Volume 2

ON THE WATER FRONT

Selections from the 2010 World Water Week in Stockholm

Edited by **Jan Lundqvist**

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TABLE OF CONTENTS

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Photo: SIWI

PREFACE

Since 1991, the World Water Week in Stockholm is an annual event and meeting place for people from various professions, cultures and parts of the world with a common concern and ambition. The ambience in well over 200 sessions during the week and also in the informal exchanges in corridors and other meeting places is characterised by dialogue and an urge to scrutinise, learn, reassess concepts and standpoints and capture the best and most appropriate knowledge with regards to water and development issues. The scope is broad and goes beyond an academic search for new knowledge and better understanding per se. A prime task is to promote the use of this knowledge for necessary change, for policy and concrete action at appropriate levels in different parts of the world. This task presumes a process where new insights and skills are tested and integrated into our ways of thinking and doing things.

Each year, the World Water Week features a theme. In 2010, the theme was "Responding to Global Changes: The Water Quality Challenge – Prevention, Wise Use and Abatement". As illustrated by the range of issues discussed in the articles in this volume, the World Water Week programme includes sessions that elaborate also on issues outside the scope of the theme.

Presentations and discussions during the World Water Week generate a remarkable level of energy and commitment. Based on the comments that we hear from participants, we are convinced that seeds are sown for improvements in water policy and management for the betterment of humankind and the life support system on which we all depend. This is a very stimulating response. However, 51 weeks will pass until the next opportunity arises in Stockholm to learn more and to inform each other about what has been achieved since last time. Together with other documentation from the World Water Week, On the Water Front provides an opportunity to recapture key features from the World Water Week throughout the year.

This edition contains a selection of articles that cover important scientific and policy issues.

They are written by colleagues who made presentations at workshops, seminars and plenary sessions during the World Water Week, September 5-11, 2010. The full programme for World Water Week and documents from the deliberations in 2010 as well as from other years can be accessed and downloaded from www.siwi.org and www.worldwaterweek.org.

With the analytical character and with appropriate illustrations and references, the texts in this publication are intended to play a role in the thinking and work of colleagues from research, governments, international, national and local organisations. One important feature in the texts is an ambition to combine and merge new thinking, concepts and experiences with practice, in policy and in the field. The texts aim to illuminate the need for scientific findings in policy and in practice and vice versa; the need to formulate scientific enquiries and carry out scientific studies, which are relevant for policy and human endeavors.

The Scientific Programme Committee (SPC) plays a central role in the identification of the authors together with staff at SIWI. The texts submitted have been peer reviewed by the members of the SPC and other colleagues who are familiar with the topics discussed in the articles in line with the procedures applied in Scientific Journals. The texts mirror the range of presentations that are made at the WWW. Apart from highly positive responses and contributions from distinguished authors and the work by esteemed colleagues in SPC, many other people have contributed to this publication, in particular, Elin Weyler, publication manager and Elin Ingblom, design manager, to whom we would like offer our special thanks.

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THE IMPOSSIBLE DREAM? THE UPPER GUADIANA SYSTEM: ALIGNING CHANGES IN ECOLOGICAL SYSTEMS WITH CHANGES IN SOCIAL SYSTEMS

The Upper Guadiana system (and Western Mancha aquifer) is a dramatic example of a deep (and reversible?) change in a socio-ecological system. Intensive groundwater use over 40 years, with 20,000 Mm3 abstracted from a 5500 km2 aquifer, has fuelled a spectacular socio-economic development of a poor and backward region at the expense of a Man and the Biosphere reserve, the Mancha Humeda, of which only 20 per cent of the original area remains. This analysis reviews these changes, with a new focus on the drivers of ecological and social conflict over water. The paper also analyzes the potential of the Special Upper Guadiana Plan, a large-scale effort aiming to restore a complete socio-ecological system.

Key words: socio-ecological systems, restoration, agricultural policy, Bayesian networks, extended water footprint

Introduction: starting at the end

The Upper Guadiana Basin in central Spain is a dramatic example of a deep but potentially reversible change in a socio-ecological system. It offers room for reflection on some of the main opportunities and obstacles to aligning social and environmental systems through choices made over the use of water in arid environments. Although this example reflects a specific case study in Spain, many of the issues raised have echoes in other parts of the world facing similar development dilemmas. The issues include the economic incentives that drive the use of natural resources and finding opportunities to change the behaviour of key 'water managers', such as farmers, who are responsible for more than two-thirds of global consumptive water use.

Our analysis refers to the so-called wicked policy problems (Smith, 2007), i.e. problems that are highly complex, with clusters of inter-related and dynamic interactions with high levels of uncertainty. The Upper Guadiana Basin is a case with many production and consumption externalities (in this case wetland destruction and aquifer drawdown), which need an inter-disciplinary approach to solve them. How do you make a decision when it seems that solutions for one group will generate problems for other groups? Are these problems solvable by any single organization? Or do they require a new, negotiated type of solution, based on a broad and agreed societal response by scientists, farmers, service agencies and civil society?

In the Upper Guadiana system and the Western Mancha aquifer, intensive groundwater use has meant that, over the last 40 years, about 20,000 Mm3 were abstracted from a 5500 km2 aquifer to fuel spectacular socio-economic development. Of those 20,000 Mm3, about 3000 came from storage; the average groundwater level depletion was about 30 m. The Mancha region had been a poor and backward region, experiencing strong outmigration from the area. Socio-economic development, however, has been at the expense of a Man and the Biosphere (MAB) reserve, the Mancha Humeda. It is a series of wetlands, the most iconic being the Tablas de Daimiel National Park

Photo Credit: E. Lopez-Gunn (2003)

Figure 1. The Tablas de Daimiel National Park.

Figure 2. Location of the Guadiana Basin and the Tablas de Daimiel National Park. Source: Zorrilla (2009).

(Fig. 1), where it is estimated that only 20 per cent of the original area remain and very few of the wetlands function naturally (de la Hera, 1998).

This paper offers two complementary perspectives on analyzing changes in socio-ecological systems. First, it undertakes a retrospective analysis of a dramatic regime shift over the last 40 years. This is achieved through a series of snapshots of changes in the Upper Guadiana Basin to understand and explain the drivers that led to the current impasse over the deterioration and ecological problems of the Tablas de Daimiel National Park. The impasse and conflict are between irrigated farming and wetlands, which are effectively competing for the same water resources. As seen by farmers, “It is a stark choice: the duck or the farmer”.

The paper then offers a prospective analysis of the Special Upper Guadiana Plan. The plan, with a budget of €5 billion, started in 2008 and will be operational until 2027. It is currently considered the main measure contemplated within the European Union (EU) Water Framework Directive for groundwater water bodies identified in the Western Mancha aquifer (Martinez Cortina et al., 2011). Compliance with the EU regulatory framework means achieving good quantitative and qualitative status by 2015 (or 2027 under justified derogations). The Special Upper Guadiana Plan (CHG, 2008) has now been operational for three years, and some preliminary analysis can be undertaken on the implementation of the plan from the perspective of the stakeholders and the re-allocation of water rights. It can offer some insights into the potential and the limitations for a regime shift towards restoring the whole socio-ecological system. The plan in many ways can be analyzed as a large-scale effort not only in ecological restoration, but also in incorporating its social aspects, i.e. aiming to restore a complete socio-ecological system.

The land of honey: a retrospective analysis

Tablas de Daimiel National Park (Fig. 2) has a strong symbolic value for a number of reasons. ‘Daimiel’ translates as the land that gives honey, a landmark in a largely arid and poor region which, thanks to natural springs and so-called tablas fluviales, provided sustenance for the local population from fisheries, crabbing and associated land uses like small orchards. Tablas de Daimiel is also a landmark in Spanish conservation history. The creation of the park in 1973 was largely driven by policies of the 1970s to drain wetlands because they were perceived as insalubrious wastelands, full of malaria and of little economic value. The Ley Cambó (Cambo Law), dating back to 1918, was re-vitalised with a new Act in 1956 to facilitate the reclamation of marshland as agricultural land. The rationale for incentivizing irrigated agriculture was the depopulation of the area, which in 1981 had regressed to numbers similar to the 1930s. The regional government gave soft loans to farmers to encourage the irrigation of a dryland farming system that consisted mainly of vines and rainfed cereals. The funding was based on the belief of many analysts (both academic and political leaders) that groundwater could be the engine driving regional development, encouraging farmers to tap ‘the sea beneath their feet’. This intensive groundwater use was part of the hydraulic paradigm dominant in Spain (Lopez-Gunn, 2009a), a semi-arid country that, because of its history, saw water and irrigation as the route to modernizing the country. In the context of rural and agricultural regions, this was a strategy to settle a rural population that would otherwise migrate to cities and other more industrialised regions.

