This report has been prepared as input to the 2013 World Water Week and its special focus on Water Cooperation – Building Partnerships.

Cooperation for a Water Wise World

– Partnerships for Sustainable Development

WORLD WATER WEEK in Stockholm

SIWI

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Note to the Reader

This report provides input into the discussions at the 2013 World Water Week in Stockholm, which is held under the theme of *Water Cooperation: Building Partnerships*. The editors of the report are Anders Jägerskog, Director, Knowledge Services, Stockholm International Water Institute (SIWI); Torkil Jønch Clausen, Chair, World Water Week Scientific Programme Committee, SIWI; Karin Lexén, Director, World Water Week & Prizes, SIWI; and Torgny Holmgren, Executive Director, SIWI. The report has been language edited by Josh Weinberg, SIWI and layout of the report has been made by Britt-Louise Andersson and Elin Ingblom, SIWI. The report focuses on some of the key opportunities and challenges to effective cooperation over transboundary waters; in the private sector and for environmental protection. The authors also explore emerging issues such as the role of information and communications technology in advancing water cooperation; the importance of climate mitigation and adaptation coherence; the interplay between actors in the water, food and energy 'nexus'; as well as provide new insights to resolve long standing challenges, such as improving coordination and collaboration in the management of freshwater and coastal systems.

The chapters in this report do not necessarily represent the views of SIWI but are contributions from individuals and organisations to the theme of the 2013 World Water Week.

Contributing authors of the chapters are Lina Barrera, Conservation International (CI); Ana Cascão, SIWI; Joppe Cramwinckel, World Business Council on Sustainable Developmen (WBCSD); Anna Delgado-Martin, World Bank; Anton Earle, SIWI; Mats Eriksson, SIWI; Madeleine Fogde, Stockholm Environment Institute (SEI); Jakob Granit, SEI; Johan Hellström, Stockholm University; Holger Hoff, SEI; Maria Jacobson, SIWI; John Joyce, SIWI; Anders Jägerskog, SIWI; Louise Karlberg, SEI; Karin M. Krchnak, World Wildlife Fund (WWF); Peter Koefoed Bjørnsen, UNEP-DHI Centre on Water and Environment (UNEP-DHI); Johan Kuylenstierna, SEI; Karin Lexén, SIWI; Andreas Lindström, SIWI; Birgitta Liss Lymer, SIWI; Jan Lundqvist, SIWI; John Matthews, CI; Fang Qinhua, Xiamen University; Diego J. Rodriguez, World Bank; Arno Rosemarin, SEI and Josh Weinberg, SIWI. The production of the report was made possible through the support from the Swedish International Development Cooperation Agency (Sida).

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Introduction

By Anders Jägerskog, Torkil Jønch Clausen, Karin Lexén, and Torgny Holmgren, SIWI

In a changing and increasingly uncertain world it has become even clearer that we all depend on the same finite and vulnerable water resources to sustain life and well-being on our planet. In parallel, our interdependence grows every day as population numbers soar towards the predicted milestone of over 9 billion citizens by 2050. With so many of us, and with limited water available, to ensure a sustainable future we must become smarter at using, consuming and cooperating over this precious resource.

Three years ago, the UN General Assembly declared 2013 to be the International Year of Water Cooperation. As such, water cooperation was selected to be the topic of this year's World Water Week. As outlined in the Thematic Scope for the Week, the proceedings will address key aspects relating to cooperation, including the impact of cooperation at different levels, between sectors and among actors. We intend to inspire participants from different communities across the world to engage, discuss and develop solutions to the multi-sectoral challenges posed in achieving water cooperation.

A major challenge to the international community is to reach agreement on the Post-2015 Development Agenda. SIWI is involved in the discussions over the assessment of the Millennium Development Goals, the follow up of the "Rio+20" conference in 2012 and future Sustainable Development Goals. This challenge is in itself an important area for cooperation between nations as well as across different disciplines and actors. It is also a critical opportunity to achieve concrete and forward-looking decisions on common global goals and to implement necessary means to achieve sustainable development. Therefore, the Post-2015 Development Agenda is an important theme during World Water Week 2013. The World Water Week will offer the participants an opportunity to voice a common message through the Stockholm Statement. Designed to elevate the status of water in the Post-2015 Development Agenda, the Stockholm Statement will be submitted to the UN General Assembly in September. In June the Stockholm Statement Digital Forum, a collaborative online platform for the exchange of ideas, was launched as a tool

Photo: Biju Joshi

to receive input from a wide range of stakeholders. The results from this online collaborative forum will be presented at this year's World Water Week before submission to the UN General Assembly. In SIWI's capacity as a neutral, collaborative institute that connects science and policy, we have actively advocated for a Sustainable Development Goal on water throughout this process.

Cooperation between sectors is fundamental to realising success and is evident not just in the topic of the World Water Week, but also in the range of actors involved. This year, our key collaborative partners the Global Water Partnership (GWP), World Wide Fund for Nature (WWF) and World Business Council on Sustainable Development (WBCSD) will extend their considerable influence to ensure that messages generated from the week go beyond the 'water box' and into wider contexts.

At the World Water Week, we firmly believe that promoting effective cooperation will enable us to reach wiser decisions on water as well as spur implementation for sustainable growth and increased welfare. Providing platforms to increase and improve public-private partnership opportunities is a critical component of this vision.

Why do we need to cooperate?

Few oppose cooperation in principle. Most are schooled in the ethics of sharing and working with others from the first day they step into a classroom as a child, and feel that they understand what it means to cooperate. But cooperation is not always simple. The pathway to finding the right partners and approaches to cooperation is both a science and an art.

Considerable research has been done to create a formidable knowledge base on what cooperation is; how it comes about and how it can be sustained at various levels. In the 1980s Axelrod applied game theory to show that a 'tit-for-tat' approach – where a defection from one party is countered by defection of the other – was a 'winning' cooperation strategy (Axelrod, 1984). However, if one allowed the model to run simulations over a long period of time, it was shown that at a certain point the sub-optimal solutions

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that emerged were "too" sub-optimal for parties to continue. Axelrod maintains that over time, interdependence between parties will develop and become beneficial to the actors involved. The research showed that what makes it possible for cooperation to emerge is that the actors are meeting many times. He achieved a scientific demonstration of what we know intuitively: people want to cooperate and it helps when they get to know each other better. Another important insight is that when actors meet each other many times over a period of time, clusters of increased collaboration and cooperation will emerge.

In and beyond the water community it is clear that sustained interaction has and will yield increased benefits when parties cooperate. Quite simply, the more adept organisations become at cultivating their partnerships the more they will achieve.

In the chapter on transboundary waters, Cascão *et al* note how trust can be built over time. Indeed, how can the clusters of cooperation outlined above – where actors meet over time – within and beyond the water community be established and strengthened further?

Coming at the issue of cooperation from a slightly different perspective – namely that of a biologist and mathematician – Nowak (2006) showed that cooperation often tends to favour the defector, quite opposite from the economist's view of a static equilibrium. He argues that cooperation will break down from time to time but the key is how quickly the trust can be rebuilt. Thus, the stability of the cooperation, and the ability of partners to quickly restore relations following disagreement, will largely determine the overall level and potential quality of the collaboration (Novak, 2006). Thus, the stability and chances of re-establishing cooperation between individuals, groups, sectors and even states is a key challenge within the water community as well as beyond it. This provides an important insight to transboundary waters – where cooperation often breaks down – restoring cooperation swiftly after a crisis is crucial to the immediate and long term health of the relations between parties. Similarly in the private-public sphere (see Cramwinckel *et al*, this volume) the ability to quickly rebuild cooperation between parties is imperative.

From the international relations perspective it is argued that unless there is a potential conflict you have nothing to cooperate over. Indeed, it is a common perception that a conflict is needed in order for cooperation to happen. Otherwise it would be harmony. Keohane (1984) argues that when there is harmony between two or more actors the policies pursued by each actor automatically facilitate the attainment of the goals of the other actor. When discord (or conflict) prevails the actions taken by each actor effectively hinder the attainment of the others' goals. Regardless of whether harmony or discord characterises relations between two actors, there is no incentive for either of them to change its behaviour. Cooperation, as distinct from harmony (and definitely as distinct from discord), 'requires that the actions of separate individuals or organisations – which are not in pre-existent harmony – be brought into conformity with one another through a process of policy coordination' (ibid). From this perspective the international relations governing a shared resource such as water is seldom characterised by harmony but rather by conflict of some sort. Similarly is the case of water, food and energy (see chapter by Granit *et al* as well as Rodriguez and Delgado, both in this volume) where a conflict in terms of use exists and where it is imperative to achieve a process where all relevant actors come together and find ways to cooperate. Such conflicts also exist in relation to the environment and the use of water along the continuum from source to sea where freshwater, coastal and sea water systems come together (see Lundqvist *et al*, this volume).

