EXPOSICIÓN INTERNACIONAL
ZARAGOZA 2008

Final Document.
Thematic Weeks.
Water Tribune.
Expo Zaragoza 2008

THE WATER TRIBUNE
An expo with no expiry date

EXPOAGUA ZARAGOZA 2008 S.A.

Index

WATER AND LAND
Land Management, Forestation

WATER AND CITIES
Sustainable criteria for local government

WATER FOR LIFE
Health
Water Quality

WATER FOR LIFE
Rivers and sustainability

WATER A UNIQUE RESOURCE
Shared waters
Water geopolithics
Basins and aquifers

WATER SUPPLY AND SANITATION SERVICES
Regulatory and institutional framework
Society and service quality
Efficiency, management and development

CLIMATE CHANGE AND EXTREME EVENTS

Towards a world of water scarcity and uncertainty

WATER ECONOMICS AND FINANCING

Water markets in integrated water management
Financial solutions for emerging countries

WATER AND SOCIETY

Education, Mass Media and Communication and Culture
Workshop on Universal

WATER AND ENERGY
Water for energy and energy for water
Non-conventional energy resources

NEW SOURCES OF WATER
Reuse and Desalination

THE ZARAGOZA CHARTER 2008

BOOK CREDITS

PRESENTATION

In recent years Spain has established itself as a global pioneer in the management of water resources and sustainable development. The Zaragoza 2008 International Expo, an event in which the Spanish Ministry of the Environment and Rural and Marine Affairs played a very active role, provides a very clear example of the country's status in that regard.

As the theme of the Expo, Water and Sustainable Development represents a genuine challenge for Spain, one to which we are fully committed and involved in. Sustainable development represents a global and integrated process in which water plays a key role. It is our belief that the development of a country or region is dependent upon the creation of policies and organisations that work towards the integrated management of water and do so with an environmental, social, economic and future-oriented focus. Failure to administer and manage water resources properly, both in terms of quality and quantity, and ensure close collaboration between water and environmental authorities, will make it impossible to harmonise management with sustainable demand, protect the environment, and, therefore, bring about sustainable development.

The many scientific-technical activities that formed part of last summer's ExpoZaragoza comprised forums for specialists and informative events aimed at the general public and organised within the framework of the Water Tribune. Chief among them were the Thematic Weeks. The most important results from these events are presented here in this document, for which I have the honour of writing the foreword. The activities that formed part of the Weeks were attended by experts and members of the public from all over the world, all of whom took away with them experiences and initiatives that will contribute to the improved management of water resources across the planet.

The content of the Thematic Weeks at the Expo Zaragoza 2008 Water Tribune encompasses, from a variety of different but always innovative viewpoints, a series of approaches and challenges in which Spain has much to offer. By way of example I would like to list a few of them: desalination, the recycling of water, and the rational use of new sources of water; the modernisation of irrigation processes with productivity improvements per unit of volume of water and the active participation of various sectors in the decision-making process; the enhancing of public health through modern drinking-water and treatment services with an integrated and efficient management of these resources; the coordinated management of water in river basins; the economy and finance of water in line with modern and sustainable approaches; and the efforts being made to tackle climate change or the use of sources of renewable and sustainable energy, efforts that involve a commitment and results that are an example for the rest of the world to follow.

The papers, forum agendas and conclusions presented and generated at each of the Thematic Weeks deserve serious consideration as they represent the opinions of the many different parties connected to the water industry. Debate is always an enriching process, and when the topics under discussion are central to the issue of water resources and involve internationally renowned experts, as was the case at Zaragoza, it generates even greater interest.

Finally, I must also mention the Zaragoza 2008 Charter, a document that brings together all the main conclusions to be drawn during the Thematic Weeks and which also expresses, in a number of different ways, a desire for better and fairer management of water around the world. It is a text that prompted the President of Spain, Jose Luis Rodriguez Zapatero, to make the following pledge during the Expo Zaragoza 2008 Closing Ceremony: "We will make these recommendations our own and will put them into practice in developing environmental initiatives and in carrying out our work in the field of international cooperation."

In its aim to bring about sustainable development, this document promotes the rational use of water and I sincerely hope that it will be of interest to you.

Elena Espinosa Mangana
Minister of Natural, Rural and Marine Enviroment of Spain

FOREWORD

As the world's first ever themed expo, the Zaragoza 2008 International Expo centred on the issue of "Water and Sustainable Development". The development of the Expo project focused on three different areas determined by the contents of the event: architecture and town planning, with the construction of a venue in line with the criteria of efficiency and environmental sustainability; displays, the aim being to inform and educate visitors in a clear, visual manner about problems and solutions connected to the central theme; and events, with the creation of an ambitious plan encompassing modern, striking and high-quality artistic productions put on by performers from all over the world.

The technical/scientific focal point of the Expo was the Water Tribune, which was conceived as an intellectual instrument enabling participants to debate, exchange experiences and opinions and propose solutions in the areas of water management and sustainable development. The Tribune's activities were guided by the basic objective of specific and practical solutions to the analysis of situations.

This process provided a platform for pooling knowledge, learning and responses to the challenges and problems currently presented by the management of water resources. Suggesting, proposing, debating and agreeing on solutions, the lessons learnt, experiences that can be applied elsewhere and specific recommendations: these are the processes that generated specific knowledge in relation to sustainability-oriented water management. Taking place throughout the 93 days of the international exhibition, the various activities of the Water Tribune were developed at the Expo Pavilion and at a number of forums in Zaragoza and Huesca.

More than 320 thematic sessions were held, and a total of 3,200 participants from 111 countries and representing multilateral agencies such as the European Union, the UN, the World Bank, intergovernmental and non-governmental organisations, and a wide number of fields and sectors were in attendance. Taking part in the sessions was a broadly representative and wide-ranging group of water stakeholders: politicians, diplomats, business executives, scientists, technologists, managers, economists, researchers, lawmakers, philosophers, writers, journalists, artists and the general public. As a result, the Expo became the largest and longest ever international event to take water as its central topic for discussion.

The activities of the Water Tribune were based on nine instruments, with the Thematic Weeks playing a very prominent part among them. Organised as specialist forums where water experts could come together, they comprised ten thematic blocks and represented the main tool generating the substance of the content of the Zaragoza 2008 Charter.

This document provides the reader with a synthesis of the results of the Thematic Weeks and also gives the forum coordinators, all of them internationally recognised specialists in their respective fields of professional activity, an opportunity to summarise the main findings and proposals.

This text forms part of the Blue Box, a resource that represents one of the most valuable legacies of the Expo, and which comprises all the information generated by the 93 days of sessions in a freely accessible format featuring over 500 scientific/technical documents, 500 presentations, 400 bulletins and news releases, over 500 videos and 3,500 photographs. This compendium is sure to become a valuable source of reference for students, technicians, government representatives and members of the public with an interest in the subject.

I feel compelled to point out that in a career stretching back over 30 years I have never witnessed any other event that brought together so many experts to discuss and propose new ideas on the issue of water. The figures the event generated are hugely impressive: Some 422 speakers, originating from 148 countries and 329 public and private organisations, attended the Thematic Weeks, and the total audience of over 3,000 comprised water experts, technicians and managers from the countries taking part in the Expo, not to mention journalists, students and members of the public. The high degree of satisfaction of the participants and the impact the events had in the media underline both its success and importance.

The Water Tribune added value, perspective and depth to the Expo and will help consolidate Spain's position as a global point of reference in water and sustainable development. The results are a series of proposals and solutions designed to enhance the planet, water and the environment and put forward by a hard-working team that has achieved valuable objectives. I would like to congratulate them for their efforts.

I would also like to offer my warmest thanks to the public organisations of Spain, the Bureau International des Expositions and the sponsors of the Expo, whose generous support made this ambitious project possible.

There can be no question that the goal of bringing about a more efficient and sustainable use of water and creating a fairer society and a better planet in the process is one well worth pursuing.

Roque Gistau Gistau
President of Expoagua Zaragoza 2008

Introduction

TEN THEMATIC WEEKS

Conceived as the intellectual pillar of the International Expo Zaragoza 2008, the Water Tribune allowed experts to assemble exchange experiences and proposals, engage in dialogue and debate and reach consensus on the most important issues related to water management and sustainable development.

Participating in the Water Tribune was a broadly representative and wide-ranging group of water stakeholders: politicians, diplomats, business executives, scientists, technologists, managers, economists, researchers, lawmakers, philosophers, writers, journalists, communication experts, artists, academics, students and laypersons.

Specific and practical solutions to the analysis of situations: that was the leitmotiv that ran through every aspect of the activities at the Water Tribune within the framework of Expo Zaragoza 2008. The guiding principle behind the Water Tribune, which represented an innovative forum for debate and enlightening knowledge, was to foster and pool practical responses as a means of tackling the main challenges posed by water and sustainable development.

The result of this unique process was the creation of a forum for exchanging knowledge and then disseminating it among broadly representative groups taking part, thereby enhancing the learning process and generating responses to some of the greatest challenges and problems now posed by water resources management and sustainable development. Suggesting, proposing, debating and agreeing on solutions, rindling lessons learnt, experiences that can be applied elsewhere and specific recommendations: these are the processes that generate knowledge and expertise necessary to drive a change of paradigms in insustainable water resources management.

The Water Tribune took place between June 14 and September 14 2008 at the Pavilion located on Expo 2008 site and at a number of forums in Zaragoza and Huesca. Comprising 93 days of sessions with water and sustainable development providing the topic of debate, the Water Tribune has been the most extensive and lengthy international event ever dedicated to the topic of water.

More than 320 thematic sessions were held, and a total of 3,200 participants from 111 countries and representing multilateral agencies such as the UN, World Bank and European Union, intergovernmental and non-governmental organisations, and a wide number of fields, sectors and countries passed through the amphitheatre at the Water Tribune Pavilion.

As a vital platform and working resource, Expo Zaragoza 2008 Water Tribune organised Thematic Weeks to provide specialised forums allowing experts in key issues regarding water and sustainable development and university students to come together. All participants fulfilled the objective of coming up with solutions and proposals to the various challenges presented by water and sustainable development, putting forward new water management policies and highlighting positive practices and experiences that can be applied elsewhere and help change the current water resources model.

Organised into ten major thematic blocks, Thematic Weeks were the main components of the Water Tribune, which provided the most relevant substance of the Zaragoza Charter 2008 and its legacy, which has as its focal point the so-called Caja Azul (Blue Box).

A total of 422 speakers participated in the ten Thematic Weeks together with audiences comprising over 3,000. The speakers and expert audience hailed from 54 countries and 253 public and private organisations.

More than 120 specialised sessions were held during the Thematic Weeks and were based on the most important issues related to water and sustainable development.

The ten issues discussed during the Thematic Weeks are presented below along with 25 thematic axes that provided the basis for all activities carried out:

	NAME OF THEMATIC WEEK	THEMATIC AXES	DATES
1	Water and Land	• Land Management • Forestation • Irrigation	June 16 - 20, 2008
2	Water and Cities	• Local Governments and Governance • Development of Urban Surroundings	June 25 - 28, 2008
3	Water for Life	• Health • Water Quality • Rivers and Sustainability	June 30 - July 3, 2008
4	Water, a Unique Resource	• Shared Waters: Governance and Governability • Water Geopolitics • Basins and Aquifers: Planning and Management	July 7 - 10, 2008
5	Water Supply and Sanitation Services	• Regulatory and Institutional Framework • Society and Service Quality • Efficiency, Management and Development	July 15 - 18, 2008
6	Climate Change and Extreme Events	• Climate Change • Extreme Events	July 21 - 23, 2008
7	Water Economics and Financing	• Water Markets • Financial Solutions for Emerging Countries	July 28 - August 1, 2008
8	Water and Society	• Education • Communication • Culture	August 4 - 6, 2008
9	Water and Energy	• Water for Energy and Energy for Water • Non-conventional Energy Sources	September 1 - 3, 2008
10	New Sources of Water: Reuse and Desalination	• Reuse • Desalination	September 8-10, 2008

Key statistics on the Thematic Weeks are given below.

BASIC INFORMATION ON SPEAKERS AND EXPERT AUDIENCE PARTICIPATING IN THE THEMATIC WEEKS

Thematic Week	Speakers	Organisations	Countries of origin	No. of expert audience members
Water and Land	76	59	30	660
Water and Cities	40	38	18	220
Water for Life	34	31	19	305
Water, a Unique Resource	38	28	17	240
Water Supply and Sanitation Services	44	38	19	310
Climate Change and Extreme Events	27	19	8	205
Water Economics and Financing	49	38	11	287
Water and Society	58	42	10	289
Water and Energy	33	23	10	250
New Sources of Water: Reuse and Desalination	23	13	6	245
TOTAL	422			3.011

The presentation format very often consisted of conferences and round tables that were enhanced by broad and valuable participation of the expert audience, the aim being to come up with specific proposals to tackle the most pressing challenges in the area under discussion in each session. All the sessions were chaired by a moderator and counted on the support of a group of reporters, who compiled detailed notes on the sessions, work that provided valuable assistance to the coordinators and their scientific committees in drafting conclusions.

On other occasions, the format was based on a series of talks followed by debates, which provided a platform for consensus and concrete proposals. These sessions were also supported by moderators and reporters.

Both processes yielded positive, multidimensional results that have been embodied in the Zaragoza Charter 2008 and in the Blue Box.

COORDINATORS OF THE WATER TRIBUNE THEMATIC WEEKS

THEMATIC WEEK	COORDINATION
WATER AND LAND	Ramón Vallejo
WATER AND CITIES	Javier Celma
WATER FOR LIFE	Antonio Sarriá Marta González del Tánago
WATER, A UNIQUE RESOURCE	Raymundo Garrido
WATER SUPPLY AND SANITATION SERVICES	Francisco Cubillo
CLIMATE CHANGE AND EXTREME EVENTS	José Manuel Moreno
WATER ECONOMICS AND FINANCING	Josefina Maestu
WATER AND SOCIETY	Luis Guijarro Víctor Viñuales Germán Bastida Mario Gaviria Artemio Baigorri
WATER AND ENERGY	Gonzalo Sáenz de Miera
NEW SOURCES OF WATER: REUSE AND DESALINATION	Ángel Cajigas

The chapters presented from hereon were drafted by the coordinators of each Thematic Week with the support of their respective teams and scientific committees of each Week. Therefore, the texts that follow are a true and accurate record of their manuscripts and contain no subsequent amendments or additions.

Thematic Week 1

WATER AND LAND

[Land Management, Forestation]

Positioning document[1]

Coordinator: **V. Ramón Vallejo**

Lecturers, moderators and speakers : **C. Steinitz, L. Rojo, F. Luizao, M. Millán, A. Pulido, R. Schemenauer, C. Gracia, J. Ruíz de la Torre, J.J. Ramírez, J. Cortina, M. Acevedo, F. Prieto, C. Kirketerp, J. Bosco Senra, J. Botey, D. Gómez Orea, J.F. Bellot, S. González Alonso.**

ABSTRACT:

Economic development and land productivity should be compatible with nature conservation and landscape values and this requires rational use of water resources. From a human perspective, land uses are competing for water. The formation of the landscape and the way uses are distributed across the land affect water flow in terms of quantity and quality. Thus, both the use of the land and the ground vegetation have a great impact on the water cycle and its possible regulation by society. Decisions regarding a change in land use should carefully consider the degree of reversibility of such changes. Many alterations in land use are practically irreversible on an ecological or human timescale. Frequently, social and economic processes change very quickly in terms of ecological time – particularly in the case of forest ecosystems. Therefore, these changes should be viewed from a long-term perspective if there is the intention to take into account ecosystem sustainability. Objectives related to water should be compatible with other types of management – such as the conservation of biodiversity and the fight against desertification and climate change.

At a regional level, rainfall could be affected by the ground vegetation. The case of the tropical rainforests is emblematic as they play a critical role in triggering convective rainfall. The reduction in ground vegetation within the pattern of high global water recirculation generates a drop in evapotranspiration that could cause a decrease in rainfall.

Fog constitutes a precious water resource in some regions – particularly in arid zones. It can be used to supply drinking water to small rural communities or to support forestation programmes. Its exploitation is still rare – far below its potential contribution. The challenge is to develop the appropriate technology and bring it to its potential users. Along the same lines in increasing (and conserving) water inlets, techniques are oriented towards increasing the refilling of aquifers, especially during times of heavy rains – both in rural areas and in urban ones.

The forest is a great water consumer. However, in some geographical situations, it could be an efficient fog collector and, perhaps, a catalyser for rainfall in the local circulation pattern. The vegetation layer is also very efficient for water regulation, which is a critical function in areas where torrential rain is frequent with high erosive power and great flooding risk. The question, therefore, is how to design the location and management of forests in a region so as to optimise their positive effects the regional water balance. Forest vegetation management allows combining various objectives conservation, supply and regulation of water

[1]This document has been compiled from the written speeches, oral presentations, discussions during sessions and the distillation of all the above prepared by the moderators, speakers and coordinator, supported by the Water Tribune team.

resources. It is necessary to promote forest management adapted to Mediterranean conditions and focused on water regulation. For more than a century, forestation has been a key instrument in the protection and regulation of water basins. Forest restoration projects have to fulfil the ground protector role: improvement in biodiversity and productivity of the woodland, and optimising water resources. Forest restoration techniques must be oriented towards overcoming water stress of plants and the runoff limitations when torrential rain occurs. In the last few years, there has been a rapid development of forest restoration technology for woodlands threatened by desertification, using a broad range of species and techniques to optimise efficient water use. These have significantly improved the survival results and growth of plants. There are mild, proven techniques which allow optimisation of water use, particularly in arid zones.

The water cycle has many bio-geo-chemical functions that are necessary for biosphere functioning, in addition to consumption. The water cycle cannot be manipulated without affecting its biosphere functions. Land organisation should take water management into account by considering its three main outcomes: plants transpiration in the natural vegetation, water flow that reaches the sea and fertilises coastal ecosystems, and human consumption (including irrigation). Clearly, this organisation of water resources needs to be compatible with other objectives and limitations that should be considered in land planning. Likewise, the various sector policies that affect changes in land use and vegetation layers should take into account water repercussions and include them as part of the planning criteria. Despite their uncertainty, the creation of scenarios is a very useful tool for planning land uses, in a context of preventive measures for water resources. Decision-making in land planning can be evaluated through the examination of alternative futures which have water repercussions. Planning at a regional, water basin or urban level allows contrasting interests and local risks with principles and global risks of common interest. Multi-party decision-making models adapted to water models provide a method that allows the inclusion of various human players regarding changing a water basin.

The implementation of successful integrated water resource management programmes requires institutional coordination to achieve socio-political legitimacy and constructing agreements that involve public and private sectors and civil society organisations.

Key words: rural planning, forestation, desertification, landscape, land uses, fog, underground water, integrated basin management.

1. INTRODUCTION

Water is the greatest global limiting factor on photosynthesis ground-based plants and, therefore, on that of forests and crops.

Land, the ecosystems and countryside units are all linked in terms of energy and matter through fluids flow – that is from water – and movement – and air. The same thing that happens with ground-based ecosystems occurs with marine systems and between regions around the globe. Water is continually moving from land to plants to atmosphere. Water and carbon cycles are intimately linked, given that stomas simultaneously control transpiration and CO_2 absorption. Water flow through plants and its evaporation via transpiration is the price that ground-based ecosystems pay to produce photosynthesis – in other words, the main production process for the majority of foodstuffs and fibre required by human society. Ground water left unused by plants and water that flows rapidly can reach the aquifers or turn into run off down the slopes towards the rivers and, eventually, to the sea. This excess could be used by society for cultural uses (consumption). Ground-based plants compete for water – particularly in times of scarcity. From a human perspective, land uses also compete for water. Landscape shape and land uses distribution affect water flow in terms of quantity and quality and, therefore, land uses and the ground cover have a serious effect on the water cycle and its possible regulation by human society.

> *"Water is Earth's blood"*
> **Native wisdom (Brazil)**

THE WATER CYCLE: FROM GLOBAL TO FOREST SCALE

2. THE GLOBAL WATER CYCLE

Water movement through the atmosphere determines rainfall distribution on Earth. Oceans are the greatest water reserve on Earth – as well as the largest source of water susceptible of evaporation and sooner or later to precipitation. Annual evaporation of the oceans represents some 100 cm of water per year. Evaporation exceeds precipitation in the oceans, while the opposite occurs on land masses – where runoff returns excess precipitation to the sea. Groundwater also represents a large reserve, though volume estimations are uncertain. The ground contains 121,800 km^3 of water, of which 50% can be found in the stratum where deep roots exist and helps maintain their growth.

> **Food production requires high water consumption – 1,200 litres kg of wheat grain produced.**

Water availability is the greatest individual limiting factor on ground-based vegetation development. Considering the net primary production of ground-based plants (60 x 10^{15}g C/year) and estimated evapotranspiration in Fig. 1 (71 x 10^{18}g H_2O/year), the average global water use by vegetation is 1.28 mmol CO_2/mol water lost (about 600 l/Kg dry material produced). In the case of wheat grain, the relationship is approximately 1,200 liters consumed per Kg grain produced. When precipitation exceeds evapotranspiration on land masses, runoff is produced and transports eroded rocks to the sea. On a global scale, rivers runoff is 40,000 km^3 /year. Freshwater and dissolved matter and particles that reach the sea fertilise marine ecosystems. The total contents of water in the atmosphere is very small – the equivalent of 0.3 cm of rainfall at any particular time. It is estimated that over 10% of the humidity in the atmosphere is produced by the transpiration of plants.

As a global average, rivers transport about 1/3 of the precipitation that falls on the land to the sea and less than 10% of the precipitation reaches the water table (data from Schelesinger, 1997; Fig. 1). In short, only a small part of the Earth's total water quantity is circulating via evapotranspiration and precipitation through the oceans, atmosphere and the ground-plant system and the rivers in the land masses.

Human society depends on a relatively small reserve of freshwater in rivers and lakes and, more and more, on underground reserves. Freshwater is but 3% of all the water on Earth and the water in lakes and wetlands represents just 0.29%. 40% of freshwater is contained in the Baikal lakes and in the Great Lakes. Rivers only transport 0.006% of all freshwater reserves (USGS Water Science, http://ga.water.usgs.gov).

> **Human society depends on a relatively small reserve of freshwater in rivers and lakes and, more and more, on groundwater reserves.**

In arid regions, potential evapotranspiration (PET) exceeds precipitation, groundwater reserves are scarce, and rivers is very low; These regions are often restricted to a few storms per year where rainfall intensity surpasses ground percolation capacity. Due to water scarcity, primary production is poor – unless water is provided via irrigation from an external source, eg groundwater.

Ground use for sustainable water use from a global perspective

Ground uses and their changes generally depend on social and economic factors, though limitations and potential of natural resources should also be considered – in particular primary resources such as water and earth. Social and economic factors often change very quickly in terms of ecological time, especially in the case of forest ecosystems. Therefore, changes should be modulated through long-term perspectives ecosystems sustainability. Furthermore, objectives related to water should be compatible with other management objectives such as biodiversity conservation and effects in mitigation desertification and climate change.

The water cycle on land must maintain plants transpiration necessary for primary production, of natural ecosystems and in crops. At the same time, water flowing through the ground and geological substrata is necessary for erosion phenomena and freeing mineral nutrients. Water from surface runoff – enriched by nutrients and sediments, including organic matter – reaches the sea and fertilises marine ecosystems. Oceans are heterotrophic: therefore, organic matter and nutrients provided by rivers runoff are critical to sustain marine ecosystems productivity and, consequently, fishing. Land water flowing is essential for the biosphere and for humans in the long term. As a reference guide, Margalef (1996, Fig. 2) suggested the rule of “three thirds” to distribute water

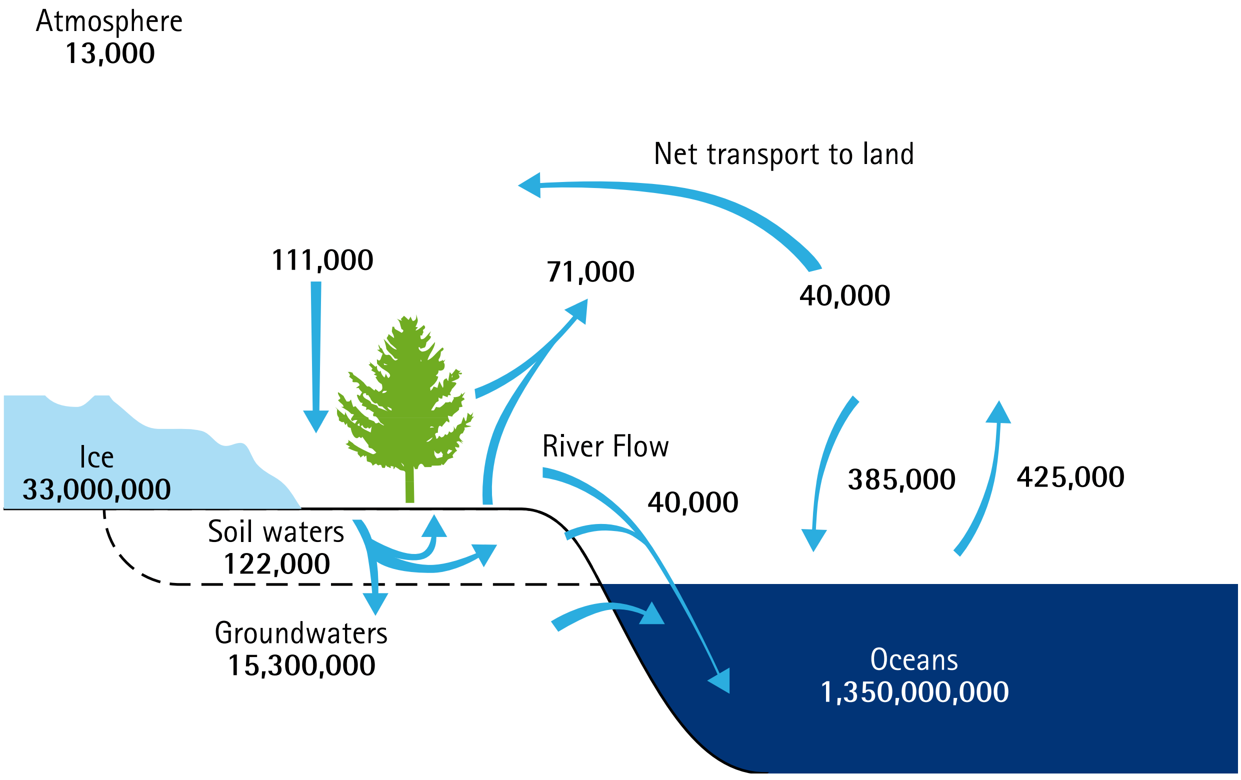


Figure 1. *Global water cycle. Reserves (km^3) and flows (km^3/year). From Schelesinger (1997).*

on land masses. One third should flow into the sea, another third should exits in the atmosphere by mesis of plants transpiration in natural ecosystems, and the final third should be used for human consumption – including agricultural irrigation, urban and industrial uses. According to the same author, total water available for consumption should not exceed 40,000 km^3 per year to avoid negative impacts on the global water cycle.

The water cycle has various bio-geo-chemical functions necessary to the biosphere to property, in addition to human needs. The water cycle cannot be manipulated without affecting its biosphere roles.

3. SOME OPTIONS TO INCREASE WATER AVAILABILITY

Water collecting methods in arid regions: improvements in replenishing aquifers

Water scarcity in arid regions is often accompanied by brief periods of very intense rainfall that may cause catastrophic flooding. In such cases, runoff could be collected to replenish aquifers – improving flood prevention and water resources management.

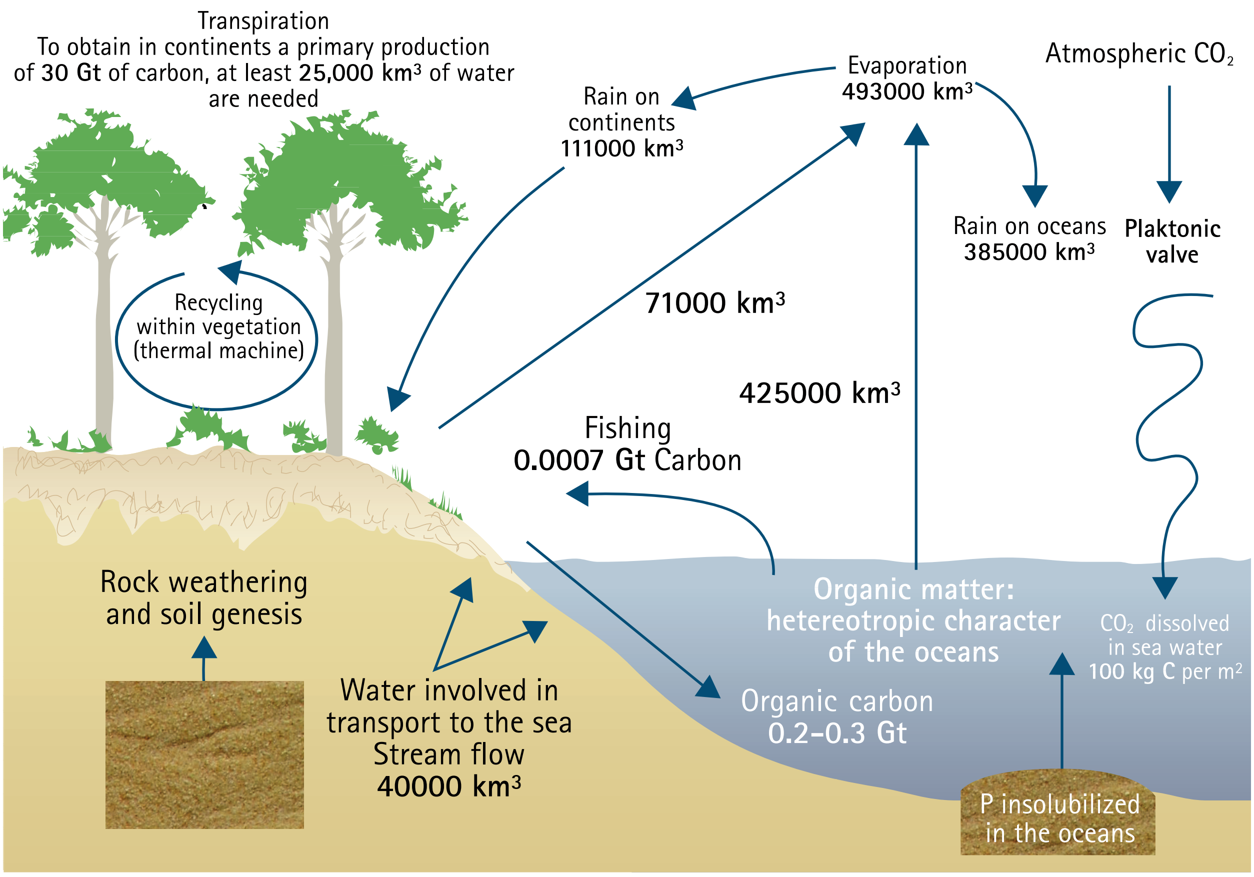


Figure 2. *Global water cycle and main linked bio-geospheric processes. The flow is expressed in annual values. Taken from Margalef (1996). The values for flow are comparable to those in Fig. 1.*

In arid and semi-arid areas, surface runoff is scarce and often the only water source is groundwater. There is a threshold below which aquifer recharge is negligible. In the driest years, filtration into the aquifer recharge can be practically non-existent. In wet years and/or when intense rainfall occurs, filtration can be very high – above 50% of the precipitation. At the same time, intensive irrigation farming in semi-arid regions is of great economic importance – which leads to a higher demand on water for irrigation and, often, to heavy aquifers abstraction.

Semi-arid regions have a long survival history realted to water scarcity and, therefore, have developed systems to collect water in any form. Table1 shows various traditional methods of collecting water and recharging aquifers.

Tabla 1.- *Different methods for collecting water and refilling aquifers*

Recolección de lluvia y niebla
Lluvia artificial
Recolección de niebla
Recolección de lluvia y escorrentía
Medio rural
Cajas de agua
Agua de tormentas
Infiltración en el lecho de las ramblas
Diques, balsas y zanjas
Careos
Presas de arena
Presas convencionales
Depósitos recolectores
Pozos de infiltración
Medio urbano
Sistemas de recolección en los tejados
Asfaltos porosos, hormigón poroso
Pavimentos alveolares abiertos con vegetación

There are examples of ancient subsistence agriculture based on runoff collection exploitation. It was used by the Nabateans more than 2000 years ago in the Negev desert and was well developed in the semi-arid regions of South America by the time of the arrival of the Spanish (for example, the Mexican water boxes, Hebert *et al.*, 1998). The most widespread example are *aljibes* or cisterns – abundant in south-east Spain – which continue guaranteen water supply for livestock in many rural places (van Wesemael *et al.*, 1998). In urban zones, architects have been concerned about negative effects of urbanisation on the water cycle – particularly in terms of water percolation to replenish aquifers and the increase in runoff. Some of the most common practices include cisterns that collect rainfall from roofs, vegetation-covered surfaces, porous surfaces, permeable pavements, porous concrete and tarmac, as well as collectors to improve percolation incorporated into the urban network (Ferguson, 1994).

Surface runoff – particularly during flooding periods – could be exploited through percolation into the very bed of a watercourse or by promoting percolation in the basins and lateral ditches following the construction of a drainage system. Examples on the southern face of Sierra Nevada (Spain) – which might have been begun by the Romans – were in operation in Moorish times: these were breaks exploited using water from snow and ice melting to artificially recharge aquifers to guarantee water supply during summer and into autumn (Pulido Bosch and Ben Sbih, 1997). “Sand dams” existing in some areas of Africa (Kiviiy and Sharma, 2002) used material deposited behind the dams to store surface runoff. These water collection systems were sufficient to maintain irrigated areas of (1.402.000 ha) in Pakistan, (165.000) in Morocco, (150.000) in Somalia, (110.000) in Algeria, (98.000) in Yemen and (30.000) in Tunisia (Prinz, 2000).

Reservoirs in semi-arid regions face particular problems due to the high erosive power of water runoff and a tendency for relatively quick silting.

The Isabel II reservoir provides an extreme example: it never came into operation due to heavy silting that occurred as a result of some intense rainfall occuring as soon as such inrastructure finished. Another problem in these areas comes from the great flow variability – obliging to over-dimensioning any engineering work to guarantee "reguiating" extreme rainfall events. Should this be not the case, then there would be years when the reservoirs would be completely empty and others when they would remain overflowing world occur. Thus, regulation based on average flow is no guarantee. The water level in the river Almanzora, for example, varies between null up to 255 hm^3/year.

In semi-arid regions, it is possible to increase water resources by constructing "soft" engineering projects, of relatively low cost and low environmental impact, at the same time they any reduce soil erosion and stimule laminar flow of this potentially highly destructive phenomenon. It seems impossible to guarantee great volumes with these systems, though thought recharge volumes can be large with the help of other anthropic actions – such as gravel-traps and hollows created by other abandoned quarries. The Andalusia Water Agency is currently funding – experimentally – a construction project for an impermeable barrier over the transverse section of the river Almanzora, with the intention of accumulating water in an area upstream from the barrier. The tests undertaken show high hydro-geological efficiency in the abandoned quarries – due to their great size and the high land permeability. Although the network of dykes only produces an induced recharge of 10% of the runoff generated by a storm, some sub-basins have shown especially promising results.

Capturing fog

Fog can be found in almost all countries on Earth. Fog is a natural part of the water cycle and, like rainfall, provides a vital source of water. Its contribution to water input in a specific place can vary between 0% to almost 100% – in some high-altitude desert areas. Fog is composed of tiny drops of water measuring from 1-40 μm in diameter – the typical diameter being 10 μm. Some tree types are efficient at collecting these tiny drops that are moved around by the wind. They coalesce on leaves into larger drops that then fall to the ground. This natural process for capturing fog supplies nebulous forests on the tropics; it is also an important water contribution in coastal forests in temperate climes and the only water resource for plants in some desert zones around the world (Follmann, 1963). In forests at high altitudes, this process can provide 20-50% of the water input in the ecosystem. The combination of fog and moderate wind can lead to large fog flows which can be used by vegetation or collected by artificial fog collectors. In addition to providing significant quantities of water, fog can also be a source of nutrients for the forest and a wet separating or degrading method for pollutants (Schemenauer *et al.*, 1995).

Evaluation of fog flow using a standard fog interception and collector has shown that in the desert of Chile, Yemen and Eritrea the average flow varies from 3 to 9 $l.m^{-2}$.in vertical meshes (fog catchers) per day. Given the efficiency of these collectors is 50%, in these arid zones there is a magnitude of 10 $l.m^{-2}.day^{-1}$ of freshwater moving across the surface of the ground. In other countries, the average fog flow has provided values as low as 1 $l.m^{-2}.day^{-1}$ in Namibia and as high as 70 $l.m^{-2}.day^{-1}$ in the Sultanate of Oman.

The fog collectors or catchers are made of polypropylene or polyethylene mesh – cheap and long-lasting (Schemenauer and Joe, 1989). The mesh contains fibres that collect fog droplets and is braided in such a way as to permit rapid draining of the water collected that runs down into gutters. The mesh is placed in vertical collecting panels measuring 4 m high by 10 m or 12 m long. Depending on its location, each panel produces 150 to 750 l of drinking water per day during fog season. The currently operating projects use between 2 and 100 fog collectors. The projects have even had successes in places where there is only 1 mm of annual rainfall.

Figure 3. *Large-scale fog collectors generate water when visibility is below 300 mm (Chile). Photograph: R. Schemenauer.*

There are two main applications for the collected water in arid zones:

1) The collectors can provide water that complies with World Health Organisation standards for drinking water – which could be used in rural communities and groups of houses; this water is produced cheaply and can be brought to houses using gravity;

2) The collectors can provide water for reforestating crests and upper mountain reaches where it is not practical to transport water by conventional means; fog water can be distributed via gravity-induced drip irrigation systems. The resulting forests – if located adequately – can become self-sustaining through direct collection of fog water. An important experiment, funded by the European Union, took place at the end of the 1990s to research on reforestation techniques in the hills of the Peruvian desert coast. Another project began in northern Chile in 2008 to establish a plantation in the heart of the Atacama Desert, using fog collectors as water resource. An additional positive point about water collection at heights outside desert areas is that it could be available to be used by aircraft in the fight against fires in at-risk areas.

Fog is a low-cost and environmentally sustainable natural water source which can be collected to produce drinking water and to generate new forests. Artificial collection is of special interest in desert regions with high fog occurrence and intensity.

4. VEGETATION LAYER AND WATER

The types of vegetation are characterised by the dominant life forms, dependent on the types of climate and modified by the treatments or conditions to which they are subject to. A different type of vegetation is favoured according to each climate unit. Except in the high mountains, compact rocky areas and in arid to desert zones, the optimal type is that of the more or less dense forest.

Among vegetation roles affecting water availability, the following stand out:

▸ Modification of the albedo or incidental energy level that is reflected. The albedo is at its highest in the desert and its lowest in dense forest.

▸ Regulation of surface runoff – conditioned by the slope – but growing with vegetation size, density and rigidity. The beginning of runoff is delayed after dead vegetation, earth and land is soaked. The trunks, stumps and smaller stalks rising from the ground provide an obstacle to waterflow across the surface, increasing drainage delay. Through all of this, the beginning of the concentration of runoff in primary drainage channels is delayed, something which is passed along the successive channels. The peak runoff (maximum flow volume) is reduced and drainage time extended. There is a damage reduction caused by rises and flooding, but an increase in acuifers recharge throught out the basin and an increase in water retention in dead vegetation, earth and land. The progress of runoff regulation leads to a consequent regularisation water course

▸ with general stability of routes and riverbeds: plants become part of the course, transversal sections become narrower and fit, and riverbanks become stronger.

▸ The vegetation layer is a carbon drain, climate regulator and fosters cahnge reduction.

▸ Expelling water into the atmosphere via photosynthesis and transpiration implies a consumptive water use, but it can contribute in some way to increasing rainfall – a matter being studied by CEAM (see section 8).

▸ Mature ground is an edaphic water reservoir, regulating water consumption.

▸ Erosion reduction through a growing vegetation layer density has beneficial influence on water quality and the lasting operation of regulation and transfer systems.

▸The retention of atmospheric dust – which provides nutrients to the ground and helps vegetation. The result is that "the dense forest provides purer runoff water than the rain falling from the sky".

▸ Water loss through snow sublimation is considerably reduced with dense foresting – below the timber line – a matter that is not usually taken into account in water resource planning.

Forest fires produce a temporary loss of the vegetation layer which means that for several years degradation is present in the current regulation and water quality – in which most ashes are transported. Massive regeneration in a large proportion of Mediterranean vegetation favours reincidence fire. The decline in logging and stockbreeding – formerly very profitable – increases the possibility of fires in our hills. Species in the fire cycle which are in great danger when they are abundant and provide denseness in the lower levels of wooded zones include heather, thickets of retamoideae, gorse, cistus and cistus albidus, thinleaf false brome and tall labiates, such as rosemary. The generalised ending of used for energy of logging material (previously very important in kitchen blocks and home heating, bread-making, slates, pottery, ironworks and other industries) has caused the progression and densification of the thickets of trees and of varied and widespread bushes that fill our hillsides. Among other consequences, the increase in fire risk stands out.

Vegetation layer growth improves the ability to capture resources (solar energy, water, aerosols) and its in situ recycling capabilities regulate water flow down the slopes.

5. THE ROLE OF FORESTS IN THE WATER CYCLE

The stage of the water cycle that occuring on a hillside is one of the key scenarios to explain most of the influences of human activities on the physical world. The complexity of the process is notorious. This leads us to give rigorous thought based on identifying which resource and which part of the cycle are being analised in each case. Additionally, regarding forest influences on water resources, it is vital to clarify which of the three basic attributes of water – quantity, quality or pattern – is being examined. Furthermore, the length of time water remains in the basin represents another key point in the analysis: while the volume from a storm could leave the basin in a matter of minutes, the base runoff could remain for years in the ground or the sub-strata.

Figure 4 shows the main components of the water cycle in a forest and the factors which control flows and volumes. The vegetation layer directly intercepts water from rain and fog (interception) that latter evaporates or reaches the ground through treedrops and cortical runoff. Interception is related to the foliage area (LAI) and varies according to rainfall intensity and frequency of the rainfall. Water reaching the ground could percolate or generate runoff. The critical property at this stage is the filtration capacity which depends on grund texture and structure. Runoff could produce flooding and ground erosion, especially when heavy rainfall occurs. Erosion risk is related to ground properties (texture, organic matter contents, structure) and is expressed in forecasting models through ground erosion (k). The organic horizons increase filtration and protect the ground against erosion processes; in addition, dead leaves reduce direct ground evaporation. Uninterrupted forests protect the ground very efficiently against erosion and, at the same time, regulate flooding – making the risk of catastrophic flooding lower.

The water contained in the ground could be absorbed by roots or recharge aquifers through seepage. Permeability ground affect deep filtration. Filtrated water – and the fraction of this that percoaltes into aquifers in the saturated area – comprises, in the majority of cases, the source that feeds rivers base flow. In other words, it allows them to flow in the absence of rainfall, and even in times of low water level. Water absorbed by the roots is lost through transpiration via the ground-plant-atmosphere continuum. Water deficit in the atmosphere is the mechanism that moves the transpiration flow – specifically, the difference between watervapour concentration in the free atmosphere and in leaves. This evaporative atmospheric cability of the atmosphere to evaporate is generally estimated via the concept of potential evapotranspiration (ETP).

Deforestation has been accused of everything regarding water from flooding to water scarcity (Dudley and Stolton, 2005). Generally, the connection between the forest and water quality is clear; in other words, forested basins produce higher quality water than those that withstand other possible uses. The link between forest and water quantity depends on bio-climatic conditions (Piñol *et al.*, 1991, Fig. 5). In areas with an arid climate, i.e. with high ETP and low rainfall, (such as the case of the Mediterranean climate) during wet years evapotranspiration in the forest and runoff flow during a storm is always low and basically conditioned by events of heavy rainfall. On the contrary, in temperate climates – limited by solar radiation, ie low ETP – the runoff flow is much higher and wet years produce greater volumes while evapotranspiration stays approximately constant.

Back in 1965, having reviewed 157 studies of chartered basins and small plots in many parts of the world, Shachori and Michaeli showed a lower runoff flow in forests and thickets than in pastureland or areas with little or not vegetation. In 1969, Molchanov mentioned the greater transpiration of forests compared to meadows in the forest-steppe transition in the south of the former Soviet Union (Molchanov, 1971). Bosch and Hewlett (1982) showed – based on the results of 55 experiments in basins around the world – that the increase in runoff volume was related to the percentage of decrease in the vegetation layer: conifer forests produced a greater increase in runoff with the decrease in vegetation, followed by the deciduous or mixed leafy forests, and, finally, the thickets. Per Calder (2000), both in wet areas and those drier, the evaporation is probably greater in forests than in other types of vegetation – involving a lower volume of runoff in forest basins compared to places with other ground uses. Equally, the temporary or permanent removal of forest cover, for example due to a fire, involved an increase over all basin lfow, and also an increase in nitrates (contaminants), in the specific case of a fire, and in the risk of flooding. Generally, it is supposed that virgin forests are the best cover to regulate the flow of water in water basins and to minimise the risk of floods (*i.e.*, the frequency and/or destructive impact.)

The experiences in the Experimental Basins in Vallcebre (Llorens, 2005), located in the foothills of the Catalonian Pyrenees, through the follow-up of volume changes resulting from a series of plots over a 10 year period and a water model suggest that if in a small basin complete reforestation was acomplished compared to the current situation (70% meadows and 30% pines), then volumes would diminish by 18%.

In summary, in accordance with general experimental evidence, we can conclude that a reduction in arboreal cover could be the solution to water problems that could threaten us. Taking this conclusion to the extent of completely eliminating forests to obtain greater volumes would be a case of reducing matters to absurdity. Forest ba-

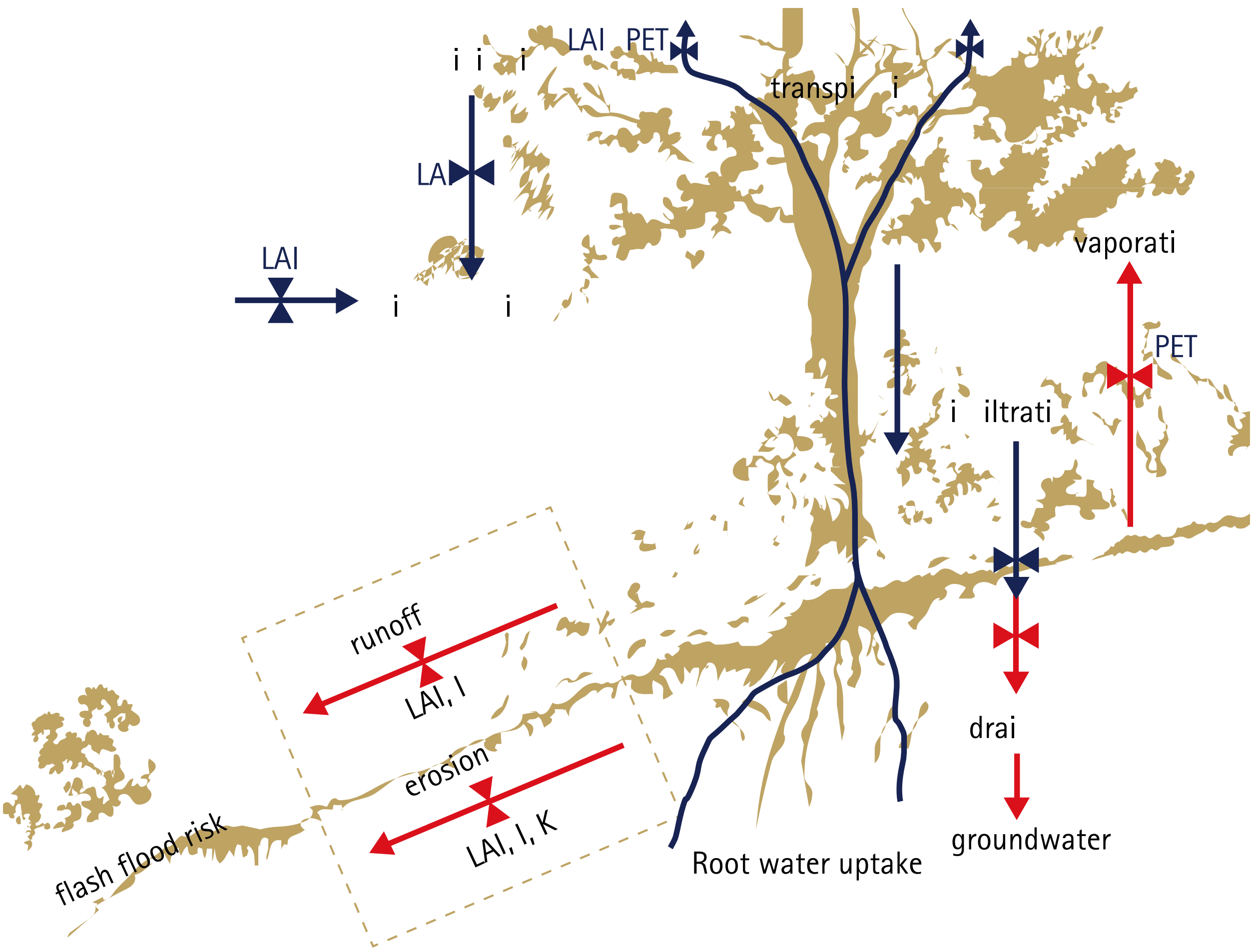


Figure 4. *Water cycle in forests. The most important regulatory factors for water flow are: LAI (Foliage area), ETP (potential evapotranspiration), I (ground filtration capacity), Kh (ground water conductivity), k (ground erosionability). The organic horizons – characteristic of well-preserved forests – also increase water infiltration capacity, and reduce ground evaporation, runoff and erosion. The factors in blue increase flow and those in red reduce it. From V. R. Vallejo.*

sins and woods cuithin them have many functions, not just a single one forest management resides in harmonising multitorshing with demands from society, safeguarding the continuity and perhaps improvement of ecosystems and their values. Therefore, we have to find the solution to each case and adapt it to the needs established by society, safeguarding future options – ie reversibility. This solution should satisfy – aside from the conservation of natural values – various uses and demands: leisure, cultural, protective, scientific, landscape, productive, ecological, hydrological, cynegetic and economic, among others.

The decrease in arboreal cover densty leads to increases in quantity basin water outflow to a significant degree.

By contrast with the evidence available that forests are great water consumers, evidencists that nebulous forests have a high interception capacity for fog water – even above that of transpiration losses (Langford, 1976; Holmes & Wronski, 1982; Bruijnzeel, 1990).

The influence of the forests on water patterns is another key point in forest water. From water resources viewpoint, the basic volume is of particular interest in connection with the needs for water supply and reserving volumes for such use. The lower water flow – the basic volume – is what determines a river supply capacity and not its high volume, or even an average one. Therefore, we can point out that regarding water supply, we have two options: increase reservoirs (withstanding all complications that sucha measure implies) or, instead, increase the basic volume. The question is what role the forests and their management could play in a possible increase basic flow. If, thanks to lesser filtration and percolation or a prolonged reduction in the piezometric level for whatever reason (excess water abstraction), basic volumes

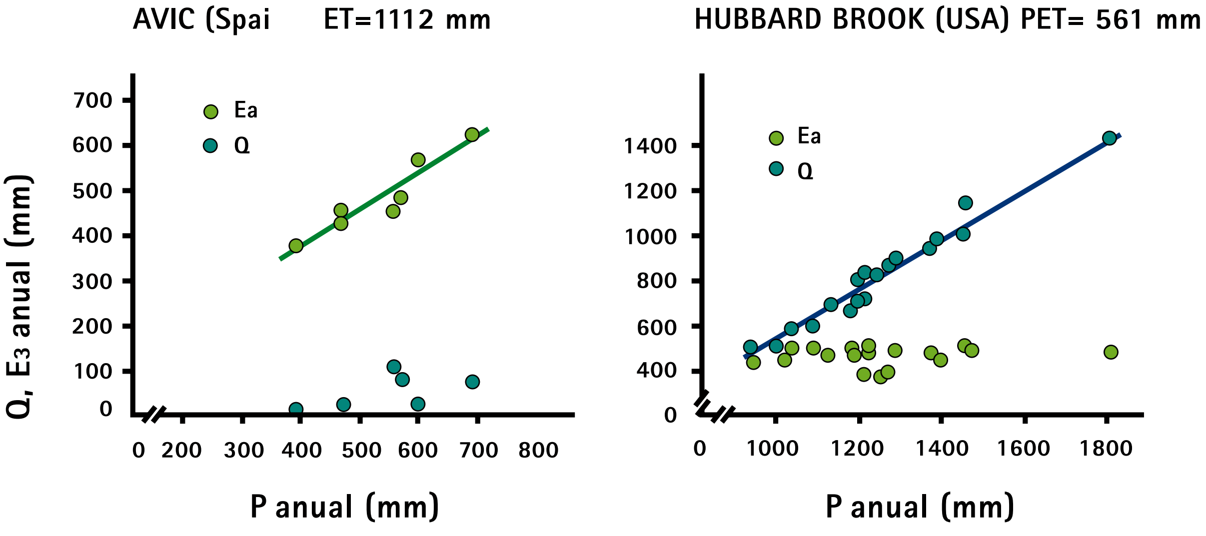


Figure 5. *Comparison between water properties of basins contrasted over the course of various years. Left: Avic Chartered Basin (Poblet Forest, Tarragona, Spain), with Mediterranean climate, shows an increase in evapotranspiration (Ea) as the annual rainfall rises, without a clear response from the runoff flow (Q). Right: Hubbard Brook (New Hampshire, USA) Forested Basin, temperate climate, shows an increase in runoff flow according to the increase in annual rainfall, without appreciable response from evapotranspiration. Taken from Piñol et al., 1991.*

were to diminish, we would be reducing the natural regulation that will intum require artificial regulation (reservoir). Contrary to the case of forest influence on winter availability of a specific basin, here we have no experimental evidence. However, this evidence opens the perspective of designing forest management oriented towards optimising basic volumes.

Forest effects, their conservation and management on water quality and fluvial ecosystems is clear and is unnecessary justifying a conclusion recognised by everyone. The effect of the forests on erosion and sedimentation, water temperature, dissolved nutrients, oxygen exchange and, eventually, chemical substances used in forest culture is a decisive factor. In forest basins, water quality objectives should generally surpass in importance those related to water quantity.

Riverbanks are of great importance as a protective filter for water flowing through rivers, in addition to their specific value for harbouring ecosystems of great intrinsic value and serving as biological corridors. Establishing sufficiently broad protective strips along riverbanks should be a generalised practice. Any eventual strategy for an increase in water production in forest basins should have the water quality maintenance and erosion protection specifically established as pre-requisites.

The American Forestry Service provides practical ways to incorporate water objectives into forestry management (Tewry and Hornbeck, 2001). Among these water targets figure those related to water quality maintenance and within these it points out: improving fish habitats and intensive protection of riverbanks. Among possible goals related to water quantity, it under first increasing water production, maintenance or improvement minimal flows, limiting flood peaks and recovering water functions of previously altered areas. It provides directions for the forest manager to achieve specific targets. For example, in terms of increasing water production, it states that the minimum management unit will be 20 ha and all that is contained within and will be identified as adjacent to water, wetlands or strips of protected riverbank that should comply with the following requirements: (1) evergreen species must not exceed 30% of the base area; (2) the percentage of covered space must not exceed 70%; (3) if the clearing is regenerating, the relative density of parent trees must not exceed 30% and the saplings should not occupy more than 30% of the clearing. These recommendations could involve the following treatments: (1) reduction in numbers of clearings to below 70% of the percentage of the covered zone; (2) employing short shifts; (3) stimulating the leafy trees; and (4) helping the regeneration of the saplings.

The contribution of forests to the production of regulated quality water is one of the main benefits of the forest ecosystems and one of the primary objectives in their management.

6. THE MEDITERRANEAN FOREST

The main distinctive characteristics of Mediterranean vegetation derive from the condition of growth limited by water. At a regional level, the precipitation/potential evapotranspiration relationship offers low values for the Mediterranean ecosystems – with frequency below the unit – and this is one of the most important differences compared to temperate ecosystems. The values for real evapotranspiration/potential evapotranspiration obtained in various experimental water basins clearly show that Mediterranean ecosystems will never reach their potential values. As a consequence, trees are strongly limited by water, to such an extent that it has been demonstrated experimentally that a reduction in trees density involves a greater transpiration of the remaining trees, but this translates into water use that is practically the same despite the reduction in density per foot. Various characteristics of the Mediterranean forests – such as the index of foliage area, structure of tree tops and productivity – depend greatly on forest density per foot.

Water use efficiency in Mediterranean forests is close to 5 mmol C/mol H_2O or, in other words, plants must transpire 1,000g of water to fix between 2 and 3 g C (*i.e.,* between 300 and 500 times the weight of carbon). The cost of fixing C in terms of water is high. The crucial question is how much it costs to maintain forest structure. This is interesting because the response will give us an idea up to what point water availability is limiting the survival of the Mediterranean forests – both currently and in future conditions.

In the experimental holm oak forest in Prades (Tarragona, Spain), the average water use efficiency is 3.68 mmol C/mol H_2O – in other words, trees transpire 150 kg of water to produce 1 kg of organic matter. The maintenance cost for leaves, ossified surfaces and fine roots in this forest is 844, 204 and 95 gC m^{-1}/land/year^{-1} respectively. This means that to balance respiration costs of the leaves, the trees invest 844 gC·m^{-2}/land/year^{-1}. Similarly, the forest invests 189, 146 and 184 gC·m^{-2}/land/year^{-1} annually in the creation of new surfaces.

The photosynthesis necessary to balance this carbon cost requires a transpiration of 452 mm of water per year, or if we consider that transpiration represents 80% of the precipitation, it needs 670 mm of rain per year to sustain the photosynthesis needed to balance the respiratory cost of the forest. Thus, with less than 570 mm of annual rain, the forest reduces the creation of new layers and below 392 mm cannot maintain its current biomass. From these data, the conflict between water and carbon is clear and the high cost of carbon absorption in terms of water.

From a water management perspective, it is clear that many management systems that we could adopt will not affect the transpiration balance. Given the extreme water limitation of Mediterranean forests, a reduction, for example, in trees density will have an effect on the water balance of remaining trees that could increase the quantity of water transpired by each tree or per foliage unit, but it has no effect on the global water balance in the clearing – as has been shown in experiments. global de l'eau du peuplement, tel qu'on l'a vérifié expérimentalement.

In Mediterranean ecosystems, it is expected that an increase in air temperature coupled with changes in rainfall distribution will bring higher evapotranspiration and a greater summer drought (IPCC, 2007). Currently, water is already a limiting factor for the growth of the Mediterranean ecosystems; therefore an increase in drought intensity could have a major impact on current and future forest growth rates. Among all the bio-climatic regions, the Mediterranean bears the highs risk from global change.

7. ALTERNATIVES IN FOREST MANAGEMENT

The need to safeguard water quality and for ground protection, together with the continuity of forest ecosystems, comprise the basic pre-requisites for any action aimed at increasing water production.

Figure 6 shows the principle alternatives for harnessing and/or conserving water in forests or other natural ecosystems. The increase in water inputs can be favoured in places with frequent

Table 2. *Cost of formation and maintenance of foliage biomass, non-photosynthetic surfaces and fine roots (gC/year) in the evergreen holm oak forest in Prades (Tarragona, Spain). The column on the right and the row below show the transpiration needed to balance the cost of each component of the tree. The necessary precipitation has been estimated assuming the empirical factor of transpiration consuming 80% of the precipitation in this forest. Gracia et al., 2002.*

	FORMATION	MAINTENANCE	TOTAL	WATER
		gC /m²/year		mm
Leaf biomass	189	844	1033	281
Non-photosyn. surfaces	146	204	350	95
Fine roots	184	95	179	76
Total	519	1143	1662	
Transpiration (mm/year)	141	311		452
Precipitation (mm/year)	178	392		570

fog by increasing the foliage area (LAI). This is possible in uninhabited areas through forestation. In some meso-meteorologically specific situations, where the local circulation is relevant, water vapour produced through transpiration could catalyse the formation of clouds and, eventually, rainfall and, therefore, the forest locally increases rainfall. As forests are large water consumers, a reduction in the forest layer would increase runoff flow flow and/or aquifer recharging. However, this possibility must be considered vis a vis risks associated with forest layers loss to be faced – i.e. floods and ground erosion.

DO FORESTS ATTRACT RAIN?

8. THE INTERACTION BETWEEN GROUND USES AND THE CLIMATE. TWO PARADIGMATIC EXAMPLES: THE AMAZON BASIN AND THE MEDITERRANEAN BASIN

The decrease in vegetation layer should high global water recirculation occur generates a reduction in evapotranspiration which could lead to a drop in rainfall.

Amazon Region

The Amazon basin is a gigantic region measuring some 7 million km^2, covered to a great extent by a dense tropical rainforest criss-crossed by thousands of streams and rivers which comprise by a great extent the largest water basin in the world. It discharges 210,000 m^3 s^{-1} or 2.9 mm/day^{-1} – representing 18% of the world's freshwater (Marengo, 2006). The average evapotranspiration in the Amazon basin is on the order of 3.5 – 4.0 mm/day^{-1}, while daily precipitation varies between 5.5 and 7.9 mm/day^{-1}. The average annual precipitation is about 2300 mm, but various sub-regions within the basin present annual precipitation far below this – such as in the west, north-west and the extreme north (Marengo, 2006). The Amazon region is tropical, where energy exchange between the land and the atmosphere is very intense. Due to its enormous territory and its physical characteristics, the region is a large source of evapotranspiration that greatly affects the pattern of regional and extra-regional rainfall. Thus, changes in the Amazon ecosystems could have profound consequences on atmospheric circulation, on the transportation of humidity and, consequently, on the water cycle – not just in South America, but also in other parts of the world (Almeida *et al.*, 2007).

The Amazon jungle is a mix of water and forest, which due to its size plays a vital role in regulating the regional water cycle as well as in all South America.

Rain in the Amazon region originates in part from local evapotranspiration from the ecosystems – representing 55-60% of the precipitation and an annual evapotranspiration-precipitation recycling of the same water in the area of 20-35%. Therefore, changes in the vegetation layer due to deforestation – which would cause a drop in the evapotranspiration – would surely affect the region's water balance and that of its neighbouring regions. A second factor of caudal importance for the regional and extra-regional climate – and particularly for the water cycle – is the role of the Amazon region in the reception and exportation of water vapour over and back across long distances. The annual water balance shows that the Amazon region is a great importer of water vapour,

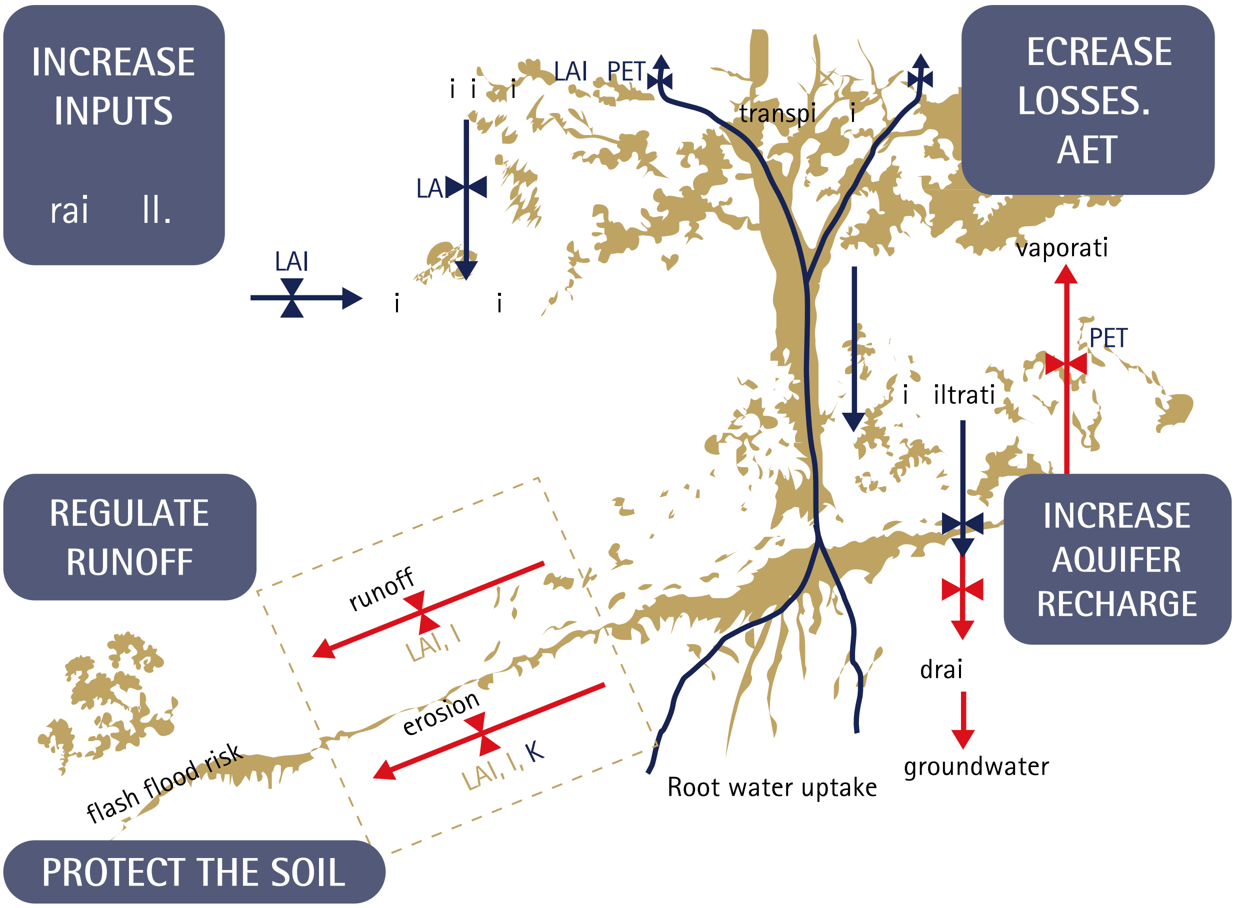


Figure 6. *Alternatives to increase water harnessing or its conservation, and limitation associated upon considering AET: Real Evapotranspiration. From V. R. Vallejo.*

especially from the Atlantic Ocean which provides three-quarters of the total humidity circulating around the region (Correia *et al.*, 2007). The remaining quarter is produced by evapotranspiration, while the annual rainfall is double that value. Thus, the Amazon region exports humidity in a quantity equivalent to twice the regional rainfall or four times its evapotranspiration. Half of this humidity is transported towards the south of the region while the rest goes to the Pacific Ocean or the Caribbean. From this, it can be concluded that the Amazon region controls to a great extent the circulation of water vapour in the South American continent, affecting the distribution of rain in the centre and south of South America (Marengo, 2006).

In the last few decades, the Amazon region has been facing an accelerated deforestation process. In Brazil alone, 18% of the Amazon forest has become pastureland and cropland (INPE, 2007). This deforestation for the creation of pastureland has increased the albedo and reduced evapotranspiration. However, it has not been possible to demonstrate an effect of a reduction in local precipitation. At the same time, climatic models have been used to evaluate possible effects of deforestation in the Amazon basin. The majority of these studies imply annual reductions of between 5% and 20% in precipitation, from 20% to 30% in evapotranspiration and an increase in air temperatures near the ground of 1° Cto 4°C (Correia, 2006). However, other models offer opposite results through the creation of a convergence of humidity from the surrounding forests onto the hottest deforested surfaces. Intending to reconcile the results of the different models, Avissar *et al.*, 2002, concluded that deforestation up to a threshold of 20-40% in the region would generate an increase in rain; above this level, there would be a significant decrease in rain.

Despite a general lack of field measures to demonstrate the direct effect of deforestation on the quantity or distribution of rain, a study in Rondonia (SW Amazon region) presented the first direct evidence of a decrease in precipitation following deforestation. Through continuous measurement of cloud formation and precipitation by radar, a decrease of 5% in precipitation in the deforested region was noticed – in comparison with the low altitude forests – and a 20% decrease when compared with higher level forests.

In areas of well-preserved Amazon forest, the emission of volatile organic compounds by the vegetation generates natural aerosols – in low concentrations – through photo-chemical reactions that give rise to the formation of low-lying “hot clouds” which rapìdly produce rain, in a similar way to those produced over the ocean (Fig. 7). In the dry season and because of the fires used in vegetation an deforestation management, there is a drastic increase in the concentration of particles which affects the radiation balance – lowering the incidental radiation by up to 70% (Eck *et al.*, 2003), in addition to effects on the local population. In a polluted atmosphere, the available water vapour disperses across a large quantity of particles (condensation nuclei, CCN); water drops slowly grow to form extremely vertical clouds. Very often, these clouds do not produce rain, the drops evaporate and the water vapour is transported to other places along with aerosols. If water drops rise to more than 6 or 7 km up, they might freeze (“cold clouds”) and generate a subsequent growth until they form clouds of 10-15 km height – forming cumulonimbus. These clouds replace the ground-level ones and only really big ones occasionally produce rainstorms (Fig. 7; Andreae *et al.*, 2004).

While at the basin scale, the effects of ground use changes are not yet detectable in the Amazon region, significant changes happening in the fluvial ecosystems at micro- and meso-scale. Deforested water courses show higher water temperatures and nutrient concentrations and dissolved organic carbons, whereas oxygen is very low – showing a drastic change in the workings of the ecosystems (creating an anaerobic system) and their hydrology. These water bodies are expected to produce higher CO_2 emissions and evaporation rates.

Deforestation could cause feedback processes: more fires, less precipitation in dry periods, more dead trees and, then, greater fire susceptibility. The end result could be the decline of forests and/or its replacement by types of vegetation adapted to longer dry periods (Oyamma and Nobre, 2004).

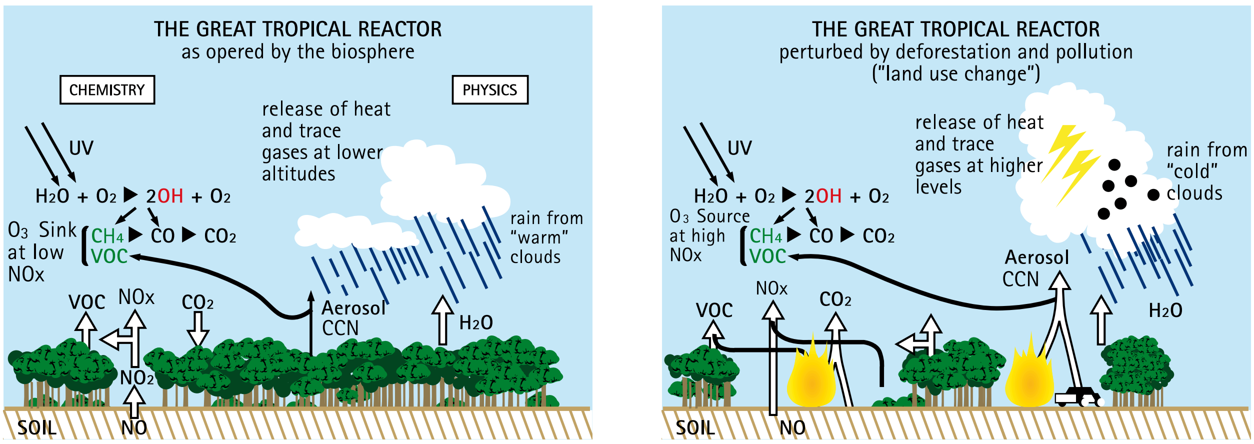
Large-scale deforestation of the Amazon rainforest could alter the processes of cloud and rain formation with effects in neighboring and, even farther off regions.

The case of the Mediterranean basin

The potential evapotranspiration in Mediterranean conditions is approximately double that of precipitation.

Mediterranean climate features boast a dry season – in summer – coincides with the highest growth potential for vegetation. All regions around the world with a Mediterranean climate have this same distinctive characteristic – which determines a lack of water to ecosystems and society. However, the different Mediterranean regions around the world – central Chile, California, South-West Australia, South Africa and the Mediterranean basin – have their own bio-geographic, climatic and historical characteristics. The Mediterranean basin is one large geographical unit with its particular climate that probably has repercussions beyond the region itself – affecting the global climate system. Around the Mediterranean sea, we can find deserts and semi-desert conditions (the coasts of Algeria, Tunisia, Libya and Almeria in SE Spain), as well as mountain chains very close to a warm sea and, therefore, a marine atmospheric block with high humidity content.

The rainfall pattern around the Mediterranean is greatly affected by local processes that, in turn, can be modified by human activities in land management – especially in changes of land use and atmospheric pollution. In this area, Millán *et al.*, 2005, analysed the types of precipitation across the Spanish Mediterranean landmass and identified three groups: (1) summer



Biosphere-Atmosphere interactions in the Amazon:
(a) in pristine conditions
(b) as disturbed by deforestation and land use.

Figure 7: *Main biosphere interactions involved in clouds formation and rain in the Amazon region: (a) over forest – pristine conditions; (b) over large areas disturbed by deforestation and changes in ground use (Source: Andreae et al., 2004; LBA web page).*

storms caused by sea breezes; (2) “classic” frontal Atlantic precipitation; and (3) Mediterranean cyclo-genesis. All of these respond in a different way to the climate indices for use, eg the NAO.

Territory changes and, more recently, the effects of air pollution could be combined to surpass the critical precipitation threshold – i.e. the height of the levels of cloud condensation with respect to the height of the coastal mountain chains. The result of this is a loss of summer storms and a propensity for a climate more towards desertification and drought. Modifications and changes in the water cycle in any part of the basin could sweep through the whole basin and neighbouring areas and, ultimately, reach the world climate system through other mechanisms. This means (Fig. 8): (1) an increase in Mediterranean cyclo-genesis in autumn-winter through the accumulated heat (greenhouse effect) of the sea surface by water vapour and contaminating agents (ozone) that accumulate over the sea; (2) accumulated water vapour being sent to other places at the end of each 3-10 day accumulation-recirculation cycle, which could contribute to summer flooding in Central and Eastern Europe; and (3) changes in the evaporation-precipitation balance over the Mediterranean, which would increase its salinity and stimulate the Atlantic-Mediterranean salinity valve.

According to Mediterranean breeze patterns, in the summer sea air bodies often need a water supplement to create precipitation in coastal mountains. The fact that scale-wise this water supplement could be provided by evapotranspiration along the coastal area offers a reference from which to orient managing ground uses that could have consequences on rain patterns.

The conservation and increase in forest areas could improve precipitation patterns in areas in which local circulation predominates.

DESERTIFICATION AND RESTORATION OF ARID ZONES

9. THE CASE OF THE DRY ZONES: THREAT OF DESERTIFICATION

Desertification is the degradation of land in dry zones around the world (CLD, www.unccd.int). Drought is one desertification cause. The lack of water is a consequence of natural phenomena and induced by human activities and it turns into desertification when becomes permanent (Table 3; Santos Pereira, 2004). Regarding water, desertification is a permanent imbalance in water availability, and is combined with soil degradation, inappropriate land use, groundwater abstraction salinity increase, and increase in catastrophic flooding, wetlands loss and a fall in the load capacity of the ecosystems. Ground degradation in a dry climate reduces water filtration – sometimes raising salinity – and both processes cause a reduction in water availability for plants. In brief, desertification is caused by land over-exploitation in dry conditions – particularly in arid, semi-arid and sub-damp dry climates.

In addition to current desertification due to land over-exploitation, abandoning crop farming in the semi-arid climate could also cause extra land degradation – with the destruction of conservation structures such as terraces. In the Mediterranean basin, the drier the climate the slower the recovery of degraded ecosystems. Disrupted ecosystems are characterised by a net loss of resources (water, ground, nutrients), so restoration is conceived to increase harvesting of these resources and in situ conservation (Ludwig & Tongway, 1995).

In these places, drought – together with land degradation through human activities – will produce a loss of vegetation layer, capacity to percolate water in the ground and, consequently, soil’s dampness thus increasing erosion risk. All of this will cause greater water scarcity that, in turn, feeds back into the processes of land degradation.

CEAM

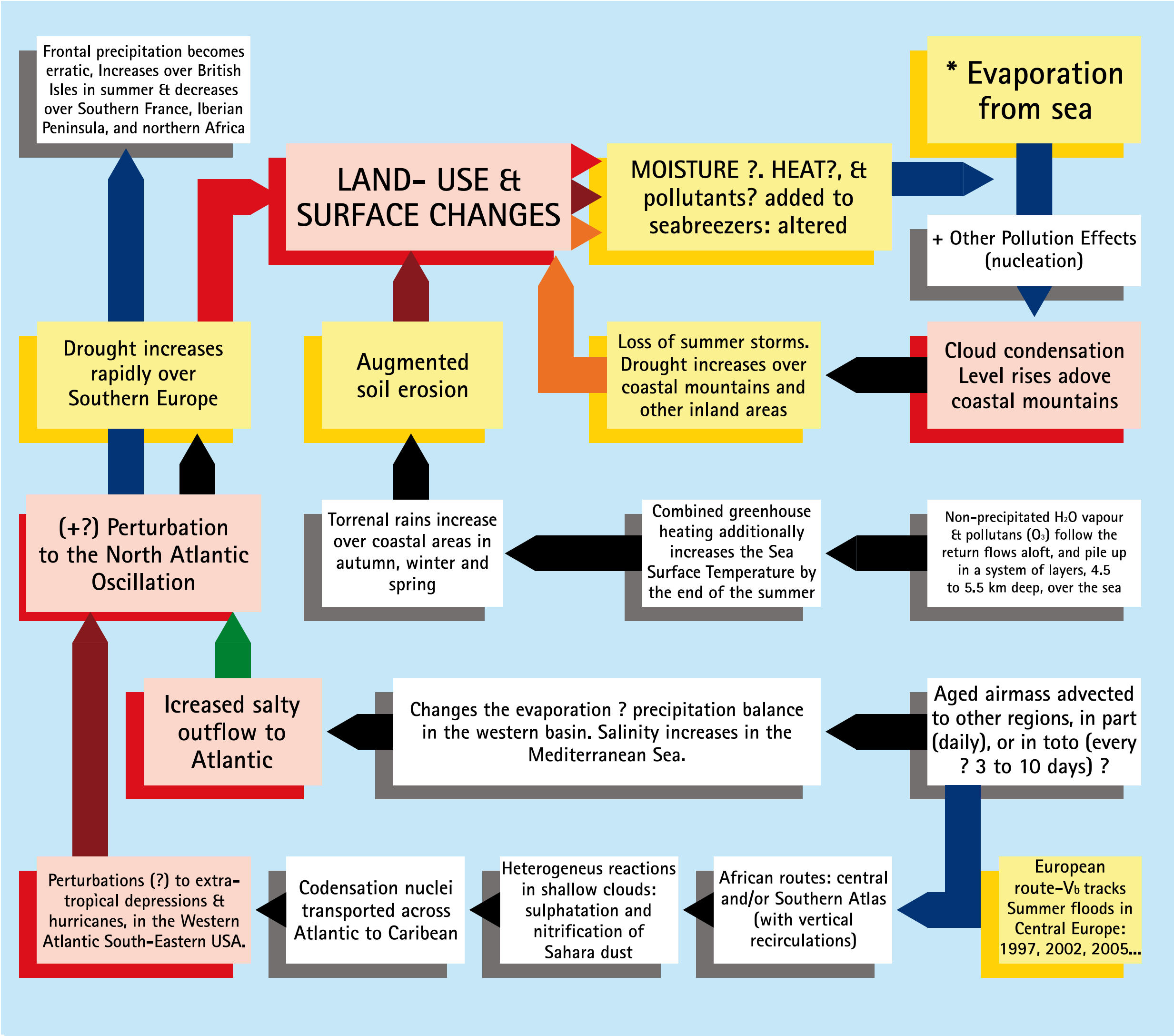


Figure 8. *Feedback loops between the disruption in ground use in the Western Mediterranean basin and the climate system at local, regional and global levels (Ulbrich et al., 2003; Hamelin 1989; Savoie et al., 1992; 2002; Prospero and Lamb 2003, Kemp-Shellnhuber 2005; Gangoiti et al., 2006). The first loop – local – involves sea breezes and storms that occur during the afternoons along the coastal mountains. It has a diurnal cycle and a scale on the order of 100-300 km for the input flow in surface and the return flow in height, and it can be repeated consecutively over 3 to 10 days in the Western Mediterranean basin. The regional loop has an influence over the evolution of sea surface temperature during summer. This warm sea – or warmer through the effects of pollution or the high greenhouse effect of water vapour – feeds torrential autumn rainfalls and, more recently, those in winter and spring. Lastly, the Atlantic-global loop has two components that could affect the North Atlantic Oscillation (NAO): excessively salty waters going into the Atlantic, and the possible alterations in the extra-tropical depressions and the hurricanes in the Gulf of Mexico – caused by changes in the characteristics of the Saharan dust carried over the Atlantic. The blue arrows show the water vapour route and the black ones show the processes presented caused at each stage of the route. The final results are signalled in other colours and critical thresholds are in red boxes. From M. Millán.*

In order to break these degradation cycles that worsen water availability situation, forest restoration projects must improve the water balance in degraded ecosystems (Fig. 9). In semi-arid land, the direct input of rainwater into shallow surface areas – often with reduced infiltration possibilities – does not allow for colonisation by plants – whether naturally or artificially. An improvement in water percolation for water retention capacity in the ground, and runoff harvesting are the main strategies to restore these degraded semi-arid lands – mostly at risk from desertification. Abandoned terrace crop farms can generally be found in the deepest slope areas, so they are preferential places to begin restoration. Furthermore, these terraces are suffering from a slow degradation process following this abandonment, so their restoration is a priority to avoid lineal erosion and rills.

Restorating of degraded land in semi-arid conditions should be based on the introduction of vegetation in accordance with natural patterns – the objective being to recover pre-existing working natural processes on a countryside scale.

Rstoring degraded land in semi-arid conditions should be based on the introduction of vegetation in accordance with natural patterns – the aim being to recover pre-existing working natural processes on a countryside scale. Such restoration efforts can be improved by including knowledge about the spatial heterogeneity of the edaphic resources and the vegetation. When the vegetation layer is very low – below 30% – the spatial patterns of ground surface properties– such as flattening, physical layers and rock fragments – are crucial for establishing saplings due to their predominant role in water redistribution across ground surface and filtration dynamics (Maestre *et al.*, 2003). When vegetation is not so degraded, the "islets of resources" that typically form beneath the vegetation layer can be used to increase the success of the restoration project. These fertile areas are spots of high biological activity where provision often dominates over the rivalry among plant species and, as recent studies have shown (Maestre *et al.*, 2001), can improve the establishment of saplings, like in other degraded areas in climates that are wetter or colder.

Forest fires are one of the most significant disruptions perhaps needing restoration projects for the burnt hills in the Annex IV countries (Northern Mediterranean) in the Convention for the Fight against Desertification (CLD).

10. FORESTATION WITH VARIOUS OBJECTIVES

Forest restoration has been taking place for over a hundred years to combat land degradation. In the first plans, the objective of forestation was to preserve the water basins, reduce the risk of flooding, fix dunes and provide employment in the rural environment – as well as wood and other benefits. Millions of hectares were forested according to these ideas in Europe, starting at the end of the XIX century. Therefore, forestation was a common practice for degraded land rehabilitation in dry climamtes far before the term "desertification" was coined (in the 1970s). More recently, the objectives of the forestation programmes have been expanded to explicitly combat other global threats and objectives, such as the fight against desertification and climate change, and to improve biodiversity.

Various elements have changed substantially since the first restoration work. The concept of forest restoration – generally reduced to forestation/reforestation – had an essentially dual objective: preserve the edaphic and water resources, and increase the forested layer. For these objectives, restoration was undertaken through mono-specific plantations, using (generally) pines [and other conifers] due to their frugal nature, rapid recovery of the arboreal layer and easy management, as well as the likelihood of some economic benefit for the local population. Exotic species were used on occasion, less on the Mediterranean side

Table 3. *.Concepts related to water scarcity (taken from Santos Pereira, 2004).*

Xero pattern	Produced naturally	Induced by human activity
Permanent	Aridity	Desertification
Temporary	Drought	Water stress

than the Atlantic in the Iberian Peninsula. Since the 1970s, socio-economic changes in Southern Europe have substantially altered social demands on forests and woodland in general. While abstraction was still important in the better quality land, other objectives were appearing: 1) the fight against desertification, which would include preventive actions to protect the forest water in the basins, through broadening perspectives to the scale of the ecosystem and landscape – fire prevention and post-fire restoration appeared as priority areas in the last quarter of the XX century; 2) recreational and cultural use of the woodland has gone beyond production interests in many areas – since the 1960s; 3) the improvement in biodiversity introduced a new reference point for restoration projects, especially from the 1980s; 4) climate change mitigation has been an important objective since the 1990s and it can be faced by increasing the forest areas to fix atmospheric carbon. Lastly, the change in weighting of the direct production objectives compared to other objectives of conservation and forest restoration – producing goods and services with no actual market

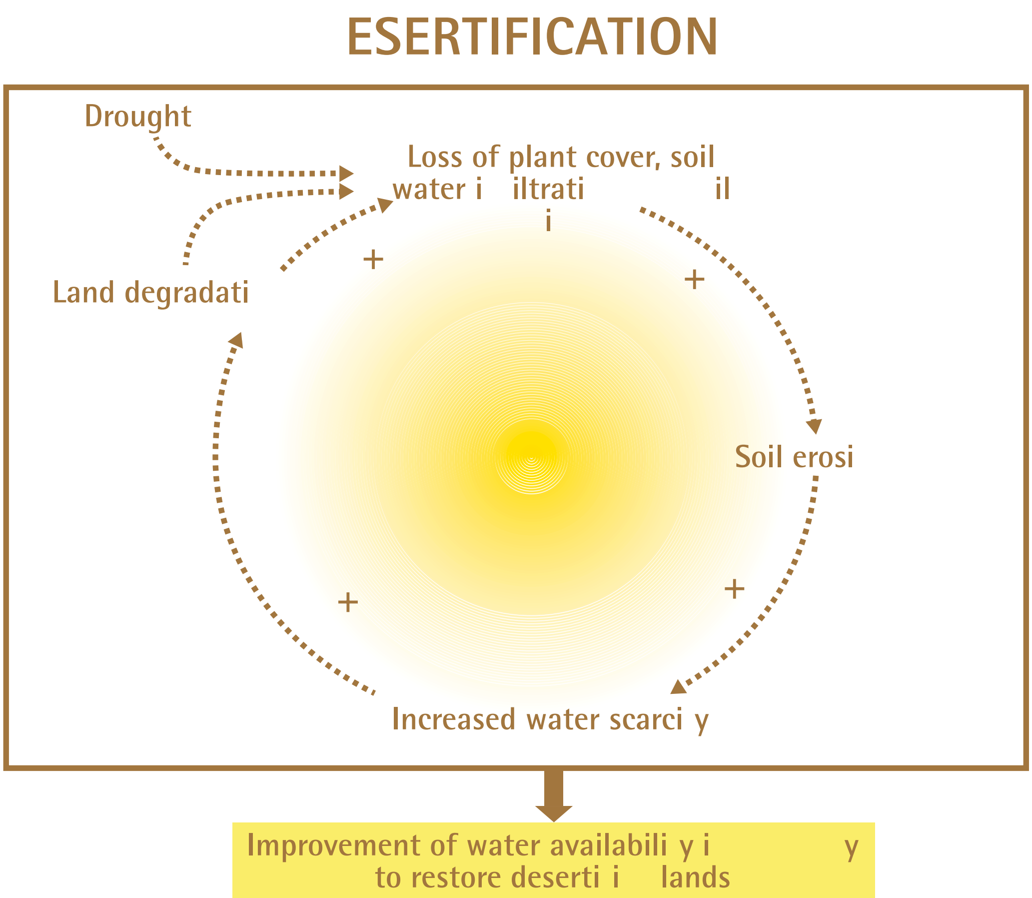


Figure 9. *Feedback cycle for desertification that leads to growing water scarcity for the ecosystems.*

value (externalities) – provided a new economic reference framework. It seems clear that the forest restoration strategies and techniques need to be adapted to this new social framework. Ecological restoration is an emerging field of knowledge that aims to promote the recovery of a degraded, damaged or destroyed ecosystem.

As an example of the change in strategies, traditional forestation based on planting a single tree type – within a small range of species – is evolving into forestation using various species – based on a broad range of species to adjust to the potentially great diversity of habitats, state of woodland degradation and diversity of specific management objectives. Native species offer a high potential for the restoration of degraded ecosystems. Herbaceous, shrub-like and arboreal species should be used according to the specific state of degradation of the ecosystem and the management and planning objectives examined.

Native species offer a high potential for the restoration of degraded ecosystems as a response to the potentially great diversity of habitats, state of woodland degradation and diversity of specific management objectives.

As a consequence of the changing situation, recent forest restoration projects have been conceived as a response to a broad range of objectives – both new and traditional – and their technical development can, likewise, be very diverse – even contradictory from one country or region to another. It seems clear that the effectiveness of the restoration initiatives can be improved through evaluation and spreading of technologies that have shown their technical, environmental and economic feasibility and socially acceptable.

Forest restoration techniques usually include repopulation. The greatest difficulty in restoring degraded ecosystems in dry climes is water stress. Therefore, forestation techniques need to improve water use through the plants introduced, as well as the harvesting and conserving of water in the restored ecosystem (Vallejo *et al.*, 1999). This objective affects all the steps throughout the forest restoration process (plantation in this example): production of quality saplings in a nursery, preparation and amending the ground, use of protective pipes, treatment of existing vegetation in the woodland, and post-plantation forestry.

Forestation techniques need to improve water use through introduced plants, as well as harvesting and conserving water in the restored ecosystem.

The death of saplings usually occurs in the first summer in the field when their roots have not grown sufficiently down into the ground – thus suffering serious water stress. The growth of the root outside the root ball and quick and deep rooting are vital factors in the survival of the sapling. The main cause of their demise is drought, aggravated by low water grand retention capacity which tends to be shallow and stony. Considering these limitations, diverse techniques have been developed to overcome post-plantation water stress (Vallejo *et al.*, 2000, 2006).

OPTIONS TO OPTIMISE WATER USE IN DRY REGION PLANTATIONS

Selection of species and genotypes

Selecting species for restoration projects should take into account ecological compatibility with the habitat to be restored and its contribution to the specific restoration objectives (Table 4). Recent restoration programmes have promoted using local species and genotypes, aimed to recovering the native ecosystems (SERI, 2004). Another reason for prioritising the use of native species is their adaptation to local conditions. However, this supposition is not necessarily true if climate change is considered (Bakkenes *et al.*, 2002). Dry regions have experienced unusually high temperatures and droughts in the last few decades (De Luis *et al.*, 2000). In some zones, these conditions have been too extreme for some species – resulting in massive mortality (Peñuelas *et al.*, 2001). Extreme climate events do not affect all the species everywhere homogeneously. Species that are closer to their climatic limit should be more at risk. Varieties of sclerophile bush from Tertiary laurisilva forests (humid subtropical laurel forests) that have adapted to dry climes can be especially sensitive to the changes in precipitation volume and its distribution (Valladares *et al.*, 2004). Therefore, it is necessary to explore if existing flora can actually adapt successfully to the future climate scenarios and, in particular, determine whether the vital workings of the ecosystems will be sustained.

Exotic species can also play a role in ecological restoration to the extent that they fulfil some requirements – especially a low risk of naturalisation (Ewel and Putz, 2004). They have been used extensively in dry zones when the priority was producing of forage, firewood and other forestry products (Dumancik and Le Houérou, 1980; Forti *et al.*, 2006).

Genotypes can also differ in their capacity to tolerate drought. For example, studies about the cork oak (*Quercus suber*) undertaken in Alicante University (T. Bitinas, unpublished data) showed that water use efficiency (WUE, the capacity for fixing C per unit of water transpired) in well-irrigated saplings varied between 1.1 and 8,5 μmol CO_2 (mmol H_2O)$^{-1}$. If these differences continued, the highly efficient saplings in this family would transpire an average of 7.7 times less water to produce the same quantity of organic material than less efficient saplings. These saplings respond in diverse ways to drought – some families increase their WUE while others decrease it.

Genotype variation offers adaptation possibilities in plant selection for restoration from the perspective of climate change.

Provision practices

Establishing the plants and their long-term development – and, therefore, their capacity to tolerate drought in dry zones – depends greatly on the quality of the saplings (Cortina *et al.*, 2006). Thus, recently, new regulations have been adopted by the public administrations regarding the quality of woody species saplings (CE Directive 2006/21/CE, Spanish Government RD 289/2003, Valencia Generalitat Order 19/02/1997). These regulations ensure minimum quality levels for plants. However, within the range defined by the legislation and common practices, it is unclear which morpho-functional features are linked to a better result in the plantations. A recent review of Mediterranean species showed that it is difficult to generalise about the relationship between sapling quality and size, distribution of biomass to the roots or nutrient contents (Navarro *et al.*, 2006). These results are not surprising as the quality of the sapling is rather dependent on the species strategy and the seasonal conditions. However, there is a certain consensus in the need to produce plants with high carbon, nutrient and water reserves content and a completely operational photosynthetic mechanism that allows for rapid colonisation of the ground following planting.

Recent advances in provision practices have incorporated protocols to reduce water consumption that include efficient irrigation systems, water recycling, late sowing and the use of pre-germinated seeds to reduce cultivation time in nursery, and a reduction in the quantity and frequency of irrigation to pre-condition saplings to drought. When it is successful (depending greatly on the plasticity of the species), pre-conditioning has the advantage of producing high quality saplings at the same time as saving large quantities of water.

Nursery cultivation must be adapted to specific characteristics over the course of the sapling's growth process. For example, Quercus sp. quickly develops a pivotal root – not branched out – with a higher radial than aerial biomass, by contrast with pines. The CEAM group has tested deep containers to facilitate the development of the pivotal root in the rooting stage; the objective is to facilitate the pivotal root reaching deep into the ground quickly where it will be able to find a minimum of dampness, even in summer (Chirino., 2008).

Ground creation that roots can colonise

In the field, effort is directed towards creating an appropriate medium for radial colonisation and harvesting resources. The challenge consists of preparing the land to facilitate saplings rooting without having a negative impact on the countryside.

Applying organic amendments can also help establishing plants to the extent that the ground that degrades is frequently poor in organic matter, nutrients and water retention capacity (Valdecantos *et al.*, 2006). The sludge from purifiers and solid urban residue have been successfully used to improve sapling growth (Valdecantos *et al.*, 2004; González-Barberá *et al.*, 2005), and there are already technical prescriptions for its efficient and environmentally safe use (Bailly *et al.*, 2004; Valdecantos *et al.*, 2004). Recent studies on the adult kermes pine (*Pinus halepensis)* have shown that the organic amendments can improve water use efficiency as a result of an improvement in its nutritional state (Querejeta *et al.*, 2008). Organic amendments could have negative effects on plants due to an increase in salinity, ground cracking and an increase in the rivalry with the pre-existing vegetation. These factors explain why many studies have had negative results – or zero effect – on the survival of saplings after sludge application. However, in general, these applications increase growth: in dry Mediterranean ombroclimate conditions, the addition of composted bio-solids favoured the growth of the sapling – with moderate doses, on the order of 20-30 Mg (dry weight) ha-1 year-1 (Fuentes *et al.*, 2007).

Improving micro-habitat conditions

Sapling development can be unbalanced by an excess of radiation and temperature. Many types of protective tubes are available on the market to avoid these effects (Bellot *et al.*, 2002; Oliet *et al.*, 2003). Ventilation is necessary to avoid excessive temperatures and to maintain high atmospheric CO_2 concentration (Jiménez *et al.*, 2005). The tubes could simulate frosts as minimum winter temperatures are somewhat lower inside the tube (Oliet *et al.*, 2003). The shade provided by the tube reduces photo-inhibition; it also produces a decrease in sapling transpiration and, therefore, also in water needs and it stimulates growth in height (Figs. 10 and 12).

The branches piled on the ground could be an economic alternative to provide shade and generate a micro-habitat for the favourable establishment of the sapling (Ludwig and Tongway, 1996). Although it is not as efficient in avoiding excess radiation as the tubes, it has some advantages. It generates an environment of heterogeneous radiation similar to natural conditions and it could allow a gradual acclimatisation to full sun exposure. As the branches are in direct contact with the ground, they can retain particles, seeds, water and dissolved nutrients transported by runoff water and the wind. Lastly, the branches contribute to the improvement of soil fertility when they decompose.

Efficient low-cost irrigation methods for extreme conditions

In desert regions, water availability is limited and its transportation is expensive. Water requirements for a small plant is only 1-2 l per month.

Table 4. *Morpho-functional characteristics of the plants that contribute to specific restoration objectives. Points 1 to 4 are directly related to production and quality of water. Modified from Cortina et al., 2006.*

RESTORATION OBJECTIVE	PLANT CHARACTERISTICS
1. Water control	High coverage, efficiency in water use, high infiltration , percolation, seepage
2. Ground protection	High degree of growth, horizontal growth, precocious and high reproductive capacity, vegetative reproduction
3. Genetic diversity, phenotypical plasticity, avoid endogamic depression	Genotype diversity, origins
4. Resistance to current and future stress	Phenotypical plasticity, morpho-functional characteristics associated with resistance and resilience against drought, frost, pollution
5. Resistance and resilience of ecosystem against disturbances	Capacity for re-sprouting, high relative water content, serotinia, persistent seed bank, defences against plagues and illnesses
6. Sustain herbivore populations	High palatability, tolerance of animal consumption
8. Sustain populations of frugivores and grain-eating animals	Extended production of high quantities of seeds and fruit
9. Improve soil fertility	High productivity, fixing nitrogen, fibrous root systems, deep-root systems
10. Ecosystem engineering, niche construction	Characteristics associated with changes in water flow, radiation and nutrients, structural complexity
11. Production of forest goods	High growth level, straight trunks, quality wood, resin production, turpentine, honey species and varieties, truffle species and other associated edible fungi
12. Aesthetics	High/low level of growth, shape, chromatic changes, flower and fruit production

There are traditional irrigation methods in many parts of the world that are oriented towards using the minimum quantities of water necessary for the survival and growth of the plants emplaced. These alternative and not well-known irrigation systems improve plant growth even in desert conditions (Bainbridge, 2007). Supplementary irrigation should be applied as much time as possible – along the lines of once every two weeks for the first three months and, then, once a month for two summers. The cost of these systems is modest compared to the total cost of a plantation in a remote location. Below, the traditional and new methods that have shown the greatest effectiveness are presented.

In conditions of extreme aridity, temporary irrigation could be vital to guarantee the rooting of saplings and their initial growth. There are various efficient techniques – of low cost and low water consumption – that have been shown to be effective in diverse arid zones around the world.

Deep pipe irrigation

This system uses an open vertical pipe to concentrate the irrigation water in the area of the deepest roots (Bainbridge and Virginia, 1990). Experiments undertaken in Africa have shown that this method is far more efficient than irrigation by surface dripper (Sawaf, 1980). Deep pipe irrigation develops much larger volumes of roots than other form of irrigation and helps the development of a plant that is better acclimatised to survival once irrigation is halted following rooting. The system can use simple materials and unqualified labour, without using high-pressure water. Deep pipes improve water use efficiency due to low evaporation and no loss of water as runoff down the slopes, and it also improves weed control.

Buried clay containers

Unvitrified sealed clay containers filled with water are used to produce a stable water supply to plants that grow nearby (Bainbridge, 2001). Water is exuded through the walls of the container at a speed that, in part, is determined by the speed of absorption of the roots. This process makes for very efficient irrigation.

The controlled water supply in the container provides the saplings with stable irrigation even in times of very high temperatures, with low humidity and drying winds. The system works especially well in sandy and stony ground as these drain rapidly. It is also a good method for direct seeding. Researchers in Pakistan used buried containers to establish acacias and eucalyptus in a region with 200 mm of annual precipitation (Shiek'h and Shah, 1983). The trees irrigated using the containers grew 20% more than those that received the same quantity of water manually and survival increased from 62% to 96.5%. It is also interesting to irrigate via buried clay containers in ground affected by salinity or where there is just salt water available for irrigation (Mondal, 1984).

Irrigation by wick

The systems with a wick were first used in India in combination with buried clay containers (Mari Gowda, 1974). One or more holes were made in the buried container and a porous cotton wick was inserted into each hole. Thus, the wick slowly moved water to the soil in a way that stimulated root development. The wicks can be fed by capillary action or by gravity. The capillary action systems use a wick in a pipe that emerges above water level: water movement is slow but consistent. In the gravity system, the wick is placed below the level of the water which then flows through the wick.

Porous capsules

The porous capsule is a modern adaptation of the buried clay containers (Silva *et al.,* 1985). They are made with lightly cooked clay and can be connected to an intubated network more easily than the containers (Fig. 11). They are effective but more expensive to make and install than the containers and the deep pipes. Two tubes must be connected to each capsule to allow air to exit when water enters.

Porous hose

This method uses a porous hose placed vertically to moisten a column of soil. It can be installed before the plantation using a drilling system to almost any depth desired (depending on the ground and how stony it is). It can also be installed after the plantation. It is connected to a water bottle or a tank and a distribution system.

Figure 10. *Holm oak sapling within protective tube, Ayora (Valencia, Spain). Photography CEAM.*

Harvesting runoff water

Soil preparation through harvesting runoff techniques increases water contribution for planted saplings. The technique consists of channelling surface runoff down a funnel – using two grooves – towards the hole or gangway where the sapling is being placed (Fig. 12). This creates a micro-basin for water harvesting. The construction of the gangway and distribution of micro-basins around the hillside must be calculated so that quantities being funnelled can be absorbed mostly by the gangways, that in any case must be designed with a lateral wastepipe that impedes the breaking of the front ridge and produces an irrigation channel along the greatest slope (De Simón *et al.*, 2004). Thus the plant receives a natural irrigation supplement during the time when the grooves are operational and the water filtration capacity in the plantation hole is high – between 1-2 or more years.