In the same year the park was designated (1973), some existing watercourses were channelled and modified to increase the amount of agricultural land. The first wells were drilled to tap groundwater resources, which had been inaccessible due to lack of technology and knowledge. Wells were authorised to irrigate maize and barley, thus replacing a traditional, extensive dryland Mediterranean agriculture of olives, vines and wheat (Fig. 3).

This meant a silent revolution (Giordano and Villholth, 2007; Llamas, 2004; Llamas and Custodio, 2003) where, over a relatively short time, the area experienced a deep process of socio-ecological transformation. One of the main causes of the silent revolution is low abstraction costs (even without ‘perverse’ energy subsidies), usually within 0.02-0.20 €/m3. Intensive use of these previously untapped

Photo Credit: P. Zorrilla (2009)

Figure 3. Old and new agriculture.

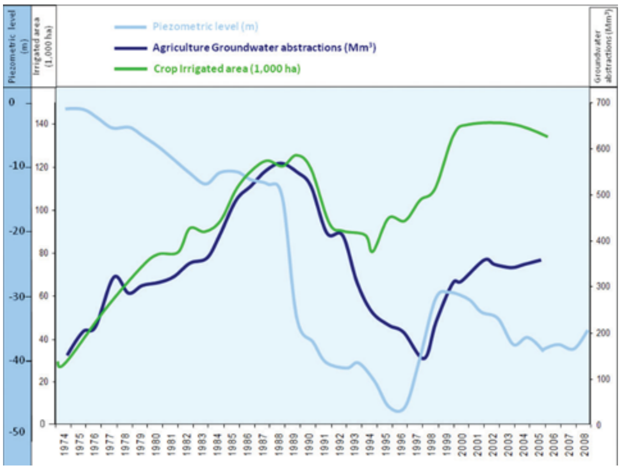


Figure 4. Aquifer levels, groundwater abstractions and irrigated area. Source: Zorrilla (2009).

and extensive groundwater resources meant that, over a short period between 1974 and 1984, groundwater use grew from a mere 200 Mm3/y to 500 Mm3/y, when the estimated renewable resources were around 300-320 Mm3/y. The area under irrigation over the same period almost tripled, from 30,000 to 85,000 ha (Table 1 and Fig. 4). In the following years, groundwater abstraction increased substantially. Although the accuracy of the data on real abstractions is illusory, we have estimated an average of 500 Mm3/y during the last 40 years.

The consequence of intensive groundwater use was felt from the mid to late 1980s as a result of dry years coinciding with the expansion of irrigated land. The drop in aquifer levels reached 40 to 50 m in some areas. Many wells dried up and farmers deepened their wells (the so-called 'war of the well'). The push for modernization continued despite the fact that there was a growing awareness of the negative externalities associated with intensive groundwater use. A series of studies in the late 1970s and early 1980s had already predicted the impact of intensive groundwater use on dependent wetlands (IGME, 1980; IGME/IRYDA, 1979).

The Guadiana River Basin Authority declared the Western Mancha aquifer provisionally over-exploited on 4th February 1987 and made this definitive on 15th December 1994. The result of this declaration was a series of tough restrictions: (1) the drilling of new wells was forbidden, (2) the compulsory, top-down formation of Water User Associations, (3) the delimitation of the aquifer perimeter, (4) the ruling that existing wells could not be deepened, and (5) a strict reduction in water use allowed per hectare (water quotas) (Blanco Gutierrez et al., 2011). These restrictions under the Exploitation Regime (or Regimen de Explotación) applied to any farmer with a public or private well and established an annual abstraction regime. However, the Guadiana River Basin Authority did not follow through to ensure compliance, due to a lack of capacity and the large transaction costs associated with an estimated group of 16,000 beneficiaries.

Table 1. Evolution of irrigated area and aquifer abstractions

Year	Irrigated area (ha)	Volume abstracted (Mm3)
1974	31,166	205
1984	85,053	373
1990	123,321	576
2006	180,000-200,000	650-700

Source: Consorcio del Alto Guadiana (2009).

The regional government – responsible for agricultural policy, but with no regulatory powers over water use – had calculated that implementing the Regimen de Explotación would cost the region 7700 million pesetas (at 1990 prices, equivalent to €46 million). This was confirmed by an independent report for the European Commission:

> "… (the costs) were such that the authorities set up a scheme to provide compensation for having to reduce consumption of water for irrigation purposes. It should be remembered that, according to official data, there were around 8,400 irrigated farmers in the study area (7,900 in Western Mancha aquifer and 500 in Campo de Montiel), with an irrigated area of more than 135,000 ha. Assuming 100 per cent water availability (approximately 5,000 m3/ha/yr) and a cropping regime comparable to that which prevailed in the area in the 1980s, we estimate that irrigation was providing some 18,000 jobs per year. The reduction in water availability by half (to around 2,500 m3/ha/yr) implies a loss of around 25 per cent of these jobs, i.e. approximately 3,500 jobs. The regional authorities, for their part, estimated the loss of income as a result of the possible disappearance of irrigation at 7.7 billion pesetas per year (at 59,250 pesetas/ha x 130,000 irrigated ha)." (Viladomiu and Rosell, 1996; p. 12)

The loss of cultural and natural heritage: the status quo

The result was an economic model incentivised by the regional government that prioritised socio-economic development over the con-

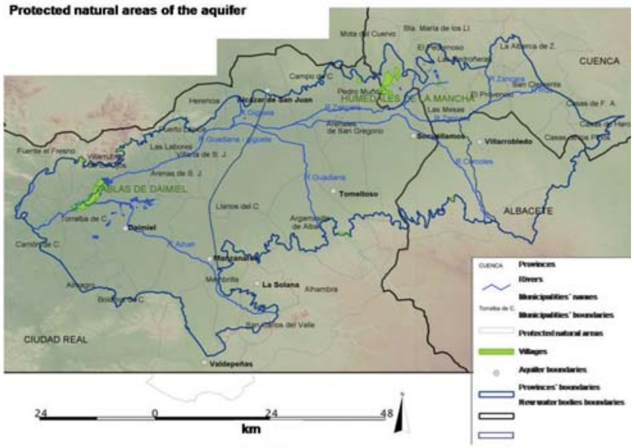


Figure 5. Main features of the Mancha Humeda Man and the Biosphere reserve. Source: Zorrilla (2009).

servation of natural resources , thus placing the emphasis on social and economic stability over ecological integrity and function. By 2010, 30 years after the start of the silent groundwater revolution in the 1980s, there was a dramatic transformation based on the linchpin of intensive groundwater use.

By 2010, only 20 per cent of the original MAB Reserve remained, with very few of the wetlands functioning naturally, particularly those dependent on the aquifer (Fig. 5). Yet the region has experienced a change from a largely rural, autarchic economy to a mature water economy, dominated by the service sector.

