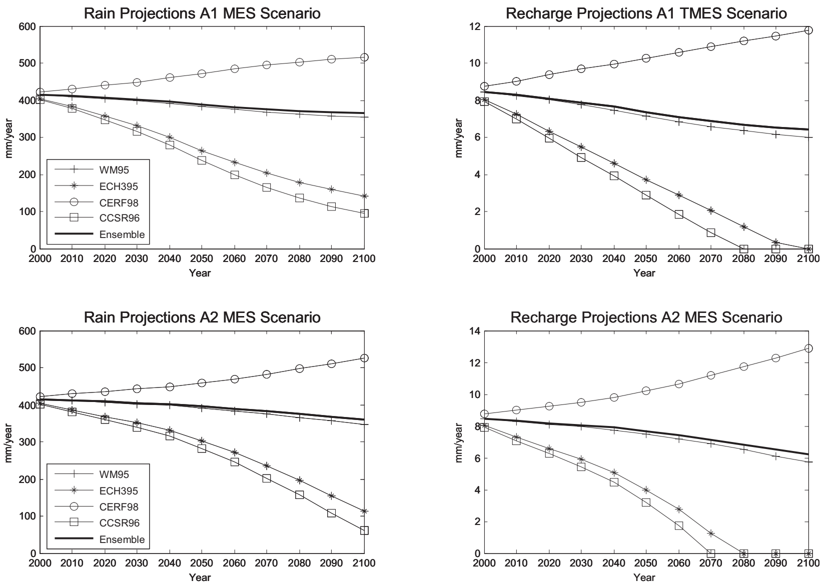

Figure 4. Rain projections for Scenarios A1 MES and A2 MES, and their corresponding recharge estimates derived using Anderson's (1992) equation.

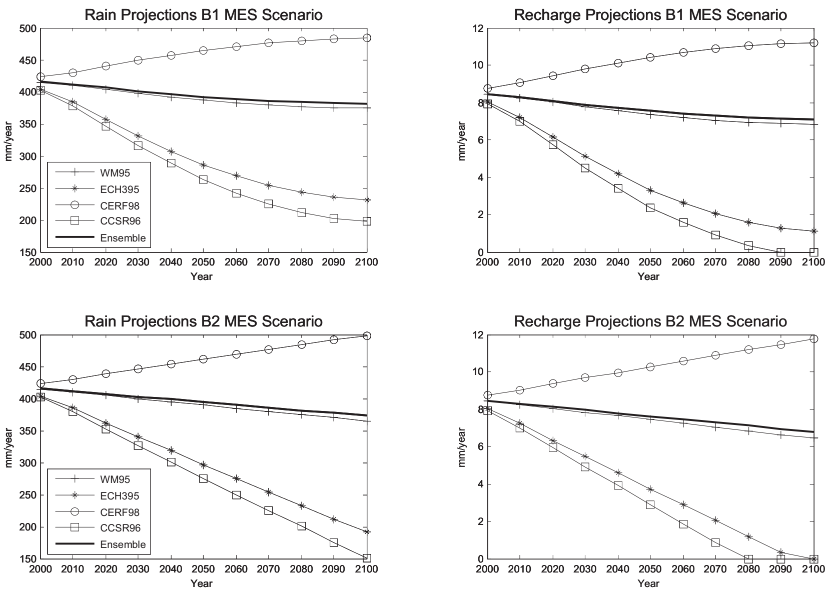

Figure 5. Rain projections for Scenarios B1 MES and B2 MES, and their corresponding recharge estimates derived using Anderson's (1992) equation.

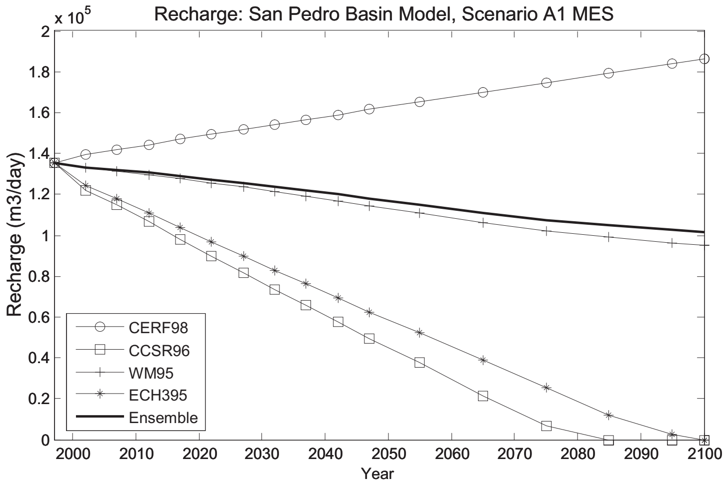

Figure 6. Total modeled basin recharge in the San Pedro for Scenario A1 MES using estimates from 4 global circulation models and the average of a 17 model ensemble.

Decreases in precipitation result in twice the percentage change in recharge, as can be seen for the top scenarios. When model WM95 projects a 12% precipitation decrease, its recharge estimates go down about 25%. A 50% decrease in rainfall in models CCSR96 and ECH395 resulted in the complete loss of basin recharge. When precipitation falls below 203 mm (8 inches) recharge, as calculated from the Anderson equation becomes zero, this occurs for all scenarios in the driest model and for scenarios A1, A2 and B2 in the hottest model. This can be explained by the rainfall threshold that has to be exceeded for Anderson equation to start computing recharge.

Results from the hydrological model: Scenario A1 MES

The hydrological model of the San Pedro Basin has been run with the new recharge estimates. Eight runs have been performed corresponding to the four average model ensemble projections for the four scenarios and the four extremes models run under scenario A1MES. The new climate change influenced recharge rates have been implemented in the hydrological San Pedro Basin model. For scenario A1 MES, the multipliers for the four extremes models (wettest, driest, coldest and hottest) and for the average projections of the entire 17 models ensemble, were used to modify current recharge rates in the hydrologic Model of the San Pedro Basin. Figure 6 shows the total recharge in the San Pedro Basin after implementing changes in recharge from future precipitation estimates.