Interactions with other organisms

The use of interactions between species is currently one of the most widely developed areas in dry land restoration. Various positive ecological interactions have been observed (Azcón and Barea, 1997; Callaway, 2003; Maestre *et al.*, 2001; Gómez-Aparicio *et al.*, 2004) which open up ways of progress in benefiting from existing communities in the place to be restored. It is worth noting that provision interactions were already present in traditional knowledge. For example, at the beginning of the XX century, they used rows of cereal, grasses and branches to provide shade for the saplings emplaced in Eastern Spain (Mira-Botella, 1929).

The use of mycorrhiza fungi – with the selection of species and stumps – has also been developed to improve the quality of the saplings, including their capacity to tolerate drought (Querejeta *et al.*, 2007), and could be of interest in soils where the fungal propagation is absent.

Animals could also play a key role in the dynamics of the community and the workings of the ecosystem. Some studies suggest the use of artificial perches to stimulate the visits of seed-distributing birds (Zanini and Ganade, 2005), the introduction of edaphic fauna and organic amendments to improve ground properties (Roose *et al.*, 1999).

The use of interactions between species is currently one of the most widely developed areas in dry land restoration. Various positive ecological interactions have been observed (Azcón and Barea, 1997; Callaway, 2003; Maestre *et al.*, 2001; Gómez-Aparicio *et al.*, 2004) which open up ways of progress in benefiting from existing communities in the place to be restored. It is worth noting that provision interactions were already present in traditional knowledge. For example, at the beginning of the XX century, rows of cereal, grasses and branches were used to provide shade for saplings emplaced in Eastern Spain (Mira-Botella, 1929).

The use of mycorrhiza fungi – with the selection of species and stumps – has also been developed to improve the quality of the saplings, including their capacity to tolerate drought (Querejeta *et al.*, 2007), and could be of interest in soils where the fungal propagation is absent.

Animals could also play a key role in the dynamics of the community and the workings of the ecosystem. Some studies suggest the use of artificial perches to stimulate the visits of seed-distributing birds (Zanini and Ganade, 2005), the introduction of edaphic fauna and organic amendments to improve ground properties (Roose et al., 1999).

Priorities in fighting desertification

Restoration efforts should prioritise the most sensitive areas in terms of risk of desertification. Once these sensitive areas have been identified, the next step is to define the threshold degradation conditions that allow for successful restoration, both in technical terms and in economic and social ones. It is very risky to undertake costly and extensive forestation programmes in very degraded woodland – with no sound predictions of the possibility of success. A third step would be to design specific mitigation and restoration techniques for these extremely sensitive areas, including both active and passive media, related to the driving forces behind the degradation (active desertification) or to the prior disturbances that still push desertification on. The starting point for these activities should be an analysis of restoration undertaken in the past in the most sensitive and degraded areas. Thus, monitoring and creation of data bases should form an essential part of all restoration projects.

LAND PLANNING TO OPTIMISE WATER RESOURCES

11. PLANNING SOIL USE TO MANAGE WATER OR PLANNING WATER TO MANAGE THE LAND?

The water cycle is affected by the majority of land-based activities in one way or another, although these activities might not have objectives specifically related to water. Water is a vital resource for human society and for ecosystems both in terms of quantity and of quality and, in some cases, it is the most limiting factor for development. Therefore, the water cycle is a key subject that must be considered in all land management activities and, particularly, when planning.

The first great civilisations developed in arid lands – such as the Sumerians in Mesopotamia – and were based on innovative water resource management. Centuries later, the degradation of the land caused in the long term by irrigation led to the destruction of this extraordinary civilisation. Therefore, interactions between water and land can result in unforeseen dynamics that could cause catastrophic effects on human society. Over the course of history, human development in arid land has been limited by water scarcity. Excessive development without a prediction of water availability has led to the desertification of arid regions,

Figure 11. *Porous capsule made from clay pots with a 20 litre tank. Photograph by D.A. Bainbridge*

lowering the productivity of the land and a reduction in water regulation capacity. In the worst situations, desertification creates a non-reversible loss of land productivity. Therefore, water management affects land productivity and processes at landscape scale, and ground uses affect the water cycle. The challenge laid down is for the reasonable planning of ground uses and water management to satisfy water demand and to conserve the natural resources.

The development challenge is one of reasonable planning of ground uses and water management to satisfy water demand and conserve natural resources.

12. PERSPECTIVES IN GROUND USE CHANGES AND THE CONSEQUENCES FOR WATER BALANCE: THE SPANISH CASE

The development of various land occupation scenarios is vital for an analysis of the foreseeable effects on the water cycle. Particular categories of land occupation require irreplaceable capital. The case of urbanisation is particularly non-reversible while it is high in deforestation or loss of wetlands (Pearce, 1993).

The basic interactions between the different coverage of ground use and the water cycle can be summarised thus:

▸Natural vegetation, particularly forest layers, is a protector of the ground and affects the filtration of rainwater; radial development establishes particle structure and pores in the ground, which directly influences the level of filtration and the water retention level – in addition to increasing evapotranspiration and lowering runoff.

Figure 12. *Harvesting runoff water in forest repopulation. The sapling is protected by a tube. Demonstration project in Albatera (Alicante, Spain). DGB (Ministry of the Environment and Marine and Rural Affairs) – Valencia Generalitat – CEAM.*

▶ Agricultural areas have different levels of filtration, runoff and evapotranspiration. Irrigated crops are those that present greatest negative effects on the water cycle – the high water demand affects water quality – because of the use of fertilizers and phytosanitary products and the quantity of water available – as this is the source of the greatest demand (80% of the demand in Spain).

▶ Areas without vegetation covering and an excessive slope facilitate erosion processes, with an increase in runoff and a fall in filtration.

▶ Urbanisation modifies the water cycle by increasing runoff and occupying many areas of agricultural interest and fragmenting the countryside (Henríquez and Azocar, 2000). On the other hand, it generates demands that involve – once conceded – strong guarantees of use.

In the analysis of land occupation changes (Table 5), information available from the CORINE Land Cover (CLC) project about the current state of and the changes in ground use in Spain has been used. Statistics available in the INE (National Statistics Institute) have been used to obtain information about water use and its relationship to consumption associated with different coverage of the area of interest. Different simulations were also undertaken by the Economic Analysis group at the Ministry of the Environment – published in different reports (2007a, 2007b) – and by a group at Cordoba University regarding estimations of water consumption in agrarian areas (Berbel, 2007). It can be seen that there have been very fast changes in the land, with notable social, economic and environmental implications. The most profound changes – and possibly transcendental – are those linked to two processes: the creation of artificial surfaces and irrigation areas. The spatial location of these changes should be pondered as they directly influence economic, social and environmental restrictions or limitations, guarantees of usage or the probability of ensuring it by the management system.

Spain, together with Ireland and Portugal, is one of the countries with the highest growth in artificial surfaces (a rhythm of 1.9% annually) – far above the average for the 23 countries in the CLC2000 programme (Corine Land Cover 2000 project related to the comparison in ground occupation between 1990 and 2000) of 0.68% (AEMA, 2005). The main causes are the type of economic growth (depending on sectors with high ground consumption such as construction, transport and tourism), consolidation and expansion of the new model of disperse urbanisation and the major investment in transport infrastructure during the 1987-2000 period. The significant rhythm in making the ground artificial in the interior and along the coast of Spain has a markedly non-reversible nature that will cause negative environmental effects on environmental resources such as water, atmosphere and ecosystems.

In Spain, the area of permanently irrigated land has increased (10.3%) as a result of the link between the transformation of forested areas with natural vegetation and open areas into agricultural sectors, on one hand, and the loss of agricultural areas that have become artificial surfaces, on the other.

Water use has grown almost exponentially with population growth and industrial development (Vörösmartry and Sahagian, 2000). In Spain, an increase in the population in the coming decades is foreseen which will cause an increase in water consumption.

Rivalry between artificial surfaces, irrigated surfaces and natural wet zones

In addition to water consumption for artificial surfaces and irrigated surfaces, a rivalry related to water is occurring between different types of ground use. So, different processes are happening to replace irrigated areas with artificial areas. The process often begins with irrigation replacing non-irrigation and later becoming an artificial area. This process happened in a total of 36,000 hectares in Spain between 1987 and 2000.

Another process related to water that has happened from changes in ground occupation is the loss of natural wet areas and water laminates due to the increase in artificiality and the rise in agricultural areas. According to the Corine Land Cover 1987-2000 data, these processes have produced a total of 2,537 ha, of which 31% correspond to the increase in artificial areas and the rest (69%) to an increase in agrarian areas.

Scenario design and evaluation: predictions for 2030

Estimates have been made regarding possible future evolution of artificial and irrigated areas in Spain and their effect on the rest of the ground coverings and their possible implication in water management. These scenarios were based on the scenarios created by the World Water Council which intended to predict the situation in 2025 (Cosgrove and Rijsberman, 2001), and urbanisation is considered to be one of the main factors causing the patterns of disruption (Wear *et al.*, 1998).

Three scenarios were developed for 2030: (1) "Trend", which maintains the trend towards change in occupation observed between 1987 and 2000 with the increase in artificial surfaces and in irrigated crops; (2) "Mad Max", which accelerates these trends, associated with overexploitation of water; and (3) "Technogarden", which predicts a stabilising of these surfaces connected to technology developments – with the help of knowledge and maintenance of the ecological processes.

Performing these scenarios achieved very different levels of change in 2030 (Fig. 13). From the analysis of the trends observed in the change in ground use and the effects on the water cycle, it was possible to establish that should Mad Max or Trend be achieved, the wetlands would be affected by size reduction – necessary for the conservation of their biodiversity and basic ecological processes. Equally, traditional and cultural landscapes of high importance in the Mediterranean area would also be affected – such as forest ecosystems with sclerophile vegetation. This is very important from the point of view of conserving natural and semi-natural habitats.

Despite the probable improvements in savings, water use efficiency and unconventional methods (desalination and reuse), it is unlikely that these can increase water availability to satisfy the water demands of the Trend or Mad Max scenarios due to the physical limits of resource availability and climate change effects. In this case, the quantity of water wanted for domestic, industrial and agricultural ends would probably be unsustainable – causing additional adverse effects on ecosystems and the water cycle.

With the effects of climate change and the demographic predictions from the INE, it is likely that there will be effects that are damaging to the water cycle through the increase in the level of evapotranspiration and the appearance of serious territorial imbalance (MMA, 1998). These would create a series of uncertainties and conflicts over the majority of the economic sectors and over the stability of the ecosystems, with the consequent non-reversible effects on biodiversity. Depending on the forest management undertaken in the coming years, forest ecosystems could be affected more or less by climate change, but it is possible that the changes in primary net production and the distribution of forest bodies could have serious consequences on the regulation of the water cycle.

The improvement in and appearance of new technology by 2030 related to the water cycle and the increased social awareness regarding this resource have not been explicitly considered, but it is likely they will occur. In the case of the current trends continuing (Trend) or accelerating (Mad Max), the following effects on the extent of development will be noticed:

▶ Economic: conflicts over water use between different economic sectors, particularly between irrigation and urban use.

Table 5. *Processes observed in land occupation change from 1987-2000 in the types of land use of CLC level1 (Corine Land Cover) except class 5 and its effect on the water cycle. Source: self-created from Changes in Land Occupation in Spain data (OSE, 2006).*

	OBSERVED TRENDS	EFFECTS ON WATER CYCLE
Artificial surface ▶ **2.1% of the total surface** ▶ **Clear increase with great dynamism on the coast**	Increase of 29.5% in artificial surfaces with high development in working land and permanent cropping, areas covered by pastureland (20,879 ha), esclerophile vegetation (18,577 ha) and woods (14,854 ha). The speedy rhythm of making the ground artificial in the heart and along the coast of peninsular Spain has a markedly non-reversible character that causes negative environmental effects on environmental resources such as water, atmosphere and ecosystems. The coastal wetlands have also been negatively affected.	Areas of demand with high guaranteed use (MMA, 2006) Increase in runoff and fall in refilling aquifers. Effects on water quality (MMA, 2005) Rapid population growth together with growing problem between different users and different regional or local administrations over water use and sharing (Vlachos and Evan, 2003) Seasonality in uses for tourism Lack of purification of sewage in tertiary treatment.

	OBSERVED TRENDS	EFFECTS ON WATER CYCLE
Agrarian land ▶ **49.9% of the total land** ▶ **Important internal transformation**	Slight fall in agricultural areas with intensification in crop types: increase in irrigation, fall in unirrigated crops, abandonment of peripheral agricultural areas and loss of heterogeneous agricultural areas. The majority of the loss of agricultural land happens in the change to artificial surfaces and, to a lesser extent, in forest removal and open spaces, and woods.	Policy of irrigation expansion to find greater productivity and diversification (MMA, 2006). Increase in water consumption. Drop in water quality due to use of fertilizers and pesticides. Increase in evapotranspiration due to rise in vegetation biomass following rural abandonment
Forest and other surfaces ▶ **47.1% of total surface** ▶ **Important internal transformation**	Slight reduction due to increase in artificial surfaces and agricultural areas, despite colonisation in agricultural areas in peripheral regions. Important surfaces burnt. Shrink in glaciers and areas of perma-snow which could be related to the process of global climate change or to different short climate cycles. Important exchanges within class.	Effects on filtration, percolation, increase in runoff. Effects on evapotranspiration. Fall in water resources
Wet Zones ▶ **0.2% of total surface** ▶ **Slight fall**	The wetlands and marshy areas have been partly replaced by agricultural areas (40%, mostly irrigated), salt marshes (25%) and reservoirs (18%). 80% of the coastal and estuary lagoons that have disappeared have been replaced by industrial, commercial and transport areas and 45% of the marshes that have been replaced by other uses have become salt marshes, 26% agricultural areas and 25% artificial surfaces.	EEffects of drop in volumes Drop in availability of underground water due to overexploitation of aquifers (Vlachos and Evan, 2003)
Water laminates ▶ **0.7%** ▶ **Increase**	Increase in artificial surfaces for construction of reservoirs (20%) from forested areas with natural vegetation (almost 60%).	Increase in evaporation. Increase in storage capacity (MMA, 1998)

▶ Social: conflicts over water use between different places and different social groups.

▶ Environmental: lack of guarantee of resource, greater pressure on water resources would lead to a non-reversible decline in wet areas and ecosystems associated with water, a drop in linked species, etc.

However, in the most sustainable scenario (Technogarden), a sustainable use of water could be attained, based on stability or a slight increase in artificial surfaces, and a fall in irrigated areas – especially in those situated in arid and the least profitable places. Application of new technology, unconventional methods and demand management would free up water resources which are vital for the improvement in ecological quality of the bodies of water. The effect on the water cycle of this restriction of the demand would be positive for the ecosystems (increase in ecological volume, riverbank areas, wetlands, etc). This would allow the conservation of the great diversity of aquatic ecosystems present in Spain and an increase in the possibility of social use of the resource (urban demand and leisure use). The objectives of the Water Framework Directive largely coincide with the predictions of this scenario.

In any scenario, the urban, industrial, agricultural and stockbreeding uses will continue to be the driving forces behind the trends in the relationship between ground occupation and the water cycle. Population growth and economic evolution broken down by sectors – will be fundamental in the evolution and geographical location of the demand and the dumping.

13. FUTURE ALTERNATIVES FOR PLANNING FROM THE PERSPECTIVE OF SUSTAINABLE MANAGEMENT OF WATER RESOURCES

The key question in land planning and, particularly, in water resources is the scale at which to operate: local, regional, global, all of them, simultaneously, how? And is planning at all these scales synergetic or difficult? As Galileo said, “Many devices that work on a small scale do not work on a larger one”. There are Planet Earth, many nations, regions and water basins; and there are many individual places and people. The numbers are very different and this fact is very important: there is but one Earth, but there are millions of people who take decisions on land and water.

On a global level, general principles operate and bring laws and global treaties based on – in theory – scientific knowledge. Global studies must understand changes with the objective of stabilising them. The concept “sustainable” has this attribute. A global perspective is very important, particularly for topics relevant on this scale such as global warming, increase in sea levels, desertification and the loss of biodiversity.

At the intermediate level – regional and often one water basin or urban region – instead of working with the whole of humankind, specific cultures are contemplated with internal social differences. Processes are analysed and hypotheses are examined. Alternatives are created and evaluated on a basis of knowledge obtained from physical and ecological science, but also from human sciences. Contrary to the search for stability, there is the search for understanding and the route to change, though the destination is unknown. Here, there are politicians with legitimately conflicting visions and possible consensuses – and this is particularly the case in the matter of water.

At the most local level, individuals and small groups are involved. The managers are often dominated by private interests – especially related to scarce resources. Sometimes, innovative ideas come out to confront specific local situations that would be difficult to encounter at regional or global levels. On this scale, it is a question of recognising diversity and its advantages. The things that make a place different – its people and means of individual expression – are reflected in many local landscapes. At this level, the key point is to study interactions: where are the species going to interact – including humans – and how they interrelate, with the land and its resources. Planning at this level is not abstract but tangible.

Landscape planning at global, regional and local levels is very different. Each scale requires different training, work style, knowledge and experience – despite the diffuse limits between levels and the existence of overlapping in topics and characteristics.

There are other links between the levels. Firstly, the diversity of the local scale creates new ideas and ways of thinking. The core phrase in this EXPO – “...a thousand solutions” – is not coincidental. Local invention can influence regions and nations and reach the global level which, in turn, can (and should) turn its influence back upon the nations, regions and individuals. David Browder coined the famous phrase of “think globally, act locally”; we could also say “think locally, act globally” (C. Steinitz). In any case, it is as difficult to understand

TRENDS IN GROUND OCCUPATION ACCORDING TO VARIOUS SCENARIOS

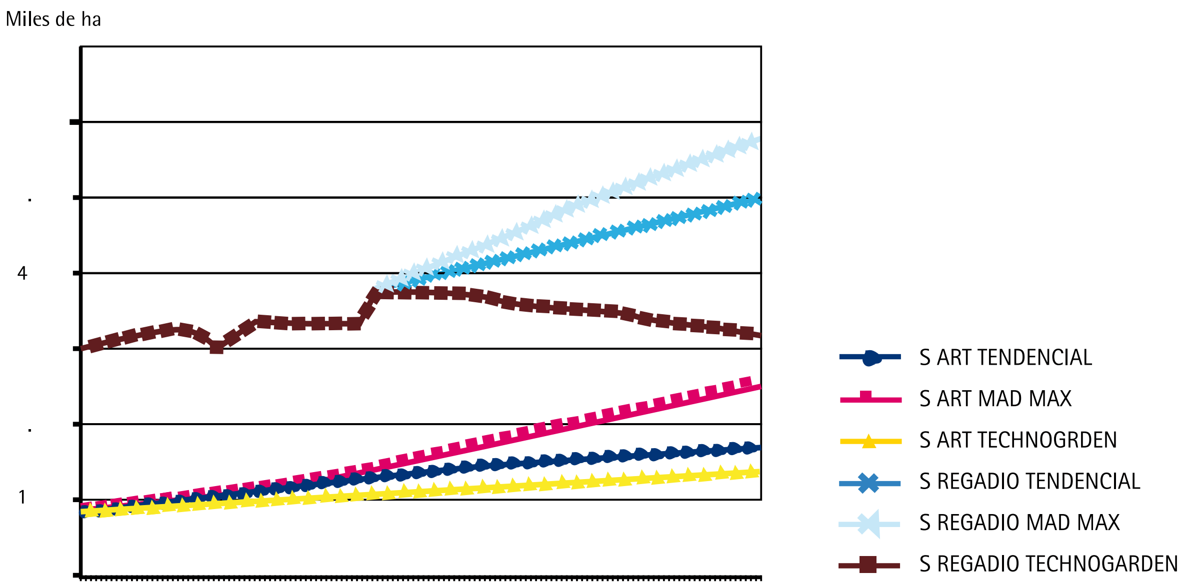


Figure 13. *Trends in ground occupation according to various scenarios. Data in thousands of ha. Created by F. Prieto.*

the world and then act locally as it is to have an idea at local level and then try to change the world.

However, there are also potential conflicts and risks in these interactions between levels. The weaker the local and regional levels, the stronger the global level will be in its more questionable aspects – to the extent that the great principles of global thought could lose diversity, adaptability, ability to self-renovate and flexibility when faced with change, perhaps leading to authoritarian policies. On the other hand, if the local approach becomes predominant then it can lead to chaotic situations with inequality between rich and poor countries and between areas with more and less water. Therefore, a world composed of many individual local situations is difficult to understand, coordinate and plan. All in all, the dilemma linked to levels oscillates between an exclusively global approach which can lead to possible authoritarian planning and the exclusively local approach which can be chaotic and unfair. The balanced concept – which allows people to act locally, nationally and globally – is the idea of risk. Risk provides useful tension in all aspects of decision-making and establishing priorities. If a phenomenon is a risk to the whole world, then it becomes global – for example, global warming. If a risk is cultural – such as conserving heritage, countryside or language – it becomes regional. Individual interests obviously function at local level.

Based on the previous reflections, actions at regional level would be especially recommendable (Steinitz *et al.*, 2003). This could be the most complicated scale because there are global and local influences at work. One specific problem with this approach is how to communicate that massive changes in the landscape that could happen over a period of 20-40 years are a result of many local decisions. How is an owner to be told that his actions could affect his region and that the actions of his neighbours could affect him in the future? Currently, there are methods and technology that allows for growing assessment, planning and representation through different levels.

Planning at regional, water basin or urban region levels allows interests and local risks to be contrasted with global principles and risks in the common interest.

An example of this approach is the research undertaken in the Upper Basin of the river San Pedro in Sonora, Mexico, and Arizona, USA (Steinitz *et al.*, 2003).

Alternative futures for changing landscapes: The case of the Upper Basin of the river San Pedro in Sonora, Mexico, and Arizona, USA

The area under study is a desert region with high diversity – particularly in birds – with a river in an accelerated degradation process and a continuous process of urbanisation and agricultural development.

To the extent that no individual vision of the future is sure, it is better to consider various alternative futures that include a range of possibilities. Therefore, this study created various alternative policy scenarios and examined all of the generated future alternatives that the region could experience. Three groups of scenarios were predicted for 2020 using the development model. The first scenario is based on the interpretation of the planning documents and practices in ground use in the region (PLANS); the second is based on lower population growth than predicted and a more controlled urban development (CONSTRAINED); and the third anticipates a higher population growth than predicted and less controlled low density urban development (OPEN).

The analysis process included an economic model of urban development, water, vegetation and fauna habitat models and a visual model to estimate the aesthetic worth of the landscape.

In the evaluation of the alternative futures, the following effects were deemed positive: slowing the diminishment in underground water storage, slowing the drying out of the river, conserving or improving natural habitats, maintaining or improving species richness, maintaining landscape beauty and improving attraction for development.

All of the alternative futures created through scenarios – even those that considered more restricted growth in population and water consumption – resulted in a global loss in underground water storage and a drop in the volume of the San Pedro River. All of the alternatives would lead to a drop in the water table of up to 10-15 m. However, the alternatives that placed more restriction on irrigation lead to an increase in the water table in one place in the region. The river San Pedro would continue to lose volume under OPEN and PLANS – and in the OPEN alternative, it would lose the greenbelt of the riverbanks. The alternatives that restrict irrigation and, particularly, also concentrate urban development could increase the volume and improve the downstream riverbank habitats in the water basin. This could improve the region's biodiversity.

The comparison between alternative futures reveals that the policy decisions about irrigation in Arizona had a greater impact on the region's water and ecology. The second most important policy refers to control of urban development. Policies stimulating population growth and relaxing urban controls have a great influence on negative environmental effects; the increase in mining and agriculture in Sonora have a lesser influence by comparison. These results indicate that the future of the Upper Basin of the river San Pedro will bring the environmental crisis closer to the direct perception of more people.

One topic of special interest is that of showing land owners the accumulated consequences of their actions. The most effective way was through animated images of the results that could focus on any property. This exercise blurred the scales intentionally: from local owners to a regional water basin and on to global diversity related to bird species under threat.

14. LAND PLANNING OPTIONS FOR THE OPTIMISATION OF WATER RESOURCES

Changes in land use in the water basins are very prevalent human actions that affect the behaviour of the quantity and quality of the water in the basins. The main factors are changes in the permeability of the surface, the removal of soil and the changes in vegetative covering. For example, urbanisation produces changes in the quantity of runoff water, a shortening of the time it takes to reach peak volume at the basin exit (Cheng & Wang, 2002) and, additionally, the recession in the hydrograph is faster (Rose & Peters, 2001). It has been common practice to effect these changes without careful planning to take into account the potentially negative effects on water resources. The advance in water models provides a tool that allows the anticipation of the potential effects of these changes.

The multiple-agent decision-making models connected with the water models provide a method by which to include the various human players in water basin changes.

Water models can be used to predict how the changes in land use will transform into changes in the area's volume and, thus, warn about erroneous planning decisions or suggest better strategies (Post *et al.*, 1996). With this end, water models need reliable information about basin coverage and the precipitation patterns that occur or could occur in the area. Geographical and tele-detection information systems help greatly in the preparation of spatial data to supply the water models. In the same way, meteorological radar systems contribute vital information about spatial distribution of precipitation (Bronstert *et al.*, 2002). Even simple models – such as those based on the "Curve number" empirical method – can give good results is they are appropriately implemented (Garen & Moore, 2005).

Meanwhile, the multi-agent model (M-AM) provides behaviour simulations for human systems, as they take in the essence of the decision processes and values or preferences that come with changes in land use. In turn, these changes cause effects on the natural system – simulated in models based on basin processes and functions, as with the water models explained previously (Acevedo *et al.*, 2007, Monticino *et al.*, 2007). Interactions between pressure groups are simulated using M-AM which acts on forest landscape models in the style of a change of use; M-AM receives the reaction to or effects of these actions in metric forms of water responses provided by the water models. Inhabitants and pressure groups can therefore see the potential effects of their decisions and reconsider them in order to attain system sustainability.

An example of M-AM application includes owners of rural land, residents, developers and the local government as agents. M-AM collects relevant traces of decision processes and the preferences of the agents which lead to coverage changes. The objective of the model is to help reveal trends in land use changes and, thus, orient the decision-making bodies. The preferences of the agents could be explicitly represented using utility functions with multiple attributes (Keeney & Raiffa, 1993). These functions express the inherent uncertainties in the decisions of the agents when these respond to economic opportunities within a cultural and government context. For example, when land owners decide they have to sell or cling on to their land, they weigh up the additional wealth to be obtained by selling against the bio-cultural integrity of the place where they live. Compared with purely monetary metrics, this is a more realistic way to model decisions on land use changes that the people really make.

Agents can alter their preferences in response to the decision of other agents, to local government changes and to land use changes. For example, in response to a change in use that gives rise to greater local flooding due to a loss of permeable ground, the residential agents can adjust their value structures to place a higher emphasis on the environmental effects of suburban development. These residential agents could also influence the change in government agents by voting for a government that places greater emphasis on the negative consequences in development policy than on maximising the base tax.

M-AM operates according to several social and economic scenarios and receives a reaction from the natural system models. These models simulate how the countryside and water systems are affected by agent action and how they produce changes in habitat and water quality in climate scenarios. These changes are passed on to the human system model. In our example, the environmental metric detected by the M-AM model is the volume of flow peak, to show that the residents in the area perceive this metric as a consequence of the area's increased urbanisation.

The agents represent individuals, groups of individuals, private organisations and governmental institutions who take actions that affect land use changes – directly or indirectly. The results of the simulation indicate that when considering the values of the agents in the creation of growth management, more correct results can be obtained. Interactions between agents produce complex dynamics and the simulations reveal dominant sensibilities in these dynamics. In particular, the greatest sensitivity to the primary factors in the change in land use was towards the price of land, the development of neighbouring areas and spatial interactions between land owners. While the sensitivity towards economic values was unsurprising, the simulations revealed another area of sensitivity that could be of particular governmental interest: land owners tend to cling on to their plots if the neighbouring plots continue not to be built on. Therefore, if governments bought plots or the development rights in the form of "strategic open spaces", then neighbouring land owners who were sensitive to their neighbour's land use would ignore the temptation to sell upon modest increase in land prices. Thus, the conservation funds to preserve spaces could be more efficient if it were distributed in a disperse form. Of course, local governments would need to be aware of the potential effects of such a strategy. Low density development gives rise to higher costs for services distribution. However, such a strategy would ultimately help to achieve the goal of sustaining human and natural systems.

15. THE EFFECT OF POLICIES ON WATER RESOURCES: INTEGRATED WATER RESOURCE MANAGEMENT – THE CASE OF BRAZIL

The search for synergy and complements within environmental management, water resources and ground use should see, among other aspects, the establishment of a land planning unit that can link together the various land use strategies. Thus, the water basin presents advantages as a planning unit, given that it is a geo-environmental unit comprising a primary river and its tributaries – whose limits are defined by the relief, and "its environmental character should reflect the sum or synergy of the effects or interventions that happen within the basin territory" (Lino, 2003). It is worth highlighting that several physical-chemical and microbiological parameters vary in response to the forms of water and ground use in a water basin. Then, the author cited concludes that to understand what happens in a basin, it is vital to consider the many uses of water, its potential conflicts and, no less important, the fundamental role and ecological worth of the aquatic ecosystems for the conservation of woods and other natural resources. Equally, it is vital to evaluate ground use according to its ecological potential and limits, keeping resource sustainability as the point of reference.

Another highly relevant aspect lies in the coordination of the planning instruments associated with policies on water resources, the environment and ground use, such as: water resource plans, ecological-economic zoning and municipal directive plans, respectively. When they are well-created and coordinated, these instruments can provide significant dividends for the actions of the public powers-that-be and society-at-large. Ecological-Economic Zoning (ZEE) was created in the Brazilian legislation to orient public policy related to land planning, use and occupation, considering the potential and limitations of the physical, biotic and socio-economic media, according to the principles of sustainable development. The water resource plans, for example, when proposing the creation of zones subject to use restrictions – with an eye on protecting water resources – can offer information to the municipal directive plans and the ZEE, as well as receive useful contributions from them. Furthermore, according to the PNRH (National Water Resources Plan [PNRH, 2006]), "the management of water resources has to be directly linked to the actions that happen in the land and the decisions that were and are taken in the territory that corresponds to the water basin while considering that water planning should be undertaken based on the definitions from the ZEE as much as possible".

It is worth stressing the importance of the institutional coordination necessary to achieve socio-political legitimacy and to construct agreements involving the public and private sector and organisations from civil society. Thus, the place of the Water Basin Committees as forums with the appropriate characteristics to construct pacts involving different social players is to be highlighted. In these forums, representatives of, for example, municipal public power can and should try to find the coordination necessary for integrating water resource management and ground use with direct influence on environmental conservation and economic production – both local and regional.

The setting up of an integrated water resource management program with guarantees of success needs the institutional coordination necessary to achieve socio-political legitimacy and to construct agreements involving the public and private sector and organizations from civil society.

During its creation process, the PNRH involved nearly 7,000 people; various players debated the need to emphasise conservation activities that stimulated the integrity of aquatic ecosystems, as well as the functions represented by the strategic role of woods, forestation and the conservation units so as to improve the water pattern. In addition, this process was looking to consider the need to integrate land and water conservation actions into the area of micro-basin management in the rural environment. These directives set out the bases for the development of a sub-programme entitled "water and land conservation – micro-basin management in the rural environment". This sub-programme seeks to stimulate integrated ground and water management and conservation in micro-basins in the rural environment through adopting and diffusing conservation practices and technology, the resetting of permanently preserved areas of legal reserve, the stimulation of the recovery of areas which are degraded or of low production capacity, environmental education action in rural communities and the training of technicians and farmers in the efficient and sustainable management and administration of the production units, among other matters.

Lastly, it is worth mentioning that through the PNRH, the Brazilian aquatic eco-regions[2] were outlined as a way of associating water resource management with environmental – considering the characteristic interactions between ground and water in the various Brazilian biomasses. Currently, the country is increasing its effort to work on the detailed character of these regional sub-units.

The CULTIVATING GOOD WATER program: An experiment in integrated management of water resources, the environment and ground conservation

The Cultivating Good Water mega-programme was developed by Itaipú Binational, Enterprise manager of Itaipú hydro-electric power plant. In 2003, it was officially included in the Itaipú Binational mission: the focus for social and environmental responsibility, a fact that formed the basis of the development of various actions into a programme whose essence lies in the management of the water basins applied within the area of influence of the dam's reservoir.

By monitoring water conditions since 1982 in the region affected by the Itaipú reservoir – the water basin of the river Paraná III – five main environmental effects have been identified as defying the company's stated mission:

i) Sedimentation: From data interpretation, it is estimated that an annual average of 6 or 7 million tons of sediment is deposited at the main entrance to the reservoir – with a bit of variation from one year to the next, depending on the greater or lesser incidence of storms upriver;

ii) Eutrophication: caused by an excess of mineral and organic nutrients mainly from livestock, pig farming and poultry farming in the area, with negative effects on water quality in the lateral arms of the reservoir;

iii) Presence of golden mussel (*Limnoperna fortunei*): exotic mollusc species originally from Asia, comes attached to boat hulls and whose presence has been seen in the pipes, filters and generator cooling systems for the power plant;

iv) Agrotoxins: the intensive, abusive and irresponsible use of these products in agriculture and livestock is an important factor in the deterioration in the water and ground in the basin region which affects the Itaipú hydro-electric plant and compromises the sustainability of economic development and the quality of life of the people in the area;

v) Deforestation: disappearing jungles and forests – basically caused by anthropic activity, mainly by obtaining land for agricultural cultivation, logging undertaken for livestock and logging for the wood industry. The environmental effects caused by deforestation are diverse and include the emission of greenhouse gases; and

vi) Many uses of the reservoir: a topic covered via a commitment of the people with Itaipú and vice versa, looking for an improvement in water quality in the reservoir and the water basins that supply it.

The objective of the Cultivating Good Water programme is to establish criteria and conditions to orient socio-environmental actions related to the conservation of natural resources – focusing on quantity and quality of water and quality of life of people. This is a movement with permanent participation, in which Itaipú Binational – in addition to mitigating and correcting more significant environmental liabilities – is working with society to change its values: ways of being, thinking, producing and consuming, based on an aesthetic of caring for natural resources and living beings in general. The name "Cultivating Good Water" highlights a need: as the ground is cultivated so as to provide its fruits, so water needs "cultivating" or care, so that it will remain abundant and of good quality, now and forever.

The programme acts on various subjects through the development of programmes which in and of themselves have a strong crossover, among which can be highlighted:

i) Fish production in our water: Stimulating the sustainability and increase through professional and sport fishing of the production of proteins of biological value via the increase in fisheries, thus promoting socio-economic development with environmental responsibility.

ii) Environmental education: Preparing and making people and social groups aware for the creation of sustainable societies, defining and implementing a continuous programme of environmental education – the objective being to achieve a culture of social responsibility and environmental commitment in Itaipú Binational.

iii) Biodiversity – our heritage: Contributing to the maintenance of and improvement in the genetic variety of the wild regional/ecological corri-

[2] The Itaipú dam has an installed power of 14,000 MW and produces 20% of all the energy consumed in Brazil and 95% of that consumed in Paraguay, bearing in mind that about 60% of the Brazilian Gross Domestic Product (GDP) is generated on the back of the energy from this hydro-electric power plant.

dor flora and fauna. This project is working on the implementation of an ecological corridor which includes a greenbelt for the connection between Iguaçu National Park and Ilha Grande National Park. Connected results: 23,000,000 saplings planted in protected areas; 257.5 hectares of the Santa María Biodiversity Corridor preserved through forest management.

iv) Management per Basins: Cultivating Porá Water – Executing the conservationist management of water and ground to control the liabilities and environmental aspects on livestock properties, on society with its municipal prefectures, owners, associations, cooperatives and other parties.

v) Efficient infrastructure and Sanitation in the region: Work, services and maintenance of the support structure for energy production, beyond basic sanitation in the Itaipú Hydro-electric Dam and areas belonging to the entity so as to contribute to improving basic sanitation in the region.

vi) Sustainability of at-risk segments: Aiming to create conditions to improve the quality of life of the less well-off sectors of society in the region – particularly in low income populations.

vii) Environmental monitoring and evaluation: Undertaking diagnoses and environmental evaluations of the reservoir and its surroundings, aiming to supply parameters and indicators that orient and check environmental aspects controlled by actions that are developed in the reservoir and the water basin.

viii) Sustainable Rural Development: Undertaking complementary actions to those of the Federal Government, aiming to attract the attention of the rural population to areas of interest to Itaipú Binational through environmentally sustainable livestock production programmes for personal consumption and for income. Work areas: (a) Organic agriculture; (b) Livestock diversification in rural properties; and (c) Valuing and developing family agriculture.

It is worth noting that the results obtained to date – according to the executors – are attributed to various factors that act in an integrated and co-dependent way, among which the following stand out: i) business decision to adopt a new mission focused on environmental and social responsibility; ii) environmental management model (that aims to link together environmental and land management, placing priority on participation); iii) the structure of the Cultivating Good Water mega-programme based on planetary documentation; iv) strategies of implantation methods; v) competence of the technical team; vi) financial resources, material and teams; vii) coordination to establish collaborative societies with rural producers and other parties in the surrounding area. It is worth noting that participation management is considered of vital importance to politically and technically make all the necessary collaborative societies viable together with the methods used for basin management, community commitment and partners (agreements) for the conscious execution of socio-environmental actions before signing agreements with municipalities, in which the necessary compensation is detailed by those involved.

16. FINALTHOUGHTS

Land planning should reconcile various objectives in a particular place, ensuring short- and long-term sustainability. Among these objectives, economic development and land productivity should be compatible with nature and landscape values conservation, and all of these require rational use of water resources. In order to ensure territorial balance, particularly on a large scale, one part of the land must be dedicated to natural ecosystems and, eventually, to the forests. There is probably no single universal answer to the question of how much forest is enough. However, some authors have suggested that between 30% and 50% of the land should be dedicated to natural ecosystems (Odum & Odum, 1972; Noss, 1992; Mosquin *et al.*, 1995). In any case, the decisions on ground use changes should carefully consider the degree of reversibility of these changes. Many transformations in land use are practically non-reversible on an ecological or human scale, for example: sealing the ground for structures. Other transforma-

Figure 14. *Painting from second half XVI century: Anthropomorphic Landscape (School of Southern Netherlands).*

tions require the investment of huge quantities of energy (and money) to be reversed, for example: deforestation of native forests. In both situations, there is a reduction in the degree of freedom for future land use, so sustainability is reduced. In dry zones, desertification can produce non-reversible land degradation, creating positive feedback processes between ground degradation and drought – resulting in growing and permanent water scarcity.

Since the 15th and 16th centuries – when painters began to represent landscapes – forests and water have been included in the scenery in the majority of cases, together with the representation of ideas – religious motifs – and even man himself (Fig. 14, anthropomorphic landscape). Hopefully, this integration between human spirituality and countryside with forests and water will continue for the enjoyment of future generations.

17. REFERENCES

Acevedo M.F, Rosales J., Delgado L., Ablan M., Davila J. , Callicott J. B., Monticino M.. 2007 Modelos de interacción humano-ambiental: el enfoque de la Biocomplejidad. *Ecosistemas,* 16(3): 55-67.

Aema.2005. Corine land cover 2000 (CLC2000) vector by country

Almeida, C., Vorosmarty, C.J., Hurtt, G.C., Marengo, J.A., Dingman, S.L., Keim, B.D. (2007). The effects of deforestation on the hydrological cycle in Amazonia: a review on scale and resolution. *International Journal of Climatology,* 27: 633-647.

Andreae, M.O., Rosenfeld, D., P. Artaxo, P., Costa, A. A., Frank, G. P., Longo, K. M., Silva Dias, M. A. F. (2004). Smoking rain clouds over the Amazon. *Science,* 303: 1342-1345.

Avissar, R., Silva Dias, P. L., Silva Dias, M. A. F., Nobre, C. (2002). The Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): Insights and future research needs. *J. Geophys. Res.* 107 (D20): 54.1-54.6.

Azcón R. & Barea J. M. (1997) Mycorrhizal dependency of a representative plant species in Mediterranean shrublands (Lavandula spica L.) as a key factor to its use for revegetation strategies in desertification-threatened areas. *Applied Soil Ecology* 7: 83-92.

Bailly, A., Gautry, J.-Y., Carnus, J :M., Ben Brahim, M. (2004) État de l'art sur l'épandage en forêt de boues de stations d'épuration urbaine et de boues de papeteries. *Marché AFOCEL-ADEME N° 99 75060.* INRA. 72 pp.

Bainbridge, D. A. (2007). *A Guide to Desert and Dryland Restoration.* Island Press, Washington, DC

Bainbridge, D.A. (2001). Buried clay pot irrigation. *Agricultural Water Management.* 48(2):79-88.

Bainbridge, D.A. and R.A. Virginia. (1990). Restoration in the Sonoran desert of California. *Restoration and Management Notes.* 8(1):1-14.

Bakkenes M, Alkemade R, Ihle F, Leemans R, Latour J B (2002). Assessing effects of forecasted climate change on the diversity and distribution of European higher plants for 2050. *Global Change Biology* 8 (4), 390–407.

Bellot, J., J. M. Ortiz de Urbina, A. Bonet, and J. R. Sanchez. 2002. The effects of treeshelters on the growth of Quercus coccifera L. seedlings in a semiarid environment. *Forestry* 75: 89-106.

Bellot, J., Sanchez, J.R., Chirino, E., Hernandez, N., Abdelli, F. and Martinez, J.M. (1999). Effect of different vegetation type cover on the soil water balance in semi-arid areas of south eastern Spain. *Phys. Chem. Earth* (B), vol. 24 (4): 353-357.

Berbel, J, Gutiérrez, M, López, J. 2005 Herramientas para el análisis de escenarios de política en el regadío del Valle del Guadalquivir. *Revista española de estudios agrosociales y pesqueros,* ISSN 1575-1198, Nº 205, 2005, pags. 65-98

Bosch, J.M. and Hewlett, J.D. (1982). A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. *J. Hydrol.* , 55: 3-23.

Bruijnzeel, L. (1990). *Hydrology of moist tropical forests and effects of conversion: A sate of knowledge review.* UNESCO, Paris.

Calder, I.R. (2000). Forests and hydrological services: reconciling public and science perceptions. *Land Use and Water Resources Research* 2(2): 1-12.

Callaway R. M. (2007) *Positive interactions and interdependence in plant communities.* Springer Verlag, New York.

Cheng, S. y Wang, R., 2002. An approach for evaluating the hydrological effects of urbanization and its application. *Hydrological Processes,* 16:1403-1418.

Chirino, E., Milagrosa, A., Hernánadez, E.I., Matos, A. & Vallejo, V.R. (2008). Effects of a deep container on morpho-functiona characteristics and root colonization in Quercus suber L. seedlings for reforestation in Mediterranean climate. *Forest Ecology and Management* 256: 779-785.

Correia, F. W. (2006). Impacto das modificações da cobertura vegetal no balanço de água na Amazônia: um estudo com modelo de circulação geral da atmosfera (MCGA). *Revista Brasileira de Meteorologia,* 21: 153-166.

Correia, F.W.S., Manzi, A.O., Cândido, L.A., Santos, R.M.N., Pauliquevis, T. (2007). Balanço de umidade na Amazônia e sua sensibilidade às mudanças na cobertura vegetal. *Ciência e Cultura,* 59: 39-43.

Cortina, J., Navarro, R.M. & Del Campo, A.D. (2006). *Evaluación del éxito de la reintroducción de especies leñosas en ambientes Mediterráneos. Chapter 1. In Calidad de planta forestal para la restauración en ambientes Mediterráneos. Estado actual de conocimientos.* Cortina, J., Peñuelas, J.L., Puértolas, J., Vilagrosa, A., y Savé, R. (Coord.). Organismo Autónomo Parques Nacionales. Ministerio de Medio Ambiente. Madrid.

Cosgrove y Rijsberman, 2001. The making of the World water vision exercise. In Rijsberman, F. Ed. *World Water Scenarios: analysis Earthscan*, Londres.

De Luís, M., González-Hidalgo, J.C., Raventós, J., Sánchez, J.R. & Cortina, J. (2000). Spatial analysis of rainfall trends in the region of Valencia (east Spain). *Int. J. Climat.* 20(12): 1451-1469.

De Simón, E., Ripoll, M.A., Bocio, I., Navarro, F.B., Jiménez, M.N. y Gallego, E. (2004). Preparación del suelo en repoblaciones de zonas semiáridas. In: Vallejo, V.R. & Alloza, J.A. eds. *Avances en el estudio de la gestión del monte mediterráneo.* Fundación CEAM, Valencia: 161-193.

Dudley, N. and Stolton, S. (2005). Restoring water quality and quantity. In: Mansourin, S., Vallauri, D. and Dudley, N eds. F*orest restoration in landscapes*. Springer, New York. Pp. 228-232.

Dumancic, D. and Le Houérou, H. N., 1980. Acacia cyanophylla Lindl. As supplementary feed for small stock in Lybia. In 'Browse in Africa. The current state of knowledge'. H.N. Le Houérou, ed. *International Livestock Center for Africa.* Addis Ababa.

Eck, T. F., Holben, B. N., Reid, J. S., O'Neill, N. T., Schafer, J., Dubovik, O., Smirnov, A., Yamasoe, M.A., Artaxo, P. (2003). High aerosol optical depth biomass burning events: a comparison of optical properties for different source regions. *Geophysical Research Letters,* 30(20): 2.035-2.048, doi: 10.1029/2003GL017861.

Ewel, J. J. and Putz, F. E., 2004. A place for alien species in ecosystem restoration. *Front. Ecol. Environ.* 2: 354-360.

Ferguson, B.K. (1994). *Stormwater infiltration.* Lewis Publ. Boca Raton, 269 p.

Follmann, G. (1963). Nordchilenische Nebeloasen. UMSCHAU, Heft 4, 1010104.

Forti, M., Lavie, Y., Ben-Dov, Y., and Pauker, R., (2006). Long-term plant survival and development under dryland conditions in an experimental site in the semi-arid Negev of Israel. *J. Arid Environ.* 65: 1-28.

Fuentes, D., Valdecantos, A., Cortina, J. & Vallejo, V.R. (2007). Seedling performance in sewage sludge-amended degraded Mediterranean woodlands. *Ecol. Engineering* 31: 281-291.

Gangoiti, G., L. Alonso, M. Navazo, J. A. García, M. M. Millán, (2006): North African soil dust and European pollution transport mechanisms to America during the warm season: Hidden links shown by a passive tracer simulation. *J. Geophys. Res.*, 111.

Garen, D., y Moore, D. (2005). Curve number hydrology in water quality modeling: uses, abuses, and future directions. *Journal of the American Water Resources Association,* 41(2):377-388, 2005.

Gómez-Aparicio L., Zamora R., Gómez J. M., Hódar J. A., Castro J., & Baraza E. (2004) Applying plant facilitation to forest restoration: a meta-analysis of the use of shrubs as nurse plants. *Ecological Applications* 14: 1128-1138.

Gonzalez-Barbera G., Martinez F., Alvarez J., Albaladejo J., & Castillo V. (2005) Short- and intermediate-term effects of site and plant preparation techniques on reforestation of a Mediterranean semiarid ecosystem with Pinus halepensis

Mill. *New Forests* 29: 177-198.

Gracia C. A., Sabaté S. and Sánchez A. (2002). El cambio climático y la reducción de la reserva de agua en el bosque mediterráneo. *Ecosistemas 2* http://www.aeet.org/ecosistemas/022/investigacion4.htm

Hamelin, B., F. E. Grouset, P. E. Biscaye, A. Zindler, J. M. Prospero, (1989): Lead isotopes in trade winds aerosols at Barbados: The influence of European emissions over the North Atlantic. *J. Geophys.* Res., 94, 16,243-16250.

Herbert , H., Eling, H.H. y Sánchez, M. (1999). Presas, canales y cajas de agua: la tecnología hidráulica en el Bajío mexicano

Holmes, J.W. and Wronski, E.B. (1982). On the water harvest from afforested catchments. In *Proceedings of the First National Symposium on Forest Hydrology,* Melbourne, 11-13 May 1982: 6p.

INPE. (2007). PRODES. [Accesible: http://www.inpe.br/prodes] [Acceso: 09/06/2008]

IPCC. 2007. *The Physical Science Basis. Fourth Assessment Report of Working Group I, Solomon* S.,Qin D, Manning M, Marquis M. Averyt K, Tignor M.M.B. Miller H and Chen Z., editors, (Cambridge Univ. Press, Cambridge).

Jiménez, M.N., F.B. Navarro, M.A. Ripoll, I. Bocio, and E.De Simón, (2005). Effect of shelter tubes on establishment and growth of Juniperus thurifera L. (Cupressaceae) seedlings in Mediterranean semi-arid environment. *Annals Forestry Science* 72: 717-725.

Keeney, R.L., Raiffa, H., (1993). *Decisions with Multiple Objectives.* Cambridge University Press, Cambridge.

Kiviiy, J.K. y Sharma, T.C. (2002). Sand dams: source of water in arid and semi-arid lands of Kenya. In *Surface water hydrology*, Singh, Al-Rashed y Sherif, eds. Pp:643-653. Balkema

Langford, K.J. (1976). Change in yield of water following a bushfire in a forest of Eucalyptus regnans. *J. Hydrol.*, 29: 87-114.

Lino, Clayton F. (2003). *Águas e florestas da Mata Atlântica: por uma gestão integrada.* São Paulo,

Ludwig J. A. & Tongway D. J. (1996) Rehabilitation of semiarid landscapes in Australia. II. Restoring vegetation patches. *Restoration Ecology* 4: 398-406.

Ludwig, J.A. and Tongway, D. (1995). Spatial organisation of landscapes and its function in semi-arid woodlands, Australia. *Landscape-Ecology* 10 (1): 51-63.

Maestre, F.T., Bautista, S., Cortina, J., Bellot, J., (2001). Potential for using facilitation by grasses to establish shrubs on a semiarid degraded steppe. *Ecological Applications* 11 (6): 1641-1655.

Maestre, F.T., Cortina, J., Bautista, S., Bellot, J., Vallejo, V.R. (2003). Small scale environmental heterogeneity and spatio-temporal dynamics of seedling survival in a degraded semiarid ecosystem. *Ecosystems* 6: 630-643

Marengo, J.A. (2006). On the hydrological cycle of the Amazon Basin: a historical review and current state-of-the-art. *Revista Brasileira de Meteorologia,* 21: 1-19.

Margalef, R. (1996). Apropiació de l'aigua epicontinental i cicle global. *Quinzè Congrés de Metges i Biòlegs de Llengua Catalana (ed.). Llibre de Ponències.* Barcelona, pp 35-46.

Mari Gowda, M.H. (1974). Dry orcharding. *The Lal Baugh* 19(1/2):1-85.

Mayor, A.G., (2008). El papel de la dinámica fuente-sumidero en la respuesta hidrológica, a varias escalas, de una zona mediterránea semiárida. Tesis doctoral, Universidad de Alicante.

Mayor, A.G., Bautista, S., Gimeno, T. (2002). Logging of burned pines and rill erosion in Mediterranean drylands. International Arid Lands Consortium Conference 'Assessing capabilities of soil and water resources in drylands: the role of information retrieval and dissemination technologies', Tucson, Arizona, 20-23 October 2002.

Millán, M.M., Mª. J. Estrela, J. Miró, (2005). Rainfall Components Variability and Spatial Distribution in a Mediterranean Area (Valencia Region). *J. Climate,* 18, 2682-2705.

Mira Botella F. (1995) Repoblacion de las dunas de Guardamar del Segura. Memoria y láminas. (1929). In: pp. 1-12. Ilmo. Ayuntamiento de Guardamar del Segura, Guardamar del Segura.

MMA, 1998. *Libro Blanco del Agua en España: Documento de Síntesis.* Ministerio de Medio Ambiente, Madrid, 43 pp.

Molchanov, A.A. (1971). Cycles of atmospheric precipitation in different types of forests of natural zones of the USSR. In: P. Duvigneaud ed., *Productivity of forest ecosystems.* Proc. Brussels Symp., 1969 (Ecology and conservation, 4). UNESCO. Paris, pp 49-68.

Mondal, R.C. (1983). Salt tolerance of tomato grown around earthen pitchers. *Indian Journal of Agricultural Science* 53(5):380-382.

Monticino, M., Acevedo, M.F, Callicott, J.B., Cogdill, T., Lindquist, C. 2007.Coupled Human and Natural Systems: A Multi-Agent Based Approach. *Environmental Modeling and Software.* 22:656-663.

Mosquin, T, Whiting, P.G. & McAllister, D.E. (1995). *Canada's biodiversity: The variety of life, in status, economic benefits, conservation costs and unmet needs.* Canadian Museum of Nature, Ottawa, Ontario.

Navarro, R.M., Villar-Salvador, P. and del Campo, A. (2006). Morfología y establecimiento de los plantones. Chapter 4. In *Calidad de planta forestal para la restauración en ambientes Mediterráneos. Estado actual de conocimientos.* Cortina, J., Peñuelas, J.L., Puértolas, J., Vilagrosa, A., y Savé, R. (Coord.). Organismo Autónomo Parques Nacionales. Ministerio de Medio Ambiente. Madrid.

Noss, R.F. (1992). The wildlands project. *Wild Earth Special issue:* 10-25.

Observatorio de la Sostenibilidad en España (OSE), 2006. *Cambios en la ocupación del suelo en España. Implicaciones para la sostenibilidad.* Ministerio de Fomento, Madrid. 485 pp.

Odum, E.P. & Odum, H.T. (1972). Natural areas as necessary components of man's total environment. *Proceedings of the North American Wildlife and Natural Resources Conference, 37: 178-189.*

Oliet, J., R. Navarro, and O. Contreras. 2003. *Evaluación de la aplicación de mejoradores y tubos en repoblaciones forestales.* Córdoba: Consejería de Medio Ambiente de la Junta de Andalucía.

Oyama, M.D.; Nobre, C.A. (2004). A simple potential vegetation model for coupling with the simple biosphere model (SIB). *Revista Brasileira de Meteorologia,* 19: 203-216.

Pausas, J.G., Bladé, C., Valdecantos, A., Seva, J.P., Fuentes, D., Alloza, J.A., Vilagrosa, A., Bautista, S., Cortina, J. & Vallejo, V.R. (2004). Pines and oaks in the restoration of Mediterranean landscapes of Spain: New perspectives for an old practice – a review. *Plant Ecology* 171: 209-220.

Pearce, D. 1993. *Blueprint. Measuring Sustainible Development,* Earthscan, Nueva York.

Peñuelas J.; Lloret F.; Montoya R. 2001. Severe Drought Effects on Mediterranean Woody Flora in Spain. *Forest Science* 47: 214-218.

Piñol J, Lledó MJ & Escarré A. (1991). Hydrological balance of two Mediterranean forested catchments. *Hydrological Sciences Journal,* 36:95-107

Post, D., Jakeman, A., Littlewood, I., Whitehead, P., Jayasuriya M., 1996. Modelling land-cover-induced variations in hydrologic response: Picaninny Creek, Victoria. *Ecological Modelling,* 86: 177-182.

Prinz, D. (1999). Water harvesting in the Mediterranean. *Science for Peace Series,* 9: 295-314. UNESCO

Prospero, J.M., P.J. Lamb, 2003: African droughts and dust transport to the Caribbean: Climate change implications. *Science,* 302, 1024-1037.

Puigdefábregas, J and Mendizabal, T. (1998). Perspectives on desertification: Western Mediterranean. *Journal of Arid Environments* 39 (2): 209-224.

Pulido Bosch, A. y Ben Sbih, Y. 1995. Centuries of artificial recharge on the southern edge of the Sierra Nevada (Granada, Spain). *Environ. Geol.*, 26: 57-63.

Querejeta I., Allen M. F., Alguacil M. M., & Roldan A. (2007) Plant isotopic composition provides insight into mechanisms underlying growth stimulation by AM fungi in a semiarid environment. *Functional Plant Biology* 34: 683-691.

Querejeta, J.I., Barberá, G.G., Granados, A., and Castillo, V.M. (2008). Afforestation method affects the isotopic composition of planted Pinus halepensis in a semiarid. *Forest Ecology and Management* 254: 56-64.

Roose E., Kabore V., & Guenat C. (1999) Zai Practice: A West African traditional rehabilitation system for semiarid degraded lands, a case study in Burkina Faso. *Arid Soil Res.Rehab.* 13: 343-355.

Rose, S. y Peters, N. (2001). Effects of urbanization on streamflow in the Atlanta area (Georgia, USA): a comparative hydrological approach. *Hydrological Processes,* 15:1441-1457.

Santos Pereira, L. (2004). Combating desertification: Water conservation and water saving issues in agriculture. In: Enne, G., Peter, D., Zanolla, C. and Zucca, C. eds. *The MEDRAP Concerted Action to support the Northern Mediterranean Action Programme to Combat Desertification. Workshops results and proceedings*, NRD, Sassari, pp 138-159.

Savoie, D.L., J. M. Prospero, S. J. Oltmans, W. C. Graustein, K. K. Turekian, J. T. Merrill, H. Levy, (1992): Source of nitrate and ozone in the marine boundary layer of the tropical North Atlantic. *J. Geophys.* Res., 97, 11,575-11589.

Savoie, D.L., R. Akimoto, W.C. Keene, J.M. Prospero, R.A. Duce, J.N. Galloway, (2002): Marine biogenic and anthropogenic contributions to non-salt sulphate in the marine boundary layer over the North Atlantic Ocean. *J.Geophys. Res.*, 107(D18), 4356, doi:10,1029/2001JD000970.

Sawaf, H.M. (1980). Attempts to improve the supplementary irrigation systems in orchards in some arid zones according to the root distribution patterns of fruit trees. *In Rainfed Agriculture in the Near East and North Africa*. FAO, Rome, Italy. pp. 252-259.

Schelesinger, W.H. (1997). *Biogeochemistry. An analysis of global change.* Second Edition. Academic Press. San Diego.

Schemenauer, R.S. and P. Joe (1989). The collection efficiency of a massive fog collector. *Atmospheric Research,* 24, 53-69.

Schemenauer, R.S., C.M. Banic and N. Urquizo (1995). High elevation fog and precipitation chemistry in Southern Quebec, Canada. *Atmos. Environ.*, 29, No. 17, 2235-2252.

SERI - Society for Ecological Restoration International Science & Policy Working Group. 2004. The SER International Primer on Ecological Restoration. www.ser.org & Tucson: Society for Ecological Restoration International.

Shachori, A.Y. and Michaeli, A. (1965). Water yields of forest, maquis and grass covers in semi-arid regions: a literature review. In F. D. Eckardt ed. *Méthodologie de l'écophysiologie végétale*, UNESCO, Paris. pp. 467-477.

Shiek'h, M.T. and B.H. Shah. (1983). Establishment of vegetation with pitcher irrigation. *Pakistan Journal of Forestry* 33(2):75-81.

Silva, D. A. da, S.A. de Silva and H.R. Gheyi. (1985). Viability of irrigation by porous capsule method in arid and semi-arid regions. In *Transactions 12th Congress on Irrigation and Drainage.* International Commission on Irrigation and Drainage, New Delhi, India. pp. 753-764.

Steinitz, Carl, H. Arias, S. Bassett, M. Flaxman, T. Goode, T. Maddock, D. Mouat, R. Peiser, and A. Shearer. (2003)., Alternative Futures for Changing Landscapes: *The Upper San Pedro River Basin in Arizona and Sonora,* Island Press, Washington, D.C. 2003

Twery , M.J. y Hornbeck, J.W. (2001). Incorporating water goals into forest management decisions at a local level. *Forest Ecology and Management* 143 (2001) 87-93.

Ulbrich, U., T. A. Brücher, A. H. Fink, G. C. Leckebusch, A. Krüger, G. Pinto, 2003: The central European floods of August 2002: Part 2 - Synoptic causes and considerations with respect to climatic change. *Weather,* 58, 371-377.

Valdecantos, A., Cortina, J. & Vallejo, V.R. (2006). Nutrient status and field performance of tree seedlings planted in Mediterranean degraded areas. *Annals of Forest Science* 63: 249-256.

Valdecantos, A., Fuentes, D. & Cortina, J. (2004). Utilización de biosólidos para la restauración de ecosistemas mediterráneos. In *Avances en el Estudio de la Gestión del Monte Mediterráneo.* (V.R. Vallejo y J.A. Alloza, Eds.). Pp. 313-344. Fundación CEAM, Valencia.

Valladares, F.,Vilagrosa, A., Peñuelas, J., Ogaya, R., Camarero, J.J., Corcuera, L., Sisó, S. and Gil-Pelegrín, E. (2004). Estrés hídrico: ecofisiología y escalas de la sequía. In: *Ecología del bosque mediterráneo en un mundo cambiante* (F. Valladares, ed.). Ministerio de Medio Ambiente, Madrid.

Vallejo, V.R. & Alloza, J.A. (1998). The restoration of burned lands: The case of eastern Spain. In: *Large Forest Fires.* J.M. Moreno ed., pp 91-108. Backhuys Publ., Lieden.

Vallejo, V.R., Aronson, J., Pausas, J. & Cortina, J. (2006). Restoration of Mediterranean Woodlands. Chapter 14 in *Restoration Ecology.* The New Frontier. J. Van Andel and J. Aronson (Eds.). . Blackwell Publ., Oxford. pp. 193- 207.

Vallejo, V.R., Bautista, S. & Cortina, J. (1999). Restoration for soil protection after disturbances. In: *Life and Environment in the Mediterranean,* L. Trabaud ed., WIT Press, Southampton. pp. 301-343.

Vallejo, V.R., Serrasolses, I., Cortina, J., Seva, J.P., Valdecantos, A. & Vilagrosa, A. (2000). Restoration strategies and actions in Mediterranean degraded lands. In: *Desertification in Europe: mitigation strategies, land-use planning.* G. Enne, Ch. Zanolla and D. Peter eds. EC DG XII, Environment and Climate programme, Brussels. pp. 221-233.

Van Wesemael, B., Poesen, J., Benet, A.S., Barrionuevo, L.C., and Puigdefábregas, J. (1998). Collection and storage of runoff from hillslopes in a semi-arid environment: Geomorphic and hydrologic aspects of the aljibe system in Almeria Province, Spain. *Journal of Arid Environments* 40 (1): 1-14.

Vörösmarty, C.J. y Sahagian, D., 2000. Anthropogenic disturbance of terrestrial water cycle. *BioScience,* 50 (9), 953-765.

Wear, D.N., Turner, M.G., Naiman, R.T., 1998. Land cover along urban-rural gradient: implications for water quality. *Ecological Applications,* 8(3), 619-630.

Zanini, L., and Ganade, G. (2005) Restoration of Araucaria forest: the role of perches, pioneer vegetation, and soil fertility. *Restoration Ecology,* 13: 507-514.

CONCLUSIONS

Does forests attract rain? Interactions between ground use and regional climate

The Amazon is a mixture of water and forest that, due to its size, acts as a carbon drain on a planetary scale. Due to its great size and water content, substantial alterations in its forests would affect regional and global circulation and the climate pattern.

The deforestation in the states of Rondonia and Matto Grosso are causing an alteration in the climate pattern of rainfall production both locally and globally.

Loss of 20-40% of the forest causes rises of 1-2.5 ºC in air temperature reduces evapotranspiration by 15-30% and decreases rainfall by between 5% and 20%.

A concept model of the workings of the Mediterranean climate system and its links with regional and global climate is provided. A model of atmospheric circulation in Mediterranean areas is examined with circulation patterns that explain the occurrence of rainfall in Mediterranean coastal zones due to changes in ground use and its link with extreme precipitation in Central Europe or even in the Northern Atlantic area.

In the Mediterranean breeze pattern, air bodies often need a water supplement to generate precipitation in mountains near the coast. The fact that size-wise this water supplement could be supplied by evapotranspiration from the coastal zone offers a reference point to orient ground use management that could have implications in rain patterns.

Alteration in ground use and deforestation could have consequences on climate mechanisms to a diverse degree.

Optimising water inputs

It is suggested that both in the rural environment and the urban one there are many structures that could be used to collect and channel precipitation and runoff – increasing filtration.

Dykes and gravel-traps are effective at retaining and filtrating water, as they on average filtrate 29% of the precipitation.

As regards effectiveness, infiltration or seepage is greater in the gravel-traps than in dykes, but both are effective structures to increase percolation and recharge aquifers.

Harvesting water from high level fogs is a viable system tested in many parts of the world which generates drinking water and is sustainable in the long term.

Fog harvesting is a complement to inputs via precipitation and is vital in areas with scarce vertical rainfall.

Fog can be managed to create new inputs and used to increase wooded areas that, in turn, act as harvesters and produce a progressive increase in the water availability in the area.

Does the forest reduce water resource consumption or improve it through basin water regulation? – How should forest planning be managed from a multi-purpose perspective?

Potential evapotranspiration in Mediterranean conditions is approximately double that of precipitation.

One gram of C fixed by photosynthesis requires 500 g of water transpired.

In forest clearings, evapotranspiration is constant, independently of the number of feet per hectare.

Evapotranspiration takes over 90% of water precipitated. Therefore, it is the most relevant parameter to take into consideration in forest management.

Infiltration or seepage capacity and the length of time water stays in the basin are the basic parameters to guarantee the base flow in rivers.

Forest restoration from the perspective of the fight against desertification

Transpiration management, in part, retains within the ground and vegetation producing it can contribute to the development of a Mediterranean hillside management model.

Modification of the albedo by vegetation could affect the characteristics of air bodies and, eventually, local humidity pattern.

Restoration programmes need the maximum amount of information about the character of plant quality, incorporating best varieties and origins which can differ greatly in their efficiency in water use; non-aggressive land preparation techniques for an increase in the harvesting of runoff – using knowledge of interactions between plants and the effects of spatial heterogeneity; use of protective tubes for the micro-climate conditioning of saplings; and ground improvement through moderate organic amendments.

Updated traditional techniques are available in forestation techniques (landscaping and cropping) in desert conditions for localised irrigation using tiny quantities and at a low economic cost.

Land planning options to optimise water resources.

The existing concern within the scientific community and social organisations and political declarations about bad usage and water resource limits do not correspond to the reality of actions at local, regional or global levels.

There are management support tools (scientific knowledge, models, data bases, evolving indicators, evaluated scenarios) that could make a new development model more effective and more in accordance with a rational management of the water resources.

Coherence is needed – currently non-existent – between different management instruments and various authorities and regulations that affect decisions and actions on water resources.

The effect of politics on water resources

Water management should be coordinated and congruent with land use policies and with energy and environmental politics.

Citizen participation and that of local public organisations should be guaranteed during the creation of water resource management instruments.

The policies of rural development programmes should include compensation for the environmental services provided by the inhabitants of the rural area.

Diversification of activities – not strictly agrarian – is a hopeful road towards progress in the maintenance of farmers' income.

AUTHORS AND COLLABORATORS

Acevedo, M. Programa de Ingeniería Biológica y Ambiental, Universidad del Norte de Texas, Denton Texas 76203 EEUU

Bellot, J.F. Departamento Ecología, Facultad de Ciencias. Universidad Alicante.

Bosco Senra, J. Director de Recursos Hídricos, Secretaría de Recursos Hídricos y Ambiente Urbano, Ministerio de Medio Ambiente, República Federativa del Brasil

Botey, J. Secretario General de Arco Forestal Mediterráneo Europeo (ARCMED)

Cortina, J. Departament d'Ecologia. Universitat d'Alacant i Institut Multidisciplinari per a l'Estudi del Medi, Universitat d'Alacant. Ap. 99 E-03080 Alacant, España

Gómez Orea, D. Doctor Ingeniero Agrónomo. Universidad Politécnica de Madrid

González Alonso. S. Catedrático de la Universidad Politécnica de Madrid (España). Área de Proyectos de Ingeniería.

Gracia, C. Departamento de Ecología, Facultad de Biología, Universidad de Barcelona y CREAF, Centre de Recerca Ecològica i Aplicacions Forestals, UAB

Kirketerp, C. Press Officer. European Commissioner for Agriculture and Rural Development

Luizao, F. Brazilian Institute for Amazonian Research (INPA), Manaus (Brasil)

Millán, M. Director Ejecutivo. Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM)

Prieto, F. Departamento de Ecología, Universidad de Alcalá.

Pulido, A. Catedrático de Hidrología. Universidad de Almería.

Ramírez, J.J. Alliant International University, San Diego (California)

Rojo, L. Jefe de Servicio y Coordinador del Programa de Acción Nacional contra la Desertificación. Ministerio de Medio Ambiente y Medio Rural y Marino.

Ruíz de la Torre, J. Profesor Emérito, Universidad Politécnica de Madrid

Schemenauer, R. Director Ejecutivo de FogQuest y Profesor Adjunto de Thompson Rivers University

Steinitz, C. Professor of Landscape Architecture and Planning. Universidad de Harvard

Vallejo Calzada, R. Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM)

PLANNING FOR THE FUTURE OF LAND AND WATER:
GLOBALLY? REGIONALLY? LOCALLY?

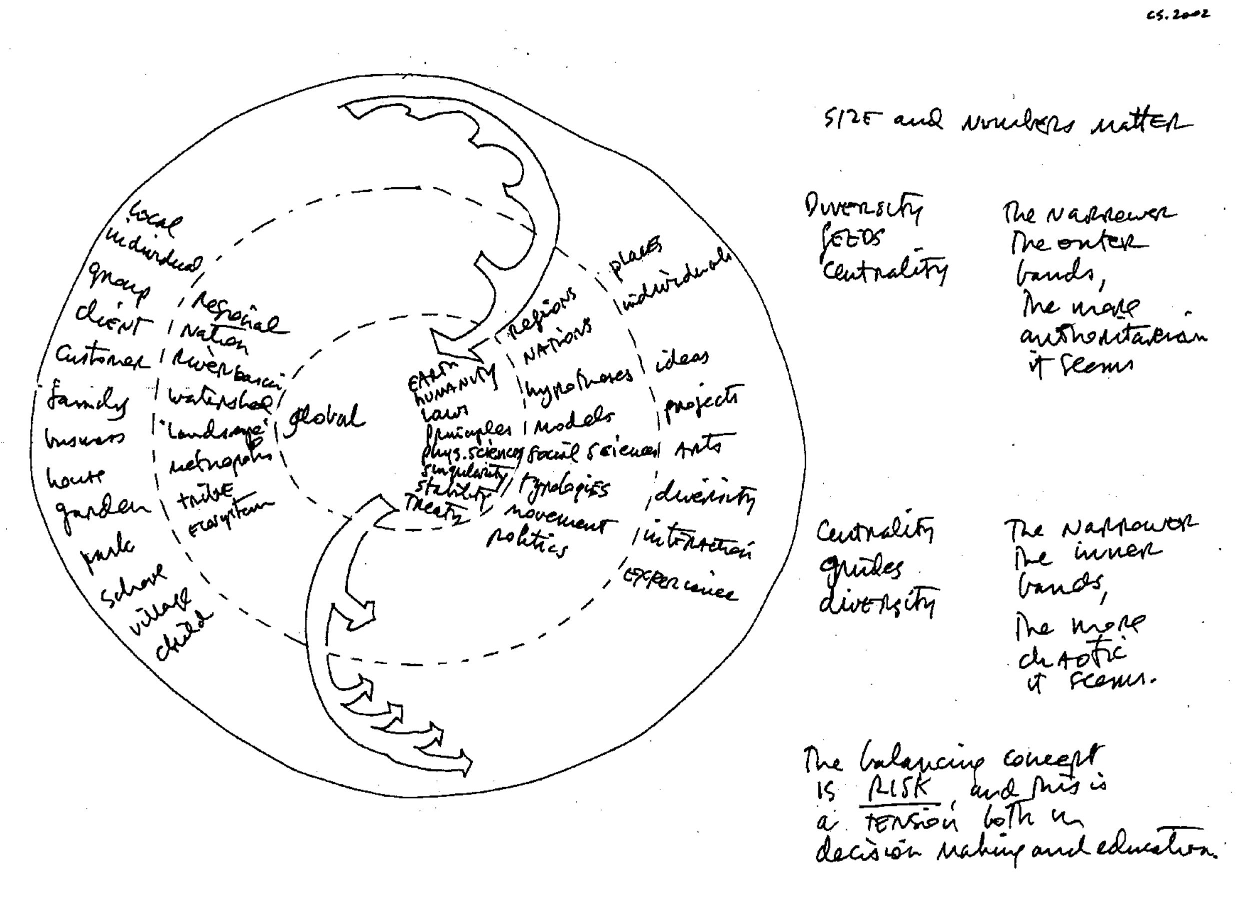
Carl Steinitz

Keynote Conference

The central theme of this week of the EXPO Zaragoza is land-water relationships. I have organized many landscape planning studies and worked with some of the world's finest hydrologists and water economists. Water has always been a central issue, often as a binding constraint on potential policies and plans. My experience has raised an important question which will be focus of this talk-- At what scales should we plan for the future of land and its people and resources, and especially for water? At the local level? At the regional level? At the global level? At all levels? Simultaneously? How? And is planning at these scales mutually supportive or in fundamental conflict?

As Galileo said, *"Many devices which work on a small scale do not work on a large scale."*

The quotation from Galileo and this diagram summarize my lecture.



EFFECTS OF DEFORESTATION IN THE AMAZON ON THE RAINFALL AND EVAPOTRANSPIRATION REGIMES

Flávio Luizão, Carlos Nobre, Antonio Manzi,
Paulo Artaxo and Francis Correia

ABSTRACT:

In South America, Amazonia represents 7 million km^2, mostly of dense tropical rain forest, thus representing a huge source of evapotranspiration and strongly affecting the regional rainfall regimes and beyond. In recent years, new findings of the LBA Project (now, the Research Program on the Biosphere-Atmosphere Interactions in Amazonia) have confirmed and explained better the role of the forest as a vital regulator of the regional water cycle, as well as of the whole South America. The forest emit a large amount of volatile organic compounds (VOCs) which contributes to produce shallow and relatively warm clouds, very efficient to induce rains in the region. Large scale deforestation can disrupt strongly this mechanism and deeply modify the processes of formation of clouds and rains, with reflections on other neighboring, or even far away regions. Amazonia functions as an important center for redistribution of the water vapor entering the basin from the Atlantic Ocean, thus partly regulating the annual distribution of rains in the central and southern regions of Brazil and even of South America. On the other hand, the large scale environmental and climatic changes affect the rainfall regime in Amazonia, as illustrated by the phenomenon El Niño, more frequent in the last years, and the strong Amazonian drought during 2005.

KEYWORDS:

Forest ecosystem services, climate change, amazonian clouds and rains, hydrologic cycle in Amazonia.

CLIMATE CHANGE AND THE WATER CYCLE IN SOUTHERN EUROPE:
THE ROLE OF CRITICAL THRESHOLDS AND FEEDBACKS

Millan M. Millan

ABSTRACT:

Around the Mediterranean sea, deserts and desert-like conditions can be found in close proximity to a very warm sea and thus to a marine airmass with a high moisture content, e.g., the coasts of Morocco, Algiers, Tunisia, Libya, and Almeria in Southeastern Spain. These regions were covered with vegetation in historical times, e.g., during the Roman Empire, and in the case of Almeria, just 150 years ago, before the forests were used to fuel lead mines. The question is: did they run a feedback cycle towards desertification by removing the forests? The results from seventeen European Commission Research Projects (acknowledgements) suggest that this could be the case.

This work shows that the hydrological system in this region is very sensitive to land-use changes and, more recently, to air pollution effects as well. Both of these can combine to exceed critical threshold levels, e.g, the height of the cloud condensation levels with respect to the height of the coastal mountain ranges. This results in the loss of summer storms and tips the regional climate towards desertification and drought. In the Western Mediterranean Basin the non-precipitated water vapour returns and accumulates over the sea, to heights reaching over 5000 m, for periods lasting from 3 to 10 days in summer.

Moreover, changes and perturbations to the hydrological cycle in any part of the basin could propagate to the whole basin and adjacent regions, and ultimately to the global climate system, through other mechanisms. These involve:

(1) an increase in Mediterranean cyclogenesis in autumn-winter through cumulative (greenhouse) heating of the sea surface by the water vapour and the pollutants (ozone) accumulated over the sea,

(2) the export of the accumulated water vapour and pollutants to other regions at the end of each 3-10 day accumulation-recirculation cycle, which can contribute to summer floods in Central-Eastern Europe and,

(3) changes in the evaporation-precipitation balance over the Mediterranean, which increases its salinity and drives the Atlantic-Mediterranean salinity valve.

KEYWORDS:

Climatic feedbacks, drought, hydrological cycle, mediterranean climate.

TECHNIQUES FOR INCREASING AQUIFER RECHARGE IN SEMIARID REGIONS

Antonio Pulido-Bosch and Wenceslao Martín-Rosales

ABSTRACT:

Principal potential methods for recharging aquifers in semiarid regions are presented. Scarcity of water resources in semiarid regions is often accompanied by brief periods of highly intense precipitation that can generate potentially catastrophic floods. In such areas, runoff water can be harvested for aquifer recharge providing valuable contributions to flood prevention and water resources management. We present a study undertaken in south-eastern Spain in which the recharge from several check dams is estimated, as well as that from various gravel pits excavated to provide gravel for use in greenhouses. The gravel pits are situated in the apical sectors of alluvial fans overlying hydrogeological units that are widely overexploited, so they are well-positioned for use for artificial recharge. The study demonstrates the high hydrogeological efficiency of such gravel pits for this purpose.

KEYWORDS:

Check dam, aquifer recharge, gravel pit, hydrological modelling.

FOG: A SUSTAINABLE SOURCE OF WATER FOR PEOPLE, FORESTS AND AFFORESTATION

Robert S. Schemenauer

ABSTRACT:

Fog is a natural part of the hydrologic cycle and, like precipitation, provides a vital water source for all life. Its contribution to water inputs at a particular location can vary from 0 % to nearly 100 % in some high-elevation desert environments. Fog is composed of tiny, water droplets from 1 to 40 µm in diameter. Typical droplet diameters are around 10 µm. Some types of trees are efficient at collecting these small, wind-blown fog droplets. They coalesce on the needles or leaves to form larger drops and then drip onto the ground. In high-elevation forested areas, in temperate latitudes, this process can provide 20 to 50 % of the water input to an ecosystem. FogQuest, a registered charity, uses specially chosen meshes to collect fog water in arid environments, to provide water to communities, for domestic, agricultural and forestry uses. The background to fog collection and some current applications will be presented in this paper.

KEYWORDS:

Fog, fog collection, desert, forest hydrology.

INTEGRATION OF WATER PRODUCTION INTO THE CRITERIA OF FOREST MANAGEMENT.

MULTIFUNCTIONALITY AND PREREQUISITES

Leopoldo Rojo Serrano

ABSTRACT:

The growing needs to consume water together with the forecast of higher aridity heralded by climate change in large areas have generated a new interest in the role of forests in water production. After almost a century of field work, we know that the reduction of the density of tree coverage leads to a significant increase in the amount of water which is evacuated by the basin. The complexity of the superficial phase of the hydrological cycle and the need to consider the influence of forest coverage in the hydrological regime, together with the fact that it is the low water levels and not the maximum nor the average, which determine its capacity to satisfy a certain supply, add a new dimension to the analysis of the issue. This should be covered by additional research. The need to safeguard the quality of water and the protection of soil, together with the persistence of the forest ecosystem, constitute the fundamental prerequisites for any action oriented towards increasing water production.

The diversity of uses and demands on forests determine the approaches used in multifunctional management. In accordance with current knowledge, however, it is possible to study admissible approaches to forest management which contemplate water as a main product. Some initial criteria will be provided for discussion at the EXPO 2008 Water Tribune, Zaragoza.

KEYWORDS:

Hydrology. forest management. water production. soil protection.

WATER YIELD DEPENDS ON THE WATER AND CARBON TRADE-OFF IN FOREST ECOSYSTEMS.

Carlos Gracia

ABSTRACT:

The cycling of water and carbon between vegetation and the atmosphere is an essential biospheric process with feed-backs to the physical system at various spatial and temporal scales (Claussen 1998; Houghton et al. 1998; Waring and Running 1998; Prentice et al. 2001). A key element of the water/carbon cycles comprises the fixation of atmospheric carbon dioxide (CO_2) by photosynthesis and its release by autotrophic and heterotrophic respiration. Net ecosystem exchange (NEE) is the net uptake or release of carbon by terrestrial ecosystems.

The terrestrial water cycle includes the precipitation that enters vegetation from the atmosphere and its recycling to the atmosphere by evapotranspiration (evaporation from wet surfaces and transpiration through the stomata) and runoff to lakes or oceans.

The partitioning of incoming precipitation into evapotranspiration and runoff is determined in part by climate (Monteith and Unsworth 1990) and in part by factors such as Leaf Area Index (LAI), canopy structure and hydraulic properties of the vegetation and soil. The carbon and water cycles are tightly coupled because stomatal responses simultaneously control transpiration and CO_2 uptake and because microbial decay is strongly constrained by soil moisture conditions, as both too much and too little water reduce microbial activity.

KEYWORDS:

Water cycle, carbon uptake, water use efficiency, maintenance and formation cost of living tissues.

PLANT COVER AND WATER

Juan Ruiz de la Torre

ABSTRACT:

The broad outlines of the links between vegetation and water resources are explained in brief.

Reference is made to the position of the vegetation layer in the biosphere and its complex character which lends it indicative value, aside from other values and functions. The vegetation types are characterised by the dominant life forms – depending on the climate type and modified by the treatments to which they have been subject.

Among the vegetation functions that affect water availability, the following are alluded to:

▸ Modification of the albedo or incidental energy level reflected – maximum for dense forests.

▸ Regulation of surface runoff, conditioned by the relief, but growing in size, density and rigidity of the vegetation.

▸ The vegetation layer is a carbon drain, climate regulator and a reductant of its own changes.

▸ Water ejection to the atmosphere via photosynthesis and transpiration is a water consumption expense, but it could contribute in some way to an increase in precipitation – a matter under study by CEAM.

▸ Mature ground comprises an edaphic water bank – regulator of water consumption.

▸ Reduction in erosion through increased density of the layers has beneficial influences on water quality and lasting operating capacity of the macro-regulation and transfer systems.

▸ Retention of atmospheric dust – with its nutrient contribution to the edaphic bank and help for the vegetation.

▸ Water loss through snow sublimination is considerably reduced in thickly forested areas below the timber line – a matter that is not born in mind typically in water resource planning.

▸ Negative role of forest fires and effects of reoccurrence.

▸ Fauna action and the consequences of excessive weighting.

▸ Consequences of changes in sectorial distribution of the population on the exploitation of renewable resources and big reduction in those of energy, extensive stockbreeding and peripheral agriculture.

It concludes with a reference to protective vegetation and the origin of restoration by stages.

MORE EFFICIENT IRRIGATION SYSTEMS FOR DESERT AND DRYLAND RESTORATION

David A. Bainbridge and Jose Javier Ramirez Almoril

ABSTRACT:

One of the great challenges for agriculture, agroforestry, forestry, and restoration is establishing plants and growing crops on sites that are seasonally dry or dry all year. This is becoming increasingly important as global change creates new areas of drought and more erratic rainfall patterns. Although vast areas of the world are still managed by resource limited owners, low cost simple irrigation methods that would help them increase yields have been ignored by scientific research and international development programs. Drip systems are well known, but more efficient traditional methods of irrigation that could be of great help have not been well studied or publicized. These include: deep pipes, buried clay pots, porous capsules, wicks, porous hose, and subirrigation with perforated pipe. These require much less water and work well on slopes. They also reduce weed growth dramatically and ensure that water is used to grow the crop, not weeds.

KEYWORDS:

Irrigation, efficiency, deep pipe, buried clay pot, wick, porous capsule, porous hose, perforated pipe, remote site, slopes, drought

OPTIONS TO OPTIMIZE WATER USE IN PLANTATIONS

Jordi Cortina Segarra

ABSTRACT:

Restoration ecology aims at recovering ecosystems that have been damaged, degraded or destroyed. In drylands, restoration commonly involves the establishment of a protective plant cover which will reduce ecosystem vulnerability to disturbances and stress. In the last decades, substantial advances have been made to improve plantation success by selecting suitable species and genotypes, producing high quality nursery seedlings, creating favourable microhabitats for seedling establishment, managing biotic interactions, and landscape-scale planning. Here, we review some of these advances and discuss some of the challenges ahead.

KEYWORDS:

Ecological restoration, water use efficiency, state and transition models, ecotechnology, facilitation.

MODELLING CHANGES IN TERRITORIAL COVERAGE AND THEIR HYDROLOGICAL CONSEQUENCES

Miguel F. Acevedo and Howard Redfearn

ABSTRACT:

Changes in land use in hydrographical basins are prevailing human actions which affect the behaviour of the quantity and quality of the water in those basins. The main factors are changes in the permeability of the surface, the removal of soil, and the changes in vegetation coverage. It has been common practice to implement these changes without careful planning which takes into account the potentially negative effects los on water resources. The hydrological models, together with the progress made in geo-spatial technology and radar, provide a tool which enables us to anticipate the possible potential effects of these changes of use on land. Furthermore, the development of multi-agent decision making models, together with the hydrological models, stands out as a methodology which makes it possible to include the many human players in the transformation of a river basin. In this article we present two examples of models applied to a basin in the Northern centre of the State of Texas USA. In the first example the application of a hydrological model for the planning of land use is described, and in the second we present the use of a multi-agent model to understand the dynamics of the process of change in land use. The model presented in the second example may use results from the model presented in the first. In this way an integrated approach is achieved.

KEYWORDS:

Models, basins, land use.

PROSPECTIVA 2030 IN THE CHANGES IN LAND OCCUPATION IN SPAIN AND ITS IMPACT ON THE HYDROLOGICAL CYCLE:

A FEW IDEAS FOR A SUSTAINABLE FUTURE

Fernando Prieto and Paloma Ruiz

ABSTRACT:

The development of different land occupation scenarios is fundamental for the analysis of the foreseeable effects on the hydrological cycle. Artificial areas and irrigated farmland have the greatest impact on the hydrological cycle, due to the demand and drainage of water, which has a qualitative and quantitative influence. Depending on how these different types of occupation come about in the future there will be different repercussions on the hydrological cycle. Three scenarios have been developed for 2030:

(1) “Tendencial”, which maintains the tendency of changes in occupation observed between 1987 and 2000, of the increase in artificial surface and in irrigated farmland;

(2) “Mad-Max”, which accelerates these tendencies and is associated to the over-exploitation of water, and

(3) “Technogarden”, which predicts the stabilisation of these surfaces associated to the development of technologies, supporting knowledge and maintenance of ecological processes.

Emphasis is placed on the need for society to reach an optimum, sustainable scenario or “technogarden” by 2030, in order to ensure the availability of water for the population and the ecosystems, which is accentuated with the foreseeable conditions of climate change.

The important relationship between changes in land occupation and the hydrological cycle is illustrated and it is concluded that, in spite of the existing uncertainties associated with the prediction and generation of scenarios, it is a useful preventive tool which is necessary for the future joint planning of the uses of water and land.

KEYWORDS:

Changes in land occupation and use, hydrological cycle, irreversibility of processes, artificial surface, irrigation, water demands, new technologies, precaution principle, sustainability measures, sustainable future, joint planning.

WATER AND ENVIRONMETAL RESOURCES MANAGEMENT AND LAND USE IN BRAZIL:

REFLEXIONS, POLITICS AND LEGISLATION BAKCROUND, ASPECTS FOR A INTEGRATION

João Bosco Senra

Water is Earth's blood

ABSTRACT:

Several negative impacts are originated by the inadequate land use and occupation which are generated by the increasing pressure on natural resources without consideration of their carrying capacity. Thus, it becomes necessary that public sector and society at large find solutions to this challenge through solidarity and pact-building processes, taking into account the importance of advancing in legal and institutional frameworks, building synergies between public policies, particularly those referring to land use, water resources and environmental management for their practical application and equitable benefit for all citizens. This article attempts to present briefly and objectively the progress and challenges that Brazil finds in the quest of articulating these themes.

Thematic Week 2

WATER AND CITIES

[Sustainability criteria for local governments]

Positioning document[2]

Coordinator: **Francisco Javier Celma Celma**

THE INCREASE IN URBAN POPULATION

Approximately 3% of Earth's surface is covered by urban areas: the majority of these can be found along the coasts and the river courses. The close link between water as an essential resource and as a means of transport has led to the continental waters and the river courses being important when organising the space and distribution of an urban settlement.

In the 20th century, the world population grew by a factor of ten; at the same time, the rural population also grew, though it merely doubled in size. The majority of the urban population lives in cities containing over 500,000 inhabitants. Currently, there are 20 megacities each with over 10 million inhabitants.

Nowadays, cities continue to attract great migratory rushes as people come looking for opportunities for work, stability, education, relationships, etc. However, the very urban, economic and social structures of these places are incapable of providing adequate solutions to these migratory waves.

According to the estimations of the United Nations, by 2030 some 3,000 million people will be living in rural zones compared to 5,000 million in and around urban zones.

In the second half of the 20th century, the majority of urban population growth occurred in countries with average to low incomes. This makes it probable that in the next 20 to 30 years this same phenomenon will occur at a greater rate in the urban areas of Africa, Asia and Latin America.

The concentration of the water demand within urban areas adds a very local dimension to these broader demographic trends. Where water use exceeds the capacity of local supplies, society depends on external collecting systems and their associated infrastructures (reservoirs, pipes, canals, etc.) to carry the water over long distances or, alternatively, on the extraction of underground water – both of which are unsustainable practices in the long term.

Many great cities have had to extract or transport freshwater from far-off water basins because either the local supplies no longer cover the demand or because they are, in fact, polluted. Paradoxically, this situation affects not just the cities with average or low economies but also healthier economies.

In 2000, over 900 million inhabitants of urban areas in countries with average or low incomes were living in suburbs without access to drinkable water or with insufficient quantities or without

[2]This document has been compiled from the written speeches, oral presentations, discussions during sessions and the distillation of all the above prepared by the moderators, speakers and coordinator, supported by the Water Tribune team.

the necessary guarantees of hygiene or health; at the same time, the daily water consumption per person in Spain was at 178 l/day.

Therefore, it seems necessary to rethink the urban growth models, their anabolic and catabolic needs, the sources for collecting, the infrastructures, the treatment systems, the tax policies, etc: in other words, a rethinking of the governing system for urban water management. We can not face the challenges of the 21st century with solutions from the past. It was along this line of thought that the work in the thematic week on "Water and City – Sustainability Criteria for Local Governments" was established.

REFERENCE FRAMEWORK

The Rio Conference of 1992 on development and the environment (organised by the United Nations) was the starting point for the definition and establishment of the general principles (of a universal nature) for environmental policy. The value of the Rio de Janeiro Declaration on the environment and development (defining the concept of sustainable development) should be highlighted with its 27 principles that are internationally accepted nowadays and developed to a large extent by the Nation States. However, in the aforementioned Conference, no explicit mention was made of water nor was any other natural resource singled out.

In Rio, it was shown that no environmental problem occurred in an isolated manner and, therefore, the solution could not be attempted if there were no integrated policies developed aimed at dealing with the causes behind the problem and that these would be within a framework that had an international outlook.

The Water Charter was established in the Council of Europe in 1968 wherein the basic principles for the management of the resource were defined – forming the preamble to the "Water Action Plan" in Rio de la Plata in 1977.

It is important to highlight the World Summit on sustainable development held in Johannesburg in September 2002 as it covers some of the agreements specifically referred to in the Implementation Plan, including:

- halving the percentage of the population with no access to water or sanitation by 2015 (points 7 and 24).
- developing integrated land, water and living resource management strategies (point 23).
- developing integrated water resource management plans by 2005 (point 25).
- reinforcing research into water matters (point 27).
- reinforcing coordination among international bodies working in the area of water (point 28).

In the Ministerial Declaration of 2003 in Kyoto, three principles were acknowledged as priorities in actions on water: good governance, construction capacity and funding. Related to governance, the important areas to face the new challenges include information to and participation of social agents as well as the need to achieve the principles of cost recovery in financial aspects and collaboration between public and private interests which will allow for the enormous investments to be undertaken.

The role to be played by local governments in the achievement of the sustainability objectives is set out in Article 28 of the AGENDA 21, passed in the Rio conference: *"Local authorities will deal with the creation, running and maintenance of the economic, social and ecological infrastructure, supervising the planning processes, establishing the local ecological policies and norms, and contributing to the execution of environmental policies at a national and sub-national level. In its position as the authority closest to the people, it plays a* *vital role in the education and mobilisation of the people in favour of sustainable development".*

The origin of this thematic week can be found in the "Aalborg Charter", signed on 27 May 1994 in Aalborg. In this document, the vital role of the cities and their governments in the sustainability of the planet is highlighted – understanding that 80% of Europe's population lives in urban areas. Ten years later – and following the "Lisbon Action Plan – From Charter to Action" (1996), the "Appeal from Hannover to the European leaders and municipal governors regarding the XXI century" (2000) and the "Johannesburg Appeal" (2002) – local governments adopted some commitments in the "Aalborg Conference + 10 – Inspiration for the Future" (2004). It is there where, under the title "common natural goods", among other matters, the commitment referring to water can be found: *"improving the quality of water, saving water and making efficient use of the same".*

The contents of this thematic week revolved around various topics: water efficiency in cities; city models; the urban countryside; the role of civil society; uncertainty and climate change; and, lastly, the role of the network of cities. Thus, it was proposed to change the subject of "management of the water demand" to "management of the limits", which would oblige a focus on clear objectives and policies and action being designed that would allow us to prepare and adapt ourselves to climate change.

CORE THEMES

The following aspects were included in EFFICIENCY OF WATER IN CITIES, the first core theme: the role of the new technologies, good urban practices and tax systems. Specifically, it was intended to work in depth on the extent to which new technology related to digital counters, network design, systems for making water drinkable or purifying it, among others, allow there to be improvement in water management. New technology is advancing in various directions: from the designing of models that, for example, identify when and how to restore or renovate particular drinking water transport systems – looking for a systematic reduction in losses in distribution; to different methods that aim to save and reduce domestic consumption – as in the case of cisterns with smaller capacity, the use of efficient home appliances; and the new technology of efficient irrigation for public gardens, for example; through to the use of grey water in those cases where it is possible.

Meanwhile, the designing of new tax systems intends that, in addition to recovering service costs for the supply of water as a service, costs be shared in a fair way among users, thus attaining efficient assignment of water to its various uses and minimising the negative environmental effects. Of necessity, the tax systems must be different in different places in accordance with the relevant socio-economic factors. Therefore, it is not expected that the technology and tax systems being used in different cities will be the same; on the contrary, each city must develop its own best practices as it adjusts the water policies to the local area and its economy so as to achieve efficient water use.

It is important to understand the difference between value and price. The value of water is determined by its environmental, landscaping and socio-cultural importance and through the broad range of direct and indirect benefits that it offers. The price of water is what users are charged. Equally, the cost of water in its strictest sense – as a resource – corresponds to the cost of being able to use it: in other words, with the value that is lost through not being able to use it for its best alternative use (including its environmental functions). However, in practice, water for urban use includes further costs connected to the supply of drinking water and the later treatment of liquid sewage. Distinguishing between these concepts is the vital first step in understanding the role of economic worth in the management and governance of water. At the same time, it guarantees fair access to the resource that is water, satisfying the needs of the most underprivileged members of society.

In the case of societies with resources, this intelligent measurement equipment takes on a greater relevance: not only does it measure water used, but it also indicates how it has been consumed – thus allowing for the development of new tax systems as it detects anomalous or bad practices as well as being able to locate leaks.

Finally, in the search for efficiency, an in-depth debate revolves around the participation of the private sector in the supply of water and sanitation services. The experience of some cities has shown both positive and negative sides to the different management models. It is understood that what should outweigh other matters is not the scheme adopted, but that it is set up according to criteria of honesty, equality and quality in the management of a service that is always in accordance with the local land, environment and socioeconomic conditions.

The second core theme – CITY MODELS – revolves around the influence of the chosen urban scheme on water management. Disperse and diffuse cities need more complex network systems that, in the end, are more at risk and difficult to control than those corresponding to compact cities. However, the main problem is the extraordinary pull cities continue to exercise which leads to the consequent constant population increase. Cities continue to be focuses of economic dynamism, cultural exchange and human relationships; they continue to be places that attract large migrations. In addition, current world trends show that in the next few years this process will intensify – with a particular focus on coastal areas. The great development happening in Asian cities and, in the near future, along the Mediterranean is proof of this. Generally, this process occurs without taking into account either the basic principles of land organisation or of the availability of water resources in order to supply the demand from these cities – something that could lead to serious environmental effects. The obligation of this is the undertaking of great works of infrastructure so as to bring the water over great distances, leading to the safety of the systems themselves becoming ever more costly and at risk.

The matter is thus: if the starting point – the management of water in the cities – is exclusively water-based in nature, then it will be ever more difficult for us to tackle the great problems of urban settlements. The new mouthpieces resulting from the Rio Conference – the Agenda 21 – demand the urban systems be rethought from a more complex point fo view in which economic and land models, resource availability, social policies and the coping mechanism of the natural resources are treated in an integrated fashion. Certainly, thought is required on the concept of unlimited growth and the view of sustainable development as the new paradigm to be born in mind for the urban settlements of the future.

In the third core theme – URBAN INDICATOR SYSTEMS – the different current follow-up methods in city freshwater management were analysed. One critical challenge is to identify or develop indicator systems that provide us with the necessary information so that decisions can be taken.

Currently, there are different measurement systems which are flawless from an academic perspective but fail to provide objective answers to the realities of urban settlements. Effort must be put into searching for indicators that are simpler and more realistic and allow urban managers to establish the policies and link them to the reality of their environs.

Thus, there is a new generation of indicators that are intended to approach the parameters of sustainability based on the principle put forward by the Rome Club: do more with fewer resources. The increase in wealth (GDP) or the growth in population should not increase the quantity of water consumed – something currently under development in Zaragoza.

The fourth core theme – COUNTRYSIDE AND CITY – refers, firstly, to the importance of water as an environmental, aesthetic and leisure resource, taking into account, among other matters, the role of rivers, lakes and the restoration of riversides. At the same time, it looks at the wide range of possibilities of gardening uses in the urban environment and how this can be adapted to the very climatic characteristics of the city.

The use of plants that consume small quantities of water (xerogardening) and green roofing for buildings helps to create micro-climates and improve the thermal insulation of buildings. All of this, plus the new technology that allows irrigation to be adjusted to the vital needs of each plant, leads to important savings in gardens and public and private green zones.

The fifth core theme – THE ROLE OF CIVIL SOCIETY in developed and developing countries – places emphasis on two aspects of the importance of what is usually referred to as the tertiary sector: firstly, in its capacity to act as a vehicle to transmit the current situations and the possible solutions to the people-at-large; and, secondly, the influence it has to make citizens aware so that they are persuaded to improve their habits and practices.

It would be very difficult to understand modern society without the very important role played by the NGOs. Not only do they represent worldwide social conscience, but also their participation is needed and that of civil society jointly with local governments in order to resolve current problems.

The sixth core theme – UNCERTAINTY AND CLIMATE CHANGE – analysed how water use should be adjusted in accordance with the expected changes.

There is a typical confusion between climate change and climate variations. Climate change is linked to global warming and is a long-term change caused by natural factors and, as is now recognised, by human activities.

The possible responses in terms of adjustments by the cities in the light of the climate change scenarios and their effects on water as a resource, and the protocols for action in extreme situations of drought or flooding should be analysed. Although it is difficult to design a model that will show how climate change will develop and what its effect on water resources will be, some particular measures should be analysed – those that can be considered as good practices which will help prevent the adverse effects that, currently, can be expected.

In any case, cities must adopt the principle of caution and advance planning through a series of adaptation programmes per the possible consequences derived from climate change.

The seventh core theme refers to the NETWORK OF CITIES and, specifically, to what extent an exchange of experiences can contribute to improvements in the criteria of local governments as regards sustainable water use. The objective is to foment citizen participation and to redirect scientific research towards more useful areas – specifically, in the direction from which it will serve decision-makers in the management of water or those who are affected to some extent by those decisions. This should all be accomplished so that those good practices that some cities are able to develop can be adapted and transposed to other cities.

In this area, there is the experience of SWITCH – a project run by UNESCO and funded by the European Union – that brings together 4 continents and is supported by some thirty universities; the experience of Zaragoza as a city that saves water – an initiative that was propelled by the Ecology and Development Foundation and Zaragoza Council; and the experience of City Alliance, among others.

Over the course of the Thematic Week, all of these core themes were developed on a basis of specific experiences in different cities so as to show how – in accordance with needs – different procedures have been developed to encounter solutions.

As a consequence of the above, thought is necessary in various areas. What will the cities of tomorrow be like? Will we be able to think in such a way as to be in accordance with the needs of the 21st century without repeating the mistakes of the 20th century? Will the new technology be enough? Or, to be more specific, it is necessary to look at different models for the economy, life and consumption.

The thematic week concluded with a discussion of the document entitled "Istanbul Urban Water Consensus", in collaboration with the World Water Council, in preparation for the commitment through which various cities from around the world wish to show their pledge to undertake sustainable water management policies in the urban environment of their cities in the world Water Forum in Istanbul in March 2009.

The thematic week was held from 25 to 28 June 2008 and 43 speakers and 2 panellists participated. Based on the speeches and the subsequent debates with the expert audiences and together with the documents written by the speakers and the mediators of the round tables, we have prepared the following conclusions and proposals.

CONCLUSIONS AND PROPOSALS

Human cities and/or settlements behave like living creatures – with anabolic needs (water, energy and food) and catabolic consequences (solid waste, liquid waste, etc.).