As noted above, the theoretical perspectives are useful for our understanding of how we can promote water cooperation and strengthen partnership – during and through the World Water Week but more importantly beyond the week and beyond the water community. Increasing the number of meeting places and platforms for interaction will help to create clusters where cooperation and partnerships can merge, develop and thrive. While the theoretical perspectives on cooperation are important, often the quality of the cooperation is what matters most for individuals and groups. For the Palestinian farmers that cannot access water to irrigate their fields or for the marshes in Iraq that are not receiving enough water, improved and more effective cooperation is the key. Zeitoun and Jägerskog (2011) outline that effective cooperation in the Transboundary Water Management (TWM) setting includes perspectives of equity and justice and not merely that a group of actors are working together. Such a perspective seems instructive for not only TWM but also between sectors and groups. For effective and sustainable implementation of projects, programmes and policy decisions, quality cooperation between actors within the water community and even more importantly those beyond it, is needed.

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Thematic Scope of the 2013 World Water Week

2013 has by the UN General Assembly been declared the "Inter-national Year of Water Cooperation". The questions to be addressed in 2013 include: why do we need to cooperate, on what, for what aim, at what level, with whom and, not least, how?

With an expected world population of more than 9 billion people by 2050, basically depending on the same finite and vulnerable water resource as today for sustaining life and well-being, our inter-dependence is growing every day. In 2015 we shall take stock of the achievement of the Millennium Development Goals (MDGs), and a process of developing a new set of Sustainable Development Goals (SDGs), has been initiated as an outcome of the UN Conference on Sustainable Development, "Rio+20", in June 2012. The Rio+20 outcome document clearly states water as one key area for achieving sustainable development and thus on important part of the upcoming SGDs and post 2015 development framework.

We need to understand how 'my water use' effect everybody else's, and enter into meaningful and informed dialogues with other people and communities of practice, inside and outside the "water box", engaged in using, or wasting or polluting, our common and shared water resource. In this endeavour we need to engage with groups of people who can help us understand the very essence of co-operation: what is cooperation? What drives people, states and organisations to "cooperate" rather than "defect"? What determines the direct and indirect reciprocities that make us cooperate, and the mechanisms of selection of those with whom we want to do so? And how do we identify and measure the quality, aim, benefits and barriers to cooperation, and create an enabling environment for cooperation? How can more effective cooperation enable us to reach future-oriented decisions and force implementation, and how can we best build partnerships among actors to achieve common goals?

In the following thematic scope of the 2013 World Water Week in Stockholm in is formulated from the perspective of the "what's" and who's"; but in developing the workshops, seminars and other events the "how" questions must be central. Each workshop will also review the progress made in water cooperation.

Perspectives for building partnerships, advance future water cooperation and find solutions to the world's water related challenges will be explored.

Cooperation between actors in different sectors – optimising benefits to water

Cooperation between actors in different sectors is essential for proper water development and management, and water managers need to reach out and work closely with actors in most of sectors of society. Water as an important driver of economic and social development needs to be addressed by people both 'inside and outside of the water box'.

With renewed global focus on the 'green economy', and the challenge of meeting the sharply increasing food and energy demands, the need to address water, energy and food security as a particularly important 'nexus' has been highlighted. This calls for increased cooperation between these fields, with an ecosystems services perspective, sharing water benefits, costs and risks, and cooperating with the stakeholders concerned. A shared understanding and analysis of the economic and financing aspects is a prerequisite for meaningful cooperation.

Ensuring adequate domestic water supply and sanitation, not least in the rapidly growing urban centres, and satisfying the need of other strongly water dependent sectors, such as industry, tourism/recreation and transport, also calls for cross-sectoral collaboration.

Cooperation between stakeholder groups – recognising water as a common good

The right to safe drinking water and sanitation has been recognised as a human right by the UN; for all other uses government has a responsibility to ensure the optimum allocation and management of the water resource for the whole of society. This calls for the involvement of all relevant stakeholder groups, and for getting central and local governments, civil society organisations, private sector, academia and practitioners to the same table.

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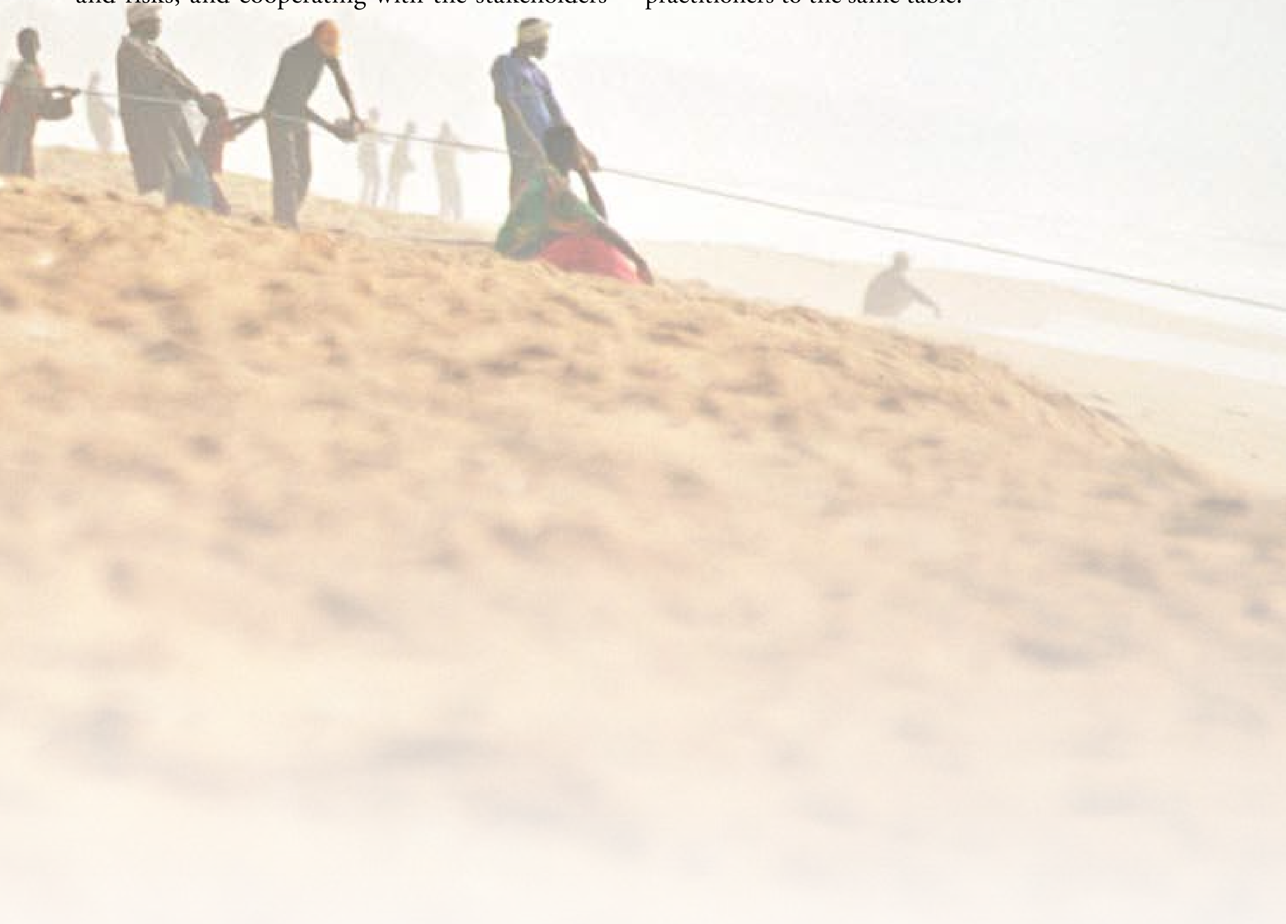

Taking this involvement 'outside the water box' to a broader group of stakeholders requires working with all actors in the supply chain, referred to as 'field-to-fork', 'field-to-fuel tank', 'cradle-to-grave' etc.

In this process, involvement of civil society organisations, and the general public, is not only a question of information; transparency and inclusiveness in decision-making requires early identification, consultation and involvement of those who will share the benefits, those who 'lose', bear the costs and run the risks. In this context it is important to recognise that cooperation needs to involve all people and cultures, ensure gender equality, work with and build on youth as the foundation of our future, and respect cultural values while bridging to ethnic and tribal groups.

An increasingly important stakeholder group for effective water development and management is the private sector. This includes both large-scale and small-scale enterprises for whom safe access to water, and water efficient production, is important in the face of the challenges of increased water scarcity. Private infrastructure investors and developers share similar concerns, and are faced with increasing demands for achieving environmental and social sustainability of infrastructure developments. Effective public-private-civic partnerships to ensure dialogue, and share benefits, costs and risks, are critical to make this work.

Water is a local resource, but cooperation on water also needs to be global. Enhancing the 'north-south' and 'south-south' cooperation between high income, transitional and low income regions and countries is a continuous challenge. However, the traditional divides between 'north' and 'south' are rapidly changing in a globalising world, and so are the mechanisms of cooperation.

Cooperation across traditional management – from hilltop to ocean

Managing water means different things to different 'water communities': freshwater resources management, often divided into specialties around rivers, lakes, groundwater and glaciers; drinking water and sanitation management; wastewater management; coastal zone management etc.