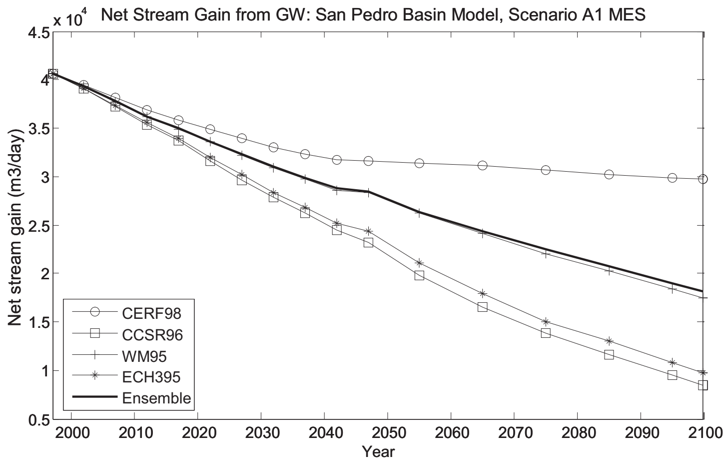

Figure 7. Net modeled stream gain from groundwater in the San Pedro for scenario A1 MES and along the study period.

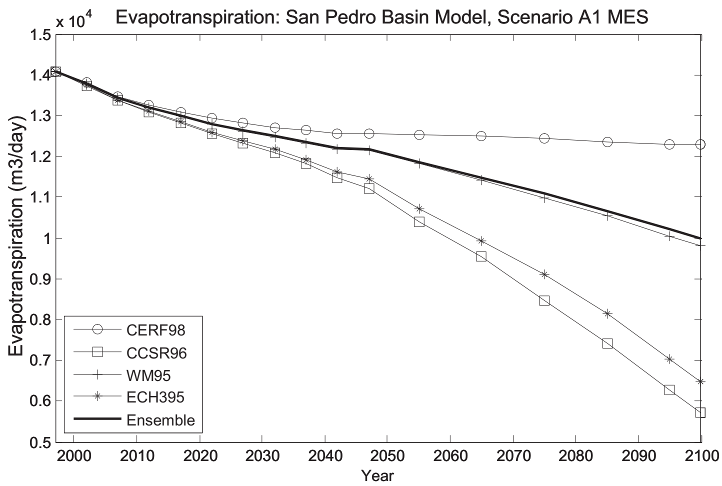

Figure 8. Modeled evapotranspiration in the San Pedro for scenario A1 MES.

Although the model ensemble presents a decrease of 26% in recharge by year 2100, its trend shows more recharge than the coldest, hottest and driest models. On the other side the wettest model shows a trend of increasing recharge up to 35% at the end of the study period.

The study area contains the *San Pedro Riparian Natural Conservation Area*, and as all riparian areas depends intimately on interactions between surface water and ground water. Since these interactions are so important for the health of the ecosystems in the protected natural area, they need to be carefully studied. Figure 7 presents the net stream gains from groundwater for the different runs in scenario A1 MES. Overall, the studied reach in the San Pedro River is a gaining reach, meaning that it receives water from the underlying aquifer. While at the initial model reference year (1997) the riparian area receives close to 41,000 cubic meters of groundwater per day, this supply decreases dramatically from a quarter in the best case to about 80% with the driest and hottest models. It is worth to point out the decreasing trend corresponding to the wettest model, which estimated an increase in precipitation and recharge: The amount of water entering into the stream system is dependent upon the balance between water going into the aquifer (recharge) and water going out of the aquifer (pumping and ET). The continued loss of water into the stream indicates that more water is being lost to the aquifer than gained. Thus, the increase in recharge from the wettest scenario is not enough to offset the level of groundwater pumping within the basin. Since the water supply to the riparian area is less, one may expect the water available to the riparian ecosystems to decrease.

Evapotranspiration in the hydrological model is computed with constant yearly rates that depend on the depth of the water table. If the water table level decreases, so does the evapotranspiration. Thus, changes in modeled evapotranspiration along the river cells provide information on ecosystem health: if evapotranspiration decreases over the years, vegetation in the San Pedro Riparian Natural Conservation Area (SPRNCA) is being lost or is changing. Figure 8 shows the evolution of modeled evapotranspiration in the study area of the San Pedro Basin. All model runs show a decrease in evapotranspiration rates in the basin, going from the reference 14,000 m^3/day to less than 6,000 in the worst case to about 12,200 m^3/day for the wettest model. The steeper declines after approximately 2045 indicate that the riparian areas are going dry. Larger and larger areas have zero ET as the water table disconnects with the stream and riparian ecosystem, signaling the death of the riparian habitat.

Based on differential rooting depths, different types of vegetation can go to different depths to reach the water needed to survive. Cottonwood trees usually have problems when the water table is continuously deeper than 4 meters,

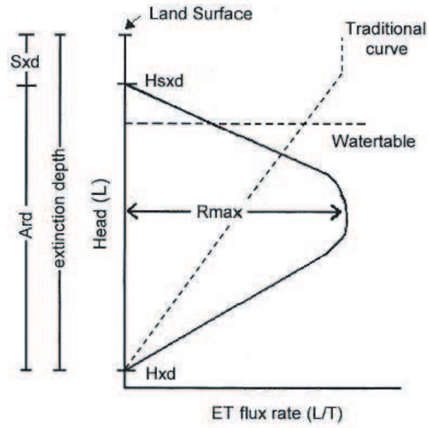

Figure 9. Generic ET flux rate curve for a plant functional group. *Sxd*, saturated extinction depth (L); *Ard*, active rooting depth (L); *Hsxd*, saturation extinction depth elevation; *Hxd*, extinction depth elevation (from Baird and Maddock III, 2005).