Cities, therefore, develop an urban metabolism, in which human activities can be found at the heart of the flow of energy and raw materials, not as static components but as the point at which there are rapid and radical changes – comprising an unstable system but one with a reactive capacity in which water and air play vital roles.

As a matter of principle, every functioning system is dynamic because it operates in a changing environment. As there are constant fluctuations in the relationships between the system and its environs, the system identifies the external changes and initiates processes to adapt to them. Clearly, cities do not lie outside this dynamic though they have their own peculiarities: while the human body can live without breathing for a few minutes, three days without drinking water or several weeks without consuming food, urban systems have little reactive capacity when the air is of poor quality or there is a lack of water. Thus, the water supply becomes an essential part of the life of the city.

Local Agenda 21 introduces a systematic analysis to face current and future problems; it sets out the global efficiency of urban ecosystems and their relationships with environments both near and far. Sustainability does not allow objectives of economic development, social cohesion and environmental quality to be covered separately.

The chosen urban model has a large influence over water management: disperse and diffuse cities require complex network systems that are more at risk and difficult to control than those corresponding to compact cities.

However, the main problem is the extraordinary pull that cities continue to exert: this generates a notable increase in population. Cities remain hubs of economic dynamism, cultural exchange and human relationships; specifically, they continue to attract great floods of migrants.

In addition, current global trends suggest that this process will intensify in the next few years and in particular along the coasts. This is being shown by the major development in Asian cities and, closer to home, along the Mediterranean.

In general, this process fails to take into account either the basic principles of land organisation or the availability of the water resources to satisfy the demand of these cities – something that can lead to severe environmental effects as well as powerful social tension.

These standpoints lead to the development of great works to bring water in from far-off locations, leading to the safety of each system being ever more costly and at risk. Thus, the criterion of proximity to the resource provides greater guarantees for the workings of the urban systems.

The problem is the following: if the decisions related to city water management are taken exclusively from the point of view of water engineering, it will be ever more difficult to be in a position to guarantee a sustainable and consistent model for water in urban settlements.

The rural environment supplies foodstuffs that use great quantities of water in agricultural and cattle raising activities – which are vital to the urban metabolism. This, together with the gradual reduction in volume that can be seen in particular water basins and the uncertainty suggested by climate change, leads us to rethink the models of growth and consumption in our cities. There, the management of the demand is in the background behind the management of the limits of the resource that is water. This obliges the application of the principle of caution more evidently in decision-taking regarding planning – both for the cities and their environs and for the rural environment. The models of consumption and particular food habits must be re-examined.

In addition to that previously mentioned, the availability of water must be adapted to the land development and to the socio-economic situation in each area.

New urban planning must not be a mere continuation of what happens currently: there must be a substantial change both in the concepts and in the actions so that cities will progress towards improvement and not towards non-sustainability.

Over the course of history and in the most diverse settlement areas, man has always been able to resolve his water needs problem. However, currently, despite technological advances, it appears very difficult to find a solution to the outstanding water problems, particularly in the large and medium-sized cities in the developing world. Furthermore, cities in the developed world are evolving at a slower rate than scientific and technological advances in improving the indices of efficient use of water in the urban environment. In the light of this, it is concluded that:

- A model of sustainable water management in cities requires thinking of a new form of governing in which information about water management is rigorous, complete and adjusted to the citizens to be one of the basic parts of government policies.
- Information should be the element of substance to foment participation processes in which not only the most affected groups and social collectives are involved, but in which the adequate courses are present so that citizens can have roles in the changes. Thus, the use of the new information technology – such as web pages – is a good tool to boost this process.
- The NGOs can and should undertake an important role, not just as the backbone of society but also as driving forces behind policies and actions most closely related to the principles of sustainability.
- Local authorities must find formulae agreed by consensus through the participation processes that will allow for the definition of short-, medium- and long-term objectives for the reduction in the consumption of water both at a global level and per capita.
- As a consequence of the aforementioned processes, it is equally as necessary that cities have an indicator system that permits the evaluation of advances or otherwise of the pre-established

objectives. Among the principal characteristics of these indicators, stress must be placed on them being adequate and useful for the land and the socio-economic situation of the cities. They should last and provide accurate and simple information that will allow us to see the evolution and to permanently evaluate the fulfilment or otherwise of the pre-established objectives, so they are accessible for the whole of society.

Thus, the current system of international indicators could serve to give a global overview of the evolution of water management and allow for comparison with other cities.

▶ To improve water management, it is necessary to embark on a plan for the land, urban organisation and for the use of urban and rural land. Among other crucial aspects, this includes determining the procedures for changing the use of land, of the limits that must be observed by the urban sprawl and the ideal conditions to be complied with by the area immediately adjacent to the urban area.

▶ Water must be treated as the heritage of everyone residing in a territory and, therefore, it must be managed bearing in mind the future – fomenting responsible and sustainable use.

▶ If we consider that access to water should be a universal right for humankind – both individually and as a whole – then ownership must be public. A different matter is the management model: it is not so important whether it be public or private as to whether it should be transparent and ethical, in accordance with the socio-economic situation in the area and based on principles of transparency, fairness and solidarity.

▶ The aforementioned aspects have a direct repercussion on the needs and costs for the provision of the services of water supply and sanitation.

The tax system must adapt to recover the whole cost – including the environmental one – in developed countries. Therefore, there should be ways to measure consumption that allow a tax policy to be applied that penalises excess consumption – fomenting efficient and sustainable use of water.

The tax system in developing countries must adapt to the social situation – but always fomenting general access to water and the appreciation of the same, supporting the need to keep a balance with the environment around.

The water tax must ensure that everyone can have their basic needs covered; it must not be forgotten that access to water and sanitation for the neediest sectors lies within the Millennium Development Objectives. To comply with these, it is essential to promote cooperation policies between developed and developing countries.

▶ Infrastructures for the management and distribution of water must be designed and constructed under criteria of quality, allowing them to be long-lasting and equipping them according to sensible and sustainable economic and financial criteria.

▶ Thus, and over the course of history, the various water solutions developed by the peoples of the world to fulfil their water needs are a grand heritage that must be preserved.

▶ The Bodies developing projects in developing countries to improve access to water and sanitation conditions must also establish management systems with solidarity criteria, promoting actions that are sustainable economically for the users – adapting to the social situation in the land where the projects are being undertaken – and they should be honest, viable and sustainable from an ecological and an economic point of view. One strategy to ensure the long-term strength and application of the water management tools is by adapting them to traditional and local customs.

▶ Returning used water to the physical environment should be undertaken in the best conditions possible and in accordance with the medium receiving this water, so that the resource continues to fulfil its function within the aquatic ecosystems linked to the water cycle.

▶ Then, the intimate relationship water has with the cities and the environment must be born in mind: it is vital to maintain the countryside.

▶ The creation of a network of cities permits and ensures an exchange of good practices and successful experiences, as well as an information transfer – perhaps constituting essential elements for cooperation and solidarity.

The new mouthpieces resulting from the Rio Conference and the application of the Local Agenda 21s demand the urban systems be rethought from a more complex angle in which economic and land models, resource availability, social policies and the coping mechanism of the natural resources are treated in an integrated fashion.

Definitively, thought is required on the concept of unlimited growth and the view of sustainable development as the new paradigm to be born in mind for the urban settlements of the future.

Those cities that know how to adapt themselves to water will be even better prepared to face the new challenges. They will be economically competitive, socially strong, environmentally respectful and healthy. They will be the cities of tomorrow.

AUTORES Y COLABORADORES

Anton, Barbara
International Training Centre, ICLEI – Local Governments for Sustainability

Asunción Higueras, Mar
WWF/Adena, Bióloga, Responsable Programa de Cambio Climático.

Awuah, Esi
Department of Civil Engineering KNUST and SWITCH Accra Learning Alliance

Barberán Ortí, Ramón
Catedrático de Economía Aplicada. Universidad de Zaragoza.

Belamari1, Fatiha
Chef de Service "Planification et Programmation" Office National de l'Eau Potable. Rabat – Marruecos.

Berrini, Maria
Directora de Ambiente Italia Research Institute. Milano.

Bono, Lorenzo
Ambiente Italia Research Institute. Milano.

Bruttomesso, Rinio
Centro Internazionale Città d'Acqua, S.Polo 2605, Venezia, Italia.

Bueno Bernal, Víctor (adjunto coordinador)
Agencia de Medio Ambiente y Sostenibilidad del Ayuntamiento de Zaragoza.

Butler, David
Director, Centre for Water Systems, School of Engineering, Computing and Mathematics,
University of Exeter.

Butterworth, J.A.
IRC International Water and Sanitation Centre, Delft, the Netherlands.

Cabrera, Enrique
Catedrático de Mecánica de Fluidos. Instituto Tecnológico del Agua. Universidad Politécnica. Valencia.

Celma Celma, Francisco Javier
Director de la Agencia de Medio Ambiente y Sostenibilidad del Ayuntamiento de Zaragoza.

Costa, Heloisa
Universidade Federal de Minas Gerais, Instituto de Geo-Ciências, Departamento de Geografia. Belo Horizonte

Costa, Geraldo
Universidade Federal de Minas Gerais, Instituto de Geo-Ciências, Departamento de Geografia. Belo Horizonte.

Darteh, Bertha
Department of Civil Engineering KNUST and SWITCH Accra Learning Alliance

Dias, Janise
Universidade Federal de Minas Gerais, Instituto de Geo-Ciências, Departamento de Geografia. Belo Horizonte.

Dziegielewska-Geitz, M.
European Regional Centre for Ecohydrology under the auspices of UNESCO, Polish Academy of
Sciences, and Integrated Restoration Institute,
Poland

Egea, Pilar (adjunta al coordinador)
Profesora Titular de Economía Aplicada. Universidad de Zaragoza.

Fraguas Herrero, Alberto
Director Ejecutivo de Green Cross España.

Garrote de Marcos, Luis
Universidad Politécnica de Madrid, ETS Ingenieros de Caminos.

Hernández Moreno, Enrique
Gestión Integral del Agua de Aqualia.

Ibáñez Carranza, Juan Carlos
Canal de Isabel II. Madrid..

Kleiner, Yehuda
National Research Council Canada

Knauer, Sônia

Prefeitura de Belo Horizonte, Secretaria Municipal de Meio Ambiente. Belo Horizonte.

Lama Pedrosa, Beatriz

Universidad Politécnica de Madrid, EU Ingeniería Técnica de Obras Públicas.

Lasa García, Vladimir

Delegado de Recursos Hidráulicos de La Habana – Cuba

Manning, N.

International Water Management Institute, Addis Ababa, Ethiopia

Marchena, Manuel Jesús

Consejero Delegado de Empresa Metropolitana de Abastecimientos y Saneamiento de Aguas de Sevilla, SA (EMASESA)

Martín Carrasco, Francisco

Universidad Politécnica de Madrid, ETS Ingenieros de Caminos.

Minta, Aboagye

Director, Water Directorate, Ministry of Water Resources Works and Housing, Ghana

Nascimento, Nilo

Universidade Federal de Minas Gerais, Departamento de Engenharia Hidráulica e Recursos Hídricos, Belo Horizonte.

Pozo, Cristina del

Presidenta Fundación Paisaje.

Quiñones Jalisto, Lucio

Centro de Educación y Comunicación “Guaman Poma de Ayala”. Coordinador del proyecto Gestión Integrada de los Recursos Hídricos.

Rajani, Balvant

National Research Council Canada.

Rodríguez Briceño, Emiliano

Director General del Sistema de Agua Potable y Alcantarillado de León, México.

Romero Tierno, César

Subdirector General de la Fundación San Valero, Zaragoza.

Saldaña Rodríguez, Juan Francisco

Asociación Vigilantes del Agua. República Dominicana.

Sancho Díaz, Javier

Director general de CONTAZARA. Zaragoza. Correo electrónico:

Silva C., da

IRC International Water and Sanitation Centre, Delft, the Netherlands

Sutherland, A.

Natural Resources Institute, Chatham, University of Greenwich, UK

Vairavamoorthy, Kalanithy

Professor. University of Birmingham, UK; UNESCO-IHE, Netherlands.

Valle, Javier del (relator)

Departamento de Geografía y Ordenación del Territorio. Universidad de Zaragoza

Vela Pardos, Noelia

BSH Electrodomésticos España, S.A. Avda de la Industria 49, 50016 Zaragoza.

Verhagen, J.

IRC International Water and Sanitation Centre, Delft, the Netherlands

Wagner, I.

Department of Applied Ecology, University of Poland and European Regional Centre for Ecohydrology under the auspices of UNESCO, Polish Academy of Sciences

Werthmann, Christian

Harvard University, Massachussets Graduate School of Design.

Wolff, Gary

Vice Chairman, California State Water Resources Control Board, and Research Affiliate, Pacific Institute for Studies in Development, Environment and Security, Oakland California.

WATER AND THE CITY IN THE 21st CENTURY
A PANORAMIC VIEW

Enrique Cabrera

Keynote Conference

ABSTRACT:

Those formulating water policies are being set enormous challenges through humankind's population explosion over the last few decades, the impressive increase in people's standard of living and the pronounced trend of the population to congregate in urban areas. This is a completely different framework to the one that existed until just a few short decades ago and it is faced with problems that were inexistent until not long ago. The solutions that the future needs require serious investment – probable not one-time only – and, in the majority of cases, must reconcile opposed interests.

Following a brief historical journey that shows the speed of the changes undergone, what follows is an analysis of the larger problems, the main actions that his solution requires and some of the difficulties caused by the implementation of this solution. The conclusion features broad outlines that, independently of the individual case (within the water and city context, the casuistry to be found around the world is, practically, infinite), will always be useful to follow.

KEYWORDS:

Water, city, sustainability.

WATER MANAGEMENT IN MOROCCO WITHIN A COMPLEX AND UNCERTAIN ENVIRONMENT

Fatiha Belamari

ABSTRACT:

Supplying Moroccan villages with drinking water was conceived in a progressive form, but through a dynamic process it has changed from crisis management to a long-term outlook. In fact, Morocco's geographical location and the large growth in urbanisation have forced the public powers to define strategies to improve the level of service and to make it more generally available. The actions undertaken have particularly looked at using surface water, the creation of ONEP as a long-term planning body, the establishment of a tax system according to consumption, the setting up of a surcharge in the name of national solidarity and making people aware of the water economy.

However, the radical change came about at the beginning of this century when an integrated and lasting management approach to the problems of this resource was adopted in order to perpetuate the experiences, make the drinking water installations safer and reinforce them taking them even to the outer edges of the villages affected by high levels of migration.

Nevertheless, beyond the actions of national politicians based on a dynamic planning strategy, good governance and the availability of a reliable information service, the complexity of the current system means we need to develop other forms of local, national and multi-national partnerships with the aim of preserving the environment and the survival of natural resources.

KEYWORDS:

National solidarity surcharge, good governance, Morocco National Drinking Water Department (ONEP).

THE EXPERIENCE IN HAVANA

Vladimir Lasa García

ABSTRACT:

Havana has a population of 2.2 million inhabitants, of whom 98.9% are supplied through the aqueduct networks. There is an organizational structure appended to the Provincial Water Resources Delegation which provides the services of the complete water cycle – fulfilling the legal requirements related to making the most of water resources, the optimisation of infrastructure exploitation and the protection of the environment.

The main problem with the supply system is its serious deterioration and its obsolescence due to years of exploitation – leading to losses estimated at 58%. The consequence of this is a reduction in the hours of service and work pressure within the distribution network; in addition, there is deterioration in public roads and an increase in the cost of water production expenses due to the consumption of extra electrical energy and chemical treatments.

The Cuban State tries to mitigate the effects of this situation by giving priority to the funding of programmes to restore the networks and pipelines, modernising the water quality systems, equipment and through rehabilitating the Supply Sources and guaranteeing energy for these.

KEYWORDS:

Rehabilitation, modernisation.

THE SEVILLE EXPERIENCE IN URBAN WATER MANAGEMENT

Manuel Jesús Marchena

ABSTRACT:

The Seville Metropolitan Water Company (EMASESA) has been managing water in the city of Seville for 34 years. This lengthy experience includes having a complete system for managing the whole water cycle in 11 municipalities – with a population of about a million inhabitants – but it is conditioned by the geography of the area (in particular by the river Guadalquivir) as well as by the regional climate.

Seville is a constantly growing city where population increase is balanced by a drastic reduction in water used by the system. This reduction is the result of a consumption per capita drop in (down to 129 litres/inhabitant/day for domestic uses) as well as a fall in the total losses within the system. These achievements are a direct consequence of demand management reducing losses throughout the network through the development of a system that detects leaks as well as through continuous investment in installation overhaul.

With an annual average investment of more than 40 million – the equivalent of 45% of the company's annual invoicing – the effect of the climate has been minimised. This climate brings droughts lasting two to four years and occurring approximately every four years. Despite this climate, Seville currently has a quality service and a guaranteed supply for about three years.

The activities performed to achieve water efficiency (centralising data, follow-up on ANR values, sectoring and diagnosis of the network, renovation of networks and modernising of the counters) allow us to have currently fulfilled the objective that we had set for 2011: total losses in the system below 15.5% (currently at 14.8%).

The achievement of these goals, as well as the guarantee and quality of the service provided, have been accompanied by starting up other activities relevant to EMAESA system operation: a progressive tax structure, a plan to encourage the use of individual counters in communities (Plan 5), help in the planning for the "correction" of dumped polluting industrial waste, agreements by sectors, installation of saving devices in public installations, establishment of alternative networks for non-drinking water intended for irrigation and the corresponding norms and restrictions to regulate this.

Placing emphasis on Innovation is one of the factors that have allowed the company to remain at the forefront of technology, improve its efficiency and have information systems with the target being a collection of commands that will allow decisions to be taken effectively and with agility. The purpose of these projects is in communication systems (fibre optic network, digital radio-telecommunications network, etc), management systems (supercritical oxidation of the sludge in the purifiers, mobile management of incidents, management programme for AQUA company), and efficiency (energy audits, photo-voltaic solar power plants, changing diffusers).

KEYWORDS:

Management of complete cycle, EMAESA, water efficiency.

FOCUSES IN WATER RESOURCE MANAGEMENT IN THE DOMINICAN REPUBLIC

Juan Fco. Saldana R.

ABSTRACT:

Water management in the Dominican Republic has varied from one focus to another. In each transition, it has established a very interesting element of management from the perspective of water management and its situation at the time. Currently, the change in management required is becoming an unprecedented challenge wherein the level of integration of the various players needs not just governmental policies but also participation and the re-structuring of the sector. The characteristics of these focuses and future angles are laid out in this paper.

KEYWORDS:

Management, water, Dominican Republic.

SUSTAINABLE DEVELOPMENT IN WATER SUPPLY AND SEWERAGE IN CITIES: THE CITY OF ACCRA, EXAMPLE OF LEARNING ALLIANCE SPONSORED BY SWITCH PROGRAM

Esi Awuah, Aboagye Minta and Bertha Darteh

ABSTRACT:

Within the West-African region, Ghana is one of the strongly growing economies. Accra is the administrative, political and commercial capital of Ghana with a population of over 3 million. It is the largest and fastest growing metropolis in Ghana with an annual growth rate of 4.3 % (National Population Census, 2000). Accra, like many parts of the world, faces challenges managing its water. A large part of the population is not connected the regular water supply network, less than 5% of the households are connected to the city sewerage network, and many areas in Accra are prone to frequent floods. Moreover, water is becoming increasingly scarce and the institutional framework is fragmented and ill-equipped to deal with the ever increasing complexity of managing urban water in Accra (SWITCH Accra City Story, 2008). With the launching of the National water Policy framework in 2008, coordinated by the Water Directorate, it provides leadership and direction towards sustainable water and sanitation plans, policies and programmes. The policy framework also supports the establishment of learning alliance initiatives such as the EU sponsored SWITCH Learning Alliance and other stakeholder collaboration. There has been an increased participation of stakeholder and joint sector reviews.

KEYWORDS:

Learning alliance, stakeholder engagement, sustainability.

INTEGRATED URBAN WATER MANAGEMENT IN BELO HORIZONTE, BRAZIL

Nilo Nascimento, Heloisa Costa, Geraldo Costa,
Janise Dias and Sônia Knauer

ABSTRACT:

Integrated urban water management (IUWM) presents a wide range of different challenges to be effectively implemented. This may concern, at a first level, to promote integration of different water domains, such as water supply, sanitation, storm water management and receiving water protection at the urban environment. Due to the close relationship between water and land use, promoting IUWM requires also the development of integrated policies consistent with the territorial management. That is the case of urban development policies having major impacts on land use, such as housing and road system and transportation. Furthermore, local policies usually reflect on the water management at other territorial scales, beyond the municipal borders, usually involving the metropolitan and the river basin scales. Therefore, significant political and managerial efforts have to be developed by a wide range of institutions and stakeholders in pursuing sustainable and integrated urban water management within this complex political and institutional environment. The present paper centres on the assessment of the Belo Horizonte city experience in IUWM policy formulation and institutional development, focusing on the recent implementation of its Municipal Environmental Sanitation Policy. Since 2001, the Belo Horizonte municipality implemented a Municipal Environmental Sanitation Policy, aiming at providing universal access to urban infrastructure and services at the municipal scale, promoting participatory decision-making and social control on water policy formulation and implementation, recovering environmental degraded areas, particularly urban water bodies, and improving managerial instruments such as planning and funding for environmental sanitation actions. Belo Horizonte is a planned city built in 1898 to become the capital of the Minas Gerais state, in Barzil. It has 2,227,400 inhabitants with a population density of 6,900 inhabitants/km^2.

KEYWORDS:

Integrated urban water management, participatory processes, urban policies, water management planning.

BEYOND PRIVATIZATION:
LESSONS FROM THE UPPER MIDWESTERN UNITED STATES AND THE CANADIAN PROVINCE OF ONTARIO

Gary Wolff

ABSTRACT:

Water managers face significant challenges meeting the water supply, wastewater collection and treatment, and stormwater management needs of the communities they serve. Numerous solutions have been proposed, including private sector involvement, known generally as privatization or public-private partnerships.

The debate over privatization has overshadowed discussion of the determinants of performance. Research on water systems in the upper midwestern United States of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin, and the Canadian Province of Ontario, demonstrates that 'public versus private' is not the bright line that separates success from failure. Instead, performance depends on effective staffing, consistent public support for sufficient funding, better asset management systems, performance measures and rewards, and more stakeholder involvement and transparency. These lessons extrapolate to other regions of the United States, and beyond.

This paper summarizes research and examples that will assist urban and rural municipal-level decision-makers to assess problems, identify possible solutions, and choose among those solutions. It provides practical information about improving the effectiveness of water, wastewater, and stormwater governance systems, whether public or private.

KEYWORDS:

Privatization, public-private partnerships, water utility restructuring.

THE ZARAGOZA EXPERIENCE IN THE DESIGN OF FINANCIAL TOOLS FOR MANAGEMENT OF WATER FOR DOMESTIC USES

Ramón Barberán Ortí

ABSTRACT:

The taxes that are levied for public use of the water supply and sanitation in cities should have four main functions: sufficient funding for the service, fair sharing of costs amongst users, efficient assigning of water to its various uses and minimising negative environmental effects. These tasks should be undertaken without the imposition of exorbitant costs on the body responsible for the service for their application or on users for their fulfilment. The correct running of these tasks can be summarised in the following main rules: sufficiency, equality, efficiency, sustainability and simplicity. In this speech, the recently implemented tax from the city of Zaragoza (Spain) is presented: through this they have tried to make these 5 principles compatible – paying special attention to equality, typically ignored in traditional designs. Specifically, the aim is to resolve the problem created by growing block taxes that tax the aggregate consumption per household (the problem consists of the satisfaction of water needs of the individual being taxed more heavily the larger the family to which they belong), without this leading to a loss of incentives to use water efficiently and not waste it. The new design of this tax is – at the most basic level – applicable to any other city and, therefore, of general interest.

KEYWORDS:

Design of water taxes, water prices, water for domestic use, equality, efficiency, sustainability.

ECONOMIC PROBLEMS IN WATER MANAGEMENT IN POOR COUNTRIES

Alberto Fraguas Herrero

ABSTRACT:

In poor countries, the water crisis is one more indicator of social and political inequalities. The problems derived from deficient water management – environmental, health, economic, etc – hit a high percentage of the poorest sectors of the population in many cases. The lack of collection infrastructures and, above all, those for water distribution contributes to the worsening of the situation as this makes access ever more expensive, making the situation in the poorest sectors ever worse – as these must, on occasion, pay 20 times the cost of water compared to other wealthier families. The fulfilment of the Millennium Development Objectives is an opportunity to improve in the medium-term and, in the long-term, solve the problem, thus minimising negative global economic balances at the same time as helping to resolve a situation that is unjust and has its own social, sanitary and ecological problems. Greater public action compared to that currently apparent as well as strict regulation of private initiative could be the important weapons in a solution that must always start from the principle of considering access to water and sanitation as a Universal Right for humankind.

KEYWORDS:

Water Crisis and poverty. millennium development objectives. public and private funding.

INTELLIGENT MEASURING EQUIPMENT FOR MANAGING WATER DEMAND

Javier Sancho Díaz

ABSTRACT:

At the beginning of this century, a European Directive started to function and this establishes a framework to be applied across these nations so as to protect the environment, treating it as heritage rather more than as a resource, to act consequentially to improve the state of waters and ensure sustainable development. To achieve this goal, the focus on the classical balance between supply and demand – more a thing of the last century – needs to be converted into one of management and use, looking, in addition, for a permeability between the two concepts in which the role played by the management of the demand seems more opportunely oriented towards management and efficient use of water. For this new angle, intelligent measuring equipments are very powerful tools that go far beyond the old concept of mechanical water meters, incorporating electronic technology and the provision of information and communication. The idea is not just to mesure water used, but to know how it has been used as well. As an example, the equipment can supply information concerning time of use or volume used in such a way as to be able to locate leaks, bad practices, anomalous consumption and wasteful habits. This would provide definitive information so as to be able to act consequently – together with the optimisation of water management and consumption.

KEYWORDS:

Water measuring equipment, demand management, management and efficient use of water.

URBAN WATER INDICATORS SYSTEMS

Maria Berrini and Lorenzo Bono

ABSTRACT:

The UEE - Urban Ecosystem Europe - Report provides an integrated assessment of the urban environment in the main and bigger European cities and focuses on their local responses capacity and needs. The set of indicators (25) has been selected focusing to the main scope of the survey (benchmarking EU cities) so the data availability is a relevant criteria. It has been taken into consideration as much as possible the most valid and recent "common" and "integrated" European local Indicator systems and related research projects. The policy framework considered is represented by the Aalborg Commitments, the EU Thematic Strategy on Urban Environment, the Leipzig Chart. The UEE set of 25 Indicators includes 2 Water related indicators: "Domestic water consumption" and "Inhabitants served by water treatment plants". The report provides interesting data about 32 EU cities performances on this field. The concrete experience of collecting data directly with cooperation of the cities open the way for Indicators improvement and for further research and dissemination about local good practices behind the best results.

KEYWORDS:

Urban indicators, water indicators, European cities, benchmarking.

ADAPTATION IN THE FACE OF CLIMATE CHANGE SCENARIOS

Luis Garrote de Marcos, Francisco Martín Carrasco and Beatriz Lama Pedrosa

ABSTRACT:

The perspective of climate change brings up various questions regarding the adaptation policies that will be the most appropriate in the medium- and long-term in the water resources management sector. Although there is a broad consensus in the scientific community regarding the possible evolution of temperatures and rainfall at a regional level, it is still very difficult to quantify the effect that this will have on the availability of resources at a local level. The latest studies undertaken in Spain conclude that climate change will mean extra pressure to go with the many existing pressures on the water resource exploitation systems. this paper presents a review of a range of adaptation measures that are considered appropriate reactions to the new situation created by climate change. These policies could be seen as a collection of good practices or general principles whose application over the course of time would depend to a large extent on the initiative of public powers-that-be, the evolution of the climate situation and on perception in the eyes of users.

KEYWORDS:

Water resources, climate change, adaptation.

INCIDENCE OF CLIMATE CHANGE ON WATER RESOURCES

Mar Asunción Higueras

ABSTRACT:

Climate change is here and advancing at a speed and intensity above that foreseen. The fourth Evaluation report from the Inter-governmental Panel on Climate Change makes it clear how human actions contribute to global warming and the need to reduce emissions to avoid abrupt and irreversible effects.

Climate change threatens not just our ecosystems but also our societies and economy, with a higher risk of droughts, heat waves, floods, glaciers melting and rising sea levels. The consequences of climate change can already be noticed across all the continents, but it is the poorest countries that are most at risk from current effects and probably from those that will occur in the future.

In addition, in the south of Europe and in the Mediterranean region, predictions show a worsening of conditions in a region that is already subject to climate variation and risks, as well as a reduction in the availability of water, of hydroelectric power, of harvests and of summer tourism. The increase in temperatures will cause greater evaporation and transpiration from the vegetation. In Spain, it is predicted that the rainfall will decrease in quantity and change in its seasonality – with droughts occurring more frequently and in greater intensity, directly affecting water resources.

It is vital that the predictions and the climate change scenarios are taken into account in the planning of policies and infrastructures related to water.

KEYWORDS:

Climate change effects, droughts, floods, heat waves, planning in accordance with climate change scenarios.

DROUGHT ACTION PROTOCOL

Enrique Hernández Moreno

ABSTRACT:

This papers begins with an approach to the concept of drought and its types, as well as quantification through a series of international indices (ISS, IEP, PPN, ISAS, IHC, etc.).

Droughts in Spain will be looked at, placing particular emphasis on the contents of Special Plans – created by river basin organisms – and Emergency Plans – the work of managers of water supplies for populations adove 20,000 people.

Likewise, the National Drought Observatory is mentioned: this was created in a joint initiative between the former Ministries of the Environment and of Agriculture, Fish and Food.

The conclusion empashises on what is stipulated in the Water Framework Directive regardins droughts.

KEYWORDS:

Drought, indexes, special plans, emergency plans, drought observatory.

SUSTAINABLE URBAN LANDSCAPES

Cristina Del Pozo

ABSTRACT:

Currently, there is a greater awareness regarding what is referred to as water conservation used in the maintenance of urban green zones – promoting rational consumption not just in times of drought, but also as a prediction of the future as water can no longer be considered an unlimited resource. However, this rational use of water in the maintenance of green zones would be more efficient if those zones had originally been designed with the focus on rational and sustainable water use – thus avoiding both areas and species that require high water consumption for their maintenance.

In the Landscape Foundation, we aim to promote efficient water management in the design of public zones using landscaping techniques and from the design onward having these urban landscapes being more sustainable. This will achieve more efficient water and energy use, using non-polluting materials and creating micro-climates that regulate and reduce temperatures in cities, increase urban biodiversity and lead to a higher quality of life.

The basic principles in designing sustainable urban landscapes are commented on: natural design, use of native plants – plants that are adapted to the place – with a greater diversity of species, efficient use of water, greater energy efficiency, control exercised over the use of fertilisers and pesticides, mulching and composting, generating higher ecological value and techniques of xero-landscaping.

KEYWORDS:

Urban landscapes, sustainability, efficient water use, savings, reuse, xero-landscaping, urban green zone design.

WATER AND GREEN ROOFS IN DRY CLIMATES: A SPECULATION

Christian Werthmann

ABSTRACT:

In temperate climates green roofs have proven to be beneficial for urban water management. Green roofs retain storm water, ease flooding and reduce combined sewage overflows. Green roofs can have a positive effect on storm water quality and alleviate groundwater recharge. In the last decade, an increasing amount of green roofs have been installed in dry and Mediterranean climates. This paper surveys the potential benefits of green roofs as part of urban water management strategy in these climates. It comes to the conclusion that green roofs can have hydrological benefits if certain conditions are given. Their usefulness might increase due to predicted changes induced by global warming. In regions of water scarcity, green roofs can only be installed if their irrigation is part of a sustainable water regime. Besides hydrological advantages other benefits of green roofs, like cooling effects, might be of equal or higher importance in hot and dry cities.

KEYWORDS:

Green roofs, urban hydrology, Mediterranean and dry climates.

CITIES OF THE FUTURE AND URBAN WATER MANAGEMENT

Kalanithy Vairavamoorthy

ABSTRACT:

Cities of the future are likely to experience difficulties in efficiently managing scarcer and less reliable water resources. To address these difficulties successfully, there is a need to change significantly the way we manage urban water cycle. There are several key concepts that underlie this change including: flexible and robust system design, interventions over the entire urban water cycle; reconsideration of the way water is used (and reused); and greater intervention of natural systems for water and waste water treatment. Clearly changes based around these concepts will substantially contribute to a reduction in the vulnerability of cities and an increase in their capacity and preparedness to cope with global changes. SWITCH is a research project that aims to create this change by developing scientific, technological and socio-economic solutions for the sustainable and effective management of water in the city of the future – 2050.

BEHAVIOR OF A TOILET TANK WITH A VERY LOW DISCHARGE

David Butler

ABSTRACT:

A key challenge in water management over the coming decades is the issue of limiting the consumption of water in the domestic environment, without reducing levels of service. Quantification of the components of domestic demand highlights toilet flushing as taking the major share of potable water consumption (30%), making it an obvious target for improved water efficiency. This paper presents the results of a work package of the WaND research consortium (www.wand.uk.net) concerned with the field and laboratory evaluation of a prototype ultra low flush toilet that uses under 2 litres of water per flush. Specific areas of study are water saving potential, hydraulic performance and user acceptability. The study showed that replacing conventional toilets with this type of ultra low flush toilet saved over 80% of water demand in this case. Despite using much lower quantities of water, the reduced flows did not adversely affect drain and sewer function when they are appropriately designed. It was also found that although this type of technology is generally acceptable to users, women by their practice preferred to use a conventional toilet, yet rated the new toilet higher than men.

KEYWORDS:

Demand management, sewers, ultra low flush toilet, user acceptance, water conservation.

REUSE OF GREY WATER IN THE URBAN SECTOR

Emiliano Rodríguez Briceño

ABSTRACT:

The majority of the world's largest cities have limits to keeping up their growth in the medium- to long-term due to a lack of water resources in terms of quality and quantity. The great investment projects to repair the over-exploitation of the aquifers are devoted to the construction of dams or the exploitation of new underground sources both inside and outside geographical borders. However, little is made of exploring other paths such as water resources that reuse of previously used volumes. In particular, in the areas of agriculture or industry, the possibility of reusing treated waste water is broad and generally cost-effective and more attractive than producing more drinking water. Larger cities in Mexico are not unaware of water availability problems and, in particular, the city of Leon – in the State of Guanajuato – has had to implement diverse strategies to continue to grow, develop and be sustainable in the long term. The alternatives vary from reusing grey water in the private sector to removing waste for reuse in agricultural or industrial processes. The current work has as its objective sharing experiences and strategies implemented by the Drinking Water and Sanitation System of Leon and its long-term view for good management of available water resources.

KEYWORDS:

Reuse of water, grey water, liquid waste, treated water.

MANAGEMENT AND RENEWAL OF URBAN WATER INFRASTRUCTURE

Balvant Rajani and Yehuda Kleiner

ABSTRACT:

Large-diameter transmission water mains and small diameter distribution mains are essential components of urban water supply systems. Large proportions of these pipes have average ages greater than 50 years and their condition is rarely known with any accuracy. As water mains age, they deteriorate. An immediate question that arises from the utility's perspective is which pipes require attention and when. This question is discussed in terms of failure management for small diameter mains and failure prevention for large diameter mains.

This paper focuses on failure management and prevention strategies for water mains. The most common measure of deterioration of small diameter distribution mains is the frequency of failure, which can be proactively mitigated using cathodic protection to control external corrosion. This paper highlights the importance and the benefits of data collection and how subsequent analyses using models can help plan the renewal of deteriorated water mains. These analyses can assist water planners to identify which pipes to renew, when and how, subject to service levels and budget constraints. These analyses are discussed in the context of a case study.

KEYWORDS:

Water mains, failure management, cathodic protection.

THE EXPERIENCE OF ICLEI IN PROMOTING SUSTAINABLE WATER MANAGEMENT THROUGH A LOCAL GOVERNMENT NETWORK

Barbara Anton

ABSTRACT:

ICLEI is an international local government network promoting urban policies and practices that are suitable to positively contribute to global sustainability conditions. The management approaches developed by ICLEI aim at building sustainable communities while protecting global common goods such as fresh water.

The core of ICLEI's Water Programme is the Water Campaign approach. This is a performance based framework in which local governments work along a process of five milestones. The generic milestones - to be adapted for application in different regional settings - are: (1) an inventory of the current local water (resources/management/access/...) situation, (2) the setting of targets, (3) the development of a local water action plan, (4) the implementation of policies and measures, and (5) the monitoring, evaluation and reporting of achievements.

The ICLEI Water Campaign was launched in the year 2000 and has so far become especially successful in Australia. Starting with originally 5 pilot local governments, there are now close to 120 city councils participating in a voluntary capacity-building programme all across the continent.

ICLEI Oceania, located in Melbourne, aggregates the outcomes of the activities into national reports. These provide a snapshot of water situations, trends and priorities at local level in Australia and an overview of the targets to which the participating councils have committed themselves. The more than 40 local water action plans that have been formulated up to now reveal a broad range of practical approaches striving to keep a balance between sustaining precious eco-systems and meeting the water needs of the local communities.

KEYWORDS:

Water resources, local water management, sustainability, network, performance orientation.

LEARNING ALLIANCES FOR INNOVATION IN URBAN WATER MANAGEMENT

J.A. Butterworth, M. Dziegielewska-Geitz, I. Wagner, A. Sutherland, N. Manning, C. Da Silva and J. Verhagen

ABSTRACT:

The Sustainable Water Improves Tomorrow's Cities' Health (SWITCH) consortium - a research partnership focused on long-term improvements in urban water management in developed and developing countries - is piloting innovative research processes that aim for more effective urban water science and wider and more integrated use of research within cities. In this paper, learning alliances are introduced as an approach to build multi-stakeholder partnerships for more demand-led research and wider scaling-up of the use of research findings. The need for an integrated approach to deal with the complexity of urban water management is discussed. Using the example of the city of Lodz in Poland the learning alliance approach is illustrated, and some examples are given on how impact evaluation can be used innovatively in the design and implementation of research partnerships. Finally, some more general lessons learned to date are synthesised from SWITCH and other similar learning projects.

KEYWORDS:

Cities, demand-led research, innovation systems, learning alliances, SWITCH, urban water management.

THE LIFE OPTIMIZAGUA PROJECT:
A EUROPEAN REFERENCE POINT FOR EFFICIENT WATER MANAGEMENT IN IRRIGATION

César Romero Tierno

ABSTRACT:

The pilot projects within the framework of the European OPTIMIZAGUA project – passed within the framework of the European Union's LIFE Programme – has shown the importance of applying mechanisms, methods and efficient irrigation technology so as to obtain great water savings in various different irrigation uses. The starting point for the experimentation is in two public gardens in the city of Zaragoza, private green zones within a residential estate in Logroño and applying these prototypes to various crops in two agricultural farms in Huesca and Soria.

The philosophy of the project is that of combining traditional rainwater collecting and water regulation systems with the incorporation of expert systems based on emerging technology (telemetry, dampness finders, programmable automatons, etc) fed by renewable energies which have made it possible to irrigate according to the specific plant's needs and to do so only in climate conditions in which irrigation is efficient.

Savings in water have passed 60% in the irrigation of public park lawns, in addition to obtaining results that are of great environmental interest – such as the reduction of the number of times it is necessary to cut the lawn thanks to efficient irrigation or the savings in emissions associated with the energy bill for "moving water".

KEYWORDS:

LIFE OPTIMIZAGUA Project, efficient irrigation, water saving, public parks, savings in the energy bill for "moving water", tradition and innovation, mechanisms for intelligent irrigation, renewable energies.

RESEARCH INTO EFFICIENCY POTENTIAL THROUGH USE OF DISHWASHERS

Juan Carlos Ibáñez Carranza and Noelia Vela Pardos

ABSTRACT:

In the Community of Madrid, residential use accounts for over 60% of the total amount of water supplied. The use of water in the home in its various final forms has been the object of several studies undertaken by Isabel II Canal, the supply company, and, in other regions and countries, by various bodies and companies. However, with the exception of some laboratory tests, there are no known studies that show the use of water in the domestic task of dish-washing.

Isabel II Canal and BSH Home Appliances Spain took on a joint piece of research into the use of water in dish-washing in households and the improvements in efficiency that can be achieved through the use of an efficient dishwasher – comparing this to hand washing.

The study was undertaken in real conditions in a total of 155 households. Over a period of two months, the participants committed themselves to only hand-wash their dishes. Later, efficient dishwashers – class AAA – were installed and over a further two-month period the consumption continued to be measured – now using the machine supplied.

Monitoring of the consumption was achieved through speed counters installed in kitchen taps and a precision counter with a digital pulse emitter at the stopcock in the house. This counter, connected to an electronic mechanism, constantly measured consumption, allowing for there to be a distinction made between water used for various tasks and, in particular, the use of the dishwasher. The continuous measuring of consumption meant it was equally possible to measure absences in the household and other circumstances that could affect the final results. Through taking these conditions into account, it is possible to homogenise the results obtained.

The first results showed a clear improvement in the efficiency of water use, with a reduction in consumption equivalent to 10% of the total amount of water used in the household. As regards the energy consumption, the result was also positive with an average saving of 1kWh per day.

KEYWORDS:

Efficient water use, domestic use, dishwasher.

THE CUSCO RETURNS TO ITS MOST PRICELESS RESOURCE: ITS RIVER

Lucio Quiñones Jalisto

ABSTRACT:

The current speech aims to show aspects of water management in the Peruvian Andes (Huatanay-Cusco sub-basin). A shared problem and favourable conditions made it possible to begin a participatory plan more than 11 years ago, allowing the population of Valle de Sur in Cusco to become aware of the existing problem and of the need to participate in the search for solutions. This joint activity has meant the people being able to access water for consumption and irrigation, additionally favouring the management of certain natural risks and the recovery of the ecosystems. The remaining challenge is to do something about the enormously polluted state of the Huatanay River – the backbone of Cusco Valley and the current gathering point for the city's liquid waste.

Many projects aimed at the sustainable consumption of the resource have been implemented with the participation of local players with support coming via international cooperation – highlighting the importance of collecting and of information to ensure the sustainability of the process. Nowadays, the main political players in the Valley are impelling the authorisation of a zone for agreement for the integrated management of the water resources – this being one of the first such cases in Peru. The process continues but there have been significant advances and we believe that in a short while we will be able to say "Cusco will never turn its back on its river again".

KEYWORDS:

Integrated management of water resources.

WATER AND THE CITIES OF TOMORROW. GROWTH AND DEVELOPMENT

Javier Celma Celma

ABSTRACT:

Cities should re-examine their current models of unlimited growth and adapt them according to the guaranteed supply of local resources – among them water.

At the same time, and bearing in mind the objectives of sustainability, rational use of water should be encountered and its management be accomplished in accordance with criteria of efficiency and savings – guaranteeing the supply to the citizen in terms of quantity and quality. This involves reducing water consumption, recycling and reusing the supply as much as possible; during use, it must be polluted as little as possible and then it must be purified before being returned in an acceptable condition to natural water bodies so that its effects on the ecosystems will be minimal.

The involvement of civil society – through participation processes – is vital to be able to face the necessary changes in the management of water resources and the linked ecosystems.

KEYWORDS:

Management of water, taxes, awareness, efficiency.

CITIES ON WATER:
FIGURES OF THE NEW CENTURY

Rinio Bruttomesso

Keynote Conference

ABSTRACT:

If at the end of the last century there was a general discovery about water in cities, this century will be characterised by a re-evaluation – an evaluation of water within its fabric, thus contributing to improving the quality of urban life and favouring the development of economic activities located along waterfronts. Riverside or seaside cities in all continents will be favoured in global urban marketing as they have higher possibilities of attracting economic resources for future investment. In this framework, the city-ports will acquire great importance that, thanks to the indispensable collaboration between the various public administrations, will be able to undertake actions with the objective of redesigning the role of these cities and re-launching their image on an international stage.

KEYWORDS:

Urban development, city-port relationship, waterfront.

Thematic Week 3

WATER FOR LIFE

[Healt, water quality]

Positioning document[3]

Coordinator: **Antonio Sarría Santamera. Instituto Carlos III**

Asistant Coordinator: **María Sandín Vázquez.Universidad de Alcalá**

Scientific Committee:
Luis Gómez López. SESPAS
Francisco Falo Fornies. Director General de Salud Pública. Gobierno de Aragón

Rapporteurs:
Verónica Orosa Monteso. Universidad de Alcalá
María Dolores Belenguer Sánchez. Universidad Politécica de Madrid
María Sandín Vázquez. Universidad de Alcalá

The possibility of not one single drop of that precious liquid falling from the taps of the houses had not occurred to the doctor's wife; this is a defect of civilisation, we are used to the comfort of piped water, taken to our homes, and we forget that, for this to happen, there must be people who open and close the distribution valves, pumping plants that require electricity, computers to regulate the debits and administer reserves, and eyes are necessary for everything.

1. INTRODUCTION

Health and the environment around us are closely related. The air we breathe, the water we drink, the place where we work or the buildings where we live play a very important role in our well-being and health. This relationship between environment and health has been a constant factor in public health. Here we would have to mention, for instance, the ground-breaking work by Edwin Chadwick and his Report on the sanitary condition of the labouring population of Great Britain (1842) where he shows the impact that the deteriorated British urban environment has on health and where he defends the intervention of public powers in the sanitation of the cities. This work had a considerable impact on the opinion of the time and influenced the adoption of the subsequent and timid health reform measures contained in the 1848 Public Health Act.

Lalonde's work is another milestone worth highlighting, where he comments on the factors that determine health: health services, human biology, lifestyles and the environment. Nowadays the factors that determine health are discussed in

[3]This document has been compiled from the written speeches, oral presentations, discussions during sessions and the distillation of all the above prepared by the moderators, speakers and coordinator, supported by the Water Tribune team.

a broader sense. Hence, we can highlight those factors that can be controlled by the individual (behaviour and lifestyle) and those that he or she cannot (social and economic conditions and the environment). Water, including its access and its good quality, is one of the determining factors that cannot be controlled by the individual. Access to water and sanitation does not depend on people, nor does the quality of water. The public powers are basically responsible for guaranteeing access to sanitation and water quality.

This week's objectives are divided into three blocks:

- Water for life and public health: Reflect upon the idea of water as a basic factor that determines people's health and access to water as a pre-requisite for people's quality of living; show that a large part of the global morbidity-mortality is related to the access and quality of water and identify current lines of work in public health in this setting.
- Water for life and society: Discuss the different intervention models to guarantee access to sanitation and water as well as the results that the different social players (international organisations, governments, unions, associations, universities and women's movements) have achieved thanks to their research and work, implementing programmes to improve the access and quality of water and sanitation.
- Water for life and implications for the decision-makers: Discuss, from different viewpoints (research, media, governments), what political measures would have to be taken to guarantee water for life, water of the right quality and sufficient quantity to protect the health of the individuals and peoples.

2. REFLECTIONS

Is having water an acknowledged human right?

Water is an essential element for life. It is a basic determining factor of health and an essential pre-requisite for the realisation of all other human rights. The Committee on Economic, Cultural and Social Rights of the United Nations approved a "general comment" in 2002 on water as a human right (General Comment number 15. Geneva, 11-29 November 2002) indicating that: "*Water is fundamental for life and health. The human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realisation of other human rights".*

The General Comment indicates that: *"the human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses"* and requests governments to adopt strategies and plans of action to make the reality of the right to water efficient.

How does access to water and to sanitation and water quality affect people's health?

The World Health Organisation (WHO) has estimated that 25-33% of the global burden of disease can be attributed to environmental risk factors. Children under the age of 5 seem to be the ones that support the greatest environmental burden. The proportion of environmental risks decreases with economic development. On the other hand, important inequalities in health related to water have also been identified.

More people die each year from diarrhoea than from malaria. The lack of access to drinking water is a pre-requisite for the quality of life of people (both due to the physical need for water to drink and due to the lack of hygiene and increase of associated pathologies derived from its shortage). Non-potable water is a vehicle of many diseases that would close the circle of poverty, lack of water, disease, inability to work, more poverty, more lack of water and more disease.

Apart from the diseases traditionally associated with water, such as diarrhoeas, malaria, schistosomiasis, intestinal helminthiasis (ascariasis, trichuriasis, anchilostomiasis), Japanese encephalitis, hepatitis A, arsenic intoxication, and dental and bone fluorosis), the presence of persistent toxic compounds (PTCs) in water must also be considered, whose real magnitude today and tendencies – as well as geographic, environmental and social diversity- are still widely unknown. It is acceptable that an important part of the negative impact that some PTCs are having on the quality of life of large sectors of society can be avoided if rapid changes are made in our working, production, transport and consumption methods, as well as other fundamental methods in the organisation of our societies.

Human activity per se contributes to worsening this situation. Climate change, the increase in the global consumption of water and the increasing pollution of rivers, lakes and groundwater, is increasing the magnitude of these problems.

Are the water-related Millennium Development Goals being met?

Goal 10 target 7 of the Millennium Development Goals (MDG) is *"Reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by the year 2015 ".* According to this and based on the 2004 data published by the WHO:

▶ To meet the water supply related target of the MDG, from 2004 to 2015, 260,000 more people per day must get improved water sources.

▶ To meet the sanitation related target of the MDG, from 2004 to 2015, 370,000 people per day must get improved sanitation services.

Just 1% of the GDP is now being invested and about 5% would have to be invested in water sources and sanitation infrastructures to reach the MDG. Not meeting the MDG would cause more than 1 million deaths from diarrhoea, high health service costs and loss of a great volume of time for training, both due to the repercussions of the diseases and due to the time lost in obtaining the resource.

The population growth predictions warn that there is going to a considerable increase in urban population (in number of cities with more than 10 million inhabitants, and 80% of them will be in poor countries). This fact must be taken into account when planning and investing in water access and sanitation projects.

What do we know about the effectiveness of the interventions?

Various types of interventions can be carried out related to water (increased access, improved sanitation, improved behaviour and lifestyles of people related to hygiene). The benefit they can bring about must be assessed in the field, on those people to whom they are destined and under the conditions in which they are going to be carried out.

There is currently evidence of the direct effect of health on the decrease of many diseases (such as diarrhoea or trachoma) and also of non-health effects (such as on gender questions, as in certain populations, girls can stop going to school if the school does not have sanitation). But it is also known that certain interventions do not work, such as carrying out sanitation programmes that do not correspond to the local reality where they are going to be applied.

Some of the factors that contribute to the success of interventions in public health would be:

- Political support and involvement of the governments
- Local leadership
- Community mobilisation
- Sufficient resources

If the needs of the people are not taken into account from the time problems are identified and they do not participate in interventions, projects run the risk of failing, as the receivers of actions do not perceive their benefit. This is a key factor for the sustainability and success of such projects and to guarantee this, the people must be given the real possibility and the mechanisms that make this participation possible.

To achieve this connection between local and government aspects, harmonisation spaces must be created, supporting decision-making and generating management policies based on group experiences.

What answers have been put forward?

The starting point for the UN Millennium Project Task Force on Water and Sanitation, to achieve water and health related millennium goals is to cut in half, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation, is to acknowledge the supremacy of the action at national and sub-national levels –as near as possible to the place where the problems and opportunities are located. The key to achieve the goals will be to mobilise the people themselves, country by country, especially people from poor districts and other marginalised communities where there is less access to the service. It is clear that the approach must begin with the causes.

Local, regional and national governments have the main responsibility to expand the access to water supply and sanitation services. They must guarantee the elimination of any inequalities that are observed in the access to water and to sanitation. Although the governments do not need to participate directly in the service supply, they do need to establish standards for the service providers (including public services and the private sector), and intervene if necessary to make things happen. An overarching question is that the starting point must be a national action – acknowledge the MDG as development goals with a national priority, preparing strategies and plans of action to achieve them, opening up opportunities for the action of the community and mobilising public awareness and support, especially on sanitation and hygiene services.

Water management must be done globally, bearing in mind all the players that intervene in the process (national, regional and local governments, water boards, NGOs, etc.) The way to guarantee the agreement of the different parties of a work process where there may be a conflict of interests is always via dialogue and negotiation. There are two directly related elements that are essential: a vocation of transparency and the availability of information systems that enable decisions to be taken. This permits creating spaces where agreements are reached from all governance levels, converting these processes into instruments for learning.

To meet water access and sanitation goals, international aid must be increased by $0.9 billion per year, but it is a tendency that is being created now, so it is a realistic goal and could be met. To be effective, it is essential for this existing aid to be redistributed. The cost to guarantee water and sanitation all over the world is 2 cents of a dollar per day and per person in developed countries.

From what perspective must the problem be solved?

The problems that affect our health are complicated and have different origins. Health depends both on social organisation that we endow on ourselves and on the actual reality of the ecosystem where we live. Both of these are related to the power structure and forms of government of our societies.

This proposal is arising from both a research perspective and from the practical application, and to pose "win-win" strategies that will improve both the social organisation and the health of the ecosystems. It is a question of looking at "upstream" problems, including aspects that have to do with how we live and where we live, with social inequalities, cultural values, lifestyles, as well as the actual water supplies and infrastructures.

The approach must go beyond the service procurement, therefore. It must be integral and also guarantee sustainability. The health and development of human beings depend on healthy ecosystems. Ecosystems deteriorate due to pressure exerted on them by human development patterns and activities. There is thus an urgent need to understand the relationships that exist between public health, ecosystems and social and economic conditions. The target is to design interventions to reconnect people and ecosystems, and thus protect both.

What is the role of the communication technologies and media?

Current challenges -(population growth, increase of population in urban areas, high consumption, climate change) demand a new water culture in society and in institutions: key water-related aspects require consensual decisions. Information, transparency and participation are key aspects for change.

Media must assume their responsibility to guarantee people's rights to be well-informed, which is essential for them to participate as users and citizens. Media, therefore, have the obligation to foster the ecological awareness of society. However, whilst the media continue to look for headlines with half-truths and absolutely without any scientific rigour with the only aim of selling copies, the information will never be transparent.

Internet is a magnificent tool that offers greater access to information. Governments must make better use of their resources to favour a speedy exchange of knowledge among users. But this globalisation of information is still not real as the map of access to the Internet is similar to the map of access to water.

Having information permits taking decisions and determining the value of the different proposals. These systems must offer versatility and the capacity to adapt to new situations, incorporating a philosophy of continuous improvement and innovation as new information and communication technologies advance.

What is the responsibility of the public health systems?

Research into public health must respond to the repercussions that changes in water quality and quantity may have on people's health. It is also essential for policy-makers to use the available evidence to implement measures that guarantee the water quality and that the information systems are used to obtain assessable data, as well as to apply them. Politicians must have and use appropriate, pertinent and reliable information about the environment to offer answers to the environmental problems of our time. The "Assessment of the Impact on Health", a combination of procedures, methods and instruments that will help judge possible effects of a policy, a programme or project on the health of a population, in this case, the effect of water policies on health, are useful tools for decision-making.

So, what is water for life?

Perhaps if there were a clear definition, this would help disseminate the fact that there are many human beings who do not even have water to be able to live. Perhaps, it may help identify who, by "closing the taps" of some families, is infringing the prerequisite for the realisation of all the other human rights. Perhaps it may help by making a clear distinction between what is water as a human right and what is water as a business, and thus begin to look for strategies so that for once and for all, the necessary actions are taken to be able to satisfy the human right, without which none of the other rights can be achieved. Water for life: water for the human being to be able to live.

3. APPLICABILITY AND REPRODUCIBILITY

Evidence shows that success is related to the participation of the beneficiary population, and when emphasis is placed on the groups with more inequalities, such as those that are affected by gender questions. Women are not victims of the processes; they are members of a society and have the responsibility to get involved and the right to be involved in water management processes.

A key determining factor is the incorporation of water and health programmes into politicians' agendas, for them to make it a fundamental part of their programmes and foster the demand in society, for society to assume this demand as a priority and essential progress to attain their right to health.

The involvement of society means that the local reality must be taken into consideration, and that in turns represents the compulsory contextualisation of solutions. The participation of society can only take place based on transparency. As mentioned above, information systems as support elements for decision-making are key pieces for the people's participation, guaranteeing transparency. It is not a matter of knowing the water cycle, but the relationship of the access, the management and consumption with the environment, (social, of political decisions). The information systems should be integrated into society to achieve positive results, providing data in real time, key information and future predictions.

An integral and sustainable approach is thus essential, providing an answer to both the need to preserve the ecosystems and to the social reality, and the transdisciplinary vision (health, environment and social) that will break barriers and would avoid conflicts that did not exist before.

4. REFERENCES

(1) Saramago J. Ensayo sobre la ceguera. 3ª ed. Punto de Lectura. Madrid, 2006

(2) Datos extraídos de la Organización Mundial de la Salud. Consultables en: http://www.who.int/water_sanitation_health/publications/facts2004/es/index.html

(3) Hinrichsen, D., Robey, B., Upadhyay, U.D. "Soluciones para un mundo con escasez de agua". Population Reports, Serie M, No. 14. Baltimore, Johns Hopkins School of Public Health, Population Information Program, 1998.

(4) World Health Organization (WHO). Our planet, our health—Report of the WHO Commission on Health and Environment. Geneva, WHO, 1992. p. 106-144.

(5) World Health Organization (WHO). Health and environment in sustainable development five years after the earth summit. Geneva, WHO, 1997. p. 19-133.

(6) Klohn, W. and Wolter, W. Perspectives on food and water. Presented at the International Conference of Water and Sustainable Development, Paris, Mar. 19-21, 1998. p. 1-6.

(7) Niemczynowicz, J. Wasted waters. UNESCO Sources, No. 84, p. 8. Nov. 1996.

(8) Havas-szilagyi, E. National groundwater protection program in Hungary. International Conference of Water and Sustainable Development, Paris, Mar. 19-21, 1998. p.1-5.

(9) Shiklomanov, I.A. Assessment of water resources and water availability in the world. Stockholm, Stockholm Environmental Institute, 1997. p. 1-88.

(10) Environmental Protection Agency (EPA). The quality of our nation's water: 1994. Washington, D.C., EPA, Dec. 1995. p. 209.

(11) "Agua para la vida. Iniciativa del agua de la UE" Luxemburgo: Oficina de Publicaciones Oficiales de las Comunidades Europeas, 2004 ISBN 92-894-4433-9

(12) "Cómo lograr los objetivos de desarrollo del milenio con respecto al agua y saneamiento: ¿qué será necesario?" Informe Sumario Provisional. Grupo de Trabajo sobre Agua y Saneamiento. Proyecto Milenio. Diciembre de 2003.

(13) Rueda Martínez de Santos, J.R. "Guía para la evaluación del impacto en la salud y en el bienestar de proyectos, programas o políticas extrasanitarias" Investigación Comisionada. Vitoria-Gasteiz. Departamento de Sanidad. Gobierno Vasco, 2005. Informe nº: Osteba D-05-04.

(14) Comité de las Naciones Unidas sobre los Derechos Económicos, Sociales y Culturales. Observación General número 15 (Ginebra, 11-29 de noviembre de 2002)

CONCLUSIONS

Water and health

When scientific evidence of the relationship between water and health is so clear and plentiful, it is time to take decisions for action. The significance of water as a prerequisite for a healthy life and the population perversities that currently exist in this sense have become evident, so political decision-makers must adopt the necessary measures to solve those inequalities and protect that right for the people.

Water and society

The debate on water use as a human right must be gone into in depth (following the comments of the United Nations) either as a business, as an asset or as a good and search for the most adequate forms of management based on the right to water in all populations.

Despite the fact that half way through the period foreseen the water-related MDG are not being met as desired, it is time to specify which measures, bearing in mind the considerable growth of the world population, are being really efficient and are reflected in improving access to the basic right which is water. A global agreement to commit to these objectives and local implementation would be useful, giving the leading role both to agents and to the receiver populations.

Water and implications for the decision-makers

Research must be incorporated into political decision-making. The assessment of the policies carried out in water and health related issues is also a key aspect to ensure that the results for which they were designed are being obtained. And regarding public health (and related institutions), adopt an integral approach, involving social and environmental disciplines, as well as the purely health-related disciplines in order to foster the understanding of this complex but not impossible, issue, which is the repercussion of the lack of access.

RECOMMENDATIONS

I. Access to water is a basic determining factor for health and a prerequisite for the lives of people.

II. Governments must assume the responsibility to guarantee citizens this right.

III. Social participation is a key element for which information and transparency is required.

IV. Governments need resources to carry out these proposals, which must be orientated towards global proposals for development and change.

V. Quality must be related to the environment and it must adapt to the contexts and specific realities.

VI. All inequalities in access to water and to sanitation must be eliminated (between countries, social class, gender, urban-rural).

VII. Decision-making must be based both on evidence of the research and on information systems, with responses aimed both at improving ecosystems and the society where we live.

INTERVENTIONS TO REDUCE WATER AND EXCRETA RELATED INFECTIONS IN LOW INCOME SETTINGS

Wolf-Peter Schmidt

ABSTRACT:

Limited access to water and excreta disposal facilities (sanitation) are associated with diarrhoea, intestinal worm infection, schistosomiasis, trachoma and many other conditions. Evaluating the health impact of water, sanitation and hygiene interventions is difficult. Even randomised trials have at times spectacularly failed to provide unbiased estimates. Estimates of non-health benefits and potential adverse effects in addition to the health impact data are therefore crucial for decision making. From this perspective, access to adequate water quantity and sanitation has the highest priority. Low cost technologies are needed, as the wasteful approaches in industrialised countries are unaffordable and probably unnecessary in many poor settings. The failure rate of sanitation interventions is high. Successful sanitation interventions are characterised by strong political support, local leadership and community mobilisation, while only relying on limited subsidies.

Such interventions can be complemented by the (mass media) promotion of personal hygiene (*e.g.,* hand washing) which may provide additional health benefits. However, actual behaviour change has proved difficult in the absence of improvements in water access and sanitation. Point-of-use (household) water treatment has been advocated as a very effective means to reduce diarrhoea, but - as with hygiene interventions - the estimates from randomised controlled trials may to a large extent be exaggerated, while acceptability among poor populations remains low.

KEYWORDS:

Public health interventions, sanitation, water, hygiene, diarrhoea.

DRINKING WATER CRISIS DUE TO ARSENIC CONTAMINATION IN BANGLADESH:
PUBLIC HEALTH CONSEQUENCES, MITIGATION STRATEGIES AND SUSTAINABILITY

Mobarak Hossin Khan, Alexander Kraemer and Mitsuru Mori

ABSTRACT:

Access to safe drinking water is a fundamental right and indispensible for healthy life. Although Bangladesh has a plenty of surface and underground water, unfortunately water-borne diseases in surface water and recent arsenic contamination in underground (ACU) water have posed a great challenge. Presently, 97% of the rural population drinks underground water through millions of hand-pump tubewells.

Long term exposure to excessive level of arsenic (>0.05 mg/l) is highly toxic and affects all organs and systems of the body. An array of adverse health outcomes is associated with drinking arsenic contaminated water (DACW). Continuous use of DACW may increase the risk of several cancers e.g. skin and liver. Higher concentration of arsenic was first indentified in 1993 and it is estimated that 35 million populations are at risk of DACW in Bangladesh. Several thousands of arsenicosis patients have already been identified with the prospects of rapid increase in the future.

To provide arsenic-free drinking water in affected areas, the Bangladesh government in cooperation with international and national organizations has already tested several alternative options, but none of them was found to be feasible and sustainable of the grounds of acceptance, maintenance, cost and health concerns. However, some prevention strategies based on significant factors associated with DACW could improve the overall situation. Briefly this paper provides a comprehensive overview about ACU water, sources of contamination, health consequences, mitigations, preventions, and implications for Bangladesh.

KEYWORDS:

Drinking underground water, arsenic contamination, health consequences, prevention strategies, Bangladesh.

QUALITY OF DRINKING WATER IN RURAL COMMUNITIES IN WESTERN NICARAGUA

Octavio Guevara Villavicencio, Aura Lyli Orozco, Oscar González, Javier Aguirre, Guadalupe Álvarez, Gema de la Cruz Saugar, Maria Enriqueta Arias Fernández and Maria Isabel Pérez Leblic

ABSTRACT:

The aim of this study was to discover the quality of water for human consumption of the north-eastern rural sector of Leon (14 communities), according to the quality standards of the Ministry of Health of Nicaragua (CAPRE standards) and their possible sources of contamination.

A study was designed to sample 69 water sources, which supplied 47.9% of the total population of the sector. Microbiological analyses, physical-chemical analyses and pesticide analyses were performed on these samples.

Soil samples were taken in order to discover its degree of permeability. A survey was applied on the state of the wells and on hygiene-health conditions of the area.

After obtaining the results, relevant statistical analyses were performed to study the possible associations between the different variables.

The main results of the study have been that 97.1% of the samples analysed do not meet the parameters established by the Ministry of Health, for human consumption. The prevailing pollution is microbial (97.1% of the samples are contaminated, according to the microbiological analysis), followed by physical-chemical pollution (31.3%) and finally pesticide pollution (18.8%).

The statistical tests significantly associated (Phi=0.580 $p<0.05$)[4] the microbial contamination with the type of well (artisan, perforated or storage tank) and the water extraction method, by rope, electric pump or pipe (Phi=0.599 $p<0.05$). There was a significant degree of association between the microbial contamination and the presence of domestic animals near the well.

The results suggest that pollution takes place mainly due to direct introduction, due to the immersion of ropes that are dragged along the ground and contaminated with faecal water near the wells.

KEYWORDS:

Bacteriological quality of water, physical – chemical parameters, pesticide residues.

[4] Statistically significant for the Cramer V and Phi tests with a confidence interval of 95%.

RELATIONSHIP BETWEEN THE ACCESS TO WATER AND SANITATION AND THE IMPROVEMENT OF HEALTH: CASE OF THE ENGINEERING WITHOUT FRONTIERS PROGRAM IN TANZANIA

Alejandro Jiménez Fernández de Palencia and Cristina Vela Plaza

ABSTRACT:

There is a proven relationship between access to water and sanitation and healt improvement. A specific case is presented that ratifies the impact on health and quality of life of people, through the results of a programme phase related to the promotion of hygienic habits, water and sanitation (Hydro-sanitary Programme) which Engineering Without Frontiers is executing in Kigoma, Tanzania.

KEYWORDS:

Water-health relationship, cooperation programmes, assessment, Tanzania.

WATER AND HEALTH IN AFRICA:
EXPERIENCES FROM AMREF

Gerald K. Rukunga

ABSTRACT:

Globally 2.4 Billion and 1.1 Billion people do not have access to Sanitation and Water respectively. Africa has the lowest coverage only second to South East Asia. Sub Saharan Africa with a population of 770 million people has the lowest coverage at 58% for water and 36% for sanitation. 70% of the morbidity particularly for children less than five years old is related to unsafe water and sanitation. Of particular interest is diarrhoea that kills some 700,000 children annually in the Sub Saharan Africa. Some of the factors contributing to this situation include climate variability including global warming, environmental degradation, deforestation and pollution of existing sources, increasing demand for water for varied use, low allocation of resources to conserve and protect sources, poverty and high cost of services, poor enforcement of appropriate laws and policies and ignorance among others. In an effort to increase access, AMREF, the largest African Health based NGO has tested and documented a model that ensures increased access to Water and Sanitation as well as ensuring sustainability of the interventions based on the beneficiaries own efforts. This has resulted in increased access to safe Water and Sanitation, significant reduction of related diseases, increased food production, deforestation, conservation of water sources, increased school attendance and performance for especially girl child and allowed some other income generating activities using the water.

AMREF has learnt and ensured that all interventions must be environmental friendly. Lessons Learnt in the process of interventions have been shared with other stakeholders for replication as well as used to influence new policies and practices.

There are still challenges that need to be overcome including that of lack of appropriate policies and legislations, poverty; effects of global warming and ensuring communities have the capacity to sustain the Water and Sanitation services across Africa.

KEYWORDS:

Water, sanitation, hygiene, access, sustainability, partnerships, capacity building, influencing policy and practice, environmental impact, poverty, morbidity, mortality.

WATER AS A PUBLIC SERVICE AND IMPLICATIONS FOR THE HEALTH OF THE PEOPLE:

THE IMPORTANCE OF URBAN SEWERAGE

David Hall and Emanuele Lobina

ABSTRACT:

The extension of water and sanitation systems is recognised as one of the greatest contributions to public health. The historic development of these systems has been achieved through the use of public finance, not through full cost recovery and private providers. In this context, taxation policies are far more important than full cost recovery. Some of the largest developing countries are choosing to pursue similar policies, with effective results. The costs are affordable for countries with the great majority of the population needing connections, with some specific low income countries clearly in need of aid to accelerate their development of systems. The importance of public finance and government policy has been obscured by the insistence of donors on involvement of the private sector. It has also been undermined by poorly-based attacks on corruption as a cultural problem specific to developing countries; by focusing the question of affordability on global aid rather than national public finances; and arguments that water and sewerage systems are northern cultural phenomena which are inappropriate and/or unaffordable in the global south. The donor policy recipe has resulted in delayed and inadequate development of water and sanitation systems, at great cost to people in developing countries, but at no cost to donors themselves. Advocacy of private sector approaches remains in the career interests of officials and politicians in donor countries. Water and sanitation policies need to be driven by national and local policy decisions, not global donor analyses, for the sake of both accountability and economic effectiveness.

KEYWORDS:

Public finance, sanitation, accountability, corruption, public choice

INTEGRATED MANAGEMENT OF WATER RESOURCES:

GOOD GOVERNANCE TO SUPPLY THE POPULATION AND TO PROTECT THE RESOURCE

Patricio Cabrera Haro

ABSTRACT:

United Nations, in its Millennium Development Goals (MDG) and Agenda 21, the World Forum of Water and other planetary spaces have established goals to increase water access, for resource management and for people participation. The targets proposed are delayed. Local initiatives that generate sustainable development practices and efficient handling of natural resources must not be disregarded.

Work on water governance in these contexts fosters the fulfilment of these principles and by doing so, the benefits extend to both people and natural resources. Negotiation is the basis of the agreements that promote the appropriate management of water at different levels. An IMWR without a negotiation approach would foster a series of legal standards and competences that may not work as these elements do not work on the needs, relations and conflicts of the players involved.

An Integrated and Negotiated Management of Water Resources (INMWR) can establish the bases for improved water distribution among the people and the preservation of the resources.

KEYWORDS:

Governance, negotiation, participation, preservation, distribution, socio-environmental conflicts, social change.

GENDER MAINSTREAMING, EMPOWERMENT AND ACCESS TO WATER

Christine Verheijden

ABSTRACT:

Water is an essential element for life. It affects our lives globally and is embedded in our culture. Access to safe and sufficient water is a universal human right but for a large part of the world population this right still has to be ensured. Many people, especially the poor, are left out of this facility, denying them a healthy life, food security and economic welfare.

All people use water but different users have different interests and benefits with regard to availability, use and management of water. This depends on sex, age, socio-economic class, ethnicity, religion, etc. Women are the main water users as managers of the household, caretakers of the family and women farmers. Yet their crucial responsibilities, interests and contributions to the water sector are hardly recognised, let alone taken into consideration by the predominantly male water professionals while planning and implementing water projects.

Worldwide data have shown that management of water resources is more sustainable, effective, efficient and equitable when gender dimensions are taken into account in the consultation process as well as in the management and implementation of water-related services. This ultimately results in poverty reduction and a lower incidence of water-borne diseases.

A further explanation of gender concepts and empowerment is given in the paper along with examples of lessons learned and good practices with gender mainstreaming in the water sector.

KEYWORDS:

Gender, empowerment, water and food production, hygiene and sanitation, and water for nature.

ACCESS TO WATER IN THE SAHARAN REFUGEE CAMPS

Zahra R. Ahmed

ABSTRACT:

The role of Saharan women in water supply to Saharan refugee camps has been essential. But to analyse the experience of Saharan women in accessing such an important need in this area of the desert, a historical synopsis of the conflict imposed on the pacific people of Western Sahara must first be presented, as if we do not understand the roots of the problem, nobody would understand why there are still Saharan Refugee Camps. Within this framework we understand the conditions in which part of the Saharan people has access to water, with all the restrictions that take place in its availability, use and consumption. The supply need through wells and tankers and the construction of treatment plants. Or the specific problem that arises from the extreme conditions of the camps and which affect the health and quality of life of the people in general and more specifically on the living conditions of women, who are responsible for water transporting.

KEYWORDS:

Wells, tankers, health, treatment plants, accessibility and conditions for women, Sahara, Refugee camps.

THE MEDIA AND THE NEW WATER CULTURE

Joan Busquet

ABSTRACT:

The lack of water and the threat of drought have emphasised the increasing attention placed by the media on the environmental problems, but they have also shown how difficult it is for journalists to transmit such complicated knowledge to the citizens and to provide them with instruments to critically interpret information that is often partial, confusing, deceiving, selfish and partisan. The paper is based on the analysis of how the Spanish press has dealt with the threat of restrictions in the Barcelona area, fights for permanent information on drought and its effects –which includes aspects relating to water quality and to the protection of the ecosystems- and underlines the need for the media to rigorously, independently and respectfully contribute to pluralism, to fostering the ecological awareness of society.

KEYWORDS:

Drought, media, ecological awareness.

WATER AND HEALTH ON THE INTERNET

Alejandro Maceira Rozados

ABSTRACT:

Information about water has traditionally been in the hands of the States and International Organisations. The arrival of the Internet has caused a deep impact on the access to information about water, democratising it and permitting any citizen to have an active attitude.

The paper describes the main online sources of information on water on a Spanish, European and global level.

In the future, the evolution of the Internet towards more interactive models will completely change the way in which this information is generated and shared. New tools, such as blogs, Wikipedia or Social Networks help pool knowledge, integrate communities and cooperate in the improvement of the policies.

KEYWORDS:

Water, internet, information, communication, participation.

WATER INFORMATION SYSTEMS AND IMPLICATIONS ON PUBLIC HEALTH

María Victoria Cañada Guallar

ABSTRACT:

With the entry into force of Royal Decree 140/2003, which establishes the health criteria on the quality of water for human consumption, the province of Teruel faces the challenge of implementing it from its demographic reality, with one of the lowest population densities in Europe: 9.24 inhabitants/Km^2.

The complexity of the management required by the Administration of small town councils goes way beyond the services that they provide at the present time. On the other hand, the citizens are now highly aware and demand the right to information and access to drinking water.

The Provincial Council of Teruel decided to support the municipalities by creating a joint-venture to manage the supplies.

Coordination with municipalities, managing companies and surveillance and control services of the government of Aragon was necessary to face up to the challenge. An Implementation Commission of Royal Decree 140/2003 was constituted, establishing objectives, assessing them and sharing information.

The goal has been satisfactorily reached and on 1 January 2008, it can be seen that the implementation of Royal Decree 140/2003 in the province of Teruel is highly satisfactory.

KEYWORDS:

Low population density, water supply management, supply information systems, transparency, coordination.

INFORMATION SYSTEMS IN DECISION-MAKING IN WATER MANAGEMENT

Andrés C. Caballero Quintana

ABSTRACT:

Water is on the front page of the political agenda and on the agenda of citizens all over the planet. Its scarcity and basic nature make it a very valuable resource. Guaranteeing quality, sustainable, efficient, effective and equitable supply and sanitation is one of the most important strategic challenges for all governments. It is thus essential to have a water management model that, based on the premises of transparency and participation, uses information systems to facilitate the decision-making process on water management.

In this regard, the latest advances have been considerable, as, apart from the significant technical and mathematic supports that have arisen, a change in approach of the information systems is occurring, which, caused by the irruption of environmental policies and social movements, is transforming the 'traditional' vision of the latter. This change is characterised by the evolution from a strictly technical perspective to another perspective that considers factors linked to social sciences and to sustainability. Innovations, together with the description of the main information system models in waters will be dealt with in this paper in a summarised manner.

KEYWORDS:

Information systems, decision-making, participation, transparency, sustainability.

ASSESSMENT OF THE IMPACT ON HEALTH APPLIED TO WATER POLICIES

José Ramón Rueda Martínez de Santos

ABSTRACT:

Individual and group health is the result of the interaction of multiple factors, including, among others: food, water and sanitation, occupational and environmental conditions, access to effective sanitary services, education, ways of life, social inequalities or genetic factors.

The Environmental Impact Assessment is a compulsory process only for certain projects. It also analyses in a very limited manner, its possible impact on the people, basically if they adapt to the permissible legal noise and contamination levels, ignoring any other relevant impact on other decisive factors related to health and well-being.

The Health Impact Assessment is a combination of procedures, methods and tools with which any policy, programme or project can be judged, in connection with all its potential effects on the health and well-being of people and on its determining factors. It also pays special attention to the analysis of the distribution of those effects among different groups of society.

The general philosophy and the methodology of the Health Impact Assessment are presented in the paper as well as specific examples of its application to projects or policies related to water.

KEYWORDS:

Social determining factors of health and well-being, assessment of impact on health, water-related policies and projects.

WATER FOR LIFE, HEALTH AND SUSTAINABILITY: AN ECOSYSTEM APPROACH TO REINTEGRATE WATER RESOURCE MANAGEMENT WITH THE DETERMINANTS OF HEALTH

Margot Parkes, Karen Morrison, Martin Bunch and Henry Venema

ABSTRACT:

The relationship between water resource management and the 'upstream' determinants of health is emerging as a new portfolio of research, policy and practice. This development is informed by growing attention to ecosystem management in the context of catchments (also known as watersheds or river basins) and the potential 'win-win' of integrated strategies that improve both health and sustainability within these settings. Sustainable and equitable watershed management can be seen as an upstream driver of the determinants of health – with influences ranging from livelihoods and poverty, to cultural values, food security and lifestyles, as well provision of basic water services and infrastructure. Drawing on an integrated framework and the key concepts of 'living systems', 'livelihoods', and 'linkages' between ecosystems and equity, this paper examines integrated catchment management as the basis for an ecosystem approach that promotes water for life, health and sustainability. These concepts are examined in the context of a community catchment health project in New Zealand, with cross-reference to initiatives in Hawaii, Ecuador, Canada and the Philippines. Implications are discussed in relation to capacity building for governance, research and education that values catchment management as a collaborative, cross-sectorial initiative with interrelated benefits for health, ecosystems and society.

KEYWORDS:

Determinants of health, water resource management, catchment, ecosystems, equity, governance.

PROMOTING SANITATION AND HYGIENE TO RURAL HOUSEHOLDS:
LESSONS FROM THE SOUTHERN NATIONS REGION OF ETHIOPIA

Peter Newborne and Jo Smet

ABSTRACT:

Despite low levels of sanitation services and poor hygiene in Africa, it has proved difficult to place Sanitation and Hygiene (S&H) appropriately on policy agendas.

Initially brought to international attention by the Water and Sanitation Programme-WSP, the post-2003 S&H policy of the government of the Southern Nations region (SNNPR) in Ethiopia has now been studied by a DFID-funded research and learning project, the 'RIPPLE' Programme, to look at how success was achieved - and how far.

Latrine construction and use, hand-washing and water storage/handling by households were surveyed, by quantitative and qualitative methods, in six localities in two districts. The project also studied the policy-making and institutional process.

In both districts, the results show a substantial increase in the number of household latrines, achieved in a few years. Some questions do arise as to the technical sustainability of this wave of latrine construction and observations suggest continued poor hand washing and water storage/handling practices.

A combination of political promotion and institutional mobilisation was successful in launching and 'rolling-out' the S&H policy as a 'movement'. S&H was made part of a basic community health package, designed to be politically attractive, and financially and administratively feasible. 'Ignition' documents were written with a strong communication orientation to motivate local politicians and civil servants, alongside more conventional (technical) documentation.

This experience offers, potentially, lessons for other countries in how political and institutional hindrances to promoting S&H strategies may be overcome and hygiene behaviour placed more 'centre-stage'.

KEYWORDS:

Political leadership, 'Ignition' documents, mobilizing institutions, averaging donor support, sustainability.

Thematic Week 3

WATER FOR LIFE

[Rivers and sustainabillity]

Positioning Document[5]

Coordinator: **Marta González del Tánago**
E.T.S. Ingenieros de Montes, Universidad Politécnica de Madrid

1. INTRODUCTION

1.1. IMPORTANCE OF RIVERS

Rivers are the main natural drainage systems of the terrestrial crust and the excess runoff water, generated from rainfall, flows through them, as well as a large amount of sediments and nutrients that are generated in their catchment basins. As they receive such a large quantity of matter and energy, rivers are also the agents that most widely influence the topography and geomorphology of our planet, playing a very active role in remodelling of valleys and floodplains in both longitudinal and transverse directions. They also determine to a great extent the degree of humidity and fertility of soils, the heterogeneity of their physical conditions and the beauty and interest of landscape.

Numerous biological communities live within the rivers, succeeding each other from upstream to downstream and from the centre of the water flow to the rover basins. Very diverse ecological gradients are organised on their banks, which permit the development of numerous species, typical of or associated with the presence of water, thus constituting very diverse ecosystems and complex wildlife.

From the geographic viewpoint, rivers form natural corridors that are extremely important for the hydrological and ecological functioning of the territory. They are very dynamic natural systems, due to the energy of the water in motion and to the habitat renewal effect of high-waters and floods. They also have great capacity to recuperate from the disturbances of agents that model them and have numerous mechanisms to naturally regenerate their wildlife.

On the other hand, rivers have historically been one of the most important natural elements for the development of human populations, which have obtained from them a large quantity of vital natural resources both for their existence (water, fish as food, wood for their houses, etc.) and for their economic growth (navigation, energy production, irrigation, etc.).

A very high proportion of towns and villages, as well as industrial corridors and roads owe their locations and history of growth and development to the presence of a river. There are also many examples of rivers acting as barriers or limits between countries or as the origin of wars and conflicts. They currently represent an extremely large potential for economic and social development, offering a multitude of natural resources in goods and services, and as privileged elements for leisure and recreation.

1.2. ENVIRONMENTAL DETERIORATION AND SUSTAINABLE USE

As towns as well as industries and economic activities have increased in size, the ecological status of rivers has progressively deteriorated. The stage has now been reached where the majority of rivers have a very poor ecological status, ha-

[5] Document prepared from written papers, oral presentations, discussions held throughout the sessions and the filtering made of all of them prepared by the moderators, rapporteurs and coordinator, with the support of the Water Tribune team.

ving lost a lot of their dynamics, biological diversity, environmental values and landscape beauty.

In a first stage of economic development, the deterioration of the environment has had the greatest effect on water quality (contamination as an external sign of urban growth and industrial development, indicating "progress"); and it has later affected the natural circulating flows (the regulation of rivers with reservoirs and transfers to increase the water supply and its availability of use) and the physical habitat (channelling as a way to control the river dynamics and make a more intensive use of the floodplain), sometimes dramatically affecting the composition and structure of wildlife populations and the dimensions of their habitat.

In a more recent phase, and as a result of the aforementioned impacts, environmental deterioration has turned into a progressive and sometimes irreversible degradation of biological communities, causing the extinction of many endemisms with their peculiar ecological requirements, the significant reduction of populations of many native species and proliferation of exotic invasive species. Many of these species are causing serious ecological as well as economic damage, as occurs with the water hyacinth or the zebra mussel that are proliferating in many Spanish rivers.

The current situation may continue to get worse in all the rivers if urgent measures are not taken to control the process mentioned above; namely water pollution, habitat degradation and invasion of exotic species, linked to an excessive use of the natural resources offered by the rivers. Water is undoubtedly the most important resource, but the river space, with a very favourable relief for urban development and transport layout, the sediments and gravel for building, or fishing for the more and more profitable sporting activities, are becoming more and more valuable and have a greater social demand.

To stop this deterioration trend of rivers, environmental sensitivity must be increased as well as the way in which the problems are perceived by water agents and by administrations or people responsible for spatial organisation and development policies. There must also be a degree of complicity and collaboration of the main users of river resources and social agents involved, as well as public participation in aspects related to the management and restoration of the rivers and to the preservation of the natural medium.

It is not a question of stopping the economic development or growth of the towns, or of the laws of nature prevailing over the well-being of human populations, but of revising the guidelines followed to date in many developed or developing countries in the management of the rivers and their resources, analysing in depth the environmental values and natural potential that man has lost with the degradation of his environment. In this sense, it is interesting to highlight that a recent study by the World Bank has doubted the traditional criteria on economic growth, preparing a new parameter related to the use of Nature, considering that this use must be deducted from the actual economic wealth, as it represents an impoverishment of the "natural capital" of each region.

In the area of "sustainability", as a basic idea of inter-generational equity and aiming at making this idea applicable to river management in its broadest sense, some procedures should be designed related to the action and use of rivers that are more in agreement with and more compatible with the preservation of natural processes, with the maintenance of the peculiarities of the habitat of each area and of its native species. There should also be greater respect for the landscape created by the river corridors throughout time and via the ecological evolution, in order for them to survive and be transferred to coming generations.

The concept of sustainability and the demand for the sustainable use of rivers are proposed based on the conviction that we do not inherit the natural systems for our exclusive benefit as final owners, but as usufructuaries of a property that belongs to everyone, and whose assets must survive and be transmitted from generation to generation, without any reduction in their value or potential for the benefit of the human species.

1.3. ECOLOGICAL RESTORATION AS AN ALTERNATIVE

A greater culture and sensitivity towards nature, together with a progressive growth and development of the human populations, with more resources, above all in certain countries, must favour the promotion of a moral responsibility to redress the damage caused to the natural ecosystems, and to create the need to invest resources and efforts in the reccuperation of water quality, the dynamics and heterogeneity of river courses, the variability and energy of the natural flow regime, the composition and diversity of the biological communities, etc.

The difference between our era and previous eras must be this change of paradigm in the dialogue with nature, going from exploiting rivers to restoring their ecological status, with the final aim of recuperating or increasing the resilience of river ecosystems and their natural capacity. In this way they will be able to recover from natural or manmade disturbances on their own, and this resilience will be interpreted as a good indicator of its integrity and environmental health.

There are now many countries whose experience in restoring rivers or in rehabilitating urban stretches or stretches with a higher level of geo-morphological or biological degradation is increasing. But, there are also many legislations and regulations that contribute to this ecological restoration process, as is the case of the European Framework Directive on Water, which fosters improving of river ecosystems in community countries, encouraging and acting as an example for many other countries.

Training and education, environmental pedagogy at all administrative and political levels, and public participation, including the collaboration of the main users and beneficiaries of the river resources, are considered very important in this environmental reccuperation and ecological restoration process. The dissemination of ideas and concepts, the exchange of experiences and the organisation of debate forums where ideas and beliefs, values and priorities as well as ethical principles of solidarity, equity and environmental justice are discussed, are also considered essential.

2. THE GLOBAL PROBLEMS OF RIVERS

The natural features of rivers differ a great deal from one country to another, depending on the different climatology, relief, geology, etc. The ways of life of the people, their food and customs, their degree of development, their culture, etc. are also very different.

Due to this, the levels of degradation of the rivers also differ a great deal, as do the consequences of their deterioration from some regions to others. Thus the degree of social training to cope with the consequences and the availability of economic resources and technology to mitigate the effects of this deterioration are also very different.

However, the causes or origin of river problems are very similar from one country to another. The problems are caused by the same pressures or human activities, although their impacts and effects on river ecosystems differ in intensity.

Agriculture is perhaps the activity that has the greatest impact on rivers on a global level, due to water demand for irrigation. An enormous number of large dams have been constructed for this purpose in many regions (in Spain there are more than 1200 distributed all over the river network). These dams are used to store water in reservoirs that will ease the seasonal irregularity of rainfall and runoff. Important transfer systems have also been carried out to palliate the regional imbalance of water resources, bearing in mind that the greatest agricultural profitability often occurs in warmer and, in general, drier areas.

This intense rivers regulation, considered as the main source of environmental degradation of the rivers on a global scale, has totally modified the natural flow regime, the frequency of floods and droughts, their synchronisation with the rainfall and temperatures of each area, and all of this has represented a deep transformation of the river habitat and also of its biological communities.

Agriculture has also fostered the overexploitation of aquifers, in those cases where irrigation demand has been met with groundwater. It has also favoured the drainage of many wetlands, thus having an impact on hydrological functioning of many regions. This has often had a very significant repercussion, reducing the size and importance of lakes and inland lagoons, increasing the degree of salting of soils, low water level of permanent rivers, the seasonal nature of intermittent rivers, etc.

Finally, agriculture has favoured the loss of large alluvial woodlands as they occupy a large part of the river floodplains, where soil is more fertile and wet. It is also the origin of non-point pollution caused by fertilisers, herbicides, insecticides, etc. which affect a great part of the river network on a worldwide level.

Housing development has also placed a lot of pressure on the rivers. In this case, the major impact is contamination caused by urban dumping and the channelling of river courses, in an attempt to avoid flooding in developed areas

The enormous growth of cities that has taken place over the last 50 years all over the world has worsened the problem of urban contamination, especially in economically less favoured areas. This has not only affected the ecological functioning of the river but also the health and well-being of the riparians.

Likewise, the urban development of the floodplains, constructing not only urban but industrial centres, transport infrastructures, recreational facilities, has favoured the sealing of the soil in the more permeable areas and areas of greater interest for recharging aquifers and retaining water during the floods. Hence, the natural recharge potential of the aquifers has worsened, decreasing the natural control capacity of the rises in water level, and increasing the hydrological risk of floods.

On the other hand, urban growth has taken place in many cases in the more benign climate regions, generally with less rainfall and higher temperatures, which has increased the imbalance between the demand for water and its natural availability. This has urged the construction of new flow regulation systems and transfers, intensifying the pressure level to which the different water bodies are submitted.

If we compare the deterioration levels caused by agriculture in the rivers with the levels caused by urban development, in the first case they may be more extensive but in general they are less intense. Likewise, the regeneration potential of the river system with respect to agricultural crops is, in the majority of cases, much greater than in developed spaces. Here, the removal of buildings and infrastructures required to recover the river dynamics many be much more costly or unfeasible in practice, as well as the regeneration of developed subsoil. Whilst, in the case of agricultural use, the restoration of floodable spaces, the recuperation of the habitat and the regeneration of natural riparian vegetation may be theoretically more simple.

The **production of hydropower** is very widespread in many countries, and it also represents a considerable pressure on rivers, altering their natural flow regime, creating barriers for the migration and dispersion of many species, preventing the transport of sediments and the geo-morphological equilibrium of the courses, etc.

River **navigation** is very important in many countries, and to foster and maintain the navigation, a quite considerable stretch of the rivers has initially had to be channelled and dredged. This has mainly affected larger rivert courses and those that are important as commercial transport channels. This has determined the loss of river dynamics and the decrease of heterogeneity of the riverbank habitat, of the diversity of species associated with the riverbanks and floodplains, etc., requiring stabilisation work on the side slopes and dredging the bed from time to time, to prevent the ecological recuperation of river ecosystem.

Finally, the **extraction of gravel** for construction, and the removal of the river bed to extract metals, are also activities that deteriorate rivers, modifying the stability and characteristics of the habitat, the subsurface and groundwater flows, the integrity of the hyporrheic medium, etc., thus greatly destroying this vertical dimension of the river systems that is essential to maintain their biological diversity.

Unfortunately, the economic development and growth of countries has accompanied the environmental deterioration of their rivers and environment. The environmental problems increased and became more widespread in European counties with the agricultural and industrial development after the Second World War. They are also spreading and worsening in countries of other developing regions, as their income per capita increases as well as their access to water and energy consumption.

As mentioned above in the "sustainability" context, and in the proposal for the sustainable use of rivers and their natural resources, it is a question of revising the development model followed to date by the more advanced countries, where a very high degree of environmental deterioration and artificialisation of the landscape has taken place, suggesting other guidelines and approaches in these countries to decrease the pressures on the rivers and mitigate the effects already produced. This will give an example to many other regions that can still avoid the deterioration of their environment to the extent that the former have done.

3. DIFFERENCES IN THE PERCEPTION OF PROBLEMS AND IN THE PRIORITIES

It is obvious that, although the pressures and impacts on rivers, are very similar from one country to another, their intensity and effects differ depending on the types of rivers where they are applied, in agreement with their geographical, hydrological and ecological characteristics.

To give an example, the biggest rivers have a higher dilution capacity, so the effect of discharges is relatively less than in smaller rivers in arid or semiarid areas, where a very high percentage or all water that flows through them corresponds to wastewater discharges. But, the impact of flow regulation infrastructures can have much more dramatic effects in bigger rivers than in small rivers, affecting a much higher percentage of the river network as well as the hydrology and ecology of regions of a much greater order of magnitude.

But, maybe the most important aspect to be highlighted is the variable perception of the problems of the rivers, in agreement with the degree of development of countries and with the availability of water resources, which determines the differences in priorities in managing and using rivers, and their preservation.

Many countries in Europe and in North America enjoy a high level of economic and social well-being today, and the perception of the problems of rivers focuses above all on environmental issues and on preservation of species. In general water needs for domestic supply, food, energy for transport and industry, leisure spaces, etc. are covered. In these countries, society often has a relatively high environmental sensitivity and education, as well as quite a broad knowledge and perception of the environmental problems, and quite an accused awareness of the need to preserve nature and use economic resources and effort to restore and preserve the natural systems. The priority lines of action in this regard are focused on protecting the habitat and recuperation of species via the restoration and preservation of ecosystems. There is also often considerable aid and legislation and regulations that significantly contribute to achieving these objectives. An example of this is the approval and implementation in Europe of the recent Water Framework Directive.

In other, less developed regions in the world, and above all in drier regions where water resources are scarcer, the perception of river problems can be very different. In these cases, increasing water availability for life and the survival of agriculture through new flow regulation and course channelling infrastructures is often a priority aspect, and the concern for the environmental effects of these infrastructures is relegated to a second place. The effects of urban contamination in areas with high density, poverty, lack of resources and technology for installation and maintenance of treatment plants, which often have health problems due to parasites or endemic diseases, etc. must be solved or mitigated more urgently.

In this regard, and once again in agreement with the sustainability concept set out above, one must ask to what extent the restoration and preservation of rivers is a priority on a global level and if it is possible to carry this out in less developed countries or countries with less economic resources. It is also necessary to reflect on if it is unavoidable to go through a stage of greater contamination and environmental degradation to achieve economic development and subsequently have more resources to be used in ecological restoration, or if this environmental deterioration can be avoided in the process to develop and increase the quality of life and social well-being.

Returning once again to the new concepts introduced by studies carried out by the World Bank, new environmental criteria must be prepared to estimate the wealth of the respective countries and deduct the use they have made of their territories and of their natural systems and resources from the actual economic wealth attained, causing a reduction of their ecological integrity and the relative loss of their Natural Heritage.

It will also be necessary to assess the extent to which the environmental and aesthetic deterioration of the environment that surrounds us, which is so frequent in the cities and taken to an extreme in the more underprivileged neighbourhoods, as well as the loss of a frequent contact with natural landscape, is generating stress, violence, marginalisation, etc. It will thus be necessary to evaluate what the potential benefit of ecological restoration in economic and psychological terms can be to improve the co-existence in urban areas with a strong demographic density and increase social well-being.

4. EXCHANGE OF EXPERIENCES. WHAT WE CAN LEARN FROM THE PAST AND PROPOSE IN THE FUTURE

The thematic conference organised on July 3 2008 by the Water Tribune of the International Exposition of Zaragoza aims to globally analyse the problems of rivers revised in the previous sections, providing examples of problems and experiences of management and restoration of rivers in very different countries, with different perceptions and priorities.

The aim is firstly to highlight the need to restore rivers, in accordance with the environmental justice and sustainability principles mentioned above, derived from a very high deterioration and impoverishment of river ecosystems in many regions, as a result of an overexploitation of natural resources and redcution of natural capital. The need for commitment and accountability with respect to the coming generations as future users of the plant must also be highlighted.

The second aim is to show the different perspectives of the problems associated with the rivers, of a geo-morphological, hydrological, biological type, etc., and the different management methods depending on the countries and geographical regions, counting on social, cultural and economic aspects and public participation.

Finally, the aim is to discuss the existing alternatives to restore the rivers in the different countries, in agreement with their geographical characteristics and development level, evaluating options and projects carried out in areas with different water resource availability and a different social context.

The conference seeks to create a forum of debate and exchange of experiences among different political, administrative, technical and social bodies, etc., as well as to foster interdisciplinarity when addressing problems and proposing alternatives. This will increase the sensitivity of those present and convincing them on the possibilities of making a sustainable use of the rivers to allow the improvement of the quality of life of the people and avoid environmental deterioration.

CONCLUSIONS OF THE DEBATE

The exchange of experiences among different water agents and technicians from different countries, as well as the participation of those attending the Conference, expressing their different perceptions of the problems and priorities to be considered in the rivers, has been very enriching and has opened up new perspectives and alternatives for the management and improvement of the environment.

Rivers have very different connotation values, offering not only natural resources but also environmental aspects of great importance, such as cultural heritage and mark of identity of many peoples and societies. The preservation of their good ecological status is necessary for the survival of many indigenous populations and for the well-being of more developed societies.

The use of rivers must be planned seeking the consensus and attention of the interests of all social sectors affected, covering the entire territory of the catchment basin.

Many of the activities for agricultural or urban development contradict the river dynamics and this determines chain effects on rivers, producing geo-morphological imbalances, changes in flows, contamination water and impoverishment of the biological communities of courses and riverbanks, as well as the invasion of exotic species.

The prevention of further deterioration, as well as the mitigation of the existing impacts, decreasing the agricultural and urban development pressure on the rivers, is priority at a global level. A restoration and preservation policy for river ecosystems is required, fostering regulations and legislations on behalf of administrations supporting this policy.

The river management and preservation strategies must be established in a specific manner for each river current, depending on the hydrological and socio-economic peculiarities of their catchment basins. The objectives and procedures must be agreed with the people's participation, bearing in mind different perceptions and priorities of each region and country.

The spatial organisation and preservation of landscape, reached via administrative cooperation and social participation, are essential to establish a successful restoration policy for rivers in the medium and long term.

The formation of adequate interdisciplinary teams, environmental education, an increase of trust in water management institutions, as well as the capacity for debate and public participation, are essential requirements to achieve not only the improvement of the ecological status of rivers, but also the sustainable use of the natural resources they offer.

The economic development and growth indicators and parameters of the countries and societies considered traditionally, where there is a preponderance of economic wealth statistics, must be revised, introducing new parameters for the use of nature, ecological status of natural systems, territorial occupation, etc., which reflect the degree of impoverishment of the natural capital of each region and the degree of loss of landscape heritage for future generations.

CONCLUSIONS AND PROPOSALS

The environmental value of rivers is very different and significant, both from the natural and social viewpoint. For us humans they are top-tier natural systems, fostering goods and services that include such valuable natural resources as water. But they also form part of a cultural heritage and have been and are a mark of identity for many peoples and societies throughout history. Rivers are also a source of economic, social and cultural benefits that are essential for the health and well-being of societies settled on their banks.

▸ *To evaluate and manage the sustainable use of the rivers, it is necessary to listen to and evalua-*

te the different perceptions, problems and proposals presented by different social sectors, seeking, whenever possible, consensus among stakeholders, but this must not become an obstacle for action.

The main pressures on the rivers come from agriculture and urban development. These are human activities, which, to a greater or lesser extent, generate the need to control the increases in water levels and reduce river dynamics. In both cases it is essential to increase the surveillance and controls over the impacts that these activities generate on the functioning of rivers as ecosystems.

▶ *It is necessary, whenever possible, to prevent the alteration of river morphology to intensify agriculture, or in the urban stretches or due to civil engineering infrastructures. It is thus essential to delimit the river mobility space required to preserve the dynamics of the rivers, and proceed to organise the use of the soil in floodable areas, managing the risk of increases in water level. It is also necessary to count on the participation of social agents involved and of local administrations, also necessary to make a more rational and sustainable use of water resources within each catchment basin.*

At times, planning economic activities can be relatively alien to the needs required by river dynamics, which is essential to preserve good health of river ecosystems.

▶ *For these reasons, it is essential to consider that flow regulation alters river dynamics providing chain effects both upstream and downstream (for example, geo-morphological, physical-chemical, biota, etc.) and that dams produce a barrier effect that causes changes from a river regime to an almost lagoon regime (reservoirs). All of this has a dramatic influence on the migrating species.*

▶ *The evaluation of the ecological status of the rivers for their restoration must take into account not only the alteration of flow regimes but also the alteration of sediment regimes, altered by dams and urban development, and with an often considerable influence on geo-morphological behaviour and imbalance of river courses.*

▶ *The river preservation and management strategies must be established specifically for each river stretch and current, depending on the hydrological and socio-economic peculiarities of their catchment basins. The objectives and procedures must be agreed with the people's participation, bearing in mind the different perceptions and priorities of each region and country.*

▶ *The actions to protect and restore rivers in rural and urban areas require interdisciplinary work both on a social and technical level (in other words, the rule of the three Ps: politicians, professionals and public).*

▶ *The river restoration principles must seek to generate the most natural functioning possible and let the actual river energy restore and redress the damage caused, after eliminating the degradation impacts and causes. This requires longer reccuperation processes, which provide much greater stability from an ecological viewpoint.*

▶ *Although the restoration measures are applied at a river stretch scale, with results expected in the short term, their design must also respond to an analysis at catchment basin level, with a vision of the medium and long-term river system evolution. Firstly an evaluation of the effects foreseen must be made as well as an integral comparison of different alternatives put forward. These measures must be implemented after a negotiation process with social agents involved.*

▶ *The action context must have the backing of political will and administrative cooperation. The spatial organisation and landscape preservation reached via this administrative cooperation and social participation are essential to establish a successful restoration policy of rivers in the medium and long term.*

▶ *The formation of appropriate interdisciplinary teams, environmental education, the increase of trust in water management institutions, as well as the increase of capacity for debate and public participation and social learning, are essential requirements to achieve not only the improvement of ecological status of rivers but also the sustainable use of natural resources they offer.*

GEO-MORPHOLOGICAL CHANGES OF THE RIVERS IN EUROPE AND PRINCIPLES FOR RESTORING THE RIVER DYNAMICS

Alfredo Ollero Ojeda

ABSTRACT:

The geomorphological processes are the key to the appropriate functioning of rivers as ecosystems. Thus, geomorphological indicators (integrated within the "hydromorphological" indicators in the Water Framework Directive 2000/60/EU) are essential to determine the ecological status of rivers. However, the important effects of human actions on river geomorphology tend to be underestimated; they are even omitted in many impact studies and they do not usually cause concern (probably due to ignorance) to water and land managers. In Europe, geomorphological alterations of rivers are very serious and widely spread. Even valuable river typologies like braided rivers that do still exist, are about to disappear.