It is undeniable that the region of Castilla-La Mancha has experienced dramatic socio-economic growth, driven by an irrigated agricultural model. What is also undeniable, however, is that this came at a cost in terms of the loss of both natural and cultural heritage and the deterioration in groundwater quality. The Ojos del Guadiana, or Eyes of the Guadiana, was a natural spring resulting from the aquifer overflow. The spring featured in history books and was used in schools to educate children about rivers, with the Guadiana as the river that played hide and seek. It featured in Don Quixote as an enchanted river that hid beneath the land. In Don Quixote, chapter XXIII, part II, Miguel de Cervantes wrote:

> "Guadiana your squire, the duenna Ruidera and her seven daughters and two nieces, and many more of your friends and acquaintances, the sage Merlin has been keeping enchanted here these many years; and although more than five hundred have gone by, not one of us has died. Ruidera and her daughters and nieces alone are missing, and these, because of the tears they shed, Merlin, out of the compassion he seems to have felt for them, changed into so many lakes, which to this day in the world of the living, and in the province of La Mancha, are called the Lakes of Ruidera. The seven daughters belong to the kings of Spain and the two nieces to the knights of a very holy order called the Order of St. John. Guadiana your squire, likewise bewailing your fate, was changed into a river of his own name, but when he came to the surface and beheld the sun of another heaven, so great was his grief at finding he was leaving you, that he plunged into the bowels of the earth; however, as he cannot help following his natural course, he from time to time comes forth and shows himself to the sun and the world. The lakes aforesaid send him their waters, and with these, and others that come to him, he makes a grand and imposing entrance into Portugal; but for all that, go where he may, he shows his melancholy and sadness, and takes no pride in breeding dainty choice fish, only coarse and tasteless sorts, very different from those of the golden Tagus. All this that I tell you now, O cousin mine, I have told you many times before, and as you make no answer, I fear that either you believe me not, or do not hear me, whereat I feel God knows what grief."

The Ojos del Guadiana is now an agricultural irrigated field of cereals (Fig. 6) and a series of bridges, part of the regional government´s heritage, are now redundant since the Guadiana river no longer flows due to aquifer depletion. As the current director of the Tablas de Daimiel National Park stated: "The drop in aquifer levels (>3.5 m in some areas) has meant there is no natural discharge (in the park). The disappearance of the Guadiana River is one of the biggest natural disasters in our country." (Ruiz de la Hermosa, Director, Tablas de Daimiel National Park, 2010).

Scientific and policy relevance: prospective analysis

In terms of the implications for the transfer of scientific knowledge to policy, this section will use a series of methodologies and tools to shed new light on 'old' problems. The objective is, on the one hand, to help explain existing inertias in the system and, on the other, to identify windows of opportunity for changing policy, i.e. the right policy lever for entry into what is currently a locked and rigid system.

Regulatory impact analysis

One of the tools applied to understanding the socio-ecological system is based on blending an institutional framework on rules in norm like laws and regulations and rules in use with a simplified regulatory impact analysis, looking at the design of the law and its implementation (e.g. in terms of effectiveness and evidence-based implementation). The Spanish water law is, on paper, a sophisticated law, but under the lens of regulatory impact analysis, it shows itself to be, in the specific case of groundwater, excessively complex for a number of reasons. It created a system under which both private and public rights to co-exist in the same aquifer, with very different implications in terms of flexibility granted to the water user and the regulator. The capacity to follow through by the authorities was limited because of the large number of users spread over a large area. In addition, given the declaration of aquifer over-exploitation, this meant that the aquifer was closed for new water allocations, and that no new rights could be issued to new users after 1991. The declaration of over-exploitation meant users who had private rights found them frozen in time, with no modifications allowed (Llamas and Custodio, 2003). Meanwhile, after 1994, new users were effectively illegal. Added to the mix were a

Photo credits: courtesy of the photo archive Centro del Agua de Daimiel

Figure 6. Changes experienced in the Upper Guadiana
Photos (top right and left) Ojos del Guadiana (1960 and 2009)
Photos (bottom right and left): Molimocho well (1960 and 2009).

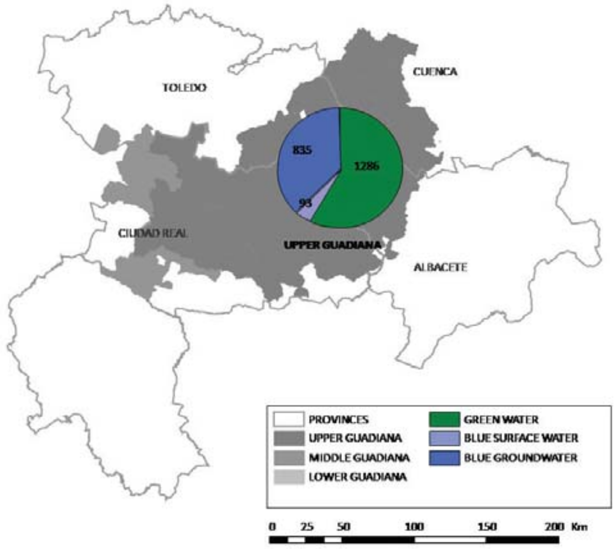


Figure 7. Agricultural water resources in the Upper Guadiana. Source: Aldaya and Llamas (2008). For the methodology used in the calculations, please refer to the original publication. Figures in the circle refer to Mm3. Blue water: water that is available in rivers, lakes and ground water aquifers. Green water: water in the root zone (Falkenmark, 1995).

strong underlying cultural element where 'norms are sometimes broken', which can be seen as a rational and logical response to a past history of autarchy, limited capacity and resources by the regulator, and the limited or eroded social capital in the past between the water authority (the regulator) and farmers. With a complex law, a difficult start and a weak regulator, the reality was that the aquifer had been over-allocated. It is estimated that around 590 Mm3/y been been allocated in water rights when the estimated average renewable groundwater resources are 320 Mm3/y. This means, in effect, almost a doubling in terms of paper rights of the actual amount of water that can be allocated per year. In 2010, under the new draft Hydrological Plan for the Guadiana, the 'renewable' resources have now been reduced further to 270 Mm3 of 'available' resources, including an environmental reserve for the gradual recovery of the aquifer by 2027.

The extended groundwater footprint in the Upper Guadiana Basin and Bayesian networks

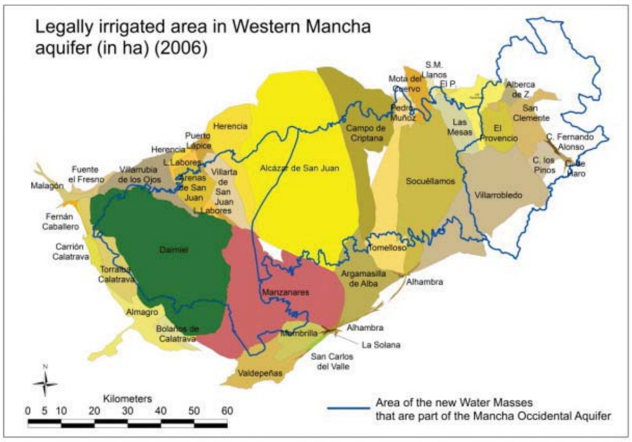
The traditional water footprint analysis is a metric, or tool, to assess consumptive water use that looks at both the direct and indirect water use of a consumer or producer (Hoekstra, 2003). The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed. The innovation of the extended groundwater footprint is that it also considers the productivity of water (Garrido et al., 2010). The traditional water footprint analysis (Hoekstra et al., 2009) – when applied to the Upper Guadiana Basin – is in itself useful because the perception in the area is that groundwater is the main water resource available, given the stored groundwater resources in a relatively large aquifer. However, the study undertaken by Aldaya and Llamas (2008), as shown in Fig. 7 below, indicates that even in a semi-arid country like Spain, in an average climate year the main water resource is green water. It is important to remember though that soil moisture as well as surface water vary a lot over time compared to groundwater. This is very important in a context of wet and dry climatic periods. In terms of agricultural water resources, almost 1300 Mm3/y is green water in an average year, while 835 Mm3/y is groundwater and less than 100 Mm3/y is surface water from reservoirs (Fig. 7). This opens a number of opportunities for more nuanced management along the green-to-blue water spectrum, as highlighted by Vidal et al. (2009).