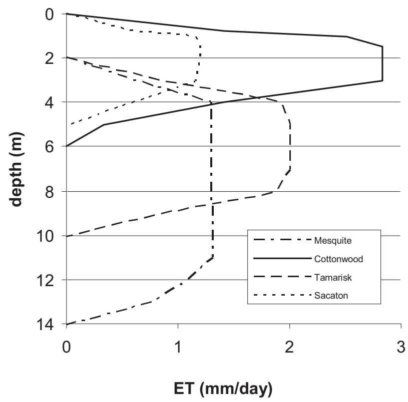

Figure 10. ET flux rate curves for different tree species (from Baird and Maddock III, 2005).

and unable to tap it beyond 6 meters. On the other hand, Mesquite trees can go down to 14 meters to pump water through their roots. As seen in Figure 9, evapotranspiration estimates drop significantly. This implies a decrease or a substitution of vegetation along the river, knowing that the highest toll will be on the most distinctively riparian species; the ones that give the SPRNCA its particular riparian character.

Baird and Maddock (2005) present new evapotranspiration flux rate curves for riparian and wetland ecosystems. In their approach, ET occurs only when water levels are located within the *active root zone depth* of the plant or group of similar plants called Plant Functional Groups (PFG). This depth is bounded by an *extinction depth* –beyond which roots are unable to tap water– and a *saturated extinction depth* –above which plants die of anoxia (Figure 9). The authors approach to estimating regional ET rates is to derive head dependent flux rate curves for specific Plant Functional Groups (PFGs) and compute the actual spatial coverage of each group within the model area (Figure 10). Accounting for spatial variability, and given the spatial coverage of each PFG, riparian evapotranspiration rates can be modeled by assigning ET flux rate curves to the model cells within each group area.

As may be seen in Figure 10, changes in water levels in the riparian area resulting from climate change will not equally affect the different plant functional groups. Sacaton and cottonwood communities, which can only be found in the heart of the riparian area where the water table is closer to the surface, will be the first ones to sense a lowering of groundwater levels. Tamarisk and mesquite are less vulnerable to water level changes in the riparian area, having the capacity to tap water at depths up to 10 and 14 meters. Thus, a lowering of the water table for a sufficient period of time would cause changes in the spatial coverage of vegetation communities. As is described below, riparian ecosystems would respond differently depending on how climate change affects seasonal precipitation regimes.

Hydrological model results: ensemble projections of the four scenarios

The San Pedro Basin model was run using the average precipitation estimates from the ensemble of 17 global circulation models for each one of the four scenarios. The results for recharge in the basin are shown in Figure 11. The variability of model ensemble averages between scenarios is lower than the variability between different models for a particular scenario. Projected recharge (Figure 12) for year 2100 ranges from 112,500 m^3/day for B1 MES

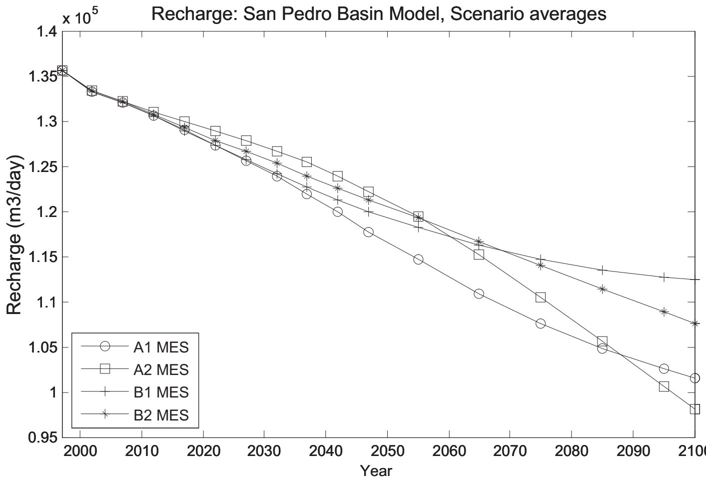

Figure 11. Modeled recharge values using the 17 GCM ensemble average estimates in each of the Emissions Scenarios for the San Pedro Basin.

to 97,500 m^3/day for A2 MES. These results are coherent with the emissions data and global change parameters of the scenarios for year 2100. Scenario recharge values at the end of the study period decrease from B1 to B2, A1 and A2 as the scenarios have higher global CO_2 concentration, sea level rise and temperature increase. It is important to point out that scenario trends cross one another along the study period. This is due to the fact that each scenario has different assumptions as to when –during the study period– the emissions are greater.

As seen in Figure 12, modeled evapotranspiration using the GCM ensemble estimates presents very little variation between the four emission scenarios. Trends of net stream gain from aquifer for the four scenarios show the same behavior (not shown). The model ensemble trend for scenario A1 MES can be seen in Figure 8.

While average recharge projections for each scenario present some variability, these differences become insignificant when translated into average evapotranspiration trends and the evolution of net stream gain from the aquifer for the study period. Differences in recharge –mountain front recharge in this case– are buffered by the aquifer and are hardly perceptible in the riparian zone.