The geomorphological deterioration of European rivers is increasing progressively, as more direct actions on channels and floodplains related to urbanization processes are carried out every time; these actions are especially aggressive against geomorphological processes and river morphologies. It is absolutely necessary to assess the geomorphological indicators and to give them higher priority within the global assessment of the ecological status. And it is urgent to establish principles for the restoration of river dynamics; no doubt it is a complex restoration, in which the river itself must develop, with time and space enough, most of the effort.

KEYWORDS:

Fluvial geomorphology, European rivers, human impacts, hydromorphological assessment, river management, river restoration.

FLOW REGULATION AND ITS EFFECT ON BIODIVERSITY

Diego García de Jalón

ABSTRACT:

The current continued growth of the human population and of its consumer habits determines a water demand that goes beyond the availabilities of the ecosystems that it is based on. The prevailing response in our Society to this imbalance is water regulation. This flow regulation has been carried out in rivers via the construction of reservoir and transfer systems.

Flow regulation means that the flow regimes that flow through the rivers under natural conditions are modified. The direct effect on river wildlife comes from the fact that the autochthonous species have evolved and have adapted to the peculiarities of the natural regimes of each place. Only the most opportunistic species can prevail and complete their biological cycles under the strongly altered regimes.

But the more harmful effects on biodiversity come from the alteration of the river habitats that the Flow Regulation produces. These are medium and long term, but unavoidable, effects. They come from the barrier effect that the dams have on the flow of sediments and slime that the river waters transport, whose absence in the courses determines geo-morphological changes. With time, in these new habitats, we only find introduced, cosmopolitan and banal species. How to cope with and mitigate this situation will be the topic to be discussed.

CASE STUDIES: RESTORATION OF ISAR RIVER, GERMANY

Walter Binder and Klaus Arzet

ABSTRACT:

Like most of the larger rivers in middle Europe sections of the Isar, flowing from the Alps down to the Danube, were canalised more than hundred years ago, to improve flood control and the use of hydropower. The floods in the last two decades showed the needs to improve flood protection and accelerated the discussions about more nature and outdoor recreation along the rivers. The basic for restoration projects are regional river concepts. They contain the guidelines for local restoration project and also for the measurements program as part of the management plan, asked by the EU-Water Framework Directive. A restoration project requires teamwork, needs ecological understanding, technical knowledge in hydraulics /construction and social acceptance. Engineers, architects and experts of different fields (e.g. ecology, urban planning, nature conservation, wildlife, agriculture, forestry and fishery) are working together to find win-win-solutions. Such projects have to be supported by the public e.g. engaged Non Governmental Organisations (NGO's). The case study Isar includes projects in the city of Munich (8 km) and outside in the rural floodplains (100 km); it describes planning steps, the restoration measurements to improve flood control, ecology and outdoor recreation and the main objective: bringing back the alpine character of the Isar by allowing again the hydro morphological processes.

KEYWORDS:

River restoration, flood control, ecology, biodiversity, outdoor recreation, hydro morphological processes.

WATER MANAGEMENT IN MEXICO.
THE CASE OF THE RIVER BALSAS BASIN

Juan Carlos Valencia Vargas

ABSTRACT:

In Mexico water is acknowledged as a strategic element and as a matter of national security. Today, it has become a central element of the environmental policy and even a key factor of social development policy and economic policy. Its availability conditions the possibility of development of some regions of the country and its quality is a decisive factor for the health and well-being of the people.

Water in the rivers, lakes and aquifers is the property of the nation and its administration corresponds to the Executive Power. It has two main elements: the National Water Act (recently modified) which establishes the principles and instruments to use and preserve water; and the National Water Commission, the authority responsible for administering the resource.

The states, municipalities, users and organised society also have attributions with respect to water management which is done for every one of the thirteen basins into which the country is divided. 10% of the population is found in the river Balsas basin. Its characteristics make it ideal for generating electricity. Therefore, for the past ten years there has been a closed decree that reserves water for this use. However, regional development has been curbed by this factor.

Regional development depends on water availability. The growth and intensification of production activities is necessary to achieve a series of strategic objectives, to reduce poverty, foster economic growth and achieve food safety.

The main elements of the regional water policy, which seeks to reconcile objectives of social and economic development with environmental preservation, as well as the regional contribution to achieve the national objectives, are presented in this document.

KEYWORDS:

Water, management, basins, Mexico, water policy, reservoirs.

WATER QUALITY CONTROL AND ITS ENVIRONMENTAL AND SOCIAL BENEFIT.
STUDY CASE: MONTEVIDEO – URUGUAY

Américo Rocco

ABSTRACT:

In the middle of the 20th century, the growth of the population of Montevideo, an industrial development with insufficient controls and limitations in the sanitation system, polluted beaches of the East and inland watercourses.

Urban Sanitation Plans I and II were executed between 1985 and 1996. A new final provision system eliminates the discharge of wastewater in dry periods to the River Plata. The bathability is immediately reccuperated when this system is put into operation. The beach monitoring system includes sanitation system discharges.

Urban Sanitation Plan (PSU) III is developed between 1996 and 2006, which places emphasis on recovering inland watercourses. Besides the sanitation works, a monitoring system of streams and of industrial effluents was put into practice. The Citizens' Environmental Monitoring has been developed. At the end of PSU III, water quality and riverbanks of the inland courses have improved, but further progress must be made to harness solid waste and eliminate liquid discharges from irregular settlements.

PSU IV (2007 – 2012) is being developed. Its main work will be the final provision system for the West, which will eliminate discharges to Montevideo Bay in dry periods.

A monitoring programme of the receiving body is developed, which includes the analysis of sediments and biota.

KEYWORDS:

Sanitation, monitoring, Montevideo.

Thematic Week 4

WATER, A UNIQUE RESOURCE

[

Shared waters:
governance an gobernability

Water geopolitics

Basin and aquifers:
planning and management

]

Positioning document[6]

Author: **Raymundo José Garrido**[1]
[1]**Civil Engineer and MSc in Economics. Consultant of the World Bank**

INTRODUCTION

Thematic Week Four was based on a variety of questions that involved different dimensions of analysis imposed by multiple water uses, as well as historical and geographical determinants and their influence on geopolitics, governance and governability problems and the application of planning and management instruments.

Topics related to these questions were divided into eleven sessions, each one with a maximum of three presentations. The main aim of all presentations was to present the results of lessons learned either via strengths or weaknesses that the agents of these experiences faced up in their archives.

A common binder in practically all the conferences was the delimitation of the problem by one or more river basins, the planning physical space adopted as a scenario to prepare and analyse each situation studied in depth.

THOUGHTS FOR THE THEMATIC WEEK.

The sessions of Thematic Week 4 were organised so that they could offer a space to incite questions. Aspects such as those presented below were expected to appear in the Week's debate:

In Session 1:

(i) What role does water play in the development of regions?

(ii) How can neighbouring regions with the same water availabilities have such different levels of social-economic development?

(iii) What must society do to place water on the permanent agenda of its government?

In Sessions 2 and 3:

(i) What main technical advances have been made in river basin planning?

(ii) What water distribution criteria are being used and are appropriate in the case of basins shared by countries and/or by states or federate provinces?

(iii) Which management instruments have contributed the most to the efficient and harmonious use of water and on which aspects of these instruments must we place the most emphasis?

In Session 4:

(i) How can water management be best used to contribute to harmony among peoples?

(ii) Can the export of water like the export of other goods be a valid experience or does it leave us at a virtual water level?

(iii) Does understanding water as a sacred good from the religious viewpoint lead to an increase in conflicts or does it contribute to peace among peoples with different rites?

[6]This document has been compiled from the written speeches, oral presentations, discussions during sessions and the distillation of all the above prepared by the moderators, speakers and coordinator, supported by the Water Tribune team.

In Sessions 5, 6 and 7:

(i) What relationship does governance have with the administrative continuity of successive governmental mandates?

(ii) Is it possible to guarantee access to water for all citizens? What roles does the sanitation sector play in this task?

(iii) How much can be done in water acts to guarantee the right to water for everyone? What mechanisms need to be incorporated into the legal texts?

In Session 8:

(i) After the advances made in computing and Internet resources, how has the basin plan preparation technique evolved?

(ii) What is the relationship between the depth and scope of basin plan specifications and parameters such as area, population and economic production?

(iii) What must be done for the plans to be followed during the basin management work?

(iv) When the plans prove to be inadequate, how can simple adjustments be made to the recommendations?

In Session 9:

((i) How can the basin management systems exist alongside the federative structures or corresponding to them?

(ii) If the power of the federate entities is too strong it normally spoils the plans or programmes studied on basin level. How can those institutional forces be balanced out? Is it possible to constitutionally give a basin entity the condition of rigid (tenacious) mechanism?

(iii) Can the legal nature of charging for the use of water be modified so that the basin authorities have the necessary freedom to independently decide in connection with the investments foreseen in their plans?

In Session 10:

(i) Which factors are considered the most important causes of conflicts over water?

(ii) How can the water use rights mitigate or avoid conflicts?

(iii) Does the hydrographical unit restrain or avoid conflicts? How?

APPLICABILITY AND REPRODUCIBILITY OF THE EXPERIENCES PRESENTED IN EACH THEMATIC QUESTION

The questions of Thematic Week 4 referred the debate to the management of water resources on a river basin level, starting with the question of **shared water**, where a specific proposal for the definition of basins as a planning and management territory is made. In that sense, basin organisation, management and development work, as in the cases of Catamaya-Chira, Pilcomayo and the Trifinio Plan (Guatemala, Honduras and El Salvador), are quite illustrative of that important debate that chooses the basin as a physical and territorial planning unit for the rational use of water.

Likewise, the participation of beneficiaries and stakeholders in the projects, programs and interventions on a basin level is essential for governability and governance in connection with water resources. Sessions 5 to 7 addressed that problem from different angles, including, as in the case of Session 6, the relevant topic of groundwater.

Thematic Week 4 also dedicated part of the debate to the topic of water management in federative regimes, addressing the Canadian and Spanish cases (case of session 9). The latter, although it is not a federation, acts as such based on its organisation into autonomous regions.

The current debate on water geopolitics is present in all those aspects, and clearly and emphatically involves the role played by water resources in the social-economic development of regions on all continents. The topic of water Geopolitics was highlighted more directly in Session 1.

This series of questions were defined to stimulate debate, seeking to clear up some often recurrent doubts. These questions were either studied more in depth or eliminated during the course of the sessions.

No answer has yet been found, however, to many of these questions despite the many experiences known in the different continents. Advancing in the discussion of aspects such as these – and others which, of course, are going to be added – will produce new knowledge that can be argued in basin management. That was one of the objectives of the Water Tribune in its aim to expand the frontiers of technical and practical knowledge.

CONCLUSIONS

Thematic Week 4 was dedicated to the search for solutions to water problems, especially where this behaves as an irreplaceable resource, that is, where water is the unique resource.

However, as it was a resource available in limited quantities, it was essential for Thematic Week 4 to deal with all the uses of the water resources, as the smaller the volumes demanded for other uses, the greater will be the volumes available for the irreplaceable uses of water.

Finally, we must bear in mind the fact that the expression Water, a Unique Resource covers an even greater and more relevant meaning. It is a resource that satisfies functions that involve practically all the segments that can be conceived of the intersectorial relationship chains. Indeed, water is a raw material, it is a navigable bed, it is an in-process product, it is an end product as a food and medicine. Also most of the human body is made up of water.

RECOMMENDATIONS

Thematic Week 4 addressed topics that contribute to the progress of water management practices with all their consequences with respect to the efficiency of its use, regional growth and considerations on geopolitics, as well as the technological development of sectors that use this natural resource.

In that regard, participants were recommended to:

(i) pay attention to the importance of water in the context of geopolitics of the different regions of the world; see water as a social-economic development factor, which, rationally used, can make an enormous contribution for societies to reach the much desired state of social well-being;

(ii) to foster the flagship to defend water quality as an element that generates wealth for society and, in that sense, that each cubic metre of polluted water, apart from being an unacceptable crime, implies a waste whose recovery costs several times more than the production of one new cubic metre;

(iii) assess the different dimensions that claim the hydrographical unit as a locus for the planning and management of the water use; and discuss the ways in which other geographical dimensions such as political divisions, hydro-geological formations and others, can best be coupled to the space of the river basin;

(iv) be watchful so that the recognition of the economic value of water as a principle of the sector excludes the poor from monetary obligations, guaranteeing them access to good quality water and to the quantities necessary for their well-being;

(v) the decision-making should be participative, with the presence of governmental and non-governmental sectors, the latter involving civil society and the private sector;

(vi) the decision-making should be at the lowest hierarchical levels and should defend both the social and environmental ethics, as well as bear in mind the rights of future generations;

(vii) present suggestions in the sessions by way of interventions that provide new knowledge in connection with the rational use of water, avoiding, whenever possible, the repetition of already existing knowledge; and

(viii) seek to publish their points of view with respect to the topics discussed, contributing to the dissemination of the current advances that are only known by a limited public.

Finally, it was hoped that each participant, each delegate, expert from the audience or member of the Water Tribune, would seek to act as a "multiplier" of best practices for the use of water, attracting collaborators for that enormous task of encouraging everyone to save and to carry out conservationalist practices on river basins.

CONCLUSIONS

Water management models have evolved historically through numerous paradigms and scenarios. We are currently facing a model that must give a global answer. The term governance arises within this context to denote the quality of the interaction between the different levels of government and, more particularly, between these and the organisations of society and enterprises. In the case of water management, a relational government is aimed at or interaction networks between the public, private and social areas along the local-global axis that will determine who, where and how water is received. The following proposals are therefore made:

▶ To agree upon the global principles to govern water policy through a World Social Covenant for Water.

▶ Firmly coordinate basin organisations and the water supply and sanitation enterprises so that decisions made by both are aimed at boosting compliance with millennium development goals.

Thus, all fields of action are covered: global, international, national, regional or local. However, and due necessarily to interactions between the hydrological cycle and other biogeochemical cycles, the global perspective becomes more and more important. On the other hand, water management environments are becoming more and more complex, so.

▶ It is necessary to go beyond the vision based merely on engineering and go on to another holistic vision enriched with different approaches such as sociological, economic and environmental ones.

With regards to the World Social Covenant for Water we must recall that in a non legally binding document of the year 2003, the United Nations Organisation recognised water as a human right to adequate and sufficient supply of healthy water. It therefore proposes:

▶ Its effective incorporation into the international legislation and the national constitutions. This is a priority task for it to become an articulated and recognised right.

▶ Modify water legislations including the co-management and co-responsibility of the users, strengthening the preservation and simplifying the administration.

▶ Governments and society must advance consistently to improve the capacities of human resources related to the administration and management of water resources. The role of multi-lateral banks and international institutions is essential to advance in this matter.

This latter proposal especially involves developing countries and also means:

▶ Fostering bi- and multi-lateral relationships between countries and agreement on support through existing empowerment networks. This can benefit from the analysis and use of experiences achieved in international agreements.

The increasing interest shown by regional governments that share basins can represent a problem, due to the risk of fragmenting their management and to the real possibility of modifications in policies derived from changes in government. It therefore proposes:

▶ To universally consider the basin as the basic benchmark for water management, beyond local and regional political interests.

And more specifically for the governments of regions that share waters:

▶ When planning a shared or cross-boundary basin, in the first instance, it must be considered in its entirety –disregarding geopolitical frontiers- to decide on the objectives, guidelines, strategies, plans, programmes, projects and different types of action, as well as investments to be made and their locations. Maximum economic and social benefit will thus be obtained from the use as well as the integrated preservation of the basin.

▶ The negotiation on investment in different regions involved in an integrated management plan of a cross-boundary basin will be carried out within a context of cost and profit appraisal regarding allocation and distribution of water and which will compensate those regions that were favoured with less investment.

Basin organisations must be innovative in their organisation and functioning. This improvement and adaptation is essential to:

▶ Advance in the exchange of experiences and river basin management and organisation models, as well as holding meetings and symposia on a regular basis to evaluate advances and lessons learned.

▶ Respect the principles of sovereignty and self-determination, so that in those countries that do not have a strong and competent water authority, or an actual water legislation and water management, their governments will evaluate the advisability of having basin organisations to strengthen their water sector.

Thus, countries that have more developed legal framework and authority projects, must:

▶ Share their advances, best practices, experiences of different kinds, as well as their failures.

▶ Promote and facilitate the creation of basin organisations with powers to act throughout the entire integral water resources planning and management cycle, with power to decide on the rights of use of the water resources, manage the costs for using these resources and financing necessary water infrastructure for management, plans and programmes to be implemented in the river basin.

The multi-lateral organisations must:

▶ Control and monitor water management.

However, the lack of specific actions may be the basis to focus on the advisability of having a worldwide agency, which, among other activities, could be responsible for the control and supervision of water management for the different countries, basins and aquifers.

To reach governability, new ethics and new administration models are necessary to avoid or overcome the conflicts between this and participation structures. The proposal is to:

▶ Foster people's participation and promote social consensus via permanent involvement of all social agents.

In water planning related matters, both on a national and basin level or by sub-national government units, the following proposals are made:

▶ Regulations that govern planning must be consistent and not differ, therefore, with applicable laws. They must be drafted in an accessible manner so that they can be easily understood by the people.

▶ Disseminate water plans, even on Internet, so that all citizens have extensive access to them and can thus contribute to their improvement and based on their compliance in agreement with public accountability plans, foster their participation, control and sustainable use of water by everyone. It is necessary, in all the developed and developing countries, for society to have all facilities to act in the water sector via permanent communication networks with the competent authorities.

▶ Countries goberments must include geopolitics basic notions in water resources empowerment programmes and plans so that participants know the dimension and relevance of the consequences of their work.

Shared waters belonging to cross-boundary basins have historically been the source of conflicts. There are many inherited suspicions that must be overcome. International cooperation must be based on dialogue and negotiation, creating the necessary climate of trust to close bridges and be able to understand the needs of the countries involved. Once reached, this must be passed onto the population, bearing in mind that this work requires time and planning. The proposals, therefore, are:

▶ Preparation of projects and specific improvements in food safety, energy and irrigation, starting with modest objectives to guarantee success and the trust of the people.

▶ For all countries sharing basins and multilateral banks and cooperation agencies to start up programmes and projects as soon as possible, to plan and manage shared basins so that, within a five-year period, the 263 shared basins in the world are planned and in the process of being managed and their conflicts solved. This proposal aims at working on prevention in places where there are no water resource problems or conflicts and on intervention to solve such problems or conflicts where they already exist.

▶ Governments of countries that share one or more basins must reinforce or incorporate into their water resources acts aspects that agree with and contribute to the most important problems of their common basins. That measure is always possible because water acts are recent or are foreseen to be enacted in a large number of developing countries.

In the case of water bodies shared between two or more countries, in those cases where management plans for this water are being or are going to be developed, the following proposals are made:

▶ On a small scale: unite the mayors in their work and promote harmonisation with social and private sectors and with central and local governments. The importance of counting on the more participative and relevant social groups is emphasised.

▶ On a large scale: to the governments of countries that share river basins, for them to increase the participation of civil society in these bodies, giving the representatives of society greater representative capacity on their councils or similar institutions as a way of guaranteeing administrative continuity with respect to the governability of water.

Water geopolitics a point of intense current debate in local, regional, national and international forums. Throughout history, water has been one of the most relevant factors to transform societies, often marking the historical, political or social destination of different cultures and civilisations. However, it has been politics that has affected this geo-factor over the last few years, because it has ignored waste and contamination, and has no solved mismanagement.

In that regard, the following proposals are made:

▶ Governments must recognise the river basin as a territorial unit for planning, covered by the legislation, even in the case of cross-boundary basins, always based on principles of cooperation and respect for national sovereignty.

▶ Governments of the countries must create bi- or multi-national centres for training and research, in order to contribute to the institutional strengthening and participation with a view to standardising the technical knowledge of the people who take part in the organisation, management and development projects of shared basins.

▶ Governments of the countries must include the basic notions of geopolitics in water resources empowerment plans and programmes so that participants are aware of the dimension relevance and consequences of their activities.

▶ Bi- and multi-lateral financing agencies must adopt the inclusion of knowledge of water geopolitics, as a criterion to support the execution of empowerment and training activities.

Lessons learned must be transmitted at all levels, from the purely local to regional or supra-regional levels, depending on the cases and experiences. The participative process and coordination are extremely useful for multiplying knowledge. That is why, it is proposed for:

▶ Stable basin organisations with a higher degree of development as well as success in their management to help others that are being developed via basin twinning programmes, which will foster the transfer of knowledge, experiences and good water resource management practices.

▶ Multi-lateral agencies: to establish and implement funding lines for basin twinning programmes, based on feasible financial plans that commit basin organisations to achieving specific results and objectives to be able to receive support from those financing sources.

▶ Basin organisations to act intensely by means of permanent and systematic public meetings, with the aim of incorporating the local sphere into the water management decisions, increasing their competences.

▶ All government and non-government bodies to include the topics of the right to water and the environment in the programs of congresses, meetings, seminars and workshops, be they local, regional or international. It will thus be possible to disseminate and incorporate this basic concept into the collective awareness of the citizens.

The collaboration in cross-boundary basins permits shared use of water resources, energy uses and transfer of knowledge. It also contributes to creating stable and prosperous areas on reducing the possibility of conflicts.

The vulnerability with respect to the climate variability is very great, and problems of water shortage arise due to droughts or flooding. Therefore, the following proposals are made:

▶ Increase the infrastructures for the regulation, distribution and use of water for irrigation, based on sustainability criteria relating to their execution, bearing in mind the effective participation of the population affected, especially those subject to being displaced.

▶ The governments of the countries must include in their water and water works regulations, as a basic requirement, the need to approve different types of water projects or dam projects, environmental impact assessment procedures that demonstrate that the project does not negatively affect the environment.

The relationship between water, energy and food with the climate is extensive and direct and the current climate change pattern only amplifies this. These four elements are strongly interconnected via bidirectional flows.

With respect to groundwater the technical knowledge must be translated into specific practices. Furthermore, the progressive use of groundwater is causing a “silent revolution”. It has important advantages and currently the value of irrigated agricultural production competes with the value corresponding to groundwater. Therefore, the following proposals are made:

▶ The groundwater management unit must be focused on the aquifer, which requires collaboration between administration and users at all levels to advance towards efficient governance.

▶ The authorities must issue rights of use of water in regions of drought, granting greater importance to the sustainable management of groundwater, as this is a source of high strategic value in times of droughts.

▶ The governments of the countries must modify the legal framework that governs water management, to specifically incorporate the co-responsibility of users, strengthen preservation and simplify administration.

▶ With respect to the master plan regulations, the governments of the countries must push forward water supply solutions that combine the sustainable use of surface water and groundwater reservoirs.

A good ecological status cannot be reached if only the needs of human beings are taken into account. A water declaration that considers water only as a heritage of mankind would only be a partial solution to a problem of an extremely greater magnitude. Therefore, this short-sighted vision of water issues will only end up generating new problems. The following proposals are therefore made:

▶ A change in paradigm that will foster solutions based on genuine sustainability whose main axis is the principle that water is an asset for all living beings and of the entire planet and not just of human beings. To develop this new paradigm so that it has the solid support of countries and regions, it is essential to discuss and approve the principle proposed.

▶ To advance in the above objective, the principle that water is a heritage of all living beings on the entire planet must be widely disseminated, via adequate means and with social participation.

▶ The role that the Spanish state can play is crucial. In this sense, it can: 1) accept this principle and therefore put it into practice in the state policy on the environment, the rural and marine environment; and 2) act as a disseminator of this principle in the geopolitical areas where Spain has favourable conditions: the European Union, the countries of the Mediterranean and South America. 3) head the creation and subsequent management of a World Water Agency.

SOCIAL WATER PACT – WATER:
THE SOCIAL QUESTION FOR THE XXI CENTURY

Riccardo Petrella

Keynote Conference

ABSTRACT:

The thesis being proposed and argued for is the following: water, synonymous with life (just like the air and the sun), while being a "vital natural resource", does not mainly come from an environmental policy ("economically viable") for a limited natural resource on the road to scarcity but from overall global policy, a societal policy. Life – society – can do without petrol (we did for thousands of years and we shall do so once more for thousands of years) but not without water.

Water access, safeguarding water, water ownership, water management, the relationship between power over decisions and over water control, social practices involving water, beliefs and symbolism of water, ways of life...everything is influenced, shaped, thought of by society. The conference is concerned with the eight main reasons that make water, from now on, the primary social question at the beginning of this century, alongside food, work and energy. They are: (1) the refusal of access to drinking water for 1.5 million people and to sanitation for 2.6 million is a worldwide social scandal; (2) poverty is the main cause for no access to water and not water scarcity; (3) if radical measures are not taken, then in 2030, there will be more than 2.4 million people living in the inhumane and non-sustainable conditions of shanty towns; (4) power inequality is a determining factor in water access for life and for the safety of the existence of human collectives; (5) water policy and use are closely dependent on the pattern of water ownership; (6) likewise, there are rules for water management and citizen participation in water "governance"; (7) the future of water and life on this planet under the glare of climate change: this goes beyond ethno-centrism and the competitive primacy of the techno-financial interests of the Northern countries; (8) the establishment of a worldwide water "pact"/"contract" during the coming years is subject to the creation of a new world political-institutional model.

KEYWORDS:

Right to water, scarcity and poverty, property, world heritage, common public good, privatisation, marketability, "petrol commercialisation" and "coca-cola-isation" of water, share, solidarity, justice, protect/safeguard, savings, water wars, peace with water, sacredness of water.

THE CHALLENGES OF GLOBAL WATER GOVERNANCE

Luis Veiga da Cunha

Keynote Conference

ABSTRACT:

In recent years, the concept of governance has gained ground, in the context of water policy, related to the concept of sustainable development. Different levels of concern with water governance have been considered, namely the local, river basin, regional and global levels. Actually, in certain cases, governance normally applied at the river basin level may be insufficient, making it necessary to try to reach a higher level, i. e. regional or even global. Effective global water governance will require an adequate legal and institutional setting which is not yet provided by the currently existent instruments. Considered from this perspective, water tends to assume the role of a geopolitical resource, similar to oil or mineral resources. And although this perspective has not, thus far, prevailed, there are signs that the current views may be changing.

KEYWORDS:

Water governance levels, water and globalization, virtual water, water as a geopolitical resource.

SCIENTIFIC GUIDE OF THE "SHARED WATER" THEMED PLAZA:
THE BASIN, THE HOUSE OF WATER, OUR HOUSE

Víctor Pochat

ABSTRACT:

It is usually hard for us to visualise the phase of the hydrological cycle within a particular area, the basin, although, it is in that geographical area where water is closer to the human being and its environment, and consequently, where it can affect them and be affected much more easily.

Nature is hidden by political maps, by the functioning of administrative jurisdictions and their respective legal rules, and by the development of countries, translated into the replacement of woodland with crops, the growth of towns and the construction of infrastructures, among other aspects.

It is necessary for the person on the street to pose the need to find a new way of relating with the physical medium. Only by understanding that water, when it flows, interrelates all of us who live in the same environment and share the same resource, regardless of the boundaries that traditionally separate us, will the people understand that the organisational structure of the world could have another formalisation – the division into basins.

We must assume that we are living in the same house, the "basin", the "house of water", "our house". And ask how – via mutual cooperation – we can make our respective interests compatible, being aware that the responsibility for using water correctly – that resource shared by all the inhabitants of the same "house" – must be assumed by each and every one of us, in agreement with our respective roles within society.

KEYWORDS:

Basin, shared resources, cross-boundary water, cooperation.

SPAIN AND ITS RIVER BASINS

Juan López Martos

ABSTRACT:

The aim of this paper is to set out the pioneer role of Spain in the introduction of the river basin as a territorial unit for water management. It starts with a brief description of water uses in Spain, which, dates back to the copper age. The Roman, Moslem and Renaissance actions are referred to. Then the modernisation of the use of water is discussed, starting in the second third of the 19th century and ending with the creation of what was firstly called the Confederaciones Sindicales Hidrográficas (Water Union Confederations) in 1926. An analysis is made of the important role that these organisations played over forty years in the construction and subsequent operation and the excellent Spanish hydraulic heritage. With the onset of the democratic regime, our water policy and also our Confederations had to adapt, firstly to a democratic regime and then to the new water requirements of a society which was no longer a rural society. Finally, a review is made of the problem that is sought to be solved today to make the state and regional competences compatible without harming the river basin unit, a functional and structural need of Spain.

NEITHER CHOSEN PEOPLE OR PROMISED LAND:

THE SELF-SUSTAINED EBRO VALLEY

Mario Gaviria

ABSTRACT:

The Ebro Valley with 85,550 square kilometres and less than three million inhabitants, about 33 inhabitants per square kilometre, is the last river space, the last river basin in Europe with a river that is still partly erratic, which will improve over the coming years. It is the land of abundance, about 2,700 cubic metres of stored water per inhabitant and year and about 2,700 hours of sun that can be captured a year and about 2,700 hours of wind that can be harnessed every year.

It is a large space with extraordinary infrastructures of all kinds of recent construction with the most advanced technologies. It has medium and small sized cities that may, one day, be sustainable with approximately 800,000 hectares of irrigated land that guarantee food sustainability. The valley of meat, fruit and good wine is going to increase its activity until it becomes the valley of the decarbonised renewable kilowatt. A future with little cement and a lot of talent is expected. Thousands of physicists, engineers, biologists, who will grow in the research and development centres, who will direct and produce the factories of wind turbines and solar followers so that within 20 years we will be self-sufficient and be able to start to export energy. Water has a special function for the operation of Thermal Power Solar Stations and for reversible pumpings that permits the storage of surplus wind power. Water will also be necessary and essential for its decomposition by electrolysis when the time comes (within 15 years) for hydrogen. The Ebro Valley must supply the Spanish north-east with wind energy, that is, Spain, Basque Country, Catalonia, Valencia. A sustainable objective that can be achieved.

THE DANUBE WATERS MANAGEMENT: BILATERALISM AND MULTILATERALISM FROM HUNGARIAN VIEWPOINTS

Kálmán Papp

ABSTRACT:

International cooperation in the field of water management started in the Danube Valley after the World War I with the activity of the Commission Regimes des Eaux du Danube (CRED). Even the first bilateral water commissions were created in Hungarian-Roumanian, Hungarian-Austrian and Hungarian-Czechoslovak relations. After WW2 five new bilateral agreements were concluded with neighbour states. COMECON also provided a framework for multilateral cooperation (see the Tisza Case). After river regulation, hydrographic measurements, flood protection the pollution control emerged as important topic for transboundary cooperation. Sofia Convention provided framework for renewed multilateral cooperation in the Danube Valley. ICPDR became an important coordinating body in the implementation of WFD EU as well. In the case of Tisza river different initiatives from international organisations provided basis for more pragmatic international projects.

REGIONAL GEOPOLITICS IN A FEDERATION:
CASE OF THE BASINS OF THE PCJ

Dalto Favero Brochi, Francisco Castro Lahóz and Alexandre Almeida Vilella

ABSTRACT:

Geopolitics in Brazil, a country with a federal system and comprised of 26 states, a federal district and more than 5,500 municipalities (there are three levels of government: federal, state and municipal), after conflicts with the legislations and different social-economic situations of the states. The proposal is to make an analysis of the industrialisation process of the State of Sao Paolo since mid twentieth century with the “deconcentration” movement of the industrial park of the city of Sao Paolo, which was transferred to other municipalities of its Metropolitan Region and also to other cities on the interior of the state, without any concern for strategic planning or the environment or water resources of those regions, in a process called “progress at any cost”. The basins of rivers Piracicaba, Capivari and Jundiaí (PCJ), suffered the impact of the industrialisation process, with an increase in population and polluting its rivers due to urban and industrial pollution. A union of local politicians, users and the civil society of the region for water resources management was created, to change the critical situation, in the face of conflicts, with difficulties posed by federal and state legislations.

KEYWORDS:

Water geopolitics, industrialisation and pollution, conflicts and management of water resources.

THE CATAMAYO CHIRA BI-NATIONAL PROJECT:
AN EXPERIENCE OF BI-NATIONALITY, PARTICIPATION AND EQUITY

Mercedes Alonso Segoviano and José Hermoza Jerí

ABSTRACT:

The Bi-national Management Project of Catamayo Chira basin on the border between Peru and Ecuador, has been working for six years through shared and integrated management of a cross-boundary basin. The project is aimed to contribute to basin integrated management through a Management Plan, support to the production initiatives and technical training and institutional strengthening.

Besides from having been an integration element following the peacy treaty signed by both countries, the project has placed emphasis on bi-national management, on participation, on integrated basin management and on the inclusion of the gender approach, as all of these factors contribute to basin governability. The experience of this first project phase has been organised around lessons learned about these factors, and it is believed that they can contribute to future experiences in similar contexts. In 2008 has started the second phase which will last for three years and where implementing the Management Plan will sustain all further activities.

KEYWORDS:

Bi-nationality, participation, integrated management, equity.

ADVANCES IN THE INSTITUTIONALITY OF THE PILCOMAYO RIVER BASIN

Claudio Laboranti and Andrés Rodríguez

ABSTRACT:

The Pilcomayo river basin, with approximately 290,000 km^2, covers an important region of natural resources of Latin America, shared by Argentina, Bolivia and Paraguay.

The basin has considerable physical peculiarities and an incipient degree of use of its water resources that configure a delicate environmental problem.

This has led governments of these countries to make efforts aimed at fostering the integrated water resources management of this basin within the framework of strengthening the integration of countries that share this basin. This has been formalised through the Tri-national Commission for the development of the Pilcomayo river basin, created on December 1995.

During the first years of its activity the Tri-national Commission devoted its main effort to increasing and improving knowledge of the basin physical processes, of its social-economic and environmental reality and the design of its future institutionality.

To carry out these activities it received technical and financial support from the European Community through the Financing Agreement ASR/B7-3100/99/136 in the “Integrated Management Project and Master Plan for the Pilcomayo River Basin”.

Compliance with the aforementioned goal posed a challenge for the Tri-national Commission to produce an evolution of its institutional structure in order to efficiently and effectively face up to the activities required by the integrated management of its cross-boundary water resources.

A new institutional structure was designed and agreed upon, comprised of three differentiated and coordinated authorities. Formalizing comunity participation of the community in basin water resources management was one of the main innovations of this institutional plan.

KEYWORDS:

Basin organisation, institutionality, water resource management.

SHARED WATER IN THE SOUTHERN CONE:
THE CASE OF THE PILCOMAYO

Arturo Liebers Baldivieso

ABSTRACT:

Is the Pilcomayo a basin shared by Argentina, Bolivia and Paraguay? Are the authorities and the settlers aware of the importance of water to achieve regional integration and development and erase the physical lines established on their frontiers?

A Bolivian vision poses the debate in four-parts:

1. The country's standpoint, which, due to water apropiator, faced three wars, losing its access to the Pacific and important territories to access the Amazon and Plata Basins. It shows the Bolivian will to respect water regulation, the Plata River Basin Treaty and the Tri-national Agreement on Pilcomayo river use.

2. The importance of upper Pilcomayo basin, generator of the most revelant water contributions of the basin, erosion, the transport of sediments and water deficit, phenomena that cause migration to nearby urban centres and to Argentina.

3. The efforts to achieve the cooperation of the European Union, specified with the approval of the Integrated Management Project and Master Plan of the Pilcomayo Basin. An analysis is made of objectives, results and exclusion of regulation projects, and factors (political, bureaucratic and technical) that will affect the results and continuity of the Project.

4. Conclusions and recommendations are formulated to strengthen and re-launch the Project.

SUSTAINABILITY OF WATER MANAGEMENT AND SUSTAINABLE DEVELOPMENT:

AN INITIATED TASK

Stela Goldenstein

ABSTRACT:

Decentralised and participative water management processes were established in Brazil following the democratic transition. These transformations led to an increase in transparency in decisions, reducing the technocratic nature that both the public and private management of the use of the natural resource historically had. The participation of the municipal authorities in the decisions of regional interest results in interesting changes in their insertion, making the need for a review of the strategies that guide all the public policies obvious. At the same time, the presence of representatives of different social segments and stakeholders in river basin committees shows the fragility of such representations, and difficulties of the public power to receive them as genuine interlocutors.

KEYWORDS:

Representation, social movements, basin committees, decision-making processes for water management.

GOVERNANCE AND GUARANTEEING THE "RIGHT TO WATER"

João Bau

ABSTRACT:

Considering water "is essential for life and health", the United Nations Committee on economic, social and cultural rights specifically recognised (in 2003) the "right to water" as a human right. The right to water is defined as consisting of "sufficient supply that are physically accessible and at a reasonable cost, a healthy and quality water acceptable for personal and domestic use of everyone". This means that, in addition to physical accessibility to a water source, it must also be financially guaranteed; in other words, provision of drinking water should be allowed to occur at affordable cost for all citizens in a quantity that guarantees the right to life. If we recognize that it falls under collective social responsibility to ensure this right is respected, now the existence of solidarity mechanisms must be guaranteed at local or regional, national and planetary levels. Such mechanisms are debated, as should be all the values, principles and strategies that they must be founded on.

Remembering the European declaration for a new water culture, a brief reference is made to a broader concept of the "right to water". In fact, more than guaranteeing individual right to water for life, water as an environmental service guarantees other important social rights. These rights must be remembered when the system of "free commerce" established by the WTO is the origin for the practice of social and environmental dumping, wherein the main victims are the poorest countries and people. Rights over the ecosystems, therefore, depend on our existence – it is a fundamental question of our time. It can not be denied that guaranteeing the durability of aquatic systems is a high priority. Once more, it is important to debate good governance that is the expression of a lasting new development culture.

In conclusion, we call for water governance that responds to the problems derived from the lack of transparency and participation of local communities and which is based, notably, on the principles of social ethics, solidarity, equality, etc, within the perspective of lasting development.

KEYWORDS:

Water, right to water, water governance.

GOVERNANCE AND THE GUARANTEE OF THE RIGHT TO WATER – THE EXPERIENCE IN BRAZIL AND THE CHALLENGES TO BE OVERCOME

Manfredo Pires Cardoso

ABSTRACT:

The Brazilian water resource legislation is considered one of the most advanced in the world; the federative provinces also have similar laws, proclaiming bases and involving instruments of a very democratic nature, simulating integrated, participative and decentralised management, fostering good governance. The conception and institution of a National Water Resource Management System, with the participation of governmental sectors at all levels, of water users and of members of civil society, represent a very important factor for governanced effectiveness, thus providing access to good quality water. However, regional diversities of Brazil, mainly related to its climate and direct effects on the hydrological regimes, on one hand, and urban demographic expansion, on the other, associated with insufficient hydraulic infrastructure prevent people from benefiting from enjoying the fair right to water. The institutional advances already attained and other in progress are presented together with successful management experience and to increase water availability.

KEYWORDS:

Governance, integrated water resource management, successful Brazilian experience, hydraulic infrastructure.

THE GROUNDWATER DEVELOPMENT SILENT REVOLUTION:
PROS AND CONS

Ramón Llamas

ABSTRACT:

During the past half-century, agriculture in most arid and semi-arid countries has experienced a true "silent revolution" of intensive groundwater use. Millions of farmers worldwide have chosen to become increasingly dependent on the reliability of groundwater resources, and as a result their countries have reaped abundant social and economic benefits. Except in very poor regions this spectacular increase in groundwater use is driven by economic reasons: usually the cost of abstracting groundwater is only a small fraction of a guaranteed crop. In less developed regions, groundwater probably constitutes the only viable alternative to meet the United Nations Millennium goals.

Data from several countries shows that groundwater irrigation presents significantly greater efficiency than surface water irrigation systems, thus contributing to fulfil the goal of "more crops and jobs per drop". Nevertheless, in semiarid and arid industrialized regions that goal is changing to "more cash and nature per drop".

This "silent revolution" has been carried out with scarce control on the part of government water agencies, and thus a series of unwanted effects have developed in certain places. While these by no means justify the pervasive "hydromyths" and obsolete paradigms that voice the frailty of groundwater, appropriate groundwater management remains a worldwide challenge. This paper provides an overview of these issues, and concludes there is a need to educate all levels of society on the importance of groundwater and create bottom-up user associations to manage aquifers as a common pool resource.

KEYWORDS:

Groundwater use, silent revolution, irrigation efficiency, world water visions, UN Millennium Development Goals, hydromyths, groundwater user associations.

GROUNDWATER MANAGEMENT:
A PROPOSAL BASED ON PARTICIPATION

Fernando López Vera

ABSTRACT:

The hydrological nature of groundwater, being dispersed over large areas and its easy accessibility has meant that it is used individually and this use is difficult to control. This has given rise to two more serious problems that affect its sustainability: over-exploitation and (overpumping) contamination due to fertilisers and pesticides.

In an unprecedented bottom-up action, starting with users, technicians, researchers and people in general linked to groundwater, a proposal has been made to modify the Water Act and the Regulation on the concept of hydraulic public domain where, based on joint management between institutions and users, procedures are established to address both problems.

EVALUATION AND GUIDING BASIN GOVERNABILITY:
THOUGHTS AND PROPOSALS

Ricardo Sandoval

Keynote Conference

ABSTRACT:

World water crisis is derived from pour management. This is a worldwide consensus – denoted by the concept of governability, property of various institutional resource management spheres which are susceptible to being assessed, improved and, therefore, measured. Thus, it seems to be agood idea having aggregate indexes that allow progress a monitoring of the improvement in world water management and even to create a positive stimulus for those countries included in comparative evaluations. In this paper, starting from revieing governability concept, its application to water management, its relationship to the focuses underlying the normal planning and resource management models, as well as identifiable variations in the various speeches on water governability, the pertinence and the specific use of the proposed measurement procedures to date are questioned in terms of their conceptual coherence and their potential consequences. The risks of creating biased perceptions and perverse effects are highlighted. Exploration and development of notice boards featuring indicators in the world sphere are proposed as well as a guiding participatory model for basin governability at the local level, based on reflection and a careful design of concepts and instruments of governability – considering the relationship between media, resources, projects and pressure/state response indicators.

GUARANÍ AQUIFER PROJECT:
LESSONS LEARNT

Luiz Amore

ABSTRACT:

The project for the Environmental Protection and Sustainable Development of the Guaraní Aquifer System is an initiative from Argentina, Brazil, Paraguay and Uruguay dating from 2003 and finishing in January 2009, funded through a donation from the World Environment Fund. The project has achieved its proposed targets: construct a common base of scientific and technical knowledge regarding the aquifer and a series of instruments for its management that the countries will make their own – such as political power input that is yet to be specifically formulated (well-monitoring network; basic map covering the 1.2 million km of the aquifer; hydro-geological data base with nearly 10,000 wells registered; aquifer information system; mathematical simulation models, etc).

Given the knowledge produced – pointing to the physical nature of the aquifer needing local management – through instruments created which can only be developed at a regional level, the challenge is to continue making progress in creating a management policy together with the framework of regional coordination and consensus that the project has triggered.

PRACTICAL LESSONS FROM THE COSTA RICAN WATER RESOURCES PLAN

José Miguel Zeledón

ABSTRACT:

The National Integrated Management Plan is a vital instrument in water resource planning and management policy that, additionally, helps progress in fulfilling common international commitments for the Latin American community. This text looks at offering a panoramic view of the criteria adopted in Costa Rica for the creation of its national Water Plan, with stress on the principle of the water basin as a planning unit – in addition to decentralised and participatory management and the recognition of water's economic value.

INSTITUTIONAL AND LEGAL REPORT ON THE WATER RESOURCES SECTOR IN GUATEMALA

Elisa Colóm de Morán

ABSTRACT:

As in all countries of the world, in Guatemala water resources are suffering from negative changes regarding quality and availability which is limiting water uses in many areas: drinking water, irrigation, hydroelectric energy or industry. This paper presents a panoramic view of the institutional and legal report on water resource planning and management in Guatemala, from the first efforts of some two decades ago to the legal initiative for water resources management at basin level – aiming to make explicit all lessons learnt during this process.

THE TRIFINIO: A TRI-NATIONAL SHARED WATER MANAGEMENT EXPERIENCE

VISION OF THE TRI-NATIONAL EXECUTIVE SECRETARIAT

Julián Muñoz Jiménez and Mario Buch

ABSTRACT:

In the Region of the Trifinio, a territory shared by El Salvador, Guatemala and Honduras, the conditions have been favourable to show the world that it is possible to share water with responsibility and equity, that it is possible to improve its quality and quantity and thus help water preservation. At the same time, advances are made in constructing Peace and regional integration, via harmonisation in the use of water in a responsible way by all players-users of a shared regional resource.

The governance in the cross-boundary basin of the Lempa river has started by signing a treaty between the governments of the countries, which has been vital as a political instrument to support the interventions in the territory and create legal and regional institutionality to develop the inter-institutional coordination of the three governments with a view to benefiting the territory. And we have learned that the cooperation for these interventions must be gradual, opportune and adequate, in order to reach maturity, where the countries in some way or another transfer sovereignty competences that they are not used to. Because if the cooperation comes at a time when the political process is not prepared, actions in defence of sovereignty can take place and it would thus become a dissociative element rather than an integrating element.

For good water governability, it is essential to address the topic of water in an integral manner and with a multisectoral approach, considering economic, social, environmental, institutional proposals and in the case of a cross-boundary region, the regional approach must be considered.

KEYWORDS:

Cross-boundary basin, tri-national, shared water, communities, water governability.

MANAGING WATER IN A FEDERAL STATE: THE CANADIAN EXPERIENCE

J. Owen Saunders

ABSTRACT:

Canada faces special challenges as a federal state in managing its vast water resources, many of which are transjurisdictional in nature, shared either with the United States or amongst Canadian provinces and territories. Although the federal government possesses an array of potentially powerful constitutional levers with which to influence specific aspects of water management, it lacks the plenary jurisdiction that would enable it to address water management in an integrated fashion. Under the Canadian constitution, provinces are vested with most of the proprietary and legislative responsibility for natural resources management, including water management, subject to some specific federal interests. However, even recognizing the primacy of the provincial role, the federal level of government has taken an exceedingly modest view of its powers. The federal reticence to exercise its authority in waters that are clearly of national interest – especially transjurisdictional watercourses – has arguably hampered the development of effective basin management regimes in Canada. As these waters come increasingly under stress in coming decades, especially in light of the expected effects of climate change, a continuing failure by the federal government to assert a clear role for itself in articulating the national interest in water management may well hamper the effective resolution of emerging water management challenges.

KEYWORDS:

Federalism, law, water governance.

RIVER BASIN TWINNING:
A TOOL FOR COOPERATION

Jean François Donzier

Keynote conference

ABSTRACT:

There are many types of twinning (among communities, schools, governments), but the type of twinning tackled within this document is regarding "integrated water resources management at river basin level". This twinning means establishing a link between two (or more) basin organisations (or similar entities that deal with water management at the basin level) to foster exchanging of knowledge, learning from each other and discussing similar problems.

During last decade, in the geopolitical context of the European Union or within the framework of the development of Southern Countries, many twinnings were undertaken between Basin Organisations (BO) to foster exchange and to improve practices related to Integrated Water Resources Management (IWRM). This paper aims at discussing the advances and setbacks experienced by the twinning process to contribute in the debate that will be carried out during the Water Tribune in Zaragoza.

SDAGE FROM ADOUR-GARONNE

Vincent Frey

ABSTRACT:

The objective of the Adour-Garonne Basin Water Plan (2010-2015) in south-west France is to comply with the commitments of the European Water Framework Directive (WFD). The preparation of this plan is based on co-creation of the documents at a local level (sub-basins). Despite the pragmatic and participatory nature of this work, the complexity of the subject creates an area that is difficult to bridge between the “planner” and the citizen. However, the awareness of the land authorities and the people will be the key factor to achieving targets at the lowest cost in financial investment.

LESSONS LEARNT IN THE CREATION OF THE LERMA-CHAPALA BASIN MASTER PLAN

Enrique Aguilar Amilpa

ABSTRACT:

The Lerma-Chapala basin is of special importance to Mexico in economic, social and political terms. It is the source of a supply for 8 million people; the industry located in the basin provides 33% of the National Industrial GDP; irrigation agriculture contributes markedly to the exportation in this sector; and it is there that 20% of the country's commerce and services occur. Due to this, there are water conflicts, pollution problems, and scarcity getting progressively worse because of low efficiency in use and environmental effects of the highest level. Over 20 years ago, a still unfinished planning process was begun in the basin, centred on one key point: rescue Lake Chapala – which is the largest natural lake in the country and is affected by upriver uses in the basin. The process instituted is a reflection of the substantial changes in the political and democratic life of the country with positive results – though still limited – that have great value for what they represent in terms of their contribution to the national design of policies that involve public participation with specific results – but there are still challenges remaining.

PROBLEM OF WATER MANAGEMENT IN POLITICALLY CENTRALISED REGIMES: THE CASE OF SPAIN

Antonio Embid Irujo

ABSTRACT:

In politically decentralised regimes, the problems of water management have some characteristic signs with respect to those with unitary States. The greater the degree of political decentralisation, the stronger the competences of the parts of the decentralised state on water usually are. When the natural division of river basins is superimposed over the political division, some management challenges that are difficult to overcome arise, as often the basin goes beyond the territory of States (provinces, regions) and it is only possible to manage common basins in some countries via agreements that are similar to international treaties. A solution has been reached in Spain consisting in attributing to the state the management of basins that cover the territory of more than one Autonomous Community and the management of the basins that are integrally within the territory to the Autonomous Community. However, this is a solution subject to tensions and with the latest reforms of some Autonomy Statutes pose new governance challenges. A problematic question in these political regimes is always water transfers which entail territorial conflicts of considerable magnitude in several cases.

KEYWORDS:

Competences, autonomous communities, river basin, basin organisations, water transfers between river basins.

SHARED WATERS, SHARED BENEFITS

Ashok K. Subramanian

ABSTRACT:

Transboundary water management has been piloted and studied in many parts of the world. Regional and national organizations have been established to build trust among countries and their leaders, to share knowledge and information and to plan and implement projects sharing benefits and costs. Many collaborative efforts have delivered evidence that conflict and lack of cooperative management would be expensive, disruptive, and would interfere with efforts to relieve human suffering, reduce environmental degradation, and achieve economic growth.

There are 263 rivers around the world that cross the boundaries of two or more nations, and an untold number of international groundwater aquifers. So, in many parts of the world, the potential for conflict still exists, and parties involved have not yet embarked on the path of assessing incentives for regional cooperation or have not started systematic dialogue for exploration of shared use of water as a unique resource. What can these countries learn from the experiences of other water basins?

In this session several experts and key players in river basins will share their experiences in the African context and formulate a set of recommendations i.e. defining steps to identify incentives to get countries and stakeholders together around the dialogue table, to assess the pros and cons of those incentives and to communicate and negotiate with each other about win-win solutions.

PROMOTION OF SECURITY AND CO-OPERATION IN RIVER BASINS

Bernard Snoy, David Swalley, Saba Nordstrom and Raul Daussa

ABSTRACT:

The sharing of water resources by two or more countries may be a source of a potential conflict. Joint management of such waters is the optimal conflict prevention measure. To this end, the Office of the Co-ordinator of OSCE Economic and Environmental Activities (OCEEAA) has developed a series of activities in the Dniester (Eastern Europe), the Chu-Talas (Central Asia) an the Kura-Araks (Southern Caucasus) river basins.

OSCE has proven to be a valid interlocutor in the field of water management, assisting its participating States in achieving international conventions and agreements, and facilitating the dialogue between riparian States by developing projects aimed at strengthen co-operation in that field.

The examples of the projects already developed by OSCE on water management aim at conflict prevention, conflict resolution and post-conflict rehabilitation steps of the conflict cycle.

KEYWORDS:

OSCE, OCEEA, security, co-operation, river basin, conflict, prevention, resolution, Eastern Europe, Central Asia, Southern Caucasus, Dniester, Chu-Talas, Kura-Araks.

Thematic Week 5

WATER SUPPLY AND SANITATION SERVICES

[Regulatory and instutional framework
Society service quality
Efficiency, management and development]

Acknowledgements

We must begin by acknowledging and recognising the participation of the following people without whom neither the development of the Thematic Week on Water Supply and Sanitation Services nor the quality reflected within these pages would have been possible.

Firstly, we wish to thank our collaborators in the coordination of the Week: Pedro García Mayordomo from Isabel II Canal and Sici Sanchez Tamarit from the Ministry of the Environment and Rural and Marine Affairs.

We would particularly like to recognise the hard work of the whole team at the Water Tribune: Eduardo Mestre and Carlos Rodriguez Casals, those who directed and coordinated the whole process; also to the volunteers, multi-taskers, sound and camera technicians, stage managers, shift managers and the manager of the Tribune Pavilion, heads of the various Departments, external assessors and collaborators, administrative personnel, without forgetting any who may have fallen along the way, and, in general, to all those who formed part of the human team at the Water Tribune. They worked wonders to smooth out processes and running the week.

We would like to praise the work of the moderators for the sessions and round tables and the panellists who help enrich and enliven the contents of the week and whose work is not featured in this document as we had not asked them for written contributions of their participation – as seen below:

- Pierre-Yves Monette, Secretary General EUREAU
- Manuel Marchena, Chief Executive EMASESA, Spain
- Dominique Demessence, Customer Manager, Agbar Agua, Spain
- José De Castro, Manager, AEAS, Spain
- Ventura Bengoechea, Leading Specialist in Water and Sanitation for West and Central Africa, World Bank
- Manuel G. Mariño, Leading Specialist in Water and Sanitation, Urban Division, Latin America and Caribbean Region, World Bank
- Enrique Hernández, Director of Services Management, Aqualia
- Frederic Certain, Chief Executive, Veolia Agua
- Erasmo de Alfonso, Senior Executive, Aquafed
- Gustavo Saltiel, Sector Leader – Mexico, Department of Sustainable Development for Latin America, World Bank
- David Sislen, Sector Leader – Colombia, Department of Sustainable Development for Latin America, World Bank
- Carlos Velez, Economist Leader, Department of Sustainable Development for Latin America, World Bank

We would also like to mention and thank the following for their outstanding participation in the Global Development Learning Network session on 15 July 2008:

- Meike van Ginneken, Sr. WSS Specialist, ETWWA, World Bank
- Karen Sirker, Social Development Specialist, WBISD, World Bank Institute
- Dario Urbina, Puerto Cortés. Technical Manager, Puerto Cortés Municipality
- Carlos Alza, Adviser of the National Ombudsman Office and former Deputy Ombudsman for Public Utilities and Environment
- Nicolas Meyer, World Bank Institute
- Thomas P. Pitaud, World Bank Institute

Finally, our special gratitude to AEAS, EUREAU and IWA for their help and support in this event.

Francisco Cubillo
Coordinator

Introduction

Between July 15 and 18 2008 and within the framework of the Water Tribune at EXPO ZARAGOZA, the conferences on “Water Supply and Sanitation Services” – coordinated by Francisco Cubillo of Canal Isabel II – were held with the participation of 42 speakers and nearly 400 experts on the subject from over 32 countries. This representation of people covered a broad spectrum of viewpoints, knowledge, experiences and responsibilities which contributed to interesting standings and to lively and enriching debates and recommendations.

The common objective was that of dialogue, joint reflection and identification of the main challenges at present and in the future in the management of urban water before, finally, pointing out the possible solutions that could contribute to sustainable use of the resource and efficient management of supply and sanitation services. In particular, the possibility othat all population worlwide could truly have access to drinking water and to sewage sanitation to complying with Millennium Development Objectives – was also sought.

The week focused on analysing the problems of providing water and sanitation services within the urban environment as well as on identifying solutions able to combine requisites being satisfied with commitments to society, the standpoints of sustainability and the search for efficiency in complying with regulations set within the legal or regulatory frameworks or simply within the goals of good practices by those in charge of managing these services.

The problem was examined according to a structure featuring five main areas for analysis:

- The regulatory and institutional framework of urban water services.
- Society’s expectations and level of services.
- Forum of good examples.
- Technological capacity, conditioners and solutions.
- Efficiency as a paradigm for the citizen, management practices and development.

Participation and standpoints were characterised by a diversity of positions, points of view and experiences.

The analysis was undertaken with notable reliance on experiences in current management, featuring debates on good practices and examples without shying from weak points, risks and the great obstacles.

This included:

- ▶ Experiences and standpoints of the institutions and financial entities, of the regulatory bodies and the regulated entities that operate under the different models of either public or private management.
- ▶ Initiatives and strategies from the international agencies and the positions at national and local levels within the broad panoply of existing development levels around the world.
- ▶ The position of the agencies that create the environmental context in which they provide services together with the objectives to be pursued water resources planning and the different ways to assign and share these resources, to the entities that supply water, or the levels of spillage and those responsible for cleaning up.

- Points of view, involvement and expectations of the entities that represent social agents and water enterprises and bodies that undertake and develop the tasks that allow for providing all services linked to water supply and its later salutation and eventual returning to the environment.

The debate was based on the rigour of analyses combined with the contribution of knowledge that allowed for practical experience providing services within different contexts – social, economic and environmental – and scientific and technological focuses that looked for and studied new solutions. The opinions and experiences of participants were complemented by those of expert audience who, during the debate, completed the analysis and supplied conclusions and recommendations to each session and subject.

The thematic week dealt with existing objectives and plans in regional and international spheres, supported by case studies at local and national levels in a context of good examples.

Experiences in information processes and public participation were revealed in establishing service levels, preferences and social willingness in regardings safety and protection in terms of acceptable risks as well as in the analysis of the feasibility, deadlines and costs of attaining them.

Initiatives were revealed and analysed within integrated management of commercial processes linked to providing services and the extent of client satisfaction, as well as the efficiency of the measures to boost and promote changes in habits regarding usage and consumption of water required by new policies oriented towards demand and environmental commitment.

Special emphasis was placed on technology, its current capacity and the solutions it could provide. Some significant advances of recent times in the areas of water and waste treatment were mentioned as well as the increase in availability of resources apt for use and consumption and in the regeneration of sewage water for reuse. Solutions adapted to the peculiarities of rural conditions and to those of low incomes were also examined.

In the section devoted to efficiency, the new paradigms with heavier weight for environmental and social factors were broached. These oblige a review of previous strategies and ensure the fulfilment of new requisites while maintaining adequate economic results for entities responsible for wss management. In this section, examples were presented from all continents with different management models allowing an assesment of efficiency in the provision of services through differing urban situations.

The thematic week dealt with the need for strategic management of urban infrastructures related to water – to its planning, its management, its productive efficiency, real and apparent losses, extreme episodes of shortage and floods, prevention and management of risks that involve safety (the requisite that has acquired greatest importance in recent times), how the aquatic environment is affected, demand management as an alternative to achieving the intended guaranteed provision, safe service and quality.

Summarizing, all problems related to providing supply and sanitation services within urban environment were covered so as to improve knowledge in this area through the exchange of experiences and opinions.

This document comprises all written material available regarding conferences that were delivered, and adds a summary report and conclusions written and revised by a group of experts selected from participants and writers.

Positioning document

Coordinator: **Francisco Cubillo**

The current summary and the following one detailing conclusions reflect, in the opinion of the committee responsible for its drafting, the results of the debates and presentations held during Thematic Week 5 at the Water Tribune.

The following experts participated in the drafting of these segments:

- Frederic Certain, Veolia Agua.
- Francisco Cubillo, Isabel II Canal.
- Erasmo de Alfonso, Aquafed.
- José de Castro, AEAS.
- Gerard Payen, UNSGAB.
- Joaquín Pérez-Novo, Veolia Agua.
- Fernando Rayon, AGBAR Agua.
- Nicolas Renard, Veolia EAU.
- Sici Sánchez, Ministry of the Environment and Rural and Marine Affairs.
- Thomas van Waeyenberge, Aquafed.

1. CURRENT CHALLENGES IN WATER

On a planet where 20% of the population lack access to drinking water, half have no access to adequate sanitation and some 3,000 million people have no nearby access to water, the paramount challenge is to palliate and resolve these situations. Notable initiatives have been taken along the lines of what was established by the Millennium Development Objectives, but the progress towards achievement is still much slower than desired. This is despite moderate expectations of these objectives – as they do not include expectations expected by more developed societies like quality, availability and reliability of both water and sanitation.

With no sanitation, hygiene conditions are catastrophic and the number of infectious diseases very high. It is estimated that these latter are responsible for the death of more than 2.5 million people around the world every year. A lack of water and sanitation is indicative of poverty and it generates further poverty.

The right to water and sanitation is fundamental in order to ensure the basic right to life.

In addition to the basic challenge of fulfilling the Millennium Development Goals, five challenges have been identified of equal importance:

- Availability of resources and climate change
- Population increase centred on cities
- Governability of water and institutional guidelines
- Financing for water services
- The urgent need for integrated efficiency

▸ Availability of resources and climate change.

Barely 5% of the water resources on Earth consist of freshwater (springs, rivers or aquifers). Of this 5%, only 0.3% is easily accessible. The rest can be found trapped in the polar icecaps or in glaciers. This tiny percentage is spread around the world in an unequal way and its distribution over the seasons is also not equal. Climate change is altering this irregular distribution and it seems there will be a reduction of resources in many areas where consumption is great and growth is huge, with the result that there will be more zones suffering from water scarcity around the planet. Water resources pollution as a result of human activities also affects water use for many purposes – reducing availability or making its end use much more expensive.

Water is a finite element which is renewed on a planetary scale and appears in various forms and locations. Its cost tends to be subsidised and, unlike in case of crude oil, it is not worth transporting it over great distances. This conditions its availability in some urban locations to the costs and prices that are determined by the local authorities.

Available accessible resources are being reduced due to the demand increase and because of climate change effects.

▸ Population increase that is centred on cities

6,000 million people inhabit the world today when just 40 years ago that number was 3,000 million. According to the latest report on population evolution from the UN, in the coming 40 years there will be over 9,000 million people on Earth. Never in human history has population grown so fast – though there are some apparent signs of stability – and never has there been such a notable difference in quality of life between various regions of the planet.

In 2008, half the population – in other words 3,000 million people – lived in cities and half of these were to be found in developing countries. Forecasts point to this trend which if continuing will mean an increase in the cities dimensions while suburbs will occupy land currently destined for crops and woodland.

Furthermore, there is an unstoppable migratory movement towards the coasts. Currently, 20% of the world's population lives less than 25 km from the coast and 40% at less than 100 km. In these areas water sources are scarcer and more complicated to tap – unless desalination processes are considered and these, while effective, are currently high energy consumers which means the cost of running them is often non-viable in countries that have under-developed economies.

Urban growth of and the population increase in the cities are making it ever more difficult to combine supply and demand while at the same time concentrating effects on water bodies.

▸ Governability of water and institutional guidelines

Water as a public service is considered a priority by relevant authorities. It gains notoriety in political programs and is the source, in many cases, of frustation and conflict of authority and governability between agents and entities that manage the complete water cycle, in particular in the urban scene where social implications regarding management are much greater. All of this leads to impediments on efficiency which always end up with repercussions for citizens and the environment and make it difficult to appropiately look at matters in the medium- to long-term.

Therefore, the following premises must be taken into account:

• Using water as a political weapon is in detriment to the people.

• Ideological aspirations should not risk the primary objectives of "user satisfaction" or "effectiveness and service efficiency".

• Policies related to water of various different governments are not ambitious enough as regards the development of access to water and sanitation.

In water government, many water and sanitation public authorities responsible for services are local and this trend is increasing due to continuing decentralisation. These bodies often do not have the human, technical or financial resources necessary to cope with this responsibility – which has its repercussions in the quality and viability of the services being provided.

The overlap in responsibilities and the lack of a clear definition of roles and of all the parties involved in the water management make implementing necessary measures to face the emerging challenges more complicated, leading to the appearance of conflicts over the use and redistribution of water. The existence of well-equipped regulatory bodies to guarantee technical criteria and which function independently should facilitate the growth of quality services.

Equally – and more often – it is necessary to have public participation (consumers' associations, professionals and civil society in general) to know the preferences and perceptions of provided services of consumers to ensure good management and good water. Governance thus far, there has been no improvements in information and transparency and in the implementation of mechanisms to incorporate public participation in urban water services planning and provision. However, it is clear how easily water matters are used demagogically. Therefore, when promoting public participation it is necessary to carefully design the relevant mechanisms to avoid public opinion manipulation

In most countries there is no basic legislation on such matter; in others where it does exist, it is necessary to adapt it to specific socio-economic and technical context that is the reference point for of water services provision.

Regulatory, institutional or technical capacity shortages or difficulties in governing water make it very complicated to efficiently or effectively satisfy citizens' expectations. Despite this, there are many and varied good examples of efficient service provision.

Financing for water services

The principle of "water pays for water" must prevail. Full cost recovery derived from access to water and the environmental deterioration must be funded by users. Nowadays, we can find many cases where the principle of cost recovery is ignored or where water serves as a crossover financial source for other services or different activities. This runs contrary to future insurance through investments and produces capital loss – definitively compromising the quality of the services provided.

Likewise, it is not possible to demand payment for services that the user can not pay, particularly when these are services without which life is impossible. Tariff models do not adapt to the socio-economic reality of many countries and, while free water is a serious mistake, the concept of solidarity must exist among users with partial or complete subsidies for those most in need. Solutions successfully implemented in some countries are not applicable in others with distinct cultural or economic contexts. However, in any case, it is advisable not to forget that one topic is water tariff policy and another is wealth redistribution policy. Just as it is reasonable not to use water tariffs to finance other services or activities, so it is unreasonable to redistribute wealth through water tariff policy – corresponding to the tax policy of governments. Subsidies to guarantee access to water for the neediest should be a result of the fiscal policy and not of the tariff policy and, in any case, should be defined in such as way as to neither encourage water misuse nor condition or compromise the technical or economic performance of the service provided.

If there is no feasible long-term funding which is recoverable for the investing party – whether public, private or mixed – then any good intentions to ensure the right of access to water will be useless.

▸ **The urgent need for integrating efficiency**

In a world in which the globalization is acknowledged in a good number of processes and phenomena, managing a resource such as water and making it available to be used by inhabitants of the cities needs to be dealt with through integrated positions. Water management for human use is an exercise in changing the natural cycle to make development possible and brings great advantages to society but it also incurs serious effects on the environment and requires the use of energy in ever greater quantities to cope with the concentration of people in the cities and the equally increasing requisites of quality, reliability and continuity in urban services. The alternatives to deal with the emerging requisites need to be efficient in economic, environmental and social terms and their achievement is only possible if, in the analyses of the various supply and sanitation systems, all factors that strongly condition and determine continuity in terms of sustainability are considered in an integrated form.

Planning and management of urban water services must be examined through an integrated focus on the environmental, energy, economic and social implications and from the perspective of sustainable global efficiency.

2. SOLUTIONS

The solutions have been brought forth from the analysis of the identified challenges and opportunities to face them.

▸ **Availability of resources and Climate Change**

It must be highlighted, in any case, that in most countries on Earth, water for urban provision does not even represent as 15% of the total water consumption. Therefore, when analyzing problems related to the lack of resources or the environmental effects derived from extraction, urban water does not represent more than such percentage. Thus, problem solving when resources are scarce for urban water supply must often be searched for in areas outside the urban wss system itself.

Ensuring the availability of resources in good conditions should begin by protecting existing sources from pollution and deterioration due to inadequate use. The use of resources according to the needs of each use in terms of water quality and operational energy costs is a principle that leads to the best efficient solutions in each case.

Sharing what is available to each end and scenario considered should combine the environmental requisites (as the route to sustainability and later use) with priorities and importance in each region or society. In all cases, the chief priority lies with the essential uses of urban water supply and sanitation, followed by those that condition economic activity in a region – also tending to be found within urban and suburban zones. Contingency plans or insufficiency through shortage or drought highlight the priorities for use and make the possibility of exchanging or transferring rights of use between urban and agricultural sectors clear, both in interim situations and within stable frameworks of resource reassignment.

Water efficiency should be a basic indicator when evaluating options for resources reassignment and global availability, not forgetting options for improvement in this search whose achievement neither need be immediate nor cheap.

Climate change could alter the conditions of resource availability and this must be taken into account when planning the evolution of urban systems. This would be through reinforcing the principles of evaluation and risk management for insufficiency and improving adaptation procedures for possible scenarios that have not been predicted and will be necessary to face.

Water loss in urban and irrigation systems represent a potentially large volume of recoverable resources, which in relative equivalent terms would mean greater contributions in the case of irrigation systems. However, it is important not to confuse real water loss within infrastructure with apparent losses due to inadequate equipment, control procedures and measures or fraud that hasve been ignored. Therefore, once real losses have been carefully assessed, it is necessary to ensure their reduction is feasible economically and environmentally within the outlooks and scenarios contemplated vis a vis to other alternative possibilities. It is also important to check – when dealing with considerable quantities of water such as irrigation improvements – that environmental effects are not generated making implementation unadvisable.

As all traditional and alternative resources are valid tools to ensure the right of access to water and its availability in sufficient quantities, new alternative resources – desalination and water reclamation – are good ways to protect the traditional natural resource. Their future depends on their energy viability – with all the environmental implications and increase in total costs – and their acceptance by society. Liquid waste is a component in the water equation that increases with urbanisation and economic growth. Reuse and desalination are a resource with less uncertainty, found within the area itself and unlimited by political issues – whether national or international.

Efficiency improvement in all water systems must be an alternative to be considered prior to mobilising resources, but no option should be excluded if is sustainable. Alternative resources imply changes in the water paradigm and energy use and should be valued equally, though their acceptance by society should be promoted.

▸ Population increase that is centred on cities

The best way to reduce migrations from rural areas to the cities and from inland to the coasts is by developing future possibilities and opportunities – including access to water – within those areas from which the migrants are moving.

Water authorities should work side by side with urban planners and with land models to integrate development and sustainability.

The environmental feasibility of water supply and sanitation must be ensured first before promoting sustainable urbanisation.

▸ Governability of water and institutional guidelines

Ensuring the right to water and sanitation is the responsibility of governments and politicians. These must plan water policy in the long term and move towards rational and responsible discourse, being able to combine the expectations of immediate solutions that institutions and citizens share with imposing long-term strategic plans consistant with global world reality.

Given that water is – and will continue to be – a political issue, water experts should duly train and inform politicians about the current and future challenges for water, to properly empowered them to make decisions.

Water is a resource common to all and as such is a matter of State.

Challenges, surrounding conditions, cost, price and, in general, any change should be understood and accepted both by the people and by politicians responsible for them. Useful and effective mechanisms should be used to improve citizen participation. No change will be sustainable if it is not shared by citizens. When change is necessary, society will accept it if been clearly informed and involved in decisions.

All users, interests and the public-at-large should participate in decision-making process: associations of domestic, industrial, agricultural, civilian, and political users. Letting everyone express themselves and bring what they consider appropriate to the table is the basis for an understanding of the decisions to be taken. With all of this, it is important to maintain truth in information, prevent demagogy and avoid a systematic blocking of necessary decisions being taken.

Public participation is a key factor in water policy.

Although responsibility for provision and sanitation services might be local matters in many countries, national or regional authorities must maintain their responsibility when promoting legal, technical and financial guidelines to ensure correct and efficient service provision. In these cases, central authorities must guarantee that local services have all necessary mechanisms to provide the citizen with a safe and efficient service.

While responsibility for the water supply and sanitation services is municipal, "management units" need not always come from this sphere. The dispersion of water sources, orography and topography of the zones to be serviced or the small size of management units suggest and, on occasion, oblige management units to be supra-municipal – as is the case of the Regional Health Companies, Consortia or the optimal Management Units in Italy. The creation of supra-municipal bodies is a solution that is being applied ever more often to improve governability and efficiency.

The decentralisation of authority should not mean abandoning global coordination either at state level or in the sphere of natural water government – as referred to in planning and managing water resources – ,that is, the Water Basin.

Political authorities, financial bodies and operators have different tasks and roles in the water management. All operators, whether public or private, need clear objectives and a fair control and follow-up system for their activities, with rules and conditions for the provision of services known by all.

Contracts that regulate service provision are always beneficial for users, authorities and operators.

Transparent, fair, stable and adequate regulation is a key factor in ensuring the success of any form of management. The regulators will have different functions in different countries, but they should have clear missions that are independent of the political powers-that-be.

It is necessary to clarify and respect the role of each player involved in water management and water supply and sanitation services.

Users really need to have a good service at a fair price and the mechanisms to satisfy the needs of the users are the same whatever the type of management. Therefore, the main debate should not be centred on whether the management model should be public, private or mixed, but on ensuring the provision of a level of service that is appropriate to each social and economic context in terms of sustainability and to provide effective guarantees to ensure management transparency and control.

The authorities must firstly define the objectives to be achieved and deadlines in which to achieve them. Secondly, they should choose both the appropriate media and the style of management (public, private or mixed) according to local circumstances. The organisation should evolve in accordance with the actual evolution of the local circumstances.

The new water cultures are going to be cultures of greater co-responsibility between all players involved in the water sector.

What is important is not the public, private or mixed model chosen for management but that services are good and at an adequate price.

▸ Funding for Water Services

Local circumstances differ according to geographical conditions, economic development of society and legal and political frameworks. Thus, solutions to be applied will vary. Not all technical solutions or management models will be applicable to all situations.

One key objective for water and sanitation services is to combine efficiency and cost. This principle will benefit both the user and the investor – public or private.

It is of no use to implement services whose prices cannot be afforded by users. Prices must be adapted to the specific circumstances of each place.

Service costs for water and sanitation should be completely recovered – something that is compatible with solidarity through discrimination in taxes according to the social circumstances or through public subsidies. In general, the move should be towards the recovery of costs even though in developing countries extreme caution must be exercised so that this cost recovery is not counter-productive as an immediate objective. Tax guidelines wherein the principle of the recovery of the full cost and solidarity are developed are the responsibility of authorities. A sustainable cost recovery should allow:

- Each user should able to pay a price within his capabilities.

• Every user has to pay for the service, including public users. A free service triggers is water misuse and abuse.

• Cross-subsidising should be avoided as much as possible. If it is necessary to subsidise the less well-off, then it sholud be done in a direct way.

• Long-term financial planning for the services, given that this is the only way to ensure investments and combine them with cost recovery and solidarity. Subsidies have to be a possibility to finance construction costs for water infrastructures and not maintenance, exploitation, replacement and environmental costs, as long as this is possible for those with a lower payment capability.

• All users – urban, industrial and agricultural – should take on their portion of responsibility.

Business models for water services need redefining:

The steady drop in availability and consumption in many local spheres as a consequence of global change and new demand management policies is conditioning economic results of service operators as these depend greatly on the volume being managed.

The operation of water services has expanded into fields and responsibilities that were never previously considered, such as those of management and treatment of storms or flood prevention. These new responsibilities increase costs and should be included in the equations that financially regulate the services. Furthermore, the new challenges require greater effort from R+D, the costs of which should also be viewed as part of the service costs.

It is necessary to organise the complete and sustainable recovery of costs.

▸ The urgent need for integrated efficiency

Efficiency in managing resources, infrastructures and water services needs to filter through into all the decision-making processes – from strategic planning to the operation of systems in normal circumstances and during contingencies. In fact, management models that integrate the complete service cycle (supply, sanitation and reuse) into one sole manager are usually highly efficient.

Efficiency should be valued and its more global acceptance pursued through all the environmental, social and economic considerations of the many players that intervene in the various water management processes in the urban medium. The presence of energy has been growing in importance in the solutions for emerging challenges in water management – from the greater legal requirements in quality for the various uses to the inclusion of alternative resources such as desalination, including protecting water bodies subject to discharges to intensive sanitation processes for sewage water. Any new solution must be accompanied by a complete evaluation of its efficiency and energy needs in its implementation and operation.

Global systems evaluation and their various options based on water esteems and ecological footprints or within parameters such as virtual water needed in each case are mechanisms that facilitate a complete analysis.

Guaranteeing the supply is a commitment for the manager. This requires regulation, models and efficient management and tools to undetake operative action. As a guarantee, there must also be infrastructures in addition to resources. This in turn requires meshed systems, redundant adductions, diversification of fuel supplies, etc. The guarantees of quantity, quality and adequate conditions for continuity and good service are the essence of urban water services and can only be achieved through efficient and all-encompassing practices.

Benchmarking is a powerful tool to motivate efficiency, though caution must be used when undertaking comparisons to ensure consistency and explain the different circumstances and contexts that can coincide within each case and system.

The technology that makes it possible to find solutions to a great many challenges and problems examined in this document must also support preserving the environment and facing climate change.

R+D have become the hope for the future. Research can no longer be just an option; it must be an unavoidable task for public authorities and private corporations, with great steps being taken towards increasing budgets destined these ends and in the pursuit of applicable and effective results.

Conclusions

A principle that cannot be waived is that "the right to water and sanitation is fundamental to ensuring the basic right to life".

▶ Available resources are being reduced by growing demand and because climate change impacts.

Improving efficiency in all water systems must be an alternative to be considered prior to mobilising resources, but no option should be excluded if it is sustainable. Alternative resources imply changes in the water paradigm and energy use and should be valued equally, though their acceptance by society needs to be stimulated.

▶ Urban growth of land and the increase in city populations is making it ever more difficult to combine supply and demand and is concentrating the effects on water bodies.

The environmental viability of water supply and its treatment must be ensured first before promoting sustainable urbanisation.

▶ Regulatory, institutional or technical capacity shortages or difficulties in governing water make it very difficult to efficiently or effectively satisfy citizens' expectations regarding these services. Despite this, there are many and varied examples of services running well.

Water is a resource common to all and as such is a matter of State.

Public participation is a key factor in water policy.

The decentralisation of authority should not mean abandoning global coordination either at state level or in the sphere of natural water governtment – as referred to in planning and managing water resources – that is the Water Basin.

It is necessary to clarify and respect the role of each player involved in the water management and supply and sanitation services.

What is important is not the public, private or mixed model chosen for management but that the service provided is good with an adequate price.

▶ If there is no feasible long-term funding which is recoverable for the investing party – whether public, private or mixed – then good intentions to ensure the right of access to water will be useless.

It is of no use to implement services whose prices cannot be afforded by users. The prices must be adapted to the specific circumstances of each place.

It is necessary to organise the complete and sustainable recovery of costs.

▶ Planning and management of urban water services must be examined through an integrated focus on the environmental, energy, economic and social implications and from the perspective of sustainable global efficiency.

THE PORTUGUESE EXPERIENCE ON THE REGULATION OF THE WATER SERVICES

Jaime Melo Baptista

ABSTRACT:

The main objectives of this paper are to provide an overview of the Portuguese Regulator's (IRAR) main strategic guidelines and its experience in those last five years. It will also described the outcome of a project carried out, in association with LNEC, aimed at defining the performance indicators (PI) systems to be used as basis for comparison of the operators' performance. Three groups of PI were defined, related to: 1) protection of the user interests; 2) sustainability of the operator; and 3) environmental sustainability. Twenty PI have been set for both services: water supply and wastewater. These PI systems are a fundamental tool for IRAR to implement the quality of service regulation, as an essential component of its regulatory model. The quality of service regulation frames the operators performance as far as the quality of service provided to users is concerned and shall not be dissociated from the economic regulation. At present, the consolidation of regulation is crucial envisaging the enhancement of the current quality of service to the users. IRAR aims at having a leverage effect in the transition of the country from the current stage of infrastructural investment in new assets to a new stage of stability and high quality of service delivery.

KEYWORDS:

Regulation, performance indicators, benchmarking, water supply, wastewater.

REGULATION AND PRIVATISATION OF THE PROVISION OF DRINKING WATER, SEWERS AND SEWAGE TREATMENT SERVICES:
CHILE – A SUCCESSFUL CASE

Magaly Espinosa Sarria and José Rodriguez Sandoval

ABSTRACT:

The development of drinking water, sewers and sewage treatment services sector in the last few decades are described comparing results obtained in coverage and quality of service provided and identifying the decisive factors that allow for the experience to be shown as a success.

Almost two decades have passed since the inception of the privatisation process of the sanitation companies and the operational and financial results achieved in this sector have placed Chile at the forefront of countries that have been successful in the transfer of property and exploitation rights to drinking water companies in the private sector.

Likewise, it was necessary to design a direct subsidy mechanism, focusing on consumers with the intention of protecting the access to a minimum consumption level for drinking water and sewers to those families most economically bereft.

Thus, it was the government of Eduardo Frei which decided to push forward and implement a model incorporating private capital based on the sale of batches of shares in the country's main state-run companies. To do so, it was necessary to pursue a series of modifications within the current regulatory framework in 1998 – which were intended to avoid concentrating property, to regulate conflicts of interest and manipulation of information, to strengthen the fiscal institutions in the sector, and to improve the methodical accuracy, clarity and transparency and the procedures in the establishment of taxes.

A second period of private participation was propelled by the government of Ricardo Lagos, but this time the scheme used was that of the transfer of rights of exploitation of the sanitary concessionaires.

The role of the Superintendence of Sanitary Services is described: this is a regulating and fiscal body for the management model that the country adopted and as such it constitutes a fundamental pillar in the success of the model applied and the results achieved. It exercises the role of Tax Fixer, granting areas of Concessions and Audit and control over the private operators.

KEYWORDS:

Regulatory framework, privatisation of drinking water, sewers and sewage treatment services, superintendency of sanitary services, successful results.

THE PERCEPTION OF THE SYSTEM SUPPLY MANAGERS:
THE AQUA PUBLICA EUROPEA POINT OF VIEW

Anne Le Strat

ABSTRACT:

Worldwide, 90% of drinking water distribution is covered by public management. In order to undo the preconceived idea that disassociates performance from public management, European public operators have decided to unite their efforts in order to promote public management at a global level and to constantly improve water services whilst respecting sustainable development priorities. That is why they decided to create the Aqua Publica Europea network. Responsible management, that is effective while truly respecting and protecting hydraulic resources, needs a long-term vision that covers water heritage, a concerted vision of the different uses of water (agriculture, industry...) and a democratic control characterised by active participation of the citizens and a reinforced role of the users in its governance.

European water companies and public authorities are aware of these challenges and wish to become actively involved in a global water policy primarily based on access to drinking water for all. It is time to fully embrace the responsibilities concerning water management as a public good.

KEYWORDS:

Public management, performance and transparency, universal access to water, public-public partnerships, Aqua Publica Europea

ITIZEN EXPECTATIONS FOR URBAN WATER

Belén Ramos Alcalde

ABSTRACT:

Citizens are showing concern about water. As an example, over 1,300 complaints were attended by the Consultancy service at the OCU in 2007 alone and over 200 complaints were received by the organisation within three months of a special section being set up in our web site www.ocu.org (report: Consumers and water).

The aspects of quality, supply deficiency, tariffs, the lack of precautionary measures for emergency situations and a lack of information, for example, are things that are of concern to us.

If we wish to achieve good management of our water resources, water policy should be undertaken in a coordinated way via a coordinating body that would establish homogeneous directives to govern and control the degree of achievement or implementation across the whole of the nation. However, above all, we must avoid submitting water management in our cities to temporary strategies that change every time there is a change in legislature.

EFFICIENCY AND GOOD PRACTICES IN SANTIAGO DE CHILE

Felipe Larrain Aspillaga

ABSTRACT:

This paper describes the successful experience in the provision of drinking water, sewers and sewage treatment services to Santiago de Chile.

Aguas Andinas S.A. is the main company in the drinking water and sanitation sector in Chile, serving nearly 6 million inhabitants. AGBAR, the controlling company, is the leader in the water sector with a strong commitment to and great experience in the supply of drinking water and treatment of sewage around the world.

The targets achieved during the management of AGBAR ihave been significant. In the operating area, with the implementation of the Operational Control Centre, the incorporation of cutting-edge technology and the improvement of processes; in the area of customers, with the improvement of service quality; and in the financial area, with the increase in value of the company.

However, it is impossible not to mention the commitment of Aguas Andinas to the largest project in the history of the water sector in Chile: that of obtaining 100% coverage for servage water treatment for the population of Gran Santiago within 10 years – including an investment totalling 600 million and the construction and operation of 16 sewage treatment plants. In fact, in just 3 years, Aguas Andinas has increased the coverage for treating of sewage from 3% to 70% using international standards.

These achievements are primarily derived from the stability and thorough organisation of the regulatory framework for the water sector in Chile, and the world class experience of AGBAR.

KEYWORDS:

Aguas Andinas, good practices, efficiency, sanitation, supply of drinking water.

INNOVATION IN CLIENT MANAGEMENT

Mariano Blanco Orozco

ABSTRACT:

The "Innovation in Client Management" in companies in the distribution of water and sanitation sector is intimately linked to the concept of "Advanced Client Management", which places emphasis on the need to know the client and the market to guarantee the later offering of a better service and to fulfil expectations, as well as in the need to innovate in each of the processes in service provision.

The current speech makes it clear how important it is to put into practice innovations in management processes, without losing sight of the fact that each of our activities and operations must help to obtain a balanced profit in the long term in our business – both Economic and Environmental.

A concept to be analysed is that of "Strategic Orientation towards the Client" – understanding this to be the implementation of a culture and a know-how that will reach all departments and employees in the company and will be translated into a solid image from the perspective of the client and a homogenising of the procedures, leading in turn to an increase in the "Level of Services Offered". To reach this situation, major investments need to be made – both in economic and human resources – fundamentally in the area of training and systems, focused on developing abilities in the employees in the various service provision processes.

KEYWORDS:

Innovation, strategic orientation towards the client, expectations, perception, alternative channels, advanced client management, differentiation, segmentation, industrialisation of knowledge, level of services, growing innovations, continuous improvement.

THE PARTICIPATION OF CONSUMERS' ASSOCIATIONS IN THE MANAGEMENT OF URBAN WATER SERVICES

María Huelin Franquelo

ABSTRACT:

The conflictivity of a resource such as water – together with the opacity of its management – requires a profound change in design, planning and management of its policies. It is essential for this to have the participation of citizens in general and of the Consumers' Associations, in particular.

Our legislation has been pioneering in this area and the now-repealed Water Law of 1985 already foresaw the participation of society in its management though this was basically limited to the exploiters of the resource – irrigators, hydro-electric and supply companies – while the organisations in defence of the environment or the consumer found great difficulty acceding to the management of the urban supply system. This paper analyses the role of the Consumers' Associations in Urban Provision, the physical, social and regulatory framework within which it performs in Spain – making special reference to the local sphere. From this point, the position of this group is detailed in this structure – with its objectives, obstacles and strengths. The conclusions of this document endorse the fact that the only way to make the management of urban provision of water to the people transparent and accessible is by counting on the Consumers' Associations.

KEYWORDS:

Social participation, consumers' associations, shared decision-making, awareness, transparency.

PERCEPTION ANALYSIS AND IMPROVEMENT OF CONSUMER'S SATISFACTION IN PARIS

Bruno Nguyen

ABSTRACT:

The delivery of drinking water supply to the population is defined in terms of quality and quantity that may differ from a place to another throughout the world, but it generally responds to local regulations and constraints whenever these last ones have been stated by the relevant authority.

However, if these regulations qualify the minimum level of service to be achieved by the water utilities, the satisfaction of the consumers regarding the same service may not coincide with the legal considerations.

The link between the utilities on one hand and the regulator and the local authority is generally well established, while on the other hand, there very often lacks any formal link between the utilities and the population grouped under several names like customers, consumers, users, citizens or third parties.

Some best practices developed during the last decades by water utilities focus on how to improve the satisfaction and needs of the population with regards to service and water related activities. These include complaints response, information, education, raising awareness about water issues, development of new services, social taxes…

This paper describes the recent work done by EAU DE PARIS on these issues.

KEYWORDS:

Consumers' expectations, surveys, education, information.

REFORM IN THE URBAN WATER SECTOR IN BURKINA FASO:
THE CASE OF ONEA

Harouna Ouibiga

ABSTRACT:

Burkina Faso is a country located in the heart of West Africa. It measures 274,000 km^2. The population is some 13,400,000, spread among some 302 rural communities and 49 urban communities, of which the capital – Ougadougou – has a population of 1,300,000 inhabitants. The level of urbanisation is estimated at 25%, with 66 hubs of over 10,000 inhabitants. The poverty line lies at 83,000 FCFA/year/person (€123) and affects 45% of the population.

Regarding water resources, Burkina Faso is characterised by poor rainfall (300 mm in the north to 1000 mm in the south per year), aquifers located in 80% of the country on a crystalline platform and which are not very productive, and notable evaporation of surface water.

Access to drinking water was estimated at 60% in the rural areas and 75% in the urban areas as of 2005. As regards sanitation, this was estimated at 10% in the rural areas and 14% in the urban areas in 2005.

The urban water sector is run by the National Drinking Water and Sanitation Office (ONEA) – created in 1985 as a public entity of an industrial and commercial nature (EPIC) but it was transformed into a State company in 1994. ONEA currently manages 42 centres spread around the country.

In order to maintain its course, ONEA relies on three handles:

- The development of the company management through the formal strategic plan for 2004-2008; the setting up of a quality management system – denominated ISO 9001 2000; the review of the information directive scheme; and the setting up of the latest generation client software.
- Audits:
  - audit from contract to contract plan: commitments of ONEA and of the State
  - audit of the integrity of the financial model and recommendations on tariffs and control over the costs
  - account audits by an international financial auditor

- Improving the coverage of drinking water in the urban areas, as a driving force behind a dynamic partnership with other players and within the context of the on-going decentralisation in Burkina Faso.

Reforming the urban water sector in Burkina Faso has meant attaining clear results in terms of improving access to drinking water and sanitation in the urban area and in terms of financial stability in the sector. The originality of this reform lies in the fact that it remains in the public domain and has benefited, under the terms of a service contract, from the intervention of a professional in client and financial matters.

The results show that a public company can perform if political will and leadership work together – as in the case of ONEA.

The challenges to be overcome are numerous, but the amount of experience accrued provides a good base from which to move forward.

THE WATER SECTOR IN SENEGAL AND THE MILLENNIUM DEVELOPMENT GOALS

Mouhamed Fadel Ndaw

ABSTRACT:

The presentation shows that the success of reforms initiated by the Government of Senegal in urban area (affermage contract) and rural area (management reform of the motorized boreholes (REGEFOR) contributed positively to the definition at the beginning of 2005 of a new sectoral policy and a national programme of investments for the achievement of the Millennium Development Goals (MDG'S) related to drinking water supply and sanitation.

In 1996, Dakar the capital (2 million inhabitants) had been facing chronic water shortages for more than ten years, amounting to 100,000 m3/day. At that time, Dakar was supplied primarily with groundwater, but there were quality problems due to saline intrusion.

Improving the water supply by bringing surface water from Lake Guiers, 240 km away, was very costly. Immediate investment needs were estimated at USD 100 million, just to increase production capacity by 25% and bring water to Dakar, regardless of the costs linked to the rehabilitation, extension and reinforcement of the water distribution systems.

It was in this context that the Senegalese Government implemented an institutional reform of the urban water and sanitation sector in 1996, with the involvement of a private operator in managing the water sector through an affermage contract and an ambitious USD 450 million investment programme via the Water Sector Project (WSP) and the Long Term Water Sector Project (LTWSP). Now 12 years later, the programme is perfectly in line with the strategy for fulfilling the Millennium Development Goals in urban areas.

Indeed, the coverage figures for the Dakar area indicate that the percentage of the population with access to water services grew from 80.3% in 1995 to 98% in 2004 (85% via household connections and 13% via standpipes). These results were obtained through the "social connections" programme initiated principally through the Water Sector Project.

The reform and the investment projects which accompanied it constitute an important step towards the achievement of the Millennium Development Goals. Within the framework of the LTWSP, the Government worked out a new program named PEPAM (Millennium water and Sanitation Program) including the rural and the urban sectors.

The targets for urban water sector are to secure the bulk water supply of Dakar region by 2020 and to reach a drinking water access rate of 100 % in 2015 in all the urban centres among which 88% in Dakar and 79% in the interior urban centres have a domiciliary connection with drinking water, against respectively 75.7% and 57.1% in 2004.

For the urban sanitation, the access rate awaited in 2015 are 85% in Dakar, 72% in the other centres against respectively 75,7% and 57,1% in 2004.

The results expected for 2015 by Senegal to meet the MDG's in rural areas are that 82% of the rural households have access to the drinking water against 64% in 2004 and 59% of the rural households have an autonomous system of evacuation of the excreta and domestic grey water against 17% in 2004.

The total cost of the program is estimated at an amount of 515 billion F CFA in ten years (roughly $1 billion). The program which has secured 54% of the funds needed developed tools including Local Water and Sanitation Plans in rural areas and a framework for monitoring and evaluation including an Internet portal and annual sector reviews. So far, thanks to the program approach of PEPAM, Senegal is considerer among the five Sub-Saharan African countries likely to meet the water and sanitation MDGs.

MANAGEMENT CONTRACTS IN ALGIERS:
THE CREATION OF AN EXEMPLARY PUBLIC/PRIVATE PARTNERSHIP TO ACHIEVE AMBITIOUS OBJECTIVES

Jean Marc Jahn and Terra Messaoud

ABSTRACT:

The objective of the Algiers management contract signed between SUEZ-Environment and SEAAL (Algiers Water and Sanitation Company) [a legal Algerian company] to last 5.5 years is – in the short term – to improve the quality of the drinking water and sanitation services for the inhabitants of Wilaya in Algiers.

To be successful, it requires serious participation from the Algerian authorities and players in the field of water and coordinated management with contractual relations to identify the objectives to be attained and to measure the progress achieved.

Specific tools have therefore been created:

A detailed follow-up for the action plans designed to achieve the technical targets.

A method by which to transfer knowledge (WIKTI), resulting from the international experiences of SUEZ-Environment.

This structured method allows the quantification and qualification of the needs in terms of abilities and to optimise the training plans for the SEAAL personnel.

Two years into the contract and the results are encouraging:

- Daily water distribution – or 24/7 – to over 85% of the population
- Water quality conforming to international standards
- Improvement in bathing water – allowing the re-opening to the public of 10 additional beaches
- Development of abilities: in situ follow-up, progression according to road plan

In conclusion:

A management contract implies – prior to it beginning – a common evaluation of the initial situation and an agreement about the objectives to be attained.

It is very demanding on the means used and the results achieved in terms of transparency.

The success of such a partnership is linked to the emplacement of a shared decision

KEYWORDS:

Management contracts, technical and managerial objectives, partnership, transfer of knowledge and know-how.

WATER SUSTAINABILITY PROGRAMME IN THE VALLE DE MÉXICO BASIN

José Luis Luege Tamargo

ABSTRACT:

In the Valle de México – which includes the Federal District (Capital city of the Mexican Republic) and parts of the States of Mexico and Hidalgo – there is a serious water imbalance as more than twice as much water is abstracted than is recharged to the aquifers. Basically, the water is not treated, one litre in every three is allowed to leak out in the distribution network and there is a risk of sewage flooding.

The re-establishment of the water balance in the area requires undertaking of various actions and strategies to eliminate overexploitation of aquifers, provide treatment for all sewage and water derived from rainstorms, renovate and provide adequate maintenance for the distribution network and, lastly, to double the drainage capacity.

Currently, the ability to clear the sewage and rainfall beyond the basin is negligible and has major problems. In 1975, when the population of the metropolitan area was 10 million inhabitants, the clearance capacity was some 280 m3/s. Today, this has dropped to 165 m3/s while the population has almost doubled.

The water demand has grown in the metropolitan area at the same rate as the population, with the main source for the supply being underground water – leading to the subsequent overexploitation of the aquifers. This does not just put the main source of the water supply at risk; it also generates one of the most serious problems in the basin: land subsidence – happening at 10 cm per year, but in some areas at 40 cm per year during the same period.

At the same time, the region has one of the lowest indices of sewage treatment in the country – with only about 6% being treated – which means hampers reuse and, aside from pollution, creates a serious water imbalance in the basin.

KEYWORDS:

Valle de México, water balance and basin recovery, sanitation systems and sewage treatment, aquifer overexploitation, drainage capacity of the basin.

TRANSFORMATION IN THE PROVISION OF AQUEDUCT AND SEWER SYSTEM SERVICES IN CARTAGENA DE INDIAS

Gustavo Robledo and John Montoya Cañas

ABSTRACT:

In June 1995, the Aguas de Cartagena Company (with 50% participation on the part of the District) took control of the provision of aqueduct and sewer system services in the city of Cartagena de Indias in conjunction with its Operating partner – the AGUAS DE BARCELONA Company.

Upon beginning operations, the infrastructure and its service were going through a major crisis – with a deficit of 60,000 m^3/day and losses within the network of around 65% – as they were over 30 years old and 30% of it was unusable. Investment was minimal and income was not covering expenses. The commercial management was deficient, there was little information, minimal measurement, few controls and the collections came to only 45%.

In just a few years, an improvement in the quantity, quality and continuity of the services was achieved: within just a short time high standards had been reached thanks to having an adequate legal framework, great support from the District and from Aguas de Barcelona – a specialised and experienced operating partner – who provided quick technology transfer.

Coverage by aqueduct went from 73.1% to 99.9% with a continuity of 100% and that of the sewer system went from 60.6% to 81.9% – to the benefit of nearly 500,000 users, most of them lower class. In order to achieve these levels of coverage, it was necessary to develop major investments, increasing production capacity from 165,000 m^3 to 270,000 m^3; enlarging the distribution network from 789 km to 1,528 km; and extending the sewer system from 541 km to a total of 978 km.

Micromeasurement reached 99% – with a reading that is 100% trustworthy. The waiting time for customer service has fallen from 45 minutes to 12 and there is the possibility to pay through the whole banking network, supermarkets and from other spots. This has meant a collection efficiency of 95%. At the same time, losses in the networks have dropped from 65% to 40%.

The above mentioned achievements are thanks to the joint effort between the private and public sectors which has allowed an investment plan in the region of $240 million (US) to be undertaken – with the country as guarantor and the support of the BID and the World Bank. The company took on 35% of the investment through taxes and the District assigned its investment capacity through commitments taken on.

After 12 years of management, we can confidently state that the model in Cartagena de Indias has been a success.

SUSTAINABLE WATER USE IN THE CITY OF QUERÉTARO

Manuel M. Urquiza Estrada

ABSTRACT:

In the last 25 years, the Metropolitan Zone in the City of Querétaro (ZMCQ) has developed growing complex problems in relation to the water resources necessary to satisfy its present and future needs: it needs enough water to cover demand from agriculture, industry and domestic use – all fundamental to maintain adequate economic growth in the region. With a population estimated at 962,240 in 2007, the challenges for ZMCQ regarding water management are clearly linked to the growing increase in demand which is mainly caused by a rise in the population and the economic development of recent years. A high percentage of the water used in ZMCQ comes from the aquifer in Querétaro Valley, which has experienced overexploitation to the order of 60% compared to its recharging – with an average lowering of the water table of 3.5 m^3 per year due to the extraction of 110 million m^3 per year. This aquifer overexploitation is creating a serious risk; therefore a series of measures to reduce over pumping was adopted. These include rationalising consumption and reusing treated water, and incorporating quantities of water from unconventional underground and surface sources. In accordance with the ZMCQ Programme for Provision and Sustainable Use of Drinking Water, the Aqueduct II, Radar and Hydro-Meteorological Centre projects have been implemented, as well as the Night-time Pressure Management and Sustainable Residential Fractioning, with which the State Water Commission of Querétaro is aiming to find sustainable water use in the Metropolitan Zone iof City of Querétaro.

TECHNOLOGY TRENDS AND EXPECTATIONS IN URBAN WATER MANAGEMENT

Fernando Rayón Martín and Icíar Ruiz Ruano

ABSTRACT:

In this document, current needs for innovation in the area of urban water are reviewed, highlighting the differences that can be seen between developed and developing countries. There is also an analysis of the state of innovation in the urban water sector following the methods of the Sector Innovation Systems and it concludes with the presentation of a model of innovation based on collaboration implemented by a world urban water operator which could serve as an example to facilitate development and application of innovation both in developed and developing countries.

KEYWORDS:

Innovation, technology, operation, Millenniu-Development Goals.

NEW CHALLENGES AND NEW SOLUTIONS IN THE PLANNING OF URBAN WATER SUPPLY SYTEMS

Francisco Cubillo González

ABSTRACT:

Planning for supply systems has always been a question of predicting the future and accommodating the resources available to the targets created.

The current scheme continues to have a similar structure but there are notable differences in the elementary components. The most outstanding element is the great uncertainty which must be faced even when considering short-term scenarios.

Uncertainty in the useful life of the infrastructures, in meteorological conditions, in demand and in the environmental conditioners as well as in the interaction with factors that are external to the mere water supply system. The safety level demanded by society and expressed in terms of service levels and their corresponding risks of non-fulfilment is the other great emerging factor in the current century. It even contributes to a more exact definition of the objectives to be pursued – representing a substantial change in the planning models for infrastructures and operating technology. The document will presents the main elements that form this new planning framework and propose a method for its effective incorporation into the establishment of actions and investments necessary in each case.

PRESSURE MANAGEMENT IN WATER SUPPLY NETWORKS: TECHNOLOGICAL MEANS

Nir Naveh, Mike Wiltshire and Pedro Luis Sánchez Rodríguez

ABSTRACT:

Pressure Management is the foundation for effective leakage management.