These communities again divide into different communities around the purpose of water development and management, such as different economic use sectors; ecosystems and habitats; climate change, disasters etc. Although all of these communities address water as a vital resource for society, they often live separate lives without much communication between them. Bridging these management divides is a major water co-operation challenge to achieve coherence in policies and practices.

Many such relevant 'management communities' could be mentioned, but some of the more obvious relate to land, ecosystems and oceans, as well as to the linkages to climate change and disaster risk reduction. Land management is critical to water management: managing water with the land from 'green' to 'blue' and 'grey' water, and managing land rights and tenure, land use and management, and land acquisition, as key determinants to water governance. Although the concept of integrated water resources management (IWRM) explicitly mentions the land-water linkage, in practice it is often forgotten.

The outcome document of the UN Conference on Sustainable Development "Rio+20" states the need to "significantly reduce water pollution" and "significantly improve wastewater treatment". These long neglected issues require significant intersectoral cooperation to address the serious backlog that exists.

Similarly, in a world with increased competition for scarce water, maintaining and developing ecosystem integrity and functions are critical. Ecosystem services for human livelihoods and bio-diversity, integrating IWRM and ecosystem approaches, along with environmental flows, strategic environmental assessment (SEA) etc. are all important aspects to include. Relevant ecosystems to water management are terrestrial and aquatic. The continuum of water management from 'hilltop-to-ocean (H_2O)', or 'ridge-to-reef', does not always receive the attention required. Bridging the freshwater-coastal-ocean management divide, reconciling and coordinating IWRM and integrated coastal zone management (ICM), is still a major challenge.

Mainstreaming water and disaster management, from 'prevention to cure', learning from the relief phases to establish cooperation for prevention, including through integrated flood management (IFM), integrated drought management (IDM) and coastal flooding preparedness (hurricanes, tsunamis etc.) calls for the two traditionally rather separate communities to come together. Although water related disasters have always been with us, and always will be, indications are that climate change may accelerate both the frequencies and severity of disasters. Considering and mainstreaming climate change mitigation and adaptation is an added dimension of good water governance. This calls for bridging the 'water-climate community' divide, and building water-energy alliances for improved synergies between adaptation and mitigation.

Cooperation between jurisdictions and levels – from village to transboundary basin

Water follows its own hydrologic boundaries, and implementing IWRM principles in practice needs to focus at the basin level by bridging administrative boundaries (districts, municipalities/cities, provinces, states), involving all relevant stakeholder groups, while respecting overall policies, strategies and laws set at the national level. This involves a combination of top-down and bottom-up processes, practicing IWRM thinking in water governance from small watersheds, through sub-basins to basins/tributaries to transboundary basins (rivers, lakes, aquifers), and building sustainable institutions at all levels to do so.

When basins transcend jurisdictional boundaries and become 'transboundary', be they between provinces, states or countries, political dimensions enter into the equation. Managing transboundary waters often start at the technical/scientific level, before moving into political cooperation, and thus 'hydro-diplomacy', with dialogues on the sharing of water and water-related benefits and products, such as food and energy, across boundaries. Evidence suggests that through proper management water can become an economic win-win agent and a 'lubricant of peace'.

Cooperation between jurisdictions and levels calls for collective action and stakeholder negotiations with proper tools and processes to make cooperation actually happen. Such processes need to recognise power perspectives and asymmetries, and the risk of 'hijacking'. This does not always come easily, and the equitability and quality of cooperation, as well as barriers in the form of e.g. corruption and exclusion, are important to consider.

Cooperation between scientists and users – bridging the science-policy gap

Knowledge must be shared based on context and needs of those involved, to develop evidence-based policy, make decisions and raise awareness. Science-policy gaps are common, often with too much "science-push" and insufficient attention to "policy pull".

To respond to the challenge of communicating research findings to decision-makers and practitioners, and ensure the science community responds to policy needs, entails understanding of the latest thinking and understanding of practical solutions to the various obstacles that can impede knowledge sharing and application. This calls for informed dialogue, based on inclusiveness, transparency and access to relevant data and information. Making science relevant to policy-makers, bureaucrats, practitioners, and not least to the public, is a major challenge, as is the clarification by decision-makers of the kind of answers they need from science. From basic to applied science, from short-term solutions to long-term visions, the challenge is to clearly communicate technical and scientific findings to decision-makers and practitioners, 'from bookshelf to policy', from 'models to decision support systems'.

The chain starts with education to form the scientists and politicians that will close this gap in the future, and ends with the development and implementation of policies that will change our behaviour towards a more sustainable world of water.

Contributions of the Report

Through its eight chapters, the report provides insights into opportunities and challenges for water cooperation across a wide range of areas. It highlights where cooperation is well-functioning as well as where more is needed. Krchnak and Barrera outline the challenges of cooperation for the environment with a particular focus on ecosystems and conservation. They draw on their World Wide Fund for Nature and Conservation International experience at the transboundary and local level to illustrate how cooperation between civil society and the private sector can contribute to efforts to maintain ecosystems, sustain livelihoods and protect biodiversity. Cramwinckel and Lindström explore the challenges and prospects for improved water management from a private sector perspective. They outline the water related risks (both short-term and long-term) and responsibilities of private sector actors to cooperate with a range of actors to engage in sustainable water stewardship. Hellström and Jacobsson examine how information and communication technology (ICT) can be used to improve water governance and cooperation while decreasing corruption. Drawing on examples from East Africa they explain how the use of mobile phones has improved market access but also how ICT has enhanced possibilities to share and access information which can be used to increase knowledge, transparency and accountability. Cascao, Earle and Jägerskog address transboundary challenges as they relate to cooperation discussing politics, food, environment, security and energy in this context. They identify the very political nature

Photo: Alfred Borchard

of transboundary water management as a key to understand why and how cooperation occurs as well as the quality of that cooperation. Looking forward to the 2014 World Water Week which will focus on water and energy, Rodriguez and Delgado discuss how the linkages between water and energy could be better addressed through improved understanding, coordination and cooperation between actors in each sector. Granit, Fogde, Hoff, Joyce, Karlberg, Kuylenstierna and Rosmarin build upon this discussion in their analysis of the Water, Energy and Food Security Nexus, which explores how tools and frameworks developed for transboundary and other settings can potentially help to better understand and manage the challenges within the nexus. Lexén, Matthews and Eriksson discuss the disconnect between climate mitigation and adaptation measures and strategies. They point to water as a common element for both mitigation and adaptation and highlight the need for more cooperation between the energy and water communities to address this challenge in a serious manner. Lundqvist, Koefed-Bjornsen, Weinberg, Liss-Lymer and Fang discuss the challenges of interaction between the river basin and the coastal and sea systems and highlight the need to improve systems of governance of land, water, coastal and marine systems. Questioning the lack of integration between freshwater and coastal and marine governance systems they call for more cohesion between the sectors usefully drawing attention to positive examples.

Photo: Elvis Santana, SXC

Promoting Ecosystem Health and Conservation through Water Cooperation: Lessons Learned

By Karin M. Krchnak, WWF and Lina Barrera, CI

"The full costs of the loss and degradation of [Earth's] ecosystem services are difficult to measure, but the available evidence demonstrates that they are substantial and growing." – Millennium Ecosystem Assessment[1]

"No one entity – no individual government, corporation or NGO – can address the sustainability issues we face… partnering across sectors will be crucial…"
– Peter Senge, The Necessary Revolution[2]

Despite growing acknowledgement that freshwater ecosystems provide the life-support systems for people, and the foundation of sustainable economies, they are under increasing threat. To ensure healthy, resilient freshwater ecosystems that sustain nature, communities and economies, close cooperation between diverse actors is essential.

As large, international conservation organisations, World Wildlife Fund (WWF) and Conservation International (CI) work to protect freshwater ecosystems and improve water access, efficiency, and allocation for people and the environment. To effectively address issues related to water conservation, water stewardship and water security, WWF and CI work in collaboration with those responsible for water protection and management – governments, local communities and businesses – helping to achieve lasting conservation that meets the needs of both people and nature.

Drawing on lessons learned from both organisations to promote ecosystem health and conservation through collaboration, we reflect on examples that highlight challenges, realities and new concepts that offer opportunities to advance freshwater conservation.

Lessons on cooperation with multiple stakeholders

Increasing competition over limited water resources in the past decade has already induced a shift away from isolated problem solving by governments, multi-lateral banks, civil society and the private sector toward more integrated resource management as a fundamental approach to resource allocation issues. This does not mean that coming to agreement on the allocation

1 Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Synthesis, Island Press (2005).
2 Senge, Peter. *The Necessary Revolution: How Individuals and Organizations are Working Together to Create a Sustainable World.* (New York: Doubleday, 2008), 93-94.

of water resources – and the benefits produced by freshwater ecosystems – is a straight forward process. Not only do we need better information on the ecosystems at risk (e.g. what flows are required, what the potential impacts of climate change are, etc.), and its beneficiaries (e.g. who they are and how they interact with the environment), but we must also develop participatory processes that engage a multitude of important stakeholders to understand the problems faced and work together on solutions. The Rio+20 dialogues[3] emphasised that governments alone cannot do everything needed to manage and protect our ecosystems. The private sector, community organisations, indigenous groups and civil society must be part of the solution.