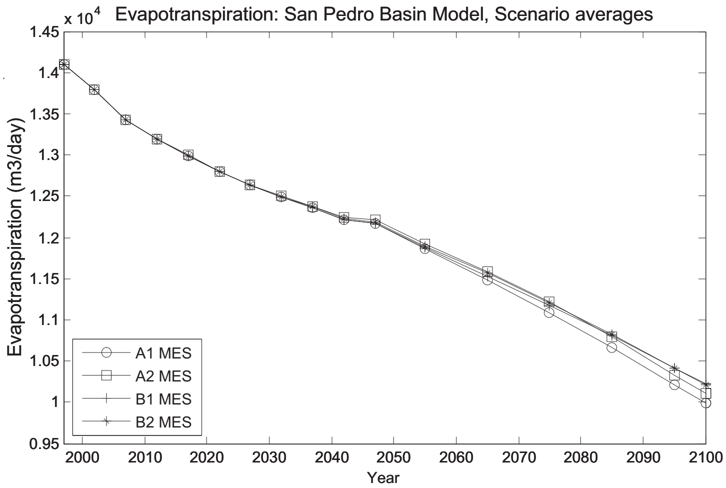

Figure 12. Modeled evapotranspiration values using the 17 GCM ensemble average estimates in each of the Emissions Scenarios for the San Pedro Basin.

Discussion and current research

The work presented above provides an insight on the impacts of climate change scenarios in the hydrology of the San Pedro Basin. It is important to note that the results of this work are preliminary and may contain a significant degree of uncertainty.

On one hand, the data ensemble of global circulation models that has been used for the present study is a very heterogeneous group of models developed by different institutions around the world. The models are different and have not necessarily been developed with aims of good performance in the southwestern United States. It is possible that some may be better suited than others for providing estimates in the San Pedro Basin Region. Their range of predictions is proof of their dissimilarities. While the range of predictions of the different models in each scenario provides a measure of uncertainty, the model ensemble provides a clear average trend, which in all cases shows a decrease of the resource. It is important to point out that, while model variability –as a measure of model uncertainty– is high, the four ensemble average trends from each of the emission scenarios present a narrower range of results. In other words, the choice of different emission scenarios does not significantly change the estimates of its impacts on the basin's water balance.

On the other hand and certainly the two most important challenges for this work are: (1) the determination of the seasonal distribution of annual climate

change estimates and (2) a better quantification of the different recharge processes occurring in the basin. Determining how annual precipitation changes are distributed between summer and winter rains is key to assessing the impacts to recharge and runoff processes. As mentioned before, winter rains are assumed to be the main contribution of annual recharge, while summer monsoon storms are important but contribute a lesser portion. In any case, contributions to recharge are made through different recharge processes, with varying importance depending on the seasons and types of precipitation events. With some limitations, the Anderson's regression equation provides a first approximation to computing annual mountain front recharge using total annual precipitation. This is done at the cost of any information regarding differences in seasonal events.

Furthermore, the way in which climate change differently affects seasonal precipitation regimes, its frequency and its variability, is indeed a key issue to evaluating in detail the impacts on riparian ecosystems. In contrast to regional aquifer recharge, seasonal flooding in response to snowmelt or monsoon storms may provide an immediate source of recharge to riparian systems. Decadal-scale climate that impacts surface runoff can rapidly affect the hydrology and biota of riparian ecosystems. Floods are critical to riparian hydrology for two reasons. First, overbank floods provide a seasonal source of soil water (water in the unsaturated zone) that sustains many short lived riparian plants as well as longer lived drought adapted plants. Second, seasonal flooding provides a significant source of recharge to the riparian aquifer (saturated zone) which can seasonally raise groundwater to levels necessary to establish or maintain riparian vegetation.

Spatially downscaling change estimates from 5×5 degree cells on the earths' surface to the smaller San Pedro Basin Region will require significant effort. If done experimentally, it will be especially difficult to disaggregate natural climate variability from human-induced climate change. However, a statistical downscaling is very likely a way to improve the needed resolution for the hydrological models.

Regional temperature change estimates will also be used to assess climate change impacts on the water resources. Currently, exiting models do not directly account for long term temperature changes. Evapotranspiration (ET) rates in the model are seasonally averaged values obtained from experimental research and are dependent only on water table levels. In the southwest, summer temperatures often exceed a plant's hydraulic capacity to move water from the root-soil interface to the leaves resulting in closure of the stomata and a reduction or limit on ET. Therefore, the uncertainty of ET rates may be greater

than its change due to a few degrees difference in temperature. This suggests that water level variations are the more important driver for evapotranspiration changes. However, changes to the timing of seasons, such as a lengthening of the growing season or a forward shift in spring could have significant impacts to the riparian biota, both flora and fauna.

Assessing the climate change impacts on the water resources of different watersheds in Arizona and Sonora –in basins with different hydrologic regimes– will provide a powerful insight on climate change effects and the degree of vulnerability of Arizona watersheds to such changes. The inclusion of these potential impacts on the hydrology in the San Pedro basin's DSS model will allow the USP Partnership to evaluate policies and conservation strategies to meet safe yield and cope with a changing water balance under future scenarios.

In parallel, a collaborative setting is being developed with academic institutions in Sonora (Mexico) in order to make the DSS model extensive and operative in the entire Upper San Pedro Basin. The goal of these efforts is to provide a common arena to facilitate public participation and transboundary communication for an integrated management of the basin's water resources.

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FUNDAMENTAL BOUNDARIES OF THE FLUVIAL SPACE. APPLICATION TO ENVIRONMENTAL PLANNING

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Abstract

Rivers are not just mere channels. Their vitality and values do not end at their margins. Moreover, Mediterranean rivers suffer particular conditions due to their irregular climate dynamics. Strong seasonal drought makes sometimes users forget the river and its floodplain. Frequently, the fluvial flood space is under extreme events such as floods, rains and other undesirable facts in dry season. Moreover, climatic factors and the effect of dams have transformed rivers into artificial channels.

So, a complete view on river systems must be taken if accuracy and effectiveness is intended, particularly when dealing with Mediterranean rivers. Different viewpoints from a varied set of interests and disciplines handle different approaches to rivers. As a whole these approaches are misleading and promote conflicts between decision makers and public interests. Management models on integrated basis are thus required.