In many countries it has been widely recognized for at least 30 years that pressure has a fundamental influence on average leakage rates in distribution systems and therefore an ever-increasing number of countries and Utilities are now recognizing that good pressure management is the fundamental foundation of good leakage and infrastructure management.

The weight of evidence now available, and the ever improving reliability with which technical and economic predictions can be made, are such that progressive Utilities can no longer afford to ignore investigating possibilities of pressure management in their systems.

Pressure management for leakage control, in its widest sense, can be defined as "The practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and consumers, while reducing unnecessary or excess pressures, eliminating transients and faulty level controls all of which cause the distribution system to leak unnecessarily"

In many cases pressure management addresses not only the effect of real losses but also the cause making it one of the most efficient tools for sustainable control of real loss.

Pressure management programs often have positive impacts on apparent loss reduction and revenue recovery, especially in relation to theft and authorized unbilled consumption. Where customers have roof tanks, pressure management often improves effectiveness of ball valve closure, and improves metering accuracy by reducing the duration of extremely low flows ('ball valve tails') which some meters cannot record.

The document shows how simple is the idea of implementing a pressure control system and, yet, how effective can be this system be for leakage management.

KEYWORDS:

Economic leakage, pressure-management, Pressure Control Valve (PCV).

WATER REUSE PLAN IN MADRID REGION

Adrián Martín López de las Huertas

ABSTRACT:

In 2005, Isabel II Canal began an ambitious reuse plan in Madrid Community, with an investment of over 200 million euros and affecting over 30 treatment plants – will be created an equal number of tertiary treatments to regenerate a portion of the effluent. Reclaimed water will serve to irrigate parks and wash the streets in over 50 municipalities of the 179 in the region. In addition, water will be used to irrigate over 20 golf courses – of the current 29 – and some industries will benefit from this resource because the price of reclaimed water will be lower than that for water appropriate for human consumption.

The current situation of the plan is described: what has been done, what is in process and what are the expected timescales to fulfil the final objective – which is to have some 40 hm^3 of regenerated water on the market annually. This will help diminish the rise in consumption of our scarce water resources and, therefore, increase the guarantee of a supply as important as that of Madrid Region.

KEYWORDS:

Reuse, regeneration, Madrid Region, irrigation of urban areas.

RECYCLING WASTEWATER, A SOLUTION TO CONTRIBUTE TO SUSTAINABILITY IN WATER

Nicolas Renard

ABSTRACT:

New shortages call for the invention of new resources. Wastewater, that so-called “hostile water,” is now deemed to be useful. Alternative resources provide room to rethink water management in regions stricken by hydric stress. Wastewater recycling is a tried-and-tested solution for producing water suitable for industrial, agricultural and even domestic use, and then, for achieving a greater sustainability in water.

In these regions, water is too valuable a resource to be used just once before being returned to Nature. For health reasons, water recycling technologies must be operated with care and a high degree of professionalism. Wastewater recycling is a win-win strategy since it increases the supply of water while reducing the pollution discharged into the environment.

3 examples of wastewater recycling are described:

- Windhoek (Namibia): direct water reclamation for potable use;
- Adelaide (Australia): wastewater recycling and aquifer recharge;
- Honolulu (Hawaii): wastewater recycling in industry.

But several challenges have to be faced to develop this promising solution and achieve sustainability in water: a psychological reluctance for treated wastewater to be accepted; energy consumption reduction; a competition from undervalued conventional water resources.

KEYWORDS:

Wastewater, recycling, sustainability, water resource, water scarcity, the price of water, water self-sufficiency, aquifer recharge, membrane technology, energy consumption.

SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS)

Sara Perales Momparler

ABSTRACT:

Institutions in some of the most advanced countries in the world have, in the last few years, begun to recognise the many benefits from facing management rainwater from an unconventional perspective – tending towards sustainable development and in harmony with the environment. From this, the Sustainable Urban Drainage Systems (SUDS) have emerged powerfully. Their objective is to resolve both problems of quantity and of quality of urban runoff, minimising the effects of urban development and maximising landscape integration and social and environmental values in the programmed actions.

This document describes the main techniques included in this innovative way of undertaking more efficient rainwater management (a natural resource not to be undervalued in the times of scarcity facing us) and its advantages with respect to traditional systems. In addition, there will be an overview of the SUDS implementation process around the world and the challenges presented by impelling a general change in trend in water management. Likewise, specific actions already undertaken (or in motion) will be shown in terms of research, planning and SUDS construction projects in Spain.

KEYWORDS:

Rainwater, pollution, urban runoff, Sustainable Urban Drainage Systems (SUDS), Best Management Practices (BMPs).

WATER SUPPLY SECURITY ISSUES AND TRENDS:
NEW CHALLENGES IN THE SAFETY OF WATER SUPPLY SYSTEMS

Ilan Juran

ABSTRACT:

Water supply security management covers a wide scope of topics and has seen growing concern by utilities together with customer demand for the quality of service. A number of various tools exist to help the water utility to optimize its management of supply security. Developing best practices, however as usual, is a very useful mean for implementing the continuous process of improvement. And the international community of water utilities can provide fruitful exchanges and experiences for the benefit of all.

BEST PRACTICES ON WATER SERVICES IN SHANGHAI PUDONG

Gustavo Migues

ABSTRACT:

Shanghai is the fastest growing economic region in China and one of the swiftest developing areas in the world. Pudong New Area, a district of Shanghai and Special Economic Zone is a fast growing new city with demand for clean and safe water permanently increasing.

Veolia Water started in 2002 a 50 years partnership with Chengtou Group, the infrastructure arm of Shanghai Municipality to face the challenges of the accelerated water demand growth and to raise the drinking water service quality to international standards.

The joint venture in Pudong has marked water management history in modern China. This is the first time a foreign water operator has been given the opportunity to share the management of full drinking water services.

The results have so far been promising. Through a 50%-50% joint venture and a system of collegial leadership and joint decision making, the management team integrated with managers from both shareholders has significantly improved the water service for more than 2.6 million residents of Pudong Area. The list of achievements and improvements in water quality, service quality, management and employees development is impressive and consistent with the targets fixed by Veolia Water and Shanghai Municipality.

KEYWORDS:

50-year long-term public-private partnership, Veolia Water's first full concession contract in China, modern drinking water network management, water laboratories in China, water solution to a fast growing city.

ACTIONS TAKEN IN ZARAGOZA TO IMPROVE MANAGEMENT OF THE WATER CYCLE SERVICES

José Ramón Entralgo Layunta

ABSTRACT:

The objective of this document is to present the initiatives started in Zaragoza to achieve greater efficiency in managing water supply and sanitation services and, in particular, water consumption.

At the beginning of the 80s, the situation of these services in Zaragoza was far from adequate. There was no sewage treatment, consumption was very high and rather uncontrolled, there was a serious economic deficit, etc.

The first stage was centred on achieving sewage purification by establishing necessary installations and collectors.

Since 2000, the priority has resided in reducing water consumption, for which a Management Improvement Plan was created aimed at modernising infrastructures and a greater control over consumption. Together with this plan, various complementary actions have been developed including campaigns to create citizen awareness, a new tariff system, creation of a new bylaw, etc.

The result of these actions has been a major decrease in water consumption, with an improvement in associated indicators such as of uncontrolled water volumes, number of breaks, consumption of reagents, etc). And all of this has come about in a situation of water abundance – reinforcing the value of the experience.

KEYWORDS:

Zaragoza, provision management improvement plan, water consumption.

INCLUSION OF INTEREST GROUPS IN THE SANITATION OF BASINS:
CASE STUDY – RIVER BOGOTÁ, COLOMBIA

Jorge Enrique Pizano Callejas

ABSTRACT:

Recognizing responsibilities, participation and the interests of bodies and different interest groups plays a fundamental role in the collective and structured construction for the environmental and ecological recovery of water bodies. In Latin America, as in many other developing areas water bodies have suffered a serious deterioration as they have been used as recipients for dumping municipal sewage. This situation has awoken the interest of various parties who, on an individual basis, have undertaken actions to improve the environmental conditions within their own orbit: among others, political, legal, regulatory, punitive, engineering, education, citizen participation, research and funding topics.

The interest in environmentally recovering the river Bogotá in Colombia – of strategic importance at regional and national levels and because of its size as it runs for 375 kilometres and a surface draining area of 5,695 square kilometres – led to the formulation of the “Sanitation of the river Bogotá” project. This project organised the various bodies and re-examined the participation of the communities within the framework of social and economic co-responsibility through actions that strengthen and promote recognition, evaluation and integrated participation to make possible project of this scale.

KEYWORDS:

Sanitation of basins – river Bogotá, environmental and ecological recovery, organisation of bodies and community, all-embracing recognition, evaluation and participation.

THE EFFICIENT MANAGEMENT OF WATER PROVISION AS THE BASIS FOR ECONOMIC DEVELOPMENT AND GROWTH

Keith M. Naicker

ABSTRACT:

The sustainable provision of water resources forms the basis for economic growth and the development and management of our towns and cities. Sound water utility management is therefore a development imperative. Therefore public water and other utilities have to discharge their duties in an economically efficient and in an operationally responsible manner.

The paper demonstrates, using various financial and operational indicators, that Rand Water – arguably the largest public water utility in Africa – has been able to consistently discharge its duties in an economically efficient and operationally responsible manner. The result is that after 104 years of operation, Rand Water places no fiscal burden on the State, has cost reflective pricing, and is able to generate sufficient surpluses to invest in its current and future infrastructure needs.

As a result of its efficient management and operations, Rand Water provides the basis for economic growth and development of the Gauteng Province of South Africa, which is the economic heartland of South Africa, and the largest economy in Africa.

KEYWORDS:

Water utility management, financial sustainability, operational sustainability, cost reflective pricing, economic growth.

PUERTO CORTÉS SEWER SYSTEM PROJECT

Marlon Lara and German Sturzenegger

ABSTRACT:

The destruction caused by hurricane Gert in 1993 and the subsequent lack of water that affected the municipality of Puerto Cortés over the following months made both the local authorities and the population aware that their problem was not going to be solved in Tegucigalpa. Thus it was that Marlon Lara (a young politician elected mayor in January 1994) became the spearhead behind the reform of a water and sanitation system that led to the decentralisation of these services and the creation of the Puerto Cortés model.

With the strong backing of the BID, the institutional model developed by Lara includes 3 components:

- A Mixed Capital Company (oriented towards guaranteeing autonomy in the provision of the water and sanitation services);
- A Trusteeship Fund (aimed at guaranteeing transparent use of the resources);
- A Regulatory Body (intended to guarantee the respect for the commitments taken on)

The case of Puerto Cortés has shown that decentralisation in Honduras is possible and that the municipality can supply the water and sanitation services to a city (98%) in an efficient way. The case provides a number of lessons that could be of use in similar reform processes.

- The reforms have a higher likelihood of success if spearheaded by a local leader.
- Institutional solidity is a key element to balance or prevent excessive personalisation of a reform and to guarantee its permanence.
- The international donors were kept out of sight of the public in Puerto Cortés, which helped contribute to the legitimacy of the process.
- The municipality had a voice and a vote in the reform development.
- Management of political time.
- Keeping the community well informed.
- Not underestimating the willingness to pay for good services.

KEYWORDS:

Puerto Cortés, Honduras, water and sanitation, decentralisation, Marlon Lara, Inter-American Development Bank (BID).

WATER TREATMENT AND COST RECOVERY THROUGH SOCIAL BUSINESS OF GRAMEEN-VEOLIA WATER LTD IN BANGLADESH

Samir Chowdhury and Olivier Gilbert

ABSTRACT:

In 2007, Grameen Bank* and Veolia Water** have joined forces to create Grameen – Veolia Water Ltd, which objective is to supply water to a disadvantaged region of Bangladesh. Currently the only sources of supply in this region are arsenic-polluted aquifers.

The new venture aims at supplying potable water at the highest quality standards at socially acceptable rates. Infrastructures to deliver the project are currently being designed. Since Grameen – Veolia Water Ltd is not-for-profit, financial gains from the service will be reinvested into the project. This initiative belongs with the "social business" model, and aims at providing potable water to an ever larger number of people within disadvantaged populations.

* Grameen Bank is chaired by Professor Yunus, father of the micro-credit concept and Nobel Peace Prize Laureate in 2006
** Veolia Eau is world leader in water services and technological solutions.

Thematic Week 6

CLIMATE CHANGE AND EXTREME EVENTS

[Towards a World of Water Scarcity and Uncertainty]

Positioning document

Coordinators: **José Manuel Moreno, Joseph M. Alcano, Luis J. Mata and Jean Palutikof**

PRESENTANTION

Freshwater is a basic resource for life on Earth and for the well being of humans. Humankind is currently using more than half of all accessible freshwater and depleting underground water resources. Water security is a problem for the many that do not have access to safe drinking water. Human development is closely related to guaranteeing safe water for all, as is acknowledged in the Millennium Development Goals (Goal 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation; UN 2002). Climate change, however, poses a great challenge for accomplishing these goals.

According to the IV Assessment Report of the IPCC (IPCC, 2007) global warming can alter the water cycle and with it how much it rains, the form in which it does, when and where. Thus, how much water is available for man and the risks related to water are likely to change. In fact, the observed global warming during the past decades has been linked to observed changes in precipitation patterns, intensity and extremes, as well as widespread melting of snow and ice and changes in soil moisture and runoff. Additional observations include increases in heavy precipitation and in land classified as dry, decrease in water stored in mountain glaciers, shifts in amplitude and time of runoff glacier- and snowmelt-fed rivers and in ice phenomena in rivers and lakes. Recent research shows that, in some regions, some of these observed hydrological changes can now be attributed to the human influence over the climate (Barnett *et al.* 2008).

During this century, as climate continues warming, climate models are consistent in projecting further changes in the water cycle (Bates *et al.* 2008). These include changes in precipitation, with increases at high latitudes and parts of the tropics, and decreases in some subtropical and lower mid-latitude regions. By the middle of the 21st century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics. Many semi-arid and arid areas (e.g., the Mediterranean basin, western USA, southern Africa and north-eastern Brazil) are particularly exposed to the impacts of climate change and are projected to suffer a decrease of water resources due to climate change (Fig. 1). In the course of the century, water supplies stored in glaciers and snow are projected to decline, thus reducing water availability in regions supplied by melt-water from major mountain ranges, thus affecting a sizable fraction of the world population. Sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas.

The frequency of heavy precipitation events will very likely increase over most areas during the 21st century, as will the risk of rain-generated floods. There is a tendency for drying in continental interiors during summer, especially in the subtropics, low and mid-latitudes. Globally, the proportion of land surface in extreme drought at any one time, as well as the frequency and severity of extreme drought events, is

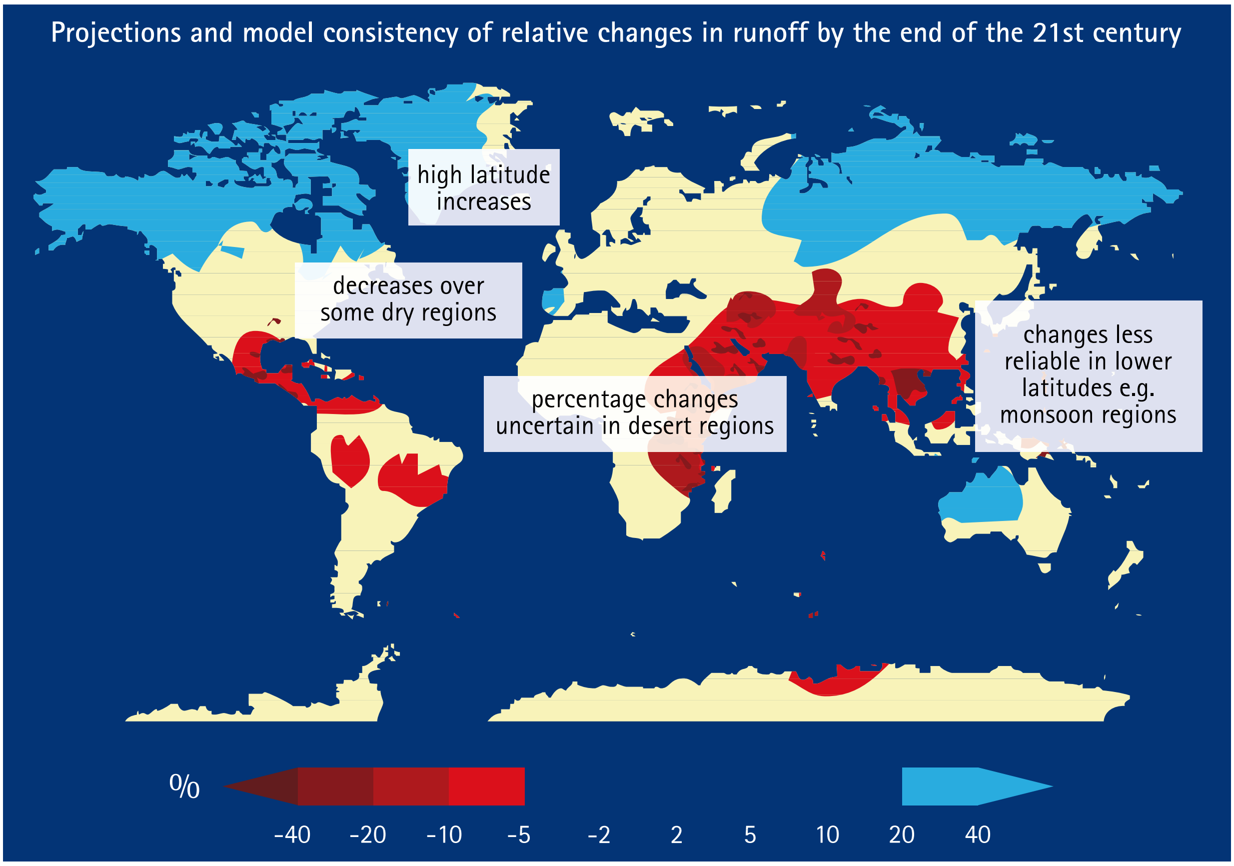


Figure 1. *Large-scale relative changes in annual runoff (water availability, in percent) for the period 2090-2099, relative to 1980-1999. Values represent the median of 12 climate models using the SRES A1B scenario. White areas are where less than 66% of the 12 models agree on the sign of change and hatched areas are where more than 90% of models agree on the sign of change. Source: IPCC, 2007.*

projected to increase. Higher water temperatures, increased precipitation intensity and longer periods of low flows are expected. This is projected to exacerbate many forms of water pollution (from sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt, as well as thermal pollution), with negative impacts on ecosystems, human health and water system reliability and operating costs.

This volume is the result of the international meeting hosted by the Water Tribune of EXPOZARAGOZA 2008. The meeting took place while EXPOZARAGOZA was open and running and allowed the over 200 participants from many countries around to world to discuss about the issue which constituted the focus of EXPOZARAGOZA: water. The week devoted to climate change water and extreme events was scheduled to address some of the major issues relating to the impact of climate change on the water cycle and its consequences for humans. The thematic week was organized in nine sessions, three per each of the three days that it lasted. The first day was devoted to evaluating climate trends and future projections, in particular rainfall, climate extremes related to water and their impacts on water bodies and systems. The first session took first a retrospective look at the trends observed with regard rainfall patterns across the globe during the past century with a particular focus on the findings of the recent 4AR Report of the IPCC and the IPCC Technical Paper on Water. Now we have learned that anthropogenic forcing has had a detectable influence on observed changes in average precipitation within latitudinal bands, and these changes cannot be explained by internal climate variability or natural forcing (Zhang *et al.* 2007). Projections for a future warmer climate are then needed to evaluate what we can expect for the coming years. The future, however, is plagued by uncertainties, particularly in semi-arid areas, and these needs to be identified in order to guide future adaptation.

Floods and droughts are among the two climate-related hazards that take a highest toll in human lives and assets every year. The two were specifically addressed in one session focussing on the changes in frequency and intensity of both hazards and on the magnitude of projected impacts. A particular case study of how Spain is addressing flood risk was also presented. As rain falls on earth, on its way to the ocean water remains as snow or ice or in wetlands for a certain period of time. Snow and ice are crucial for millions of people, since they feed the rivers in summer when rainfall might be low. Millions of people rely on water provided by these two sources. Wetlands, equally, are the main sources of water, provide support to a wealth of life and are a dearest part of our daily reference with regard to where we live. Impacts on water systems were therefore be addressed in one session.

The second day was devoted to deal with water availability and uses and its impacts on food production and on the economy and society. The first session addressed the availability of water. Much of the water that falls on earth is used by man. This amount depends on how many people will be there and on what uses it will be needed for. The quantity and quality of water as well as the demand will change as climate changes. The size of the populations living in water-stressed watersheds can increase by 62-75% by 2050, depending on the models and scenarios (Alcamo *et al.* 2007). Identifying future trends in supply and demand and the hotspots of stress are high priorities. Besides direct use of water in drinking, food security is first among our needs. Much of agriculture in the world depends on rain-fed crops; other crops depend on irrigation and livestock depends on natural grass and feed, both closely coupled to rain. The relationship between rain and annual GDP for many countries is still a reality in the sense that annual GDP varies with the rain falling each year. The risks posed by water to food provision were addressed in a specific session. In addition, changes in available food and resources due to shifting rainfall will affect many aspects of our daily life. The economic and social costs of such shifts need equally to be understood. Hunger and impoverishment may cause many people to migrate and to cause insecurity and conflict in many parts of the world (EC 2008; Raleigh *et al.* 2008). Climate change poses many challenges for the governance of our environment, including water.

The third and final day was devoted to address the issues of adaptation to live in world of water scarcity and uncertainty due to climate changes. Management systems help us organize and distribute water where and when it is needed independently of the amount of rain. Climate change is very likely to affect the function and operation of existing water infrastructure as well as water management practices (Kundzewicz *et al.* 2007). Our systems were planned based on a world that was considered stable and, therefore, predictable. The future was projected based on the past but that will no longer be the case. Climate change undermines a basic assumption that historically has facilitated the management of water supplies and demands (Milly *et al.* 2008). Therefore we need to evaluate how vulnerable we are to the changes in water resources that are projected, and what options we have to adapt to a world of less water and more variable in time and space and through the years. The way we organize our managements systems needs to be rethought to deal with this new paradigm of a changing world, and to “climate proof” them (Biemans *et al.* 2006). In addressing future needs, options for dealing with water scarcity revaluated among competing stakeholders. This is particularly necessary in less developed countries but also in the more developed world that faces new challenges.

References

Alcamo, J., M. Flörke, M. Märker (2007). Future long-term changes in global water resources driven by socio-economic and climatic change. *Hydrological Sciences–Journal–des Sciences Hydrologiques,* 52(2) 247-275.

Barnett, T. P., D. W. Pierce, H. G. Hidalgo, C. Bonfils, B. D. Santer, T. Das, G. Bala, A. W. Wood, T. Nozawa, A. A. Mirin, D.R. Cayan, & M. D. Dettinger (2008). Human-Induced Changes in the Hydrology of the Western United States. Science 319: 1080-1083.

Bates B., Z. W. Kundzewicz, S. Wu, N. Arnell, V. Burkett, P. Döll, D. Gwary, C. Hanson, B. Heij, B. Jiménez, G. Kaser, A. Kitoh, S. Kovats, P. Kumar, C. Magadza, D. Martino, L. J. Mata, M. Medany, K. Miller, T. Oki, B. Osman, J. Palutikof, T.Prowse, R. Pulwarty, J. Räisänen, J. Renwick, F. Tubiello, R. Wood, Z. Zhao, J. Arblaster, R. Betts, A. Dai, C. Milly, L. Mortsch, L. Nurse, R. Payne, I. Pinskwar, T. Wilbanks (2008). *IPCC Technical Paper on Climate Change and Water.* [http://www.ipcc.ch/meetings/session28/doc13.pdf] Accessed pm KJune 12th, 2008.

Biemans, H., H. van Schaik, P. Kabat (2006). *Water and climate risks: A plea for climate proofing of water development strategies and measures.* Wageningen : Co-operative Programme on Water and Climate, 35 pp.

[http://www.wac.ihe.nl/UserFiles/File/manifest.pdf]. Accessed on June 12th, 2008.

EC (2008). Climate change and international security. Paper from the High Representative and the European Commission to the European Council. S113/08. [http://register.consilium.europa.eu/pdf/en/08/st07/st07249.en08.pdf]. Accessed on June 12th, 2008.

UNDP (2006). *Human Development Report 2006.* Palgrave Macmillan, New York, NY. USA. [http://hdr.undp.org/en/media/hdr06-complete.pdf] Accessed on June 12th, 2008.

IPCC (2007). Climate Change 2007: *Synthesis Report.* [http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf]. Acessed on June 12th, 2008.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, (2007): Freshwater resources and their management. Climate Change 2007: Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Milly, P.C.D., J. Betancourt, M. Falkenmark, R. M. Hirsch, Z. W. Kundzewicz, D. P. Letternmaier, R. J. Stouffler (2008). Stationarity is dead: whither water management? *Science* 319: 573-574.

Raleigh, C., L. Jordan, I. Salehyan (2008) Assessing the Impact of Climate Change on Migration and Conflict. Social Development. The World Bank, Washington, D.C.

[http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/SDCCWorkingPaper_MigrationandConflict.pdf]. Accessed on June 12th, 2008.

UN 2002. *Report of the World Summit on Sustainable Development. Johannesburg, South Africa,* 26 August-4 September 2002. United Nations, New York. [http://www.unmillenniumproject.org/documents/131302_wssd_report_reissued.pdf]. [Accessed on June 12th, 2008.

Zhang, X., F. W. Zwiers, G. C. Hegerl, F. H. Lambert, N. P. Gillett, S. Solomon, P. A. Stott, T. Nozawa (2007). Detection of human influence on twentieth-century precipitation trends. *Nature* 448: 461-465.

Collaborators

Alcamo, Joseph M.: Centre for Environmental Systems Research, University of Kassel, Kassel, Germany/ The Global Water System Project.

Andah, Winston: Water Resources Institute/Challenge Program Water for Food, Ghana.

Andreini, Marc: International Water Management Institute.

Bakker, Marloes: Cooperative Programme on Water and Climate, Delft, The Netherlands.

Barry, Boubacar: International Water Management Institute.

Bindi, Marco: Department of Agronomy and Land Management, University of Florence, Florence, Italy.

Blair, John M.: Division of Biology, Kansas State University, Manhattan, Kansas, USA.

Cañón, Julio: Department of Civil Engineering and Engineering Mechanics, The University of Arizona, Tucson, AZ, USA. SAHRA (Sustainability of semi-Arid Hydrology and Riparian Areas) NSF Center, Tucson, AZ, USA.

Casassa, Gino: Centro de Estudios Científicos, Valdivia, Chile.

Cohen, Stewart J.: Department of Forest Resources Management, University of British Columbia, Vancouver, BC Canada.

Cubasch, Ulrich: Meteorological Institute, Free University of Berlin, Berlin, Germany.

González, Javier: Dept. of Civil Engineering, University of Castilla La Mancha, Ciudad Real, Spain.

Hank, Tobias: Department for Geography, Ludwig-Maximilians University (LMU), Munich, Germany.

Heisler-White, Jana L.: Graduate Degree Program in Ecology and Department of Biology, Colorado State University, Fort Collins, Colorado, USA.

Howden, S. Mark: CSIRO Climate Adaptation Flagship, GPO Box 284, Canberra, ACT 2601, Australia.

Jung, Gerlinde: Institute for Meteorology and Climate Research (IMK-IFU), Germany. Now at CNR-Institute for Atmospheric Pollution, Rende, Italy.

Knapp, Alan K.: Department of Biology, Colorado State University; Fort Collins, Colorado, USA.

Kundzewicz, Zbigniew W.: Research Centre for Agricultural and Forest Environment, Polish Academy of Sciences, Pozna, Poland/ Potsdam Institute for Climate Impact Research, Potsdam, Germany.

Kunstmann, Harald: Institute for Meteorology and Climate Research (IMK-IFU), Germany.

Laube, Wolfram: Center for Development Studies (ZEF), Germany.

Laux, Patrick: Institute for Meteorology and Climate Research (IMK-IFU), Germany.

Leichenko, Robin M.: Department of Geography, Rutgers University, USA.

Liebe, Jens: Center for Development Studies (ZEF), Germany.

Mata, Luis J.: University of Arizona, Tucson, AZ, USA.

Mauser, Wolfram: Department for Geography, Ludwig-Maximilians University, Munich, Germany.

Moreno, José M.: Department of Environmental Sciences, University of Castilla-La Mancha, Toledo, Spain.

O'Brien, Karen L.: Department of Sociology and Human Geography, University of Oslo, Oslo, Norway.

Pahl-Wostl, Claudia: Institute of Environmental Systems Research/Department of Mathematics and Computer Science, University of Osnabrück, Osnabrück, Germany.

Palutikof, Jean: IPCC Working Group II Technical Support Unit; Meteorological Office of the United Kingdom, Exter, UK.

Pérez Llorens, José Lucas: Department of Biology, University of Cádiz, Puerto Real, Cádiz, Spain.

Pulwarty, Roger S.: National Integrated Drought Information System, National Oceanographic and Atmospheric Administration (NOAA), Boulder, Colorado, USA.

Smith, Melinda D.: Department of Ecology and Evolutionary Biology, Yale University, New Haven, Connecticut, USA.

Valdés, Juan B.: Department of Civil Engineering and Engineering Mechanics, The University of Arizona, Tucson, AZ, USA. SAHRA (Sustainability of semi-Arid Hydrology and Riparian Areas) NSF Center, Tucson, AZ, USA.

van de Giesen, Nick: Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands.

van Schaik, Henk: Cooperative Programme on Water and Climate, Delft, The Netherlands.

Wilby, Robert L.: Department of Geography, Lancaster University, Lancaster, UK.

Yagüe Córdova, Jesús: Ministerio de Medio Ambiente y Medio Rural y Marino, Madrid, Spain.

WATER RESOURCES IN THE IPCC FOURTH ASSESSMENT REPORT

Jean Palutikof

ABSTRACT:

The Intergovernmental Panel on Climate Change has recently published its Fourth Assessment Report. This presents an up-to-date assessment of the scientific literature on the physical basis of climate change (Working Group I), impacts, adaptation and vulnerability (Working Group II) and mitigation (Working Group III). Some 500 authors from around the world came together over a period of five years to write the three assessment reports, together with the Synthesis Report, each of which has undergone a rigorous process of review by experts and governments. The last publication of the Fourth Assessment will be a Technical Paper on 'Climate Change and Water'. This is a distillation of all the material in the IPCC Assessment and Special Reports which deals with the topic, although naturally it focuses primarily on the Fourth Assessment, since this is the most up to date. It is expected to appear in August 2008, and will be translated into all the official UN languages. This paper presents the major findings of the IPCC Fourth Assessment as these relate to climate change and water resources. It looks at the process by which Assessment Reports are written, reviewed and approved. It reports briefly on the decisions made to date on the Fifth Assessment.

KEYWORDS:

IPCC, climate change, water resources, water availability.

FUTURE RAINFALL PROJECTIONS

Ulrich Cubasch

ABSTRACT:

The rainfall distribution in a future climate is calculated using global climate models. These models, frequently derived from weather forecast models, solve the physical equations on a grid representing Earth's atmosphere. As rainfall is very patchy, multiple simulations with various models developed by different research groups are combined. These models predict in the case of an enhanced greenhouse gas concentration in the mean an increase of precipitation due to the higher temperature, but the distribution is not even. Generally, dry regions become dryer, while wet regions become wetter. In the regions with rainfall, there is a tendency towards more intense precipitation. The grid of global models has a resolution of typically 200-400 square kilometres. This is too coarse to estimate the precipitation change on a regional scale, for example a country with the size of Spain, or river catchments. High resolution regional models are imbedded into the global models to estimate the climate change up to a horizontal resolution of 10 kilometres. Statistical models have also been developed to obtain information on a regional scale.

KEYWORDS:

Climate modelling, regional climate models, precipitation change, global warming.

DEALING WITH UNCERTAINTIES OF FUTURE CLIMATE:
THE SPECIAL CHALLENGE OF SEMI-ARID REGIONS

Robert L. Wilby

ABSTRACT:

Semi-arid regions face a range of threats from climate change, including droughts, flash flooding, soil degradation and erosion, desertification and water scarcity. For example, climate change is expected to decrease runoff and increase water resources stresses around the Mediterranean basin. However, precipitation scenarios are notoriously difficult to produce for such areas because of the high variability and intermittence of rainfall in space and time. The task may be further exacerbated by complex orography and sparse observational networks. Nonetheless, tools and techniques are urgently needed to support regional climate change assessments, especially for developing countries in semi-arid and arid regions. This paper reviews the latest techniques for constructing regional rainfall scenarios in semi-arid areas such as the Mediterranean basin, North Africa and parts of the Middle East. Projections made from different climate models and downscaling techniques typically show large variations at river basin scales. Hence, there is increasing emphasis on indentifying "low regret" adaptation solutions – those that make good sense regardless of the future climate scenario. Examples include seasonal forecasting to improve preparedness for drought, or a return to traditional water harvesting techniques. Other approaches such, as sensitivity analysis, help identify "tipping points" or limits to adaptation. However, efforts to characterise supply-side uncertainties must ultimately be balanced by initiatives to reduce water demand and hence minimise long-term vulnerability.

KEYWORDS:

Climate change, dryland, scenario, downscaling, uncertainty, precipitation.

RISK OF DROUGHTS:
CHARACTERIZATION, CHALLENGES AND OPPORTUNITIES

Juan B. Valdés, Julio Cañón and Javier González

ABSTRACT:

Climate change will have a significant impact in the water resources of the planet. Particularly the intensification of the hydrologic cycle will imply an increase of the climate variability and the frequency and magnitude of extreme events like droughts and floods. Droughts are of particular concern in arid and semi-arid regions where the competition for the water resources due to population pressure and non-sustainable use of both surface and groundwater will need to be addressed soon. The water-energy nexus will also be exacerbated and the competition between agriculture and residential/industrial used of water will be intensified. The US Southwest is a region severely affected by these pressures and current efforts to characterize, forecast and mitigate the impact of droughts will be presented. Droughts are of particular concern due to their large spatial extent and long durations and the lack of a uniform and consistent definition of their intensity and frequency. Recent advances in tele-detection and identification of climatic precursors like ENSO and its relationship to regional climates has facilitated the early warning of drought and its related impact in agriculture and possible famine.

KEYWORDS:

Drought characterization, global crisis, drought forecasting.

HEAVY PRECIPITATION AND FLOODS

Zbigniew W. Kundzewicz

ABSTRACT:

The average annual economic flood damage worldwide has increased by order of magnitude in the last four decades, in inflation-adjusted monetary units. This has been due to socio-economic changes (increasing population and assets in flood-prone areas and land-use change); terrestrial (land-cover change and reduction of natural storage); and climatic factors. The anthropogenic increase in atmospheric concentration of greenhouse gases leads to enhancement of the greenhouse effect, resulting in the global warming and such impacts as glacier melt, and sea-level rise. Increase of temperature causes intensification of the hydrological cycle, by which floods and droughts get more frequent and/or more extreme. Indeed, several examples of occurrence of a drought and a flood in the same area in a short time interval have been observed recently (*e.g.,* in Spain). The moisture-holding capacity of the atmosphere has been increasing with temperature, at a rate of about 7% per 1°C, with consequence to flood risk. Observational evidence indicates increasing probability (and number) of heavy precipitation events in the warming climate. However, due to strong natural variability in high river flows and multiple flood generating mechanisms, no ubiquitous, and statistically significant, change has been documented. Regional changes in timing of floods have been observed in many areas, with increasing late autumn and (rain-caused) winter floods. In contrast, the number and intensity of snowmelt and ice-jam-related floods has been decreasing in much of Europe. Climate-related changes in flood frequency are complex and depend on the flood-generating mechanism (e.g. heavy rainfall vs snowmelt).

KEYWORDS:

Extreme weather events, heavy precipitation, floods, climate change.

FLOOD ZONE MAPPING IN SPAIN

Jesús Yagüe Córdova

ABSTRACT:

Floods have increasingly significant social and economic repercussions. The outlook for climate change is far from encouraging in relation to this phenomenon. Consequently, both the European government and the Spanish government have incorporated a series of measures in their legislation to attempt to slow down this trend and minimise, as far as possible, the damages it causes. The coming into force of the European Flood Directive and the Modification of the Public Waters Regulations has marked the beginning of a series of actions aimed at knowing, managing and lessening risks. One of these measures is the preparation of flood hazard maps at national level and others include the organising of these maps within the National System of Flood Zone Mapping. Given that there is not one single solution to the flood problem but rather the measures put forward are of a holistic nature, apart from the two mentioned, the Ministry approaches this problem from several fronts: the safety of Spain's water heritage, which is fundamental in flood management, the restoration of watercourses, Automatic Hydrological Information Systems that incorporate Early Warning Systems, etc.

KEYWORDS:

Flood zones, public waters regulation, European flood directive, hazard maps.

SNOW AND ICE ON PLANET EARTH:
PRESENT STATE, IMPACTS AND PROJECTIONS

Gino Casassa

ABSTRACT:

Snow and ice on our planet includes mountain glaciers, ice shelves, continental ice sheets, seasonal snow, frozen ground, sea ice and freshwater ice that occur in polar regions and in high mountain zones. There is abundant and significant evidence that most of these cryospheric components are undergoing a generalized reduction in response to global warming, with already detectable effects on the environment and on different human activities. The reduction includes a strong decrease of Artic Sea ice, a decreasing snow cover at a global level, widespread glacier wastage, and the collapse of floating ice shelves in the Artic and the Antarctic, with associated flow acceleration and thinning of inland glaciers. The effects associated to cryosphere reduction include the modification of runoff patterns due to the increase of glacier melt; the earlier occurrence of spring snow melting; decrease of vehicle traffic on frozen Arctic roads; increased danger associated to glacier and slope instabilities due the mechanical weakening of soils under deglaciation; changes in freshwater and marine ecosystems affected by lake, river and sea ice reduction; changes in Arctic and mountain livelihoods; reduced skiing, ice climbing and outdoor activities in mountain areas affected by deglaciation; and higher ship traffic in the Artic.

KEYWORDS:

Snow, ice, cryosphere, glacier retreat, sea level rise.

IMPACTS OF CLIMATE CHANGE ON WETLAND ECOSYSTEMS

José Lucas Pérez Lloréns

ABSTRACT:

Wetlands cover a heterogeneous spectrum of aquatic habitats, widely recognized as biodiversity hotspots and key components of the global carbon budget. They provide a wide range ecosystem goods (*e.g.,* food, drinking water) and services (*e. g.,* water purification, climate regulation, flood regulation, coastal protection, etc.) to human welfare Wetlands are highly dependent on water levels, and so changes in climatic conditions (e.g. hydrological cycle, *i.e.,* the nature and variability of the wet and dry seasons, and the number and severity of extreme events) will highly influence its structure and functioning. There is a widespread and ongoing degradation and loss of wetlands. Direct non-climatic anthropogenic impacts (e.g. drainage, water withdrawal, habitat fragmentation, eutrophication, etc.) have been more noteworthy than impacts directly attributed to climate change. Climatic and non-climatic drivers are expected to act synergistically on wetlands resulting in abrupt and large changes that can be difficult, expensive, or impossible to reverse. Ecosystems are hierarchical and climate change is projected to change their structure and functioning by affecting the abiotic and the biotic components (from individual organisms, populations, to communities). The overall impact will depend on the ecosystem resilience and the rate and magnitude of change in several critical climate drivers such as temperature and water availability (in inland wetlands), and, in addition, the sea level and storm surges (in coastal and low-lying wetlands). Temperature will affect both the abiotic (*e.g.,* physical mixing, water quality.) and the biotic compartments (*e.g.,* throughout physiology, specie range shifts, overall community metabolism). Changes in the hydrological cycle together with a rising sea level and increasing storm surges will result in enhanced erosion of coastal habitats, salinization of groundwater aquifers and estuaries, altered tidal ranges, changes in sediment inputs and nutrient loadings, increased flooding and, consequently in a decrease of freshwater availability for humans and ecosystems. Predictions about the extent and direction of climate change on species and ecosystems are associated with varying degrees of confidence, which arise from uncertainties about how regional climate will change, the influence of non-climatic drivers and how complex ecological systems will respond. Indeed, as climate change alters ecosystem metabolism and species composition, unforeseen ecological changes are expected (*e.g.,* harmful algal blooms or invasive alien species) that may threaten the goods and services these systems provide to humans.

KEYWORDS:

Climatic drivers, coastal wetlands, ecosystem functioning, ecosystem services, forecasting, lakes, eutrophication, rivers, temperature.

CLIMATE CHANGE AND THE TRANSFORMATION OF GLOBAL WATER RESOURCES

Joseph M. Alcamo

ABSTRACT:

Over the coming decades, changes in climate and society will drive a major transformation of global water resources. But the intensity and type of risks to water resources will vary greatly from region-to-region. For example, it is likely that climate change will intensify water scarcity in specific "hot-spot regions" such as southern Europe, northeast Brazil, and southern Africa. At other locations precipitation and water availability will increase, although also with negative side effects. In the case of Europe, precipitation is expected to increase during winter and this likely to lead to more frequent flooding during this season in the central and northern sections of the continent. Meanwhile, global warming has already quickened the pace of glacier-melting in the Alps, Himalayas, and elsewhere. As the melting continues, river runoff fed by these glaciers will at first increase. Later, though, glaciers will diminish along with runoff, and this will endanger water supplies downstream. Society needs to respond immediately to these risks, and this response should take place at all levels, from local to global. At the global level there are three main tasks to take on. First, we have to reduce the immediate risk to society by establishing comprehensive early warning systems for droughts and floods. Second, we have to extend our knowledge of transformations going on in the global water system by expanding the scope of remote earth observations, and by conducting new large-scale field experiments and surveys. Third, we must protect nature and society over the long run by strengthening the global governance of water. This means exploring new ways of managing water at the global level through novel international institutions and conventions. These tasks need to be given high priority because the all-encompassing changes taking place in the global water system justify an equally wide-ranging response from society.

KEYWORDS:

Water resources, climate change, water availability.

CLIMATE CHANGES WATER DEMAND MANAGEMENT

Henk van Schaik and Marloes Bakker

ABSTRACT:

Climate is a fundamental driver of the water cycle. It determines how much water is available (supply) and it is also an important factor determining how much water is needed (demand) in the short and long term for people, food and ecosystems. By 2020, between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change. Globally, water demand will grow in the coming decades primarily due to population growth and increasing affluence; regionally, large changes in irrigation water demand as a result of climate changes are expected. If nothing is done, both trends will adversely affect livelihoods and exacerbate water-related problems. With growing evidence to the contrary, all governments must begin by re-evaluating the adequacy of their infrastructural facilities as well as their legal, technical, and economic, policy and institutions approaches for water management and water services in the light of predicted impacts of climate change. Supply and Demand Measures: Adaptation measures to ensure water supply during average and drought conditions can be distinguished as demand-side and supply-side measures. The former improve water-use efficiency, *e.g.,* by new technologies such as drip irrigation, restrictions on use, water conservation campaigns and pricing. Supply-side strategies generally involve increases in storage capacity, abstraction from water courses, and water transfers. Integrated water resources management provides an important framework to achieve adaptation measures across socio-economic, environmental and administrative systems. This article presents a brief introduction on supply and demand management and selected examples.

KEYWORDS:

Climate change, demand management, supply management, integrated water resources management.

FOOD COPS UNDER GLOBAL WARMING AND CHANGING WATER AVAILABILITY

Marco Bindi and S. Mark Howden

ABSTRACT:

Much of food availability in the world depends on rain-fed crops, thus present and future changes in the water cycle (*e.g.,* total amount, annual distribution and intensity of precipitation) may play a fundamental role in global food security. In particular, projecting further changes include increasing in temperature and changes in precipitation, with decreases in some dry regions at mid-latitudes and in the dry tropics (*e.g.,* the Mediterranean basin, western USA, southern Africa and north-eastern Brazil) that may intensify present limited water resources. Moreover, increases in the frequency and severity of heavy precipitation and extreme drought events are expected during the 21st century. Finally, sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of water availability for irrigation in coastal areas. All these projections, together with other external factors (increases in food demand, changes in human diet, etc.) may determine important impacts on food crops productions and the following food availability. This work aim to present a complete overview of the impacts that global warming and changing water availability will have on food crops and the adaptation strategies that may be used to cope with these.

KEYWORDS:

Food crops, climate change, water availability, temperature.

CLIMATE CHANGE AND GRASSLANDS:
UNEXPECTED CONSEQUENCES OF EXTREME RAINFALL PATTERNS

Alan K. Knapp, Jana Heisler-White, Melinda D. Smith and John M. Blair

ABSTRACT:

Climatic variability is an inherent feature of grasslands, with large fluctuations in temperatures combined with precipitation regimes characterized by floods and severe drought occurring within and between years. Global climate models and emerging data indicate that extremes in precipitation regimes are increasing worldwide. Thus, variability in temporal patterns of water availability in grasslands, as directly influenced by altered precipitation patterns and indirectly by forecast increases in temperature, will likely increase in the future. Analyses of long-term relationships between grassland productivity and rainfall patterns coupled with experimental manipulations of precipitation inputs have yielded a number of surprising insights regarding how these grasslands will respond to future more extreme climates. Long-term data and experiments have shown that even in relatively mesic grasslands, water availability limits aboveground productivity in most years. Thus, most grasslands will be sensitive to climate change. Sensitivity can be influenced by dormant season soil moisture conditions as well as by within-season precipitation patterns. Surprisingly, increases in precipitation extremes (larger rainfall events with longer intervening dry periods) during the growing season reduced productivity in mesic grasslands but increased production in semi-arid grasslands. Understanding interactions between rainfall amount and its distribution in grasslands is key to forecasting responses to climate change.

KEYWORDS:

Aboveground net primary production, forage production, grasslands, extreme rainfall regimes, precipitation variability.

CLIMATE CHANGE, GLOBALIZATION AND WATER SCARCITY

Karen L. O'Brien and Robin M. Leichenko

ABSTRACT:

Much of the world's population is likely to be directly or indirectly affected by climate change-induced water scarcity, which is related to changes in the amount, timing, and distribution of rainfall, in the supply of glacier meltwater, and in the amount, quality and accessibility of surface and groundwater. However, these are not the only global scale changes affecting water resources. Water marketization and cross-basin trade, combined with increasing agricultural, urban and industrial demands, are creating new contexts for accessing water, as well as new competition for water resources. In this paper we explore the relationship between climate change, globalization, and water scarcity and consider the implications for human security. Using a "double exposure" framework, we discuss why those who are most likely to be negatively affected by climate change are also most likely to experience the negative outcomes of globalization. We demonstrate that water scarcity in an era of global change is influenced by policy decisions as much as it is by changes in physical supply. As the double exposure framework shows, water policy decisions must take into account potential outcomes of both climate change and globalization.

KEYWORDS:

Climate change, globalization, water privatization, human security.

CLIMATE CHANGE:
A GLOBAL CHALLENGE FOR WATER GOVERNANCE

Claudia Pahl-Wostl

ABSTRACT:

The 21st century poses extreme challenges for the governance of environmental problems. Climate change and the concomitant increase of extreme events have exposed vulnerabilities of current resource governance regimes. This has provided further arguments for the need to develop flexible and adaptive governance approaches and innovative approaches to deal with risk and uncertainty to implement and guarantee the long-term sustainability of water management. It has also provided strong arguments for the need to adopt a global and multi-level perspective on water governance issues. Dealing with challenges of climate change requires increasing the adaptive capacity of water governance regimes. Required are robust strategies that perform satisfactorily under a range of initially uncertain but possible future developments. Such strategies can only perform effectively in water management regimes that allow for learning and adapting to new insights. The global dimension of the governance challenge is manifold. Global processes are needed to share and evaluate in a systematic fashion lessons learned to develop a “diagnostic approach” that allows linking specific characteristics of a climate change adaptation problem with appropriate governance approaches towards its solution. Further innovative processes for global governance need to be developed to deal with challenges requiring a global, coordinated response.

KEYWORDS:

Water governance, adaptive water management.

IMPLICATION OF CLIMATE CHANGE ON DROUGHTS AND WATER SCARCITY

Luis José Mata

ABSTRACT:

Droughts and water scarcity are important issues related both with climate change and sustainability. Water quality deficiency can be a major cause of water scarcity. Water scarcity is also a matter of poverty. There are many regions in the world already experiencing severe droughts and under a water scarcity situation. Climate change will substantially increase the number of people under water scarcity. If climate change implies greater water scarcity in some regions relative to water demand, then, adaptation strategies should include ways that improve water use efficiency and management. Many developed and developing countries have conducted detailed studies on climate change impacts. Several are moving toward implementation of adaptation strategies. Adaptation to climate change should be at the core of the international poverty agenda. The poorest of the world will hardly escape from dangerous climate change. Current approaches to adaptation planning in many countries center on the idea of using a climate-proofing approach. Adaptation to climate change should reduce the risk of damage when taken in advance. There are many factors that contribute to limiting adaptation; those factors influence the adaptive capacity of water management systems. Adaptation and mitigation need to be viewed as complementary responses to climate change. The presentation aims to offer a comprehensive assessment of the current knowledge about the effect of climate change on droughts and water scarcity in dry regions and also its effects on sustainability. How climate change will impact the already existing problems. Why water scarcity is a climate and sustainable development issue. Impacts of climate change on droughts and adaptation responses and the regional implications of the relation between climate change and droughts.

KEYWORDS:

Drought, water resources, extreme events, water scarcity.

CLIMATE CHANGE AND WATER: ADAPTATION

Stewart J. Cohen and Roger S. Pulwarty

ABSTRACT:

In many parts of the World, climate change is anticipated to result in greater water scarcity. Future adaptations may include technical changes that improve water use efficiency, demand management (*e.g.,* through metering and pricing), and institutional changes that improve the tradability of water rights. The availability of water for each type of use may be affected by other competing uses of the resource. Consequently a complete analysis of the effects of climate change on human water uses would consider cross-sector interactions, including the impacts of changes in water use efficiency and intentional transfers of the use of water from one sector to another. The barriers to implementing adaptation measures include the inability of some natural systems to adapt at the rate of combined demographic pressures and climate, incomplete understanding and quantifying of water demands, and impediments to the flow of timely and reliable knowledge and information relevant for decision makers. Many adaptation measures are technology and efficiency based. Early warning information, as well as decision support tools for long range planning, should be based on a mixed portfolio of experimental and scenario-based approaches for shared learning by researchers and practitioners. This becomes an integrated watershed management approach in which adaptive management is an operational tool for learning. We examine two cases from western North America (the Okanagan, and Colorado Rivers) to illustrate mechanisms for interactive learning, anticipatory coordination and communication.

KEYWORDS:

Adaptation, climate change and water, integrated watershed management.

ADAPTING TO CLIMATE CHANGE IN WEST AFRICA

Nick van de Giesen, Winston Andah, Marc Andreini, Boubacar Barry, Gerlinde Jung, Harald Kunstmann, Wolfram Laube, Patrick Laux and Jens Liebe

ABSTRACT:

Impacts of climate change vary from region to region. The 4th Assessment Report of the IPCC mentions that drier areas will be affected by more droughts and that the rainfall regime, in general, will become "rougher". In West Africa, specifically the area below the Sahel, the climate change signal may be more subtle. Anecdotal evidence from farmers suggest that the onset of the rainy season has been shifting forward in time over the past two generations. Recently, detailed atmospheric modeling over the region (Jung and Kunstmann, 2008) shows that also in the near future, the onset of the rainy season will shift to later in the year, roughly from April towards May. The end of the rainy season as well as the total amount of rainfall will remain more or less fixed. This implies that adaptation strategies should be twofold. The first part of a comprehensive adaptation strategy would be a continuation of the efforts to produce faster growing rainfed crop cultivars, mainly corn and sorghum. The second part would consist of increased water storage during the wet season for use in the dry season. River runoff in West Africa is very sensitive to the rainfall distribution. When the same amount of rain falls within a shorter period, as is suggested by climate projections, runoff will show an important increase. Also the recharge of groundwater will improve under these circumstances. Storage of surface runoff in small reservoirs would be an important part of climate change adaptation. Extensive use of (shallow) groundwater in the dry season could be a second, highly complimentary adaptation strategy. The development of large dams would probably be less successful given the flatness of the landscape and the move towards decentralized development in most West African countries. Shortening of the rainy season will reduce rainfed agriculture, which is the dominant mode of food production in the region. Use of surface and groundwater in the dry season may partially offset this negative effect. Success of any of these adaptation strategies will to a large extent depend on institutional and socio-economic developments within the region.

KEYWORDS:

West Africa, rainy season, climate change, climate adaptation.

PTING TO WATER SCARCITY IN EUROPE

Wolfram Mauser and Tobias Hank

ABSTRACT:

According to IPCC projections Europe will experience considerable changes in rainfall amounts and distribution during this century. This would lead to an increasing polarisation of water availability between the north, where rainfall amounts are expected to increase and the South, where they may sharply decrease. Results from a coupled regional climate impact model, which simulates the reaction of the runoff regime of the mountainous Upper Danube river basin on the expected climate change, demonstrates as a case study, that a complete change in the hydrologic regime of Central and Southern European mountain water resources is likely. The consequences, more severe low-flow conditions, sharply decreased summer discharges, reduced hydropower potential and an increasing demand for irrigation, are demonstrated. Possible ways to adapt by changing the operational mode of existing reservoir structures are discussed.

KEYWORDS:

Climate change, mountain hydrology, PROMET, runoff regime.

Conclusions and Recommendations

MAIN CONCLUSIONS

1. According to the IV Assessment Report of the IPCC, warming of the climate system is unequivocal, as evidenced by observations of increased global air temperature, as well as of the oceans, widespread snow and ice melting and sea level raise. Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. There is high confidence that the following effects on hydrological systems are occurring: increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, and warming of lakes and rivers in many regions, with effects on thermal structure and water quality. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gases (GHG) concentrations. Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were to be stabilized.

Global warming can alter the water cycle. Climate change is affecting water resources now. Further, climate change will affect water resources in the future, and the impacts will be predominantly negative. The effects of climate change will be seen on water quantity, water quality, and the occurrence of floods and droughts. While the rainfall in the global average increases, the local distribution will be quite non-uniform. Dry regions will become dryer due to a widening of the subtropical high pressure systems. The precipitation belts of the mid-latitudes are moved towards the poles. In middle Europe, the seasonal cycle is shifted with more precipitation in winter and less in summer. The tropics will experience an increased rainfall. There is a tendency towards more intense precipitation events and longer drought periods. Rain in semi-arid regions (like in the Mediterranean) is inherently difficult to represent in climate models (due to the high variability in space and time and often complex terrain). Therefore, scenario-led water planning may not be feasible or sensible everywhere. In these cases decisions must be robust regardless of the climate outlook).

2. The intensification of the hydrological cycle causes floods and droughts to get more frequent and/or extreme. Droughts, particularly in arid and semi-arid regions, are of particular concern due to their large spatial extent and long durations. Methods are now being developed to facilitate the early warning of drought and its related impact in agriculture and possible famine. Changes in flood risk have been observed, due to multiple factors, and even stronger changes are expected in the future. The moisture-holding capacity of the atmosphere increases with temperature and so does potential intense precipitation. In contrast, the number and intensity of snowmelt and ice-jam floods have been decreasing in much of Europe. In order to anticipate future changes in flood, countries are introducing measures to reduce flood risks, such as the National Cartographic System of Floodable Areas of Spain.

3. Snow and ice on earth are undergoing significant melting and reduction which can be mainly attributed to global warming. This includes a strong decrease of Arctic sea ice, a decreasing snow cover mainly in the northern hemisphere, widespread glacier retreat and thinning, degradation of frozen ground and reductions and ice flow acceleration of relevant portions of Greenland, West Antarctica and the Antarctic Peninsula. This is already having relevant impacts for example on water resources in glacier basins, sea level rise, changes in glacier hazards in mountain regions, and ecosystems in polar and mountain regions.

The ongoing changes in the cryosphere can be exemplified by the glacier retreat in the Spanish Pyrenees, which are among the southern-most of Europe, and are remnants of past glaciations. In the last 25 years (from 1982 to 2007) they have lost 2/3 of their surface (from 595 to 206 ha, respectively) as well as of their volume (from 107 to 30 hm^3, respectively).

Wetlands provide a wide range of important ecosystem goods and services for humankind, with an estimated value of 14 trillion US$ per year (almost 50% of the total biosphere ecosystems). Wetlands are hot spots of biodiversity. Despite their importance there is an ongoing and widespread degradation of wetlands that seems to progress faster than in other ecosystems. Non-climatic drivers (*e.g.,* pollution, eutrophication, habitat fragmentation, water withdrawal) are the main causes of degradation, but climate change is expected to intensify the likelihood of potentially abrupt changes, which can be large in magnitude and difficult, expensive or impossible to reverse.

4. Over the coming decades, changes in climate and society will drive a major transformation of the global water resources. But not all regions will be affected in the same way; the intensity and type of risks will vary greatly from region-to-region:

- Global warming has already quickened the pace of glacier-melting in the Alps, Himalayas, and elsewhere. As the melting continues, river runoff fed by these glaciers will at first increase. Later, though, glaciers will diminish along with runoff, and this will endanger water supplies downstream.
- Changes in precipitation patterns will alter the outflow of freshwater to estuaries (increase or decrease depending on location) and this is likely to disrupt coastal ecosystems.
- Water scarcity due to climate change will intensify in specific parts of the world including southern Europe, northeast Brazil, and southern Africa.
- Increasing precipitation intensity over much of Europe, especially in winter, is likely to lead to more frequent flooding in the central and northern sections of Europe.

A combination of climate change and socio-economic factors could lead to increasing water stress over roughly two-thirds to three-quarters of the entire river basin area of the world in the decades spanning 2000 and 2050.

Climate change is unequivocal, and will affect water resources availability and quality. The time has come to act now. Society needs to respond immediately to these risks, and this response should take place at all levels, from local to global. This means exploring new ways of managing water at the global level through novel international institutions and conventions. Increased water stress will exacerbate water-related problems. Governments must re-evaluate the adequacy of their infrastructural facilities as well as their legal, technical, and economic, policy and institutions approaches for water management and water services. Integrated water resources management provides an important framework to achieve adaptation goals.

5. Changes in the water cycle may play a fundamental role in global food security. In many Mediterranean-type environments (Europe, Australia and South America), as well as in marginal arid and semi-arid tropical regions, especially sub-Saharan Africa, water resource availability is projected to decline significantly due to climate change. In general, while moderate to medium increases in local temperature (1-3ºC), with associated CO_2 increases and rainfall change would benefit crop yields, even slight warming (1-2ºC) in tropical areas, or areas that are seasonally dry, would have detrimental effect on yields. Global food crops production is expected to decrease, but regional production changes may rather different (*e.g.,* increases in high latitude countries, reduc-

tion in mid to low latitude countries). Global irrigation requirements are expected to significantly increase (higher increases in developed regions). Suitable area for cultivation and growing season of food crops will be affected: a) crop producing areas may expand pole-wards, b) shorter life cycle of crops such as cereal crops and oil seed crops.

Increased competition between urban/industrial, environmental and agricultural uses is likely – with this being increased by higher populations. There will be increased pressure for irrigated agriculture to maximise the value of output per litre of water used via changes in crops, irrigation management, water use technologies (*e.g.,* subsurface drip), location of activity, infrastructure (*e.g.,* dams) and institutional arrangements. Changes in these will largely be driven by impacts in extremely dry years.

Climatic variability is an inherent feature of grasslands. Rainfalls patterns are becoming more extreme and will likely increase in the future. Primary productivity in most grasslands is limited by water availability. Even subtle shifts in rainfall timing or intensity can have significant impacts on grassland productivity.

6. Water is a critical core sector so that impacts here have cascading effects on other sectors. Economic sectors which are projected to be most affected are agriculture (increased demand for irrigation), energy (reduced hydropower potential and cooling water availability), health (worsened water quality), recreation (water-linked tourism), fisheries and navigation. Preliminary estimates of the economic impacts in developing countries of a reduction in availability of water indicate that without adaptation, reductions in growth and development can be expected. Adaptation is key in the water sector, and the continue support to countries in growth and development is key to reduce vulnerabilities. The economic variable has been until recently ignored. Economic analysis provides information to decision makers in the efficient allocation of resources.

The top priority for adaptation in the water sector should be to reduce the vulnerabilities of people and societies. Water scarcity in an era of globalization is influenced by water policies as much as by changes in physical supply. Climate change closely interacts with globalization processes, leaving many people even more vulnerable to climate extremes and water scarcity. Water marketization, in particular, can exacerbate inequalities in access to water. This has important implications for human well being and 'human security'.

Dealing with challenges of climate change requires increasing the adaptive capacity of water governance regimes. Required are robust strategies that perform satisfactorily under a range of initially uncertain, but possible, future developments. Global collaboration and leadership are mandatory to deal with climate change. Global sharing of lessons learned is also required. There are no technical or institutional panaceas, but a need for adaptive governance and 'diagnostic approach' to develop and implement adaptation options appropriate for a given political, environmental and cultural context.

7. Many countries are already suffering from drought and water scarcity. Global warming will exacerbate these impacts. Water scarcity is intimately linked to poverty and to sustainability as well. Adaptation and mitigation need to be viewed as complementary responses to climate change. Adaptation strategies to face water scarcity should include ways that improve water use efficiency and management. Adaptation should be at the core of the international poverty agenda. Current approaches to adaptation planning in many countries centre on the idea of using a climate-proofing approach.

Climate change poses major conceptual challenges to resource managers since it is no longer appropriate to assume that past hydrological conditions will continue into the future. Experiences from two case studies, the Colorado and Okanagan basins, show that the policy context, the dialogue process, and a framework for collaboration, together, can make adaptation happen. Changes in managing climate-related risks may be most readily accomplished when: (1) a major event (climatic, legal, or social) occurs and creates widespread public awareness; (2) leadership and the public are engaged; and (3) a basis for integrating research and management is established. A key component in developing such an integrated framework is the ability of practitioners themselves to manipulate data and to compare scientific claims with their own knowledge. There is a strong need for development of interactive approaches between policy, operations, and research participants to take advantage of new learning opportunities as climate adaptation research and water management practice evolve.

8. Water resource management faces critical obstacles in many areas of the world that are in a process of development and that do not have integrated political structures. At local and regional scale, global climate change can have very diverse impact on the availability of, and demand for, water resources.

In West Africa, the beginning of the rainy season is shifting forward. The total amount of rainfall seems to be steady, as is the end of the rainy season. This implies that the intensity of the rainy season increases, which has important consequences from a management point of view.

In the Middle East and North Africa (MENA), where water resources are scarce, growing populations, inefficient infrastructures and an almost certain reduction in future precipitation patterns all further exacerbate the quality and quantity of water made available to both urban and rural users. Measures are needed to alleviate water shortage in the MENA region for the near and longer-term future. It is important for policy makers to recognize the all-encompassing nature of water management, notably on the importance of accountability.

In other regions of the world, such in many Latin-American countries, where water was resources were not so limiting, are facing increasing challenges. Changes induced by tropical glacier retreat, such as in the Andes, constitute an early case of the need for adaptation and therefore an example. Other examples of climate change vulnerabilities associated with water scarcity include: coastal wetlands in Mexico, potential of salinization of aquifers in the Caribbean, Páramos in Colombia. Adaptation options need to be identified to reduce climate change vulnerability.

9. In developed areas, like in Europe, that have more integrated political structures, but where integration in policies are still occurring, climate change will pose challenges for managing water resources.

In South Central Europe, considerable changes in rainfall amounts and distribution are foreseen. Climate Change will intensify water scarcity in this part of Europe by most likely becoming more Mediterranean. Whereas Southern Europe has historical experience in adapting to water scarcity this phenomenon is new to Central Europe. The main effect in this region will be the reduced snow storage available for water management and increased evaporation. It will force water management in Southern Central Europe into new strategies regarding introduction of irrigation and construction of new storage reservoirs.

Countries in South-eastern Europe, that are new members of the European Union, candidate or potential candidates for accession face costly investments to meet EU standards and regulations, at the time they face shortage of rainfall and other hydrological changes.

In countries like Spain, that are arid or semiarid, climate change will modify water quantity and quality, reduced water recharge of aquifers and increased risk of drought. Water scarcity will most likely be highest in areas that are already vulnerable. Adaptation measures are already being taken place to face future reductions in water resources.

IMPLICATIONS FOR MANAGEMENT

1. Both adaptation and mitigation measures will be required. Adaptation and mitigation measures should be compatible with sustainable development. There are low - cost low-regrets adaptation strategies which can be implemented now to address climate change.

In mid-latitudes the decrease of precipitation in summer and the increase in winter demands water storage and distribution systems. The more intense precipitation events can cause soil erosion and flash floods. Here appropriate measures like water retention areas and dikes have to be built.

"Low regret" adaptation options include source protections (e.g., from pollution), improved rainfall-runoff forecasting and monitoring system, better water governance, development of drought resistant crop cultivars, and optimisation of water harvesting systems.

2. Longer dry periods ask for a sophisticated water management. Advanced early warning systems for floods and droughts have to be developed.

Over large areas, flood hazard is projected to increase and this calls for upgrade of flood preparedness. The possible strategies read: protect, accommodate, or retreat. The EU Floods Directive calls upon all EU Member states to assess and manage the flood risk.

At a global scale, the average economic flood damage has increased by order of magnitude in the last four decades, in inflation-adjusted monetary units, and this drives wide-spread concerns worldwide.

3. Loss of ice will force a change in the management of glacier-fed rivers.

Understanding the current wetlands structure and function and how it can change due to human-driven changes would be very useful tool for environmental managers, especially if we are able to identify early warning signals of wetland degradation (*e.g.,* sensitive species). A key approach to protect the ecological status of wetlands is to maintain the quantity and quality of the water on which these ecosystems relay on.

4. Society must respond to the risks to global water resources noted above, and this response should take place at all levels, from local to global. At the global level there are three main tasks to take on. First, we have to reduce the immediate risk to society by establishing comprehensive early warning systems for droughts and floods. Second, we have to extend our knowledge of transformations going on in the global water system by expanding the scope of remote earth observations, and by conducting new large-scale field experiments and surveys. Third, we must protect nature and society over the long run by strengthening the global governance of water. This means exploring new ways of managing water at the global level through novel international institutions and conventions. These tasks need to be given high priority because the all-encompassing changes taking place in the global water system justify an equally wide-ranging response from society.

Water management will have to cope with the changes in water resources and water services due to climate change. These changes can be on the supply side and on the demand side. Supply side coping includes increasing storage or desalination. Demand side measures include more efficient water use, pricing, water conservation campaigns and allocation policies. Best is to develop a portfolio of both supply and demand side measures specific for the local conditions.

5. An assessment of the costs and benefits on food crops of a full range of existing options to change water use across the whole system is needed to face climate change. More efficient on-farm water use technologies (*e.g.,* drip), storage and delivery systems need to be implemented. Further, investing in the next generation of approaches to increase water use efficiency across the whole agricultural system is also envisaged.

Understanding is the basis for good management. In many natural systems, such as in grasslands, we are lacking a basic understanding of how future climate will affect production and how to manage this change.

6. Countries need to take measures to adapt to the impacts of climate change, among other to the shortage of water, reduced hydropower potential, reduced navigation capacity where it exists, reduced crop production and higher water demand, increased risks to natural systems, such as forest fires, and subsequent losses. To deal with these impacts on the economy we need to build local capacity in economic analysis. There is a need to begin estimating the economic impact on the most vulnerable sectors, in order to guide future decisions.

Water management must take into account both climate change and trade policies in order to address the challenges of water scarcity for individual and communities. Different perspectives and approaches to dealing with water scarcity often represent different interests: Water management should consider the role of new actors in water management and how they respond to climate risks. The social consequences of water extremes have to be considered in water management.

Management has to undergo a mayor transition towards adaptive and in approaches for taking into account complexity and uncertainty. There is a need of capacity development for water professional for educating a new generation of engineers and professionals capable with dealing with the new paradigms of water uncertainty.

7. Developing an integrated basis for managing water resources as climate changes requires a mixed portfolio of approaches, including:

- ▶ Mechanisms for anticipatory coordination within development plans (*e.g.,* adaptive management within integrated watershed and coastal zone plans) ;
- ▶ Developing usable climate risk management triggers for early warning of potential conflicts among water users (*e.g.,* agriculture, environment);
- ▶ Developing and employing water efficient technologies;
- ▶ Actively engaging communities and states, researchers and practitioners, in bringing climate information into practice though participatory mechanisms, and
- ▶ Investing in career opportunities for climate change adaptation within local governments and water-based utilities, integrated within long-term planning for sustainability.

8. Climate change has different implications for management, depending on the conditions of each country. In tropical countries, like Central Africa, a shorter and more intense rainy season has the following implications:

- ▶ The growing season will continue to shorten, needing new cultivars of the main crops.
- ▶ River discharge will increase, which opens options for increased storage in reservoirs.
- ▶ Groundwater recharge will increase, which increases the possible use of shallow groundwater for irrigation.
- ▶ Floods, which so far have been rare, may become more frequent, as seen in 2007.

Middle East and North African nations must initialize impactful and sustainable change in the water sector. Besides the engineering amelioration of water and wastewater collection, distribution and treatment networks, these steps include accelerating the pace of reform by involving non-water sectors (*e.g.,* media, academia, policy, etc.), finding opportunities in changing the political economy, and turning promise into reality by enforcing better public accountability.

In developing countries of Latin America, governments need to develop data, tools and institutions to cope with the observed trends of impacts due to climate change. Climate change diverts economic resources from investments in other institutional priorities. Much remains to be learned from pilot projects and early initiatives to evaluate the required resource-transfers from developed nations to reduce the fiscal and investment implications needed to reduce the negative consequences of climate change.

9. In the regions affected by increased water scarcity, such as South Central Europe, management practices for reservoirs and hydropower production should be rethought to create a reliable pathway for investments into new infrastructure. The distribution of available water for up- and downstream uses should be investigated under conditions of increased water scarcity (*e.g.,* is it better to consume available water for irrigation upstream or to reduce agriculture productivity upstream, increase river flow and use water for irrigation downstream).

Investment plans in countries that are in a process of adapting their regulations to meet EU environmental standards will also need to reflect the emerging understanding of climate science. Partnerships amongst countries, international institutions and stakeholders will be necessary to understand and respond in a manner that balances risks and uncertainties. Advances in disaster risk reduction and management can provide both short and longer term benefits as climate knowledge is refined.

Climate change needs to be incorporated in hydrological planning in order to better adapt to the impacts of climate change. Countries like Spain make mandatory that future hydrological programs be consistent with the foreseeable impacts of climate change on the water resources of a given territory.

SOME FUTURE NEEDS

1. For effective adaptation, we need reliable scenarios of how rainfall (and precipitation) will change at the regional scale in future. We need a good and continuous network of observing stations to understand how climate (especially rainfall) is changing now.

Regional climate models have to be developed and improved to simulate regional catchments. More realistic scenarios of the future have to be developed. Accurate measurements have to be taken in remote areas of the globe to monitor the hydrological cycle.

2. Arresting the decay of observing networks and improving baseline monitoring is essential for better understanding environmental change. Development in real time and seasonal forecasting could increase societal preparedness for extreme events such as droughts and floods.

Detection and attribution of changes in flood hazard and flood risk is necessary, in the multifactor context (with changes in socio-economic, terrestrial, and climatic systems). Development of methodology of flood frequency assessment in the changing world and reduction of uncertainties is necessary.

3. Snow and ice bodies should be more carefully monitored in all mountain ranges and in Polar Regions, particularly in relation to ongoing climatic change. Development of this knowledge will result in an improved predictive capacity which is essential for future planning. This will improve adaptation/mitigation policies with clear future benefits for society.

In wetlands, long-term (> 10 years) ecological monitoring programmes as a base-line to detect likely changes due to climate change. Increase the knowledge of ecosystem structure and functioning, especially on those thresholds (or "breaking points") than once exceeded, the ecosystem skips to a new state (mostly unknown or unexpected). Forecasting the impact of climate change on species and ecosystems needs also to improve the capacity of prediction models about regional (local) climatic changes

4. To improve understanding of the challenges brought about by climate change on water resources it is important to: create a sound scientific knowledge base; develop political legitimacy for policy development; develop public awareness and support for measures; develop local level tailor-made measures.

5. Integrated assessment of climate change and agricultural water-use in the context of other changes, such as food demand, are needed to understand future food production. A quantification of the role of changes in frequency and severity of extreme climate events on crop responses is also required, as well as an analysis of the response of important crops for rural poor people to climate change (*e.g.,* root crops, millet). Interactions among crops, weeds, pests and disease under a changing climate need to be better understood. The role of traditional and biotechnology techniques for coping with drought, heat and other climate related problems need to be explored. We need policy-relevant science that can inform us on the pathways to cope with ongoing change.

More research is needed, both empirical and modelling for better forecast the future ecosystem services of grasslands and all other natural ecosystems.

6. Improve the estimation of costs and benefits per sector, type of risk and different levels. Identify appropriate methodologies that should be applied to conduct economic analysis of adaptation in the water sector.

We need to look at how private water companies plan to adapt to climate change, and how these responses will affect water access and availability for those who are most vulnerable to climate change. What are the social consequences of increasingly unequal access to water and how can these consequences be addressed by the international community.

Development of international and global database and research network on water governance is needed to guide developing robust policy recommendations, how to implement them, and how to sustain adaptive and sustainable water governance. Dialogue on uncertainties and new approaches to managing systemic risks in face of climate and global change is also required.

7. An intense and permanent dialog among different water users is needed in order to implement win-win adaptation measures for all. There are many examples of situation assessments and technical framing of climate change adaptation challenges, which have provided promising learning experiences. However, there is a need for greater exploration of alternate integration models and overlying policy structures that might better facilitate and sustain this learning, beyond individual research projects, thereby supporting a long-term service of co-production of knowledge for water management and governance. Such a program would link understanding of the policy contexts (as elucidated in the Colorado case) with supporting a dynamic dialogue between researchers and practitioners (as in the Okanagan case). This would include a) knowledge of changes in the climate system; b) evaluation of the acceptability of adaptation technology and practice (use of new water efficient technologies), and c) a better understanding of how to improve communication for cross-scale types of adaptation decisions.

8. Present studies use historical/observed land-use patterns. Because West Africa's climate is the complex result of global and local atmospheric patterns, climate runs with realistic future land-use patterns are still needed.

There is a need to establish new training and capacity building in developing countries affected by severe water resources limitations. The Arab Water Council, an organization of water professionals in the Middle East and North Africa Region, has established the Arab Water Academy in Abu Dhabi to build capacity in the broader management challenges for water.

9. We need integrated analysis tools to combine e.g. regional climate change scenarios, hydrological models, macro- and micro-economic evaluation models and demographic predictions. This is necessary to improve the analysis of the efficiency and effectiveness of adaptation alternatives in the water sector. We need closer transnational collaboration of countries sharing a watershed. Burden sharing should be the principle in dealing with water scarcity within watershed in the EU.

New climate change impact studies on water, closer to the region of interest, and including the various facets of hydrological system, including the future state of water ecosystems are needed in face of the impending climate change.

OTHER EMERGING MESSAGES

1. It is hard, if not impossible, to se how we can meet the European target of 2ºC global temperature change to avoid "dangerous climate change". In the new emissions scenarios currently under development, the most aggressive mitigation scenarios has a temperature change of 2.0 -2.4ºC at stabilisation.

2. The currently most effective measure to reduce global warming is to limit the emission of greenhouse gases derived from fossil fuel burning and other sources. This is a tremendous challenge which should be undertaken by all nations and all sectors of society.

3. Climate change is a critical issue for developing countries. Climate change is the crisis of today, not the risk of tomorrow. Adaptation is a key element of development, and must start now. Adaptation and mitigation go together. Energy is central to mitigation, water is so for adaptation. There are synergies among the two that need to be explored. We must act locally and integrate water measures in other sectoral policies.

4. Climate change is expected to multiply underlying pressures on water supplies. Water scarcity is already an issue in many semi-arid regions of the developing and developed world. Adaptation is needed but the capacity to adapt varies among countries. Transparency favours adaption.

5. To detect changes and to monitor drought it is necessary to improve the system of meteorological observations in developing countries some of which have deteriorated in the last years, making them to be little prepared to face future risks.

6. Climate change impacts the goods and services provided by natural systems. These represent novel changes that our past knowledge has not prepared us for.

7. National plans and strategies are needed to integrate adaptation to climate change in all sectoral policies. Integration is the most efficient way of addressing adaptation. Adaptation measures must be implemented progressively, as needs are identified. In some cases, measures are urgent.

8. Mitigation and adaptation measures must be interrelated. Adaption can be meaningless if measures are not taken to stabilize GHG at the desired levels to arrest further climate change.

FINAL REMARKS

1. Climate change is here and will continue being with us for long. Warming intensifies the hydrological cycle. That implies more rain falling on the Earth, but unevenly distributed. In many cases, dry areas will get drier and wetter areas wetter. There will be more water-related extremes.

2. Changes in climate and society will drive a major transformation of the global water system. The water sector must take into account that past records cannot solely be used to project the future. We are now confronted with an unprecedented situation about how to programme future actions.

3. The global transformation of water resources requires a response from the local to global level. Adaptation often involves trade-offs among competing water using sectors. Therefore, a goal of adaptation is to minimize such trade-offs.

4. Water is a main vector of the impacts of climate change. Water impacts have cascading effects on my sectors, and may act in synergy with globalisation. Water governance must be adapted to deal with the new challenges of water scarcity and water-risks posed by climate and social change.

5. There is a major gap between knowledge from climate science and developing local adaptation strategies. This requires new water specialists and persons with new roles to work at the interface between the two.

6. Climate change impacts on water resources can have important consequences for the development of nations and for combating poverty in the world. The crisis is here, we have created it, and we must solve it.

Thematic Week 7

ECONOMY AND FINANCE OF WATER

Water Markets
in integrated Water Management

Financial solutions
for emerging countries

Positioning document[7]

General Coordinator: **Josefina Maestu Unturbe**[1]

Assistant coordinators: **Sici Sanchez Tamarit**[2], **Almudena Gómez-Ramos**[3], **Diego Rodríguez**[4]

[1] Coordinator of Economic Analysis of Water Framework Directive (WFD).
Ministry of the Environment and Rural and Marine Affairs (MERMA);
[2] Economic Analysis Unit. Ministry of the Environment and Rural and Marine Affairs
[3] Lecturer of the University of Valladolid. School of Agricultural Engineering.
[4] World Bank

BACKGROUND

Water scarcity symtoms in the world are increasingly evident. They are clearly seen in the lack of quality water for cities and for food production; in the increasingly noticeable impacts on economic development; and in the ever-decreasing amount of water available for sustaining fragile ecosystems in particular and the environment in general. The inefficient use of water and a lack of better physical and economic use of it are inertias that need to be eradicated.

We need to examine new water supply alternatives and management options that go beyond the traditionally offer-oriented options. In the context of integrated management, market instruments form one of these management options. Market instruments, which are more feasible where there is scarcity and competition for the resource, would have the beneficial effects of, for example, increasing the physical and economic efficiency of water use, making it easier to separate economic growth from the use of water resources; reducing the pressures of uses; reallocating water use in accordance with its quality; reducing disputes and conflicts; and generating better integrated development. The experiences of different river basins where these economic instruments have been set up have demonstrated their potential as instruments for efficient allocation although certain limitations and external factors have surfaced which need to be analysed and assessed.

OBJECTIVE

The first objective of this Thematic Week was to transmit the role of market instruments in integrated water management as instruments for the reorganisation and efficient use of the resource, as well as a means of complementing governmental water management and as a tool for resolving conflicts. Water Markets are founded on the basic principle of voluntary transfer of water rights, usually subject to a prior economic agreement, to other uses and users.

The second objective of the thematic week was to analyse how to promote efficient water use and the financing of investments related to water infrastructures.

CONTENTS

The four days of the “Water Markets in integrated Water Management” Thematic Week proceeded as follows:

[7]This document has been compiled from the written speeches, oral presentations, discussions during the sessions and from the distillation of all of the above prepared by the mediators, speakers and coordinator with help from the Water Tribune team.

On the first day the problems and priorities associated with the present and future use of water were analysed; emphasis was placed on the existence and increase of water shortages with the ensuing conflicts and rivalries that this causes. This situation makes it necessary to adopt new public policies and institutional processes; new solutions that are able to adequately respond to present and future conditions of shortage and conflict.

On the second day the issues addressed were water policy initiatives and institutional changes that allow for a more efficient use of limited resources in a framework of uncertainty. New options and management plans were discussed to make better use of water, as a natural resource and an economic asset, not only to improve water allocation from a quantitative point of view but also from a qualitative one.

On the third day experiences of implementing water markets and the current state of the situation were reviewed; the incorporation of external economic factors to the price of water and the integrated environmental perspective of this practice when the water transfers are significant and permanent.

Lastly, the fourth day was dedicated to the growing shortage of water and the current role of water markets for managing drought situations and relieving pressure on aquatic ecosystems in Spain. Water availability was analysed as well as the effect of climate change; the adaptation of public policies was examined along with how laws and governmental institutions have been modified; changes in the legal and institutional framework were assessed as well as the use of market instruments and their future potential.

RESULTS OBTAINED

The Thematic Week ended with a series of specific proposals to improve the practical application and development of economic instruments. These are instruments that are useful for managing periods of water shortage and drought and for developing allocation schemes that can cope with the problems of water availability and offer long-term protection for the aquatic ecosystems in those regions that are suffering increasing problems of water shortages as well as improving the financing of water policies in emerging countries.

A) THEMATIC AXIS: WATER MARKETS IN INTEGRATED WATER MANAGEMENT

1.- Shortage, risk and water conflicts

Water is a basic commodity for sustainable development, for eradicating poverty and hunger, and it is an essential element for human health. However, according to the report entitled Water and Development Goals for the Millennium, it is a luxury for one in six people and it is calculated that 40% of the world's population (2.6 of the 6.5 billion people that live on the planet) do not have access to basic sanitation systems. Diseases transmitted by wastewater add to these situations of inequality.

In developing countries public financing is the key to overcoming the lack of drinking water and sanitation. Nearly two out of every three people who do not have access to clean water live on less than $2 a day; more than 660 million people who do not have sanitation systems live on $2 a day. These figures clearly demonstrate the limited capacity of the disadvantaged to finance suitable access to water through private sources.

Droughts and floods have enormous economic, environmental and social implications (Cooley, 2006). For one thing, they have a direct effect on human life and health. The 1984 drought in Ethiopia, for example, killed nearly a million people and the 1941-1942 drought in China led to nearly three million people dying of hunger. The consequences of the more recent disaster in New

Orleans are still patent. Furthermore, the problems of access to drinking water are increasing as the quantity and quality of water supply is compromised. This affects the most vulnerable sectors, such as agriculture, in which, in extreme cases, crop losses can lead to food shortages and job losses. Other effects and consequences include the risk to the functioning of energy systems that depend on hydroelectricity, migration from rural areas to urban ones, a rise in regional conflicts over the use of the available resources and an increase in the pressure on less affected areas, as was the case in Kenya in 2000.

Water shortage and drought is a worldwide problem that affects Europe too. Over the last thirty years droughts in the European Union have increased spectacularly in terms of their frequency and intensity. Between 1976 and 2006 the number of areas and people affected by drought increased by nearly 20%. The total cost of drought over the last thirty years has risen to 100,000 million euros. The average yearly cost has quadrupled over this period (European Commission, 2007).

The situation is highly diverse in rich countries where economic development, growing populations and preponderant lifestyles put an increasing amount of pressure on limited water resources. At the same time, there is a gradual increase in the demand for water in its natural state, which is giving rise to the development of legal frameworks and water policies to protect and restore aquatic ecosystems.

In this context of the difficult management of limited resources, which are currently under a great amount of strain, we face an additional challenge: climate change. According to the conclusions of the climate physics workgroup of the United Nations Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report –a document that has been endorsed by over 100 countries- climate change is unstoppable and will lead to temperature rises this century of between 1.6 and 4 degrees, depending on the measures adopted to combat it. Global warming will have enormous effects on biodiversity, the rise in sea level and the loss of the polar ice caps, as well as increasing the frequency and intensity of extreme phenomena such as droughts and flooding.

Again, the effects of climate change and natural disasters are very different in developed and non-developed countries. The economic loss is greater in wealthier countries, although it accounts for a higher percentage of the GDP in poorer countries where it reinforces the cycle of poverty and vulnerability. Conflicts arise over water as a direct consequence of this imbalance in water access and the growing increase in pressure and in many cases these conflicts are on a cross border scale. The socio-political framework, the hydro-climatic conditions together with extreme situations of scarcity can exacerbate existing water conflicts. Drought and flood management has traditionally involved crisis management, basically consisting of providing relief for those most affected. Over the last few years this reactive approach has started to give way to risk management, identification of the causes and the development of strategies to prevent or limit the effects. This has given rise to the idea of adapting to climate change.

The aim of adaptation is to reduce the risk and damages caused by current and future harmful impacts, profitably or by exploiting potential benefits. Adaptation has its limits. If certain temperature levels are exceeded, we can expect some climate impacts (for example, large-scale population shifts) to get worse and become irreversible. In this respect, risk management mechanisms can play a fundamental role in resolving conflicts since awareness of the interrelationships between climate conditions and hydrological variables can provide basic information for developing proactive mechanisms that anticipate situations and activate cooperation strategies.

If nothing is done, the costs of damages will shoot up between 2020 and 2080. If we act quickly it is possible to obtain clear economic gains by anticipating potential damage and minimising the threats to ecosystems, human health, economic development, properties and infrastructures. This is why the new challenges posed by the management of increasingly scarce water resources that are subjected to growing pressure call for a greater effort from institutions, on a global and national level, to implement new mechanisms that can adapt to new scenarios characterised by the uncertainty of both the availability of water resources and shifts in the globalisation of natural resources and the worldwide economy.

2.- Water shortage management and integrated water resource management

The problem of the use and allocation of water resources among competitive uses is heightened when seen within a context of risk or uncertainty. The dynamics of resource management dynamics are periodically perturbed by the occurrence of episodes of drought. Ignorance of the frequency and duration of these episodes is the main source of uncertainty in management and risk. In certain contexts in which there are recurring episodes of drought, risk can be considered as an inherent element of resource management, insofar as it has to be minimised in every decision made.

This scenario, characterised by the growing water shortage in risk contexts and the subsequent conflicts of competition for water needs to be seen within the context of the ethics of water management of recent years. These ethics are based on the idea that preserving aquatic ecosystems and satisfying people's basic needs are priority elements of water management and the criteria for economic efficiency in water resource allocation must consider these points. This management aspect forms has come to be called integrated water resources management (IWRM). This dimension of management includes the concept of sustainable development, which emphasises the idea of combining economic development and satisfying present needs without compromising the needs of future generations.

This new management approach challenges a large part of traditional water management based on the construction of infrastructures and establishing priorities of use. This is inefficient if the aim is to improve ecosystems and water quantity and quality as well as citizens' access to it at present and in the future. In short, integrated water management aims to allocate the three attributes of water: quantity, quality and accessibility under the criteria of economic efficiency, social equality and the environmental conservation of aquatic ecosystems. Current competition for the resource requires greater and better provision of water services that reduces the costs of use, improves equal opportunities for citizens and also ensures the basic maintenance of the environmental quality of the resource. Equal access to water also means meeting basic guarantees in supply, which entails a risk in satisfying the demand. Thus integrated management per se involves considering the risk element in the new management model that incorporates the allocation of resources using economic efficiency criteria and fulfilling certain supply guarantees whilst also considering social and environmental aspects.

In order to respond to the new challenges posed by the allocation of water resources there is a need for new policies and institutional changes that consist of a new understanding of water resource planning. The role of institutions and the legal framework should be to fully guarantee equal access to water and to ensure that ecosystems are preserved and that future generations can enjoy water resources in at least the same conditions as the current ones.

3.- The role of water markets in integrated management

Market instruments and in particular, the water usage rights markets, are mechanisms that are used to improve efficiency in the allocation of water resources insofar as they work as reallocation instruments capable of allocating water for the use that provides the greatest economic value.

However, results have shown that the markets work actively and efficiently when the context of the economy allows for this, but they also reveal that there are often significant flaws in the way the market works in that it fails to suitably address points that cannot always be assessed in economic terms and which affect the environment or certain sectors of the economy which may end up at a disadvantage in the resource transfer process. Along with these negative social and environmental external factors resulting from the setting up of markets there are also inefficiencies in the allocation of risks caused, to a large extent, by the high transaction costs of negotiations between parties when these take place in contexts of uncertain resource availability.

Experience over many years in different locations makes it clear that it is necessary to regulate the allocation of water resources wherever markets have been set up. Markets have difficulty in allocating the resource by themselves under the integrated concept mentioned before. The reason why different types of water markets have been developed lies in the different ideas concerning the resource and the permanent underlying debate of whether the nature of water as a public asset is compatible with the idea of it being a marketable asset and hence tradable. It is precisely this latter consideration, which guarantees the economic efficiency of the allocation, but at the same time it is largely responsible, for the environmental and social dysfunctions that many of these transactions have caused. The experience of implementing water markets in environments with mature water economies, in which water is considered to be a scarce commodity and thus has an economic value, but at the same time is clearly viewed as a public commodity, highlights the need to include these instruments in water resource planning under the premise of integrated management.

Water markets have gradually adopted different modalities in response to the demands of acquirers in different risk contexts and different legal or institutional frameworks. Similarly, water transfers may be temporary in the form of ad hoc transfers made in response to specific circumstances, or they may be permanent, in response to a structural readjustment in water usage. From a legal and institutional standpoint, markets may have decentralised management in the form of self-regulation by the participants themselves, as occurs in certain temporary allocations of rights; or else management may be regulated by the organisations responsible for managing the basins or supply systems. In this case, the bodies form water banks or trading centres to manage, regulate and promote water transactions between parties.

The integrated concept of management means efficiently allocating the water in terms of quantity as well as in terms of quality. In this aspect the value of water markets is two-fold. They can act as instruments monitoring pollution processes through the trading of discharge permits or, through the active participation of the public sector they can be potential instruments to permit the storing of water to recover environmental flows. On the other hand, they can have a negative connotation inasmuch as when they are used to redistribute water use rights they can either ignore or detail the requirements of environmental demands.

The different modalities adopted by markets in different contexts depend on the external conditioning factors and the redistribution demand of water management systems. The success of the instrument in terms of achieving the objectives for which it was established is largely determined by the capacity of market mechanisms to adapt and the consideration given to negative external factors. The following paragraphs look at the various water market modalities, briefly examining different issues regarding their adaptation to the integrated concept of water and their versatility as risk management instruments.

Temporary allocations of rights

These are the market instruments that have been around the longest, in both their informal version (markets that arise spontaneously between the users without a body regulating or controlling the process), and the formal version regulated by the public authorities activating the mechanism by establishing contacts between the intervening parties or supervising the amounts traded and their trade prices.

The development of this type of voluntary ad hoc transfer generates earnings for the economic agents taking part, especially when it occurs in a period of drought, as it affords access to water to those economic agents who are prepared to pay the most for it (those who obtain more value from it), so that the price paid reflects the scarcity value of water, unless speculation is involved in which case the price of water is adulterated by different kinds of expectations.

The success of these markets is based on the transparency and symmetry of the information available among the participants so that the necessary conditions of perfect competition exist for the efficient allocation of resources. This is why the effects that these transactions have on third parties and external environmental issues must be carefully analysed. Experience in granting these temporary assignations shows the need for bodies or agencies to monitor the transactions by establishing formal rules and, at the same, to monitor and assess their effects. For formal rules on the running of the market to be set up, water rights must be consolidated and well defined.

The objective of reducing risks through the stabilisation of the supply is more successful with temporary allocations than with permanent allocations of rights, as in these cases the risk is shared unequally between the seller and the buyer, the latter being placed in a risky position since he would need to purchase an unknown surplus of water in a drought year. Temporary markets share the risk more evenly between the parties, since this type of transaction provides greater flexibility and places the parties in a better position to face this context of uncertainty. However, this type of exchange of water rights does reveal major limitations and constraints due to the high transaction costs involved in reaching an agreement between the parties, which means that the markets lose their agility and capacity to respond to uncertain situations.

Water banks

Some of the effects related to the marketing of water resources can be overcome through centralised management instruments such as Water Banks or Trading Centres. In these cases, the regulating role of the water administration is essential for them to work efficiently. Their function basically consists of buying rights from assignation holders who are interested in temporarily selling their water assignation or allocation and to make it available for buyers at a price and under the conditions established by the regulatory centre.

Water banks can behave as genuine risk management instruments capable of activating automatic responses under pre-established conditions incorporated into the planning process. These exchanges allow the basin bodies to allocate scarce resources, to raise awareness of the cost of water scarcity and to reduce the effects of drought. The main advantage they present is that they can adjust supply and demand in terms of time and location thereby facilitating exchanges. As public institutions they are easy to monitor and regulate fiscally as they are more transparent and more widely accepted.

From the point of view of risk, centralised market instruments such as water banks reduce the uncertainty over water availability, with the equilibrium price reflecting the scarcity of water and the acquirers' decisions, which had previously been influenced by the market. Thus the market helps buyers to respond to drought tactically as in principle, they are aware a priori of all the information they need to access the market.

The experience acquired in emergency drought water banks in California provides some useful lessons for the future development of these banks. Studies analysing their implementation stress the vital role the authorities play in developing these instruments for the future adoption and acceptance of these transfers through the banks. The authorities must speed up the transfers and reduce the risk and uncertainty arising from the transfer and water transaction implementation costs. The success of the markets depends on the integration of these transfers in the supply and demand adjustments included in hydrological planning at basin level. Legal and environmental aspects, as well as the effects they have on third parties, must be considered in their development.

Options contracts

In situations of uncertain supply in which there are frequent episodes of drought, new instruments must be found to ensure equal access to water and to take into account the sharing of risks. Contracts are needed that are capable of transferring risk to reduce social and economic vulnerability to drought cycles. Operation of these purchase option contracts is based on the heterogeneity of the users with regard to their acceptance of the risk.

Options contracts may provide the ideal framework to develop long-term agreements that afford purchasers access to water rights by means of purchase options only in those years in which there is a water shortage but under a contractual relationship between the parties over an extended period of time. This method avoids the high costs involved in the transaction and establishment of a transfer contract in situations of extreme drought when there are many purchasers and the sellers take on a high risk in setting the amount and, indeed, in many cases are reluctant to sell. This is an efficient way of transferring risk because it does not need to be accompanied by the real transfer of water, and is hence a feasible alternative to the construction of new water infrastructures or reservoirs.

Option contracts may be linked to a water bank as these institutions can facilitate transfers under the terms established by the trading centre itself before a dry period. Both water banks and options contracts are able to transfer the risk as a means of reducing social and economic exposure to drought.

It is important to underline that in the case of an option contract in a context of uncertainty over water availability; water rights must be redefined and specified in such a way as to ensure the feasibility of aspects such as the time and conditions in which the water can be used. In general this involves defining pre-established conditions in relation to the time and the way in which attributes can be transferred, and this is essential for planning demand in a risk context.

Markets for water pollution rights

The concept of this instrument basically involves the creation of market in which pollution permits are traded in order to improve the overall quality of water in water systems. The design and implementation of this instrument makes it one of the most innovative mechanisms in current water management.

There are, however, limited practical experiences of this instrument in the world due to the fact that it requires a highly demanding environmental-legal framework and a set of specific economic conditioning factors. The success of this mechanism largely depends on the how ambitious the administration is in terms of reducing pollution and its commitment to achieving these levels through the application of effective punitive measures.

Apart from an appropriate legal and environmental context for the development of these instruments, extensive knowledge of the origin of the contaminating loads of basins and of their behaviour and evolution is required. Along these lines, one of the great difficulties to be overcome in these trading operations is the control of the so-called “hot spots” as they can occur more frequently in the trading of marketable permits. Another aspect to be taken into consideration in relation to how these markets operate is the difficulty of their social acceptance since the idea is that society in general accepts that one or several agents pay to contaminate more than the rest with the ultimate objective of society paying less overall to reduce global levels of pollution to the established levels. Experience acquired in the marketing of CO_2 emissions could serve to promote this mechanism although there is a generalised opinion that the existence of water markets could foster their start up.

4.- Experience in the implementation of water markets

There are numerous examples of the setting up water markets. In some places the development of these markets has arisen spontaneously through occasional transfers at informal levels (India, Canary Islands…) or by the creation of a regulatory framework that has attempted to set up exchanges through formal markets (Australia, California, Spain, Mexico). In this latter case, some countries have opted for a clearly decentralized, less interventionist management system such as Chile or Australia in which “spot” markets based on occasional transfers have been developed. In other cases the role of water administration bodies has been fundamental in supervising and monitoring exchanges (Spain, California) or opting for water banks.

Agreements on joint water use can also extend beyond national borders and become an effective mechanism for fostering the co-operative use of water between countries in conflict. Indeed, proposals have been made to develop a co-operative model of water use through transfers and exchanges, which could go a long way to resolving part of the conflicts over water that are rife in the Middle East, between Israel, Palestine and Jordan.

A glance at different experiences in trading water use rights shows us the importance of certain differentiating elements as key factors in the operating of these markets. The physiography of the basin, the local economy, the levels of risk taken on by the different agents involved or the definition of water usage rights or water ownership are aspects that explain a good deal of how the market operates.

In the case of California or Australia, with well-established formal markets, the role of the institutions and the legal framework that governs trading are essential. The Australian experience has demonstrated the success of the ten-year old instrument in which there has been an ever-increasing participation and that has created significant opportunities in water management, although, for a series of reasons, these gains have been attained at a great environmental cost. Australia has currently initiated a reform process to rectify these environmental problems whilst at the same time maintaining the improvements achieved through the water markets, as they are deemed to be a useful instrument for the allocation and use of water. The water reform is aimed at redefining water entitlement, the idea being to decouple it from land ownership and treat it as an asset that can be disaggregated in order to add greater flexibility to transactions.

California is a clear advocator of a management model in which the option preferred is to manage demand by leveraging markets and reusing existing resources rather than the traditional policies of increasing supply. The institutional context and definition of ownership rights in California has led to the development of the water markets as a viable instrument to deal with the drought situations experienced during the eighties and nineties in this state. The problem of lack of flexibility in responses and significant environmental and social externalities during the early years of the experience in implementing voluntary markets, essentially based on the transfer of water from agricultural to urban uses, highlighted the need to develop markets under centralized management and clearly incorporated in the concepts of integrated management. This is how the Emergency Water Banks arose to deal with the drought situation at the beginning of the nineties. A lack of foresight and the rigidity of the model have led the authorities to opt for water banks based on a system of purchase options to cope with future episodes of water scarcity.

Chilean experience is a highly illustrative case with which to analyse markets behaviour in economic contexts that are characterized by a low level of intervention and the inexistence of institutions that monitor water management in basins. The final outcome of the Chilean experience has both supporters and detractors. Either way the system has benefited some sectors of the economy such as the hydroelectric sector whilst also allowing modernisation of many irrigation zones but it has brought about a significant deterioration in certain aquatic ecosystems and economic losses that affect the most disadvantaged levels of society.

In Israel, the approach taken to water markets is to consider them trading and co-operation instruments with a high potential for resolving conflicts. Along these lines, the economic models developed have aimed to optimise a model of co-operation in the use of the water of the River Jordan and the mountain aquifers between three countries in conflict: Israel, Jordan and Palestine. Economic valuing of the exchanges is carried out by the shadow price, this being an indicator of the scarcity value of this resource. Many academics consider this option to be less costly and environmentally more useful than the desalination of seawater and aquifers, which are the options chosen by the international bodies acting in this area of conflict. All participants gain from this co-operative trading model.

Markets based on the trading of pollution permits are further instruments to be considered in water planning as a way of improving water quality. There are not as many examples in this case, being limited to pilot basins such as the Tar-Pamlico or Lake Dillon in the United States or the Murray-Darling basin in Australia. The success obtained in terms of improving water quality highlights the crucial role that these instruments will play in the future; to develop them we will need a suitable framework and this requires prior experience in water markets. Experience in quantitative water management through water markets should provide a basis for the development of water quality transaction mechanisms although in-depth knowledge of the pollution process in the basin and close monitoring is required, given that markets operate differently in the case of localised sources of pollution than when there is widespread pollution, and in the latter case management is a much more complex task. In either case, an ambient equivalent has to be established between traded pollutants that are hard to quantify.

The examples of water transfers analysed have revealed that the effectiveness of these exchanges is specifically influenced by various elements of uncertainty. Markets can and must adapt to risk situations to achieve not only the allocation of resources but also the assignment of risks. The experiences of Australia, America or even Spain highlight the need to advance in the development of more sophisticated markets that enable the redistribution of rights and seasonal allocations quickly and with a low cost of transaction; such markets must promote the flexibility of trading and adapt to the context of uncertainty. Option contracts fit into this context as instruments that are capable of transferring risk and as a useful mechanism to reduce social and economic vulnerability to drought cycles. At present we have little experience in these markets but there is a general consensus as to their potential as a risk-assigning mechanism and as a useful management tool to be incorporated in integrated management plans.

5.- An evaluation of market experiences in Spain

Water management problem in Spain is a clear example of management model in need of new policies to resolve the challenge of water allocation, having already exploited traditional management strategies based on an increase in water supply.

Spain’s legal framework provides water markets development under a centralized management concept by the River Basin District authorities, which are the institutions responsible for water concessions and planning at river basin level. The Spanish regulatory framework establishes that water markets (between water rights holders or at public initiative) are implemented to reallocate concession rights in situations of water shortage (and droughts) to guarantee the supply of water to those who can obtain the greatest value from it and also, if relevant, for the environmental improvement of the water resource.

Water rights are established by means of a concession system based on long-term rights of usage that provide the system with stability. Spanish law and planning establish usage priorities and allocations and decisions can be taken as to who should use water during a drought and how much water should be allowed. This system, however, does allow water allocations to be improved when the conditions in which said allocation was initially made have changed.