For example, in Colombia, CI has been working with the Bogota Water Supply Company to ensure that the capitol city and its surrounding rural communities have sufficient drinking water now and in the face of a changing climate (Conservation International, 2011). The city of Bogota receives all of its drinking water from nearby high-altitude wetlands and ecosystems that also provide irrigation for the surrounding communities. Climatic changes are expected to intensify the water cycle in the region causing physical changes that will reduce the capacity of the ecosystems to maintain a regulated water cycle and water storage capacity.

The strategy in the region has been to organise landowners – both individuals and the private sector – to participate in developing and implementing a sustainable land-use arrangement across the entire 600,000 hectares of the Chingaza-Sumapaz-Guerrero Conservation Corridor. The landscape-level management programme prioritises areas for conservation, restoration and natural resource use to help protect important headwaters and habitat, and to mitigate and build resilience to the impacts of climate change. To finance the project, CI developed the first forest carbon programme under the Kyoto Protocol's Clean Development Mechanism in Colombia. This programme mitigates an estimated 28 million tonnes of CO_2 emissions over a 20-year period, and generates carbon credits that are sold on the carbon market.

As another example, WWF worked with The Coca-Cola Company in Vietnam's Tram Chim National Park – a 7,500-hectare remnant of the once-vast Plain of Reeds ecosystem – to institute a new management statute and to improve relations with local communities (WWF-Coca-Cola Company, 2011). WWF has worked with The Coca-Cola Company since 2007 on freshwater conservation issues. For Coca-Cola, water is used for its beverages, in its manufacturing processes, to grow the ingredients it sources and is essential for sustainable communities, so the health of freshwater resources is crucial to its business.

Together, WWF and Coca-Cola worked with park officials, local authorities and communities to implement hydrology management techniques, remove 400 meters of internal dikes to improve river connectivity and flow, and establish natural resource user groups to help reduce conflicts over declining resources. Through participation in the resource user groups, communities are able to sustainably harvest firewood, fish, eels, grasses, water lilies, lotus flowers, vegetables and shellfish from within the park's boundaries. Additionally, the members of the user groups are more aware of how conservation and sustainable use of natural resources will help ensure the long-term viability of the wetland.

Significantly, the partnership team advocated for park management reform and helped pass a first-ever statute that allows park officials to optimise biodiversity within the wetland ecosystem. As a direct result of the statute and other habitat restoration efforts in Tram Chim National Park, grassland habitat has tripled, the presence of birds has increased dramatically, and, in 2012, Tram Chim was designated as the 2,000th Ramsar Site, marking it as a wetland of international importance.

Lessons on cooperation across jurisdictions

The complexity of water resource allocation decisions increases tremendously when cooperation across jurisdictions is required. Water is a local issue, so in order for cross-jurisdictional cooperative arrangements to be successful, they must offer countries more advan-

[3] See the Rio+ 20 Outcome Document, *The Future we Want* at http://sustainabledevelopment.un.org/futurewewant.html


Photo: Manfred Matz

tages than they would gain through unilateral action. They must also provide mutually agreed upon benefit allocation, combined with methods or instruments that allow all sides to evaluate the fulfillment of their interests. As water systems evolve and change, there is increasingly a need to move beyond specific allocations of water to benefit sharing that accounts for all of the benefits that freshwater systems provide – such as flood mitigation, the potential to produce hydropower, healthy fisheries, water purification and agricultural productivity.

An example of the complexity of transboundary basins can be seen in the Zambezi River, which provides the ecosystem goods and services that are central to the economies of its eight riparian countries – Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. The landscape in the Zambezi riparian countries has changed in response to human development pressures, including through increased construction of dams to supply water for agriculture, hydropower generation and industrial use. The riparian countries, the Southern African Development Community, and the newly created Zambezi Watercourse Commission (ZAMCOM) are actively advancing improved water resource management across different parts of the Zambezi Basin.

WWF and partners are assisting ZAMCOM, dam operators and river authorities to realise mutual benefits of ensuring the right environmental flows to maintain the the health of the basin, support local livelihoods and potentially enhance flood management through pilot projects in the Lower Zambezi and Kafue Flats. The potential benefits of establishing environmental flow for the Lower Zambezi have been well studied (Beilfuss & Brown, 2006). In the Kafue Flats, WWF gained important experience while working in partnership with the Zambian Ministry of Energy and Water Development and the Zambian Electricity Supply Company to change the operational regime of the Itezhi-tezhi and Lower Kafue Gorge dams to replicate the natural flood patterns to restore freshwater and floodplain ecosystems and to enhance food security in the Kafue Flats (Schelle & Pittock, 2005).

The challenge is to make technical analysis accessible and understandable for decision makers as well as for broader (non-technical) stakeholder groups, and ensure their participation in the process. Ultimately, these stakeholders make the decisions about what level of environmental flow release is desirable based on how these flows will benefit them. Although environ-mental flows are incorporated in several river basin strategies and thus known to politicians, it will require much more interaction with civil society to become a broadly accepted concept. This is especially true if environmental flows are to be considered when economic development plans are discussed and drafted.

Lessons on cooperation related to perceived trade-offs

One of the challenges in moving toward water security is convincing policymakers that protecting ecosystem goods and services is a prerequisite for promoting social and economic development. To ensure that societies have access to sufficient water to meet the needs of people, nature and industry over the long term, it is critical that these concerns are taken into account in economic development plans. This will not happen without cooperation, since interests representing the environment are often less powerful, such as Ministries of the Environment or Water, or not included in discussions, as is the case with many civil society, community and indigenous groups.

Emerging concepts like "green economy" and "green growth," including the water-food-energy nexus, (see "Unpacking the Water-Energy-Food Nexus: Tools for Assessment and Cooperation Along a Continuum" in this publication) offer opportunities to align development with smarter water management while bringing together multiple sectors and interests. A nexus approach that incorporates the inherent value of healthy freshwater ecosystems is particularly relevant in transboundary basins where identifying inter-sectoral synergies and opportunities for additional benefits from stronger integration across sectors can help structure dialogue and cooperation around specific needs, trade-offs and mutually beneficial solutions.

For example, CI is working with partners in the Mekong region to evaluate the trade-offs between hydropower development and maintaining fisheries health in the "3S" rivers (Sesan, Srepok and Sekong rivers) in Cambodia, Vietnam and Lao PDR, with the aim of developing decision support tools for the region. More than 34 small- to larger-scale hydropower dams are planned in the basins with little consideration to date of the trade-offs that may be involved. The "3S" rivers are responsible for nearly 30 per cent of sediment and 20 per cent of water movement from the upstream portion of the Mekong to downstream delta areas – ultimately supporting the lives of 60 million people (Piman, *et al*, 2012.). The area is also critically important for fish migration (including rare species like the Giant Mekong catfish), and is home to indigenous communities, many of whom are directly dependent on the flow of the rivers for food, transportation and to support their livelihoods (Mekong River Commission, 2011).

As a complement to this work, WWF is contributing strong science, such as habitat classification mapping, ecosystem assessments and connectivity studies, to the development of ready-to-use rapid assessment tools to help select the right hydropower project for the right place. This includes the Rapid Basin-wide Hydropower Sustainability Assessment Tool – a project with the Mekong River Commission (MRC) and Asian Development Bank – that guides decision makers towards the most sustainable sites, designs and operation rules for hydropower development, and creates a platform for constructive engagement and cooperation among a range of stakeholders, including government agencies, developers and civil society.

The MRC has recognised the importance of addressing water in an integrated manner in order to realise the potential for developing fisheries, agriculture, forestry and energy in the region without inadvertently undermining development goals. The 2012 "Mekong2Rio" conference addressed this nexus and emphasised the importance of integrating water in the sustainable development discussions at the Rio+20 conference in Rio de Janeiro, Brazil. CI, WWF and partners are contributing to these discussions, and working collaboratively to carry out an assessment of the water-food-energy nexus and bring stakeholders together for informed, transparent planning for the future of the Mekong region.

Conclusion

Freshwater availability, quality and security are among the fastest-growing social, political, economic and environmental challenges faced today. While water resources are local, water shortages are a global issue, and linkages with food and energy systems may create challenges and trade-offs that become increasingly difficult to manage. Many stakeholders have a role to play in developing solutions to these challenges.

The Millennium Ecosystem Assessment raised the alarm that freshwater ecosystems are being degraded at a rapid rate and that this may undermine future well-being. The challenge is to link the passion for ecosystem conservation to compassion for human well-being. This requires using sound science to inform policy and, where science is lacking, allow sufficient time for analysis to determine that development decisions will not undermine ecological integrity. It will necessitate the advancement of concepts related to integrated water resource management, the water-food-energy nexus and the "green economy" while ensuring they are underpinned by a prerequisite for healthy, functioning ecosystems. It will also mean building good water governance that incorporates environmental considerations into decision-making processes from the beginning.