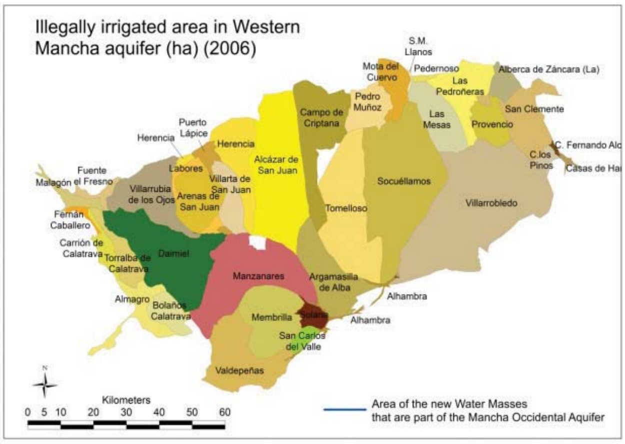
The added dimension provided by the extended groundwater footprint is more information on the economic drivers and on the incentives that influence the way farmers use groundwater, when framed in the context of water productivity (€/m3). In this context, it is highly relevant to note that it is products such as the region's traditional crops, where Spain has a comparative advantage due to its geographical location, that offer the greatest value per m3. This is the case when looking at cereals (0.1-0.2 €/m3) and vineyards (1.0-3.0 €/m3), or even new uses like thermo-solar power (10.0-20.0 €/m3). Economic water productivity in the Upper Guadiana varies, between e.g. 1.5-15.0 €/m3 for vegetables, 1.0-3.0 €/m3 for vineyards, 0.5-1.0 €/m3 for olive trees and 0.1-0.2 €/m3 for cereals (Aldaya and Llamas, 2008).

The most interesting analysis, however, comes from mixing the regulatory impact analysis and the extended water footprint, since it provides two things. First it provides a rational explanation for the current impasse in the Upper Guadiana Basin in terms of policy sclerosis or stasis (lack of action), and second, it provides new opportunities in helping to identify possible entry points for policy reform towards a process of socio-ecological restoration. The challenge is to identify opportunities where the sustainability of both systems (social-political and ecological) can co-exist in the long term without undermining the functional structure of the ecological system, and where the livelihoods of local people are guaranteed, rather than prioritizing one system (the social) at the expense of the other (the ecological) or vice versa.

When analyzing data on water rights in the aquifer area, it is important to note that three of the largest municipalities currently hold 44

Source: Lopez-Gunn and Zorrilla (2010)





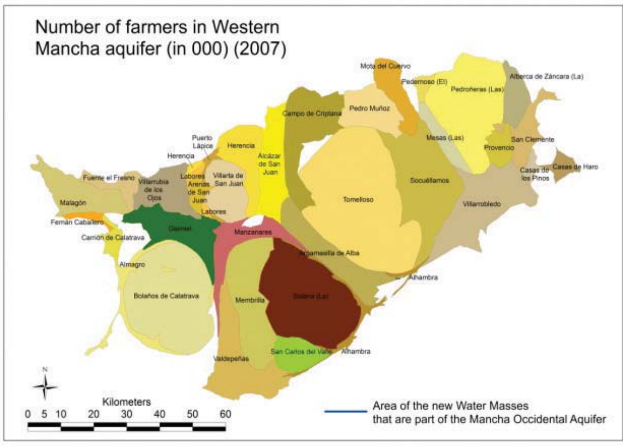


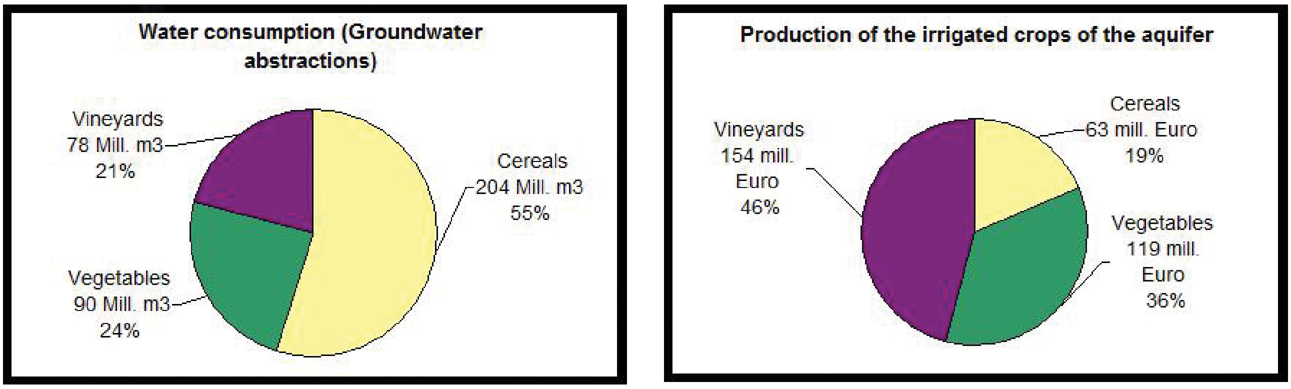
Figure 8. Cartograms of legal and illegal water use per village in the aquifer. (A cartogram is a map in which the geometry of the map is distorted so that the land area represents some thematic variable, in this case legal and illegal water use per village)

per cent of the legal water rights, for 7 per cent of the farmers (see yellow (center), green (left side) and red (left side) municipalities in Fig. 8). . Equally irrigated cereals consume 55 per cent of the water abstracted (also in these three villages), generating 19 per cent of the value. In contrast irrigated vineyards, which account for 21 per cent of the water abstracted, generate 46 per cent of the economic value (in 2006) (Fig. 9). What is more relevant, however, is that most of the irrigated vineyards had no allocated water rights, yet generate more jobs and income per drop as compared, for example, to irrigated cereals with water rights (Lopez-Gunn and Zorrilla, 2010; Dumont et al 2011).

What is most relevant in this context is that the combined use of the extended water footprint analysis and regulatory impact analysis highlights the dilemma posed by the lack of coordinated action between the regional government's department of agriculture and the central government's Guadiana water authority. The regional government successfully incentivised irrigation as a model for regional development and was very successful in achieving its aim. However, a failure to jointly implement the regulatory system and this, together with over-allocation by the water authority to highly consumptive users, resulted in the water authority having to declare the basin closed to new, more efficient water users, both in employment terms and also in terms of m3 per crop. The excessive rigidity of the regulatory system and the closure of the basin to new users, together with a lack of regulatory capacity to monitor and sanction thousands of legal and illegal users, led to an explosion of drilling. As highlighted by the extended water footprint analysis, 'illegal water use' is more efficient in terms of euros per drop (productivity of water), while it also generates more local jobs due to the types of crop (horticulture and vines), which are more labour intensive, compared to legal water use, mainly represented by cereals, which are traditionally cultivated in larger areas and with less of a need for labour (Dumont et al., 2011). One caveat is that vines grown in 'espaldera' (trellises) generate fewer jobs than traditional vines, since it is more mechanised. Also note that cereals are more dependent on rainfall (i.e. less irrigation in wet years like 2010) and are also more exposed to imports from countries with green water, e.g. France or Argentina (Garrido et al., 2010). The consequence of all the above has been the drawing up of an ambitious social-ecological restoration plan, the Special Upper Guadiana Plan, which is effectively a groundwater banking system on social and environmental grounds to address existing structural water rights towards a re-allocation on equity and efficiency grounds.

The crops with the highest economic productivity and the highest number of direct and indirect jobs associated with each drop of water used are horticultural crops, olives and vineyards. Cereals have lower economic productivity and generated employment. These differences in economic terms and jobs created suggest that a viable recovery of the aquifer from the socio-economic point of view could be achieved through a reduction in the area of irrigated cereals (Zorrilla et al., 2010). In fact, the results of an extreme socio-economic scenario show that a 'win-win' situation would imply substantially reducing irrigated cereals and maintaining – without any increase – the current vineyard, olive groves and horticultural crops (Zorrilla, 2009). This conclusion, however, has a caveat – the impact of extreme fluctuations in world cereal prices.

Olive trees and vines, which are traditional Mediterranean crops, are better able to use green water and so consume less water per hectare, so they are the most efficient in terms of water use. From the point of view of 'ecohydrology' (Falkenmark and Rockström, 2004), the best choice in social and environmental terms for the Western Mancha would be Mediterranean crops like olive trees and vineyards.



Source: Lopez-Gunn and Zorrilla (2010)

Figure 9. Water consumption and production generated by all irrigated crops (legal and illegal) in the Western Mancha aquifer.