Water management in Spain is currently undergoing a process of adaptation and definition. On the one hand there is fiercer competition for this resource due to increasing demand and on the other there are limited possibilities of increasing offer due to the high social, environmental and financial costs involved. Furthermore significant changes in the environmental quality objectives of basins have been introduced following the incorporation of the Water Framework Directive into Spain's current legal framework, making the allocation of resources even more difficult.

Spain has clearly opted for markets with public intervention (through trading centres or water banks and transfer contracts for use of resources), since it is considered that this method offers the greatest guarantees that trading transactions do not involve external factors that may affect the environment and third parties and that there is no risk of abusive prices in said exchanges (due to lack of competition, transparency or agility).

Within the framework of Spain's current legislation and in response to droughts that have affected a large part of Spain, especially in the southeast basins, various water transactions have been carried out in the different modalities laid down by law. There have been ten inter-basin resource transaction operations and five rights acquisition bids by the Trading Centres of the Guadiana, Segura and Júcar River Basin Authorities. Much higher prices have been reached for transfers carried out through the Trading Centres than the loss value in the agricultural activity of the transmitting party, which gives us a good idea of the scarcity value of water in practically the whole of the southern half of Spain in non-extreme drought conditions.

In addition, the amount of total public resources devoted by the administration to acquiring water resources through Trading Centres by means of public bids has been significant.

However, an overall appraisal of transfers reveals certain shortcomings in the system due to the fact that the social and economic effects caused by water transactions have not been taken sufficiently into consideration prior to the signing of contracts. Certain speculative aspects have been detected in movements given that the prices paid by the transferees have been much higher than the loss of profit of the transmitting parties.

In the Trading Centres there have been few trading operations and many administrative and technical difficulties in creating the infrastructure of the banks, which has almost certainly been due to the need to offer minimum guarantees as to their correct functioning. However, insomuch as the initiatives have not resulted in a stable framework for trading nor were they designed to be permanent offices, at least from an administrative point of view, it is impossible to class the Spanish experience of water banks as providing proactive instruments that respond to drought situations.

Spain has just embarked upon a new approach to water management, incorporating market instruments. The challenge of managing the current drought situation that affects most of the country, calls for responses that are capable of anticipating risk situations. This approach is going to require changes and new orientations that will lead to a greater flexibility in resource allocation. An integrated management approach to water markets requires them to be included and explicitly contemplated in the river basin and drought schemes that are currently in place in the river basin districts.

B) THEMATIC AXIS: FINANCIAL SOLUTIONS FOR EMERGING COUNTRIES

1. – The need to improve access to water, efficiency and the financial challenge

Water is essential for life. It is estimated that human beings need approximately 15 to 18 litres of water every day to survive. Although there is sufficient water for everyone, access to water is a formidable problem.

Recent studies forecast that, under current water management conditions, 35% of the world's population will not have enough water in the next 25 years. Even in areas where there is no water shortage many people will not have access to it. More than one thousand million persons do not have access to drinking water (two thirds of them live on less than 2 dollars a day) and more than 2,600 million do not have access to improvements in sanitation.

Figures recently released by the UN show that there are more than 100 million people who still lack access to drinking water in Europe with the consequent contribution to the death of 40 children a day from diarrhoea in this region. Worldwide, current evidence points to the fact that 1.7 million deaths per year could be prevented by providing access to drinking water and sanitation.

The United Nations Food and Agriculture Organisation estimates that by 2030 food production needs to grow by 1.4% every year to keep up with demand. About half of this increase will have to be generated by crops grown on irrigated land. The challenge to meet the demand is the availability of water because more than half of the world's population lives in areas of the planet where there is a shortage of water. It is necessary to come up with the means to increase food production without increasing the amount of water consumed by agriculture.

The need for investments and the shortage of water are realities that coexist with the wastage of water, inefficient management, weak institutions and indiscriminate subsidies of the price of water for agriculture and human consumption and a constant rise in the costs of investments into water resources. Most studies show that although all sectors of national economies receive water-related subsidies the greatest investments are received by users of water for industrial or agricultural activities. Most users in developed countries as well as rich consumers in developing countries do not pay the true cost of water.

Access to drinking water and sanitation is a complex problem. Water is a capital-intensive sector and requires large investments to obtain and distribute the resource. Nevertheless many people consider access to water to be a right and, as such, there is a certain reticence to pay a price concomitant to the total value delivered.

The matter is further complicated by the fact that water is essential for human health and for food production. Hence access to water is a highly charged political issue behind which lies the need to take decisions concerning investments and the control of this resource. Moreover, most of the responsibility for production and supply is in the hands of sub-state entities which add another layer of political risks arising from narrower planning horizons and a potential political difference of opinion to that of national governments, leading to an increase in the politicisation of decision-making.

Further heightening these political and price problems is the fact that the climate of investment in most developing countries is not conducive to investing in such a risky sector. Many developing countries need to improve key aspects such as macroeconomic stability, the rule of law, tax management, regulatory institutions and the functioning of their legal systems. An enabling political environment is critical in order to have access to financing for the sector.

At the present time the financial markets are in turmoil making it difficult to obtain access to financing for a sector that is considered by most to be very risky due to the aforementioned political and socio-economic characteristics. This situation is exacerbated by the reduction in public and private investments in infrastructures in general and, particularly, in the water and sanitation sectors. Private sector participation in hydraulic investments dropped from an average of 5,800 million dollars a year in the last five years of the 20th century to less than 2,200 million dollars a year in the first six years of this century. Fortunately, however, this low level of participation includes more projects that previously (although at a lesser scale) and a significant increase in the participation of local operators. The number of countries with private participation in this highly complex sector has increased by 10% over the past five years and 16 countries have private sector participation for the first time since the all-time low of 2000. Official Development Aid (ODA) for the sector has also increased considerably over the past few years, as have multilateral donations. However the amount of 4,000 million dollars (in 2005) from these two sources is still not enough.

Most financial resources come from the public sector, national and sub-national governments, although the needs are such that financial, technical and management contributions from the private sector cannot be rejected. Ways must be found to increase the availability of new public and private resources and especially to improve those already existing. Whilst admitting that private investment and structured finances are currently (temporarily) out of date, this does not mean that the sector can afford to ignore their potential contributions, especially when seen in the broader context of their possible technical and management contributions.

The following aspects must be taken into account:

a) a) Potential for increasing the availability of water supply services by improving economic efficiency (taxes, relative taxes, sector governance, etc.) and the efficiency of existing assets (operational efficiency, waste reduction, management, etc.) in order to use the existing financial resources more efficiently. Eliminating some of these inefficiencies is a long process towards the reduction of costs to improve the availability of the resource and to attract investments.

b) The water sector is complex and requires strong institutions that have access to the necessary human and financial resources; in order to guarantee an adequate balance and control, independent regulatory and supervisory mechanisms (independent of service suppliers) are required.

c) Even if water supply services were to function efficiently and the regulatory climate were suitable, there would still be an enormous need for public and private sector investment in water infrastructures and services There are ways of attracting greater financing by exploring potential sources of public and private financing and by structuring investments to improve the availability of finance (alternative financial structures and instruments to reduce risks).

2. - Improving efficiency as a source of financing

Reducing inefficiencies and providing an adequate environment for investment prove to be significant sources of financing. Before exploring the possibilities of obtaining public or private financing to carry out necessary investments, governments should consider eliminating economic, technical and management inefficiencies in the provision of water supply services as well as creating policies and a regulatory and investment framework capable of attracting investment.

The elimination of some of these inefficiencies may reduce the need for investments or generate internal savings that reduce the need for external financing. In many developing countries the provision of water supply services is relatively inefficient and hence there is a high potential for improvement. This section discusses the main sources of inefficiencies in the context of their potential for reducing the need for capital and also taking into account the need to improve the enabling environment of the water sector. Inefficiencies stem from technical, management and sectoral sources.

A thorough review of microeconomic, technical, management and sectoral inefficiencies is a good starting point in any programme to improve investments in water supply services and a good way of using international donation resources which will multiply the potential to attract investments and other financial resources.

Economic inefficiencies

Improving the economic efficiency of water supply services requires charging a fair price for said services. To understand the question of efficient prices and subsidies for water supply services it is important to take into account certain characteristics of the provision of said services. It is, in fact, possible to obtain a higher level of welfare with a uniform price schedule and prices that diverge from the marginal cost by establishing appropriate price discrimination schemes that may benefit from cross-subsidies. This does not mean that all plans with cross-subsidies increase welfare, but some certainly do. From the point of view of sustainability some cross-subsidy schemes are not suitable whilst others are appropriate. Sometimes optimum and voluntarily sustainable price schedules are not compatible. In these cases, there often has to be a trade-off between what optimum is and what is sustainable. In short, cross-subsidies are good for increasing welfare but their misuse can lead to the separation of those consumers paying a higher price and, in turn, greater costs for all.

In most cases drinking water is supplied by utilities managed by a public or private entity, operating within a national or sub-national authority (such as a ministry). Water supply and sanitation services are generally bundled, although this is not always the case. When water supply and sanitation services are differentiated, sanitation is normally provided by a relatively autonomous local agency and financed by means of local taxes. If it is not feasible to enact local and national taxes to pay for sanitation, then water and sanitation should be bundled and supplied and billed together to guarantee that consumers actually pay for sanitation. This is necessary in order to avoid creating incentives that may lead to moral confusions if water and sanitation services are provided by different utility companies and payment of both services is collected by the water company. Taking the aforesaid into account, the following comments on pricing refer to bundled and unbundled service supply.

As is the case in all segments in which infrastructure services are a monopoly, **charges for water supply and sanitation services** is the central issue in water sector regulation. The reason for this is that whilst in competitive environments companies cannot establish prices that are higher than marginal costs without experiencing a plunge in their market share, in monopolistic situations firms can do this without any risk of suffering the same consequences. Moreover, given that elasticity of demand due to water depletion is low, an unregulated monopoly will set prices that are much higher than marginal costs. There are two different aspects that must be taken into account when water supply and sanitation service companies establish rates: average prices and the price structure.

There are two main schemes for computing costs in relation to water usage: fixed rates per unit of water consumed or rates per unit of water consumed. In services in which water consumption cannot be metered, flat rates are applied,

[8] In Europe drinking water is generally supplied by a typical utility company, whilst sanitation and water treatment is provided by the municipal authorities. In many Latin American municipalities, water and saniation services are provided by one single organisation.

which are more or less independent of the amount of water consumed. Water rates may be related to the expected level of use according to the number of persons in a household or to the size of the pipe connection. Although no economic justification can be found for this practice, it may be the only feasible way of obtaining revenue in systems that do not have water meters or that are characterised by their poor management. Charging different rates to different groups of consumers gives rise to the issue of cross-subsidies.

Some definitions

- *Marginal cost criterion.* According to this criterion, a price scheme is considered to have cross-subsidies if some of the consumer prices are lower than the marginal cost. Otherwise, if all of the consumer prices are equal to or higher than the marginal cost, the price scheme does not receive subsidies.
- *Average cost criterion.* According to this criterion, a price scheme is said to have cross subsidies if some consumer prices are below average cost and others are above. It must be noted that when some costs are shared among different products, the average cost schedule cannot be precisely defined.
- *Incremental cost criterion.* According to this criterion, a price scheme is said to have cross subsidies if revenues from a consumer or group of consumers are less than the incremental cost of providing services to that consumer or group of consumers.
- *Stand-alone criterion.* According to this criterion, a price scheme is said to have cross subsidies if revenues from a consumer or group of consumers are greater than the cost of providing the service to that consumer or group of consumers alone.

Technical, management and sector inefficiencies

Amongst the main **technical inefficiencies** is the non-productive consumption of water and energy, *i.e.,* leakages from old pipes, illegal connections and non-metered water, which can amount to 50% (although the general average could be close to 20%). Some losses are unavoidable, but many can be controlled. Investments to reduce non-productive water and encourage conservation, water reuse and water treatment can help to avoid or postpone much more costly capital investments.

One of the main costs in water supply is the consumption of electricity, used basically for pumping water. In Mexico and Brazil, for example, electricity consumption represents between 30% and 40% of utility company revenues. It is estimated that energy savings by improving efficiency could reduce energy consumption by between 10 and 40% thereby saving between 5% and 15% of revenues. Moreover, the problem created by losses and energy efficiency compound each other because the water that is lost has been pumped, which means that not only is water wasted but also electricity.

Similar inefficiencies are found in irrigation and also include loss of productivity due to failures in basin management, losses due to evaporation and losses through inadequate agricultural and irrigation practices (such as irrigating low-value crops or even growing high water intensive crops in which the marginal value of water is very high: the traditional “more crop per drop”.

Amongst the main **management inefficiencies** at service provider level, are corruption, billing and collection issues, inappropriate consumption incentives, bloated payrolls (some public utilities are used for political patronage) and deficient management systems. The World Bank estimates that extraordinary costs in civil works due to connivance between contractors amount to more than 15% and those resulting from bribes for contract awards amount to between 6% and 11%.

Furthermore, the World Bank found that 40% of customers in South Asia indicated that they had paid a bribe. In relation to inefficient billing and collection, it has been discovered that all the water actually used is not invoiced, not all bills are collected and not all of the revenues collected are used efficiently. In many cases, consumption incentives that are allowed are illogical: there is no metering, illegal connections are not billed and the tariff structures do not provide for the right incentives. Moreover, little effort is put into collecting bills.

Other management inefficiencies can be classed as **institutional shortcomings** as they are related to the capacity of the sector authorities to prepare projects that can be presented to obtain public or private financing. Most investments, particularly in new services, derive from projects that have to identify needs, appraise compensations, demonstrate that they make good use of resources and include schemes to carry out effective and efficient implementation. Many developing countries need to improve the capacity of their institutions in the areas of project preparation, execution, and management of the operating of the system, particularly at sub-national level, which is where most water service projects are developed. This is a fertile territory for bilateral and multilateral aid aimed at helping these countries to help themselves. Several donor entities have, in fact, developed special programmes to support project development and the strengthening of institutions.

The third major source of inefficiency could be termed **"sector" inefficiencies** and it is related to issues of sector governance, policies and management. Numerous institutions and levels of government are involved in water services and, in most developing countries the sector has traditionally been faced with the problem of a lack of resources. In some cases there are even issues of cross-border management. Another problem that can also exist is a lack of national and sub-national co-ordination in management responsibilities as well as the inability to integrate water resource policies, institutional fragmentation, unhealthy competition for the resource and a limited capacity in the management of policies and regulatory institutions between these two government levels. Fundamental ingredients of improvement programmes are the clear assignment of ownership, responsibilities and resources and the preparation and updating of Integrated Water Resource Management (IWRM) to improve assignment and management efficiency.

Regulation and investment climate

Given that many of the investments into water supply services fall within the responsibilities of sub-national governments, their institutional and fiscal capacity has a great impact on the water sector. Thanks to decentralization in most developing countries responsibilities are nearer to where the action actually takes place and this increases the potential to respond to local needs. Unfortunately, however, in decentralized countries local governments tend to change more frequently than national governments and the possibility of rivalries between the political parties governing the different jurisdictions is more likely. This can complicate relations and make investments more unstable. Furthermore, decentralisation of responsibilities and fiscal transfers make it more possible for general taxes to be used to transfer resources from richer areas of the country to poorer ones. In water supply services these national cross subsidies make some investments viable. Management of these relations can have a significant impact on investment, regardless of the failures in public and private responsibilities.

When assessing options to stimulate investment in water supply services, legislators often concentrate their efforts on specific investments. The previous discussion has attempted to show that microeconomic and sectoral situations are determining factors, but that these investments are carried out in a wider macroeconomic and institutional environment.

As part of the reform process, it is important that institutions, policies and investment structures offer the right incentives to all those participating. Public sector ownership and operation normally lacks performance incentives and, in many instances, there may be incentives that are totally contrary to all understanding, arising from budgetary processes that assign more money to sectors that spend more and not necessarily to those that spend in a better or more efficient way. Performance contracts may help to overcome the problem of lack of efficiency incentives. Provided that the marginal benefits are greater than the cost, the private sector will have an incentive to increase coverage. Without proper supervision, however, there is always the risk that private sector providers may not offer sufficient coverage or that the quality of their services they provide may be low. Since the provision of water services is a monopoly, prices, quality, availability, coverage and all other aspects must be adequately regulated and managed.

3. - Sources and agreements for augmenting financial resources allocated to the water infrastructure

Financial planning

The first step in the funding process is to identify which needs have to be met and locate the shortfalls in funding. Numerous models have been developed in recent times to assist government with these tasks. The most widely used of them is FEASIBLE, a software tool designed to help plan environmental funding strategies for water supply, wastewater treatment and municipal solid waste services. This tool can also be used to facilitate the iterative process of balancing the financial resources necessary with those already available and to identify budget deficits and surpluses as well as the structure of potential shortfalls. The results it provides enable lawmakers to locate the main bottlenecks and to identify which additional political measures need to be introduced to enable effective funding of infrastructure-development programmes and when and where to implement them.

Governments are frequently faced with objectives that they must lower in accordance with existing and potential resources. As an alternative, they have to resort to some of the measures described above as a means of making more funding available through greater efficiency or find other funding structures in order to encourage donor and financial organisations to provide resources. To make the necessary investment and achieve their objectives governments must explore all options. Although all resources must come from users (taxpayers), funding has to be found to cover the time periods before these resources become available. This funding is provided either by governments, directly by the private sector or through donations, with the first two recouping their investments through taxes.

Sources of funding: public and private

In a sector as politically hazardous as that of water supplies, the majority of funding has to come from the public sector at a national and/or regional level. The public sector can provide resources by injecting capital and offering immediate loans to water utilities or through intermediaries, such as development banks or infrastructure funds to name but two. These banks and funds may, at the same time, look for funding through government taxation or loans (marketable debt instruments etc), and through equity contributions in national and international financial markets, including multilateral development banks (the most probable source) and bilateral aid (we will look at ways in which international aid can be used more efficiently at a later stage). These indirect instruments can provide leverage for public sector financing and attract private funding by pooling risks (assets are invested in a series of projects) and/or by offering explicit or implicit governmental guarantees (depending on the structure of the instrument). These instruments comprise quantitative restrictions on the amount of funding that can be negotiated. Great care should therefore be taken to ensure that the decisions taken observe the market rules, as funding is obtained from the general public and from financial markets.

Nevertheless, so many needs have gone unfulfilled that the sector cannot ignore the potential of direct private investment. In other words, it must explore all possibilities. The most significant obstacle to exploiting private sector financing are the characteristics of the water industry itself, above all the low returns it offers due to the socio-political risks inherent in it. In order to attract private funding that would be exposed to the risks presented by the sector it is essential that higher returns are obtained (through efficiency measures or through government grants or donations, for example) and that risks are reduced (through risk reduction instruments and financial structures, which we shall look at later on).

Some would argue that public sector financing is the preferred option as it is cheaper than private funding. There are limitations, however, with regard to the availability of public funding, and there are also other ways in which public financing can be used (e.g., for other socially desirable goods and services), namely in areas where private funding cannot be accessed. Due to the need to keep the macro-economy stable, there are also limits on the granting of loans (in both local and international markets), the raising of money through taxation, and spending. Some of these limits are set by the International Monetary Fund's guidelines on current expenditure, in spite of the fact that some of these areas can easily be categorised as investments rather than current expenditure. As a result, funding should be capable of offering "value for money" and the use of private financing should be avoided except to bypass budgetary rules. The financial structures option should take into consideration the relative efficiency returns of private funding and operations as opposed to those provided by public funding (construction, management, operation and funding) as well as transactions and management costs, the organisations charged with managing and regulating the operation, the transfer of technology, the effective allocation of risks and political and social viability.

Provided that they are properly structured (see next section) some projects can make use of national and international capital markets. Given that the revenue sources for these projects would be in local currencies, the obtention of funding from national markets is a virtual necessity. Unfortunately, in the case of developing countries, these markets usually have limited resources and are often under-developed. The most common instruments are debenture loans, provided with or without guarantees (see following sections). Some countries have developed local institutional investors, in particular pension and insurance funds that invest in these projects, again, if the instruments are properly structured to adapt to their risk/return appetites (pooled projects to diversify risk, guarantees to reduce risk, carefully selected projects to enhance returns). In addition, recent times have seen the re-emergence in national and international private funding infrastructures of funds that can be used through suitable structures. This private sector financing must be limited to creditworthy projects and utilities (creditworthy in their own right or by credit expansion).

One of the funding sources indirectly referred to above is bilateral or multilateral foreign aid. As these resources are usually available at a low cost or no cost at all, it is very important that they are leveraged as much as possible, as far as restrictions allow, of course. The favouring of subsidies should also attract other types of financial resources.

All options are open

Due to the current aversion to risk and the results of certain speculative activities based on private participation there may be a sense that we cannot see the wood for the trees. We would do well, though, not to let the current situation deter us from considering private participation as an option. At the very least, and even if it does not contribute to funding, the private sector can offer us its technical and project management experience, which can encompass anything from providing consultancy services to managing certain areas such as maintenance, invoicing, collection of payments and control of the wasteful use of water. Another option offering a greater degree of involvement has recently been proposed, namely franchises, as a result of which private operators would allow their expertise, business management model and system, and their name to be used in exchange for an upfront fee and a percentage of the revenue. This mode would be most useful in small and medium-sized systems that do not have economies of scale for developing all the management systems required to ensure the effective operation of the project. This is a mode that has yet to take off, however.

The public sector has a number of other options open to it in terms of committing to non-traditional partnerships with its private counterpart and profiting from the desire of major water consumers (the drinks and mining industries, for example) to help develop the local community as part of the responsible commitment they make in return for using a large amount of the resource. As part of their involvement in the community these companies can provide access to the water supply systems they operate or transfer knowledge, for example. Some major water consumers, such as Antofagasta Minerals in Chile, have even taken over the water utility, thus allowing them to attend to their own needs and those of the community. At the beginning of 2008 Pepsi announced a partnership with the Earth Institute and the H_2O Africa Foundation with a view to improving access to water, sanitation and irrigation in Brazil, China, India and Africa. Thanks to the partnership, it has donated $8m and also passed on its management experience. And in mid-2007 the United Nations launched the CEO Water Mandate (as part of its Global Compact). Through the Mandate it seeks to encourage large companies to enhance and strengthen their commitment to the responsible management of water resources. By March 2008, a total of 21 firms had responded to its call for action by agreeing to adhere to the strategic principles (*e.g.,* Nestlé, Coca-Cola, Diageo, Unilever and Dow Chemical).

The financial structuring of projects

In view of the widely varying nature of water supply service projects, the relatively high political and social risk they involve and the shortage of funding, all available sources of financing should be explored. The availability of these sources for a specific investment depends on the way in which the services are to be supplied, the prevailing economic, social and political conditions in the country in question, the governance of the sector and the availability of instruments for reducing the inherent risk. We should take heed of the many projects that have come to grief in the recent past as a result of their failure to take the prevailing circumstances and the environment in which the sector operates into account during the project design phase.

Depending on service provision modalities the parties involved will face different risks and rewards and will have different incentives to achieve, which, in turn, will affect the efficiency of service provision and access to financial resources. Said modalities can range from supply by a governmental department or a public utility, to customer cooperatives and private sector agreements enshrining a number of different responsibilities. With the right incentives and regulations, these broadly varying responsibilities can be used to obtain the best of both worlds, i.e. the best that the public and private sectors have to offer in the current climate.

Local conditions are crucial to determining the type of investment structure and funding. However, some weaknesses can be addressed through the use of risk-reduction instruments. Given the fact that many of the local conditions impacting on water projects in developing countries are unfavourable, the most attractive option is to rely on public sector solutions only. Taking such a course of action could mean missing out on significant opportunities for attracting additional funding, however. There is no guarantee that it would work either as the provision of water supply services depends on the fiscal space of the government.

There are certain modalities that operate effectively even when local conditions are not favourable and with or without risk-reduction instruments. If due diligence finds, for example, that the legal framework is weak, the most suitable modes would be those that are not dependent upon it (such as entirely state-owned public utilities, cooperatives and outsourcing). If, in addition to a weak legal framework, political risk is also high, outsourcing is impossible. Yet if we encounter a risk-reduction instrument such as pre-payment for services supplied, outsourcing could still be a viable option. Alternatively if the fiscal space is weak, the only viable modalities would be those that opt for the private sector and do not require government funding. On the other hand, if both the fiscal space and the legal framework are weak, these modalities are not viable. In these circumstances there is no sense in pressing for a private or Ministry of Trade assignment as such action would be doomed to failure sooner or later given that these modalities require strong and sound legal and regulatory frameworks.

Increasing the availability of financial resources by reducing risk

Once the investment environment has improved, existing assets begin to operate better, needs and shortfalls in new investment have been evaluated, and a decision has been made on the most suitable financial structures for the investment, the final step in increasing investment in water supply services is to use the financial instruments available to reduce as many investment risks as possible with a view to increasing the profile between risk and returns. Some instruments will reduce inherent structural risks and others will reduce the risks inherent in the selected sources of funding. Some of these risks will even affect solely public sector projects, although projects attracting some private backing will face a broader range of risks due to the relationships between private and public parties.

Risks can be divided into three broad categories: construction risks, commercial and financial risks and political risks. Construction risks are incurred during the construction phase of the project and encompass completion risks (the possibility that the project is not completed on time and within budget) and associated risks such as accidents and fires. Commercial and financial risks are those risks relating to how the investment operates and include exposure to inflation, currency depreciation, and loss of revenue, interest and the tenor of financing (i.e., the risks that arise when a debt has been acquired at variable interest rates or for short periods of time, thus necessitating new funding). Political risks concern changes in the contractual conditions of the investment and in the legal and regulatory framework (including currency devaluation and exchange rates), sudden expropriation and acts of war and terrorism. Some of these risks affect all projects regardless of ownership, while others are directly linked to ownership and the financial structure. Some risks can be reduced through insurance against accidents, war and terrorism, currency rates etc, while others require bank guarantees and other contractual agreements with third parties. There are other risks, meanwhile, which cannot be reduced at any reasonable cost.

The possibility of reducing financial risks may have a significant impact on the viability of investment and attractive financial resources. The most common financial risks originate from the relative lack of development of local financial markets and the aversion to risk shown by international markets that usually supply a limited amount of resources with tenors below those necessary. But while repayment schedules for investments in water supply services are long and normally require long tenors, international markets usually provide shorter tenors than are desirable. One way of reducing this refinancing risk is to obtain bank guarantees from multilateral institutions, generally in the form of a guarantee by which an undertaking is made to repay the debt in the event that the borrower is unable to do so (normally a working guarantee is taken out to guarantee the first year and is extended to a second year and beyond if the borrower meets their obligations). This guarantee allows the borrower to broaden the tenor of the loan as this increases the possibility that they can repay the debt. This also applies to public corporations, although in this case it is possible that the government extends the guarantee (although the risk of defaulting then becomes a political risk and the borrowers may wish to secure an external guarantee). As regards rates, such guarantees may help reduce the total costs of loans, thereby increasing the viability of investments and the participation of the private sector.

Exposure to foreign currencies presents a critical risk. Fluctuations in exchange rates impact on the investment because the revenue generated by water projects is obtained in the local currency. This imbalance between the currency in which the debt is held and the currency in which the revenue is received creates exposure to foreign currencies and risk caused by fluctuating exchange rates (depreciation) or variations in a fixed exchange rate (devaluation). As a result of this, liabilities and the repayment of the debt become more costly and the economic equilibrium of the project is adversely affected. There are very few easy options for reducing this risk although the most obvious is to avoid it altogether by obtaining credit on local markets. However, financial markets in most developing countries are not designed to provide loans in the amounts and tenors necessary for water supply service projects. Some countries have fostered institutional investors such as pension funds, insurance companies and collective investment funds, which have long-term obligations and which may invest in these types of projects. Nevertheless, although they may acquire assets that can be realised in the long term, institutional investors need liquidity and a good creditworthiness rating in relation to these assets. One option is to engage in various projects and issue debt instruments collectively through a standard financial intermediary (i.e., “insure” or issue bonds supported by loans for these projects, which is the most widely used method) or through a dedicated institution (which may request an explicit or implicit guarantee from the government or another institution). Another option involves obtaining a sufficient number of guarantees in order to apply for credit on the market (see below).

Another way of reducing this risk is to obtain revenue in foreign currencies, which is what Aguas Argentinas did in Buenos Aires. Unfortunately, as most people are aware, this particular course of action proved to be unsuccessful. Devaluation struck with a vengeance and the required rate increase was politically and economically unsustainable. This option may work, however, when small and gradual currency depreciations are expected. Such action would be similar to indexing rates to inflation. If the commercial risk can be reduced in such a way, the risk would become political as the government or regulatory body would have to approve the increase in rates, although whenever elections come into view this system tends to fall apart. If the forecast is for exchange rates to fluctuate (mainly downwards), another means of reducing these risks would be to set up contingent lines of credit to cover temporary shortfalls in the expectation of recovering losses when the trend is reversed. Finally, the risk generated by foreign currency can also be reduced by setting rates above the required level, a course of action that would generate additional revenue that could be set aside and used when the rates are not high enough to provide the minimum necessary revenue. Although the final option would be very hard to apply, all options should be studied.

Multilateral institutions such as the World Bank and regional development banks offer credit risk guarantees that are usually known as partial risk guarantees as they only cover payment defaults caused by certain pre-determined events (rather than just any event). None the less, partial risk guarantees cover only part of the default within a wider range of circumstances. Comprehensive guarantees for loan applications cover the total amount of the loan, are normally used to enhance the creditworthiness of local and international debt instruments and are guaranteed, which is why they are known as monoline (specialised) insurers. With regard to the rate, these guarantees may reduce the cost of the debt and increase the availability of financial resources, thus enabling the project to tap into other financial markets and other market speculators such as institutional investors.

The exposure of investments to political and regulatory decisions represents another series of risks that can be described as political in nature in that they result from government policies. There is only limited scope for reducing these risks. Possible action includes taking steps to ensure that regulators are competent and independent. These political risks are harder to control and insurance companies and underwriters offer less in the way of cover for them, although some are starting to include cover for political risks among their products.

Some companies guarantee specific outcomes such as payment for completion (for which they usually obtain counter-guarantees from the government). As the exodus of private operators from the Latin American water sector reveals, political failure is the most common cause of unsuccessful investments and renegotiated contracts. These failures may lead to what is known as creeping expropriation, in other words, the loss in value of an investment resulting from a breach in compliance with the original agreements. In the case of private venture capital, this may result in the failure of the investment, although in the case of a publicly funded utility it may also lead to deterioration in the service and the need for increased public funding.

The problems created by currency conversion are also in the hands of government. If the project is funded externally (by increasing capital and/or debt), the local currency has to be converted into foreign currency in order to pay off debts on time (the issue here being not the exchange rate, as discussed above, but the availability of the foreign currency). Although some countries provide assurances and/or guarantees of availability, the risk remains. This type of convertibility insurance (a traditional form of insurance against political risk) is provided by international organisations such as the Multilateral Investment Guarantee Agency (MIGA) and national export credit agencies (covering investments made by their citizens). This type of insurance against political risk has been expanded recently to cover the failure to honour contracts or comply with arbitration rulings (in other words, when a government refuses to recognise the results of binding arbitration).

More complex guarantees and insurance policies have also been created to provide cover in the event that a government is unable to meet its contractual obligations (political risk), the majority of which are provided by multilateral financial institutions and insure against the failure to make completion payments and payments based on consumption, to pay grants, increase rates, make contributions, introduce changes set down in acts and regulations, pay taxes, cancel permits, etc.

Once the initial project structure comprising risk reduction mechanisms has been created, a study should be carried out to ensure that a certain risk is not replaced by another, such as the conversion of a commercial risk (income) into a political risk as a result of the acceptance of a government guarantee. If such a political risk does arise, however, consideration should be given to the fiscal and political capability of the government to meet the payment, its political will and the level of independence from political interference in fulfilling these obligations.

Finally, there is always the risk that some governments may wish to take control of water supply services. At a regional level in particular, governments tend to be more visible and change more frequently and there is also a lower level of institutional development. These risks are very difficult to avoid and if analysis shows that they are present in a certain situation, consideration should be given to structures involving the public sector, while sacrificing possible sources of funding and technological and management expertise. The long-term sustainability of services is also a factor of prime importance.

CONCLUSIONS AND AN OVERVIEW OF KEY OBSERVATIONS

Transactions as an integrated water management instrument and the financing of water services in emerging countries

1 AN INTRODUCTION TO THE SESSIONS

Held as part of the Expo, the Theme Week on the Economy and Finance of Water took place between 28 July and 1 August and focused on two key areas: Water Markets and the Funding of Water in Emerging Countries.

Organised by the Water Tribune in conjunction with the Spanish Ministry of the Environment, Rural and Marine Affairs' Biodiversity Foundation, the theme week looked at how water transactions have become a reality in countries such as Australia, USA and India, and how they will represent vital tools in the future management of water. In southeast Spain, for example, they have played an essential role in guaranteeing supplies during the latest drought.

The Week was officially opened by the mayors of the cities of Zaragoza and Huesca, the director of the Water Tribune and Ana Leyva, the new head of the Biodiversity Foundation. More than 250 experts from 24 countries and 60 speakers and panellists from Australia, Chile, USA, India, Israel, Jordan, Canada and Spain attended the Week. They discussed how water transactions have been and can continue to be used as a public management tool for ensuring the efficient allocation and usage of water, for managing droughts and for resolving disputes.

A dozen experts from the World Bank and a variety of countries (Mexico, Ecuador, Peru and Israel) analysed a number of aspects relating to the funding of investments in emerging nations. In doing so they highlighted the importance of the political and economic climate in these countries in ensuring that investments are viable and that water supply systems operate correctly. Experts were agreed that financial resources should be provided by both users and taxpayers and public donors and private investors. A number of different cases were put forward to show how these principles have been applied successfully. As part of the Week the World Bank held a video conference on Hybrid Structures for Funding Water Infrastructures, which looked at the hybrid public/private financing systems that have emerged in recent years in response to the crises that have afflicted countries such as Argentina and Russia and which seek to spread risks and responsibilities between both sectors when it comes to funding major infrastructures. Participants from Senegal, Morocco, Jordan and Turkey made their contributions via video link and debated ways in which the funding of the sector could be improved and the central role played by public funding and management.

A series of parallel activities were also held during the course of the Week, including an event looking at innovative funding alternatives as a means of attaining the Millennium Goals of access to safe drinking water and sanitation, which was organised by the Basque Water Agency and the Zaragoza office of the *United Nations Water for Life Decade.* Two debates on the value and costs of water were also held. Organised by Agora and open to visitors to the EXPO, these latter forums revealed the high level of public interest in the subject of water.

The Theme Week also underlined the extent to which climate change is affecting rainfall and temperatures and the speed at which the areas of greatest concern to experts are being degraded. This is a process that will have a bigger impact on countries already experiencing difficulties in terms of meeting demand, such as Spain, and will pose a major challenge with regard to water management. Problems are being exacerbated by the increase in demand caused by population growth and economic development, and the contamination of drinking water, leading to a growing number of disputes and heightened competition for drinking water all across the globe. There is a need, therefore, to restrict demand and to use water correctly. New supply alternatives must be looked at along with management techniques that go beyond traditional supply-oriented options. One such efficient management option involves water transactions based upon voluntary agreements in which water can be assigned to other users or the water administration in exchange for payment.

Ellen Hanak (Public Policy Institute of California) and Michael Hanneman (Berkeley University) spoke about the situation in California and presented transactions as an alternative forming part of a wider menu of options that should be assessed in accordance with their costs, guarantees, the environmental impact and the social context. Climate change and the impact it is having mean that those responsible for managing water can no longer postpone or avoid changing the way in which resources are managed, the ultimate goal being to maintain the quality of the environment and ecosystems and ensure the correct management of droughts (which are largely preventable).

Leading experts from Australia, Chile and the United States, such as Richard Howitt (University California, Davis), Guillermo Donoso (Universidad Pontificia de Chile), Carl Bauer (University of Arizona) and Mike Young (Adelaide University, Australia) analysed and assessed the experience acquired in their respective countries, where water transactions have become a reality in the last ten years in a variety of different ways. Specialists from these countries are agreed that transactions have been beneficial, as revealed by the increase in the physical and economic efficiency in the use of the resource, reallocation of the use of water in accordance with quality requirements, a reduction in tension and conflict and, in some cases, by improved integrated development. However, it was concluded that economic efficiency in the allocation of water cannot be the sole objective of water policy. Other aspects such as the preservation of rural activities and the environmental services they provide also need to be considered in addition to safeguarding employment, incomes and equilibrium between the regions. The issues of equality and how these transactions have impacted on users with fewer resources were felt to be among the most important aspects of this analysis phase.

International experts of the stature of Alon Tal (The Arava Institute for Environmental Studies, Israel), Henning Bjornlund (University of South Australia and University of Lethbridge, Alberta, Canada) and Mordechai Shechter (Haifa University, Israel) underlined the fact that the model used in Israel is essentially based on cooperative agreements. In the case of Australia government intervention is essential in guaranteeing the sustainable supply of water and preventing the possible monopolising of water in transactions, which can lead to sellers imposing excessive prices.

It is extremely important, therefore, that the water administration is able to manage this new instrument and set down clear guidelines regulating and coordinating operations, including the creation of formal regulations for the execution and supervision of transactions. This would ensure transparency and avoid, for example, the transaction of water that is not being used, the use of water by those transferring it and excessive prices. It is also vital that registers be created to record the names of the holders of licences and water-use rights and details of the trading agreements themselves. This information must be transparent and easily accessible for an affordable fee, a process that should be fully supported by the law. As a result, and aside from enshrining the possibility of effecting water transactions in law, public organisations should also employ specialised personnel to ensure that no undesirable situations arise.

David Katz of the University of Tel Aviv and Robert Rose of the United States Environmental Protection Agency stated that there is a need to prevent transactions that may have a negative impact on the environment and to consider the possibility that they can also act as an instrument for safeguarding the quality of water ecosystems. To ensure this, it is essential that the water administration establishes rules governing environmental flows and quality objectives and ensures compliance with them, as well as setting up trading agreements/contracts that take into account the issue of how to deal with these environmental impacts. Under no circumstances should transactions be equated with less public management of water. In fact, the opposite is true.

The Australian experts argued in favour of the development of far more original transaction modes such as option contracts, futures markets and conditional contracts as mechanisms for improving the allocation and distribution of risk in view of the variability of the distribution of water. Through the mode of option contracts supply companies and industrial facilities requiring a guaranteed supply agree to allow other users to use their water assignments in the event of a drought. In exchange for this, potential assignors would receive an annual payment (a guarantee) for water that they would only agree not to use during a drought. The experts also highlighted the significant role played by water brokers in Australia, who, although regulated, are independent of the water administration and who enable potential interested parties to carry out transactions and thus ensure that there are sufficient suppliers and users with access to transparent information accessible by everyone via electronic means.

One of the days was devoted to water transactions in Spain, with recent experiences in this field (revolving around the Trading Centres and Assignment Agreements) being presented and debated. Speakers discussed the suitability of these centres as mechanisms for resolving problems caused by droughts and improving the quality of the environment. The Spanish experts present were agreed that transactions have provided a useful response to critical situations during the latest drought period although the flow of water involved was small in comparison with the total amount used in Spain. Transactions should be assessed in line with their importance in guaranteeing the supply of water in coastal urban areas and for agricultural activities requiring a guaranteed supply such as the cultivation of tree and vine crops (fruit trees, olives, vineyards). The speakers in the various sessions agreed that the current climate of change in the allocation of resources, which has been caused by increased pressure in certain areas and an increase in the likelihood of droughts occurring as a result of climate change, requires the introduction of these types of instruments and new policies and management approaches.

2. A SUMMARY OF THE DEBATES

In the opening session the problem posed by shortages and conflicts over water came under analysis. Contributors engaged in a debate on the origin and management of disputes centring on water in cross-border river basins and discussed, in particular, conflict over the rivers shared by Mexico and the United States (the Colorado River and the Rio Grande) and by Spain and Portugal (the Duero, Tagus and Guadiana). The conclusion with regard to the first of these two cases was that conflict is based on the fact that each state has differing concepts of property rights, which has given rise to markedly different management models. As regards Spain, differences are caused to a certain extent by the varying interests of the autonomous regions involved. It is true to say, however, that whenever water resources are limited and property rights have to be reallocated there are always going to be winners and losers. The main problem is correctly identifying to whom the rights belong. The speakers were of the opinion that a satisfactory solution to water conflicts should be based on the offering of incentives for cooperation in order to create situations in which everyone can win. It was also stressed that in the majority of cases insufficient consideration is given to external environment and economic factors. As a result, it is essential that adaptive solutions are reached as part of river-basin management models in order to tackle the challenges posed by water availability, which is being directly conditioned by climate change and rising demand. However, solutions must be reviewed on a regular basis to enable suitable and timely reactions to climate change and newly evolving hydrological and anthropological scenarios. These adaptive responses, combined with an ongoing evaluation of the impact of their actions, ought to provide solutions and agreements that best respond to immediate priorities but which provide for a long-term management model at the same time.

The objective of the second session was to analyse the challenges faced by institutions in promoting cooperation and conflict resolution and prevention. Debate centred on institutional change and the role of those affected by the management of this change. It was argued that the new management model should define the respective interests of the parties concerned and take them into consideration. Ethical values are a vital aspect in the efficient management of water, as the relationship between society and water is fundamental to the resolution of conflicts triggered by growing shortages. The management of water thus requires good governance and to ensure this it is necessary to combine the exercising of power (as a decision-making process implemented in water management at the highest levels) and a moral authority that derives from the people engaged in the task of resolving and tackling problems on the ground. The governance required for the more effective and improved management of water can only be achieved as a result of public participation.

The third session featured a debate on the water management model in California, with speakers voicing criticism of the way in which management has evolved there. In their opinion the amount of water transferred from the north to the south over the last few decades has greatly exceeded real needs, thus creating the impression that the area possesses an abundance of water, an impression reinforced by the number of green spaces (both private and public) in what is a very dry part of the world. The federal government supplies heavily subsidised water to the south and the price users pay for it does not reflect its real cost, thus increasing demand. The point was made that this is a complex form of management as most of the demand is accounted for by cities and powerful agricultural corporations who do not take kindly to being asked about the use they make of water. The current scenario with regard to the use of water in California is not based on the positive management of resources. The portfolio of proposals putting forward unconventional resources and options based on the management of demand with a view to making use of the marginal opportunities presented by water are unrealistic, however, as they do not take into account the new availability scenarios brought about by the effects of climate change in California.

The fourth session, which looked at theory and practice in institutional reform designed to bring water markets into line with integrated management, involved an analysis of the water markets in Australia and Chile. Contributors discussed whether new Australian legislation would reach its objective of allowing the integrated management of water resources. Viewpoints differ on the merits of the fragmented management model that exists in

Australia in terms of improving the integrated management of resources. Speakers said it was necessary for legal reforms be carried out so that the Australian government can devise a global plan encompassing all its river basins. This would allow it to effect cross-state coordination, with information being shared on the resources available and the actions that are carried out. A debate is currently raging on the implementation of the integrated management of water resources in Australia, and it is being argued that law reform does not take into consideration the objectives of the IWRM. In spite of this Australia is making efforts to integrate the management of water resources in such a way that non-economical uses are being interlinked with other uses in which water acts as an economic asset. New Australian legislation thus enables the allocation of water for environmental purposes through the markets by allowing environmental uses to participate as just another form of consumption, supervised at all times by the state. In practice this represents only a minimal environmental flow in river flow levels. Some participants did not see such a practice as feasible in either economic or environmental terms, as these are objectives that are diametrically opposed. Others argued, however, that this is the best way of reducing opposition from other users when it comes to securing water flows for the environment. In the case of Chile it was argued that the market system in place there is perfectly compatible with the environment, as the environment is just another user upon whom the government applies minimum flows so that only excess water is made available on the market. In the eyes of some participants, however, the facts reveal that this model does not work in practice, as environmental requirements are not respected in Chile.

In session five *the institutional framework for the quality water market* came under discussion, with debate focusing on the problem of water contamination and the dilution of high concentrations of pollutants as a solution to it. In this respect the markets could provide an alternative in making it possible to buy water in order to dilute the pollutants. Another issue that was also discussed was how to deal with the worst polluters, as this mechanism seems to have given them carte blanche to contaminate as much as they want. In the view of the speakers there are always winners and losers in this model and up to now many culprits have got away without being punished. Speakers said that this is a situation that must change, as there are instruments that can now be used to spread responsibility for polluting the environment more equally. The most practical option would be for the state to pay farmers and growers to reduce the pollution they are responsible for and to penalise those who do not. Experience has shown that the model does not work, however. In Australia, for example, penalties are not being handed out to polluters who fail to cut emissions, as the system is voluntary in nature. In addition, farmers and growers mistrust government regulations. The key question that arose in the debate was how to establish a balance between the obligations of the parties concerned *(i.e.,* between those who pollute and those who demand clean water). A model based on tax breaks for pollution controls could be a viable alternative.

Trading in emission rights on the markets would enable the implementation of institutional reforms. In discussing this point speakers argued whether it was necessary to introduce specific laws to activate these markets, with some contributors stating that the market needs a clear framework but cannot be regulated in a bid to make it flexible and dynamic. Another issue that was discussed was the fixing of a set price in agreements and whether this price should be equal to the cost of cutting pollution levels. In the opinion of the speaker the price should be set by the market although some participants said that a series of brokerage systems should ideally be in place.

In the sixth session, *entitled economically efficient water allocation models and the limitations of market instruments,* discussion turned once more to Chile as it provides a clear example of the orthodox application of economic theory in the field of water policy. The speaker pointed out that there were two fundamental decisions to be made with regard to the development of water management in Chile: private ownership of the resource and the privatisation of water resources. For many years the Chilean experience has been seen as a glowing example of the benefits of the free market and a reference point in the efficient management of water. However, a number of questions were raised: Has the management of water in Chile actually achieved economic efficiency? Has poverty been reduced? And has the environmental quality of the country's rivers improved? Above all, however, the fundamental question is whether Chile now finds itself in a better position as a result of this privatisation process, although it is not clear if a comparison should be drawn with the current situation.

Session seven on the myth of the markets triggered a debate on the true size of water markets and whether they could be considered as genuine markets. Discussion centred on the question of which criteria should be applied when assessing these markets: economic rationality, social rationality or political rationality, as in practice the three are not compatible. Some speakers questioned the markets, basing their arguments on the temporary nature of economic laws and the valuation of goods. It was also argued that existing markets do not allow free access. A secondary issue that also came under discussion was whether water could be considered a public asset or not. It should be pointed out, however, that it is more appropriate to talk of a water trade rather than water markets, as it is a commodity traded between individual parties. Markets are more feasible on a small scale as the problem of reallocation arises in larger markets. The issue of regulated or deregulated markets was only touched on, as it is essential that the specific characteristics of each case are weighed up. What is clear, however, is that the state, in its various guises, should form part of this system. Some contributors suggested it should occupy a central position as this could be vital in setting out and overseeing operating regulations (*e.g.,* by means of an auction mechanism that sets prices and allocates water to the party placing the highest evaluation on it) and in the resolution of conflicts.

The eighth session, which analysed *the Australian and Californian experiences in the setting up of markets*, proved to be very productive. The speakers assessed the impact that these markets have on the environment and on third parties. The risk of monopolies being created, which was clearly felt in the case of the water bank of California, was looked at. There is less likelihood of this happening in Australia as state law allows the government to intervene to prevent their formation. Participants also discussed the social effects of markets, particularly the role they play in the decline of agricultural activities. In the case of Australia the markets have played a positive role as they have restricted losses and removed from the sector farmers and growers who would have ceased to operate in any case. To prevent these processes from occurring in California, a state-run compensation fund was created to help those communities affected. Australia was shown to have exerted more control over the environmental impact, as most of the regulations that have been introduced have the protection of the environment as their aim.

A further subject of debate was how best to distribute costs incurred by the infrastructures required for a market to operate. The speakers felt that market-operating rules should be regulated by the government and that the cost of using these infrastructures should be paid for by a tax levied on users. In addition, the price to be paid for water should cover the losses incurred in transporting resources. Some thought was given to the advantages of water banks as opposed to trading operations between individual parties and it was concluded that although the former are less flexible, they do have the advantage of generating a higher degree of confidence among participants. The natural extension of water banks would be futures markets, which would also allow risks to be allocated. The participation of brokers in the market was also debated. Brokers have a positive part to play as they can make the market more fluid. Generally speaking, all the contributors agreed on the need to distinguish between water and land rights as this makes it easier to share water costs between parties.

Session nine analysed the role of formal markets as opposed to informal markets, with the speakers assessing the part that informal markets in India have actually played and the need to set up more closely regulated formal markets there. These types of instruments would be an essential tool for enhancing the huge social capital the country possesses. As for the role of the markets in helping to bring the Arab-Israeli conflict to an end, it was made clear that the resolution of the water problem should not hinge on who owns water. The allocation of water should not, therefore, impinge on the peace process. It was stated that the Palestinians are willing to pay for water but that they should also have access to ownership rights. In conclusion, the role of the markets should never be overestimated and the issue should be looked upon as a problem concerning the management of underground water in a context of conflict.

The debates that made up the tenth session covered issues connected to the challenge of managing drought and water shortages in Spain and complying with the Framework Directive. The problem of the need to reallocate available resources in a context of growing shortages such as those suffered by Spanish river basins was looked at, with speakers stating that current river-basin plans have taken this new water scenario into account. A significant part of the debate was given over to the environmental uses of water, which is a factor in a process of reallocating resources that respects the environmental flows set down in law, although in the opinion of some participants some assignments are granted illegally on just such pretexts. The use of water for farming is invariably questioned in these discussions as agriculture requires more water than any other sector and is a major source of disputes over the resource. Speakers said it was fundamental that the real cost of water and the subsidies paid out should be made very clear in assessing these uses, and that demand should always correspond to the sustainable use of the resource. It was pointed out that use and demand do not always go hand in hand and that consumption increasingly responds to availability, with a significant reduction in consumption having been observed. This factor should be taken into account in future planning.

The eleventh session looked at *the institutional framework and the challenge posed by risk management*. Debate centred on option contracts as an alternative to the compulsory reallocation of resources. The first few speakers pointed to the strategic interest of allocating risks and the advantages this allows in providing greater flexibility and transparency, although the existing Spanish legal framework is very clear with regard to the priority criteria applying to usage and the compulsory authorisation of modifications in usage priority in emergency situations. The issue of whether option contracts could be accommodated in the Spanish legal framework was also discussed and whether they could be considered as a solution to the problems caused by serious drought, as was the case in the supply of water to Barcelona in spring 2008. This subject has aroused a certain amount of controversy, with the speaker arguing that these types of agreements could be deemed illegal in certain contexts. Discussion also focused on the legal consequences of certain types of transfers carried out in Spanish river basins and the role played by intra-basin transfers through assignment agreements. A lack of transparency has been detected in some assignments as well as speculative activity. State regulation is therefore seen as an absolutely vital part of the process.

The twelfth session assessed the water markets in Spain and aroused a heated debate among those present. The main topic was the price paid for transferred water, with some speakers and contributors arguing that this is an area that should be subject to government intervention, as there is very clear evidence of speculative activity taking place. It was concluded that the relatively small size of the Spanish water market has prevented the setting of prices in line with supply and demand. What has occurred instead is that consumers have gone in search of suppliers, with the result that prices have been pushed very high, sometimes above the shortfall in revenue. Some speakers argued that the market should be left to evolve by itself and that only the market can determine prices. The destination of the money raised from transferred water also came under discussion, as did the issue of whether this money had a genuine impact on the region ceding the water. Other topics of debate included the use of infrastructures for transferring water and who pays for them. On a final note, the need to set up systems for monitoring transfers was stressed. These systems must ensure that transfer processes are transparent and that only the amount of water that is actually required should be transferred.

3 CONCLUSIONS AND KEY MESSAGES

3.1 Contribution to the Zaragoza Water Charter

Those gathered at Zaragoza would like to stress the importance of Principle 4 of the Dublin Charter: Water has an economic value in each of its competitive uses and should be recognised as an economic asset. It should be managed in accordance with criteria of economic rationality with a view to guaranteeing that the cost of water services is recovered.

The basic right of all human beings to have sustainable access to safe drinking water and sanitation at a price at which basic consumption is affordable must be recognised. However, the failure to properly consider the economic value of water has led to the resource being wasted and practices that are harmful to the environment. Managing water as an economic asset can make a significant contribution to improving the public management of the resource, helps ensure its sustainable use in situations where supply is scarce, safeguards the efficient and fair use of water and also promotes conservation and protects water ecosystems.

Given the backdrop of climate change and related trends, it is essential to promote a system for managing the resource and water services, and that this system encompasses all the costs generated by water services while also seeking additional social, economic, environmental and regional objectives.

To achieve this, integrated policies enabling the reallocation of water and the subsequent goal of economic efficiency and environmental quality must be put in place. Water transactions should be considered as a public water management measure as they could well represent the most effective and efficient alternative in situations where the supply of water becomes scarce and variable.

Public intervention in transactions is also an essential means of protecting the public interest, ensuring access to information and transparency with regard to the value and productivity of water in its various uses, and for ensuring that they contribute towards protecting the environment and preventing a negative impact on society and the region in question. Public intervention should be proactive and foster suitable legislation and structuring with regard to water rights, thus enabling the various attributes of water rights (quality, season, etc) to be transferred, as well as allowing interannual transactions, the creation of an effective register, sufficient capacity and the training of resource managers. It should also ensure that transactions are directly promoted, while implementing effective regulations to prevent certain parties from establishing positions of dominance and generating ineffective charges and other social and environmental effects.

Investment in water infrastructures in developing countries is a key point to tackling poverty and boosting economic growth. It is evident that the Millennium Goals cannot be achieved with the current low levels of investment, which makes it essential that governments and international agencies give maximum priority to these types of investment and objectives. Part of the reason for insufficient investment is the lack of strategic planning (including financial planning) and the inability of traditional financial instruments to attract the necessary funding. The creation of new funding structures and financial risk management mechanisms in emerging countries can help significantly in this respect.

It is also vital that water service managers become more technically efficient with regard to leakages in the network and energy efficiency, etc and manage water services more effectively. Incentives based on management results and the use of budgetary funding can help attract private capital. Water prices should reflect the actual cost of the resource, although public subsidies (with very clear and transparent objectives) may often be required to guarantee access to water and particularly sanitation services among the poorest sectors of the population.

3.1 Conclusions of the sessions

a) The challenges of the new context: climate change, increasing demands and necessary changes in water policies and institutions

Climate change is changing precipitation and river basin runoff reducing availability and adding further pressure on water supply in some cases and increasing precipitation and floods in others. Inadequate water policy exacerbates this situation and undefined water rights are a source of conflict and a barrier to sound water management.

Increasing scarcity and droughts due to climate change impacts over river basins are forcing new orientations in water policy. Under new climate scenarios the importance of planning for water scarcity and drought will increase. As a response to scarcity and uncertainty, prospective analysis and reliable climate data are needed to incorporate scenarios in strategic planning. Water modeling is an important source of information for supporting policy making and long-term planning in order to improve resilience to drought and scarcity management.

Increasing water demands are also origin of conflicts. Conflict management and resolution over transboundary river basins, such as the rivers shared by Mexico and the United States (Colorado River and Rio Grande River), and Spain and Portugal (Duero River, Tagus River and Guadiana River) must take into account local conditions. A broader perspective and river basin planning gives insights otherwise ignored.

b) Responding to the new challenges by increasing efficiency in water allocation through water trading – the legal and institutional context

Water institutions must balance economic development and environmental conservation looking for improvement on social welfare. The search of non-conventional water supply sources and demand-side efficiency are options for dealing with the new context. The decisions on river basin management need to be adaptive in order to confront the changes that are appearing regarding the availability of water. Water reallocation though trading needs to be seen as one of the options that help confronting the limited water supplies and growing demands. However such options must be evaluated in relation to costs, reliability, environmental impacts and social contexts.

The use of water in some semi arid regions of the world as in California is high. Nevertheless, over many decades, the US federal government has financed -through water- economic activities on the American West including California, e.g. through the diversions of the Colorado River to Southern California in order to support agricultural activities. At the state level there have been diversions of water from the rainy Northern side of California towards the drier Southern part of the state.

There are a couple factors that determine the high consumption of water in California. The first one is the societal perception of water abundance, which is reflected by the presence of extensive green areas –private and county administrated ones- in a dry climate. The second is that the price of water does not reflect its costs.

In California water is an unregulated resource from an economic perspective, besides its subsidies. The use of bulk water in agricultural activities has few -if any- regulations. From this perspective, the implementation of water trading is not –seemingly- the only solution to fix the system. The existence of a "portafolio" of proposals, that considers non-conventional supply and demand management options in order to get "marginal" water opportunities, is a valid alternative for managing an increased future scarcity of the resource.

Overall river basin conditions are different and there is not a single solution, but adaptive responses that need to be updated frequently in order to react on time to changing climate, hydrologic and anthropogenic circumstances. Adaptive management -with its permanent evaluation of the impacts of its actions- can deliver solutions and agreements that better respond to the main immediate priorities of water management.

Water trading needs to be seen as a tool of public water management more than as an objective by itself. When water reallocation needs to be done, there are always winners and losers. The main problem is who owns the water rights. A satisfactory solution to water conflicts should be to find the right incentives in order to reach mechanisms that incentive a cooperative use of water by sharing of the rights in a way that win-win situations are possible.

The legal framework for water trading varies in the different countries and goes from unbundled water rights systems to those building on existing water rights entitlements or allocations. They may be simple or sophisticated depending on the particular institutional context and the scale at which they operate. Water scarcity and uncertainty conditions require quick responses; flexible and dynamic rules are necessary. Water sharing, capacity sharing and risk sharing mechanisms may help to overcome these challenges.

c) Evaluation of experience and improving implementation of water trading

Water trading exists and has been developed in different ways according to the specific institutional context. Water trading cannot be seen as an end in itself but as a means contributing to well-defined public policy objectives. In many cases it represents only a marginal share of the volumes/water management, but still plays a role.

There are many examples of water reallocation through voluntary agreements with financial compensation in India, Australia, US, Chile, Canada, Spain and South Africa. There is no consensus however about whether these voluntary agreements comply with the market requirements of transparency, perfect concurrence and therefore can be named water markets.

Informal water trading is a reality in some countries; experience demonstrates the need of regulating its functioning. The regulation must be well defined ensuring other laws (e.g. environment legislation) are complied with the functioning of the market and defining the role of water brokers.

In formal water trading the degree of regulation varies from government intervention through water banks to regulating water brokers' participation. When there is low government intervention settlement procedures are needed in order to guarantee sufficient liquidity, transparency, and an effective and dependable and robust payment mechanism. When there is a weak institutional framework and difficult social conditions efficiency water trading is to be questioned.

Experience shows that water trading can help improve efficiency in water allocation. There are some elements of positive economic impacts illustrated in different countries (e.g. also for farming communities in California and Australia).

The experience also shows that trading mechanisms, if adequately designed, can also be considered to contribute providing water for the environment and to improve social welfare. In order to preserve environmental flows a proper regulatory system throughout government legislating is crucial. There is a debate about whether environmental flows should be set and respected when allocating water or the environment is one more use.

Although there are different mechanisms to account for the environment in water trading, positive environmental impact of trading need to be further demonstrated. There is debate on the environmental effects of implementation of trading in countries such as Australia. There are some positive outcomes such as full cost pricing initiatives and tax payments allocated to environmental purposes, but still farmers ask for water traded really allocated to environmental settings instead of golf courses and amusement parks. Australia is trying to inter-relate non economic uses of water and the use of the resource in productive uses.

There is conflicting evidence in relation to social impacts and potential compensation –such arrangements may be difficult to put in place (compensation for trading or drought) but possibly « buy time » for necessary structural changes (e.g. due to climate change). In fact, implementation experience in cases such as in Chile show that trading, if insufficiently regulated, can generate increased economic efficiency for productive uses, but doubtable reduction of poverty and environmental impacts.

There are also some new debates arising in relation to moving from pollution regulation and “command and control” policies to water quality trading or a combination of both. In any case in order to achieve environmental objectives it is needed to have an aggressive introduction of pollutions caps, as well as a functioning pollution monitoring and enforcement.

When we speak about water quality trading, the first thing that needs to be in place is what to measure, how to measure it and how to allocate –through pollution trading- the share of responsibilities and costs. In order to determine the actual pollution, the pollutant concentration or pollution loads can be used. What is at stake is how viable and credible the pollution control system is, its performance and costs.

Water quality trade requires knowing in depth the river basin characteristics, pollution levels and for polluters the knowledge of their costs of pollution reductions. Trading is easier for pollution from point sources and at local scale, while challenges exist for pollution from diffuse sources and at the river basin scale. Another difficulty for water quality trading is the social acceptance. When trading with water quality, it is quite important to achieve agreements on how to share pollution responsibilities. Allocation of costs may be assumed by polluters or thought taxation as society benefit on the whole. Hot spots are particularly difficult to deal with and water quality trading may not be a solution for them.

d) Evaluating and making recommendations for improving water trading in Spain

When evaluating the experience of water exchanges in Spain, some recommendations arise for future steps forward not only regarding water market implementation, but also water resources allocation. Climate Change or more appropriately Global Change have to be incorporated in the planning based on transparent information on water costs/benefits/productivity of water.

Water transactions that are possible under the existing legislation in Spain cannot be considered water market operations. The experiences of trading in Spain so far have been very few but significant. To implement properly this economic instrument as part of Integrated Water Management, market regulation may need to be amended, the regulatory framework must be clarified and better defined and a simpler standard and transparent process must be put in place. Among the two existing trading systems in some regions in Spain –exchange contracts and the water exchange centres– the latter has more support and presents greater potential; however it is not clear whether this two systems should merge.

So far, water trading has enabled water transfers from mainland areas to the Southeast (Almería and the Segura Basin). These involve inter-basin transfers using inter-basin aqueducts, which were built to transfer resources. Some regional governments are concerned about these transfers and in the future the pressures may augment to transfer more water. This poses challenges that go beyond the market regulatory framework and that should be addressed.

Trading needs to be seen as a means not an end by itself, an instrument to provide incentives for more rational economic water use –greatly needed in Spain- and as tool contributing to the achievement of environmental objectives. The Water Framework Directive does not allow for further ecological deterioration of water bodies, even under drought conditions; in this regard, the path initiated with the changes in the Law in 1999 must be carried on. Option contracts appear as a viable alternative to manage drought risks in accordance with the Spanish legal framework.

Some questions are open such as whether other reallocation mechanisms envisioned by the law should be reinforced; whether maximum prices need to be set; whether land purchases (and associated water rights/concessions) can be allowed if water is traded to be used at a different location and different purpose; whether legal differences need to be made between water trading between users within a River Basin or across basins; and whether the priority criteria of water uses in the existing law and river basin plans need to be amended.

3.3 Key Messages on Water trading and Financing in emerging countries

a) The challenges of the new context: climate change, increasing demands and necessary changes in water policies and institutions

Key messages on water scarcity and drought, futures scenarios and policy reforms

- Climate change may cause future increases in per capita water use which effects will depend on the magnitude of changes in supply and demand.

- Climate change may increase future water conflicts. To tackle water disputes, international funding and policy efforts are required to strengthen conflict resolution mechanisms.

- Tackling the inter-related issues on water scarcity, drought and climate change adaptation will require a combination of local action, national direction and regional and global coordination through international frameworks and programs.

- Alternative risk management strategies are critical for reducing the risks from water stress, drought and climate change. Uncertainty scenarios and risk must be included into water planning.

- Risk management strategies benefit from new water allocation instruments such as water trading to account for uncertainty in planning and management.

b) Responding to the new challenges by increasing efficiency in water allocation through water trading – the legal and institutional context

Improving efficiency in water allocation through water trading

• The reallocation of water rights through voluntary agreements –usually with some form of compensation- may help improve water policies and respond to the new challenges.

• Water trading may provide the missing incentives to encourage both for more responsible water use and for implementing water conservation and delaying or avoiding costly civil water works.

• Allocative efficiency on its own is not the only objective of water policy. Public policy is not only constrained by a complex of institutional arrangements but must also take into consideration objectives such as spatial balance, preservation of rural activities and the environmental services provided by them, and employment and rural income guarantee. This way water markets become an important support tool to make water efficiency compatible with the other water policies. When water trading is introduced there may a need to design complementary measures to achieve these public objectives.

• The re-allocation of water rights through water trading can help manage scarcity in general and especially during drought episodes. With this purpose many contingency arrangements can be implemented to smooth the negative consequences of temporal water scarcity.

• Water trading can help manage risk. Changing climate requires continued innovation in water trading to help cope with greater uncertainty.

• By improving potential buyers' welfare without worsening water rights sellers, the voluntary agreements allowed by water trading make room to mutually beneficial improvements.

Selecting water market options

• The options selected should consider priorities of allocation criteria and the water demand of different users and their location, as well as the existence of adequate conveyance facilities.

• When the objectives pursued are linked with structural changes (preventing aquifers over-exploitation, environmental flows recovery, local sector restructuring, local new activities) trading permanents water rights -including land acquisition- are more appropriate.

• If the purpose is to reduce risk through water supply stabilization, this may be better achieved through annual spot markets or seasonal or inter-annual option markets.

• Effective and reliable Water Banks improve water allocation and provide more efficient tactical responses to cope with supply uncertainty. Water Banks set up a framework that may include environmental, legal and third-party considerations through the drafting and enforcement of binding contracts among various entities.

• Medium or long term Option Contracts allow urban water authorities to access additional water during periods of scarcity avoiding high transaction and infrastructure costs needed to insure water provision at critical times. The main drawback is that such contracts must account for and detail any likely eventualities, and the valuation for parties involved may become quite complex.

On the legal and institutional framework to facilitate reallocation through voluntary agreements

• For water trading to occur, it is necessary to have an institutional and legal system that considers the complex nature of water. Broad social legitimacy in specifying the design and performance of the system are a necessary condition for successful trading mechanisms.

• Holistic legal reforms are needed to improve water trading, promote economic efficiency, adequate environmental allocation of water, better manage supply risks and lessen environmental impacts in the short to medium term. This holistic reform can imply adaptive statutory water planning to ensure water for the environment and other public objectives and define how much water is available for extractive and consumptive uses.

On improving water trading flexibility and transparency by water rights reform

• Well defined set of water property rights are necessary for voluntary water market agreements to function properly. The entering into the market of property rights with a legal but not a real base must be avoided. It is important to modify water rights to consider timing and peak load congestion issues and to incorporate water quality aspects in water rights.

• There should be an efficient registry of the ownership of water entitlements and of the transaction agreements transparent and readily available to all at a low cost and with the full backing of the law.

• To share risk efficiently, a new concept of water rights must be introduced. Water rights should be unbundled allowing for transferring also the right to access water more reliably.

On water trading to cope with risk and uncertainty

• It is important to implement more sophisticated mechanisms to incorporate risk and uncertainty: more efficient markets, more secure water entitlements and an unbundling of the rights traditionally embedded in the water entitlements. Option markets, futures and conditional contracts are the main new mechanisms to improve risk allocation and risk sharing between buyers and sellers.

• Improved seasonal allocation of water through water trading need to be based in long-term, secure and well-defined contracts. These kinds of mechanisms can allow water trading with more flexibility and robust response to uncertainty. Both third parties effects and environmental externalities can be incorporated in the contracts in concrete ways.

• Water right systems, regulated in a stable way and adapted to the contexts, can increase the reliability of water supplies and make them less vulnerable. Unbundled rights would allow users to directly manage risks commensurating them with their production/consumption tradeoffs, which is becoming more of an issue given the impacts of climate change.

c) Evaluation of experience and improving implementation of water trading

On the role of the public sector to regulate water trading performance

• Public intervention is essential for preserving collective goods, the control of market power of participating agents, the provision of information and transparency, and the need to guarantee that water transactions are compatible with the preservation and protection of the environment, and balancing policy objectives (including social objectives).

• Public sector needs to set up the rules of the game: potentially traded amounts of water, the permits and prices of using public facilities to convey water, maximum and minimum prices, accreditation of potential buyers or sellers and payments for potential externalities. Water market rules may consider water use priorities, risk assumed by agents, the improvement of general welfare and the environmental impact of the proposal use.

• Public sector, as a regulator, requires a clear definition of objectives for water public policy including water use and water conservation. An adaptive water planning processes sufficiently robust is necessary to ensure environmental and other public benefits.

• The Public regulator must consider local interests. Any approach through water trading should be tailored to the local circumstances

• Water market implementation requires adequate human and regulatory means and measures to monitor transactions in order to avoid non-legal re-allocations and discharges.

• It would be important to institute various screening routes to review trading requests based on the potential disturbance, third-party or externality effects. Annual assessment reports about foreseeable effects of water trading and a post monitoring of final results and impacts should be carried out. River basin authorities also have a role in monitoring and evaluating the effects of transactions in order to prevent unintended effects.

Preserving environmental flows

• Preservation of the water flow regimes needs to be more secure than water allocated for other purposes. Water market implementation should consider this premise.

• Governments should not issue more entitlements than there is capacity in the system given the set environmental objectives. To control the volume of water effectively transferred, installation of meters and conversion from “area based licences/rights” to a system of “volumetric licences/rights” are needed.

On dealing with social and equity concerns

• Trading, if insufficiently regulated, may have undesirable social effects on the poor and impact on rural development. This is an important issue to consider for the implementation of trading options.

• Social impacts may be not be dealt with sufficiently with compensation mechanisms.

Improving transparency and access to market

• Water trading is more effective when information about the opportunities for trading and the prices being paid and offered are made available to all participants at the right time. Water trading processes need to be open and contracts should be made public.

• Public participation during the whole process ensures the required transparency. This could include access to available information through a public register containing all water transfers and to all previous transactions and monitoring reports. The public regulator should make public studies about the value of water in the different uses and the real cost of water trading.

Analysing the value of water for water uses and the price in water trading operations

• Price can depend on the relative power of the concerned parts and of the intervention of water authorities and public agents. The value of water is heterogeneous because it depends on the location, the time and the usage and therefore price in trading is variable.

• Trading prices should consider opportunity cost of water use and the costs of water services including monitoring and infrastructure conveyances.

• Government intervention is essential to prevent monopolistic prices, prevent the activation of unused rights and promoting quick seasonal allocation with low transaction costs. Good performance of water trading requires synergies with other economic instruments like pricing for water services.

On improving water quality by water quality trading

• Water trading can also be an instrument to improve water quality. Markets can create incentives to use non-conventional sources such as reused or regenerated water.

• An effective policy of water quality trade (WQT) should include stringent pollution caps, measurement of pollution emissions, strong and swift enforcement, and may imply reform of the existing prescriptive or “command and control” policies. An important limitation to WQT is cultural. Policy-makers and planners need to factor in a transitional period and ensure that the main potential traders are on board.

• Spatial distribution of pollution or “hot spots” can be avoided by a good monitoring of trading and environmental conditions.

d) Evaluating and making recommendations for improving water trading in Spain

• Water trading in Spain has been useful for dealing with critical specific shortage situations in the last two years drought period. However the volume of water traded has been marginal as compared to total water used.

• The importance of trading needs to be analyzed in light of its contribution to guarantee supply in urban areas and in highly valuable agricultural activities with well established world markets.

• Water planning and management should consider this potential of water trading and include it into the planning process as a measure to manage and allocate water resources during shortages, and to insure water supply to users in the medium and long run according to socio economic objectives, and for the reduction of pressures on the water environment.

• It is necessary to increase transparency of the cost of water services and the water trading decisions to avoid speculative prices.

• It is important to review the criteria for deciding on prices of water trading and the amounts of water subject to trade in relation to existing water rights.

• As the experience suggests, water exchanges generate great administrative burden, which casts shadows on the global economic efficiency of the small volumes already exchanged. More efficient screening procedures should be instituted, but this implies investing in capacity and in monitoring.

e) Key Messages on Financing Water Services in Emerging Countries

On the Price of Drinking Water

• As in all monopoly segments of infrastructure services, pricing is the central issue in sector regulation because in an unregulated monopoly it is possible to set prices above average costs.

• Water and sanitation services may present increasing or today decreasing returns to scale -non conventional water supplies such as desalination and wastewater reuse, and reduction of leakages in networks.

• In many countries pricing practices do not allow for cost recovery. Consumer affordability often comes to play as criteria.

• To balance sustainability of service and consumer affordability, operator revenues from regulated prices may be set with marginal costs pricing guiding the higher blocks in the block tariff structures. This will allow some consumers to pay below–cost rates while protecting the financial viability of the utility.

On the Need to Increase Efficiency as a Source of Financing

• Financial resources invested in removing technical inefficiencies -such as water losses- and improving energy efficiency and water conservation are normally very profitable, reducing the need for investments in new water sources.

• Reducing managerial inefficiencies can also help generate financial resources -or reduce their need- by improving the management of the institutions involved in water production and delivery. Effective sector regulation, well defined fiscal responsibilities and relations between national and local governments, respect for the rule of law and efficient mechanisms for dispute resolution, among others, are needed to facilitate the flow of investments to the sector.

- A careful analysis of current incentives for the public and private institutions involved in the sector can uncover potential sources of financial improvements.

- Adjusting the level of ambition (service targets in terms of population covered with different service levels) is a key policy variable to ensure the financial sustainability of the sector.

On Financing Water Infrastructure

- Careful planning of water services needs and their adaptation to the fiscal and financial capacity of the actors is the first step that should be taken.

- Financial resources will come from users, taxpayers and public and private donors. The time gaps between the need for and the availability of the financial resources will have to be financed by government and private sector savings and borrowings.

- Donor resources, many times in the form of grants, must be utilized in ways that can yield maximum impact, in particular, by facilitating access to other financial resources (reducing risk investment and therefore enhancing the attractiveness and effectiveness of investments).

- Public finance should not be used to subsidise private goods, but should pay for the provisions of public goods and the achievement of public policy goals (such as ensuring access to water to those who cannot afford it).

On Designing Financial Structures

- Proper structuring and financing of delivery modalities can help increase financing and create investment structures that are more robust and efficient requiring fewer modifications later on. The relative distribution of the responsibilities between the public and private sectors must be adapted to prevailing local conditions, in particular, to the investment climate.

On Risk Mitigation to Attract Finance

- The development of local capital and financial markets is critical for the achievement of the MilleniumGoals; in particular, the development of insurance companies, institutional investors and institutions that can provide long-term financing and issue risk guarantees. While these institutions are being developed, it may be necessary to gain access to the resources of institutions outside the country. This will require macroeconomic stability and the minimization of political risk within the country.

- There are no simple solutions. Investments will have to be structured to minimize exposure to risks, and any remaining risks will have to be examined in detail and solutions sought, including access to resources and guarantees of multilateral institutions and donor resources to prevent and mitigate those risks.

FUTURE SCENARIOS:
THE IMPACT OF CLIMATE CHANGE AND DROUGHTS ON TRANSBOUNDARY WATER DISPUTE AND MANAGEMENT

Kerstin Stahl

ABSTRACT:

Future climate scenarios predict a general increase in the temporal variability of hydroclimatic conditions. With water demand on the rise at the same time, water systems will likely become less reliable and more vulnerable to the occurrence of extreme events such as droughts. The paper explores how future changes in hydroclimatic variability and drought occurrence may influence the hydropolitics of transboundary rivers and discusses the challenge of integrated management of international river basins. Analyses are based on global data of past events of conflict and cooperation in international river basins from the transboundary Freshwater Dispute Database of Oregon State University, and on hydroclimatic variables for the basins. The records suggest that drought has been a major hydrological event to influence hydropolitics worldwide. A model classifying risk for conflict explores and confirms a strong relevance of hydroclimate, in particular its variability, for potential conflict. While global climate and hydrological models do not yet produce reliable predictions of future changes to drought events, climate scenarios generally suggest that water stress will increase in many of the basins that have experienced conflict before. The likelihood for many basins in climatic transition regions to experience changes from moderate to severe water scarcity suggests an urgent need for robust water allocation agreements for transboundary rivers. Formulating such agreements is difficult in a situation in which water resources management can no longer rely on assumptions of stationarity to predict water availability and in which future water demand is highly uncertain.

KEYWORDS:

Climate change, drought, transboundary rivers, conflict and cooperation.

INFLUENCE OF INCENTIVES AND PROPERTY RIGHTS
ON FUTURE WATER DEMAND AND DISPUTES

Dannele E. Peck and Richard M. Adams

ABSTRACT:

This paper discusses the influence of climate change on future water demand, and the role property rights will play in resolving future water disputes. Climate change is expected to affect water availability through changes in the quantity, variability, timing, intensity, and form of precipitation. This new climatic setting will alter decisions that affect water demand and associated disputes. Climate change will also affect incentives for nations to cooperate over shared water resources. The ability of market institutions to prevent and resolve future disputes will depend on the assignment, enforcement, and trade of well-defined property rights to water resources. Strengths and weaknesses of alternative property rights systems are introduced, followed by a discussion of the unique challenges water presents for the efficient design and allocation of private water rights.

KEYWORDS:

Incentives, human response, demand, property rights.

MANAGING WATER STRESS:
DROUGHT, AND CLIMATE CHANGE IN THE 21ST CENTURY

Cody L. Knutson

ABSTRACT:

Chronic water shortages are a common problem around the world and promise to be growing concern in many regions during the 21st century. Drought magnifies these water problems by placing additional strain on water supply systems, and climate change adds more uncertainty about the future availability and reliability of water resources. Addressing the inter-related issues of water stress, drought, and climate change will require a combination of local action, national direction, and regional and global coordination. There is also a place for private investment, as well as public oversight and funding. A balance must also be struck between local autonomy and general standards for meeting basic human rights. Fostering better coordination between planning activities and initiatives at different administrative levels; the identification and implementation of alternative risk management strategies; and providing the funding and political will necessary to carry out these activities is critical for reducing the risks associated with water stress, drought, and climate change.

KEYWORDS:

Water stress, drought, climate change, risk reduction.

SCARCITY AND COMPETITION:
THE CHALLENGES FOR INSTITUTIONS TO PROMOTE COOPERATION, CONFLICT PREVENTION AND RESOLUTION

Maria Saleth Rathinasamy

ABSTRACT:

With increasing water scarcity, the understanding and management of the changing dynamics of the water-society interactions become ever more critical to resolve conflicts and promote cooperation at various spatial and sectoral scales. In this context, institutions—as a system defined by the interactive roles of laws, policies, and organizations—have a pivotal role as mechanisms for resolving conflicts and promoting cooperation in water allocation and management. Although the literature is vast on the subject, there are still some key issues requiring better understanding and treatment. For instance, while the focus is more on how institutions minimize conflicts and promote cooperation, there is a lack of proper treatment of how conflicts and consensus can change existing and create new institutions and what role stakeholders and other interest groups play in such process of institutional change. Similarly, there is also a need for a better empirical understanding of the relationships among water scarcity, water rights, forms of conflict resolution mechanisms, and institutional performance. This paper aims to shed some lights on these two aspects using a stakeholder-driven model of the process of institutional change and the data from an international survey of 127 water experts from 43 countries and regions around the World.

KEYWORDS:

Empirical analysis, forms of conflict resolving mechanisms, model of institutional change, stakeholders' role, water rights.

TRANSBOUNDARY WATER RESOURCES CONFLICTS [9]

Jerome Delli Priscoli

ABSTRACT:

Empirical evidence shows the importance of values and institutions to managing water resources conflicts. This conclusion affirms long recognized need to link values and institutions as a window to understanding all types of social policies. This response elaborates on these conclusions by examining how values and institutions operate to mange water resour-ces in river basins. The paper first examines various means to managing water resources conflicts – called processes and tools. Second, it looks at the ends of using these tools – the creating of more effective river basin organizations. Specifically, the paper looks at: the historical concern for managing river basins; how values an institutions are intertwined in such management; the means or process tools and techniques that can be used; some examples of river basin organization in trans boundary waters, and offers some conclu-sions which relate to the three principle questions posed for the session.

[9] (Modified from: Chapter 2, Managing and Transforming Water Conflicts, Jerome Delli Priscoli and Aaron T. Wolf, CAMBRIDGE UNIVERSITY PRESS, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, USA to be published Fall 08

THE CRIES OF WATER WARS

Munther J. Haddadin

ABSTRACT:

Cries of water wars emerged after a series of two seminars on Middle East waters were organized by the Center for Strategic and International Studies in 1986, and then affiliated with Georgetown University. Despite advice to the otherwise, the Chairperson of the seminars insisted that, "water, not oil will be the cause of the next war in the Middle East." She published extensively on the subject in famous U.S newspapers. Events proved her wrong: the war following her announcement was the Iraqi invasion of Kuwait in 1990, and that was not because of water. The war that followed was Desert Storm in 1991 to liberate Kuwait from Iraqi occupation, and that too was not because of water. The next war was the Palestinian Israeli war (1999 – present), and that was definitely not triggered by a water conflict. The war that followed was in 2003; the occupation of Iraq, and that was not because the U.S wanted to take the waters of the Tigris nor the Euphrates. The following war was in 2006 between Israel and Hizbullah, and that was not because of water. In fact water, by its very nature is used to extinguish fires; it never ignites them. But oil fires are natural. What is strange is that the cry of water wars limits their eruption only in the Middle East. We never heard of a war over the Rio Grande between the United States and Mexico, nor of a war over the Great Lakes between the United States and Canada. We have witnessed three wars between India and Pakistan last century but never the water structures were targeted.

NEW FRONTIERS FOR WATER MANAGEMENT: THE CALIFORNIA EXPERIENCE

Ellen Hanak

ABSTRACT:

In rapidly growing regions in the United States, water managers face difficult challenges in mobilizing new water supplies to meet new demands. Environmental concerns have curtailed the scope for large new surface storage projects, and basin overdraft limits groundwater's potential as a source of expansion. Drawing on the California experience, this article explores modern water planning approaches, which focus on a portfolio of options including nontraditional sources (recycling, underground storage) and more efficient use of existing supplies (conservation and water marketing). It reviews the advantages and drawbacks of the elements of the portfolio and provides examples of innovative planning approaches.

California has made considerable progress in expanding non-traditional sources, particularly since the early 1990s, when a prolonged drought and a series of environmental rulings constrained traditional supply sources. Many of the current challenges are institutional, rather than technical. For water marketing, continued progress is needed to resolve concerns of third parties in the source regions. For underground storage, further development of aquifer management protocols is a precondition. Progress in urban conservation will require more aggressive use of tiered water rates and shifts in public perceptions regarding landscaping. Changing public perceptions is also key to the successful expansion of recycled wastewater.

KEYWORDS:

Water policy, water supply, water conservation, interbasin transfers, groundwater management.

WATER MARKETS AND ENVIRONMENTAL FLOWS:
IN THEORY AND IN PRACTICE

David Katz

ABSTRACT:

The practice of allocation of water for environmental objectives is increasingly common. In practice, often only minimum in-stream flow levels are required. This is rarely economically or ecologically optimal. Water markets offer an opportunity to advance beyond minimum flows and to achieve efficient allocations, with minimal political opposition. Markets in the western United States and Australia are already securing water for the environment. Experience, however, shows that environmental uses have difficulty competing against other consumers. This is due to their public goods nature, high transaction costs, and often a lack of marketable outputs. Governments, the largest purchasers of water for environmental purposes, are often obligated to purchase water by law. As such, the market functions more as a mechanism for compensation and least cost achievement of a legal mandate, and less as a vehicle for economically efficient allocation. The environment is also often affected by water market transfers between other consumers. Methods to minimize such third-party impacts include limiting the geographical scope of water transactions, restricting trade to consumptive use only, and dedicating a portion of water from all transactions to environmental objectives. Such restrictions minimize environmental impacts, but also limit the ability of the market to achieve efficient allocations.

KEYWORDS:

Environmental flows, water markets, third-party impacts, law and economics.

TRADING INTO AND OUT OF TROUBLE AUSTRALIAN WATER ALLOCATION AND TRADING EXPERIENCE

Michael D. Young

ABSTRACT:

In the early 1990s, Australian governments committed the nation to a major water reform program that focused on establishment of a much more competitive and more market-orientated approach to the management of water resources. With a focus on the development of water trading and the emergence of water markets, this paper attempts to summarise the key lessons learned, and the difficulties in making water markets work in a cost-effective manner.

INTEGRATING WATER INTO ECONOMIC GROWTH AND SOCIAL DEVELOPMENT

Miguel Solanes

ABSTRACT:

Most water discussions tend to be either sectoral, or use oriented. Yet the integration of water into the economy and society is affected by context issues that go farther than water.

Economic and Institutional contexts are often more relevant to water than explicit water policies. Such contexts include, *inter alia,* macroeconomics, subsidies, governance, the standing of civil society, corruption, international, investment agreements, and general criteria for public decision making. Unfavorable context conditions affect efficiency and equity for societies as a whole. It is difficult for water and its services to achieve sustainable levels of efficiency and equity in contexts of general inefficiency and inequity.

In addition, there are specific water institutions that have been found to be relevant, provided that contexts are not counterproductive: they include, *inter alia,* the administrative organization of the water sector, water rights, and water markets. Limitations of space and time do not allow the consideration of other issues, of great relevance, such as indigenous rights and environment.

KEYWORDS:

Macroeconomics, economic incentives, governance, water rights, water markets.

THE INSTITUTIONAL FRAMEWORK
FOR TRANSFERABLE EMISSION RIGHTS

Robert J. Rose

ABSTRACT:

Transferable emission rights as a policy tool is widely known as a component of cap and trade, such as Greenhouse Gas emissions trading. Transferable emission rights are most applicable to water quality when addressing regional pollution from multiple polluters. Effective policy must include four components, 1) aggressive pollution reduction caps, 2) measurement of pollution emissions, 3) strong and swift enforcement, and 4) retirement of existing prescriptive or "command and control" policies. Policy makers considering the use of transferable emission rights must first ask themselves an honest question, "Will your policy be environmentally aggressive with mandatory pollution measurement and strong enforcement?" If the answer is no, then transferable emission rights should not be pursued. If the answer is yes, additional consideration should include the type of pollutants involved and how those pollutants impact localized water quality (i.e., "hot spots"). If properly applied, transferable emission rights result in "polluter pays" for all polluters involved. The advantage is that all polluters, thus society, pay an overall lower price to achieve the desired environmental outcome.

KEYWORDS:

Transferable emission rights, water pollution, measurement, cap and trade.

TRADEABLE EMISSION RIGHTS
FOR WATER QUALITY MANAGEMENT

Drew Collins

ABSTRACT:

Tradeable emission rights seek to maximise the benefits of trade between those who place the greatest value on being able to make pollutant discharges to waters with those who can provide pollutant discharge reductions at lowest cost. The market framework to bring this demand and supply together has to date focussed primarily on tradeable emission permit schemes.

However with the increasing significance of diffuse source emissions, tradeable permit schemes are becoming less relevant. This is because the costs involved in establishing the market infrastructure to define, allocate, trade and enforce diffuse source liabilities is high. This has prompted the development of a broader suite of tradeable rights instruments with lower transaction costs that can still extract most of the benefits from trade.

In this paper, experiences with water quality trading in Australia are reviewed, focussing on the shift from point-point permit trading to alternative market structures that incorporate diffuse sources. In broad terms, issues associated with transaction costs, environmental equivalence and the dominance of diffuse sources are manageable. More problematic are political and regulatory cultures.

KEYWORDS:

Water quality trading, tradeable emission rights, diffuse source trading.

WATER QUALITY TRADING AND POLLUTION FROM AGRICULTURE:

LESSONS FROM A POLICY RESEARCH INITIATIVE'S RESEARCH PROJECT

Bernard Cantin

ABSTRACT:

This paper builds on the results of a policy research project examining the use of market-based instruments (MBIs) for water management that concluded in 2006. We concentrate more particularly on the use of water quality trading (WQT) to address pollution from agricultural sources (see PRI, 2006, for the Project Report).

To answer questions asked to panelists by organizers, we review the following themes: the biogeochemical considerations that are pivotal to designing WQT systems; the regulatory context allowing (or not disallowing) WQT to be implemented; administrative requirements; 4- social acceptability of trading systems.

Based on this analysis, we suggest that WQT are a potential solution to agricultural issues but they are not easy to implement, and not applicable to all situations/contexts. There are potential issues with the geographical concentration of pollution in watersheds, and solutions have been tested, but it may be too soon to evaluate their effectiveness.

WQT systems can be tailored to regional (watershed) circumstances, and thus can be compatible with emerging forms of water governance. However, the implementation of WQT can face resistance, both from stakeholders and also from public administrations that may have relied mostly on more traditional regulatory approaches.

KEYWORDS:

Water management, pollution trading, market-based instruments, pollution from agriculture, integrated water resources management; governance.

MODELS FOR OPTIMAL WATER MANAGEMENT AND CONFLICT RESOLUTION[10]

Franklin M. Fisher, Jane Berkowitz Carlton and Dennis William Carlton

ABSTRACT:

Actual markets only perform efficiently, if they are competitive, with many small buyers and sellers. Further, all social benefits and costs must be private ones. These conditions are generally violated in the case of water markets. But, by thinking about water values rather than simply water quantities, optimizing models can be built which do achieve efficiency. The WAS model is such a tool. It maximizes the net benefits from available water, given demand and supply characteristics and infrastructure, either actual or potential. Further, WAS permits the users to express special values for water by imposing water policies implicitly expressing such values. Among the outputs are of WAS are "shadow values" for each location, giving the extent to which net benefits would increase system-wide if there were an additional cubic meter of water freely available at that location. These provide the same guidance as do actual prices in competitive markets.

WAS can be used as a powerful tool for water management and infrastructure planning. It can also be used to examine the system-wide costs and benefits of particular water policies. But, because water ownership can be expressed in money terms, with WAS permitting the user to express social values, WAS is also a tool for the resolution of water disputes for the benefit of all the parties involved.

KEYWORDS:

Water, shadow value, cost-benefit analysis of infrastructure, conflict resolution, markets.

[10] This paper draws heavily on the work of a number of colleagues (See Fisher, et al., 2005) and especially on work done jointly with Annette Huber-Lee.

OPTIMIZATION MODELLING IN WATER RESOURCE SYSTEMS AND MARKETS

Jay R. Lund

ABSTRACT:

This paper reviews the application of optimization models to water resource systems and the more contemporary application of system optimization with economic objective functions. Using economic objective functions in water system optimization models provides additional insights beyond traditional technical objectives, and allows model results to be insightful for system policy, planning, design, and operating purposes, as well as water market policies and planning. The CALVIN model of California's intertied water system is presented as an example.

THE EXPERIENCE OF CHILEAN WATER MARKETS

Carl J. Bauer

ABSTRACT:

Chile's free-market Water Code was passed in 1981. Since then Chile has become known as the world's leading example of the free-market approach to water law and economics – the textbook case of treating water rights not merely as private property but also as a fully marketable commodity. This approach is often referred to as the "Chilean model." In this paper I summarize key aspects of the Chilean experience, including the weak legal reform of 2005, in order to draw broader lessons for international debates about how to reform water laws, policies, and economics.

My fundamental conclusion is that the Chilean approach has had some important benefits as well as problems, but overall it is not compatible with the long-term goals of integrated water resources management or sustainable development.

KEYWORDS:

Water markets, property rights, governance, institutions, Chile.

WATER MANAGEMENT IN ISRAEL:
THE CONSPICUOUS ABSENCE OF WATER MARKETS

Alan Tal

ABSTRACT:

Almost all of the State of Israel can be characterized as "dry-lands" – with precipitation levels of only 500 mm/year or less. These lands were largely "barren" and the country's soils highly eroded some 60 years ago. Like much of the near-east, the negative impact of human settlement on land productivity in a Mediterranean climate was considered to be inevitable. Today, however, some 35% of the country's lands are either cultivated or afforested. (An additional 25% are set aside as nature reserves). This complete reversal of historic fertility trends was possible due to policies that aggressively developed water resources, with enormous investment in water infrastructure and subsidies for agricultural water users. Rather than using water pricing or markets to control the demand for water, decision makers focused on expanding water supply. Later, demand management was limited to diffusion of irrigation technologies and reduction of municipal water wastes. The expansion of water supply was achieved initially through the transfer of water through a national water carrier and later through the intensive utilization of waste water. Drip irrigation and the establishment of 200 irrigation reservoirs have made present rate of 72% of effluent utilization possible. Given the focus on supply, water quality and compliance with environmental standards was largely ignored by government agencies for most of Israel's history. This has begun to change with increased resources devoted to enforcement and a strengthening of standards. The focus on supply, however continues to this day with national water strategies relying on desalination to expand fresh water supplies by some 25% during the coming decade.

Economic analysis will surely find certain inefficiencies in Israel's past and present water policies. Yet, in retrospect, Israel's approach can be considered to be a rational strategy which allowed the country to use water to promote other national objectives (e.g., immigrant absorption, settlement of the periphery, combating desertification, food security, etc.) over pure economic efficiency. Israel's successful development of desalination facilities has led to recent changes in certain accepted norms of its traditional water development strategy – for example, increased privatization of water production and supply as well as subsidy reduction and differential rate pricing for consumers. Yet, it is unlikely that the traditional policy orientation will change dramatically. As present inefficiencies in Israel's traditional policy are relatively modest and as water promises to be a critical factor in future peace negotiations, non-market management strategies will probably continue for the foreseeable future. Indeed it is unlikely that markets will be welcome as a mechanism for resolving conflicts between Palestinians and Israelis over water due to the desire of Palestinians to enjoy full sovereignty over water resources and Israel's aforementioned commitment to additional national objectives, beyond efficiency, in its utilization of water resources.

KEYWORDS:

Water policy, Israel, water markets, Middle East, water supply.

THE MYTH OF MARKETS FOR WATER: PRIVATIZATION, COMMODIFICATION, AND THE WASHINGTON CONSENSUS APPLIED TO WATER

Joseph W. Dellapenna

ABSTRACT:

Global climate disruption will change precipitation patterns around the world, producing far reaching effects on innumerable aspects the lives of humans and other living things. The resulting challenge to water management institutions is also a challenge to water law regimes that create and regulate these institutions. These challenges are occurring in a world in which water management systems and water law regimes are already stressed by growing populations and growing per capita demand. The stresses will be addressed in a world dominated by the "Washington consensus"— the view that markets are the best way to manage resources and the economy, to allocate resources, and to distribute wealth within society. Insistence on markets as the primary tool for managing water is highly controversial. The controversy raises serious questions about the utility of the markets as a tool for addressing the growing global water crisis or for managing water generally. This paper considers whether markets can even work for water resources, drawing upon legal and economic theory, on the actual effects of the privatization of water utilities, and the consequences of treating water simply as a commodity.

KEYWORDS:

Privatization, property rights, Washington consensus, water law, water management.

WATER USE RIGHTS MARKETS AND WATER ALLOCATION:

THE CHILEAN CASE

Guillermo Donoso

ABSTRACT:

Economic efficiency is maximized by allocating limited water among alternative uses so that marginal social benefits are equated across the different uses. Numerous authors have presented arguments that water, being a natural resource with varying value for different agents and uses, within clearly defined market constraints will be allocated to its highest valued use through the exchange of some type of property right, either for a limited time period (lease) or in perpetuity (sale). Since the establishment of the water allocation mechanism based on a market of water use rights in Chile, a series of empirical and theoretical studies have been carried out to determine: the existence of a water use rights market and the number transactions; water use rights market efficiency; bargaining, cooperation, and strategic behaviours of market participants; and the marginal gains from trade. These studies indicate that the allocation framework based on a market allocation system established by the Water Code in 1981 has been efficient from an investment point of view, mainly due to the water use rights security granted by the legislation. This is evidenced by significant investments that have been undertaken by several economic sectors to improve water use efficiency and to increase the availability of groundwater through exploration. Likewise, the free transaction of water use rights, even though in many areas water use rights markets have not been very active, constitutes an efficient reallocation mechanism which has facilitated the reallocation of granted rights.

KEYWORDS:

Water use rights markets, water reallocation through markets, water market performance.

BEYOND WATER MARKETING MYTHS

Ronald C. Griffin

ABSTRACT:

The challenge in isolating the opportunities and pitfalls of water marketing is to accurately apply available doctrines and experiences. This is an arena in which loose rhetoric and unrefined arguments have contributed confusion. The goal here is to move beyond marketing myths by compiling clear information about pivotal elements of the marketing versus non-marketing debate.

The primary concepts are defined and applied, and some general evidence emerging from actual water markets is assembled. The discussion concludes with an abridged list of available insights.

KEYWORDS:

Water marketing, water policy.

WATER MARKETS AND THEIR ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS IN AUSTRALIA

Henning Bjornlund

ABSTRACT:

Water markets have been vigorously pursued in Australia as instruments to minimize the socioeconomic impact of increased scarcity and to provide water for environmental purposes. Initially markets were hesitantly adopted by irrigators but over the last ten years market participation has increased significantly both in the entitlement and allocation market, but most predominantly in the allocation market. There is evidence that both markets have facilitated the anticipated reallocation of water with the associated socioeconomic benefits. There are however also evidence of declining rural communities as a result of drought and policy induced scarcity or, as some argue, as a result of the operations of water markets. There is however no real evidence whether this decline has been caused by scarcity or markets; or whether, in fact, markets have reduced the socioeconomic and community impact of scarcity. With the latest generation of legislative changes, including statutory based water planning processes defining the consumptive pool of water and provisions for environmental and other public benefits, more secure water entitlements and water registers and an unbundling of the rights embedded in the traditional water entitlement, the scene seems to be set for the introduction of more sophisticated water market instruments and water products

KEYWORDS:

Water markets, market instruments, Australia, socio-economic impact, environmental impact.

WATER TRADES IN THE WESTERN US:
RISK, SPECULATION, AND PROPERTY RIGHTS

Richard Howitt

ABSTRACT:

The increasing scarcity of water in Spain, Australia, and the Western US states will lead to an increase in the use of water markets to reallocate supplies. Depending on the relative importance of water supply uncertainty and impediments to water transfers, markets are forming differently across the western United States. In many locations, trades take the form of short-term leases of water, where the underlying property rights remains unaffected. In other regions, transfers of permanent water rights predominate. Econometric analysis of 3,696 transactions reported in the Water Strategist over 1990-2005 supports the conclusion that water property rights have influenced not only whether water trades occur, but also whether trades are permanent transfers of rights or short-term leases. The paper shows that for 14 western states during the years 1999–2002, shortterm leases outnumbered permanent-rights sales by an average ratio of eight-to-one. In states with the largest volume of water trades (Oregon, Texas, Idaho, Arizona, and California) the ratio of leases to sales was nearly eleven-to-one.

Some of the emerging trends in western water markets are reviewed and examined for ways to reconcile the quasi-public characteristics of water with the reallocation, risk reduction, and equity roles that influence water markets. Finally the different systems in the US and Australia for defining transferable water rides and minimizing externalities from water trades are compared.

KEYWORDS:

Scarcity of water, emerging trends in western water markets, water property rights, water trades.

WATER MARKETS AND THEIR ENVIRONMENTAL, SOCIAL AND ECONOMIC IMPACTS IN AUSTRALIA

Tom Rooney

ABSTRACT:

In Australia, water trading has been an effective tool for distributing the risk of lower than expected rainfall in such a way as to minimise the negative impact of drought on rural communities. The system of water trading that exists in Australia operates via a framework of Federal and state/provincial government acts which, operating together, allow for water entitlements to be traded along Australia's major river systems.

As the water market in Australia continues to grow it is likely that futures contracts and other derivatives will be developed which will further aid Australian agriculture manage risk.

KEYWORDS:

Australia, water market, risk, irrigation, water market derivatives.

WATER SCARCITY IN THE MIDDLE EAST NEED NOT "SHORT-CIRCUIT" REGIONAL ECONOMIC WELL-BEING

Mordechai Shechter

ABSTRACT:

In any future peace talks in our war-scarred region, the issue of the just allocation of water resources has and will become a topic of cardinal importance. The key word which always pops up is "shortage", namely, there is not enough water for all the inhabitants of the region, and the shortage will only worsen in coming years (whether due to demographic or the impact of climate change or both).

BREAKING THE GRIDLOCK IN WATER REFORMS THROUGH WATER MARKETS:
EXPERIENCE AND ISSUES FOR INDIA

Nirmal Mohanty and Shreekant Gupta

ABSTRACT:

In India, informal water markets have existed for decades in states such as Gujarat and Tamil Nadu. Though these markets have generally been localised and confined to trades between irrigators, they have led to efficiency gains and have also helped resource poor farmers to access irrigation. The gains, however, have been limited since inter-sectoral transfers have not taken place. The current challenge in India, therefore, is to establish formal water markets that can expand the scope of trading and make inter-sectoral transfer of water possible. Further, since formal water markets have a legal basis, regulations can be designed to address concerns of ecological sustainability. Markets in water are very important for the urban sector, which faces acute shortages but has not been able to access informal water markets.

Formal water markets can augment urban supply at low cost and relatively quickly. The National Commission on Water Resources estimated that a reallocation of mere 5 percent of irrigation water annually to the urban sector could meet the latter’s requirements over the next fifty years. It is, however, important to note that water markets can only supplement and not substitute tariff rationalisation and other reforms at the distribution end in urban areas.

KEYWORDS:

Formal, informal, urban, regulation, shortage.