Much work remains to address these challenges and to find new and creative ways to slow and reverse the rapid loss of freshwater ecosystems. Collaboration and cooperation with a wide variety of actors offer the opportunities and solutions to address global challenges, like freshwater conservation. Looking forward, the need for collaboration will only increase, particularly in the next half century when several more billion people will need to share our limited natural resources. To sustain the resources that people, nature and economies depend upon, collective action is needed. It is now more important than ever for conservation organisations, governments, civil society, communities and industries to work together to successfully and sustainably meet these needs while protecting nature.

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Photo: Nora Lee, SIWI

Water Resources and the Private Sector

By Joppe Cramwinckel, WBCSD and Andreas Lindström, SIWI

Global trends in water use and availability

According to the Comprehensive Assessment of Water Management in Agriculture (2007), almost 20 per cent of the world's population lives in areas of physical water scarcity. A water scarce region is one where water resources development is "approaching or has exceeded sustainable limits" (i.e., where there is not enough water to meet all demands). The current aggregated global service gap in access to water is striking: Consider the following estimates: more than 1.8 billion people globally do not have access to safe drinking water (Onda *et al.*, 2012). Over 4.1 billion people lack adequate sanitation and/or are served by systems with improper treatment (Baum *et al.*, 2013). These staggering numbers are much higher than the most commonly used figures. They take account of the un-served as well as all the people who may be connected to a sewer but where the discharge to the aquatic environment is without treatment.

Water is also a fundamental resource in energy production. Currently underserved populations and growing economies fuel an ever increasing demand for energy and consequently water (Granit & Lindström, 2011). Climate change presents additional water management challenges at regional and local levels: droughts and floods may increase in many regions and cause shocks to both developing and developed economies, influencing water supply, demand and buffering systems. Managing water requires understanding the whole picture.

Private sector links to water resources

Water resources are used for a great number of activities. Competing demands for water intersect at the river basin level. Water is diverted and consumed as part of large irrigation schemes for crop production. Water is similarly abstracted and to some extent consumed to meet ever-increasing energy demand. Water is fundamental for energy producers as a processing component in fuel production and likewise for cooling in power generating processes. A range of industrial activities are water intensive, such as the food, drink and milk industries, as well as the metal, pharmaceutical and paper and pulp industries, in which water is required for refinement processes, for cooling, and as input for energy use (Olsson, 2012). In addition, pollution from industrial discharge impacts water quality.

Balancing these competing demands to achieve sustainable water management will have the greatest chance for success if undertaken with the full engagement of all shareholders of the resource within the river basin: government; business, including energy providers; agriculture; and communities.

As water becomes scarcer, watershed managers will need to prioritise how water is allocated. It is likely that consumption aimed at securing human well-being will be prioritised over other user groups. Consequently, restrictions and added constraints might be forced upon industrial production. Thus, business has a critical role to play in applying its expertise and experience in developing, implementing and scaling-up watershed focused solutions through partnerships. A broader focus on water management beyond the "fence-line" – outside the company – is needed by businesses to ensure the sustainable use of one of the world's finite resources. Companies should adopt (and increasingly are adopting) a more holistic "watershed approach," which considers upstream and downstream interactions, direct and indirect impacts, and the needs of the environment. It also recognises that land-use changes can impact water availability. For businesses, local participation in the collective management of water will be key to ensuring long-term access to the resource against competing demands.

Challenges

In order to grasp the importance of corporate water management, one must understand the range of business risks associated with poor water management practices. These risks can be summarised as follows:

Financial risks: Companies without sound programmes to assess and manage their water use and discharges are likely to face restricted access to capital, higher loan rates and insurance premiums.

Operational risks: Production costs may escalate, due to the decreasing availability, quality and reliability of the water supply.

Product risks: As customers and clients become increasingly concerned about their environmental impacts, companies risk losing market share to competitors that offer products with lower ecosystem impacts.

Reputational risks: Public disputes, in which corporate water use competes with local community needs, can threat the company's license to operate.

Regulatory risks: Businesses may face new fees, regulations, and lawsuits, where their water use is seen as as conflicting with the public interest.

Note that water risks are different from water impacts. A company's impacts refers to the volume and quality of water it uses or discharges, while its risks can depend as much on what happens outside its fence-line as what happens within it.

In addition, water has been referred to as a high priority, cross-cutting global issue for business and society. Water impacts take place locally, and a litre of water used in one location cannot be offset by a litre saved somewhere else. Therefore, unlike a carbon footprint, a single aggregate number for a water footprint is of little material value.

Faced with the challenges that declining water quantity and quality present, there are several actions that a business can implement to reduce its exposure to water-related risks and at the same time gain a competitive advantage.

Recover, reuse and recycle

Within its own operations, a business can lessen its impact on water quality and quality by implementing measures to recover, reuse and recycle wastewater. Reusing wastewater translates as increased efficiency – and cost savings – in water use because the same water can be used several times before being discharged into the natural environment. Of course, not all uses lend themselves to recycled water. Therefore, water quality standards should be adapted to the desired end use (i.e., fit for purpose).

Develop new and innovative products

Declining water quantity and quality offers business opportunities to develop new solutions and technologies. There are business opportunities to be seized in developing innovative wastewater treatment devices, new irrigation techniques to minimise pesticide and fertiliser runoff, and water-saving information processing technologies. Similarly, opportunities exist for the development and deployment of new infrastructure for water (including for sanitation), especially in developing countries, or for the collection, treatment and distribution of water and the disposal of solid waste.

Use nature's own resources to improve water quality

Ecosystems provide a host of water-related services including water purification, rainfall regulation, watershed protection, and soil runoff prevention, sometimes at lower costs, and with lower carbon emissions, than engineered solutions. For example, desalination through industrial facilities is both energy- and carbon-intensive. Protecting ecosystems so that they can continue to offer such services may be less costly and at the same time yield benefits beyond water purification (e.g., by reducing or acting as a sink for carbon emissions).

To date, the role of ecosystems in protecting and promoting improved water quality has been largely overlooked. This is in part because ecosystem services are not priced and, as yet, have no established market – though this is slowly beginning to change. Ecosystem valuation offers one approach to address this by extending the scope of economic analysis beyond a conventionally narrow focus on marketed commodities to more inclusive calculations that also factor in non-market ecosystem service values. Valuing ecosystems and the services they deliver can offer incentives for their protection and restoration. WBCSD's Guide to Corporate Ecosystem Valuation (CEV) provides useful guidance. CEV seeks to guide companies on how to account for appropriate ecosystem benefits and services and thus recognise nature's services as an integral part of corporate planning and decision-making. It shows how economic tools can be applied to valuing the products and services provided by nature, and can assist managers with calculating trade-offs and designing the most cost-effective and environmentally efficient solutions.

Appropriate pricing of water and wastewater can help provide incentives for water efficiency improvements, thereby reducing water contamination. Creating markets for water-related ecosystem services similar to current carbon markets can also offer a potential mechanism for protecting and enhancing nature's capital. Other mechanisms include the establishment of tradeable permits for the use of ecosystem services or the creation of markets similar to current carbon markets. Water resource allocation permits, for example, could be traded among users. Such mechanisms could be voluntary or they could be established through regulation. A concrete example is the development of mitigation banking in the US, which is a new way to foster biodiversity conservation initiatives in very large land areas, and represents business opportunities for companies that own land as part of their business activities.


Photo: Maare Liiv, SXC

As the ecosystem approach to environmental challenges – including water and climate change – gains in popularity, ecosystem services will likely be regulated. Business can keep ahead of the curve by anticipating this and developing innovative ecosystem-based mechanisms that enhance ecosystems so that they can continue to provide their range of goods and services. Public information campaigns organised or supported by companies in partnership with NGOs, to educate and inform local populations – and particularly their own workforces – on good sanitation and hygiene practices can prove very effective as part of the efforts to improve the quality of wastewater in the community. They yield the twin benefits of improving the health of members of the community while contributing to protecting water resources.

Partnerships may also prove an effective instrument in efforts to manage risks posed by uneven regulation. Managing regulatory risks can be achieved through partnerships with policy-makers and regulators at several levels. Business can engage with municipal water authorities for the provision of water technologies and infrastructure, for example. Similarly, it can use its technological expertise to deliver sanitation facilities and wastewater treatment technology. Equally, business can engage with local and national authorities to help define modalities and criteria for water use and to shape its operational environment. Another option would be to engage with governments, scientific organisations and civil society, including NGOs. Partnerships offer several very real opportunities for businesses seeking to manage water quality-related challenges.

Obstacles to effective business engagement

Forward looking and progressive enterprises have already identified risks and are actively seeking ways to mitigate them. But broad and collective action still seems lacking. There might be many reasons for this. There are some easily identified obstacles to broader involvement:

a. Attitude. Many private sector actors have identified water management risks and work progressively with the water issue, but this awareness needs to be adopted across the value chain and across sectors.

b. The water pricing dilemma. Water is both a human right and an economic good. Consequently the ability to price water has become a problematic area, not least for when it is used for water-intensive production purposes such as in industrial, agricultural and energy production processes. The chronic effect has often been the under-pricing of water, inducing over consumption and, from a water-preserving standpoint, ineffective production methods. It's plausible that a more accurate pricing structure, a sort of "scarcity pricing system," could do much to motivate more efficient utilisation of water for production purposes. Water pricing in areas where the resource is scarce must be reconsidered to reflect the value of water. Such a system would preferably differentiate water use providing for basic human

needs and other uses by mixing fixed water tariffs with variable ones reflecting actual consumption. Limiting subsidies for certain water-demanding activities would also aid this type of development. Such measures could then induce plant operational efficiency, make lower-water-demanding products more attractive, and spur innovation in water-saving technologies.

c. The lack of "bankable projects" in water resources management. The private sector is slowly but surely approaching the water resources issue to secure survival in a more water-constrained environment. A way to catalyse this movement could be for water resources managers to assess if there are areas within existing activities where resources management could be coupled with business opportunities.