A process of socio-ecological restoration

The Special Upper Guadiana Plan aims to achieve ecological restoration in compliance with the EU Water Framework Directive. The aim is to reduce the estimated current abstraction to 200 Mm3/y to recover wetlands, and by 2027 to gradually raise groundwater levels to refill part of the 3000 Mm3 of groundwater storage abstracted from the aquifer. The Tablas de Daimiel would then once again become the natural discharge and overflow from the aquifer. At the same time, there is a parallel process of 'social restoration' in the purchase of groundwater rights to be re-allocated to illegal water users on social equity grounds. These were mainly small farmers irrigating vines and horticultural products that had no water rights, yet they were more efficient in terms of water use, generating higher added-value and more employment per drop.

The plan however comes with a very expensive price tag but is motivated by a political desire to gain votes in the region. In the current economic crisis in Spain most of the money to purchase water rights has not materialised, and the only funding which is now likely to arrive refers to reforestation of land that has reverted to dryland farming after the purchase of water rights. The arrival of funding for forestation programmes occurs at a pre-electoral time linked to the generation of rural employment, as compared to the purchase of water rights, which has little political added-value. The target of the Special Upper Guadiana Plan was to purchase 130 Mm3 between 2008 and 2015, 70 per cent to be re-allocated for aquifer recovery and 30 per cent to be re-allocated to 'illegal' groundwater users, farmers who have agriculture as their main activity and source of income. The plan, although mainly focused on the purchase of water rights, has also established a parallel process of buying land (and water rights) in the park periphery (Figs. 10 and 11) with an estimated purchase of 2–3 Mm3 water rights by March 2011.

The total budget of the Special Upper Guadiana Plan is €5 billion for 2 per cent of Spanish territory, of which €810 million has been set aside for the purchase of water rights to be re-allocated on social and environmental grounds. An assessment of the early effectiveness of the Special Upper Guadiana Plan, the main measure in the draft Guadiana River Basin Plan, indicates that of the €340 million included in the plan for the period 2008–2010, only €104 million was actually budgeted for, and of this only €83 million was actually spent to purchase around 20–30 Mm3 (Barcos et al., 2010).

However, what is most problematic about the Special Upper Guadiana Plan is if it is seen as an end in itself, and the underlying incentive to irrigate is not addressed. As stated by WWF-Spain, the Special Upper Guadiana Plan should be seen as a catalyst for change, opening a window of opportunity for a long-term, robust and self-sustaining socio-ecological system.

Source: Consorcio del Alto Guadiana

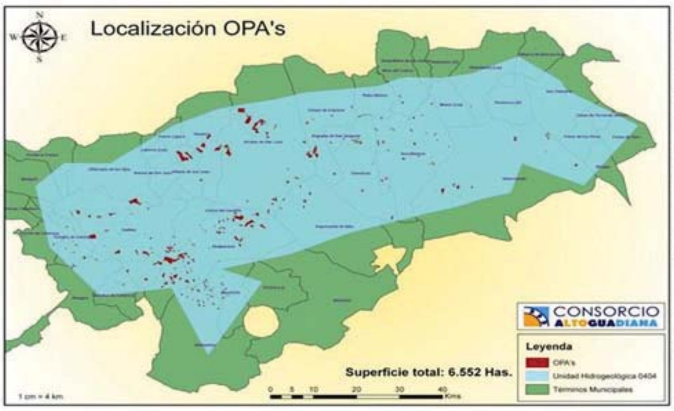
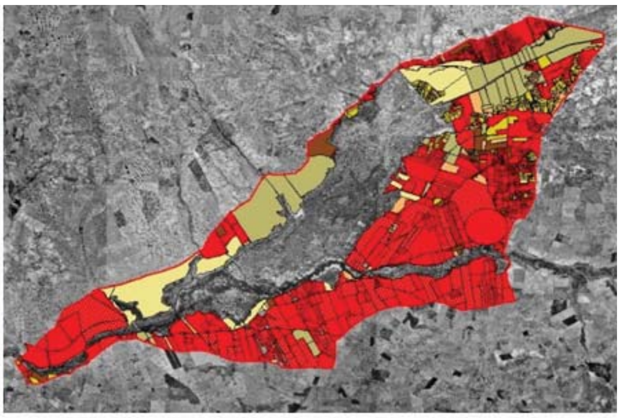


Figure 10. Location of purchased water rights 2008–2010.



Source: Ruiz de la Hermosa (2009)

Figure 11. Land (and associated water rights) purchased in the periphery of the park.

The plan is an opportunity to re-direct agriculture towards a less water-intensive growth model, freeing up water for other users, or ecological functions. In fact, it could be argued that the National Park has acquired rights, (in line with first in time first in right). A key issue is the payments received from the Common Agricultural Policy (CAP), e.g. for cereals and also for alcohol production. The current process of CAP review and reform (CEC, 2010) for areas like the Upper Guadiana Basin is crucial because subsidies received by the CAP could be re-directed to other types of payment. Freeing up some of the water currently used for irrigation, could shift agriculture towards dryland farming and forestation with endemic (low water consumptive) species, which might have added value in terms of multifunctionality and carbon sequestration. Although this might not automatically mean less water consumption (Scanlon et al., 2007), it would result in a CAP focused on integrated rural development, eco-conditionality and environmental premiums (Table 2).

Table 2. Types of irrigated crops and prices (in red – the subsidies received in 2006 from the EU CAP)

needs irrig. crops	Total irrigation crops	(Euro/t)			Prod. (Euro/ha)	Econ. Prod. (GIS, CHG, 2008)	Farmers /ha (m3/ha)	Euro/L needs (Mm3)	UTAs*/ Mil (Euro/ha)	(Mill Euro)	(UTAs*)		L water
		Low	Aver.	High									
Cereal	Wheat	150	188	225	270.9	28,841	3,018	87	926	27	494	0.3	6
	Barley	130	163	195	270.9								
	Oats	140	175	210	270.9								
	Corn	143	147	215	346.5								
Veg.	Melon	122	196	270	0	16,422	5,027	83	6,666	109	6,425	1.3	77
	Tomato	-	367	-	0								
	Pepper	186	428	670	0								
	Garlic	934	977	1,020	0								
	Onion	57	98	140	0								
	Potato	-	177	-	0								
Others	Alfalfa	-	120	-	0	2,850	7,859	22	1,926	5	144	0.2	7
	Sugar-beet	53	51	50	0								
Vines	Vines	193	337	480	0	83,640	1,575	132	3,097	259	18,624	2.0	141
Total	**-**	**-**	**-**	**-**	**-**	**131,753**	**-**	**324**	**-**	**401**	**25,687**	**1.2**	**79**

*UTAs: Unit representative of the work of one farmer in one year all the day working in the farm.
(It is important to note that both vines and horticulture also receive CAP funding, but through indirect systems and also through Axis 1 Regional development funds.) (WWF-Spain, personal communication)