THE ROLE OF THE MARKETS AND PUBLIC WATER MANAGEMENT IN SPAIN

Antonio Serrano Rodríguez

ABSTRACT:

Water should fulfil two main social functions. The first of these functions requires a public response that ensures the availability of water for life (i.e., the right to a supply of quality water and the availability of water resources that safeguard the environmental sustainability of our natural heritage for future generations). The second aspect is the consideration of water as a production resource, a framework in which market instruments must play a fundamental role. Taking this as its approach, this paper looks at the importance and the consequences of analysing market instruments in a changing environment characterised by the following: the new dynamic created by climate change, with lower rainfall levels being recorded in some Spanish reasons; the impact of new Regional Autonomy Statutes, which are changing the traditional balance of power in the management of river basins in Spain; and the creation of public, national and European Union policies (which have, incidentally, proved ineffective in response to a global economic situation) that seem have created a need to reconsider the role of agriculture and to open new fields of operation in industries such as bio-fuels, potentially giving rise to new irrigation demands, the efficiency and effectiveness of which must be guaranteed beforehand. Within this framework there is a need to promote aspects of management and intervention that enable compliance with the objectives of European directives and safeguard environmental sustainability and balanced regional development across Spain's various Autonomous Communities. In this respect, it is proposed that market instruments, applied in conjunction with the internalisation of the external effects associated with the various uses of water and activities related to it, could prove the most efficient mechanism for managing specific or structural drought situations once the resources necessary for supplying the population and ensuring the sustainability of natural heritage at risk have been guaranteed.

KEYWORDS:

Water, adaptation to climate change, water policies, irrigation, water planning.

DROUGHT AND WATER SHORTAGES IN SPAIN AND THE NEW CHALLENGES OF THE WATER FRAMEWORK DIRECTIVE

Abel La Calle Marcos

ABSTRACT:

Drought is a natural phenomenon that very often poses a problem for society.

Society's understanding of this phenomenon and the responses it has generated in the course of time have gradually changed, a change that can be analysed through Spanish water legislation. Aside from this process of change such analysis also reveals the measures that have been introduced over time in a bid to alleviate the problem. The paradigm for water policy introduced by the Water Framework Directive represents a very important change in this process. This new EC legal framework places an emphasis on the protection and sustainable use of water and, therefore, on greater control to ensure that the measures adopted in relation to drought do not represent an obstacle to attaining environmental objectives. Temporary deterioration of bodies of water is not in breach of the requirements of this Directive if it is the result of circumstances which are exceptional or could not reasonably have been foreseen and which are due to an accident, natural causes (drought) or force majeure.

THE FRAMEWORK DIRECTIVE:
RESOURCES, SHORTAGES AND DROUGHT IN SPAIN

Francisco Cubillo

ABSTRACT:

Water markets are an extremely useful support tool for the management of water in a specific region or river basin district. When used properly, the opportunities they present can contribute to the effective integrated management of resources.

There is no single cause for reduced water levels in the Mediterranean basins. In many cases they reflect growth in consumption in a particular region as a result of an increase in population or activities requiring water and which outstrip available supply or the pace at which new supply is made available.

The gap between supply and demand can also reflect poor planning or changes in regional models of use that occur more quickly than the implementation of solutions and measures to respond to subsequent water needs.

Risk management approaches are the most suitable for application on water markets. Drought plans should be based on risk management principles, both for the prevention and the mitigating and combating of the impact of droughts. The establishing of reference parameters and operating thresholds for each of the ranges and values of these parameters as part of an overall plan represents a risk management approach, as actions involving costs and impacts on different sectors and users are linked to the level of probability of them occurring.

SPECIAL DROUGHT PLANS IN THE SPANISH HYDROGRAPHICAL AREAS

Teodoro Estrela Monreal and Elisa Vargas Amelin

ABSTRACT:

Over the last few years, Spain has been hit by a situation of intense drought that continues to this day. These successive droughts have seriously affected the environment and water availability, causing major socio-economic effects. Under these circumstances, management of water resources has the necessity of creating a plan aimed at mitigating and preventing these negative effects.

With the intention of minimising environmental, economic and social effects of the drought, the Spanish regulation includes the creation of a global water indicator system that serves as a point of reference to the basin organisations so these can later create the Special Action Plans for Alert and Eventual Drought Situations.

Following an important launch window in 2006, the plans were approved by Ministerial Decree in March 2007. These plans include mitigation measures related to water resource exploitation systems – and these comprise the planning units. In addition, in 2006, the plans were submitted to a process of Strategic Environmental Evaluation (EAE) and to a period of information of the same.

Since their application, the SAPs have allowed planned drought management, establishing its stages and describing the measures that should be progressively applied, and the monitoring of this to be undertaken. Furthermore, they include measures and methods that had been agreed by consensus previously by the bodies involved: civil society, administration and the scientific community. Therefore, they are important reference documents which could help minimise drought effects in a planned and participatory manner. This document describes the creation process for the plans and the results obtained since their application.

KEYWORDS:

Drought, water resources, mitigation, prevention, water planning, drought indicators, water scarcity.

THE ALLOCATION OF WATER AND WATER SHORTAGE MANAGEMENT IN SPAIN:
WATER RIGHTS MARKETS

Antonio Embid Irujo

ABSTRACT:

Water rights markets have emerged in Spain as a new means of reallocating water resources, as traditional forms such as review of water allocations, expropriation of rights, and reallocations by law are no longer operative. Water Usage Rights Trading Centres came into being as a result of Act 46/1999, dated 13 December, which introduces and authorises the creation of Water Usage Rights Trading Centres. The legislation contains a number of clarifying points and prevents speculation and the accumulation of water in private hands. During the current drought these forms of resource allocation have been used at different times as a means of overcoming some of its harmful effects.

KEYWORDS:

Water usage rights trading centres, assignments, contracts for transfering water usage rights, river-basin agencies, drought.

WATER SHORTAGE MANAGEMENT, UNCERTAINTY AND OPTION MARKETS IN SPAIN

Almudena Gómez Ramos

ABSTRACT:

Water management within the context of shortage, growing pressure on water and an increase in the effects of climate change needs considering risk as an essential factor in reaching the goal of an effective and sustainable allocation of water resources. Traditional market instruments operate as mechanisms that allocate water and risk but which are not explicitly designed for managing this latter factor. Option contracts can, however, be seen as risk management instruments in that they are capable of allocating and distributing risk between the parties concerned. This paper assesses the potential of option contracts as a mechanism for allocating water and risk against a backdrop of uncertainty in the availability of water resources, highlighting their advantages over other market modes. It also ponders the question of whether the current legal and institutional framework in Spain enables the development of these types of instruments and assesses its possible application in the existing management model, one in which the markets have taken up a prominent role in the solution of current shortage problems in Spain by correcting the weakness detected in recent years in the existing management model and allocation of resources.

KEYWORDS:

Option contract, risk allocation, water shortage management, drought plans.

AN OVERVIEW OF MARKET INSTRUMENTS IN SPAIN

Jesús Yagüe Córdova

ABSTRACT:

The market mechanisms that form part of the Water Act have been shown as wholly ineffective in responding to exceptional situations, precisely the kind of situations they should respond to. For this reason, it has been necessary to develop other legal instruments to incorporate assignments using water-transfer infrastructures into them in addition to the acquisition of water rights through Trading Centres for environmental purposes or for assignments to Autonomous Communities. The returns provided by inter-basin assignment agreements have not resulted in any negative economic, social or environmental effects.

Pilot actions carried out to date have shown Trading Centres to be useful. Objectives have not been easy to attain, however, in spite of the fact the government has offered competitive prices. This is probably because of the mistrust aroused by these new instruments and the existing culture of holding onto water rights at any cost. Positive aspects should also be highlighted, both in terms of River Jucar flow regime (with special attention being given to the river-aquifer relationship in the case of the Mancha Oriental), and in terms of efforts to arrest the deterioration of the aquifers of Alto Guadiana, which have suffered as a result of too much water being abstracted from them.

AN EVALUATION OF THE CREATION OF WATER MARKETS IN SPAIN

Ricardo Segura Graiño

ABSTRACT:

The panel has responded concisely to the three basic questions raised by the coordinator of the Thematic Week with a view to summarising the evaluation of water markets in Spain. Responses have been drafted in the light of their experience in overseeing inter-basin rights trading procedures.

KEYWORDS:

Assignment of rights, inter-basin, transfers.

MARKET INSTRUMENTS IN SPAIN

Javier Calatrava Leyva

ABSTRACT:

Water markets ought to be just another instrument made available to river basin organisations and water users regardless of the extent to which water is in short supply. As a result, they should form part of river-basin plans.

ECONOMIC AND FINANCIAL ASPECTS-WATER DEMAND MANAGEMENT (A STRATEGY TO DEAL WITH WATER SCARCITY)

Saul Arlosoroff

ABSTRACT:

Financial and economic policies and instruments are at the basis of Israel water resources management policy and it's Water Demand Management strategy.

The paper will deal with a potential comprehensive strategy to combat water scarcities in water scarce countries and especially in the Middle East. Water scarcity in countries, as well as in cities or agricultural projects, present today a potential condition which might accompany the national growth as well as the socio- economic policies for many global sites for many years.

That strategy is defined in times as Water Demand Management, and or Water Conservation as well as the Increase of Water Use Efficiency. These 3 definitions have become a major shift of paradigm from the conventional supply management of water to the management of the demand side-producing additional quantities of water for the immediate needs of the society ,through the creation of Virtual quantities of water, whether by conservation strategies, water markets or by increased agricultural and industrial production per unit of water, as well as the import of water intensive agricultural products and decreasing exports of such products.

The experience of Israel in Water Demand Management (WDM) is presented as a potential and powerful instrument to enhance socio-economic prosperity and growth with limited water quantities, available for the societies.

Israel was established in 1948, a semi arid country, having a population of 650,000, a GDP of $300/capita and was using approximately 300 m3 of water per person for all uses. In 2007 Israel has reached a population of 7.2 million persons, a GDP of $25000/capita, and maintained it's growth on a minimum approximate parameter of 250 of fresh Cubic –meters of water per capita, supporting the large increase in personal and general income.

Despite being a semi-arid country, it balances its Agricultural production for consumption between exports and imports following the total development of its fresh natural water resources, an intensive national campaign of water conservation, improved efficiencies of water use as well as the initiation of a comprehensive waste water treatment and re use, marketing and trading treated effluents with farming fresh water allocations. In addition it adopted "Virtual Water economic and financial policy, importing grains and thus saving large quantities of water, all of which as part of its national water resources management and its Water Demand Management Strategy.(WDMS).

The pioneering works and the resulted R&D efforts of Israel, financed by the public and private sectors, have already influenced a number of other countries and global regions, as Water Conservation is becoming an indispensable global tool and need.

As other countries in water scarce regions suffer from similar or more acute levels of water scarcities; efforts have been and are going on in the present, in order to influence and spread the concepts developed in Israel to them.

BUSINESS INTELLIGENCE FOR WATER:
THE LIMITS ON INFORMATION

José Gordon Rapoport

ABSTRACT:

Private sector institutions like Hospitals, Banks or Manufacturing companies have since long benefited from Business Intelligence tools. These tools comprise analysis, reporting, score-carding and even data-mining components which make possible a better understanding of the business by allowing the processing or digestion of several thousands of individual pieces of data. The goal of this document is to introduce this type of technologies into the Water Resources management institutions. A brief explanation of concepts like multidimensional OLAP analysis, Datamart, and Data mining algorithms is given.

KEYWORDS:

Business intelligence, KPI, scorecard, data mining, datamart, decision support systems.

Thematic Week 8

WATER AND SOCIETY

[Education, Communication and Culture
Workshop for universal water peace]

Positioning document[8]

General coordinators:

Communication:
Luis Guijarro García. Editorial coordinator of the magazine Natura and president of the Association of Environmental Media Journalists (APIA).

Culture:
Germán Bastida Colomina. Member of the board of New Water Culture Foundation

Education:
Víctor Viñuales. Director of Ecology and Development Foundation

Workshop for Universal Water Peace
Mario Gaviria. Sociologist. 2005 National Environment Award
Artemio Baigorri. Lecturer, Department of Business and Sociology, University of Extremadura

1. REFERENCE FRAMEWORK

Water is an important issue for the public, important enough for the Water Tribune to devote one of its weeks to the debate on the social aspects of water, which focuses on three related contexts: education, culture and communication. The sessions and conferences that make up this thematic week look at aspects relating to education, communication and the culture of water.

Regarding education, an issue that we all have an interest in from an early age, it should be pointed out that water, like children, represents the future of any country or region. And like the youngest members of our society, water is defenceless and may be harmed by man's actions. Children can learn, however, to find out more about this resource and protect it, a process that begins at school. Adults can also learn how to bring about, in a more effective way, the changes needed to safeguard the sustainable management of water.

In terms of communication, citizens with access to information can exert a positive influence on decision-making processes regarding local river basins, the rivers that pass through their villages and towns and the water sources that provide them with their supply, ensuring governmental continuity and opening up a dialogue for the governance of water. The media plays a vital role in this process of providing information and knowledge and of forming opinions in society. And it is for these reasons that water will be a crucial topic of debate throughout the week.

Finally, the cultural value of water must be considered in the context of human life and the need to create a culture of water that reconciles human development with environmental sustainability. History has thrown up a number of

[8] TThis document has been compiled from the written speeches, oral presentations, discussions during the sessions and from the distillation of all of the above prepared by the mediators, speakers and coordinator with help from the Water Tribune team.

events that will be analysed during the course of the week. Rather than a mere chronological record of events, the past, in this particular case, represents a source of solutions to problems that are occurring on a repeated basis. As well as helping to preserve our knowledge of the history of mankind on Earth, the culture of water represents a rich source of guidance for resolving problems and safeguarding the survival of societies.

The issues of education, communication and the culture of water are essential to what is an vital initiative designed to mobilise society, an initiative that is essential to both raising public awareness about water and to motivating and stimulating people on a continual basis. The theme week therefore represents a debate that aims to keep the protection and rational use of water in the public eye by means of mobilising society. It also creates a social justice forum for discussing water-related issues and respect for the right to access water, endowing this resource with a role that extends beyond the purely economic.

CONCLUSIONS AND GENERAL PROPOSALS

Water is an essential element both in nature and in the structuring of all societies. Furthermore, because of its close links with other sectors and policy areas (environmental, energy, economic, etc), it also has a multi-functional role to play.

In spite of all this, we form part of a culture that does not appreciate the full worth of water. In fact, few people have a genuine appreciation of the water they consume every day on a direct or indirect basis. As a result, waste becomes the norm. Given this social context there is an urgent need for the creation of new parameters in water usage, parameters with the power to transform social groups and drive the global community forward, a community in which saving and managing water represent proper goals for the future. To make this social development possible it is essential that educational initiatives targeted at both children and adults are created with the aim of developing search processes based on collective participation. Along with the cultural dimension, participation, education and communication are essential tools that can help us bring about the changes that need to be made on the road to sustainability.

The scenarios currently being shaped by climate change have only increased uncertainty surrounding the quantity and quality of water, not to mention the potential for conflict involving the control of this resource. This uncertainty is becoming more and more evident in the various sectors of society. The concerns and behaviour of society have changed, and in the face of this we must ask ourselves what limits there are on social action and the role ideas can undertake as a motor for change, among other factors.

We have reached a point where it is necessary to develop new forms of water management in order to safeguard current and future sustainability. Educational processes should thus focus on conveying attitudes rather than concepts and on nurturing skills to create new forms of managing water.

As a resource, water is coming under increasingly intense pressure from society and industry. At the same time, however, the society that makes use of it is demanding an evaluation of the impact that these uses have on the environment and on mankind itself. As a consequence:

- *It is necessary to develop policies managing demand and oriented towards both economic and environmental sustainability.*

The water debate is not just a technical one, however. It also encompasses important social issues that necessitate a shift in the relationship between people and government as well as a new form of understanding water policies, one that takes its multiple dimensions into consideration and involves all members of society.

Public participation:

Far from being an obstacle, intervention on the part of a well-informed public can save time and effort, while tension and disagreements can generate significant costs. Furthermore, Spain's regional communities possess a great amount of knowledge and talent, which must not go to waste. The following actions are thus proposed:

- *To create and promote channels for participation that enable information, knowledge and expertise to be exchanged between citizens and government.*
- *To educate and train citizens in forms of participation that brings about agreements and fosters social inclusion.*

In addition, bearing in mind that a much-needed sense of calm, perspective, debate and participation is sometimes lacking from disagreements, the following actions are proposed:

- *To inform public leaders of the need to prevent conflict arising in water-related issues and to reach agreements and consensus.*
- *To prioritise investment by public authorities where agreements have been reached.*

Information and communication:

Information on water is essential, although there is an excessive amount of it at this moment in time. On occasions it is also contradictory and generates prejudiced stances that are often highly politicised and doom-laden. Messages such as "the global water crisis" abound when in actual fact it would be more appropriate to speak of a crisis in the water management model. There are many such crises and they vary greatly in their causes and solutions. We must, therefore:

- *Assess the position the water debate occupies in the media and seek to disassociate it from catastrophes, extreme events and threats. In conjunction with this, increased interest in technical, economic, social, environmental and political issues should be generated.*
- *Prevent the transmission of simplistic, demagogic and biased messages based on flimsy scientific evidence and posited following an inadequate process of reflection.*
- *Break the connection between awareness and propaganda.*
- *Improve the environmental training of journalists and media professionals and make them aware of the enormous complexity of the world of water. As a consequence, media chiefs should be aware of the need to employ specialists who use their expertise and journalistic rigour to keep society informed.*

Education:

Change from an anthropocentric paradigm to one centred on coexistence with nature also brings with it change in terms of culture and values. Our habits in relation to water and the way in which we use it can be altered by adhering to new values. This is, however, a slow process.

All future educational initiatives, both those aimed at the general public and those implemented in schools and colleges, must be based on an action plan that takes fundamental social attitudes and the global situation with regard to water into consideration. Educating people about water is a complex process as several aspects of collective culture impact upon it, not all of them positive in terms of the way we are looking at water here and the personal experiences involved. The aim of many of these educational initiatives is often to raise public awareness, particularly among schoolchildren, so that they can learn to use water better. In these difficult times, however, this intention is not enough in itself. We need to do more. We need to give society the skills it needs to face new challenges, as the social dimension of water is one that encompasses the major hurdles we currently face, namely food, energy, the environment, and the proper use of these resources. Educational initiatives in schools and colleges must take the various characteristics of water into consideration and put forward relevant strategies. In addition action plans aimed at the general public must be more ambitious and assess the extent to which they are useful. The following is therefore proposed:

- *The creation of a world water agency that promotes knowledge, culture and the dissemination of values and best practice in relation to water and sustainable development.*

Culture

Water flows. It does not divide; it connects. Different cultures share common elements and values in terms of water, although the many regions of the world all find themselves in different situations at this moment in time. That is why:

- *The cultural value of water must form an integral part of political management.*
- *The management of national and cross-border river basins must be improved as a means of strengthening international cooperation with regard to water and its management.*
- *A world water agency could resolve and mediate in water-management conflicts by means of dialogue and encouraging the participation of all the agents involved.*

COMMITMENTS OF THE ANNA LINDH FOUNDATION FOR INTERCULTURAL DIALOGUE IN FAVOUR OF WATER:

REFLECTIONS ON THE EURO-MEDITERRANEAN YOUTH FORUM ON WATER AND INTERCULTURAL DIALOGUE

Eman Qaraeen

ABSTRACT:

This paper is a contribution to the International Expo Zaragoza 2008 to the Thematic Week entitled "Water and Society" Communication, Culture and Education".

The Anna Lindh Foundation's activities have been designed in the framework of a Campaign called "Water Our Common Future", which has been originally developed by the Foundation for the 2008 Year of Inter-Cultural Dialogue, in cooperation with The European Institute of the Mediterranean (IEMED) and European Rivers Network. This Campaign has clear links with dialogue issues, and strong networking potential. Therefore, the need to reach out to and involve civil society is important. The Campaign was the result of an assessment and conception process which started with the organization of an expert meeting with qualified persons working in the field of developing a new culture of water between society, environment, and arts.

The expert meeting, which took place from November 30 to December 1 2006, gathered 15 experts among social activists, environmental scientists and researchers, artists and architects, and public officials, who were indicated or recommended by ALF national networks. The objective of the meeting aimed at identifying the aspects of the work on water the Anna Lindh Foundation wants to develop in future. A model of a multiple campaign was designed, focusing on three dimensions:

- The social mobilization;
- The research and networking for youth;
- The artistic creation.

The experts proposed three components:

- The Euro-Mediterranean Big Jump (social mobilization);
- The Water and Cultures in Dialogue Youth Forum (research and networking);
- The Aqua Treasury Artistic Competition (artistic creation).

TURNING THE TABLES:
ROLE OF MEDIA TO ENGAGE THE MASSES IN WATER DEBATES AND PRACTICES

Irfan Shahzad

ABSTRACT:

It needs little stress that water is one of the most pressing issues confronting the populace of planet today, particularly so for the developing countries. One of the many reasons for the water woes of today emanates out of the lack of proper alertness, at people's level in particular. Media has witnessed very fast developments on the back of technological advancements in recent years. These developments have both pros and cons. True that media has played an vital role in increasing awareness of social issues over past few years. Yet, the coverage of issues such as water and sanitation remains far from desired. While water is by and large a less-reported and even mis-reported issue – whatever gets place in media is often plagued by/with commercialism, vested interests and lack of proper orientation of journalists. The human touch is missing, to a large extent. Resultantly, the desired goal of making the poor a "part of solutions" to the water problems remains a dream. Media in developing countries needs to prioritize water in its coverage, rise above commercialism on this critical issue and devise people-centric approaches in coverage of water issues. If the masses are involved the way they should be, little more efforts will be needed.

KEYWORDS:

Water issues, awareness on water, role of media, involving masses, people-centric approaches.

ATTITUDE ADJUSTMENT:
CHANGING OUR RELATIONSHIP FROM WATER AS LOW-COST COMMODITY TO WATER AS SACRED, LIFE-GIVING RESOURCE

Stephen Leahy

ABSTRACT:

Much of the world treats water as if it were in endless supply or a commodity that can be easily manufactured. Neither attitude reflects water's reality. But this water fantasy is commonplace in all levels of society in Canada and many other countries. As a result water is wasted, polluted and mismanaged in most places. Changing our relationship with water from a product or commodity to a precious, life-giving resource is crucial to coping with the water challenges we face. Water has been sacred for most of humanity's history save the last two hundred. It is time for an 'attitude adjustment'.

Journalists and communicators have an important role in revealing and explaining the reality of water and exploring how attitudes shape our decisions about water. Most importantly communicators must first pull themselves out the prevailing water fantasy in order to ask the right questions. This work of vital importance because humanity is reshaping the Earth and its climate with little knowledge of what we are doing.

PROJECT WET: WATER EDUCATION
FOR 21st CENTURY GLOBAL WATER CHALLENGES

Sandra Deyonge and John Etgen

ABSTRACT:

Global water problems continue to escalate and affect the quality of life for billions of people. The mission of Project WET is to reach children, parents, educators and communities of the world with water education to help them meet 21st century water resource challenges. Project WET believes an understanding of water resources will help students and others: protect local community sources through action projects; participate in the growing global economy with an understanding of the value of water; support and contribute to innovative technologies to ensure clean water resources for an expanding world population and economy; and recognize the relationship of water resource management and international stability. Project WET is currently active in over 30 countries on five continents and its materials have been translated into several languages. Project WET's expanding international adaptation is due to: a dynamic activity and training format (focused on 21st century student skill development); its network of educators, water resource professionals and partners; its publications developed through a unique writing workshop process; and local community water resource events.

WATER WATCH PENANG:
USING WATER DEMAND MANAGEMENT (WDM) FOR WATER SUSTAINABILITY VIA CHANGING LIFESTYLE AND WATER USE HABITS

Ngai Weng Chan

ABSTRACT:

Malaysia is a country with rich water resources but mismanagement, wastage and pollution have led to water problems. Hence, Water Watch Penang (WWP), a non-profit organisation was set up in 1997 to help address water issues. Its vision is based on 5 principles of: (i) ecological sustainability; (ii) social justice; (iii) economic productivity; (iv) cultural vibrancy; and (v) popular participation. WWP teaches parents who play a vital role as "water managers" at home and in the work place. Parents manage the family's water budget and educate their children about water saving. WWP promotes water demand management (WDM) to ensure that water resources are not depleted but remain sustainable. Via WDM, the amount of water saved nationally is significant and WDM can lead to saving mega-water projects for future generations. Through domestic water audit (DWA), a form of WDM, water recycling and saving techniques become key strategies in addressing water scarcity and other water problems in Malaysia. WWP also work with government and water service providers in reducing high rates of non-revenue water, upgrading water treatment plants, increasing awareness, public education and other important water related issues. The ultimate objective of WWP is to create a "Water Saving Society" in Malaysia.

KEYWORDS:

Malaysia, Water Watch Penang, water demand management, domestic water audit, water saving society.

EDUCATION AS A MANAGEMENT TOOL FOR GENERATING SUSTAINABILITY

Javier Benayas del Álamo

ABSTRACT:

Since the publication of the Bruntland Report in the 1980s sustainable development has evolved into a concept assessed, employed and discussed by nations all over the globe. Such has been the extension of the term and everything associated with it that on december 20 2002 the General Assembly of the United Nations approved Resolution 57/254 in support of the declaration of the Decade of Education for Sustainable Development (2005-2014). As a result of this Resolution every country is obliged to identify its priorities and modes of intervention. It is also necessary that objectives and plans for the future are defined locally in order to satisfy the environmental, social and economic conditions of each community (UNESCO, 1997). We must not forget, however, the origin of this movement, which is deeply rooted in environmental education.

L'OBSERVATORI:
THE MONITORING OF SOCIOLOGICAL INDICATORS IN THE TORDERA RIVER BASIN

Martí Boada and Roser Maneja

ABSTRACT:

Acknowledging of the existence of an environmental change at a global level and the growing social demand in the search for solutions to the current environmental problems has given rise to the appearance of new epistemological and methodological proposals from science that incorporate new elements in their approaches.

WATER FOR LIFE:
TRAINING THE WATER TRAINER IN SYDNEY, AUSTRALIA

Ben Taylor

ABSTRACT:

Water for Life is the NSW Government's (Australia) flagship community water education program which has driven significant increases in water savings and understanding of water issues across greater Sydney. This paper outlines the 'train the trainer' strategies employed as part of the Program, key lessons leant and key evaluation to date.

Water saving has become second nature to business and residents across greater Sydney. During this time Water for Life has collaboratively delivered community campaigns, innovative on-the-ground water education projects and training and resources for local government. Over 3.3 million people now regularly take action to save water and 85% of residents are aware of how we are all working together to secure Sydney's water supplies.

KEYWORDS:

Water, education, training, capacity building.

COMMUNICATION, PARTICIPATION AND CHANGE IN THE PUBLIC WATER MANAGEMENT MODEL

Julio César de Cisneros Britto

ABSTRACT:

In responding to water policy problems political and social agents act in accordance with a specific system of ideas and values that are subjected to a political and social debate in which opinions are exchanged. This process of communication fosters learning and the sharing of ideas, and has practical consequences in the restructuring of said values, the partnerships that underpin them and the structures they are supported upon. As a result, the main force for change can be found in social interaction, communication and social participation.

KEYWORDS:

Participation, communication, promotional partnerships, belief systems.

WATER ON THE NEWS:
MEDIA COVERAGE OF WATER RESOURCES

Pablo Francescutti

ABSTRACT:

Television is one of the public's main sources of information on the environment. This makes the issue of how it covers the problem of water an important one. With a view to offering a provisional answer this paper reveals the initial results of a study of national television news coverage of stories relating to water resources. The year-long study was conducted by the team at the Advanced Media Studies Group at King Juan Carlos University and reveals that all news items can be summarised in two different categories only: the excess of water (flooding, torrential rain) and the shortage of water (droughts). In short, these stories are essentially negative in nature and put forward a simplified and alarmist view of the multi-faceted phenomenon that is water, while ignoring aspects as crucial as measures for saving water, storage and treatment techniques and the development of new water technologies, to name but a few of these aspects.

KEYWORDS:

Water, television news, news, alarmism.

SHOULD I TURN THE TAP OFF WHEN I'M BRUSHING MY TEETH?

CURRENT AND FUTURE CHALLENGES IN PROVIDING INFORMATION ON WATER

Eric Mollard

ABSTRACT:

There is a politically incorrect and scientifically debatable theory that holds that the excessive use of water in the cities and in agriculture should continue as water flows in cycles, not only through the water cycle itself but also as a result of the continuous recycling that allows users and the environment to benefit from it downstream. There is little question that this viewpoint is something of a provocative one, although the intention here is to create alternatives to simplistic information that is founded on the relative lack of scientific debate directed at the public.

Given the fact that scientists have acknowledged limits to their expertise, either through a lack of knowledge of certain hydrological processes or interpretations that are still under debate, can the communication of information about water extend beyond mere propaganda. Is there not a risk that by providing more information, in other words by including scientific uncertainties, the general public will lose interest and motivation?

The paper sets out the benefits of raising awareness first of all, both in developed and developing countries. It then goes on to analyse the psychological, social and political processes that hamper action from being taken with regard to the events and practices that make up the ideal notion of water. Finally, it discusses the limitations of the mass media in relation to water.

What do they [our contemporaries] need?

Not only to inform themselves. In this positive century information will often attract their attention and render them incapable of assimilating it.

Not only the arms of reason, because in fighting so hard to attain them they use up their feeble reserves of moral energy.

What they need, what they feel they need, is a type of spirit that allows them to profit from information and make use of reason so that they may, with complete lucidity, assess what is occurring in the world and also what may occur deep inside themselves.

Charles W. Mills

THE BUILDING OF PAPER MILLS ON THE URUGUAY RIVER:

AN ANALYSIS OF AN ENVIRONMENTAL CONFLICT COVERED BY THE MEDIA SINCE 2004

Claudia Mazzeo

ABSTRACT:

The announcement of the construction of two paper plants on the Uruguay River, one by the Finnish company Botnia and another by the Spanish manufacturer ENCE, triggered a series of protests the scale and like of which had never before been seen in Latin America.

This is the first time that an issue involving both water and the environment has received constant and ongoing media coverage in the region, coverage that began in 2004 and continues to this day.

The document analyses the key factors in a conflict that has gradually increased in intensity on both sides of the river, in the cities of Fray Bentos (Uruguay) and Gualeguaychú (Argentina), and also looks at its impact on other areas, and its most significant aspects as reflected by the media over nearly four years.

KEYWORDS:

Paper plants, Uruguay River, Fray Bentos, Gualeguaychú, pollution, environmental conflict, social licence, social mobilisation, environmental awareness, the media.

BUILDING A NEW CULTURE OF WATER

David Barkin

Keynote Conference

ABSTRACT:

The management of water is the cause of increasing social and environmental disorder in many parts of the globe. Far from reducing problems, increased urban development and economic growth are denying huge numbers of people their basic and universal right to quality water and in quantity, and are preventing them from exercising their collective responsibility in protecting ecosystems. In response to these serious problems, the Latin American Water Tribunal was set up as a forum for airing disputes that national organisations have been unable to resolve and for initiating processes of negotiation.

As a result of the increasing economic and political centralisation of the world today, new initiatives and capacities are being created to deal with these problems. They are frequently contested and held back. They do, however, involve making use of existing knowledge and “appropriated” technologies that have been rejected by civil servants and big companies competing for national and international contracts. This tradition has seen the emergence of the movements of the New Culture of Water and Reclaiming Public Water, which differ greatly to the cultures that continue to hold sway in global institutions and councils and in international financial institutions. Together they advocate the right to the public control of water and universal access to water to serve basic needs and for the good of ecosystems. The transformation of water into an economic good has denied these rights to millions of people and a host of national initiatives have been put forward to prevent market abuses in the management of water. It is only by taking such action that we can create institutions with the ability to revert the current trend of converting natural phenomena and faults into natural disasters, while government continues to wash its hands of the problems caused by its negligence and errors.

PROTECTING WATER, PROTECTING LIFE:
THE CONTRIBUTIONS MADE BY ANDEAN CULTURE TO A NEW WATER CULTURE

Marco Arana Zegarra

Keynote Conference

ABSTRACT:

The ongoing struggle against mining in Peru is being fought in defence of land and water and the fair redistribution of wealth. The protection of land and water is the bitterest aspect of this struggle and it is an issue made especially sensitive by the fact that the mining industry is using up both resources intensively and extensively.

To those who promote the uncontrolled growth in mining activities as being key to the success of current neoliberal economic policy, the issue of the redistribution of the wealth generated by mining is one that has been, to all intents and purposes, resolved because the mining tax levied on the industry's huge profits creates a trickle-down effect[13]. The companies and the governments that support them are intent, more than anything else, on undermining the Andean struggle against the perverse logic of a system based on mining activities that are dependent upon the appropriation of water and land from local communities, a process that involves the people from these communities being forced to move away and in which their rights to life, water and health are abused. The battle they are waging against the lack of control of the mining industry and its expansion is taking on a more global dimension. The people of the country's southern regions are fighting harder and harder to defend their right to land and water and for ownership and control of their resources so that they can broaden their opportunities and exercise their social, economic, cultural and environmental rights. This continuing struggle should be understood as a campaign for the globalisation of social, economic, cultural and environmental rights (DESCA).

In Peru, as in the rest of Latin America, the defenders of land and water are being accused of championing forms of thought that are opposed to economic growth, which is wrongly identified with development. The Peruvian president, Alan García, and the spokespersons of the mining companies have complained of a conspiracy by "international environmental movements" that are opposed to the economic growth of the country and which are behind the peasant protests organised with the assistance of NGOs and the Catholic Church. What ires the powers that be more than anything else, however, is the fact that the Andean struggle to save land and water essentially questions the very foundations of an economic model based on the irrational use of natural resources as a means of generating extraordinary profits for increasingly small power cliques. The immense profits generated by the Peruvian mining industry are merely widening the divide caused by social exclusion: "24% of the total tur-

[13] The mining tax is a percentage of the income tax that the state levies on companies, following a series of tax deductions designed to encourage private investment.

nover of Peru's largest 10,000 firms is accounted for by a mere 20 companies. Eight of these 20 firms are mining companies and a further eight are oil companies. Nearly half of the country's 100 largest companies, where most of the turnover is concentrated, are multinationals. Some 20 companies generate 46% of net profits, while 6,000 businesses only account for 1% of net profits even though they generate 14% of total turnover."[14]

The profits made by mining and oil companies would not be possible without access to the land and water of native and peasant communities, who have been fighting to ensure their basic rights are respected. An important feature in this struggle is the Andean Culture of Water, which during more than 500 years of domination has managed to survive by adapting to changing circumstances, reinventing itself and affirming the characteristics it has always maintained with regard to caring for the land and the people who live on it.

Pedro Arrojo has argued that the contributions made by other cultures need to be evaluated in order to create a new culture of water, obviating in the process a reductionist approach that has identified these contributions with "cultural animism" or "fear-filled superstitions". He has also drawn attention to the fact that rather than being based on fear, such contributions are characterised by a genuine and deeply felt respect for nature, an aspect that has been greatly undermined by the capitalist rationalisation of natural resources. It is my belief that a New Culture of Water cannot be created on the basis of the study and research into other cultural ambits, but rather that these ambits must be considered as genuine forms of knowledge and wisdom that we can draw on to enrich and give depth to new theoretical approaches and develop new water policies. Contributions such as those of the Andean Culture of Water have the capacity to inspire new ways of life and new governmental frameworks with a genuine foundation on social solidarity and environmental responsibility, and without which the peace and environmental stability of nations and the planet cannot be guaranteed.

This document looks at three issues in particular:

a) The environmental and cultural impact of modern mining activities on water and local communities.
b) The central aspects of the Andean Culture of Water in the communities of Peru.
c) The main contributions made by Andean culture in bolstering a new culture of water.

[14] 2008 Annual Report on the top 10,000 companies in Peru. Peru Top Publications. La República newspaper Lima. 17.07.2008

THE ROLE OF SOCIAL MOVEMENTS IN CHANGING THE WATER PARADIGM

Joan Corominas Masip

ABSTRACT:

Unsatisfactory management of water is impacting on a significant number of users and many social groups. Clean rivers are but a distant memory for many people and there is widespread concern with regard to the reduction in water reserves and the fact that restrictions may be imposed, thus affecting their quality of life.

This situation is not exclusive to Spain. It is a problem afflicting many countries to a greater or lesser extent, both in the developed and the developing world. Water is an essential resource for life, and at a time when the global population and economy are experiencing rapid growth traditional management models will result in inequalities in usage capacities and a deterioration in water quality and the ecosystems linked to rivers, lakes and coastal areas.

COMMON STANCES FOR ORGANISING GROUND-BREAKING WATER INITIATIVES IN SCHOOLS

Carmelo Marcén Albero

ABSTRACT:

Critical analysis of the changes that have occurred in the last few decades in collective actions focusing on the governance of water reveals all too few positive aspects and all too many shortcomings. Among the bright spots are a general commitment to including the treatment of water on the syllabus at education centres and the growth in the number of associations and networks bringing about lasting changes in behaviour. On the downside these positive developments have had relatively little impact due to the local and global problems of our times, which are conditioning the global environmental dynamic and the survival of many social groups. A brief look at the causes of this lack of progress reveals that educational initiatives generated both inside and outside the school framework may have inherent weaknesses or be hampered by external limitations. Considered analysis requires research into the variables involved in these initiatives as a means of proposing a series of requirements that seek to make them more effective. This requires specific multiple research processes that help identify the importance of developing syllabuses in compulsory education, the attitudes held by schoolchildren, the materials used and the training received by teaching staff, in addition to the interdependence of all these factors.

KEYWORDS:

Compulsory education, intervention programmes, changing attitudes, research studies.

ADVANCES IN CAPACITY BUILDING FOR INTEGRATED WATER RESOURCE MANAGEMENT AND ACCESS TO DRINKING WATER AND SANITATION

Damián Indij

ABSTRACT:

This document looks at the concept of capacity building as a dynamic, complex and continuing process that is vital to the effective creation of new paradigms such as the Integrated Management of Water Resources (IMWR) and the scope of universal objectives such as the Millennium Goals.

The contents of the document are founded on the experiences of the LA-WETnet, the Latin American Capacity Building for Integrated Water Resources Management Network, which forms part of the international UNDP (United Nations Development Programme) Cap-Net.

Given the huge requirements of billions of inhabitants around the world and the threat this poses to the sustainability of different ecosystems, there is an urgent need to find effective and efficient solutions. What makes the problem even more pressing is the generally low level of investment in all forms of education. In response to this the article shows how capacity building networks can provide an effective means of ensuring improvement processes in water management are founded on solid capacities.

Capacity building networks such as LA-WETnet have sprouted up around the globe in recent years as a strategic response to the demand for greater resources and capacities devoted to the implementation of the IMWR. These types of networks constitute regional alliances comprising prominent institutions such as universities, resource centres, associations, NGOs, government agencies, and UN bodies, which are involved in and committed to capacity building in the water sector. The potential and importance of capacity building networks is based on the experience, level of activities, scope, and the expertise of their members. The success of these alliances lies in the ability to combine all these values and resources and strengthen the capacity of each member and the network as a whole.

Knowledge management is a strategic tool that plays a part in the fulfilment of organisational objectives not as for the network as an entity in itself but also for its various member. The management of knowledge in these networks triggers a continuous cycle in which knowledge is generated, adapted, shared and transferred to the various groups in the water sector. The content of this knowledge changes when it is developed and fulfils demands, although the cycle continues to grow at the same time, giving these alliances a higher profile and making them more sustainable.

Finally, the article details a table depicting the advances and opportunities open to the various components that make up capacity building.

Workshop for Universal Water Peace

Mario Gaviria and Artemio Baigorri

METHODOLOGY

The workshop was set up to enable the participation of nearly 30 leading experts in various fields and areas of research and thought and hailing from all over Spain.

The participants were contacted between July 22 and August 1 and invited to the workshop. Some experts were unable to attend, however, due to other commitments.

A total of 29 people, including the coordinators, took part in the workshop. The Mayor of Zaragoza, Juan Alberto Belloch, introduced the event. Also in attendance were the lecturer Ramón Tamames and the director of Expozaragoza 2008 Jerónimo Blasco, both of whom gave presentations and introductory proposals. Joining them were the former president of Aragón Santiago Marraco, the senator Francisco Javier Tuñón, and the ombudsman for Navarra Francisco Javier Enériz, who had also been invited to participate in the workshop.

A number of other leading water experts were also in attendance, among them Carlos Blazquez from Aragón, and specialists from Argentina, USA, Belgium, Yemen and other countries, who had been invited over to take part in some of the Water Tribune's other sessions.

It was initially planned that a free debate lasting four to five hours would be held in the morning to provide an opportunity for analysis of the issues. A two-hour session oriented towards the design of proposals for action based on the main themes of the morning session was also scheduled for the afternoon. Changes in both the programme and protocol impacted on this original schedule, however, and there was only time for one of hour of discussions in the morning, which severely restricted the opportunities participants had to express their opinions and also reduced the creative potential of the workshop as a whole. In addition the fact that the workshop was opened up to overseas contributors to the Water Tribune meant that translation services had to be provided in some cases, which also curtailed the time set aside for the workshop's activities.

All the content of the workshop was recorded to create a document of interest to researchers studying water-related issues.

The summary, conclusions and proposals have been based both on the notes taken during the session and contributions forwarded at a later stage by some of the participants. In particular those experts who had less of an opportunity to speak were invited to write down the ideas and opinions they had been unable to express during the session due to time restrictions. The specialists who sent in written contributions were Emilio Rico, Ignacio Rodriguez Amor, Javier Enériz, Josep Espluga, Cipriano Marin, José María Perea, Georgina Cortés, Mercedes Martinez and Regina Lafuente.

However, in view of the fact that this document is the result of a "collective creative process", as with the contributions made during the session no names have been attached to these additional ideas.

A SUMMARY OF THE CONTRIBUTIONS

The report makes a clear distinction, first of all, between the introductory session and the work session that followed it. A differentiation is thus made between the analytical contributions and the proposals

Introductory section

The terms of the debate were set out in the introductory session, which was made up of a series of mini papers.

Professor Tamames, supported by the work of engineer Lorenzo Pardo (particularly his thoughts on the river basin as an instrument of management, and on the imbalances in Spanish hydrography), discussed the connection between the Spanish water system and the importance (implicit in his presentation) of not demonising terms such as "trasvase" (river diversion). We can also add to this the reappraisal/reinterpretation of Garrett Hardin's theory on the Tragedy of the Commons, from which we can (once again implicitly) deduce the need for water (as one of the commons at risk as a result of individual/commercial abuse) to come under state control once and for all, as a form of expressing the interests of the common good (in other words, the population as a whole), regardless of who owns "the commons".

It was the contribution made by the former president of Aragón Santiago Marraco that truly set the agenda, however, and set out which proposals for action should come under discussion. In providing an appraisal of the current situation, Marraco said it should be termed a "brawl" rather than a conflict and was almost entirely attributable to the politicians of the day and their electoral interests. He also offered a specific proposal, which was modified during the course of the session before meeting with general acceptance. This proposal involved reaching a water agreement and called upon the Senate, in its capacity as the national chamber, to become involved in the issue. The subsequent contributions made in this preliminary section all followed more or less the same line, singling out politicians as the ones responsible for the general dispute in relation to water and making direct proposals for action.

Work session

The work session began with a discussion centring on the proposals put forward in the introductory session. However, an effort was to structure the report into two clearly differentiated sections: analysis and proposals. In doing so the chronological order of the views presented has been broken in order to make them more accessible.

The appraisal

Some of the participants made the point (one that was underlined in one of the subsequent written contributions) that the whole issue of water needs to be discussed more calmly as it is a subject almost synonymous with conflict. It is not to be expected that conflict should not exist, but merely that it should not provide grounds for war, at least in the civilisation we form part of. For over two thousand years (or for at least as long as written texts have been in existence) Spain has played witness to quarrels over water, and in that time there have been some agreements (which is just as well for if there had not have been, we would have never evolved). No sooner had the Romans set up what would become Caesar Augustus's camp than they had to mediate between tribes fighting over the waters of River Huerva, upstream from aragoza that centuries later would send troops to destroy the irrigation dams on the River Jalón. In taking all this history into consideration, one should bear in mind the etymology of the word "rival", which comes from the word "rivus", which is also the origin of the words "río" (river) and "ribera" (riverbank), and which comes from the Latin term "rivales" (in plural because it is a collective noun, like the groups that are locked in disputes over water today), a word that was used to define people who had the right use water from the same stream.

Given this background, all we can expect to do is use this collective experience to learn how to manage this "natural" and inevitable conflict properly. As was also pointed out, the problem is we have made a significant qualitative jump forward in the last few years. Whereas in civilised societies it has become standard practice for the interests implicit in conflicts to be expressed in political debates, in Spain we have witnessed in recent years not so much a debate as something resembling a squabble, a general squabble between political territories (regional communities, provinces, counties, districts, municipalities) and natural territories (mountains receiving water and valleys consuming it) and between social groups (rural and urban groups, farmers and growers, and environmentalists[16]. All of which begs the question, will we soon be needing the Romans to come back and mediate once more between the "rivales", the local tribes? This concept of some advanced form of mediation that characterises the first documented disputes of our history is one that surfaced again and again throughout the workshop, with contributors stressing the need for a higher authority capable of mediating in, influencing and shaping the course of conflicts.

If we take into consideration how certain water-related conflicts were resolved in the past and how they are resolved in other societies, there would be a need to agree with the appraisal that was least widely posited by the contributors, namely that the intensity of conflicts appears to have reduced somewhat and that we are now in a better position to tackle them. Furthermore, conflicts are opportunities for change and innovation, a viewpoint that was held by more participants.

Whatever the case may be, there are many dimensions to the conflict over water.

- It impacts on the political arena, not just because it has become a strategic weapon for winning votes but also for the reason that it is viewed by some analysts as the result of a lack of participation. Conversely, others see it as the result of too much participation. Some contributors also pointed to specific political decisions as the trigger for conflict. The last critical contribution in this respect pointed the finger squarely at the Water Act promoted during José María Aznar's period in office, and which allowed the de facto privatisation of Spanish water (with 75-year concessions), and which also provided the catalyst for the whole issue of river diversions.

- The conflict over water also has, of course, an important technical dimension in a somewhat unpredictable sense as it has impacted on the credibility of the technical proposals. This is most evident in the extent to which many experts have become accomplices of the politicians and preachers who make a cause out of water. In the face of this a lukewarm form of self-criticism has been posited by those of us who, in the process of building an environmentally friendly, decentralised, participative and local concept, have possibly contributed over the last three decades to providing arguments ("arms" for "wars") for those who have created misleading identities around water. As has been posited in other political spheres in recent times (Who pays taxes? Regions or people?), there is a clear need to identify those agents with a genuine interest in a conflict that is presented in almost ethnic terms in some regions (a factor that undoubtedly leads to the expression of feelings, in other words, to the triumph of beliefs and irrationality).

At this point it should be said, however, that the points put across during the session were of-

[16] Conflicts over resources are always of the same type, as disputes over land have demonstrated.

ten confusing and at times contradictory (as is always the case in Spain whenever observations are made about its regions). As pointed out above, some see decentralisation is the cause of the problem (the aims of some of the regional Statutes providing the latest consequence of this)[17], while others look upon decentralisation as a basis for resolving current conflicts, while there are even those who advocate further decentralisation. All the observer can do is ask themselves if everyone is talking about the same subject when decentralisation is the topic of conversation[18].

Most of the participants who came to some conclusion, either during the session or in the subsequent written contributions, appeared to agree on certain points, and there was a lot of agreement in terms of the diagnosis.

The first point to make is that the problem of water today is not a technical one but a conflict that needs to be dealt with using conflict-resolution techniques. The basis for this is another premise on which, logically, there is complete agreement, namely that water is a key resource, which is a factor that some believe explains the continued existence of a certain technocratic risk.

Doubts and disagreements then arise. Unanimity is partly a pretence. Water is, for example, vital, but vital for what? Which uses of water are to be given priority over human consumption? And what do we understand by human consumption[19]? Some contributors pointed out, for example, that while mass tourism is now an undoubted source of wealth for Spain, will it always be more important than agriculture? Tourism is a very recent phenomenon, having been in existence for less than half a century, and its future cannot be predicted, neither that of the industry itself nor Spain's position among the world's leading destinations. Will Spain continue to be a tourism power?

Then there is the question of the traditionally sacrosanct needs of agriculture. Will they continue to be sacrosanct when newer plant species that are more water-efficient begin to appear?, and most importantly of all, to whose detriment? This question is particularly pertinent given that we know, for example, that the projects such as the diversion of the Tagus/Segura will never be completely repaid for by users. In conclusion, then, while there appears to be plenty of agreement, the reality is somewhat different. In fact there are many dichotomies that remain unresolved:

- Are we in a better position (there is less conflict), or worse (we are involved in a dangerous squabble)?
- It is by no means clear that we ought to pay whatever price necessary in order to resolve conflicts.
  - Are conflicts are the root of innovation or social decay?
- Is the problem one of a lack of participation or a lack of authority (national, higher)?

[17] It must be remembered that although most of the conflicts discussed in the session are water conflicts involving the resource itself – as some of the subsequent written contributions correctly pointed out – they are not only triggered by the distribution of a scarce resource, but are also the result of conflicts of power. The desire to gain control of a river basin is, therefore, a manifestation of the desire for power. As some of the subsequent written contributions implied, certain regional statute projects can be viewed in this light.

[18] The listener was, in fact, bewildered at the sheer range of terminology used. Very often the terms employed were confusing and were almost always ambiguous. There was also a surfeit of terms that were badly translated both in terms of what they were intended to signify and their meaning (governance, empowerment, etc).

[19] The former president of Aragón, Santiago Marraco, provided an illustrative example in his initial presentation. In 1973 a request was made for the urgent transfer of 1,400 hm^3 to Barcelona, as it was argued the city would not survive without it. The transfer was not carried out, however, and following the crisis of the seventies the AMB (Metropolitan Barcelona) continued to grow without any water crisis occurring. A further request was made in 1993 for a reduced amount of 1,300 hm^3. Once again the transfer was not effected, and once again nothing happened; the AMB continued to expand. When another request was made in 2000 the amount was reduced to 1,100 hm^3. Even so, it was still not carried out and even with the recent mini-crisis, nothing serious occurred.

Is more citizenship required or more laws?

- Are political parties responsible for the situation or are they the solution[20]?
- Is there still evidence of technocracy or are experts being undermined?

Observers will have been perplexed in one respect, however; doubly perplexed in fact because not even the call for subsequent reflections yielded any contributions in this respect. First of all this can be put down to the fact that the role played by certain social movements and the idolised Civil Society as catalysts of the most recent conflicts was not debated at any point. And secondly (and this is a point closely linked to the previous one) the part played by the mass media, and by certain sections of the media in particular, was not discussed at all either.

Proposals for action

Naturally, the proposals were not made in the order in which they appear here but were made at different points during the course of the sessions, as part of the analysis and debates. I have, however, tried to place them in some kind of sequence.

There is agreement on the basic idea that this is a subject that needs to be dealt with now, as the tension that characterised the "war" appears to have lessened somewhat, giving way to a new chapter, with participants repeatedly pointing to the need to anticipate the problem – always the starting point in any basic conflict-resolution manual.

1. TOWARDS A WATER AGREEMENT

And in the opinion of the observer there was also agreement on the issue of the Water Agreement, which bears the entire semantic charge of all state agreements, such as those relating to terrorism.

The problem raised by some people is that this agreement process necessarily involves a first step, that of "demanding" (which was the word used although it was not made clear to whom it referred) a truce involving all the sides using water as a political weapon. According to other contributors, however, this is an impossible aim as it would involve losing votes.

2. IDENTIFYING THE PARTIES

The second step involves identifying the conflicting interests, in other words, distinguishing clearly between the sides involved. However, as stated above, different parties appear on more than one occasion, with the result that we may to some extent still perceive "the parties" as "the regions", which is but a blurring of the reality. It is not the regions who pay taxes, irrigate the land or play golf, but people, interest groups, and in the most abstract of terms, development models (which was a term repeated on various occasions and which appeared over and over again in the written contributions sent at a later stage by some of the participants)[21].

This process of identifying the parties has various implications:

- The conflicts involve several sides, as has been the case for many decades now in conflicts focusing on the use of land.

- As a result different types of alliances are formed.
- It is essential that attention is given to two types of demands.
    - ▶ Explicit: this encompasses the "distribution" of water.

[20] Participants affirmed time and again that there had been manipulation and confrontation. It was also pointed out, however, that in a context of alliances, politicisation (understood as management by political agents) can help bring about legislative agreements.

[21] No one seems to be aware of the fact, however, that in talking about a confrontation between development models we are in actual fact discussing ideologies and in doing so are legitimising a return to political confrontation. This begs the question, is the journey one worth making?

▶ Implicit: identity-related (Some contributors asked, But do we really have to respect these pre-rational components? In dealing with water are we also going to play with historical rights, the rights of nations, ethnic groups, races? In short, contributors pointed to the delicate nature of this aspect).

• In methodological terms, a principle of differentiation was proposed as a means of defining the parties more easily, and it was suggested on several occasions that national river basins be considered and treated as if they were international basins, in other words under the same regulatory principles. Some contributors pointed, albeit without much conviction, to the risk that this involved of extending nationalism or confederalism.

Perhaps the intervention of the senate as a body enabling what someone defined as "union through elevation" (sic) would resolve this problem.

In fact, from this point on in the senate becomes an ever-present factor in the workshop.

Sociology becames an essential tool in this particular phase, with plans involving the different agents and the possible alliances they could strike up to resolve the conflict being identified. The aim here was to reveal the points where they agreed, disagreed and where they could find some common ground with a view to bringing about a union through elevation[22].

3. USING THE THIRD SIDE TO BUILD MORAL LEADERSHIP

During the course of the sessions the need to create moral leadership capable of establishing boundaries and clear and acceptable guidelines for everyone was stressed time and time again, as was the role of people, throughout history and up to today, as the leaders of the causes involved in water conflicts.

The plan outlined was as follows:

In its capacity as a national chamber the senate should promote what conflict-resolution experts term as the Third Side: a platform made up of figures with the ability to foster agreement on certain principles of water regulation, government and management. With regards to the people making up this platform, some participants insisted on the need to speak of representativeness rather than representation (which is provided by the senate). These figures should come from all sectors, spheres, regions and levels but should not represent them, although they are of course representative of these socio-economic and/or cultural areas. One of the contributors even suggested a name for the platform: Red Española de Reflexión Hidráulica (RERH) (Spanish Water Think Tank Network).

A forum for negotiation was also put forward. Based on the experience acquired in this area, the panels set up for this purpose (the RERH or forum, for example) would draw up a road map and a ten-point code of ethics. This road map and code should:

• Not focus on the major problems involved in the conflict
• Allow all sides to establish common ground
• Bring about "union through elevation" (sic)
• Should identify common ground between the parties involved and where they have right on their side
• Distinguish between ends and means
• Be capable of promoting agreement between the two main political parties

4. A HIGHER AUTHORITY

This point needs to be emphasised as it came up again and again during the session, with contributors expressing the belief that a higher authority would apply the principles of the Third

[22] Sociology was also put forward as a means linking together innovative experiences that could be applied in these phases of the process, such as citizens' panels, a natural development of the focus group.

Side. But, if we are to consider it as non dependent on any political party, as proposed by some contributors (and no opposition to this has been expressed) then fundamental doubts certainly arise. The question is then, who is it dependent upon? No answer was given although a nice name, reminiscent of the New Deal, was put forward: the National Water Authority.

The ideas proposed during the session failed to bring the proposal into sharper focus: Red Eléctrica (Electrical Network) and Consorcio de Seguros (Insurance Consortium). Contributors overlooked the fact that the issue involves companies and organisations directly controlled by the Executive and comprising the economic agents affected (producers, distributors, users).

The pragmatic arguments supporting this higher authority were made clear, however. There was even some unintentional verbiage on the part of some participants, who, for example, pointed out the importance, within the framework of the risk society, of consumers using a resource as strategic as water, not because of its shortage but because of its quality. It was felt that the water confederations had succeeded in giving reassurance to users concerning this aspect.

It was no surprise, then, some contributors responded to this proposal by pointing out that there was already something to that effect in place, that we already had a ministry regulating water and the perfectly sensible 1985 Water Act. And if the confederations (argued a larger section) have provided a solution/service for over half a century, what was the point in devaluing them? Why not use them? But after noting another contradiction (or an ambiguity at the very least) following other comments made during the session, the observer was forced to ask himself: Was that not where some of the most dangerous remnants of the water technocracy could be found?

5. NO NEED TO REINVENT THE WHEEL, MERELY APPLY SUCCESSFUL MODELS

Several contributions focused on the fact that most of what was being proposed was already in place, with one expert stating: "There is a lot of agreement with regard to water already. All we have to do is extend it."

In some cases the specific successes of conflict resolution were highlighted and it was argued that all that needed to be done was to apply the method used in these particular disputes to all cases. This raised the question, though, of whether a dispute between fruit and vegetable growers and dam builders is the same as one between environmentalists and golf course builders, or between farmers and nuclear power station coolers? As a result, and as we shall see in a later section, the issue of conflict-resolution techniques was discussed in depth.

As well as specific capabilities, institutions with centuries of tradition such as the Water Tribunal, were also held up as shining examples. There were compelling arguments in favour of its use as a model, a view that met with some support. The fact that the disputes referred to involved parties with shared cultural codes and similar general objectives, namely irrigation, was overlooked, of course, which begged the question of whether the expectant irrigators of the ill-starred Channel of the Right Bank of the Ebro, for example, can share the same cultural codes as the hotel owners of the Levante coastline?

The same idea was proposed at different points throughout the rest of the session.

Some participants chose to call it "learning from cultures that work", while others spoke of identifying "intelligent communities" that know how to avoid disputes. Examples were given, such as the Networks of Nature Reserves, which have managed to overcome the divisions that may be created in or between communities by the creation of strict conservation criteria.

Another model put forward were islands rich in natural resources, small enclosed universes that are nevertheless open to transfer processes in the shape of subsidies, something that makes it difficult to apply the model on a general basis.

6. TAKING STOCK

Strangely, and despite the fact that it was agreed that most water conflicts are essentially rooted in financial interests, the issue of economics barely came up during the sessions. It could be said that as the assembly adhered to the Kantian dream of universal peace, it resisted the lure of material concerns, although it is true to say that Kantian idealism is founded on deep-rooted pragmatism.

It is perhaps because of this that economic aspects appear in a pragmatic sense. As has already been stated, it was proposed that parties able to resolve disputes (agents, collectives, regions) be rewarded for it financially.

And in an even more pragmatic sense several participants stressed that it is merely a question of getting the compensation payments right, although it was not made clear who needs to be compensated. Who does it rain on, as it was argued three decades ago, a question that added fuel to the fire of serious regional conflicts? Who is the victim of flooding? Anyone who has any expectation of using water ? The state? In short, to whom does water belong?

Other contributions and subsequent written submission focused more bluntly on the price of the resource. If everyone paid what water was worth, then there would be no problems. Yet, doubts arise if we take as a given the determining role that has been played by the application of prices that more closely reflect costs in the implementation of water-saving measures. Would such a step really put an end to disputes or would it simply place water under the control of the powerful? Will the price of water represent an obstacle to certain projects when it plays such an insignificant part in their creation?

7. APPLY CONFLICT-RESOLUTION TECHNIQUES

If there was one aspect that took up a significant amount of time during the sessions, however, particularly the section devoted to proposals, and then it was the issue of mediation and conflict-resolution techniques. The fundamental concepts of theory were cited repeatedly as well as proposals for action. To summarise them, theory and praxis can be combined in the following principles, which were largely agreed by contributors:

- Anticipate disputes, taking it for granted that they will arise.
- Accept conflict and everything it involves:
    - Aim to resolve it in a peaceful way.
    - Share principles so that dialogue is possible.
        - Some experts said this meant that the parties would have to start off by stating what they understood as “agreement on water-related issues”.
- See it as an opportunity.
- Use it as a tool for innovation.
- Managing conflict involves:
- The need to keep politics out of the issue was stressed repeatedly
    - Although it was not explained what was meant by this: at the senate or not?
    - Ensure cooperative management of the conflict (Does this refer to management that all parties are involved in?).
        - Which requires the creation of participation structures
- Promote the culture of peace
    - Which (note) involves fighting against inequality. Failure to do so, it was claimed, would mean that someone suffering as a result of agreement being reached.
    - The new school subject of Citizenship Education is a vital tool that we can now

use to promote this culture of peace among the generations who will have to deal with new conflicts in the future.

- These issues should be raised, therefore, so that young people can learn not only about ethics but can also understand social processes.
- This commitment should bring results: the prioritisation of investments where agreements have been reached,
  - Or, at the very least, promote those who achieve peace as an example.

Some participants resumed the above in a single concept, the meaning of which was expanded upon in some of latter contributions. This concept can be summarised using the terms honesty and sustainability. Some contributors said the honest application of the Framework Directive in the river basins would be enough in itself, which is something that (as a means of closing the circle) can only be achieved, of course, by the aforementioned higher authority.

FINAL PROPOSALS

The above can be summarised in the following proposals:

1. That the senate be presented with the demand made by this regional representative body that the political parties and regional governments be called upon to agree to a lengthy truce in relation to water until such time as mechanisms ensuring equality, justice and sustainability have been created with a view to tackling both existing and potential disputes.

2. The creation of a body capable of taking an unbiased and impartial view of the basic aspects involved in the use and management of water in Spain, and able to announce its findings with the necessary moral authority. This body should provide a democratic platform so that all the parties may voice their current and potential requirements.

3. It was agreed that water be made an issue of national importance, with all parties with political representation in state institutions at all levels pledging not to use water as an identifying characteristic or for electoral purposes.

4. That a National Water Authority be created and set down water management criteria (By parliamentary mandate and in the same way as the bodies governing the judiciary or the board of Spanish state broadcaster RTVE?).

5. That the school subject Citizenship Education focus on aspects relating to water management, the Framework Directive and disputes over water.

6. That all levels of government reach agreement on strengthening/encouraging public investment in water infrastructures in those areas where management of the various interests involved can be held up as a model.

Thematic Week 9

WATER AND ENERGY

Water for Energy and Energy for Water

Non-conventional Energy Resources

Positioning document

General Coordinator:
Gonzalo Sáenz de Miera. Universidad Antonio Nebrija

Assistant coordinators:
María Mendiluce. Universidad de Comillas

Throughout history, water and energy have been **engines for economic growth and human development** and they will continue playing a **fundamental role in the future,** in a scenario characterised on one hand by increasing demographic pressure, and on the other by climate change.

Up to now **the relationship between these two basic resources** has usually been studied only from the point of view of hydraulic energy generation, considering water as a valuable raw material to produce electricity. However, it is evident that **this relationship goes much further;** it is much deeper:

- **Water is vital for the extraction, transformation and use of energy;** it is used as a productive factor in hydroelectric energy production and as coolant in all other energy generation processes, to the point that the electricity sector is currently, after agriculture, the main water user in advanced economies.
- **Energy is fundamental in the water system:** For pumping, transport and distribution; in desalination processes; for its treatment and purification and for its final domestic, agricultural and industrial usage.

Furthermore, a common feature of water and energy is that both **are governed by unsustainable models.**

- The current model in the **energy sector** is based on **fossil fuels and constant demand growth,** and is responsible for the transformation and use of energy of two thirds of all greenhouse gas emissions.
- The water management model is based on **intensive use of the resource and the exponential increase in demand** that today shows clear signs of unsustainability with regard to processes of resource degradation and aquifers overexploitation.

Climate change processes have worsened the problem, increasing the need to introduce criteria of sustainability in the use of energy and water resources. And this critical situation must lead to the development of integrated responses that are able to harness important synergies in "new water and energy cultures".

Current challenges must lead to the creation and definition of **feasible and sustainable future scenarios in the area of energy and water,** which enable us to guarantee universal access to these resources (currently 2,000 million people have no access to water or modern energy services), which are basic for economic progress and development, without this leading to a worsening of current environmental and safety problems.

Spain is an **especially interesting country to study** this **joint water-energy problem.** On the one hand, it is a country where energy consumption has increased significantly in the last decade due to a substantially higher economic growth than in neighbouring countries. In Spain, however, water is a scarce resource and therefore policies and habits of responsible consumption as well as efficient management of resources are even more important. Under these premises, it **is necessary to carry out energy consumption estimates to find out energy needs** for the next few decades will be, how we are going to cover them, **and what water consumption will be** in relation to this energy production. Such an analysis will enable us to answer concerns over the supply security of these resources and the environmental feasibility of demand.

The **relationship that exists between water and energy is so intimate** and it has such an important impact on the economy and wellbeing of society, **that it should be the focus of very special attention** by public authorities and the object of a detailed and thorough analysis by industry, academic institutions and society as a whole. However, it is currently **a question that is insufficiently analysed and valued** when drawing up sector policies.

This document aims to examine these questions by, firstly carrying out an analysis of the relationship that exists between water, energy and economic development, focusing on the case of Spain. Secondly, the unsustainability of current water and energy models will be analysed, as well as the consequences that these have on supply security and the environment in Spain. In third place, a series of recommendations for integrated policies in Spain will be proposed, ending with a series of conclusions.

1. RELATIONSHIP BETWEEN WATER AND ENERGY

1.1 Water and energy as motors of economic development

Water and energy are two essential elements for human development. Without water, human life is not possible; man depends on it for survival as well as for physical, economic, social and cultural wellbeing. **Access to energy promotes economic development and improves standards of living,** as it enables health, education, IT and communication services to be provided.

Energy allows water to be obtained in the necessary quantity and quality for human consumption and for production activities, while in turn water is an important element in energy processes.

Over the last centuries, water and energy availability has been the motor of economic growth in western economies. The infrastructures that have been set up in these countries since the second Industrial Revolution have permitted access to safe, quality water and energy (basically electrical), which has contributed to an unprecedented economic growth.

Lack of access to these resources in less advanced countries has inevitably led to situations of extreme poverty: Currently, there are more than 1,000 million people who do not have access to drinking water and almost 2000 million consume water that has not been suitably treated.

- The World Health Organisation estimates that one third of the deaths in the world are produced by the intake of polluted water and half the world's population is exposed to diseases derived from drinking water of an inadequate quality. It is calculated that diarrhoea kills more than 3 million children a year.
- **2,400 million people (*i.e.,* one third of humanity) have no access to advanced forms of energy: electricity or liquid or gas fuels.** To cover their primary needs such as lighting or heating, they still need to burn wood, waste and animal excrement, a situation that is typical of pre-industrial societies.
- **Lack of access to these advanced forms of energy,** especially electricity, means that they **do not enjoy technologies that are essential in the provision of basic services in life,** such as clean water, lighting or healthcare, or key factors for development, such as education, telecommunications or computer services
- Furthermore, according to data published by the World Bank, five million people die every year in developing countries due to breathing in the smoke produced by burning biomass in homes.

Access to **clean water, sewage systems and advanced forms of energy and energy services** (which in turn improve access to water as they enable it to be pumped, its transport treatment, desalination, etc.) **has a positive cross impact on all the Millennium Development Objectives:** reducing extreme poverty, facilitating access to education and gender equality, reducing infant and maternal mortality, improving health conditions and in general, contributing to economic and social development.

The geographical and climate conditions of countries and regions define to a large extent the natural limits, in terms of natural resources, which are available to them for development, causing great differences between regions. The Mediterranean arc is of special importance for Spain. The Gibraltar straits, together with the USA – Mexico border, are frontiers that markedly separate two very different realities both in socio-cultural and economic development terms.

In spite of the fact that over the last few years North African countries[23] have increased their economic wellbeing, the differential with EU Mediterranean countries[24] has not decreased, indeed in many cases, it has increased. Water and energy are two factors that limit the development of North African countries, especially water, as Libya, Algeria and to a certain extent Egypt, have important fossil fuel reserves. (Willstedt, 2008)

Future development of the countries in this area will depend, to a great extent, on their capacity to satisfy their need of water and electricity, for an increasingly more urban population that could grow by about 40 million in 20 years. In addition, the possible climate changes that are expected to occur during the 21st century could worsen the already critical situation of the water resources in the region. (Willstedt, 2008)

Sumarising water and energy **availability is a limiting factor in economic growth and human development in the whole world** and will have an even greater effect in the future, especially in areas that are vulnerable the impacts of climate change.

1.2. Need for water resources in the energy sector

Water demand for energy uses can be of two types: **demand for use,** which consists of it simply deriving water and later replacing volums to the water course (non-consumptive), and **demand for consumption,** which occurs when the water is no longer available in its natural state, either because of evaporation, pollution or because it has been incorporated into other products.

Each phase of the energy production cycle needs water: extraction and production, generation of electricity, refining and processing, transport and storage. **These processes may affect the amount of water** available for other uses, but furthermore they may also have a significant effect on the **quality** of the resource. The table below summarises the effects of production and use of energy on water, according to the US Department of Water (US DOE, 2006)

Water is used in large amounts for extracting oil and in the coal and uranium mining sectors. **Oil refining is one of the most water-intensive industrial activities.** Water is consumed in the form of high-pressure steam (heated by natural gas), necessary to separate heavy oil from sand, especially with bituminous sands. In this use, it is considered that all the water used is consumed, usually due to the pollution level it acquires, making it impossible to return it to its original course or medium. **Transport and storage of gas and oil** requires the use of water for hydrostatic tests. Water is also needed in the preparation of underground storage for gas and oil.

To generate electricity water is used in thermal power stations **to move turbine-alternator systems and produce electricity.** All thermal power stations operate according to the same principle, which only changes depending on the primary fuel used to produce steam (uranium, coal, gas, biomass, solar). Water **is also used for cooling in these same power stations,** either in open or closed circuits.

In the case of **hydraulic energy,** water is used as raw material; falling from one level to another it passes through one or several turbines that transmit energy to an alternator that converts it into electrical energy. This is considered a **non-consumptive use** because it usually stays in its original state and undergoes no significant changes in temperature.

[23] Morocco, Algeria, Tunisia, Libya and Egypt.
[24] Spain, France, Italy and Greece

Table 1. *Water for energy*

Energy cycle phase	Amount of water	Quality of the water
Extraction and production		
Gas and oil prospecting	Water to drill, fracture and complete	Impact on underground water quality
Pumping gas and oil	Large volumes of water produced, polluted	The water produced can pollute underground and surface water.
Coal and uranium mining	Mining can generate large amounts of contaminated water	Waste and drainage can pollute underground and surface water
Generation of electricity		
Thermo-electric (fossil, nuclear, biomass, solar, geothermal)	Water for cooling and cleaning	Atmospheric and thermal water pollution
Hydroelectric	Losses through evaporation	Impact on water temperature, quality and ecology
Photovoltaic and wind	Small impact during construction	
Refining and processing		
Refining oil and gas	Water for refining	Possible pollution problems
Biofuels	Water for cultivation and refining	Wastewater in refining and cultivation
Hydrogen and synthetic fuels	Water for synthesis or reforming	Wastewater
Transport and storage		
Gas- and oil pipes	Water for hydrostatic tests	Wastewater
Coal waste	Water for transport	Wastewater
Transport by ship tm		Accidents
Underground storage of gas and oil	Water for preparing gas and oil storage	Sludge

The **flexibility in the operation** of hydroelectric power stations is highly valued, as it enables almost instant harmonisation of electricity production and demand. In addition, these power stations have a regulating pond in which water can be stored, enabling peaks in demand to be covered and ensuring **the stable operation of the system.** The complementary nature and synergic effects of the electricity-water partnership is particularly significant enabling the setting up of reversible power stations, which allow the alternative operation of the power stations, either as turbines or pumps, between two regulating ponds (Yagüe, 2008).

Regarding **bio-fuels, water consumption** takes place fundamentally during the cultivation phase since consumption for refining is similar to that required in oil refining. Water consumption varies considerably depending on the raw material used. Another aspect to be considered is whether or not the crop in question replaces previous crops, in which case the water consumption of the bio-fuel crop has to be calculated as the difference between the previous situation and the current one. It is even possible that cultivating bio-fuel crops instead of food crops could reduce water demand. (Linares. 2008)

Table 2. *Specific consumption of water for extracting and refining of fossil fuels (thousands of m^3 per Mtoe)[25]*

	Minimum	Maximum
Uranium mining	1,667	1,667
Coal mining	6,042	8,333
Oil pumping	125	29,167
Oil refining	1,042	5,000
Exploiting bituminous sands	7,500	7,500
Gas processing	250	250

Source: Gleick (1994)

Other energy alternatives are still at an early stage of development but may alter the water balance of the energy sector, such as hydrogen production by electrolysis.

1.3. Integral water cycle energy needs

Energy also plays an important role in water supply, to the extent that it would not be possible to offer water supply of good quality without energy. The cycle of water supply and use starts with water abstraction from a source, either an underground aquifer, surface water, by desalination or reuse of treated water. Once it has been obtained, it is transported through a complex and highly heterogeneous system of conveyance infrastructures that will depend on the characteristics of the terrain, until it reaches the treatment point, where chemicals are applied and it is subjected to the processes necessary for its final use, which may be agricultural, industrial or urban. The use of water entails, to a varying

Table 3. *Specific use and consumption of water to generate electricity (m^3 by GWh)*

	Use		Consumption	
	Minimum	Maximum	Minimum	Maximum
Thermal open cycle	75,700	190,000	1,100	1,100
Thermal closed cycle	1,100	2,300	1,100	1,800
Nuclear open cycle	94,600	227,100	1,500	1,500
Nuclear closed cycle	1,900	4,100	1,500	2,700
Combined cycle open cycle	28,400	75,700	380	380
Combined cycle closed cycle	870	870	680	680
Geothermal	7,400	7,400	5,180	5,180
Solar thermal	2,775	3,404	2,775	3,404
Hydraulic			5,400	26,000

Source: EPRI (2002)

[23] Mega ton of oil equivalent

degree, a certain amount of deterioration in its quality, generating wastewater, which increasingly undergoes treatment before being released back into watercourses.

A reference study carried out in 2005 by the California Energy Commission quantified the relationship between water and energy as representing 19% of the consumption of electricity in this State and also indicated that 30% of gas consumption is related to the use of water.

In Spain's case, due to the distribution of competences, integral management of energy consumption throughout the complete water cycle is not possible. In the case of surface waters, which account for around 76% of water usage, capturing, storage and transport services in the major surface water systems are supplied by the River Basin Authorities for inter-community basins and by the Autonomous Communities for intra-community basins. (Yagüe, 2008).

Underground waters supply around 20% of water uses, and generally the users themselves (Municipalities, Irrigation Communities or individual farmers with irrigation rights) carry out the tasks of extraction, storage and distribution. Supply services (treatment and distribution of drinking water), collection and treatment of wastewaters are the responsibility of municipal authorities and sometimes of the Autonomous Communities. Irrigation water distribution services are supplied by irrigation groups or irrigation communities. (Yagüe, 2008).

Together with these natural resources, over **the last few decades, non-conventional resources such as regenerated and desalinated water have gained in importance.**

An initial evaluation of **energy consumption associated with the water cycle in Spain** must take into account the demand for water, which, according to the estimates of current river basin management schemes is 35,000 hm_3/year, of which **68% corresponds to land irrigation, 18% to water supply for towns and industries** and the remaining 14% is destined to cooling power stations (MIMAM, 2000).

If we consider a unit energy consumption of 3 kWh/m^3 for the integral water cycle and 0.2 kWh/m^3, shown in table 3 for irrigated land, the demand for electrical energy to manage water in Spain is that shown in the table below. (Cobacho, 2008). Thus, average energy consumption associated with the water cycle in Spain amounted to 24,000 GWh of a total, in 2005, of 223,000 GWh, representing slightly more than 10% of said total consumption in Spain.

The increased weight of desalination processes due to the shortage of water in Spain has an important impact on the energy bill. The minimum energy required for desalination, considering the pre-treatment needed and pump and membrane performance, is around 3.5 KWh/m^3 (Zorrilla, 2008). This doubles the energy consumption per m^3 when water is obtained from this source.

The conclusion is that energy dependence of the water sector is an ever more important aspect, not just due to the growth of energy consumption, but also because of increased costs that will increasingly affect users as progress is made in implementing the basic cost recovery principle of the Water Framework Directive (Yagüe, 2008).

2. FORECAST ANALYSIS OF THE RELATIONSHIP BETWEEN WATER AND ENERGY

2.1. Water as a potential limiting factor in energy forecasts

Current demand of water for the energy sector in the large world regions is not highly significant in relation to total supply, except in the case of the Middle East where, due to scarce annual rainfall, the increased demand for energy in 2030 in the reference scenario may jeopardise the satisfaction of other demands. (Linares, 2008)

It is, however, important to highlight that although in some cases water supplies may be significant, what is really relevant is water consumption, as water that is used can be reused, while water that is consumed cannot and it competes with water demand to produce energy. (Linares, 2008)

The increasing relevance of water demand to produce energy is clear. In many regions it will account for 10 to 20% of total consumption and this may begin to cause problems of competition with other supplies, especially irrigation and hence the supply of food. As in the previous example it can be observed that the case of the Middle East and Latin America are becoming a cause of concern, and it will be especially important for them to use energy technologies that enable them to be as close as possible to the minimum estimated values. On a global scale, the share percentage does not increase greatly, and in fact it may be less in the alternative scenario. (Linares, 2008)

If we consider water demand for energy with regard to other industrial uses, to quantify the competition of energy production with regard to other industrial uses in terms of water demands,

Tabla 4. *Estimated demand for electrical energy related to the use of water in Spain*

Use	Demand for water	Average unit consumption	Energy necessary
Urban and Industrial	6,300 hm^3/year	3.0 kWh/m^3	18,900 GWh
Irrigation	23,800 hm^3/year	0.2 kWh/m^3	4,760 GWh

Tabla 5. *Energy consumption in irrigation, agriculture and fishing by autonomous regions (MAFF, 2002)*

Autonomous Community	Irrigation					Agriculture and Fishing	
	Pumping		Work	Total	Consumption	Consumption	Consumption
	Electric	Diesel	Diesel	Diesel	Energy	Diesel	Energy
	MWh	tm	tm	tm	Ktep	tm	Ktep
Andalusia	530863	48047	108505	156552	270	467191	581
Aragon	103,254	7,058	55568	62626	85	177389	199
Asturias	0	104	377	481	0	52492	52
Balearic Islands	21,961	1,901	2360	4281	9	36800	41
Canary Islands	139,294	9.419	4,061	13,480	43	49,210	79
Cantabria	39	99	356	455	0	36,842	37
C. la Mancha	595,817	22,044	49,047	71,091	198	301,970	429
C. Leon	190,330	27,627	67,866	95,493	136	436,927	476
Catalonia	46,221	14,334	36,663	50,998	61	286,221	296
Extremadura	58,686	13,813	29,309	43,122	56	95,567	108
Galicia	525	3,260	11,793	15,054	15	413,306	413
Madrid	10,111	1,710	3,804	5,514	8	81,953	84
Murcia	543,652	15,226	27,238	42,484	159	85,507	202
Navarre	26,281	1,450	11,416	12,866	18	44,053	50
Basque country	2,953	519	1.878	2,398	3	137,211	138
Rioja	7,353	864	6,803	7,667	9	32,557	34
C. Valencia	589,868	14,903	48,556	63,459	190	214,691	341
TOTAL	2,867,228	182,399	465,601	648,000	1,261	294,9884	3563

relevant cases begin to appear; apart from those of the Middle East and Latin America already mentioned. However, caution must be taken over these conclusions since the increased participation of energy in relation to the rest of industrial demand may be due to two causes: an increase in energy production in its own right and the current demand for water in industry. (Linares, 2008).

In China, transition economies and the OECD-Pacific, industry already demands large amounts of water and it this may result in serious problems of competition for water. This is especially relevant in the case of China given its perspectives of significant industrial development in the future. In other cases, such as India, the rest of Asia, and especially Africa, it is above all due to the scarce participation of industry in water consumption. (Linares, 2008)

2.2. Energy as a potential limiting factor in water scenarios

Due to an increase in energy production with fossil fuels and the **impact** this has on the global climate, the next few years will almost certainly bring **changes in water availability,** and these will be much greater at regional level, according to estimations of the Inter-governmental Panel for Climate Change (IPCC, 2007).

This could heighten some of the problems detected, especially in regions such as Asia, Africa and the Middle East, in which water availability for consumption may decrease. In other larger regions, there could be significant interregional variations, which however cannot be captured due to the geographical resolution of this study. These problems will possibly increase in time, as the impact of climate change on rainfall will be greater, as well as global energy consumption.

Generally, predictions point not only to a reduction of water resources in some areas and increases in others, but also changes in availability patterns, possibly with a greater concentration of rainfall. This can affect different aspects: Less water availability for consumption, less production capacity in hydroelectric power stations, and finally perhaps a greater need for regulation of the rainfall. However this may be, a thorough analysis of this question requires a greater breakdown of data at regional level, both in relation to the possible impact of climate change and the effect on energy production.

3. UNSUSTAINABLE MODELS

The UN report on Human Development concludes that economic development involves unsustainable ecological impacts. The inhabitants of countries with a higher human development index consume biological resources at a much greater rate than the Earth can regenera-

Tabla 6. *Demand of water for energy in relation to total supply*

	2005	2030 Reference	2030 Alternative
OECD- North America	0% - 1%	0% - 1%	0% - 0%
EUROPE-Europe	0% - 1%	0% - 1%	0% - 1%
PACIFIC-Pacific	0% - 1%	0% - 1%	0% - 1%
China	0% - 1%	1% - 2%	0% - 2%
India	0% - 0%	0% - 1%	0% - 1%
Rest of Asia	0% - 0%	0% - 0%	0% - 0%
Middle East	1% - 15%	1% - 27%	0% - 1%
Latin America	0% - 0%	0% - 0%	0% - 0%
Transition economies	0% - 1%	0% - 1%	0% - 0%
Africa	0% - 0%	0% - 1%	0% - 0%
TOTAL	0% - 0%	0% - 1%	0% - 1%

Source: (Linares, 2008)

Tabla 7. *Water demand to produce energy in relation to current consumption*

	2005	2030 Reference	2030 Alternative
OECD- North America	2% - 9%	3% - 9%	2% - 5%
EUROPE-Europe	3% - 11%	3% - 11%	2% - 9%
PACIFIC-Pacific	3% - 7%	4% - 9%	2% - 6%
China	2% - 5%	5% - 12%	2% - 8%
India	0% - 1%	1% - 2%	1% - 2%
Rest of Asia	0% - 2%	1% - 3%	0% - 2%
Middle East	1% - 26%	2% - 47%	1% - 1%
Latin America	2% - 16%	4% - 26%	3% - 15%
Economies in transition	2% - 11%	2% - 15%	1% - 5%
Africa	1% - 10%	2% - 14%	1% - 4%
TOTAL	1% - 7%	3% - 11%	2% - 9%

Source: (Linares, 2008)

Tabla 8. Water *demand for energy in relation to current consumption in industry*

	2005	2030 Reference	2030 Alternative
OECD- North America	5% - 20%	7% - 22%	4% - 11%
EUROPE-Europe	6% - 22%	6% - 22%	5% - 17%
PACIFIC-Pacific	17% - 41%	24% - 54%	15% - 38%
China	8% - 21%	20% - 45%	9% - 31%
India	7% - 18%	19% - 44%	11% - 36%
Rest of Asia	8% - 33%	17% - 57%	9% - 33%
Middle East	44% - 932%	84% - 1.693%	22% - 53%
Latin America	19% - 126%	34% - 213%	27% - 125%
Transition economies	6% - 37%	8% - 51%	4% - 16%
Africa	26% - 223%	45% - 336%	25% - 95%
TOTAL	7% - 36%	13% - 54%	11% - 48%

Source: (Linares, 2008)

te them. Nations where consumption is at a level that does not damage the Earth's regenerative capacity tend to be below what the UN considers an adequate level of human development. **As these countries develop, global pressure on biological resources increases** which makes it a highly unsustainable growth model.

A **very high percentage of the planet's inhabitants do not have access to water or to modern energy services** in the quantity and quality necessary for human development, but their incorporation into a consumer model similar to that of developed countries **will considerably increase pressure** on these finite resources in terms of both supply security and environmental protection.

3.1. Energy model

Numerous studies with different approaches and perspectives carried out by institutions of undisputable prestige coincide in stating that the **current global energy model** – based on fossil fuels and with constant growth of demand - **is unsustainable in economic, social and environmental terms.** And this is true, fundamentally because **the transformation and use of energy generates two thirds of the total amount of greenhouse gas emissions.** The fourth IPCC report states that to maintain the concentration of greenhouse gases (GHG) below 450 parts per million (ppm) it will be necessary to reduce emissions globally by 50% in 2050 in comparison to 2005 and 70% in relation to 1990. The IAE predicts that the probable scenario in 2030 will be a concentration of GHG of between 850 and 1130 ppm, which could mean an increase in temperature of 4.9 to 6.1 °C, with catastrophic consequences for our planet. The demand for electricity and oil products is behind this increase in GHG.

3.2. Electricity sector demands

The demand for electricity in the world has grown by 54% from 1990 to 2005 and forecasts estimate that this energy demand will continue replacing other energy sources and that its demand will grow by 94% from 2005 to 2030. This growth will result in a 71% increase of emissions in the electrical sector in the reference scenario of the IAE, representing 45% of CO_2 emissions in 2030. Developing countries, with an average annual growth rate of 4.6%, will consume half the world demand. We can highlight the case of China, which will consume 24% of all the electricity produced in the world in 2030.

Different sources of energy are used to produce electricity, however coal is the most polluting and the most widely used as it is currently very competitively priced and there are large reserves all over the world, especially in China and the USA. For this reason, and if it is not possible to significantly reduce GHG emissions of coal, the current energy model will be unsustainable in the medium term.

In the reference scenario of the IEA in its World Energy Outlook 2007, in 2030, coal will supply 45% of the demand and will be responsible for 71% of the CO_2 emissions. Nevertheless, in the alternative scenario, greater development of clean energy sources (29% of electricity generation in comparison to 20% in the reference scenario) and a restrained demand (with a reduction in the demand of electricity of 12% due to increased energy efficiency) could reduce emissions in the electrical sector by 27% in comparison to the reference scenario. **Despite this improvement, this scenario will still be unsustainable and will not achieve the objectives established by the IPCC** as greenhouse gas emissions will increase by 27% from 2005 to 2030, all this growth occurring in developing countries.

Regarding the water problem, as has been mentioned, technologies for generating conventional thermal energy employ water to produce the steam needed for transforming energy or as a coolant, in which case most of the water is recovered. **According to the IAE reference scenario, in 2030, 80% of electricity generation in the world will need water.**

These growing needs for water enter into conflict with pressures for its use, as a result of population increase, more prosperity and the resulting increased demand for food and industrial production. The consequences of climate change will heighten these pressures in some areas of the world.

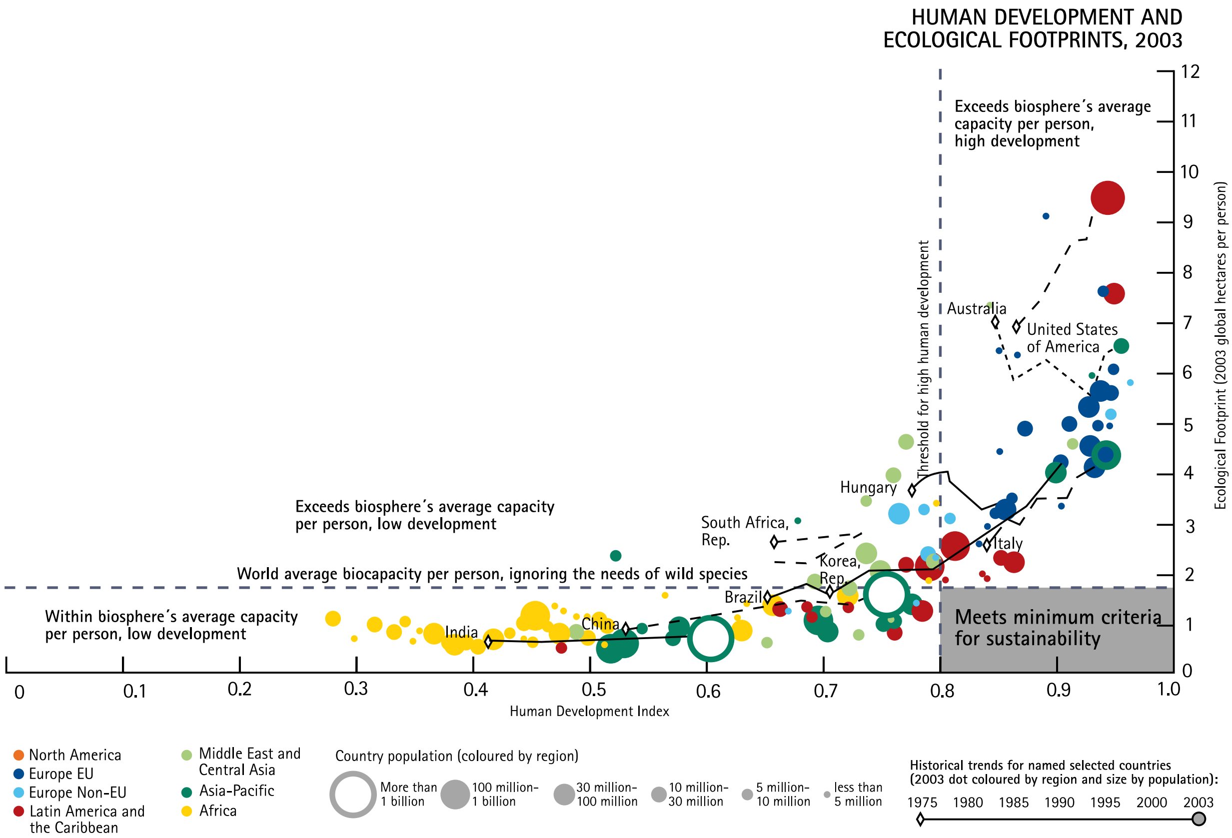


Illustration 1: *Greater levels of human development are associated with unsustainable ecological impacts.*

3.3 Oil demand

Oil demand accounts for 41% of energy demands of the OECD and 29% of those of developing countries. As these countries grow the demand for oil increases, which creates market tensions. As time passes, oil reserves will be concentrated in a small number of countries. According to the IAE reference scenario, OPEC countries will increase their weight in the global offer, from the current 42% to 52% in 2030. Countries not included in the OPEC will increase their offer slightly, principally through non-conventional resources. However, from 2015 onwards as, conventional reserves decrease, only Latin America, Canada and Africa will continue increasing their production. It is expected that in the 2006-2030 period, the USA and Europe will register an average interannual reduction in their oil production of 0.5% and 3% respectively.

Growth of oil demand is unsustainable as it is a finite resource with **limited reserves concentrated in a small number of countries.** At the moment, **there is no clear substitute for oil,** but some future alternatives have emerged such as **bio-fuels, hydrogen, renewable energies, and electric cars.** Any substitute for oil will have implications on water demand.

The main oil consumer is the transport sector. According to the IAE reference scenario, the transport sector will continue to be the main driving force behind oil demand, increasing its weight in the total consumption of oil from the current 47% to 52% by 2030. Although energy efficiency of vehicles has improved considerably, increased mobility, both in terms of the volume of vehicles purchased and the longer distances travelled, has amply offset the gains obtained by this increased efficiency. Taking into account the IAE forecast, there will be a spectacular growth in the total number of vehicles, from the current 900 million to 2.1 billion in 2030.

The lack of decoupling between transport and economic growth is a symptom of unsustainability. Economic growth in developing countries will lead to greater mobility, increasing impacts on the environment in terms of local and global emissions of pollutants and water consumption for extraction and refining of energy and because alternatives to oil, such as bioethanol or hydrogen, are also highly intensive in water usage.

3.4 Water model

The water available on Earth to satisfy human demands is very irregularly distributed and therefore **water shortage problems are local and aggregated statistics conceal these problems. The water model based on intensive usage of the resource and an exponential growth of demand shows clear signs of unsustainability** in terms of processes of water deterioration and overexploitation of aquifers. Underground water bodies supply one third of the world population and the phreatic and well levels are descending due to the overexploitation of aquifers. If the current trend continues, two out of every three people will live in areas with water shortage problems in 2025.

Currently more than 20% of humankind faces problems of access to water and 2,600 million people have no access to sewage services. Polluted water is the main cause of diseases that occur in developing countries, with an impact on more than 1,200 million people.

Added to the pressure of water demand is the fact that for the first time in the history of mankind, **we are facing global changes that affect the water cycle.** The fourth IPCC report comes to the conclusion that humankind has caused global warming, which is affecting the climate. With the passage of time it has been proven that climate change is moving even faster than expected. Each IPCC report has underestimated the speed of climate change and the consequences of the increased temperature on ecosystems.

The impact of increased temperatures is linked to water availability, and this results in an increase in sea levels (leading to the eutrophication of aquifers), in **water stress (insufficient water to cover all uses)** due to changes in rainfall, drought, floods, storms, hurricanes and tornados and the melting of the Arctic, Greenland's ice cap and mountain glaciers.

Water stress mainly affects developing countries, but the UNEP **predicts that it will spread considerably throughout the world, including Europe and the USA.** Demand for water will intensify with economic growth and population increase, as both of these types of growth imply an increased demand of agricultural and industrial products and of the residential sector.

The predictions of population and economic growth will mean a strong increase in demand for water and this will accentuate the unsustainability of the water model. In 2030, the world's population is expected to hit the figure of 9,000 million inhabitants and many emerging countries will reach similar levels of prosperity to the most advanced countries.

The agricultural sector of many countries with water shortage problems faces the **dilemma** of choosing between producing food or **importing it** from countries with optimum climate conditions. The problem lies in that with the current increase in food prices aspects related to safe supplies are increasingly relevant and the question posed is whether countries prefer to increase pressure on local resources or remain at the mercy of globalised markets.

Added to the problem of an increased demand for water, is the fact that this will occur in areas in which there were already problems of water shortages, such as the Mediterranean area, Spain or southern California, making water shortage a local problem that can derive in unsustainable practices. In these locations, **increased demand for water to satisfy energy production needs** (also in greater demand in these areas) **will generate more pressure between the different uses** and heighten the negative consequences that this has on the exploitation of water resources.

This situation is especially serious in countries on the Mediterranean coasts, where 60% of the planet's "water-deprived" inhabitants (with an annual water availability per capita of less than 1000 m^3) reside. In addition, we can highlight that agricultural products exported from this region are also transfers of so-called “virtual water” to receiver countries. Thus, all the countries in Northern Africa are net exporters of virtual water. (Willstedt, 2008)

Overexploitation of available resources, together with their climate conditions mean that these countries suffer a chronic fresh water shortage, leading to the overexploitation of aquifers, causing an important intrusion of seawater into them. The situation is especially serious in Libya, Egypt and Algeria, where the intensive use of desalination plants is necessary to cater for the increasing demand for water (Willstedt, 2008).

These pressures are not only reflected by aquifers overexploitation, which is a generalised situation in many countries (Libya, Egypt, Algeria, Tunisia, Israel, the USA, Russia and Spain amongst others) but also by the negative impact on diffuse pollution (nitrates and biocides), due to unsustainable use of fertilizers in the agricultural sector together with the overuse of pesticides, causing the contamination of aquifers.

The demand for good quality water in developing and emerging countries is faced with the difficulty of providing sewage treatment services for smaller towns, which due to their dispersion require innovative and more expensive technological solutions. Disposal of domestic, industrial and agricultural wastewater into public watercourses results in a deterioration of the quality of rivers, progressive loss of their environmental quality, a reduction in their drainage capacity and can ultimately affect the health of citizens.

These problems are worse in less developed countries, where the lack of sanitation causes a high rate of child mortality. In many cases a lack of funding for constructing of energy production plants is behind the absence of adequate water treatment systems. When energy is available, water can be obtained from wells, desalination plants or by wastewater treatment and reuse.

To conclude, **energy can solve some problems that make the water cycle unsustainable,** but the key is **how to produce this energy in a sustainable manner** so it does not contribute to climate change and therefore, aggravate the water cycle.

4. RECOMMENDATIONS FOR INTEGRATED PUBLIC POLICIES

4.1 Energy efficiency and renewable energies

Climate Change processes have made the **sustainable** use of energy and water sources a more **serious and urgent issue.** Climate change hence encourages an integrated search for answers, given the significant **synergies in the new water and energy cultures.**

The current challenges should lead to the establishment and definition of viable future scenarios in the energy and water sphere (within each area, *i.e.,* islands, river basins or catchment areas, coastal areas, etc.) in which the innovative concept could be self-sufficiency and maintenance of the functionality of ecosystems that form the basis of their sustainability.

Most authors consider **renewable energies as the most viable alternative to solving some of the major energy and water challenges**.

- The technically viable potential of renewable energies at global level is enormous (85TWh annually), far exceeding current energy consumption (15,18TWh) and future energy consumption in 2050 (25-30 TWh).
- Renewable energies are local and therefore can be adapted to the needs of disperse locations and facilitate access to water in population centres.
- They do not produce emissions and therefore are the most obvious solution to climate change problems.
- They are based on renewable and autonomous fuels and therefore reduce external dependence and provide supply security.

- In most cases they do not consume water; they are mainly non-thermal energies such as hydraulic, wind, marine or geothermal.
- Solar energy may provide a good solution in certain coastal areas where there is not much water, but there are high levels of solar radiation and often a higher concentration of inhabitants. It is in these locations where solar and wind energy can provide solutions as their cost decreases and the efficiency of desalination technology increases.
- They generate other positive local effects such as the creation of rural employment, development of a high added value activity, promoters of R&D&I etc.

One of the challenges to be solved to reach this renewable future is the intermittency of these sources. To maximise the implementation of renewable energies it is possible to develop different storage methods that help to convert intermittent supply energies into reliable energy sources, e.g. batteries, pumping systems and in the mid term, hydrogen produced by electrolysis. We will need innovative technologies to do this and ambitious R+D+I programmes as, according to IPCC forecasts, we do not have much time left to find solutions.

Another important aspect that is required to exploit the full potential of renewable energies is to reconfigure power grids to make them intelligent. This involves the creation of mini grids enabling homes, companies and industries to produce renewable energy locally. An intelligent network with intelligent electricity meters will enable local producers to achieve greater efficiency and to sell or buy from the power grid when necessary, so that the flow of electricity is two-way, thus reducing peaks and troughs and optimizing electrical energy generation systems.

Saving water implies saving energy. Saving water outside reduces the energy needed for pumping, treating and distributing it. Saving water in homes and companies enables in addition saving the energy used in tertiary transport, sanitation, transport of reused water and water treatment. Finally, saving hot water avoids all the above as well as energy needed to heat water.

The figures presented on energy required to provide water for consumption clearly highlight the importance not only of 'direct savings' of energy in the form of user-oriented campaigns or by improving specific processes (such as those employed in recent years for desalination techniques), but also of 'indirect savings' of energy derived from water saving policies. (Cobacho, 2008).

In Spain's case, in general terms, every m3 of water not used would reduce the energy bill by about 3 kWh.[25] Thus, if **water consumption for urban and industrial use were to be reduced by 30%** (around 1,900 hm^3/year), with a more conservative energy expenditure of 2 kWh/m^3 **the reduction in the global energy bill would be around 3,750 GWh,** a figure that represents almost **2% of total consumption in Spain** (Cobacho, 2008).

Bearing in mind the above, the study carried out by the California Energy Commission in 2005 proved that in this particular case, **investments being equal, rationalising water use saves more energy than introducing other measures of energy efficiency.**

Water-saving policies consist of two phases. In the first phase, distribution efficiency deals with reducing losses in existing pipes. The magnitude of savings will depend on the performance of the system, if it is low, then significant savings may be obtained. The second phase is focused on rationalising end consumption with user awareness campaigns and the installation of low water consumption devices in homes. The volume consumed will depend on users' habits, but savings will rarely exceed 20% of consumed volume.

Other options to reduce energy demands in the water cycle are: energy saving by means of reducing use and consumption, for example in cooling thermal power stations; improve operational efficiency (*e.g.,* by increasing the size of pipes and using more efficient pumps), move water cycle operations that are more energy-intensive to trough hours (*e.g.,* pumping and processing, this could be done with good price signals), develop

[25] It is necesary to add the energy consumption for water treatment.

renewable energies associated with the two cycles, for example, include micro electrical power stations in the pipelines, increase the capacity and use of pumping, and, in addition, use sewage sludge as biomass to generate electricity.

These improvements in energy efficiency imply a reduction in the demand of the water needed to take the energy to its points of consumption. Saving electricity or vehicle fuel thus leads to further savings of water. In the case of fuels, the saving is on the extraction of oil products, their refining and transport to the point of consumption, for which fuel is also needed. In the case of electricity, water for cooling turbines is saved in its use in power stations as well as the opportunity cost of not using the hydrological potential.

4.2 Technological proposals

As commented above, current energy and water models are unsustainable. In this document we refer to aspects of sustainability in relation to the connection between water and energy. Nevertheless, there are serious sustainability problems in the water cycle, which require more specific study.

The availability of reliable energy may solve some aspects that make the water cycle unsustainable but, as previously commented, the key question is how this energy can be produced in a sustainable manner and limiting consumption of water resources. Technological development will play a fundamental role in meeting this challenge.

Several studies that examine future trends in emissions predict that these will peak in 2030 and from then on begin to decline. The IAE carries out an analysis of two scenarios in its Report on the Outlook for Energy Technologies with a horizon of 2050. The first refers to the massive use of existing technologies and dropping inefficient technologies (ACT scenario). The conclusions of the analysis are that by 2050 emissions could be stabilised at the level of 2005 with these technologies. The second scenario contains optimistic hypotheses on important developments in technologies such as solar and wind energy, carbon capture and sequestration, nuclear energy, and mobility, amongst others, (BLUE scenario). In this scenario, emissions could fall by 50% by 2050, which would enable the temperature increase at global level to be maintained 2 and 2.4 ºC.

In both scenarios, energy efficiency in buildings, equipment, transport, industry and generation of electricity will be responsible for most of the emission reductions, but also for the reduction in water consumption, as commented above. Following this is the decarbonisation of electricity generation, achieved above all with a combination of renewable energies, nuclear, and the use of carbon capture and sequestration (CCS) in power stations. In the BLUE scenario, the most expensive options, such as CCS in industry and the use of alternative fuels for transport are developed.