Therefore, this paper briefly reviews different policy instruments which operate in river management in Spain. This paper presents an integrated approach on river management. The proposed model is built on the review of river envi-

ronmental functions such as morphology dynamics, water flows, water quality, ecological processes involved, river uses, historical heritage and community appraisal. Several case studies are presented. These were chosen to review the effects of river policies. The criteria for their selection are explained. The idea is to establish some general rules on river policies and to develop proposals for management guidelines, which could be handled by decision makers.

Conclusions drawn from the analysis of features and policies applied in the Deba River (Basque Country, North of Spain) are also presented in this paper as an example of the line of work undertaken. Finally, basic points for management and planning guidelines are established.

Starting Point: Planning policies and criteria on rivers

This paper assumes rivers as water flows and all the environmental and cultural functions they are involved into. Therefore, traditional view on river hydraulics appears to be short-sighted since it ignores environmental and cultural functions and values which depend on river resources, processes and conditions.

Besides, a varied and complex group of uncoordinated policies operate on river management following different approaches, which are neither always consistent nor efficient. The complex Spanish administration has developed different systems of environmental planning which operate at different levels (local, structure, regional, national and European) following different commitments (water, nature conservation, land use, infrastructure, etc). Moreover, licence and rights on water use at rivers are different according to the terms of exploitation and legal implications involved.

There are different environmental policies in Spain; some of them have an integrated point of view, but others handle only fragmentary aspects. Policies aimed at water and their management may be included among the latter.

In Spain, water policy has been traditionally prevalent in river management. Local authorities have some responsibilities in water management, such as distribution and sewage disposal. Regional authorities deal with projects such as dams, hydroelectric developments, channels and irrigation networks, whereas central administration has the sole responsibility for water planning within the boundaries of the so-called "Hydrologic Public Domain" (DPH) through the Water Boards (Confederaciones Hidrográficas). At the European scope, the main aim of the Water Framework Directive (WFD) is improving water quality through the delineation of relatively homogeneous river system units and

the monitoring of water quality indicators. The process of delineating spatial boundaries for river protection is still being accomplished within the Spanish Water Act (Ley de Aguas). The WFD includes provisions to identify ecological conditions of reference in river stretches, which has not been carried out by Water Boards yet.

Other policies, such as land use planning and nature conservation, affect river management through different procedures. Urban planning deals with land use. Local authorities design local plans according to guidelines from regional governments. These plans must be submitted to regional government for approval. The main trouble rises from the fact that urbanism only plans the urban land (supporting land use), and has an only restrictive view on non-urban land (tool land use). However, most land surface is rural; as a result, there is no coverage for the countryside and natural reserves in local guidelines.

At the environmental scope, land management is a responsibility of the regional governments (CC.AA.). On the other hand, general laws on environment are a responsibility of the national government, with tools like the Natural Resources Management Plans (PORN), for regions, and the Use and Management Framework Plans (PRUG), for natural reserves. Finally, there is a broad range of initiatives at the European scope, from the most specific ones (e.g., the European Centre for River Restoration, ECRR), to international agreements (e.g., the Natura 2000 Network includes river stretches when these have exceptional natural values.

Integral policies include all aspects related to rivers, but while there are a few river restoration programs at the local scope, they are fragmentary. At the regional scope, there are only a few number of cases in the Basque Country and Catalonia.

State of the Art

There are different legal instruments for acting on river areas:

- Urban planning can define the areas of development in river margins by designing specific objects of protection.
- Plans of conservation of natural reserves may module the uses in the river channel and its margins.
- Nowadays, administrative initiatives on fluvial areas are legally guaranteed only by the delineation of the Public Hydrologic Domain (DPH), according to the scheme in Figure 1.

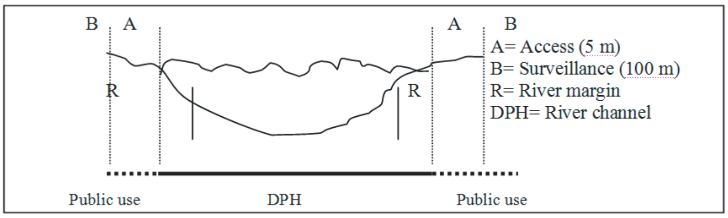

Figure 1. Scheme of the concept of Public Hydrologic Domain in Spanish legislation.

Review of study cases

It is assumed that rivers perform certain functions, thus river units can be defined more or less homogeneously by major uniform functions. This will serve to obtain a planning expert system which will show the different scenarios derived from analysis of the case studies. Information required includes literature, maps, previous studies in the same area, applicable planning tools, local experts expertise, knowledge about local people, and/or another hydraulic, physical-chemical, biological, historic and cultural data.

The input of all this information into a GIS will be selective since a too discretionary approach would be inefficient. Thus, synthetic major units will be define so that they reflect the main sources of variability throughout the study area. Thus, functional delineation of rivers will be accomplished by identifying units or typologies in terms of hydro-geomorphology, water quality, hydrologic regime, and natural, cultural, historic and ethnic factors. More specifically, a river is considered to be:

- Its lithological and morphological base.
- Its discharge regime.
- Its water quality.
- The ecological processes that it maintains.
- Its uses.
- Its history.
- How local people looks at it.

All river functions will be systematised after study case selection; further, reference stretches will be used to calibrate indicators such as those described in Figure 2.