Photo: Samuel Rosa, SXC

Examples of progressive business involvement in water resource management

- Coca-Cola, which operates 39 bottling plants in China, has joined forces with WWF, the environmental organisation, to improve the water quality of the upper reaches of the Yangtze River, one of the ten most-threatened rivers in the world. In one project, Coca-Cola is working with rural farmers to reduce the runoff of animal waste into the river by turning pig waste into biogas for cooking and heating. The company has also launched a communication programme to educate communities along the river basin about environmental issues.
- In India, PepsiCo has worked with farmers to implement an agronomic practice in paddy cultivation called "direct seeding." Rather than growing seedlings in a nursery, planting them and then flooding their fields, direct seeding allows seed to be planted directly into the ground, bypassing the nursery. This also removes the need for flood irrigation, reducing water use by as much as 30 per cent. In 2009, direct seeding was extended to 6,500 acres of paddy fields, saving more than 5 billion liter of water. There is also a reduction in greenhouse gas emissions in excess of 70 per cent using direct seeding, versus conventional methods.
- The Stockholm International Water Institute together with 33 textile and leather retail companies formed the Sweden Textile Water Initiative (STWI) in 2010, aiming to transform their operations and the operations of their suppliers worldwide to meet sustainable business criteria. By forming working groups the companies developed guidelines for sustainable water use in the production and manufacturing processes of textiles and leather. A recent phase (2013) funded by member companies focused on implementing the setup and agreeing to guidelines.
- In the Ohio River Basin, the Electric Power Research Institute (EPRI) is working to develop a voluntary trading programme on a watershed basis that will allow the exchange of water-quality credits for nitrogen and phosphorus, thus helping to meet regulatory requirements and improve water quality. The trading programme will enable facilities facing high discharge control costs to

buy reductions from another facility with lower control costs. This exchange, or trade, will result in the same reductions at a lower overall cost, providing more flexibility in achieving water quality standards. The project enables entities in the Ohio River Basin to control nitrogen and phosphorus discharges through a trading market rather than individual treatment solutions, which vary in cost.

Conclusion

There is an intrinsic link between the challenge we face to ensure water security and other global issues, most notably climate change and the need to sustainably manage the world's rapidly growing demand for energy and food. Managing and balancing supply and demand requires a range of policy and technological solutions, and the engagement and cooperation of a broad spectrum of actors. The United Nations International Year of Water Cooperation highlights the need for cooperation spanning areas such as education, financing and transboundary water management. To push through needed projects, facilitate vital infrastructure development and enhance operational efficiency in different processes, cross-sectoral cooperation and expanded partnerships between public and private sectors are crucial.

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Photo: Istockphotos

Using Information and Communication Technology to Improve Water Governance and Cooperation

By Johan Hellström, Stockholm Universty and Maria Jacobson, SIWI

Information and communication technology (ICT) offers a largely untapped potential to improve the governance of water and the provision of domestic water supply services. By facilitating the flow of and access to information, ICT can enhance transparency, accountability and participation in the provision of public services (Sasaki 2010, World Bank 2007). ICT also provides new avenues for cooperation and can help bring new stakeholders to the table.

Despite this potential, unforeseen implementation and scaling up challenges have turned many ICT-projects into short lived and forgotten pilots. This high frequency of failure to expand and sustain ICT projects, combined with the reluctance of many organisations to publicly share their failures, have led to a relative shortage of analysis on the "real" benefits ICT can provide, particularly in the field of governance (Sasaki 2010, Hellström 2013).

Through an assessment of current ICT-enabled water supply projects in East Africa, this article addresses the following questions:

- How can ICT be used to strengthen transparency, accountability and participation in the provision of water services over time?
- What are the main benefits and challenges for increased and sustainable use of ICT in the provision of water services?
- Based on the above, how can ICT be used to stimulate water cooperation?

The assessment is based on an extensive literature research and field visits to Uganda and Kenya December 2012.

The rise of ICT in East Africa

Today, 780 million and 2.5 billion people, respectively, lack access to safe drinking water or basic sanitation (WHO, 2012). In sub-Saharan Africa, one quarter of the population is undernourished (UNDP, 2012). Over the past decade, the potential of using ICT for development (ICT4D) to address some of these challenges has been widely recognised by the international community.

ICT, particularly mobile phones, has spread rapidly in sub-Saharan Africa in recent years. As shown in Figure 1, mobile subscriber rates in East Africa has increased quickly over the past decade and is now accessed by a large share of the population.

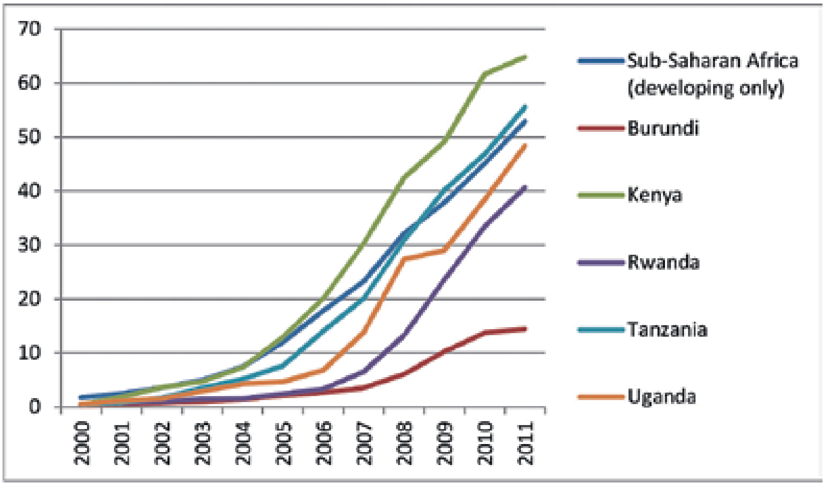

Figure 1: Mobile subscriptions (per 100 people) in East Africa (World Bank 2013)

Decreased implementation and user costs, due to both advancements in technology and deregulation of the telecommunication sector, has contributed to their spread (Hellström 2010a).

However, subscription statistics do not reveal much about the actual ownership and use of the phone. Data on physical access, does not reveal information on access frequency or quality of network. Further, to be able to use the mobile phone financial injections are required, something that many rural users, especially rural women (due to patriarchal societies/structures), do not have (Wamala, 2010). More challenges are identified below.

Using ICT to improve water governance and cooperation

The effectiveness of governance systems has a profound impact on the management and provision of water resources and services. In many places, weaknesses in governance systems – such as fragmented and ineffective institutions, a lack of clarity over roles and responsibilities between actors, questionable resource allocation, unclear or non-existent regulatory environment, low levels of accountability of politicians, policy-makers and implementing agencies, and outright corruption – lead to inequitable access to water, poor water quality, unreliable services and faulty infrastructure. Low awareness of rights and responsibilities among water users, as well as incomplete data sets to base decision making upon, are additional common challenges that exacerbates the problem (Dubreuil & Van Hofwegen, 2006). For government, ICT can be used to increase accountability, transparency, responsiveness and efficiency (in delivering government services to citizens and businesses as well as improved intra-government services). By increasing access to information, ICT can empower citizens and civil society to influence opinion, voice concerns, demand accountability from government and service providers, mobilise politically, participate in decision making processes, and "bypass traditional and official channels of information and communication" (Sida, 2009).

Despite a relatively late start compared to other sectors, ICT "solutions" are now beginning to change the way water is governed (WIN-SA, 2012). ICT applications are used in real time monitoring of river flows and levels, early warning systems for water related disasters, and to detect water leaks. ICT is also increasingly applied to facilitate regulation and licensing and to inform water policy (ITU, 2010). For example, the United Nations and civil society organisations have recently initiated a public web-based platform – **www.worldwewant2015.org** – to conduct the Thematic Consultations on Water for the Post-2015 Development Agenda. Another example is the several water focused 'Hackathons', events where programmers and other practitioners collaborate or compete with each other to develop digital solutions for a specific purpose (see **www.waterhackathon.org**), which have taken place over the past couple years.

In water supply services, which is the focus of this article, ICT is used for a number of purposes including data collection and project monitoring, measuring water collection times (Davis *et al.*, 2012), water quality monitoring (Champanis & Rivett, 2012), simplifying billing and metering through mobile water payment (Hope *et al*., 2011), advocacy on water issues, improving transparency on sector funds, and strengthening consumer voice through online platforms (Odugbemi & Lee, 2010) (see Table 1 for further examples from East Africa).