In **the electricity sector,** the IAE forecasts that there will be a massive movement towards the generation of electricity with renewable energy sources, especially wind, photovoltaic, high concentration solar energy and biomass, generating **46% of the world's electricity in 2050 and 21% of emission reductions in the BLUE scenario. Carbon sequestration in power plants and industry** will contribute with a 19% reduction of CO_2 and nuclear energy with a 6% reduction in emissions.

Hence, **improved sustainability in relation to water and energy will be achieved, from a technological point of view, by the massive development of renewable energies.** However, to guarantee that the development of these technologies minimises impact on water consumption, it will be necessary to provide technological solutions for thermal generation (coal, nuclear and gas) and for concentration solar energy.

In this sense, it is possible to reduce the consumption of water in power stations by means of:

- Improvements in energy efficiency in combined cycles or supercritical coal boilers.
- Search for locations with less impact on water use where cooling can be carried out in open circuits, which involves a lower net consumption of water and greater efficiency and when this is not possible, to choose dry cooling systems with a lower performance and greater cost, but with less consumption of water or to opt for coastal

locations to apply cooling with seawaters or the reuse of wastewaters with zero liquid discharge (ZLD) policies.

- Combined wind-hydraulic generation systems such as, for example, the integral project of El Hierro island, which reconciles the management of renewable electricity generation with the production of drinking water from seawater, its storage in reservoirs to supply the population, as well hydraulic generation and pumping to refill the reservoirs.

Another area in which water has to be saved is in the entire mobility lifecycle, both that associated with oil as well as in alternative fuels (*e.g.*,bio-fuels, hydrogen, etc).

Finally integrated solutions must be found for the agriculture, water and energy triad. In this respect, new initiatives with a great potential are being undertaken using seawater and solar energy to produce food, fish and bio-fuels with integrated systems that reduce discharges of pollutants and absorb carbon.

4.3 Economic policies

Together with technological and sustainability proposals, there are a series of sectoral and transverse economic policy actions that enable the efficient management of these resources.

Economic policies have instruments to guide the use of water and energy towards means of exploitation, consumption and investment that provide the maximum wellbeing for society, while at the same time guaranteeing citizens' access to these essential services. (Gradolph, 2008).

The economy has traditionally used the market as a reference to solve questions relating to the management of scarce resources. It is a simple, effective instrument, which, through prices, sends out signals for agents to make decisions on the optimum level of consumption, the efficient pace of exploitation of resources or the size of investment required. The market is the reference instrument for the efficient assignment of water and energy resources. But there are deficiencies in the functioning of the water and energy market, known as market failures, which result in the prices not transmitting to the agents all the information necessary for an efficient decision to be taken that will ensure the greatest wellbeing to society. This occurs because the price of both resources often does not internalise the real and environmental cost generated, leading to unnecessary or inefficient consumption. In addition, water consumed often has no price or it is consumed from illegal tapping of underground waters. A revised water and energy price policy is a prerequisite to ensure its sustainability (Gradolph, 2008).

The prices of water and energy should be calculated to cover the costs of the service, while at the same time guaranteeing an essential service for the more vulnerable consumers.

Establishing artificially low prices does not send out the signal of the scarcity of the resource, leading, in the short-term, to overexploitation of resources and in the long term, posing a threat to sustainability because of exhaustion and the lack of economic incentives for investment.

With regard to this, policies that orient water prices towards its actual costs and policies that adapt the prices of electricity to market signals are essential. The deficit in electricity charges, for example, is the result of a price policy that dampens the market price signals and charges this cost to consumers in the following years. This means that by separating this payment and the price of the energy consumed, the consumer is not aware of the real cost of the electricity consumed and therefore cannot manage its demand. The result is that there is an unnecessary intervention in the agents' decisions, since they may not share the decision of deferred payment, and there are fewer incentives to adopt savings and energy efficiency policies (Gradolph, 2008).

It is thus necessary to highlight the role of the market in determining water and energy prices, avoiding the problems of setting a price, unless this were necessary to protect vulnerable consumers.

[28] It is necesary to add the energy consumption derived from purifying.

In the case of water and energy EU regulations trust the market to be the most effective instrument for transmitting the intensity of scarcity signals to agents. In Spain the EU guidelines are taken into consideration in decisions, e.g., doing away with certain electricity and gas taxes or the transfer of public water rights or the partial recovery of funding (charged to water taxes) of certain hydrological infrastructures by State Water Companies (Gradolph, 2008).

One of the main difficulties in correctly evaluating the relationship between these two elements is the absence of reliable statistics on water usage, which also makes it more difficult to control. In Spain there is no control of water usage, consumption being quantified by estimations. The information regularly published on this subject by the National Institute of Statistics is the result of questionnaires and statistical analysis. It is thus necessary to implement modern water audit systems that contain a record of energy consumption as well as establishing some sort of administrative control, which, to date, does not exist. The creation of Regulatory Agencies is an option that many countries are adopting (Cobacho, 2008).

The development of economic policies should include the joint planning of water and energy policies, from an integrating point of view, as well as the drawing up of regulations that are coordinated between the political heads of the water, industry, energy and environmental departments. The solutions that have been put forward in this document imply an increase in R&D&I actions in the water-energy sphere. In addition, this analysis should involve all social agents, business confederations, institutions, research centres, universities and companies.

CONCLUSIONS

On a global level, **"Water for life, energy for development"** acquires a significant value in the configuration of development policies to achieve the Millennium goals. Political world leaders must ensure that **the supply of these energy services, which are necessary for life, is organised in an energy-sustainable manner,** *(i.e.,* **reducing** greenhouse gas **emissions** that are generally associated with the consumption of energy, as well as **minimizing water consumption** to avoid conflicts with other uses).

Water and energy are two key elements to ensure **supply security** in all countries, as they are the essential raw materials required for production activities. It is thus important to take into account that both resources are intimately linked; if we want greater food security and more national products, we will need more energy. If we need more energy, we need more water, in more reliable and abundant supply. Hence, it is important applying efficient technologies and implementing technologies that reuse water.

The relationship between water and energy is so close that it has a profound impact on the economy and wellbeing of our societies, and hence should be the focus of very special attention by the public authorities and **careful and thorough analysis** by industry, academic institutions and the civil society. To date, this issue has not been sufficiently analysed and valued when drawing up sector policies. The connections between water and electricity generation systems are not taken fully into account and the same applies to technological proposals advocating the replacement of fuels used in transport. The end result of all of this is lost opportunities for economic and social development.

Bibliography

AZQUETA (2008): "Proposals from an economic standpoint on the connection between water and energy." Water and Energy Theme Week, Water Tribune, September 2008.

COBACHO (2008): "Energy implications in water supply and the need to increase efficiency". Water and Energy Theme Week, Water Tribune, September 2008.

GLEICK, P.H. (1994). Water and Energy. *Annual Review of Energy and the Environment,* 19: 267-299.

GRADOLPH (2008): "Economic policies on water and energy." Water and Energy Theme Week, Water Tribune, September 2008.

IEA (2007). World Energy Outlook. International Energy Agency, Paris.

IEA (2008). *Energy Technologies Perspectives.* International Energy Agency, Paris.

LINARES (2008): "Implications for water in world energy scenarios." Water and Energy Theme Week, Water Tribune, September 2008.

US DOE (2006). *Energy Demands on Water Resources.* Report to Congress on the Interdependency of Energy and Water. U.S. Department of Energy, December 2006.

YAGÜE (2008): "Energy for water", Water and Energy Theme Week, Water Tribune, September 2008.

WILLSTEDT (2008): "Water, energy and sustainability. The challenges faced by the countries on the southern shore of the Mediterranean", Water and Energy Theme Week, Water Tribune, September 2008.

ENERGY FOR WATER

Jesús Yagüe Córdova

ABSTRACT:

Water administration has significantly contributed to energy generation in Spain. Both hydroelectric exploitation and refrigeration of thermal energy plants have significant water requirements and are good examples of this contribution.

Hydroelectric energy production is modest within the total demand, though it plays an important role in satisfying primary demands.

In recent years, the growing modernisation of water use has increased the energy needs for the management of that (pumps, pressure irrigation, desalination) via which there is a growing interconnection between water and energy and vice versa (water for energy and energy for water).

This situation has created greater sensitivity in the water administration which is making all possible efforts to support the growth in energy production. Although the possibilities of increasing hydroelectric water production in Spain are limited, they are trying to optimise all possible action courses to achieve it – relying on the private sector to ease the start-up of the new exploitation that is still possible – the renewal and optimisation of the current exploitation and the development of reversible plants, in addition to driving forward with plants at the foot of dams from the public sector where this is possible. With all of this, it is hoped to achieve balance, to a certain extent, regarding the growing increase in demand.

HYDRO-WIND PLANT FOR EL HIERRO ISLAND. OBJECTIVE:
100% RENEWABLE ENERGY

Gonzalo Piernavieja

ABSTRACT:

El Hierro Island – the smallest of the Canary Islands (10,500 inhabitants and an area of 276 km², marked by steep orography) was declared a World Biosphere Reserve by UNESCO in 2000. Currently, its energy demand is covered by fossil fuels – burning diesel in a thermal plant – which leads to a complete energy dependence on outside forces. The El Hierro inter-island council – in its determined push for sustainable development – has committed itself to implanting a scheme that will allow them to be supplied via their own renewable energy. In order to guarantee a constant electricity supply, it is intended to "accumulate" wind energy (of enormous potential on the island but fluctuating) using a hydraulic system comprising two tanks located at distinct heights: when the wind energy is above that of the island's demand, water will be pumped up to the higher tank; when the wind is not enough, the fall of the water stored in the upper tank will move the hydroelectric turbines. This Hydro-Wind Plant is promoted by a consortium formed by the El Hierro inter-island council, ENDESA, the Canary Islands Government (through ITC) and IDEA. Other actions using different renewable energies will join together with wind power to achieve total energy self-sufficiency for the island.

EFFICIENT DESALINATION

Julio Zorrilla

ABSTRACT:

With the growing demand for drinking water, desalination as a technology that is competitive with other supply sources has featured important advances in the last few years regarding energy consumption and environmental impact.

The theoretical energy requirement for desalinising one cubic metre of sea water is 0.9 kWh; however, none of the existing industrial technologies on the market fall below 3.5kWh, including the necessary pre-treatment and performances in the processes.

Advances in pumping systems have improved consumption in the last few years and research into new membranes could improve this still further in the future. Meanwhile, the tendency is to optimise the process as far as possible according to the water to be treated in pilot plants and, then, incorporate measures that reduce the environmental impact of the installations.

Two of these development lines are centred on sea desalination – either established in conjunction with in situ renewable energy creation or mobile on boats – that in some cases offer exclusive advantages.

PROSPECTIVE 2030:
IMPLICATIONS FOR WATER AND ENERGY

Ignasi Nieto

ABSTRACT:

Water and energy have been united ever since man discovered technology to make progress. Water and energy comprise separate current and future challenges – the former in many countries and the latter for all mankind. One of the best ways of fighting against climate change is by promoting renewable energies, some of which continue to use water. Furthermore, in the future, we will have to continue having a large part of our energy production coming from conventional sources and technology. Therefore, the long-term analysis of the energy demand and offer must include an impact analysis on water consumption. Thus, advances in terms of sustainable energy (environmental, social and economic) must also be undertaken with responsible water consumption.

There is a transverse vector which unites water and energy which is land and its management. Land is a scarce good and is gaining greater appreciation in our societies as a good to be conserved and protected. This change in energy model involves more land infrastructure that is more disperse than in the past. Therefore, a coherent and coordinated policy that bears in mind the water-energy-land trinity is needed.

IMPLICATIONS OF THE WORLD ENERGY: SCENARIOS FOR WATER

Pedro Linares

ABSTRACT:

A growing concern in the energy sector is how to face the growing water demand in the sector – in an environment in which water is becoming an ever scarcer good all the time. Indeed, the increase in energy demand at a global level will require more water for refrigeration of the power stations, for the cultivation of bio-fuels or for the extraction and refining of fossil fuels. However, the intensive use of fossil fuels significantly contributes to climate change which in some countries will reduce the water supply but in all others it will do so in a more irregular way. The objectives of this document are to analyse water use according to future water scenarios (starting from the estimations of the International Energy Agency) and evaluate the changes in water demand for energy use in relation to the expected water supply for the various geographical regions. The results will provide valuable indications about the extent to which water could be a conditioning factor in predicted energy scenarios and about the measures that could be adopted in the light of the limitations that could appear.

THE NEED TO IMPROVE EFFICIENCY IN WATER AND ENERGY:
DISTRIBUTION AND USE

Ricardo Cobacho, Enrique Cabrera and Miguel Ángel Pardo

ABSTRACT:

Within the current context of the scarcity of both water and energy resources, it is necessary to reinforce the orientation of management policies to increase efficiency in their management. Specific programmes of this type exist in both fields. This document, however, does not focus on each of the resources individually but on the relationship between the two and, especially, on its implications for urban water supply. Thus, examining reference work undertaken in California, the main objective is to quantify this relationship in the case of Spain and to acquire the figures corresponding to each stage that this supply follows – as a calculation tool to help in decision making. Lastly, from the results obtained, directives considered most appropriate for the future are proposed.

KEYWORDS:

Urban water, energy, efficiency, demand management.

THE CHALLENGES FOR THE COUNTRIES ALONG THE SOUTHERN SHORES OF THE MEDITERRANEAN IN THE LIGHT OF CLIMATE CHANGE

Heikki Willstedt Mesa

ABSTRACT:

Along with the border between the USA and Mexico, the Straits of Gibraltar is a border that separates two completely distinct cultures – not just due to the socio-cultural differences between either shores but also to the great difference in economic development of the countries that are found on one and the other side.

There is actually a great difference in the current energy and water consumption indicators for the formation of riches between the countries on the northern shore and those on the southern shore of the Mediterranean. The most outstanding is that the countries to the south have an index of renewable exploitable water resources above 107% between them and that they also need 10 times more water and 3 times more energy to generate each unit of GDP than their neighbours to the north. By choosing desalination, the majority of these countries are only worsening the sustainability of their economies at the same time as increasing their energy consumption and their CO_2 emissions.

According to the climate scenarios for the end of the century, the region will see its precipitation diminish while its temperatures will rise by up to 3.5 ºC, so that the stress on the water resources will increase considerably – in addition to that caused by predicted population rise and consequent demand on water and energy.

In the light of these challenges, it is necessary to urgently establish regional development policies that place sustainable water (and energy) management at the heart of their development plans. Not doing so means that the capacity of these countries to improve their people's conditions of life will be diminished – particularly starting from the second half of this century when the effects of climate change could be dramatically obvious.

SUSTAINABLE BIO-FUEL PRODUCTION

Carlos Alberto Fernández López

ABSTRACT:

Demanding the fulfilment of sustainability requisites has become commonplace in the current debate on development in the bio-fuels sector. However, the lack of a common interpretation of what this means is a problem that threatens to discredit the very concept of sustainability.

Starting with the interpretation that is given in the Spanish Sustainable Development Strategy and the latest advances in the writing of the Guidelines Proposal related to promoting renewable energies, this document analyses the aspects that define sustainable production of bio-fuels according to the arguments that have maintained the Spanish position to this end in the work groups in the European institutions.

The basis of these arguments can be found in the attention to the various dimensions of sustainability, that together with environment (balance in greenhouse gases, pressure on water resources, etc) always include social and economic issues (for example, working conditions or effects on the local economy). Only through this focus can criteria and useful tools for society be developed with the intention of achieving the objective of reconciling economic prosperity, social wellbeing and respect for the environment.

THE ROLE OF RENEWABLE ENERGIES IN THE SUSTAINABLE WATER-ENERGY SOLUTION

Julián Blanco

ABSTRACT:

In the context of the energy crisis that is upon us, it is clear that water problems are going to get substantially worse. Reciprocally, due to the close link between water and energy, such water problems will contribute to an increase in the consequences of the energy problems. For the same reasons, just as it seems clear that it will be difficult to attain an energy-sustainable environment without a large contribution from renewable energies, so it seems unlikely that there is a sustainable solution to the future of water without the inclusion of these same renewable energies: 85 TW technically feasible (of which 60 TW correspond to solar energy) compared to the global human energy consumption of 15.18 TW in 2005. Furthermore, in the case of solar energy, coincidentally, around the world where water scarcity problems exist high levels of radiation are also present. Thus a – clear conclusion is that it makes sense to support the development of adequate technology that will allow existing renewable energies to simultaneously help solving both energy and water problems.

NEW FOCUSES AND SOLUTIONS IN THERMAL (REFRIGERATION) AND WATER (MULTIPURPOSE, PUMPS AND WIND) GENERATION TECHNOLOGY

Alfredo Cillero

ABSTRACT:

Traditionally, in industry, water has been used as if it were a limitless resource but in any thermal transformation process water is needed as an energy transformation vehicle and as a source or drain for residual heat from the process (refrigeration).

Thus, we find that of the water used by industry, 2/3 of the waste water generated occurs in process refrigeration and this, in turn, is partially purified and returned to nature – partly degraded and reduced due to losses and evaporation.

In hydroelectric energy creation, water is used as a transformation vehicle for the energy stored to become electrical energy, but as water is a good that is getting scarcer, there is interference between the supply needs of the population and the need to generate energy. This interference is getting more obvious as the population increases and requires a greater quantity of water and, in turn, of energy.

Naturally, this model is subject to revision before the need to reduce consumption in a scenario of population growth, for which the more realistic and technologically achievable immediate proposals are based on applying savings policies through the improvement in growing energy efficiency, reuse of water, policies defined as “zero dumping” (ZLD) and the reuse of water in the process that has been purified after human use. In this way, development technology is aligned:

- In energy efficiency; from more efficient combined cycles (>60% performance), super- and hyper-critical carbon boilers in development stage, CO_2 harnessing.
- In reduction of water consumption, dry refrigeration, energy emplacement along the coast, open cycle refrigeration or using towers with sea water.
- Reuse of water through micro-filtration and inverse osmosis processes until achieving “zero dumping” (Zero Liquid Discharge).

To this, the policy of reduction in dependence on fossil fuels with the increase in renewable energies (basically wind and water) can be added. Europe believes that by 2020 it will be possible to supply all electrical energy with 20% participation of renewables. Therefore, an increase in electricity generated by the wind and exploitation of available water resources was envisaged, as well as mixed generation solutions. Among these latter, pumping installations and mixed projects exist such as the wind-water plants – to be found on the island of El Hierro.

R+D+I ACTIONS IN THE WATER-ENERGY INTERRELATIONSHIP

Milagros Couchoud

ABSTRACT:

The work of R&D&I in the Water-Energy interrelationship is to search for a common objective: achieving the necessary development and technological framework so that the energy system consumes less water and a lower quantity of energy is used when supplying water. Therefore, this is an attempt to create a new Binomial Water-Energy Economy in line with policies on efficiency, sustainability and environmental regulation that are being implemented in the European Union and in other countries around the world.

Achieving this objective means facing the R&D&I challenges that will help us escape from the technologically obsolete models. It is necessary to choose energy-sustainable technology that optimises water needs, as well as to propagate technology oriented towards energy savings for each litre of water that enters the supply cycle.

A clear example of this is the Solar Platform in Almeria – belonging to CIEMAT – where research projects and technological development takes place, such as the Solar Detoxification of Liquid Waste or the Solar Desalination of Sea Water. From an energy perspective, there are other proposals such as the hydroelectric plant in Cortes-La Muela (Valencia), or the construction of a new combined cycle plant in Malaga – refrigerated using regenerated water from the treatment facility in Guadalhorce.

However, there is still much to do. The work in R+D+I in the Water-Energy interrelationship must be oriented to analyse our country's water and energy needs, to search for technological solutions, improvements in management and efficiency, optimisation of resources and, in short, to find the necessary strategies that will help us face this important 21st century challenge.

USE OF RENEWABLE ENERGIES TO MINIMISE THE ENVIRONMENTAL EFFECTS OF THE WATER-ENERGY RELATIONSHIP AND THE USE OF HYDROGEN TO STORE ENERGY

Luis Carlos Correas Usón and Carlos Javier Navarro Espada

ABSTRACT:

Hydrogen is proposed as a complementary new energy vector to electricity and to substitute fossil fuels in transport, though technological advances and investment in infrastructure over the coming decade will determine the percentage for each vector in the future energy panorama. Its importance lies in the fact that it could will be the only alternative fuel able to supply the transport fleets per generation capacity.

In order to satisfy sustainability criteria, hydrogen production should use renewable sources and not those that emit pollutants or greenhouse gases – thus the importance of a good connection with the generation of renewable electricity. Even more, as water is the raw material from which hydrogen is obtained, there are serious implications that link the water cycle with the hydrogen cycle as an energy vector.

Likewise, reflection on the ever greater use in absolute and relative terms of renewable sources in electricity production leads to the need for a greater – and, perhaps, different – adaptation capacity for demand and production of electrical energy – including storage solutions. In this area, hydrogen could play an important role in particular applications linked to renewable energies.

Lastly, the progressive substitution of technology based on fossil fuels for hydrogen means a change whose magnitude requires a long-term strategic view that involves administrations, citizens and businessmen, that is starting to shape up in various places around the planet.

WATER AND ENERGY FROM
AN ECONOMIC ANALYSIS PERSPECTIVE

Diego Azqueta

ABSTRACT:

Economic analysis has provided a valuable service when rationalising such an important aspect of life as production and distribution of energy. With the help of corresponding emission inventories and adequate dispersion models, there has been an advance in rationalising decisions referring to what, where and how much electrical energy to produce – providing a monetary value for the social and environmental effects linked to each of the possible alternatives to solve the problem. The ExternE model or the Uniform World Models comprise the best examples of this effort. The case with water is parallel: essential for life, it also needs to be produced and distributed from scarce resources. Both energy and water production are strongly conditioned by geography. Therefore, it is necessary to have an economic efficiency analysis that also illustrates a more efficient production, distribution and use of water. The concept of "virtual water", along with the economic assessment of the environmental and social services of water, provides a good starting point. When, finally, it is seen that water plays a very relevant role – directly or indirectly – in energy production and that energy is a practically indispensable element in the production and distribution of water, the need for a Cost-Benefit Analysis becomes unavoidable.

WATER AND ENERGY IN ECONOMIC POLICY

Juan Gradolph

ABSTRACT:

Water and energy are two key natural resources for sustainable economic development. They both share characteristics of special import: their scarcity and their social relevance. In Spain, water and energy condition economic decisions in agriculture, urban development, tourism and industry. Water and energy management are a challenge for public managers who have to take a decision on the appropriate level of protection of consumers and, at the same time, establish a level of efficient consumption – one that guarantees sustainability. Indicated prices in the market could be subject to distortions and, very often, are simply unknown. Economic policy has instruments so, taking the vital nature of water and energy for granted, the agents have a price indicator to make an efficient decision on levels exploitation, consumption and investment to guarantee the sustainability of the resource and maximize society's wellbeing.

WATER SCENARIOS FROM A CORPORATE PERSPECTIVE

Jürg Gerber

ABSTRACT:

No water - no business. Companies must understand local water conditions to make intelligent decisions. Many are only just now beginning to grasp how essential water is to everything in life – food, energy, transportation, nature, leisure, identity, culture, social norms, and virtually all the products used on a daily basis. With population growth and economic development driving accelerating demand for everything, the full value of water is becoming increasingly apparent to all. Scarcity usually encourages better management of resources.

For some business this trend means new economic opportunities in making water available to meet demand or in finding solutions to improve water quality and water use efficiency. For others, it means closer scrutiny of how they, their supply chains, and their markets access and use water, and of how new business risks emerge as they compete with other users.

The World Business Council for Sustainable Development (WBCSD) has been documenting successful business experience in water management, partnerships, and provision of water services to the poor since it formed its first water working group in 1997. In 2004, the group of WBCSD member companies that we represent decided to reinforce our collective effort to help businesses understand why they should be thinking about water and what they can do about it.

THE WATER-ENERGY-GREENHOUSE GAS CONNECTION

Gary Klein

ABSTRACT:

In 2005, California began a serious look at the water-energy-greenhouse gas relationship in the state. Saving water saves energy. Saving energy saves water, both where there are cooling towers on buildings and at thermal power plants which use water for cooling. You save more in Southern California than in Northern California because of the energy attached to imported water. Saving water used outdoors is good (pumping, treatment and delivery), saving water used indoors is better (no waste removal, treatment and discharge) and saving hot water is still better (no energy to heat the water too). The objectives are:

1. Understand the magnitude of the water-energy-greenhouse gas connection in California. Learn about the variability of this relationship in different regions in the state. Extend the discussion to other parts of the country.
2. Identify synergies in this connection that make it a prime candidate for joint programs among water and energy agencies.
3. Discuss programs and policies that simultaneously improve the efficiency of the water-energy-greenhouse gas connection.
4. Expand the implications of the analysis from California to the United States and other countries.

ENERGY AND CLIMATE SECURITY FOR EUROPE AND BEYOND

A. Battaglini, J. Lilliestam and A. Haas

ABSTRACT:

Increasing energy needs and the threats posed by climate change pose new and unexpected challenges to the current energy system. A fundamental shift to a decarbonised economy is required to achieve energy and climate security. Europe has committed itself to 20% emission reduction by 2020, to a 20% share of electricity from renewable energy source and to keep global mean temperature increase below 2°C over pre-industrial levels. In order to achieve its targets Europe needs to develop and implement policies which foster a transition towards a 100% renewable electricity system. Among the different options taken into consideration there is the possibility of linking Europe to North Africa with high voltage direct current (HVDC) lines for transporting electricity produced from renewable energy sources. For the ongoing UN-post 2012 agreement negotiations it could be an important breakthrough if the EU, together with partners, would come up with a plan, which combines a realistic sharp increase of renewable energy for the EU, with a co-operative approach with a developing country region to secure energy security and greenhouse gas reduction in both regions and possibly with a breakthrough for important technologies and instruments which can play an important role world wide.

WATER-ENERGY INTERACTIONS:
A LOOK AT THE CHALLENGES ON DIFFERENT LEVELS

Jean François Bonnet

ABSTRACT:

This document provides a general presentation about the existing relationships between water and energy and a quick analysis of associated challenges. It refers to various scientific and technical works completed or begun since 1998 in relation to this topic at Bordeaux University and Trefle. Different ideas have been taken from work on a thesis by X. Goznes regarding energy matters in the area of irrigation, as well as from various collective works. Around the matter of “water and bio-energy”, there is also reference made to the work being undertaken per the CLIP prospective study “water and bio-fuels in France in 2030” – working in collaboration with D. Lorne (IFP).

The aim of the presentation is to contribute a general overview of the water-energy interactions focusing on different levels: global, regional/national and local. The methodology is based on:

- Identifying the main relationships which link water and energy;
- A physical description of the processes, systems and flows involved;
- A quantitative evaluation in terms of amplitude;
- A study of specific cases to complete the analysis – particularly at local level.

The first part of the document presents figures relating electric production, hydroelectricity and the supply of water in context. The connections are studied via the cases of some developed countries (France, United States) and some developing countries (India, China). Studying the case of the city of Jaïpur (India) allows a comparison of energy costs to be made with the water supplied – according to several alternatives (1. initial case; 2. long distance transportation; 3. shared management of local resources with irrigation.

The second part deals with water and biomass production. The study of energy flow in the world food system allows the size, performance and level of consumption of vegetable resources to be placed at a global scale. The basic processes for moving water (evapotranspiration, water balance) are briefly described and values are compared for several representative crops. As a conclusion, the development of bio-energies should be examined within a global system viewpoint.

One part of the results derive from works developed togeter with X. Goznes and from D. Lorne.

KEYWORDS:

Water-energy relationships, developments, energy for water supply, water and bio-energy, food energy.

Thematic Week 10

NEW SOURCES OF WATER

Reuse and Desalination

Positioning document

General Coordinators

Ángel Cajigas. Executive Director-General of the Technology Association for Water Treatment (ATTA)

Miguel Torres. Centre of Studies and Experimentation for Public Works (CEDEX)

SOME PRELIMINARY THOUGHTS

Episodes or situations in which available water resources are not sufficient to cover demand are becoming more frequent.

Causes of various types come together not allowing for optimism – above all in a period in which they all coincide.

There are really fewer resources because climate conditions are ever more frequently adverse in specific places – there are lands that are condemned by this to suffer a significant reduction in water contributions which will get worse as a result of the predicted climate change. The UN estimates that rain in the Mediterranean area will fall by between 20% and 25% in the coming decades and it is foreseen that water stress could affect 30% of the world's population by 2025.

On this point, we can only hope that reality contradicts gloomy forecast.

Meanwhile, the environmental factor also works against water resource availability, not just in terms of poor quality in some cases which could lead to the polluted bodies of water becoming unusable, but also because – bearing in mind the European policy whose backbone is greater protection of the ecosystems – of the imperative to maintain circulating volumes of flow with an environmental objective of reducing the possibilities of its consumption use. In other words, on the offer side, we find ourselves with a reduction in usable resources.

Therefore – and on the demand side – we are facing greater necessities to attend to a larger population, concentrated, additionally, in coastal areas where – specifically – the resources are most at risk and, on the other hand, subject to matters of seasonality which occasionally impedes the offering of the guaranteed supply required.

If we conclude that we have a development model based on consumption where leisure culture – contributing to the economic growth in a particular place – causes greater water consumption, then we are facing a scenario of growing demands where we have least water resources available.

The diagnosis thus revealed, what could the therapy be?

The World Forum in Mexico in 2006 concluded that globally there is no scarcity of water but the crisis in governance is what makes a deficit in resources perceptible. And it stressed that there is no water problem in the world, instead there is bad management and, in some cases, total absence of management.

Should we accept this conclusion as a paradigm just so?

It would be acceptable as a half-truth. After all, how can the absence of management be understood in a country where the differences in rainfall from one region to another is from 1 to 5 and where the possibilities of transferring the volume of flow is becoming ever more complicated for various reasons?

However, it is easy to understand that it is different to manage abundance compared to scarcity. One only needs to look at central and northern Europe. Otherwise, how is Spain the European country with the largest capacity for producing desalinated and regenerated water?

Therefore, we have two great challenges before us:

- improving the quality of the bodies of water
- greater availability of water resources

The vulnerability of rivers to dumped pollutants obliges us to undertake corrective measures that minimise the environmental impact and raise the capacity of water use through collection systems and sewage treatment.

Following the start of the National water treatment Plan, Spain has reached a high level of treatment of its spillage (>80% to purifying more than 3,500 hm3/year producing a notable improvement in the indexes that measure the qualitative state of water.

A new water treatment Plan has replaced the old one to face the new challenges – some technological and some courtesy of a greater organic weight caused by the population increase.

In order to have greater resource availability, we must undertake measures of a very different type.

Regarding the demand, it is necessary to continue to improve the efficiency of the water storage and distribution etc systems, limiting leaks. A modernising plan for irrigation should be continued with to better exploit the water and reduce consumption per hectare. In short, we will have to save water as individual consumers and as groups.

These measures – many of them started – undoubtedly achieve significant savings but though they are necessary, they are not sufficient.

And if they are not or appear not to be, what can we do on the offer side?

Where natural resources are deficient because the surface water during droughts is insufficient and because the underground water – due to problems that are at times qualitative and others quantitative – does not provide the necessary resources either, forcing them into the undesired condition of overexploitation or to exhaust non-renewable resources. Given the difficulties in transferring water from other basins, there is no alternative but to explore the possibilities that technology offers to obtain new water resources – new water sources that contribute complementary resources that undoubtedly will help us to a better and more sustainable water management.

The new water sources are:

- Regenerated water – generally from a more advanced treatment of already purified sewage
- Desalinated sea water or brine

Regenerated water can be reused for distinct purposes from agricultural irrigation – less restrictive and needing a lower quality – to urban uses or human contact – which has a more demanding quality – to the emerging uses such as street cleaning or irrigating golf courses, without forgetting environmental uses that will be widely accepted in the future. All of these uses and the degree of quality demanded for each case have been regulated in the recent Royal Decree that established the legal regime for the reuse of purified water.

Desalination leads to the securing of high quality water using an unlimited resource such as sea water that is uninfluenced – in theory – by climate conditions and, therefore, when technological innovation permits, it will be competitive as a public supply. This is a complementary resource and, as such, it should be understood that when other natural resources are lacking in particular places or due to particular conditions it could become the clear alternative.

Both regenerated water for reuse and desalinated sea water or brine involve the application of sufficiently established technology of proven efficiency so as to allow us to consider these options as viable and feasible when facing the challenges that any water crisis situation could provoke.

Therefore, the lack of water should not be accepted as a limiting factor for sustainable development. A boost for the water treatment technologies should be given in their dual function of improving the quality and increasing availability.

This means, therefore, reinforcing the demand management with elements from the water offer that are completely compatible with the new objectives set out in European water policy.

"A more efficient use of water based on a demand strategy (limiting its growth) that stops the waste of the limited resources (not always of good quality) by limiting abusive water use practices".

REUSE

Reuse of regenerated liquid waste is an established practice in Spain above all in agricultural irrigation. For over 30 years, the Canary Islands and the south have been the areas where there has been most application of this practice due to the lack of natural resources. In recent years, it has prospered as it is the main inspiration in sustainable management behind the Water Framework Directive as it permits:

- An increase in existing resources where the alternative to purifying water is to dump it into the sea
- An improvement in the management of human resources by freeing higher quality water for uses that need this (supply)
- A guarantee of reliability and regularity

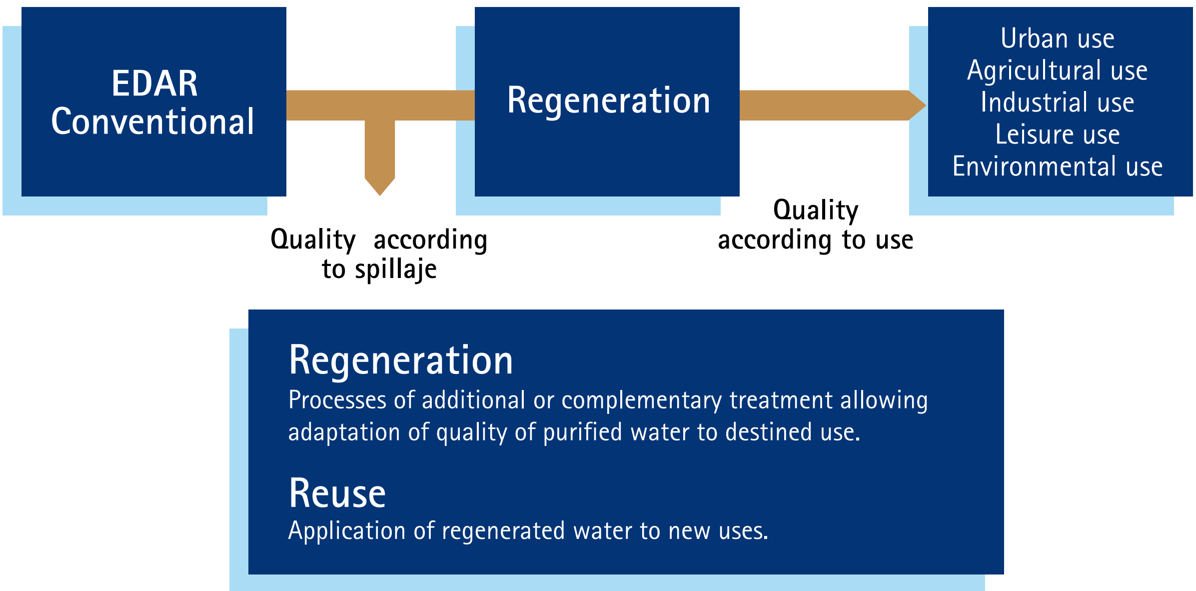
There are two key elements which should govern the practice of reuse:

- Guarantee and reliability related to the concept of quantity and, therefore, resource availability
- Health risk related to quality

However, the very strengths become weaknesses when we are not able to exploit the opportunities to the maximum.

Not all purified water can be reused as certain amounts have to be returned to the recipient riverbeds to ensure minimum water levels in some cases and to confront exiting concessions in others.

It must be emphasised that the opportunities for reuse are greater when the purified water goes to the sea and, therefore, this guarantee of a new resource will be linked to the regeneration of the area it is from.



However, there are limits to the reuse closely linked to the concept of quality.

- Health risk related not just to consumers but also to users of regenerated water.
- Excess salinity as a general consequence of the quality of the water supplied or the large-scale intrusion of collectors into the network.

The objective of the regulation recently approved by the Ministry of the Environment is to regulate the use of purified water by specifying the quality required according to the foreseen uses as well as the necessary controls that should be undertaken to ensure this being fulfilled.

The quality of regenerated water is variable and, on occasions, does not fulfil the quality criteria and, consequently, it loses reliability which does nothing to generate users' confidence and here the aesthetic question (including smell) plays an important role as the irrigators, golf course managers and industrial use customers will not accept inadequately regenerated liquid waste and even less so if this is an exchange or replacement of resources.

Therefore, the guarantee and reliability are conditioned by the users themselves as they have to perceive that the regenerated water fulfils their qualitative expectations – thus bypassing the possible adverse psychological effects.

And it is here that purification and regeneration plant operators, the relevant water authority, technologists and, also, users have to be rigorous both in the monitoring of the control programmes and in the fulfilment of quality regulations and good codes of practice.

Only thus can we truly consider or reclaimed water as a complementary resource or alternative and, above all, as a "new water supply source".

REUSE IN SPAIN

If we refer to direct, planned use, we have to go back to the 1970s when the first purifiers were constructed in the Canary Islands to provide water for the irrigation of crops, golf courses, garden areas, etc in a land characterised by its lack of water resources and occurring practically at the same time as the first sea water desalination plants.

Soon after, purified liquid waste was used for crop irrigation in Mediterranean areas such as Murcia, Alicante and Almeria, leading later to more ambitious projects over the length and breadth of the coast. This was done in such a way that most purified water was not disposed of via underwater outlets as they were subject to extreme pressure from particular users for their application in the main in agricultural and golf course irrigation.

As the practice of reusing began to become more common, it became more necessary to create a regulatory framework to regulate use.

When the use of purified water began to extend to parks and public gardens, street cleaning, to environmental uses or to the refilling of aquifers and in the light of any possible risk of consuming raw products which had been irrigated with purified water, it was inevitable that a regulatory law would be enacted. The legal basis of this lies implicitly in the Water Law itself when stating that "The Government will establish the basic conditions for water reuse".

In the period between the Water Law and the enactment of the Royal Decree on Reuse, many liquid waste treatment projects incorporated regeneration treatments to allow them to obtain water of a high quality that is perfectly compatible with the majority of foreseen uses – even for those most demanding. This is shown through the innovative use of membrane systems in many installations, a general use of ultra-violet disinfection systems, etc.

From a legal viewpoint, it is the health risk that needs to be minimised while leaving the agronomic parameters for rules or recommendations to be supplied by the sector itself.

Thus the micro-biological parameters or those that allow a greater efficiency in the disinfection systems are those for which quality criteria are es-

Quality Criteria for Water Reuse According to Uses

	Exceptional Quality	Quality I	Quality II	Quality III
E. coli	0/absent	100 UFC/ 100 ml	1000 UFC/ 100 ml	10000 UFC/ 100 ml
Solids in suspension	10 mg/l	20 mg/l	35 mg/l	35 mg/l
Intestinal nematodes	1 egg/10l	1 egg/10l	1 egg/10l	1 egg/10l
Cloudiness	2 UNT	10 UNT	not established	
Observations	MES<5 Refrigeration towers Cloudiness <1	For park irrigation and street cleaning E coli < 200 UFC/100 ml		Cloudiness 15 UNT for process water
Uses	• Irrigation of private gardens • Refrigeration towers • Refill aquifers by injection	• Crop irrigation (raw food and direct contact) • Golf courses • Park and garden irrigation • Street cleaning	• Crop cultivation (direct contact not raw consumption) • Water process and cleaning in food industry • Refill aquifers – percolation • Irrigate pastures	• Irrigate industrial crops, nurseries, woods, flowers, etc. • Water process and cleaning • Ponds and bodies of water with no public access

Royal Decree 1620/2007 by which the legal regime is established for the reuse of treated water

tablished. Solids in suspension, cloudiness (due to its link to viruses), intestinal nematodes and *Escherichia coli* were the indicators selected to classify water according to use following a long analysis and debate. Given that special uses require special controls, other complementary indicators should be kept in mind such as salmonella (according to higher or lower risk of creating aerosols), nutrients for environmental use, etc.

If we examine the *E. coli* criteria, it can be seen that the limits imposed run from zero (or absence) to 10,000 UFC/100ml – establishing the most rigorous standards for uses in which there is a high probability of human contact with the water, hoping even not to motivate these.

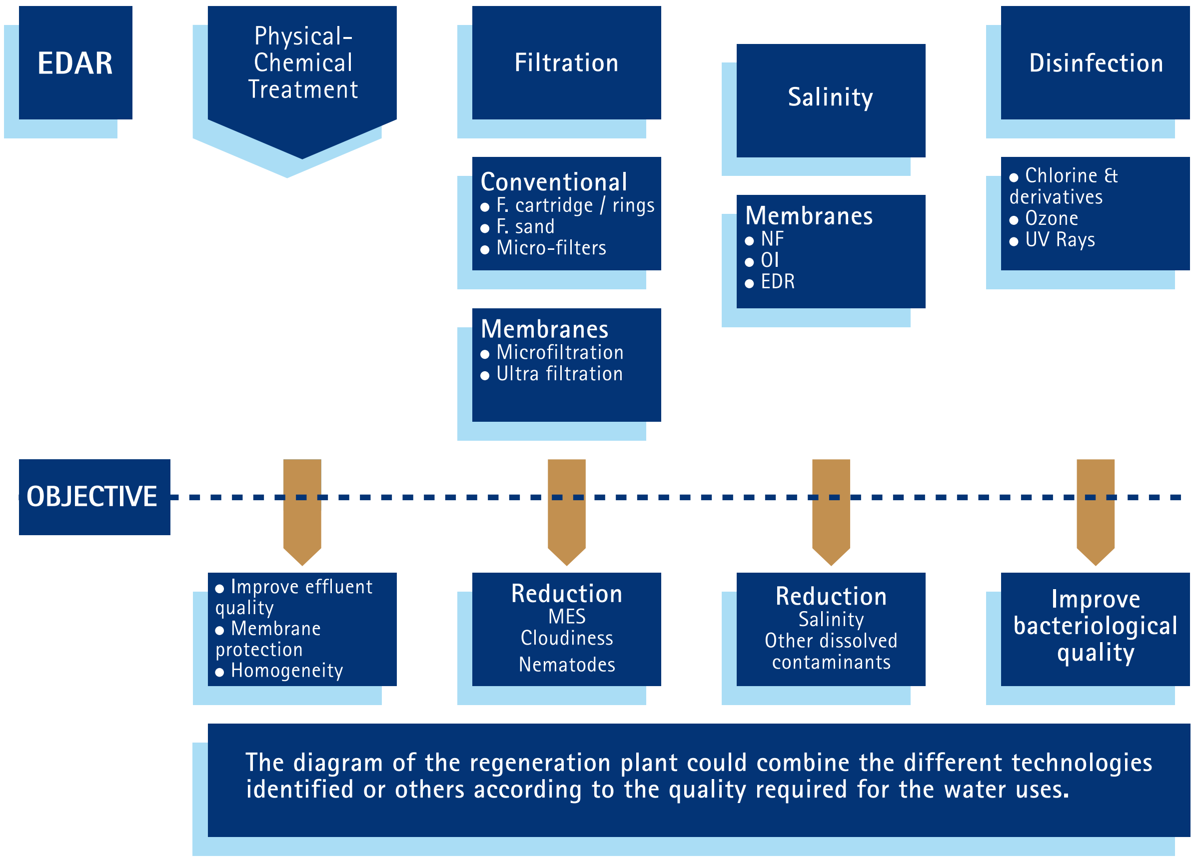
In any case, the multi-barrier technology and the disinfection systems allow for sufficient performance to be guaranteed so as making the bacteria use quality compatible in each case.

In Spain, currently, there is a purified water regeneration capacity of 450-500 hm^3/year which constitutes 13% of the quantity of purified water, remembering that regions such as Murcia and Valencia are far above this percentage.

It is clear – as previously stated – that not all purified water is susceptible to reuse and that users do not need the same volumes during the whole year and that it works according to the climate. However, it is also true that mistakes in planning and, occasionally, a lack of quality guarantee have been detected which have caused the rejection of regenerated water.

The currently operating Plan to increase regenerated water to 1000-1200 hm^3/year must bear in mind these considerations when identifying the projects and their needs, uses, technology applicable and exploitation costs, and, above all, by providing sufficient incentive to guarantee the acceptance of the potential users.

REGENERATION TREATMENTS



THE CHALLENGE FOR THE FUTURE

In accordance with figures from various studies published by the UN and other organisations, the future is not an optimistic one given the expectations offered produce more uncertainties in relation to water resources.

Therefore and aside from the necessary reflection on development models, all alternatives in the area of water are going to be needed: from inter-connections at greater or lesser distances, to a better management of underground resources, use of crops or lower consumption irrigation practices such as the provision of technological systems which provide new resources that, in many cases, give supply guarantees to the so-called conventional resources.

Currently, both the reuse of reclaimed water and desalination represent a very small percentage (2-3%) of total water consumption but, undoubtedly, in areas along the Mediterranean coast the percentage is already higher and will rise further in the future.

From the standpoint of regenerating purified water, the use of membrane technology means an immeasurable improvement in water quality allowing for any use but there are also greater costs.

Therefore, technological innovation should search for energy sustainable and competitively priced systems.

Demonstration projects that analyse viability from both a technical/economic angle and the environmental one without rejecting any use should be boosted.

As a practical exercise feasitability, analysis of its use as drinking water is proposed. It has been done in California and Australia – two good examples upon which to support it as another element with which to face the future lack of water resources.

FINAL THOUGHTS

• Planning is a key element for reuse to succeed which must, among other things, identify potential users.

• The point to which the market and/or water stress should condition potential users to use reclaimed water.

• Risk management should be used in reclaimed water; zero risk versus assumable risk.

• Salinity as a limiting element in reuse should be taken into account though as it is an agronomic conditioner it is still not included in the law.

• Within a sustainable development of water resources framework, demand rationality and supply optimisation must be stressed. Reuse has a key role here despite its limitations.

• The greatest threat reuse is quality variation and guarantee errors that cause a lack of trust in the users.

• Reclaimed water could be complement or an alternative to natural resources and, as such, should be considered in available resources management.

• Boosting or fostering exchange of available resources makes the search for incentives for users inevitable.

• Water institutions must play a predominant role in reclaimed water regulation.

• It is vital to make reuse attractive and highlight its potential.

DESALINATION

It is almost impossible to find pure water in nature. What we commonly call water is, in reality, a solution of various salts in water. Desalination, therefore, separates the salts and the water that create such solution.

The age-old dream of man to be able to exploit sea water has become a reality with the development of desalination technology. Although it may seem an exaggeration, this new water treatment converts sea water into a fresh water resource which needs to be included in a new way in water planning. In fact, more than considering desalination as a new source, it should be considered as a new water treatment that changes the sea into an alternative source.

Among water's properties are those of being a great dissolver and cleaner. These two important virtues are, in turn, the cause of progressive loss of the original quality of water coming from rain. In addition to maintaining "freshwater" on the planet, the sun in its maintenance of the water cycle also maintains quality. Through evaporation and later condensation via rain or freezing (iceberg), salts are separated from water – converting the sea into one great universal desalination plant. This is not then merely a question of terminology about whether desalination is a new source or a new treatment, but of understanding that if the water is not exploitable for all the uses on earth, then it is obligatory to treat it for its use and remove the impurities that – naturally or otherwise – have been acquired, in the same way that the dissolved salts from its earth-bound journey must be removed.

Regarding desalination from this perspective, the separation of dry and wet zones according to the rain they receive must be reconsidered. Should a maritime city be considered a dry zone because it has low rainfall while next to it lies a great source such as the sea?

Desalination technology has developed extraordinarily over the last 50 years. A non-coincidental series of circumstances have contributed to this advance. Industrial development and its great dependence on fossil fuels caused the enrichment of the Middle Eastern countries – united by a lack of water, vital for life, and the existence under their land of the most important oil deposits.

Oil pumping and refining industry obliged the provision of water resources both for the industry itself and to supply the population that settled nearby. Where would Dubai, Kuwait, Saudi Arabia and others be without desalination? It is not difficult to imagine if we examine other deserts around the world that lack the highly valued black gold.

It was in Middle Eastern countries where the extraordinary desalination adventure began, applying the physics principles of evaporation and later condensation of steam as a way of separating out the components in salt distillation (mainly sodium chloride) of water. In reality, this was sea water. Thus, Prometheus' dream of stealing the secret to obtaining freshwater from sea water from the gods – the sun in this case – was fulfilled, as if it were rainfall controlled by a matter of will.

It is easy to understand that the need for water in the oil-producing countries and the domination of the old technique of the primitive desalination machines used at small scale on boats would, in the hands of more industrialised countries, produce a beneficial symbiosis that would soon deliver its fruits. Thus, the first wave of the desalination industry occurred halfway through the 1950s and since then it has not stopped advancing – as will be seen further on.

If desalination is separating the components of dissolution that comprise sea water and if dissolving salts in water frees up energy, then it will be necessary to provide at least the same amount of energy as is released on dissolving. This is the stubborn thermodynamics law.

Although these unchanging physical laws determine the minimum energy for the separation – seen from the viewpoint of theory independent of the process monitored – in practice real consumption is different according to the process and even within the same process. It will be different in accordance with the design employed in each case.

The ultimate objective is to obtain desalinated water as cheaply as possible. The useful mix of distinct components of this cocktail to lead to the lowest cost does not have a single valid recipe everywhere and every time. If the components weighing the most are energy cost and investment and funding, how the reality in each country visibly marked the various technological solutions applied in countries with oil resources and those that depend on these countries would be understandable.

The price of oil and its repeated and serious increases in the 1970s marked the design trends of the only desalination process used on an industrial scale at the time – the evaporation process. Cheap oil prices gave rise to installations with a higher energy consumption and cheaper investment. From 1973 – with the hike in price dictated by countries grouped together as OPEC – the efficiency of desalination plants began to be improved, leading to evaporators consuming less but costing more. This advance in design reached its technological peak at the beginning of the 1980s.

This constant search to reduce specific consumption as the most correct way to reduce the cost of desalinated water – in which battle the pioneering role of Spain should be highlighted as it constructed installations that beat worldwide efficiency levels – forced the development of reverse osmosis technology as the only viable way to challenge water demand in areas where it was being used and, even, to withstand new demands.

Without exaggerating, it could be said that successive increases in oil prices – from 1970 to nowadays – have been the major reason desalination technology improvement: optimising evaporation processes to achieve their technological limit, then moving on to reverse osmosis due to its better energy efficiency.

Desalinated water is currently cheaper than it was in 1970 despite the great increase in fuel prices. This "miracle" is due entirely to development in the area of osmosis technology. The advances happening in this field should be called an authentic technological revolution. The reason for the great increase in installed desalination capacity around the world has been the change from 50 KWh/m^3 total energy in the process to 3.5 KWh/m^3 currently.

The fall in cost has meant, on one side, an increase in demand (according to the obvious economic law), but also an increase in the demand for osmosis membranes. This means that industry building these elements can dedicate more effort to research to obtain better and cheaper products. This interesting race has meant that prices on the international market have recently reached between \$0.55 and \$0.60/m^3 – utterly unimaginable just a very few years ago.

The very general criterion that desalinated water cost is high brings with it another criterion: that it can only be used in extreme cases and exclusively for urban supplies. This happened from the start until the surging appearance of reverse osmosis. It is true that desalination via evaporation has demonstrated that, despite its high cost, it could be applied to supply areas that are water deficient but with potential tourism growth. This is the case of Lanzarote, Fuerteventura and Gran Canaria in Spain. These three cases perfectly demonstrate that the factor that is really limiting development is not water price but the lack of water. It was also demonstrated that among unconventional ways of resolving the water deficit – desalination, transport by boat and artificial increase of precipitation (fake rain) – the only one that was viable technically and economically was desalination. The spectacular change in the development of tourism on these islands just demonstrates what was said previously regarding the limiting factor.

Currently, we are seeing a new rupture in the concept that desalinated water can not be applied to agriculture. While it is true that desalinated water can not be used for traditional agriculture, high added value agricultural products – in which the whole process is like an industrial process – do allow the real current costs of desalination to be assumed. The current open expectations regarding the use of desalinated water in this field are very encouraging.

The Global Water Intelligence magazine – with a prestigious reputation for in depth information – presented the following very realistic data at the end of 2006:

Growth 2001 to 2006	12% annually
Predicted Growth	13.4% annually
Forecast 2010	64 hm^3/day
Forecast 2015	98 hm^3/day

The main investors in desalination to 2015 will be: Saudi Arabia, UAE, China, Algeria, Kuwait, USA, Libya, Spain, Oman, Qatar, Mexico and Iran.

The Spanish case speaks eloquently of the change in use and the extension of desalination. The change from the transfer from the Ebro as the almost exclusive way of solving the water deficit of the Mediterranean coast to an action plan with reuse, saving and, above all, desalination is highly significant of the importance that sea water desalination has in current water planning. If, at the beginning of 2004, 150 hm^3/year was the capacity installed, then by the end of 2010 that figure will be above 900 hm^3/year. These values considered in the A.G.U.A. Programme[11] would have been impossible without the technological advance achieved and the subsequent cost reduction. It can be categorically stated that the A.G.U.A. Programme would have been impossible without the evaporation technology. The case occurring in Israel is very similar to Spain and the same conclusions are equally as valid.

The environmental aspects which must be regarded without fail to make desalination a sustainable activity are mainly fixed on two areas: the dumping of rejected brine into the sea and the energy consumption with its role in emitting greenhouse gases.

[11]Actions for water management and its use

Regarding brine dumping, it must be made clear that the desalination installations do not dump salt into the sea as is often interpreted and highlighted ignorantly – if not maliciously. Desalination plants return the same amount of salt to the sea that has been extracted. It is true that this volume of salt is dissolved in about half the volume of water, meaning that the same amount of salt is returned as part of a doubly concentrated fluid. In order to avoid this higher concentration and higher density brine heading to the sea floor where there could be species that can not tolerate such salinity, the brine must be mixed with sea water to dissolve it to reduce salinity before any contact with the sensitive flora. The ways of producing this dissolution are varied and, anyway, it is always possible to find the best form, technically and economically, to completely avoid the damaging effects of brine. In brief, the technical solution to design brine dumping always exists and, therefore, it can be clearly stated that a well-designed desalination plant produces not one negative effect either on flora or marine fauna – reagarding brine dumping.

Regarding greenhouse gases, it must also be made clear that desalination plants do not eject CO_2 into the atmosphere. Electric energy necessary to run desalination plant may cause CO_2 emissions and, therefore, such matter should be solved. The best way of contributing to the reduction in global emission of greenhouse gases in desalination activity is via a drop in specific consumption. This means looking for the best energy efficiency in the process, just as with any other energy-consuming activity. The best contribution of the electrical industry would also be to improve its own efficiency and include renewable energies to as large an extent as possible in global electricity production.

Desalination has yet to reach its technological ceiling. The membranes should be the basic element upon which future development must be centred. The reduction in energy consumption should come via the improvement in membranes, productivity lowering the current work pressure. We must think that in the short- to medium-term the exciting field of nanotechnology will provide satisfactory results.

We have to think that the future of desalination that turns sea into a great new source (though ancient) will come to help solve water problems from which so many people suffer. If water for life becomes a new human right, desalination could contribute to its achievement and allow many people who need it to enjoy water as the great good it is.

NEW WATER SOURCES

Available water resources being insufficient to meet the demand is becoming a situation or episode that is ever more frequent.

Vulnerability of rivers to polluting spillage obliges us to undertake corrective measures to minimise environmental impact and raise the capacity of water use via systems of collection and sewage treatment.

Management, saving and greater system efficiency measures are necessary but insufficient. Therefore, we propose:

- Integrating alternative or complementary solutions into water planning, via sewage water reclamation technology for reuse and through desalination of sea water and brine.

Where natural resources are deficient because surface water in times of drought is insufficient or because underground water does not provide the necessary resources either, it is proposed to:

- Explore the possibilities offered by technology to tap new water resources. This means new water sources which could provide complementary resources.

The new water sources are: reclaimed water from an advanced treatment of already purified liquid waste and desalinated sea or brine water.

Reclaimed water can be reused for different purpouses from agricultural irrigation – less restrictive and lower quality – to urban uses or those with human contact, requiring a more demanding quality. There are also other emerging uses such as street cleaning and golf course irrigation, without leaving out environmental-type uses that in the future will be widely accepted. Therefore, it is proposed:

- That all these uses and the degree of quality demanded are duly regulated, establishing an adequate legal pattern for sustainable reuse of treated water.

In turn, desalination allows high quality water to be obtained from an unlimited water supply such as sea water. This is a complementary resource to other natural water resources. Therefore, it is proposed to:

- Apply technology that is sufficiently consolidated and of proven efficiency to allow the consideration of these options as feasible and solutions to combat the challenges set forth by any water crisis situation, under the condition that energy should come from sustainable sources.

Therefore, and without accepting a lack of water becoming a limiting factor on sustainable development, we must:

- Promote the advance of water treatment technology in its dual function to improve quality and increase availability.

- Reinforce demand management with elements of water supply that are perfectly compatible with the new objectives of the European water policy.

REUSE

There are two key elements that should govern the practice of reuse: guarantee and reliability linked to resource availability and health risks.

Currently, the possibilities of reuse are greater when purified water is dumped into the sea which means that the guarantee of the resource is linked to the very original source media.

Meanwhile, there are other limitations: health risks for consumers and users of reclaimed water and excess of salinity due to water supply quality.

The quality of reclaimed water is very varied and, occasionally, does not conform to quality criteria and, consequently, loses trust and gains suspicion in users. The senses play a vital role so that irrigators, managers or clients of industrial uses are willing to accept treated water. Therefore:

- *Guarantee and trust must be conditioned by the needs of users themselves.*

- *The users' qualitative expectations must be fulfilled.*

- *The operators of treatment plants, the relevant water authority, technologists and also users have to be rigorous in monitoring, control and fulfilment of quality rules.*

In Spain, currently, a purified water reclamation capacity of about 500 hm^3/year which represents 13% of the quantity of treated water, though Autonomous Regions such as Murcia and Valencia are far above this percentage.

Not all treated water is susceptible to reuse. Users do not need the same volumes during the whole year and it may work according to the climate. Mistakes in planning and an occasional lack of quality guarantee have been detected and these have caused the rejection of reclaimed water. Therefore:

- *The currently operating Plan to increase regenerated water to 1000-1200 hm^3/year must bear in mind these considerations when identifying the projects and their needs, uses, technology applicable, and exploitation costs and, above all, it must provide sufficient incentive to guarantee the acceptance of the potential users.*

Aside from the necessary reflection on development models, all alternatives regarding water sources are going to be needed: from inter-connections at greater or lesser distances, to a better management of underground resources, use of crops or lower water consumption irrigation practices, as well as the provision of technological systems which provide new resources that, in many cases, give supply guarantees to the so-called conventional resources.

Currently, both the reuse of reclaimed water and desalination represent a very small percentage (2-3%) of total water consumption but, undoubtedly, in areas along the Mediterranean coast the percentage is already higher and will rise further in the future. Therefore:

- *From the standpoint of reclaimed treatment water, the use of membrane technology means an immeasurable improvement in water quality allowing for any use but there are also greater costs. Therefore, technological innovation should search for energy systems which are sustainable and competitively priced.*

- *Demonstration projects that analyse feasibility from both a technical/economic and an environmental angle without rejecting any use should be boosted.*

Some considerations regarding reuse:

- *Planning is a key element for reuse success which must, among other things, identify potential users.*

- *Salinity as a limiting element in reuse should be taken into account though as it is an agronomic conditioner it is still not included in the law.*

- *Within a framework of sustainable development of water resources, demand rationality and supply optimisation must be stressed. Reuse has a key role here despite its limitations.*

- *Reclaimed water could be a complementary or alternative source to natural resources and, as such, should be considered in available resources management.*

- *Boosting or fostering the exchange of available resources makes inevitable the search for incentives for users.*

Water insittutions must play a predominant role in the regulation of regenerated water.

- *It is vital to make reuse attractive and highlight the capacity of the resource itself.*

DESALINATION

Desalination technology has developed extraordinarily over the last 50 years.

The ultimate objective is to obtain desalinated water as cheaply as possible. The useful mix of the distinct components of this cocktail to lead to the lowest cost does not have a single valid recipe everywhere and every time. If the components weighing the most are the energy cost and the investment and funding, it would be understandable how the reality in each country had visibly marked the various technological solutions applied in countries with oil resources and those that depend on these countries.

The price of oil and its repeated and serious increases in the 1970s marked the design trends of the only desalination process used on an industrial scale at the time – the evaporation process. Cheap oil prices gave rise to installations with higher energy consumption and lower investment. From 1973 – with the hike in price dictated by the countries grouped together as the Organisation of Petroleum Exporting Countries (OPEC) – the efficiency of desalination plants began to be improved, leading to evaporators consuming less but costing more. This advance in design reached its technological peak at the beginning of the 1980s.

- *The most correct way to lower the cost of desalinated water is to lower specific consumption.*

Currently, we are seeing a new rupture in the concept that desalinated water can not be applied to agriculture.

- *High added value agricultural products – in which the whole process is like an industrial process – do allow the real current costs of desalination to be assumed.*

• *The environmental aspects which must be regarded without fail to make desalination a sustainable activity are mainly fixed on two areas: the dumping of rejected brine into the sea and the energy consumption with its role in emitting greenhouse gases.*

Regarding brine dumping, it must be made clear that the desalination installations do not dump salt into the sea as is often interpreted and highlighted ignorantly – if not maliciously. Desalination plants return the same amount of salt to the sea that has been extracted. It is true that this volume of salt is dissolved in about half the volume of water, meaning that the same amount of salt is returned as part of a doubly concentrated fluid.

• *In order to avoid this higher concentration and higher density brine heading to the sea floor where there could be species that can not tolerate this salinity, the brine must be made to mix into the sea water to dissolve it before contact with sensitive flora.*

• *The ways of producing this dissolution are varied and, anyway, it is always possible to find the best form, technically and economically, to completely avoid the damaging effects of the brine.*

Regarding greenhouse gases, it must also be made clear that desalination plants do not eject CO_2 into the atmosphere. The generation of the electrical energy which is necessary to run the desalination plant may cause CO_2 emissions and, therefore, it is there that the matter should be resolved.

• *The best way of contributing to the reduction in global emission of greenhouse gases in desalination activity is via a drop in specific consumption. This means looking for the best energy efficiency in the process, just as with any other energy-consuming activity. The best contribution of the electrical industry would also be to improve its own efficiency and include renewable energies to as large an extent as possible in global electricity production.*

Desalination has yet to reach its technological ceiling. The membranes should be the basic element upon which future development must be centred.

• *The reduction in energy consumption should come via the improvement in membranes productivity, lowering the current work pressure. We must think that in the short- to medium-term the exciting field of nanotechnology will provide satisfactory results.*

If water for life becomes a new human right, desalination could contribute to its achievement and allow many people who need it to enjoy the great good that is water.

The technology available allows freshwater to be produced from saltwater and, additionally, to reclaim and reuse water at reasonable prices and with fewer environmental effects. It is proposed:

• *To grant basic water and sludge treating services, in accordance with local situations, and to incorporate world-renowned health levels that ensure health, hygiene and wellbeing.*

• *To promote and apply technology that allows for saving, desalination, purification, reclamation and reuse of water with a high level of efficiency in energy consumption and a low environmental impact – empowering sustainable energy.*

Research, development and innovation are vital pillars that sustain knowledge, solution discovery, wellbeing and sustainability in water topics. Therefore, it is proposed:

• *To promote and foster research, development and innovation regarding water and to accelerate the transfer of results and benefits to society.*

WATER IN THE WORLD

Emilio Gabbrielli

ABSTRACT:

Mankind took a long time to recognize water as a limited resource and its direct link with sustainable development. While the world population has doubled in 3 decades, water consumption has increased six times and over half of the available fresh water resources are committed.

Reuse and development of new water resources has become essential. This must be supported by a more efficient consumption of water in all sectors, especially in agriculture, which is by far the greatest consumer.

The World is struggling in finding effective and equitable policies to manage surface and groundwater resources. At the same time the development of new water supplies such as desalination is becoming essential to sustainable development.

The key challenge is to ensure that every human being has access to a minimum quantity of water which safeguards the right to a healthy and dignified existence, while optimizing the consumption of the resource for food security, sustainable development and a healthy environment.

The lack of finance in the water sector remains a critical issue to face such a challenge. The solution to the problem of water scarcity cannot be solved solely by technical advancements or increased financial availability. However, the rapid progress of new technologies, such as those based on membrane technology and their decreasing costs offer tools which, if properly implemented, can contribute to the successful implementation of sustainable water resource management policies.

SEWAGE WATER TREATMENT AND SUSTAINABLE DEVELOPMENT

Iñaki del Campo, Miguel Ángel Sanz,
Rodrigo Moreira Rato y Hektor Orbe

ABSTRACT:

Sustainable development is becoming ever more important within water treatment activity, with the main objectives currently being:

- Finding the way in which economic activity can maintain or improve the environmental system.
- Efficient use of resources.
- Promoting recycling and reuse greatly.
- Placing trust in the development and implementation of clean technology.
- Restoring damaged ecosystems.
- Recognising the importance of nature for human wellbeing.

On a daily basis, ever more demanding requisites in terms of the quality of purified liquid waste is leading to an increase in exploitation costs, mainly in the area of energy consumption.

Meanwhile, the residue generated – mainly sludge – is getting progressively more difficult to reach its final destination – as it is necessary to use expensive technology both in investment costs and, in some cases, in operating costs for its reduction or final assessment.

In order to efficiently undertake the activities related to sustainable development, various technologies and processes have been developed both in sewage water treatment and in that of the sludge by-product. Among other matters, the objectives are the minimisation of fossil fuel consumption, maximising reuse of treated water and improving the quality of what is dumped.

Various alternative treatments are explained in the document both for water and sludge, as well as examples of the application of these processes in plants designed and/or run by Degrémont, in addition to showing a preview of the future trends in both fields.

KEYWORDS:

Sustainable development, purification of liquid waste, sludge assessment, fossil fuels.

ADVANCED TREATMENT TECHNOLOGY

Jesús Galdós

ABSTRACT:

This document is divided in two different sections.

The first section is focused on the Liquid Waste Purification Plant in San Pedro del Pinatar (Murcia), whose most revealing characteristic is that of having the largest membrane bio-reactor currently working in Spain. The main elements of the plant are described, as well as the design and operating conditions since its beginning.

The second part is related to the treatment and final disposal of bio-solids produced in liquid waste treatment – a vital aspect so as to examine treatment from an integrated angle.

On these lines, thermal drying technology is presented, highlighting the advantages that this provides from an environmental perspective and its reliability. This is based on the wide experience obtained with different types of dryers both in Spain and elsewhere.

KEYWORDS:

Membrane bio-reactor, bio-solids, thermal drying.

APPLICATION OF NEW TECHNOLOGY FOR REUSE
OF RECLAIMED WATER

Nazaret Ontañón

ABSTRACT:

Population growth, increase in funds per inhabitant, agricultural and industrial development and Spain's climate as a Mediterranean country: all of these mean that traditional water supply sources have become limited attending to existing demands. This fact has made regenerated liquid waste an alternative supply source.

The technology employed in regenerating liquid waste has been evolving from the traditional filtration and disinfection systems to the use of new technology such as micro-filtration, ultra-filtration, membrane bio-reactors, reversible electro-dialysis and reverse osmosis.

Drace Medioambiente, S.A., has extensive experience in liquid waste regeneration treatment and has designed and built various installations using new technology for reuse reusing reclaimed water.

KEYWORDS:

Micro-filtration, ultra-filtration, MBR, reversible electro-dialysis, reverse osmosis.

INTEGRATED CLEANING AND REUSE OF WATER
IN THE CITY OF SAN LUIS POTOSI, MEXICO

Urbano Díaz de León Barroso

ABSTRACT:

The State of San Luís Potosí is located in the heart of the Mexican Republic. It is located on the main road connecting the main industrial States (including Jalisco, Ciudad de México, Querétaro, Nuevo León, Aguascalientes, Michoacán and Guanajuato) with the United States of America.

The aquifer in San Luis Potosí valley has over-pumping problems – with are a large number of wells in the city which are a source of destruction. It is estimated that this over-exploitation is 2 to 1; in other words, double the quantity is being abstracted that is being recharged.

The stability and future urban and industrial growth of the metropolitan area depends to a large extent on water abstraction from the aquifer.

Given the current situation, the State Government has begun a series of works aimed at gradually lowering the dependence on the supply from the aquifer in San Luis Potosí valley and, thus, alleviate the over-exploitation with the intention of finally recovering and stabilising the situation.

Reuse of treated sewage water is currently a valuable resource for the metropolitan area, given that it has already made for the rescuing of water for personal use first. This was used for industrial activities, green zone irrigation and other uses. The metropolitan area generates approximately 2,545 lps of municipal liquid waste, of which 1,795 lps are treated bringing together the quality necessary and complying with the current regulation for reuse in industrial, sporting, recreational and agricultural activities.

It is important to point out that sewage water reuse is regulated through the Water Law by the State, wherein it establishes that treated sewage water should be reused in industries located in the metropolitan area in productive processes where drinking water is not required: park, garden and sports field irrigation – whenever the availability exists.

In the IV World Water Forum, Mexico 2006, we clearly learnt that through little local actions like this, we can combat humanity's great challenge: finding solutions for the water supply for future generations.

KEYWORDS:

San Luis Potosí valley aquifer, over-exploitation problems, water supply dependency, reuse of liquid waste, IV World Water Forum, Mexico 2006.

DESALINATION IN SPAIN

Miguel Torres Corral

ABSTRACT:

The practice of desalination of sea water in Spain began in the 1960s. Due to the lack of resources to supply urban use in the islands of Gran Canaria, Fuerteventura and Lanzarote and in the city of Ceuta, the first desalination plants were installed – all MSF (Multi Stage Flash). This evaporation process was basically the only one available that had verified development that allowed it to be safely used to supply the urban population.

Strongly linked to the price of oil and to copper, nickel and aluminium (above all), the evolution of the MSF process was perfectly revealed in Spain through the desalination plants constructed up to the beginning of the 1980s.

The need to lower the cost of water led very quickly to the inclusion of reverse osmosis technology and this ended up supplanting the evaporation technology.

The serious drop in specific consumption and its immediate repercussions on the cost of desalinated water allowed it to be used in fields that had previously been prohibited – such as that of high valued added agriculture. The A.G.U.A. (Actions for management and its use) Programme, which has added 750 hm^3/year to the 150 hm^3/year present in 2004, is proof of the development happening in desalination in Spain.

Tables showing the evolution of the capacity installed from the start in 1964 to the present day will be presented and contrasted with the fall in specific consumption.

KEYWORDS:

Multi stage flash, reverse osmosis, AGUA Programme.

DESALINATION IN THE SEGURA BASIN

Mario Urrea

ABSTRACT:

This article analyses precedents from the point of view of current water planning related to the resource/demand equation, then lists and justifies the various desalination installations which are intended for water supply and irrigation that have been and are being emplaced in the Segura basin.

A description of the processes used and the technological evolution will be given from the original designs to those of the plants currently executed.

Lastly, economic considerations are examined from the information as regarding costs and tariffs provided by the owners of the installations.

KEYWORDS:

Water planning, desalination, water supply, irrigation.

ENVIRONMENTAL ISSUES OF DESALINATION

Sabine Lattemann

ABSTRACT:

The technology of seawater desalination offers a wide range of human benefits and opens new economic opportunities by providing an additional, infinite, and reliable supply of potable water in many parts of the world. However, despite the many benefits, concerns are also raised over potential negative impacts of the process on the environment.

Major new desalination projects are therefore typically evaluated by means of project-specific environmental impact assessment (EIA) studies. The key issues in this evaluation process are often the concentrate and residual chemical discharges into the sea, and the energy demand of the process and related indirect emissions of carbon dioxide and air pollutants.

The presentation will provide the latest figures on installed seawater desalination capacities, followed by a synopsis of the key environmental concerns and ways of mitigating the impacts on the environment. A short outlook on recent initiatives will be given that address the environmental concerns of desalination plants, such as the World Health Organization project “Desalination for safe water supply”, a new Guidance and Resource Manual on Desalination to be published by the United Nation Environment Programme in 2008, and the European research project “Membrane-based desalination – an integrated approach” (MEDINA).

KEYWORDS:

Seawater desalination, environmental impact assessment

BRINE DISPOSAL:
EFFECT AND SOLUTIONS

Antonio Ruiz Mateo

ABSTRACT:

This speech analyses the environmental aspects related to disposing of rejected water from desalination plants.

The most important waste product from a desalination plant by size is rejected water. A plant with a production of 70,000 m^3/day of water will create a liquid waste of 1 m^3/s if this is reverse osmosis feeding off sea water (conversion of 45%), 0.2 m^3/s if this is reverse osmosis feeding off brine (conversion of 80%) and 7.3 m^3/s if it is from distillation (conversion of 10%).

In order to estimate the real impact of the waste from a desalination plant, a bionomic register of the area that could be affected by the waste is necessary as is the quantification of the effects of the waste on the bio-cenosis observed at the individual, species and community levels. While the former is a common practice in many countries – Spain included – the latter is still very difficult to undertake because very little is known about it – except in some specific cases such as, for example, the impact on the grasslands of the marine phanerogam Posidonia Oceanica (a species endemic to the Mediterranean Sea and of great ecological value).

The pollutants potentially associated with liquid waste from the desalination plants come from substances brought in with the water feed or in the substances used to clean the filters and membranes. The former are of less concern – particularly when the disposal is done in the same medium from which the water was extracted (as happens when water is taken from the sea) as no additional weight of pollution is added to the system. However, the concentration is higher.

Fortunately, good knowledge of the hydrodynamic behaviour of effluents that has been disposed of into the medium allows the selection of a more adequate and better located disposal point. Furthermore, an appropriate design allows higher effluent dilution in a reduced area, so it is almost always possible to find a solution that respects the environment.

KEYWORDS:

Desalination plants, brine disposal, underwater outlets, maritime works, environmental impact on marine environment.

ENERGY ASPECTS OF DESALINATION

Manuel Fariñas

ABSTRACT:

In this document, various parameters involved in specific energy consumption of sea water desalination using technology known as reverse osmosis are analysed: sea water temperature, pretreatment complexity, work conversion, pumping system efficiency and the recovery of rejected energy as well as the characteristics of permeability and salt penetration through membranes.

Among all these parameters, both the simplification of the pre-treatment and the improvement in permeability and rejection of salts by the membranes will significantly reduce the specific energy consumption in the coming years for sea water desalination.

All expectations for the achieving of this goal are centred on a new generation of membranes, made with nano-particles and known as “Thin Film Nanocomposites” – or TFN.

KEYWORDS:

Specific energy consumption, reverse osmosis desalination, TFN, nanocomposite membranes.

ANALYSIS OF I. O. DESALINATION PROCESS CONFIGURATIONS

Jorge Salas

ABSTRACT:

Water planning is an instrument for sustainable water management which allows the increase of availability, protects its quality, economises and rationalises its use – respecting the environment. On these lines, desalination is another water treatment technology that allows resources unused by other methods to be included as drinking water (brine, sea water, etc).

Of the existing desalination technologies, desalination by reverse osmosis is the one that has imposed itself for the great majority of uses now that – as for some time – it has reached a degree of maturity sufficient for large scale applications due to its flexibility, robustness and lower costs for water production.

Besides attaining the desired water product, in sea water desalination – as in any other industrial processes – the intention is to (i) minimise energy consumption, (ii) make the operation easy and flexible and (iii) minimise investment and exploitation costs.

In order to achieve this, it is necessary to know the pros and cons offered by different possible configurations in the desalination process using reverse osmosis and its integration with pumping and regulation elements.

This could be translated into selecting a number of production lines and configuring the reverse osmosis framework, into the introduction of energy exploitation elements, into designs that can be considered to operate in the environment of highest pumping performance (BEP), and into avoiding as much as possible energy losses through regulation by introducing regulation systems.

KEYWORDS:

Desalination, reverse osmosis, design, dual step, dual stage, hybrid systems, frequency changer, high pressure, pressure exchange systems, energy recovery, brine, permeated, recirculation.

PROBLEMS ASSOCIATED WITH DESIGN OF PRE- AND POST-TREATMENT IN LARGE DESALINATION PLANTS

Domingo Zarzo

ABSTRACT:

The construction of large desalination plants around the world – with sizes that today reach 500,000 m3/day (in the case of reverse osmosis) – is providing new challenges in the design and engineering for these plants, affecting both implantation and the later operation. Leaving aside other problems linked to membrane systems or high pressure pumps and energy recovery – which are relatively resolved or at least cause fewer problems – we will focus in this document on the peculiarities of the pre- and post-treatment systems for these facilities, where it is indeed necessary to decide between different technologies.

Due to the size of these installations, harnessing through drawing from wells is practically impossible and given that open drawings require more pre-treatment, it is necessary to choose between different technologies: either systems with double filtration stages (with or without physical-chemical treatment) or through micro- or ultra-filtration membrane systems.

The conventional filtering systems for these systems have large space requirements and a high labour cost, while the MF and UF systems – apart from their high price – are not yet widespread in the large plants, which to a certain extent means a degree of technological risk aside from the problem of the non-exchangeable nature of the systems.

An additional problem in these installations to bear in mind is the storage and dosage of large quantities of chemical reagents that also require a design and adequate management. Solutions to avoid this large consumption could include in situ reagent creation – such as that of chlorine through electro-chlorination.

Regarding post-treatment – basically referred to as re-mineralising – the transportation and management of large quantities of lime and calcite creates a serious group of logistical problems. Therefore, in many cases doubt is cast over which of these technologies is most adequate and this does not depend solely on the size of the installation but also on the quality of water provided, product, water use, availability and price of product, etc.

Some real cases are considered comparing various treatment alternatives economically in terms of investment and operation.

KEYWORDS:

Reverse osmosis, pre-treatment, post-treatment, re-mineralising.

NATIONAL QUALITY PLAN: ECONOMIC ASPECTS

Adolfo Gallardo

ABSTRACT:

In collaboration with Autonomous Regions, the Ministry of the Environment created the National Water Quality Plan (2007-2015) which was passed by the Cabinet on 8 June 2007. The Plan considers a series of actions in water treatment to comply with the demands of various European directives and, in particular, for achieving a "good state of the waters", as specified by the Water Framework Directive. The total investment foreseen for the Plan is some €19,000,000 of which about a third will be provided by the Ministry of the Environment (some €6,200,000).

For developing the Plan, bilateral agreements are being established with the Autonomous Regions that include actions corresponding to four great areas:

- Works pending execution declared of general State interest (the General Administration of the State to pay 100% of the cost).

Actions motivated by new declarations of sensitive areas (the General Administration of the State to pay 25% of the cost).

- Actions whose cost is financed to 50% by State Water Companies and recovered – together with the management expenses attributable to the Company itself in each action – through tariffs established by the Company and guaranteed by the Autonomous Region for a maximum 45 years.
- Actions needed in nuclei with land in the Nature 2000 Network (those that have at least 5% of their area or a minimum of 10 ha in this Network and a population under 20,000 inhabitants). These actions will be included – by common agreement with Autonomous Regions – in the Sustainable Rural Development Programme which was approved by Government (the General Administration of the State to pay 50% of the cost).

KEYWORDS:

Cleaning, purification, quality plan, reuse.

FUNDING OF PROJECTS IN A LICENCE SYSTEM

L. González, J.A. Membiela, Z. Sanz

ABSTRACT:

This document studies the particularities of the various types of licence contracts for infrastructure and analyses the pros and cons these present as regards the provision contracts for traditional services.

Firstly, the concept of licence is defined and the different modes of existing infrastructure licence contract are described. Then, the singularities of each mode, the risks associated with each of them and the distribution of them among the parties involved are analysed. Particular attention is paid to a study of the BOT contracts as they are commonplace in the field of desalination and purification for the licensing of new initiatives and infrastructure and because of its more complex financial structure.

Lastly, singularities studied are contrasted with those of the traditional service provision contracts for engineering, construction and infrastructure operation.

The authors conclude that by choosing the right licensing model, the public sector can tap the experience – "know-how" and necessary funding for investment – without losing control of either management or ownership of infrastructure or of water resources and thus minimising risks which are then transferred to or shared with private partners.

KEYWORDS:

Licences, funding, desalination, purification, BOT, Project Finance.

THE 2008 ZARAGOZA CHARTER

THE 2008 ZARAGOZA CHARTER

The 2008 Zaragoza International Exhibition was the first ever to exclusively deal with “Water and Sustainable Development”. The 2008 Expo was a great international event held on the banks of the River Ebro in which 104 countries, three international organisations, and all of Spain’s autonomous communities and cities took part.

Following the guidelines set by the International Exhibitions Bureau (BIE), the Exhibition at all stages tied in with the work of the United Nations on water.

The Exhibitions, which are run in the spirit of the aims of the BIE, have become international events that obtain more direct participation from everyday citizens and are a prodigious exercise in civic education. At the International Zaragoza Exhibition, millions of visitors have gained a deeper insight into the planet’s water and sustainable development problems.

As the scientific and technical platform for the 2008 Zaragoza Expo, the Water Tribune served as a stage to disseminate knowledge transfer, and gave rise to debates and proposals to overcome the major water-related challenges that face humanity now and in the future. Throughout the 93 days that sessions were held, the Tribune was the largest, all-embracing international event on Water and Sustainable Development.

The Water Tribune’s activities came to an end two days ago with the presentation of its conclusions, and today at this closing ceremony it is to present its final analysis in the shape of the 2008 Zaragoza Charter.

PREAMBLE.
A NEW COMPREHENSIVE VISION OF WATER:

Those of us who have been involved with the Water Tribune are well aware that water is essential to life and to the planet.

New paradigms on water and sustainable development aim to supersede a purely anthropocentric viewpoint by positing that the integrated management of water resources will ensure the survival of the human race and protect the planet.

Considering:

1 That the Earth’s water and ecosystems must be preserved and protected.

2 That access to drinking water and sanitation is a human right that must be guaranteed by all public authorities.

3 That by accepting Millennium Development Goals, the Earth’s nations have pledged a serious commitment to water-related issues.

4 That access to water has an enormous influence on development.

5 That water plays a fundamental role in the production and transfer of energy.

6 That there will be an ever-increasing demand for water, mainly due to the growth of the population and the economy, all of which may result in a bigger "water footprint".

7 That forecasts show that climate change is capable of modifying the availability and demand for water all over the planet.

8 That current technologies make it possible to produce fresh water from sea water and fog, as well as to regenerate and reuse it, at reasonable prices and with less environmental impact.

9 That the durability and transformation of rural areas are directly linked to the availability and sustainable use made of water.

10 That the sustainable production of food is directly linked to the efficient use of water.

11 That education, culture, communications and participation must form the basis of the transformation in the management of the world's water resources.

12 That it is essential to strengthen all levels of governance in order to bring about integrated water management and sustainability, which implies the greater participation and sharing of responsibilities by society.

13 That river basins are the best suited environments for harnessing water and their good management makes it possible to resolve conflicts between countries, regions and users.

14 That ensuring channels of financing and ways of sharing financial risks, using criteria of sustainability, is essential to the success of initiatives and actions in the water sector.

15 That the investment in water infrastructures in developing countries is essential in order to reduce poverty and to bring about economic growth and that current levels of investment fall short of those set by the Millennium Development Goals.

16 That the public authorities must take the initiative in promoting the legislation and arrangements required to ensure access to water by all.

17 That research, development and innovation are the cornerstones that underpin our knowledge, solutions, well-being and sustainability in water-related issues.

THE WATER TRIBUNE RECOMMENDS:

A. AS GENERAL PRINCIPLES:

A1 That the development of societies should be based on sustainable and environmentally friendly criteria.

A2 That priorities must be set and commitments made with regard to water that are in the general interests of humanity, and that are founded on ethical sustainability principles, transparency, and intra- and inter-generational equality.

A3 That water management schemes should promote community participation, efficiency and solidarity through shared knowledge and experiences, whose end purpose is to being about individual and collective awareness.

A4 That commitments and regulations should be established to mitigate the negative effects of climate change and extreme weather events, and to adapt to such circumstances.

A5 That solutions and water management schemes must adapt to the rate of development, the culture, the social environment and economic climate of each region and society.

A6 That the basic management units of water resources should be river basins and aquifers, even in cases in which they are of a supranational nature.

A7 That every individual must have access to safe drinking water and proper sanitation, both in rural and urban areas, through the acceptance of global commitments, the setting of realistic targets and the adoption of specific solutions.

A8 That the supply of drinking water and the collection and treatment of wastewater are priority issues. Public administrations must provide these services at a fair price and also be in a position to cover their costs.

A9 That the management of demand must be at least as important and the management of offer in decisions on policies, strategies, plans, programmes and budgets.

A10 That the research, development and innovation in water-related technologies must be encouraged, and that the transfer of results and benefits to society must be speeded up.

A11 That a World Water Agency must be set up whose main missions would be:

a To draw up and present the Charter of the Rights and Responsibilities of Human Beings with Water to the United Nations.

b To devise a universal framework of standards on water within the context of sustainable development that is recognised by all countries.

c To prepare and promote the development of the International Convention on Climate Change, Extreme Weather Events and Risk Management for dealing with water resources.

d To encourage the approval of the International Protocol for the Pacific and Productive Management of Cross-border River Basins in the world.

e To help countries that ask for support in the integrated management of water.

f To foster the knowledge, principles and values, in coherence with the above, that will lead to acceptable ethics of water.

g To promote the efficient and global dissemination and exchange of good practices, lessons learnt, models, reproducible processes and experiences that have been successful, and to issue recommendations though an information and knowledge transfer centre about water and sustainable development.

h To encourage alliances between the public and private sectors that make it possible to join forces so that universal water supplies and sanitation become a reality.

B. TO THE PUBLIC AUTHORITIES, USERS OF WATER AND CITIZENS

B1 That ecosystems be effectively protected for their intrinsic values and to guarantee the durability of sources of water.

B2 That basic sanitation and wastewater treatment services be provided to match local realities, which attain world standards of sanitation that ensure health, hygiene and wellbeing.

B3 That measures be adopted to guarantee a basic water supply to all homes or as close to them as possible. In situations of poverty, governments must guarantee a minimum supply of water.

B4 That legal systems and the regulations drawn up take non-detrimental cultural habits and the ancestral rights of local communities into consideration.

B5 That the management of public water and sanitation services be under the control of public authorities.

B6 That the demand for water should be monitored to fit in with educational, informational, participative and tariff-based criteria.

B7 That delays in water supplies reaching rural areas should be shortened through the exchange of experiences and participative management schemes, which should be adapted to and accepted by the communities using them.

B8 That technologies be promoted and applied to bring about water savings, desalination and sea water applications, the harvesting of fog and rain, and the purification, regeneration and reuse of water. Such technologies should be energy-efficient with a low environmental impact in order to reach sustainable energy targets.

B9 That given the anticipated figures in population growth, countries should consider agriculture to be both an economic and strategic sector.

B10 That measures be devised and disseminated to improve irrigation systems through a more efficient use of water energy.

B11 That viable funding schemes with guarantees be drawn up between countries and institutions. They should provide for the possibility of attracting capital from the market for investments in the water infrastructures necessary to provide public supply and sanitation services, as well as attracting the human resources required to do so.

B12 That rational economic criteria be applied that promote efficiency and sustainability, which should likewise adopt the principles of social and environmental justice in the management of water.

B13 That integrated policies be set to facilitate the allocation of water for its various uses, providing that in doing so economic efficiency and environmental quality are favoured.

B.14 That all citizens share the responsibility of the integrated management of water and sustainability.

B.15 That citizens come to realise that water is the heritage of all living beings, not just a resource for human use.

ZARAGOZA 2008: AN EXPO WITHOUT AN EXPIRY DATE

In order to promote its recommendations, this 2008 Zaragoza Charter will be entrusted to the Secretariat General of the United Nations Organisation, the International Exhibitions Bureau and the Government of Spain.

All of the documents on which this Charter is based—speeches, debates, analyses and conclusions— are kept, as a heritage to be shared, in various appendices to the Legado (Legacy) and the Caja Azul (Blue Box), which shall be left in the custody of Spain, as the host country of the 2008 International Exhibition.

Zaragoza, 14 de September 2008

Closing Day of the 2008 Zaragoza International Exhibitions.

BOOK CREDITS

AUTHORS

Baigorri, Artemio
Bastida, Germán
Cajigas, Ángel
Celma Celma, Francisco Javier
Cubillo González, Francisco
Garrido, Raymundo José
Gaviria, Mario
González del Tánago, Marta
Guijarro, Luis
Maestu Unturbe, Josefina
Moreno, José Manuel
Sáenz de Miera, Gonzalo
Sarría Santamera, Antonio
Torres Corral, Miguel
Vallejo Calzada, Ramón
Viñuales, Víctor

Acevedo, Miguel F.
Adams, Richard
Aguilar, Enrique
Aguirre, Javier
Ahmed, Zahra R.
Alcamo, Joseph M.
Almeida Vilella, Alexandre
Alonso, Mercedes
Álvarez, Guadalupe
Amoré, Luiz
Andah, Winston
Andreini, Marc
Anton, Barbara
Arana Zegarra, Marco
Arias Fernández, María Enriqueta
Arlosoroff, Saul
Arrojo, Pedro
Artaxo, Paulo
Arzet, Klaus
Asunción Higueras, Mar
Awuah, Esi
Azqueta, Diego
Bainbridge, David A.
Bakker, Marloes
Barberán Ortí, Ramón
Barkin, David
Barry, Boubacar
Battaglini, Antonella
Baú, João
Bauer, Carl J.
Belamari1, Fatiha
Belenguer Sánchez, María Dolores
Bellot, Juan F.
Benayas del Álamo, Javier
Berrini, Maria
Binder, Walter
Bindi, Marco
Bjornlund, Henning
Blair, John M
Blanco Orozco, Mariano
Blanco, Julián
Boada, Marti
Bonnet, Jean François
Bono, Lorenzo
Bosco Senra, João
Botey, Juan
Bruttomesso, Rinio
Buch, Mario
Bueno Bernal, Víctor
Bunch, Martin
Busquet, Joan
Butler, David
Butterworth, J.A.
Caballero Quintana, Andrés C.
Cabrera Haro, Patricio
Cabrera, Enrique
Calatrava Leyva, Javier
Campo, Iñaki del
Cantin, Bernard
Cañada Guallar, María Victoria
Cañón, Julio,
Carlton, Dennis William
Carlton, Jane Berkowitz
Casassa, Gino
Castro Lahóz, Francisco
Chan, Ngai Weng
Chowdhury, Samir

Cillero Floren, Alfredo
Cisneros Britto, Julio Cesar
Cobacho, Ricardo
Cohen, Stewart J.
Collins, Drew
Colóm de Morán, Elisa
Corominas Masip, Joan
Correas Usón, Luis Carlos
Correia, Francis
Cortina, Jordi
Costa, Geraldo
Costa, Heloisa
Couchoud, Milagros
Cubasch, Ulrich
Cunha, Luis Veiga da
Darteh, Bertha
Daussa, Raul
Dellapenna, Joseph W
Delly Priscoli, Jerry
Deyonge, Sandra
Dias, Janise
Díaz de León Barroso, Urbano
Donoso, Guillermo
Donzier, Jean François
Dziegielewska Geitz, M.
Egea, Pilar
Embid Irujo, Antonio
Embid Irujo, Antonio
Entralgo Layunta, José Ramón
Espinosa Sarria, Magaly
Estrela, Teodoro
Etgen, John
Fadel Ndaw, Mouhamed
Falo Fornies, Francisco
Fariñas, Manuel
Favero Brocchi, Dalto
Fernández López, Carlos Alberto
Fisher, Franklin M.
Fraguas Herrero, Alberto
Francescutti, Pablo
Frey, Vincent
Gabbielli, Emilio
Galdós Aller, Jesús
Gallardo, Adolfo
García de Jalón, Diego
Garrote de Marcos, Luis
Gaviria, Mario
Gerber, Jürg
Gilbert, Olivier
Goldenstein, Stela
Gómez López, Luis
Gómez Orea, Domingo
Gómez Ramos, Almudena
González Alonso, Santiago
González Serrano, Luis
González, Javier
González, Oscar
Gordon Rapoport, José
Gracia, Carlos
Gradolph, Juan
Griffin, Ronald Curtis
Guevara Villavicencio, Octavio
Gupta, Shreekant
Haas, A.
Haddadin, Munther
Hall, David
Hanak, Ellen
Hank, Tobias
Heisler-White, Jana L.
Hermoza, Jose
Hernández Moreno, Enrique
Howden, S. Mark
Howitt, Richard
Huelin Franquelo, Maria
Ibáñez Carranza, Juan Carlos
Indij, Damian
Jahn, Jean Marc
Jiménez Fernández de Palencia, Alejandro
Jung, Gerlinde
Juran, Ilan
Katz, David
Khan, Mobarak Hossin
Kirketerp, Christiane
Klein, Gary

Kleiner, Yehuda
Knapp, Alan K.
Knauer, Sônia
Knutson, Cody L.
Kraemer, Alexander
Kundzewicz, Zbigniew W.
Kunstmann, Harald
La Calle Marcos, Abel
Laboranti, Claudio
Lama Pedrosa, Beatriz
Lara, Marlon
Larrain Aspillaga, Felipe
Lasa García, Vladimir
Lattemann, Sabine
Laube, Wolfram
Laux, Patrick
Le Strat, Anne
Leahy, Stephen
Leichenko, Robin M.
Liebe, Jens.
Liebers Baldivieso, Arturo
Lilliestam, J.
Linares, Pedro
Llamas, M. Ramón
Lobina, Emanuele
López de las Huertas, Adrián Martín
López Martos, Juan
López Vera, Fernando
Luege Tamargo, José Luis
Luizao, Flávio
Lund, Jay R.
Maceira Rozados, Alejandro
Maneja, Roser
Manning, N.
Manzi, Antonio
Marcen Albero, Carmelo
Marchena, Manuel Jesús
Margot Parkes,
Maria Saleth, Rathinasamy
Martín Carrasco, Francisco
Martín Rosales, Wenceslao
Mata, Luis J.
Mazzeo, Claudia Nora
Melo Baptista, Jaime
Membiela, J.A.
Mendiluce, María
Messaoud, Terra
Migues, Gustavo
Millán, Millán M.
Minta, Aboagye
Mohanty, Nirmal
Mollard, Eric
Monje, Crisitina
Montoya Cañas, John
Moreira Rato, Rodrigo
Mori, Mitsuru
Morrison, Karen
Muñoz Jiménez, Julián
Naicker, Keith M
Nascimento, Nilo
Navarro Espada, Carlos Javier
Naveh, Nir
Newborne, Peter
Nguyen, Bruno
Nieto, Ignasi
Nobre, Carlos
Nordstrom, Saba
O'Brien, Karen L.
Ollero Ojeda. Alfredo
Ontañón Nasarre, Nazaret
Orbe, Hektor
Orosa Monteso, Verónica
Orozco, Aura Lyli
Ouibiga, Harouna
Pahl-Wostl, Claudia
Palutikof, Jean
Papp, Kálmán
Pardo, Miguel Ángel
Perales Momparler, Sara
Pérez Leblic María Isabel
Pérez Llorens, José Lucas
Petrella, Riccardo
Piernavieja, Gonzalo
Pires Cardoso, Manfredo
Pizano Callejas, Jorge Enrique
Pochat, Victor

Pozo, Cristina del
Prieto, Fernando
Pulido, Antonio
Pulwarty, Roger S.
Qaraeen, Eman
Quiñones Jalisto, Lucio
Rajani, Balvant
Ramírez, José Javier
Ramos Alcalde, Belén
Rayón Martín, Fernando
Redfearn, Howard
Renard, Nicolas
Robledo, Gustavo
Rocco, Américo
Rodríguez Briceño, Emiliano
Rodriguez Sandoval, José
Rodriguez, Andrés
Rodríguez, Diego
Rojo, Leopoldo
Romero Tierno, César
Rooney, Tom
Rose, Robert J.
Rueda Martínez de Santos, José Ramón
Ruíz de la Torre, Juan
Ruiz Mateo, Antonio
Ruiz Ruano, Icíar
Ruiz, Paloma
Rukunga, Gerald K.
Salas, Jorge
Saldaña Rodríguez, Juan Francisco
Sánchez Rodríguez, Pedro Luis
Sánchez Tamarit, Sici
Sancho Díaz, Javier
Sandín Vázquez, María
Sandoval, Ricardo
Sanz, Miguel Ángel
Sanz, Z.
Sauga, Gema de la Cruz
Saunders, J. Owen
Schemenauer, Robert S.
Schmidt, Wolf-Peter
Segura Graiño, Ricardo
Serrano Rodríguez, Antonio
Shahzad, Irfan
Shechter, Mordechai
Silva, C. da
Smet, Jo
Smith, Melinda D.
Snoy, Bernard
Solanes, Miguel
Steinitz, Carl
Sturzenegger German
Subramanian, Ashok K.
Sutherland, A.
Swalley, David
Tal, Alon
Taylor, Ben
Urquiza Estada, Manuel M.
Urrea Mallebrera, Mario Andrés
Vairavamoorthy, Kalanithy
Valdés, Juan B.
Valencia Vargas, Juan Carlos
Valle, Javier del
van de Giesen, Nick
van Schaik, Henk
Vargas Amelin, Elisa
Vela Pardos, Noelia
Vela Plaza, Cristina
Venema, Henry
Verhagen, J.
Verheijden, Christine
Wagner, I.
Werthmann, Christian
Wilby, Robert L.
Willstedt Mesa, Heikki
Wiltshire, Mike
Wolff, Gary
Yagüe Córdova, Jesús
Young, Mike
Zarzo Martínez, Domingo
Zeledón, José Miguel
Zorrilla, Julio

Tribuna del Agua de Expo Zaragoza 2008

SOCIEDAD ESTATAL EXPOAGUA ZARAGOZA 2008

PRESIDENT
Roque Gistau

GENERAL DIRECTOR OF OPERATIONS AND CONTENTS
Jerónimo Blasco

GENERAL DIRECTOR OF CONSTRUCTION
Eduardo Ruiz de Temiño

GENERAL DIRECTOR OF MEANS AND RESOURCE
José Luis Murillo

CHIEF EXECUTIVE OFFICER SECRETARY
Ignacio Salvo

MANAGING DIRECTOR. CABINET OF THE PRESIDENCY
José María Ortega

DEPUTY GENERAL DIRECTOR OF OPERATIONS AND CONTENTS
Francisco Pellicer

PUBLICATIONS, DOCUMENTATION AND CONTENTS MANAGER DEPARTMENT
Javier Albisu Iribe

WATER TRIBUNE DIRECTOR
Eduardo Mestre

CONTENTS MANAGER DEPARTMENT
David Baringo

PARAREL EVENTS MANAGER DEPARTMENT
Eva Zuazua Schücker

THEMATIC WEEKS COORDINADOR
Carlos Rodríguez Casals

PRESIDENT OF THE WATER TRIBUNE'S SCIENTIFIC COMMITTEE
Juan López Martos

SCIENTIFIC ADVISOR
Ricardo Segura

WATER TRIBUNE STAFF
David Corellano
Sara Delgado Castillo
Javier Del Valle
Elena García Rubio
José Espona
Raymundo Garrido
Josué I. Hernández
Eduardo Jara Roncati
Cintia Liz Santiago
Santiago Marco Mommens
Patricia Martín Díaz
Alfonso Pardo
Pilar Pérez Cebrián
Lucía Soriano
Jorge Tabuenca
María Pilar Torres Solanot
Gaizka Urresti
Javier Aparici
Javier Arbués
Bárbara Ávila
David Barco Val
Carlos Enrique Bayo
Olga Becerril
Luis Carlos Betes
Carmen Brusel Muñoz
Nuria Calleja
Antonio Casado Rubio
Juan Andrés Clavera
Diego Colón de Carvajal Perales
José Luis Fernández Gutiérrez
Pablo Gómez
Pilar González Meyagui
Miguel Lobera
Mª Rosa Medina
Maite Puntes
Wilmer A. Ruiz Rickly
Francisca San José Pérez
Luis Segui Amórtegui
Marisa Sesé Tizón
Carlos Val

© PUBLISHED BY:
Expoagua Zaragoza 2008 S.A.

TRANSLATIONS:
GLS Servicios Lingüísticos and Target Traductores

DESIGN:
El Vaso. Estudio de diseño y comunicación

PRINTING:
INO Reproducciones

FIRST EDITION:
February, 2009

Printed in Spain

Printed on ecological paper, free of chlorine and
coming from certified sustainable forests.

D.L.:

ISBN:
978-84-936572-6-0

PARTNERS
SOCIOS

SPONSORS
PATROCINADORES

CONTENT SPONSORS
PATROCINADORES DE CONTENIDO

MEDIA SPONSORS
MEDIOS PATROCINADORES

ARAGÓN RADIO • ARAGÓN TV • COPE • Grupo HERALDO DE ARAGÓN • Grupo INTERECONOMÍA • Grupo PRISA
Grupo ZETA • HACHETTE FILIPACCHI • RTVE • UNIDAD EDITORIAL • VOCENTO

MEDIA COLLABORATORS
MEDIOS COLABORADORES

EL CONFIDENCIAL • Grupo ARAGÓN DIGITAL • Grupo EL PROGRESO • Grupo JOLY • PERIODISTA DIGITAL • PROMECAL • TELEVISIÓN CASTILLA Y LEÓN

ISBN 978-84-936572-6-0

PVP: 10 €

PLAN DE DIVULGACIÓN EDITORIAL
DEL CONOCIMIENTO DEL AGUA
Y DESARROLLO SOSTENIBLE

partners and sponsors