Functions	Processes	Indicators
Geomorphological	Karstic agents	Topography, geologic materials
	Erosion	Slope, desertification, plant cover
	River basin morphology	Channel shape, silting
Water quality	Water abstraction and wastewater	Physical, chemical and biological variables
	Nutrient immobilisation	Riparian vegetation maturity
Discharge regime	Runnoff	Time series of discharge
	Ground water flows	Time series of piezometric levels
Maintainance of natural habitats and biodiversity	Habitat support	Vertebrate diversity
	Food-web support	Vertebrate diversity
	Suppport of featured plant communities	Energy flows
Cultural	Wood production	Forestry
	Distribution of settlements	Urban planning
	Archaeological sites	Archaeological datation

Figure 2. Examples of river functions, the processes that maintain those functions, and possible indicators

Interactions between functions may raise conflicts, such as:

- Development of the river space, e.g. by urbanisation. Its influence on the river system may vary, but can be summarised reminding river habitat destruction, channel straightening, occupying the river margins, etc. These rivers have lost their physical setting, their margins are inert and their channels are transformed into artificial ones.

- Water quality may be altered because wastewater input to rivers is not properly done and self depuration is not possible. Wastewater discharge depends on population settlements, the population income and the economic activities responsible for wastewater production.

- River ecosystem conservation. Its ecological connectivity is broken. The different ecosystems connected by the river depend on each other. Their richness, biodiversity and associated ecological processes depend ultimately on river connectivity.

- The cultural system that is represented by the river and its history. Many aspects are involved. Archaeological and wealth richness, historical evolution of population settlements close to the river and a diversity of activities on the river area result in the present river landscape.

- River regulation by means of water transfers, dams, water abstraction and others result in disturbed river systems (i.e., winter drought in Mediterranean zones, artificial floods, etc.).

According to the above, certain stretches were selected from the rivers Guadiana (Central-Southwest Spain), Lozoya (Tagus tributary, Central Spain), Segura (South-East Spain), Asón and Deba (North Spain). Table 2 describes the study cases in terms of the descriptors mentioned above, as observed during the first field visit.

Aspect	Asón	Deba	Guadiana	Lozoya	Segura
1 Spatial occupancy	C	A	C	C	C
2 Regulation	B	A	A	B-C	A
3 Cultural richness	A	A	A	B	B
4 Pollution	B	A	B	C	C
5 Nature conservation	A	C	B	A	A-B

Table 1. Preliminary diagnostic of study cases (A strong influence, B intermediate influence, C less/no influence).

The case of the DEBA river

The Deba river, an Athlantic river whose basin is mainly in Gipuzkoa, Basque Country, was chosen as a case study. The river length is 58 km and its catchment surface covers 554 km^2. Deba river posseses the bigger water resources in Gipuzkoa, amounting for 471 cubic hm per annum. The stretch selected for the case study goes from Deba and Mutriku in the coast up to Soraluze, including the populations of Mendaro and Elgoibar in between (Figure 3).

River basin morphology is very steep and, as a result, river valleys are V-shaped (Figure 4). Calcium carbonate rocks predominate, appearing singular karstic features such as the Olatz Poljé, water springs like the Mendaro sources, many caves, and other karstic phenomena. Ground water flowing through the karstic aquifers eventually feed the Deba river.

Average hydroperiod of the Deba river shows that maximum values of monthly average discharge occur in spring (Figure 5), mainly in May, with a low discharge period extending smoothly from July to November. However, discharge is very variable on interannual terms, as it corresponds to the Mediterranean climate that influences this region. As a result, late summer or early autumn episodes of torrential rainfall are not rare, with a very irregular distribution both in time and in space. An example are the historical floodings have occured in Bilbao, being the latest in 1983. As a result of this, the Basque

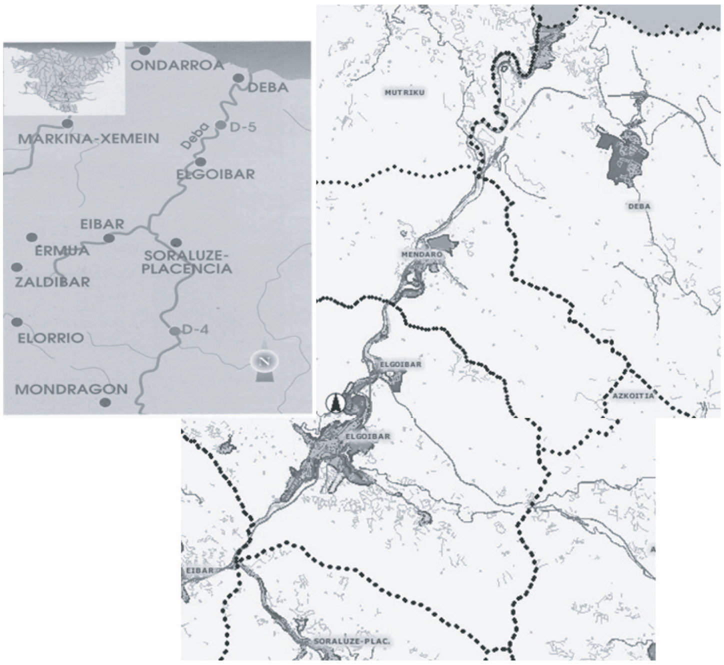

Figure 3. Location of the Deba river catchment (Udalplan, 2005).

Figure 4. Panoramic view of the Deba river valley from Elkorrieta (Deba town).