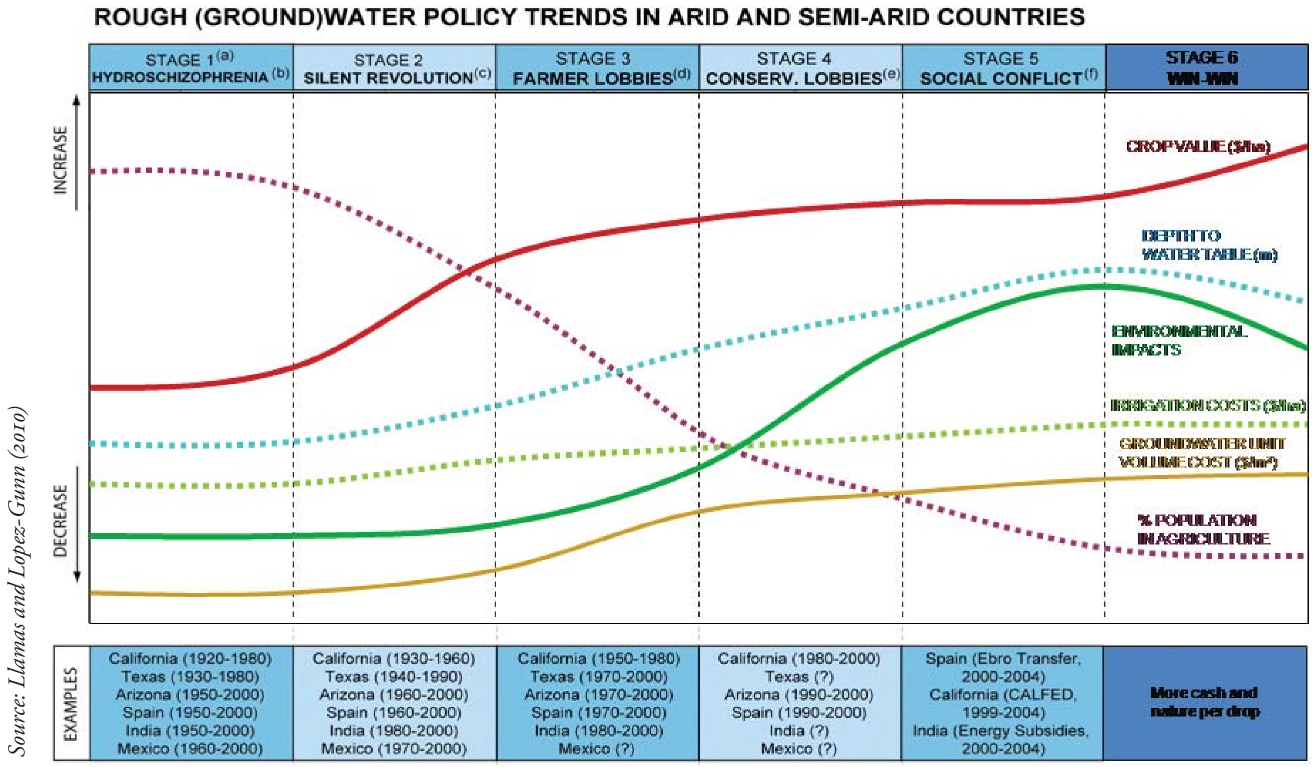


Figure 12. Evolution of conflict over groundwater resources towards 'win–win' solutions.

In this context, the Special Upper Guadiana Plan can be seen as a means to an end, a catalyst for change. It provides an opportunity for the gradual 'weaning' of the regional economy away from perverse external subsidies and also ensures that political rents are decoupled from water. At the moment, there is a clientelistic culture in the region, which is rent-seeking and has used the park as an excuse for subsidies. The shift increasingly is to ensure that public subsidies are ring-fenced as far as feasible for public goods (SEO/Birdlife and WWF-Spain, 2009). For example, shift the agricultural model towards reducing blue-water use with less irrigated cereals, and towards more high-quality vines, achieving true 'water savings', which are then kept in reserve for aquifer recovery. Also develop an agricultural model with a more sophisticated interplay between the conjunctive use of green and blue water (Vidal et al., 2009).

Results from the Bayesian network for the Western Mancha aquifer (2008–2027)

In a complex socio-ecological system, it is increasingly clear that the application of single measures from the Special Upper Guadiana Plan would not be effective. For example, key measures currently unfunded are those that focus on economic and social development and a programme for agricultural modernization and development. This is relevant because even if all groundwater rights were purchased as anticipated in the Special Upper Guadiana Plan, groundwater abstractions would not be reduced sufficiently if wells are not monitored, sanctions not executed, or the conditionality of CAP payments not overseen to ensure that groundwater abstractions stay within the given allocated quotas. The capacity of the organization created to manage the Special Upper Guadiana Plan and apply the measures (the Consorcio del Alto Guadiana) depends largely on available funding to execute the plan. Both funding and its use depend on political will, which thus becomes the main conditional factor for the future recovery of the aquifer. This was confirmed in a personal communication by the Director of the Consorcio del Alto Guadiana (November 2010).

In the context of the dramatic transformation of a socio-ecological groundwater-dependent system, and the six stages described in Fig. 12, the re-allocation of water towards more economically and water-efficient crops, which are also more socially equitable would represent the evolution from hydro schizophrenia to a win-win outcome for the environment and the socio-economic vitality of the region. An evolution from the formation of powerful farmers' lobbies asking for surface water transfers, to the consequent formation of powerful conservation lobbies, towards a final stage of reconciliation between social and environmental demands though 'win–win' solutions (Fig. 12).

Conclusion: from extrinsic motivation to intrinsic motivation: weaning the social system away from intensive groundwater use

The challenge is to change the current agricultural model where the social system in the short term is thriving at the expense of the ecological system towards a more balanced model, which aims to allocate

Table 3. Preliminary thoughts on a PES scheme bolted onto an alignment of 2013 CAP reform and river basin plans.

Crop	Current subsidy	Suggested PES
Cereal e.g. conversion to dryland wheat	180 euros/ha	Only available for dryland farming (green plusprima 50 e/ha carbon storage 50 euros desertification 50 euros for aquifer conservation
Vineyards	(through OCM)	Other (smaller) measures Green marketing (SEO)

water more equitably than at present between all users, including the biosphere reserve and the park itself. A process of socio-ecological restoration ultimately could have as its aim to develop a self-sustaining system (social, environmental and economic) through system re-design. In Europe the year 2013 – due to the CAP reform – presents a clear window of opportunity to create catalysts and tipping points in the re-design of the agricultural model. In the case of water in arid environments, facing strong competition between all users, moving away from the current trade-offs (and stand offs between sectors) requires identifying win–win solutions. In Spain the biggest challenge, therefore, will be to shift the paradigm, from 'more crops and jobs per drop' to 'more cash and nature per drop' (Llamas and Lopez-Gunn, 2010), and where the future reform of the CAP (and the wider context of World Trade Organization and increasingly regional or bilateral negotiations and agreements) will be pivotal. To put it simply, farmers and their behaviour whether to irrigate or not, is sometimes more heavily dictated or influenced by higher order systems and decisions like subsidies in Brussels (the EU) or protective fiscal barriers related to the World Trade Organization than by the rainfall regime.

The current Special Upper Guadiana Plan, which aims to re-allocate rights on the basis of environmental and social equity and justice, is an interesting experiment in the region. The downside is that the cost of the Plan is – in the current economic climate with an estimated budget of €5 billion over the period 2008 to 2027 for 2 per cent of the land in Spain –simply unaffordable by the national budget, even if the current economic crisis is overcome. But a parallel window of opportunity appears with the reform of the CAP. There is an opportunity under the concept of payment for environmental services (PES) and the rural development pillar of the CAP, to change the incentive structure away from irrigated agriculture by adding an environmental premium for dryland agriculture in the form of payments that include part of the payment for the services derived from soil conservation (Table 3).

A potpourri of visions is now available in the literature, with ideas and options under payment for environmental services and multi-functional agriculture (Wilson, 2010), with a more holistic vision on agriculture to produce not just food, but also 'clean water', the co-production of environmental and agricultural goods, and the re-direction towards a green economy model. As stated earlier, in the Upper Guadiana Basin this would be open to options like adding an environmental premium for dryland agriculture, e.g. green water credits, payments for soil conservation (although taking into account that the amount of rain-fed land doubles the irrigated area),

Photo credits: P. Zorrilla (2009); J.J. Rodríguez Barbero (2010)

Figure 13. Irrigated cereal farm and solar farm: growing cereals or Kwh.

for the training of rain-fed farmers on ecological rain-fed agriculture and green marketing, e.g. a label that certifies that the crop has been grown using only green water.

Other options are, for example, a 'climate adaptation fund' since Spain is a hot spot for climate change and the Upper Guadiana Basin has been identified as one of basins potentially most affected (Lopez-Gunn, 2009b). In preparation as a backstop adaptation measure even if predictions on climate change shift, would be a transfer of payments, that could be seen as part of a national adaptation and mitigation fund to pay farmers in rural areas to prevent desertification, and/or as investment in aquifers as green infrastructure (zero-cost storage for drought periods). Ultimately, it represents a growth model which inverts the existing incentive structure – paying for good behaviour instead of paying for not harming the environment – as well as the previous step of capacity building. This vision of a 'multifunctional' agriculture opens options. However, for this to be possible it has to go to the heart of the existing payment structure and deep inertias in the incentive structure for farmers to irrigate.