The use of ICT in the water sector also creates new avenues for cooperation. Trust is a key driver for collective action (Poteete *et al*., 2010, Rothstein & Uslaner, 2005) and access to information is essential to the trust building process, as it can help reduce uncertainty and strengthens accountability between actors (Blind, 2007). By facilitating safer ways to access and communicate information, ICT has an important role to play in creating an enabling environment for cooperation. By doing this, ICT can bolster collaboration between stakeholders in different sectors (such as water professionals, decision makers, technologists, and development practitioners) as well as between various stakeholders at different levels in the decision making process (such as government, private sector, civil society and most importantly, users) (Kyla *et al*., 2013).

Challenges of using ICT4D

Despite the increased access to ICT and many excellent ideas of how applications can contribute to development, rather few "solutions" are turned into effective, user friendly tools that are sustained over time (Heeks 2002, Hellström 2013). Many prototypes do not make it outside the venue of the hackathon and out of the initiatives that are piloted, few are sustained beyond the pilot phase. A study of over 40 ICT-enabled governance initiatives in East Africa identified the major social, financial, technical and organisational factors that commonly cause many projects to "pilot-then-die" (Hellström, 2011). Affordability, usability, illiteracy, training, equitable accessibility and localisation issues are primary challenges that end-users face. Lack of trust in the system, both in terms of user privacy and system security, as well as low levels of faith in government's responsiveness, is another barrier. High costs for the initial investment, marketing and maintenance of ICT systems all have financial implications for the organisation. Absence of basic infrastructure, such as electricity and network coverage, must also be taken into account. Many organisations face challenges to create a sustainable business model that can be replicated and scaled up and to reach out to a critical mass of users.

Findings

Table 1 shows the results of an assessment of current ICT-enabled water supply projects in East Africa, and provides examples of the functions performed by different ICT projects. The table indicates how each function relates to transparency, accountability and participation. The assessment also identified a number of benefits and challenges that are outlined in the following section.

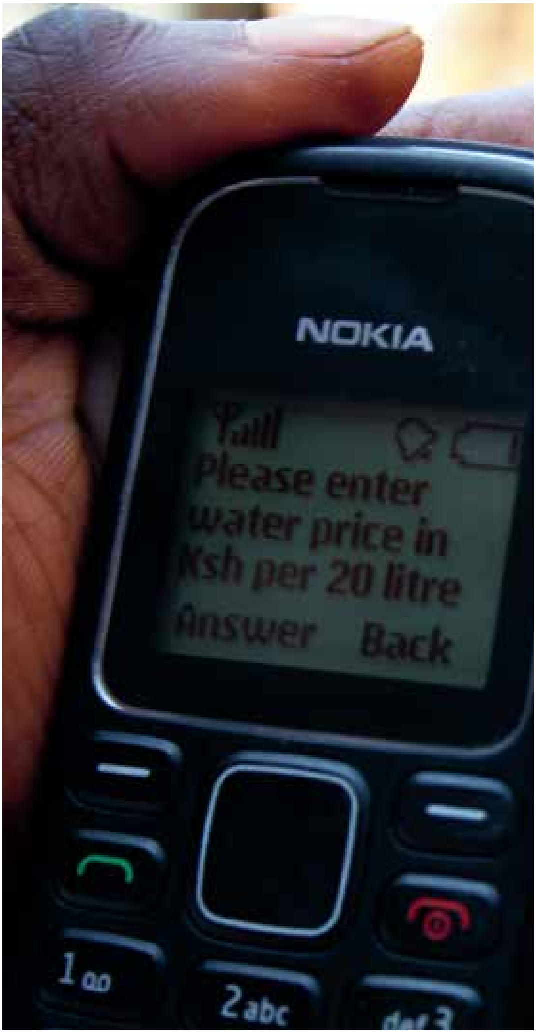

Photo: Maria Jacobsson, SIWI

Table 1: A selection and categorisation of ICT enabled water supply projects in East Africa

CATEGORY	USAGE AREA	EXAMPLE
Transparency	Awareness raising on water issues among citizens through information campaigns	Text To Change: Various one time campaigns where interactive, incentive-based SMS quizzes are sent out on water, sanitation, hand washing and HIV/AIDS in Uganda. www.texttochange.org/
	Transparency in water service delivery	M-Maji: Residents in Kibera, a large slum in Nairobi, Kenya, can access information on water from vendors (location, price, quality) via USSD. http://mmaji.wordpress.com/
	Billing, payment, meter reading, sales points, smart metering and consumption tracking	Maji Mashinani: ICT platform that enables water consumers in Kenya to use a mobile phone to send their own water meter readings, query and receive current water bills, then pay using mobile money. www.nairobiwater.co.ke
	Data on donor funding	Akvo Marketplace: Internet based match making tool between vetted and monitored projects and co-funders where founders can choose the location, type and size of projects that fit their objectives. Also enables direct online payment. www.akvo.org/
Accountability	Mapping/monitoring the status of water sources to improve local planning and accountability	M4W: Monitoring and collection of baseline data on rural water points by hand pump mechanics using mobile phones to inform planning at district level. Also allows users to report a problem with their water source via SMS. http://m4water.org/
		Field Level Operations Watch (FLOW): Data collection on location and functionality of water points using Android mobile phones. The data is submitted to a central database and uploaded on a map using Google Earth. www.waterforpeople.org/flow-mapping/
	Advocacy on water policy/commitments	WASHwatch.org: Open, online platform for monitoring government policy commitments and budgets for water supply, sanitation and hygiene (WASH). http://washwatch.org/
Participation	Participatory budgeting	Ugatuzi: Project provides information on development funded initiatives allowing Kenyan citizens and communities to input comments and identify incidences of corruption and mal-practice. http://ugatuzi.info/
	Citizen reporting	Maji Voice: Platform where Kenyan citizens can share their concerns on service delivery with service providers using mobile phones or website and receive timely feedback on how their cases are addressed. www.wsp.org

Table 2: Benefits and challenges in ICT enabled water supply services

BENEFITS
What is the specific added value of using ICT as a tool to support the governance of water supply services?
Improved service delivery: New applications provide opportunities to facilitate billing and payment of water services. Mobile phones increase efficiency by reducing the time taken from reporting a faulty water source to have it repaired. ***New and better data:*** ICT enables the generation of quick, accurate and standardised data in a user friendly way. The ability to update data in real time and to 'geotag' water infrastructure offers new possibilities for monitoring, as well as to capture trends over time. Location data minimises the risks of forged monitoring and 'double counting' of water sources. By uploading the data into online maps, accountability for project funds is improved as well as coordination between funders who can see each other's contributions. ***Strengthened consumer voice:*** ICT empowers water consumers by providing them access to information on their rights and the responsibilities of water providers. ***Reduced costs:*** The efficiencies gained through the use of ICT cuts costs and saves scarce sector funds for more productive use.
CHALLENGES
There are also a number of specific challenges faced by water supply services.
Social ***Lack of incentives to use and contribute to the system:*** End users tend to be passive receivers of information, and do not have access to the full picture. Too often the "crowd" is relied upon to generate content without proper incentives in place. ***Gender:*** Women are traditionally responsible for collecting water, and therefore the first to identify a water problem (mal-functional pumps, worsen quality of water etc.). At the same time, women have less access to ICT. ***User costs:*** Although communication costs have gone down, total cost of mobile phone ownership, i.e. cost of device, airtime (for data, voice and SMS), charging, etc., present barriers for participation. ***Privacy:*** New possibilities to capture data linked to a specific individual/household (such as customer number, address, GPS coordinates) could raise privacy concerns for water users (particularly related to complaints to service providers). **Financial** ***High initial investments:*** More advanced applications require "smarter" and more expensive phones which can make scaling up and harmonisation with government-led initiatives difficult. ***Sustainability:*** Running costs for an ICT-project are constant as there is a continuous need for preventive maintenance, training and awareness raising. **Technical** ***Data collection format:*** The type of data that can be entered into digital forms is limited and cannot always be adapted to the local context. Valuable knowledge that is hard to structure into a form is lost. ***Absence of basic infrastructure:*** Electricity, network coverage, technical know how and support. **Organisational** ***Lack of responsiveness:*** If institutions lack capacity to respond to and act on the information generated through ICT solutions, then the information provided will be of no use. ***Poor marketing:*** Many ICT projects depend on participation from the "crowd" or users to succeed. Yet, many of the available services never reach out to the intended target group due to non-existing meta-data, insufficient marketing and little effort applied to raise awareness.

Conclusion

As shown in this chapter, ICT can increase transparency and accountability, as well as facilitate citizen participation. Accountability may be the most important element in this equation. Access to information and increased transparency will only lead to actual results on the ground if there are mechanisms in place to ensure that someone will be held responsible to act upon it. In addition to information, other pressing resources are usually lacking too (i.e. financial, human, technical). Thus, while ICT presents opportunities for exerting accountability by providing better data, this rests on the assumption that there is someone at the receiving end of the information chain who can be held accountable. To assure such responsiveness, it is crucial that the responsible institution has the willingness, capacity, and most importantly, the mandate to act on the information. Since public water services is a long term commitment, for which accountability ultimately rests with government, ICT-projects that aim to increase accountability need to be institutionalised in, and aligned with, government structures – and not compete with or undermine them.