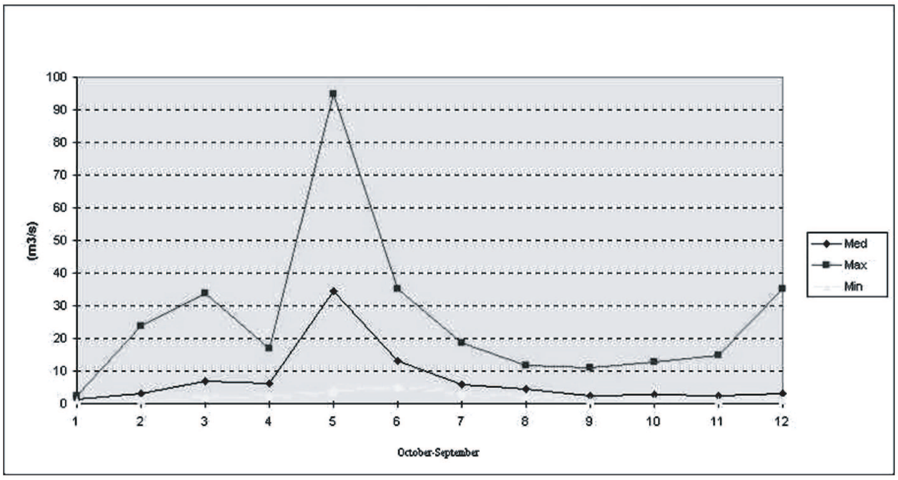

Figure 5. Diagram of monthly average discharge of the Deba river at Elgóibar

Country Flood Prevention Comprehensive Plan was set up in 1992.

Hydraulic works, river regulation and monitoring hydrochemical water quality, together with administrative authorisation for water abstraction and wastewater spill are covered by the Hydrological Plans of Northern Spain.

The subcatchment of the study stretch hosts a total population of 26.391 inhabitants; population density is 168,4 inhabitants per km^2, but human settlements concentrate in the bottom of the river valleys. The largest city of this subcatchment is Elgoibar.

Despite the upper catchment of the Deba river suffers no pollution or physical alteration, it becomes downstream the most polluted river of the Gipuzkoa province because of the huge amounts of urban and industrial untreated sewage inputs to it. At present a sewage plan is being undertaken at the medium and lower Deba, and at the Deba mouth (Gipuzcoa Water Board Plan, 2002–2012) where sewage pipes and treatment stations are being renewed. The following are registry points in the selected river segment.

Population settling all along the valley makes up for a continuous fringe of urban land uses (industrial, housing, infrastructures) along the river margins (Figure 6). There are some productive land uses such as forestry (in Arno Mountain), extensive cattle grazing in the prairie areas within the forests and pasture and crops at the bottom of the valley. The area is well suited for rural

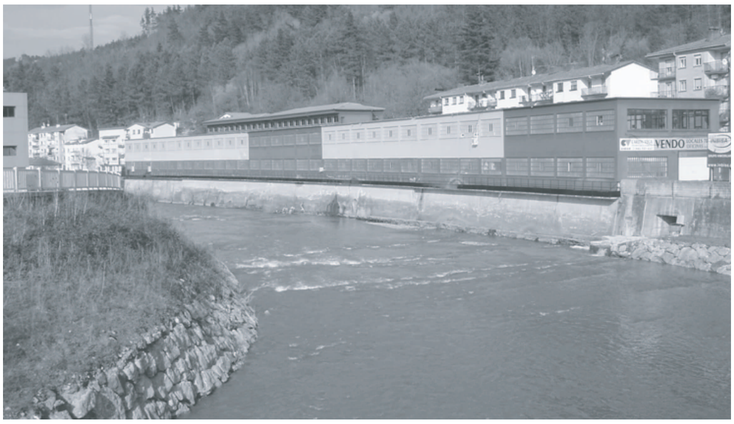

Figure 6. Lerun industry and Elgoibar housing areas.

sports, while the coast is a traditional tourist resort. There are some quarries (limestone in Saint Andrew).

Different sectorial policies deal with the spatial mosaic resulting from the diversity of land uses that affects the river and its environs, ranging from the regional to the local scope:

- The agrarian and forestry management plans for the Basque Country.
- The Basque Country Railway Plan.
- Public land state promotion for special economic and trading facilities of the Basque Country.
- Plan for wetlands management in the Basque Country.
- The Gipuzkoa Province Road Plan.
- Local land use plans.

The latter exist in five towns of the studied subcatchment: Deba and Mutriku (under review for its renewal), Mendaro, Soraluce and Elgoibar. Specific programming is only considered in the case of Elgoibar town, the rest towns have subsidiary plans.

Finally, the norms having a comprehensive approach to the planning of the land covering the river and its area of influence are:

- The Regional Planning Guidelines for the Basque Country, which set main reference guidelines for comprehensive planning.

- The Lower Deba Regional Plan, which covers the Eibar functional area, aiming to develop and coordinate all land use strategies from the above mentioned guidelines at an intermediate or structural level.

- The Plan for River and Streams Margins Management in the Basque Country, which establishes the building constrain alignments following land use, hydraulic and environmental criteria.

Due to its biogeographical location, the Deba catchment presents specific ecological features of potentially high quality and representativity, such as the climacic forest of the evergreen oak, the Cantabrian forest and the riparian forests, as well as tree plantations of the exotic Monterrey pine tree. Because nature conservation policies considers that this catchment is fundamental as a core area for the ecological corridors of the Basque Country, there are several areas under protection for its natural values.

The most remarkable ones are the Arno Mountain and the Deba Mouth, which make part of a sole environmental unit. While the Deba Mouth is protected at the regional scope, the Arno Mountain is included in the definitive list of Sites of Community Interests in the Atlantic Biogeographic region by the European Union (CEC, 2004a).

Antique settlements, e.g. in caves, took place in the catchment in prehistoric times (Praile Haitz I or Ermitia), and old infraestructures such as the Altzola port[1], steelworks, and religious architecture such as the church of Saint Andrew of Astigarribia and others are preserved. In all villages there are old manor houses bearing heraldic shields and some of the townships preserve their original Middle Age layout. Several bridges of historic and cultural interest cross the river (Alzola, Deba y Sasiola).