Buying water rights for both ecological and social equity reasons can be the key to opening the social consensus necessary for a change in the agricultural model towards a more diversified, self-sustaining 'green economy', which can in theory be bolstered by the reform of the CAP, with more emphasis on the rural development pillar. Equally, there would be a more diversified use of available blue and green water, e.g. re-allocating some existing water resources currently 'captured' by low-value irrigated cereals to free up water for the wetland itself (and associated tourism and the "experience economy" where consumers are ready to pay premium prices for various experience-aspects) and also for thermo-solar plants in the region. A new rural development model would aim to diversify the local economy, making it less dependent on large-scale irrigated farming. Instead, it would opt as a local farmer stated for 'growing kWh rather than maize', while also making more use of other economic sectors, like ecotourism, quality agricultural produce or payment for environmental services like carbon storage, exploring the water/energy nexus in its positive aspects.

The key is to be able to zoom in and shed light on options and finance schemes for self-sustaining green economic growth models. Most important is to make possible achieving the alignment of social and environmental systems, until now perceived in the local area as an impossible dream.

Alice laughed: "There's no use trying", she said; "one can't believe impossible things"."I daresay you haven't had much practice", said the Queen. "When I was younger, I always did it for half an hour a day. Why, sometimes I've believed as many as six impossible things before breakfast".

By Lewis Carroll(1832-1898) – "Through the Looking Glass and what Alice Found There (1871) http://en.wikipedia.org/wiki/Through_the_Looking-Glass

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BIOGRAPHIES

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Dr. Rita Colwell is Distinguished University Professor both at the University of Maryland at College Park and at Johns Hopkins University Bloomberg School of Public Health, Senior Advisor and Chairman Emeritus, Canon US Life Sciences, Inc., and President and CEO of CosmosID, Inc. Her interests are focused on global infectious diseases, water, and health, and she is currently developing an international network to address emerging infectious diseases and water issues, including safe drinking water for both the developed and developing world. In 2010, she received the Stockholm Water Prize for her pioneering research on the prevention of waterborne infectious diseases, which has helped protect the health and lives of millions of people worldwide.

Dr. Michelle Perez

Michelle Perez is a Senior Associate for the World Resources Institute's Water Quality Team. She leads a nutrient trading feasibility study in the Mississippi River Basin and a national Farm Bill environmental performance improvement project. Michelle received a doctorate in environmental policy from the University of Maryland School of Public Policy. Her dissertation is a three-state comparative case study of agricultural regulations in Delaware, Maryland, and Virginia. She has a Masters degree in environmental policy from Maryland and a degree in biology from Occidental College. Michelle also serves as President-Elect of the Soil Water Conservation Society's National Capital Chapter.

Mr. Allestair Wensley

Allestair Wensley has a degree in Civil Engineering from the University of the Witwatersrand (Johannesburg). He is a registered Professional Engineer in South Africa and a Chartered Civil Engineer with the Institute of Civil Engineers in the UK.

Allestair is a Chief Engineer within the Water Services Branch (community water supply) in the Department of Water Affairs, South Africa. He has extensive knowledge in the planning and development of sustainable rural water supply projects and specialist knowledge in the planning, development and deployment of engineering related information systems. He initiated the establishment of the Water Services National Information System (www.dwaf.gov.za/dir_ws/WSNIS).

Mr. Eddie Delport

Eddie Delport is a qualified Civil Engineer with an MBA. Early in his career he moved to municipal engineering and at Stellenbosch Municipal Council he distinguished himself as an innovator and a leader in the water and sanitation field and township development, presenting papers at several international conferences. He led the SALGA Technical Team in formulating the Strategic Framework for Water Services and represented the Institute of Municipal Engineering in Southern Africa at various forums and projects.

He currently teaches Project Management and Engineering Economy at the University of Stellenbosch and is a specialised consultant in water management services.

Mr. Grant Mackintosh

Grant Mackintosh is an experienced water utilization engineer in non-metro water services, water quality management, water treatment, capacity development, regulatory and cooperative governance. Grant has played a leading role in the research, development and implementation of municipal water quality management systems in South Africa. His company, Emanti Management, developed an electronic Water Quality Management System, eWQMS, which has received both national and international recognition. This system has added value to the South African community via the significant enhancement in efficiency of water quality management by local government, provision of information to water services sector partners, and raised awareness of the public.

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Dr. Monique Dubé is a Canada Research Chair in Aquatic Ecosystem Health Diagnosis at the University of Saskatchewan, Canada. Her area of expertise is integrated water resource management and watershed-scale cumulative effects assessment. She has published over 180 contributions, is the recipient of numerous awards, and her research has influenced policy, regulation, environmental impact assessment practices, and cumulative effects assessments for freshwaters. She serves on Scientific Advisory Panels for national and international (including UN) agencies. Her THREATS software is an exceptional contribution for defining a diagnostic process for assessing and managing watersheds towards sustainability.

Dr. Nicole Nadorozny

Dr. Nadorozny is a Landscape Ecologist whose research focuses on understanding landscape level influences on ecosystem processes. Her multidisciplinary approach branches fields of ecosystem science, spatial ecology and environmental geochemistry. Her work is focused on understanding how space and time influence patterns and trends in ecosystem structure, with specific applications to river water quality and quantity. Dr. Nadorozny provides the fundamental scientific leadership for Dr. Dubé's river research programs across Canada. Her current work is focused on the development of frameworks for effects based assessments within a Cumulative Effects Assessment (CEA) context across watersheds and for effects-stressor linkages within landscape-watersheds.

Ms. Allison Squires

Allison Squires is a PhD Candidate at the Toxicology Centre, University of Saskatchewan, Canada under the supervision of Dr. Monique Dubé. Her PhD research focuses on developing and implementing a watershed-scale framework for cumulative effects assessment using the Athabasca River in Alberta, Canada as a model river. She completed her MSc in Aquatic Toxicology at the University of Saskatchewan, and her BSc in Environmental Toxicology at the University of Guelph. She has presented her research at both national and international conferences and has received several awards for her presentations and research.

Dr. Peter Gleick

Dr. Peter H. Gleick is president of the Pacific Institute in Oakland, California. His work addresses the critical connections between water and human health, the hydrologic impacts of climate change, sustainable water use, privatization and globalization, and international conflicts over water resources. Dr. Gleick was named a MacArthur Fellow in October 2003 for his work, dubbed a "visionary on the environment" by the British Broadcasting Corporation in 2001, and in 2006 elected to the U.S. National Academy of Sciences. D.C. Gleick received a B.S. from Yale University and an M.S. and Ph.D. from the University of California, Berkeley and is the author of 8 books and many scientific papers.

Ms. Meena Palaniappan

Meena Palaniappan directs the International Water and Communities Initiative at the Pacific Institute. An engineer with more than 15 years experience in community-based environmental planning, Ms. Palaniappan has worked extensively on water, sanitation, and hygiene issues internationally including in Mexico, East and West Africa, and India. Previous projects include documenting successful water management worldwide, planning for future water infrastructure needs, and Peak Water. She is currently leading projects on a Community Choices decision-support tool (www.washchoices.org), and improving the resilience of communities to climate change induced water insecurity. She has degrees from UC Berkeley and from Northwestern University.

Prof. Patricia Burkhardt-Holm

Since 2003, Patricia Burkhardt-Holm is a professor of Ecology and heads the Institute Man-Society-Environment at the University of Basel (Switzerland). Before, she was director of a nation-wide project on fish catch decline (Fischnetz). Her research focuses on aquatic ecosystems, particularly on fish and the impact of natural and anthropogenic factors (e.g. endocrine disruptors, climate change). She is member of several national and international commissions and scientific boards and is Swiss delegate in the Scientific Committee of the International Whaling Commission. She initiated and co-chairs the curriculum commission of the interdisciplinary Master course in Sustainable Development at the University of Basel.

Prof. Takashi Asano

Takashi Asano is a Professor Emeritus at the University of California at Davis. Dr. Asano has more than 40 years of academic and professional experience in environmental and water resources engineering. He has conducted water reclamation and reuse studies at the California Water Resources Control Board in Sacramento and the University of California at Davis.

Professor Asano served as a member of the steering committee for the World Health Organization's Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Professor Asano is the 2001 Stockholm Water Prize Laureate, the members of the European Academy of Sciences and Arts, and the IWA Council of Distinguished Water Professionals.