In old times the Deba river was the border between old pre-Roman tribes, the Vardulian and Caristian peoples. At present, it is actually the border between two main Basque language dialects, i.e. the Gipuzkoan and Bizkaian dialects. This area has been a traditional tourist area including the old Altzola

[1]In old times boats sailed up to Altzola township (Elgoibar), where there used to be a trading port, some of whose structures still remain. Wool coming from Castille was ship in this strategic port to England, while ore was brought from England and retailed to steel works around. This sailing was done on long and flat boats called "gabarras". Wool from Altzola was taken on donkeys to Deba, where it was shipped while ore was discharged. In the mouth shores, ships were being built until the third quarter of the 20th century.

Figure 7. Lineal infrastructure overlapping on the Deba river valley at Sasiola.

spa, whose waters enjoyed quite fame and are now bottled and sold. The river Deba has been a historic axe for economic and industrial growth.

Conclusions

Physical occupation of river space: all types of human activity take place in the river margins: industrial estates, green areas, agriculture. Linear infrastructures go across or border the water course: paths, roads of different functions, railways and even the Saint Jacques Path. The number and type of bridges over the river reveal this infrastructure complexity. For example, in Sasiola there are four different bridges in hardly 150 meters, i.e. the A8 two-lane motorway bridges (one per direction), the N634 national road bridge, the old cross bridge, and those for access of two provincial roads and the Euskotren railway; to complete the dense occupation of the fluvial space, there are huge industrial building on the left river margin (Figure 7).

Water quality: The Deba river is very polluted as it comes from the main industrial areas upstream, such as Arrasate-Mondragón, and receives the Ego water course, which comes from Eibar industrial city. According to the European Water Framework Directive (CEC, 2004b), the Ego rivers does not fulfil any Environmental Quality Standards related to pollution disposal, being the most polluted river in the Basque Country. Sewage plants have been inefficient or non existent until recently.

Figure 8. River margin defence against erosion at Karkizano (Elgoibar).

River ecology: According to a recent report on ecological quality of rivers in Basque Country, the Deba river suffers high pressure, high risk and tested impact due to the ecological degradation of river conditions. Its poor ecological integrity is a good synthesis of the general condition of the river.

Cultural system: Along history, civilizations related in different ways to the river system have been always adapted to the river resources and relief constrains. At present, the river is the main axis of spatial, economical and social relationship of the area.

River flows management: Dams, water provision and other actions on river flows have created a perverted dynamic which differs greatly from natural conditions. Works on the margin such as embankments and other infrastructures are notorious generally on built up areas such as industries, housing areas or transport infrastructures. Alignment and foundation works on the river shores are nearly continuous along the river (Figure 8). The Deba river bears 15 hydroelectric power plants (more than any other Basque river), and it is the most important source of energy in the Basque Country, amounting 7806 kW thanks to the high proportion of river discharge allocated for that purpose (40392 liters per second), mainly because of its low cost.

Achievements

Summarising the information on Deba river, and as a first step to further cases of study, some aspects can be put forward in relation to river management criteria:

- Existing planning systems are far from being comprehensive in terms of river management, as they do not consider the complexity of these systems.
- Historically, only hydraulic aspects have been taken into account.
- Despite the fact that human systems (settled population, mobility, resource exploitation, etc.) are closely related to river areas, these have not been considered when planning river catchments.
- As a preliminary result, different river functions are well represented even in the Deba river, despite its degradation, that suggests the validity of the case-study analysis for the purposes of the work.
- A major specific result of this case study is the increasing denaturalization of the river, far from its history, its natural and cultural heritage, the perception of its community and the loss of its ecological and cultural richness.

Bases for future guidelines

Objectives are:

- To define real river functions for each study case
- To obtain indicators to represent those river functions
- Generalize reference types
- To obtain management guidelines
- To present these to river decision makers

Steps to follow are:

1) To classify
2) To establish relationships between processes and functions
3) To define functional profiles (merging of functions in an ideal river segment, concluding reference types)
4) To identify reference segments of rivers to represent reality
5) Functional assessment by handling indicators for reference segments

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The natural distribution of water resources within a territory is often at odds with local water demands. This implies a need for waters management at a trans-boundary scale, taking resources outside the natural territories in which they flow or reside, and transcending the limits of subbasins, basins or hydrological systems limits. Besides natural boundaries, water resource managers often face anthropogenic boundaries. Water resources are coupled with the larger reality of a region, including its environmental, social, and economic characteristics. Barriers presented by international borders, regional borders, or just competing uses require dealing with individuals, institutions and entities with various levels of responsibility. These natural and human boundaries are some of the factors to be considered in developing effective strategies for overcoming waters management boundaries.

The Third International Symposium on "Transboundary Water Management" (TWM) was devoted to identifying, exploring, and analyzing all the boundaries related to water management. The third symposium has served as an integrating element for the continuous transfer of knowledge on transboundary waters management, through the presentation of new ideas, technologies, and advancements in hydrological and water system modelling, management policies, integration of nonconventional water resources, public participation processes, water markets, water law, etc., while taking into account technical, environmental, social, and economic realities so that this knowledge could be applied in practice to water management.

This book is intended as the Acta of conclusions arriving from the celebration of the III International Symposium on TWM, held at the University of Castilla-La Mancha, in Ciudad Real, Spain, from May 30th to June 2nd, 2006. The book contains twenty one selected papers, which deal with a wide range of issues related to water management in a transboundary context. This Acta has been divided into six parts: *Water Law and TWM, Government Mechanic for TWM, Resolving Transboundary Waters Conflicts, TWM and the EU-Water Framework Directive, Transboundary Aquifer Management*, and *Decision Support System for TWM*. The set of papers provides an integral perspective of today water management boundaries in the world, and the way for implementing Transboundary Waters Management strategies. This work is expected to help to the effort of water managers, policy makers, experts, and researches for overcoming water management boundaries.

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Editor and Symposium Chairman

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