Ms. Akiça Bahri

Akiça Bahri is the Coordinator of the African Water Facility, African Development Bank, Tunis, Tunisia. Dr. Bahri has academic and professional experience in water resources management. Her specialization is in the area of agricultural use of marginal waters (brackish and wastewater), sewage sludge and their impacts on the environment. She has been working for the National Research Institute for Agricultural Engineering, Water and Forestry in her home country Tunisia. She had been a member of IWMI's Board of Governors before becoming the IWMI Director for Africa. She is a member of different international scientific committees and has received international honors.

Dr. Arno Rosemarin

Arno Rosemarin PhD is Senior Research Fellow and currently Research and Communications Manager within the EcoSanRes Programme at Stockholm Environment Institute. Arno is an aquatic biologist with a research background in limnology, eutrophication, ecotoxicology and ecological sanitation. Since 2003 he has been working on the introduction of dry sanitation systems in urban communities and also the topic of global phosphorus reserves and methods to close the phosphorus nutrient loop in sanitation systems with agriculture. In 2009 he was selected to be a member of the World Academy of Art and Science.

Mr. David Osborn

David Osborn was recently appointed as the Coordinator of UNEP's Ecosystem Management Programme. Prior to this he was the Coordinator of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. A formal Officer of the Royal Australian Navy, David has also worked with the Australian Government's Department of the Environment and Water Resoruces as the Director, Water Quality, and Director, Coastal Policy, and the Great Barrier Reef Marine Park Authority. He has served as an Adviser to the Australian Government's Minister for the Environment and holds degrees in Environmental Science and Environmental Law.

Mr. Björn Stigson

Bjorn Stigson had a long career in international companies, among others as CEO of the Fläkt Group and Executive Vice President of ABB. He is a member of a number of boards/advisory councils, among others, Prince Albert II of Monaco Foundation; China Council for International Cooperation on Environment and Development; Energy Business Council of the International Energy Agency (IEA); America's Climate Choices Initiative of the US Congress, the Veolia Sustainable Development Advisory Committee and the Siemens Sustainability Advisory Board.

Mr. Joppe Cramwinckel

As Director for the Water Project at the World Business Council for Sustainable Development (WBCSD), Joppe Cramwinckel coordinates the implementation of an enhanced water programme in support of responsible water management. Before joining the WBCSD in 2010 he worked as Issue Manager for Water at Shell, which he joined in 1985, where he was, among others, the driving force behind the development of the WBCSD Business in the World of Water scenarios. Joppe is a member of a number of Advisory Boards and Advisory Councils including the European Water Partnership and the World Water Week in Stockholm, and is a member of the Supervisory Council of the Water Footprint Network.

Dr. Jiri Marsalek

Dr. Jiri Marsalek is research scientist and Head of the Urban Water Management Section at the National Water Research Institute, Environment Canada, in Burlington, Ontario. His research interests focus on the sustainable management of the urban water cyle. He serves as secretary of the International Association for Hydro-Environment Engineering and Research (IAHR) & International Water Association (IWA) Joint Committee on Urban Drainage and has worked extensively with UNESCO and NATO on urban water management. His recent awards include Environment Canada's Citation for Excellence (2005), two honorary doctorates from Sweden (2006) and Denmark (2008), and the IWA Honorary Membership Award (2010).

Prof. Maria Viklander

Prof. Maria Viklander, is Professor in Urban Water at Luleå University of Technology. She has a Ph.D. in urban water engineering (1997) and thesis focused on snow quality in urban areas and the paths of pollutants in urban snow deposit. Her research interests encompass broad aspects of urban water, ranging from water quality and quantity to management and strategies. She has served as a co-ordinator for a number of research projects, and organised many workshops and seminars. She chairs the Working Group on Urban Drainage in Cold Climate, under the IWA/IAHR Joint Committee on Urban Drainage.

Mr. Moses Masah

Moses Massah was born on 05 November 1959 in Liberia. He obtained a B. Sc. in forestry in 1985 and M.Sc. in regional planning with emphasis on environment/natural resources management in 2003 from the University of Liberia. Since 1985 Moses Massah has worked in many capacities including Lecturer of forestry and environmental planning and management, University of Liberia, Project Coordinator, Environmental Foundation for Africa, Program Officer/Natural Resource Management, Catholic Relief Services Liberia, Moses Massah joined the UNDP in Liberia in 2007 as Program Manager for Energy and Environment and was appointed as Programme Specialist in October 2010.

After 15 years working for a multinational corporate in the support services sector Chantal Richey changed gear to embark on a different career path and joined charitable sector. She is a leader with 20 years experience in post conflict, developing and developed nations in Africa in the private, humanitarian and development sectors. She has served in Liberia with Tearfund and Oxfam Great Britain in programme leadership. She is an expert in establishing and managing consortia and coordination in both the emergency stage and the post conflict transition and holds a Master of Science degree from Cranfield University, School of Applied Sciences.

Dr. Elena Lopez-Gunn

Dr Elena Lopez-Gunn is a Senior Research fellow at the Botin Foundation Water Observatory at the Universidad Complutense Madrid, where is currently leading a project studying collective action on groundwater. She is also a Visiting Senior Fellow at the London School of Economics and Political science and Associate Professor at Instituto Empresa. She was an Alcoa Research Fellow at the LSE Grantham Research Institute, where she was engaged on applying a rights based approach to Water in Bolivia. Her interests focus on governance aspects of water management, particularly the institutional analysis of different aspects related to collective action dilemmas at different scales.

Dr. Pedro Zorrilla Miras

Dr. Pedro Zorrilla Miras, PhD in ecology and environmental sciences, holds a Dipl.-Eng. degree in landscape and spatial planning. His current research fields are biophysical quantification of ecosystem services, ecosystem services and natural capital mapping, adaptive water management and public participation in natural resources management. His PhD research focused on the development of an participation tool for the analysis of groundwater management in the Upper Guadiana Basin (Spain) (as part of the EU-funded NeWater project).

Prof Ramon Llamas

Prof Ramon Llamas Director of the Botin Foundation Water Observatory, Prof. M. Ramon Llamas is currently emeritus professor of Hydrogeology at the Complutense University of Madrid. Since 1986 he is a Fellow of Spain's Royal Academy of Sciences. He chairs the Section of Natural Sciences (2000- present) and the International Relations Committee (2003-present) in this Academy. He is also a fellow of the Spanish Royal Academy of Doctors (2001) and of the European Academy of Science and Arts (2005).

Mr. Daanish Mustafa

Daanish Mustafa is a Reader in Politics and Environment at King's College, London. He received his Ph.D. from the University of Colorado, Boulder and his MA and BA degrees in geography from the University of Hawaii-Manoa and Middlebury College, respectively. His research interests lie at the intersection of development, water resources and hazards geography. He has been particularly interested in the role of social power relations at multiple geographical scales in influencing geographies of access to water and vulnerability to hazards. He has also maintained a parallel research interest in the spatiality of terror and violence.

Mr. David Wrathall

David Wrathall is a Ph.D. researcher at King's College London, studying environmental migration from coastal villages in Northern Honduras that have been irreversibly affected by tropical flooding. His research interests involve the development challenges of climate related hazards, social-ecological regime shifts and migration. From 2005 to 2007, he worked for Peace Corps/ Habitat for Humanity in La Ceiba, Honduras to mitigate tropical cyclone risk in marginalised neighbourhoods along the ferocious Cangrejal River. Previously he earned a MPA from the University of Georgia, and a BA from Brigham Young University, where he studied public policy and international development, respectively.

WORLD WATER WEEK IN STOCKHOLM

Building Capacity – Promoting Partnership – Reviewing Implementation

The World Water Week in Stockholm is the leading annual global meeting place for capacity-building, partnership-building and follow-up on the implementation of international processes and programmes in water and development. It includes topical plenary sessions and panel debates, scientific workshops, independently organised seminars and side events, exhibitions and festive prize ceremonies honouring excellence in the water field. Stockholm is the meeting place for experts from businesses, governments, the water management and science sectors, inter-governmental organisations, non-governmental organisations, research and training institutions and United Nations agencies. The World Water Week is organised by the Stockholm International Water Institute.

SIWI

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