This study has also shown how ICT can present new ways for water users to participate in the management and provision of water services. For this to happen, however, users need to be made aware of these opportunities through marketing and awareness raising campaigns. For users to trust the system, issues around privacy and security must be addressed. Ensuring access to the technology itself is also needed, but is often outside the control of the project. Further, to sustain participation, clear incentives need to put in place. Users must see a direct benefit from spending their time and resources to interact and not just be a feeder or a passive receiver of data. Continued user engagement is vital and must be supported by regular interaction. Project owners need to verify and provide feedback to users about their contributions and act on it to avoid user fatigue.

Finally, by increasing interaction and building trust, ICT provides opportunities for increased cooperation between different stakeholders. Cooperation is also a requirement for successful ICT projects. At the same time, the current hype surrounding what these technologies can do also presents risks to cooperation with many separate and poorly planned projects/pilots working in isolation. To avoid this, openness and learning from each other is key.

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Photo: Maxime Perron Caissy, SXC

Transboundary Water Cooperation: A Rubik's Cube

By Ana Cascão, Anders Jägerskog and Anton Earle, SIWI

Introduction

By declaring 2013 the "Year of Water Cooperation" the UN General Assembly raised cooperation over water resources to the highest political level. The social, cultural, economic, environmental and political importance of water resources is incontestable. The key question to ask is how policy-makers are cooperating across borders (be they national or international) and across sectors. Labelling something an 'international year' can mean two different things: either there is reason to celebrate progress or there is reason to sound the alarm and call for urgent action. Regarding transboundary waters; 2013 is a clarion-call for action. At the international level most rivers, lakes and aquifers are transboundary, however they are still managed at the national level – responding to country interests. This chapter analyses transboundary water cooperation through the metaphor of the six faces of the Rubik's Cube – a puzzle game that aims to solve a complex topological problem.

Face 1: Water is colourful

Debates about cooperation in transboundary water settings focus on water flowing in lakes, rivers and aquifers – blue water; and then mainly on surface flows and very little on groundwater. But water can assume other hues; green, black, grey and virtual water all making a contribution to satisfying our water needs (Falkenmark & Rockström, 2006). The greater visibility of blue water in management structures is understandable as it is physically visible – either directly in streams and lakes or through pumping to the surface in the case of aquifers. But in conditions of water scarcity this limits policy-makers to a small portion of the total water-cycle. By looking at the full spectrum of water colours it may be possible to identify trade-offs, opportunities and efficiency gains; allowing improved cooperation between countries and water-use sectors. This does not imply that negotiations and agreements should start mixing waters and find legal and institutional solutions that address all kinds of water simultaneously, but rather to consider them as added value to efforts to reach agreement on blue water allocations.

For example, by including discussions on producing food where green water (rainfall and soil moisture) is more abundant and 'more crop per drop' can be produced efficiently, with or without supplementary irrigation (Giordano & Rijsberman, 2007); potentially wasteful water uses such as irrigation schemes in the desert can be avoided. Innovative approaches to supplementing green water resources can be identified; such as recycling grey water (easy to re-use non-contaminated household run-off) and possibly black water (more difficult to reuse sewerage water). Such approaches turn intensive water use areas such as cities into a potential water resource for other users. It also seeks to implement a virtual water trade approach – ultimately producing products and services in locations where they enjoy a geographical comparative advantage.

Dialogue and negotiations incorporating supplementary inputs form the non-blue part of the water spectrum will prove complex – however they hold the possibility of identifying more efficient and effective outcomes; bringing the greatest benefit to societies, ecosystems and economies which they supply.

Face 2: Water is food

Agriculture is the biggest consumer of water resources (across the colour spectrum) in the world – be it irrigated or rainfed. In this sector there are huge losses at all stages of the value-chain. In the production stage, there are significant losses due to poor technology, low levels of productivity and selection of unsuitable crop types for the climatic conditions (IWMI, 2003). In the storage, distribution and consumer-use stages the physical loss of food is high; representing huge volumes of water wasted (Lundqvist *et al.*, 2008). Can these challenges be overcome? The answer is positive – so long as tough political choices around water use and allocation are taken and consumers are willing to change their behaviour through reducing food waste, reducing consumption of water intensive foodstuff such as meat and cereals and accepting products produced (safely) using recycled grey and black water. To solve the puzzle we need to consider other parts of the food-agriculture complex – such as livestock, fisheries and bio-fuel production. Efficiency gains in one area may negatively impact another, however if a holistic and adaptive approach to management is taken it is possible to identify synergies; where the waste-product of one activity becomes an input to another. Technical solutions alone will not solve the problem. Serious political investments are needed to promote social and participatory management processes; all recognising the need to support sustainable eco-system services.

In this regard world trade in agricultural products is part of the solution to the global water crisis. Demand in one country or region can be met by producing food where land and water resources are more abundant. This is already going on – wheat from Ukraine, beef from Argentina, tomatoes from Morocco, asparagus from Chile are commonplace in today's kitchen. But if we hope that this global food trade is contributing to increased food security of the poorest people, most likely we will be disappointed. History is written by the victors; in this case the well-fed. Food is more abundant today than at any time in human history, however a substantial number of people remain malnourished. Food and the water resources to produce it may be readily available at the global scale, but at the local level there are cases of extreme scarcity of both. This local disparity is bound to be exacerbated by the impacts of climate change.

Face 3: Water is energy

Modern society is reliant on energy – be it from hydropower, thermal (coal, oil, gas), geothermal, biomass, wind or solar – to a degree unprecedented in human history. A key driver of this increased demand for energy is urbanisation; and with more than half of humanity being urbanised this demand is set to increase (UN-HABITAT, 2010). Cities are large consumers of energy, requiring highly concentrated sources of heating, cooling and transportation systems. Water needed to supply cities is sourced from ever greater distances and frequently needs to be pumped to consumers (Earle, 2013).

The generation of hydro-electricity is arguably the most tangible evidence of the water-energy relationship. Hydropower dams need a steady flow of water to generate base-load efficiently, which can place it at odds with the needs of other sectors. Irrigators may wish for water to be stored through the wet season and only released during the dry. Flood control objectives may be best served by drawing-down the level of the dam. These potentially conflicting objectives make multipurpose dams difficult (but not impossible) to implement, especially as it is vital that the interest of human and environmental communities are taken care of during the construction and operation of dams.

The second area of cooperation needed in the water-energy relationship is the consumptive use of water by energy producers. Biofuels are an increasing

Photo: Gili Fahima, SXC

part of the modern energy mix; and despite the potential competition with agricultural demands for water, it should not be excluded as a sustainable energy source. Thermal electricity production also needs water, mainly for the cooling process; which even for dry-cooled power stations can amount to substantial water consumption. The extraction of shale gas through hydraulic fracturing holds opportunities for providing great amounts of energy – however there are well-founded concerns about the large volumes of water required and the possibility of chemicals used in the extraction process polluting groundwater resources. In parts of the world experiencing water or energy scarcity, trade-offs need to be made.

A third area of cooperation in the water-energy relationship is on the regional scale. Envisioning the possibility of a regional approach to generate energy (whether hydropower or thermal) and transferring it across a regional grid it is possible to pursue win-win solutions. Electricity is an order of magnitude easier (and cheaper) to transfer over long distances than water. Cooperation will contribute to regional energy security and allows a more diversified energy-production mix to be pursued.

Face 4: Water is political

An often overlooked aspect of water is its inherent political nature. Politics deals with the central question of "who gets what, where, when, why and how?" (Lasswell, 1936). The answer hinges on power – that is power to command resources (material power) and their allocation as well as power over discourse, ideas, negotiations and agenda-setting. The UNDP's Human Development Report of 2006 identified power and inequality to be "at the centre of the water management dilemma" (UNDP, 2006). Striking for many readers was the report's conclusion that it is power and inequality that affects people's access to water more than natural factors. This acknowledgement is a first step to accepting that sustainable solutions to water problems are fundamentally political.

The political nature of water is most pronounced in transboundary settings. While that is well understood by the riparian states that share transboundary waters, it is not equally well understood by the development practitioners (here including researchers, academics, technical experts and financiers) involved in supporting transboundary water programmes (Earle *et al.*, 2010). Riparian states still operate in a framework where national interests, litical sovereignty and national security are key drivers of the decision-making process of development, management and allocation of water resources. This tends to outweigh the perceived benefits from engaging in a multi-lateral approach to water management.

Intentionally or not, development practitioners tend to be blind to the fundamental political issues influencing transboundary water management; seldom undertaking a thorough political analysis of the various interests of states and actors in a specific transboundary setting. The "cooperation leads to more cooperation" functionalist argument is intuitively persuasive, but it may prove flawed in some situations. The functionalist perspective typically ignores the high level of politicisation and securitisation prevailing in most basins; and how difficult this makes it to build on cooperation in one realm to strengthen cooperation in another. In such settings national interest are paramount, even to the degree of foregoing possible (national) benefits which would accrue from a regional approach (Phillips *et al.*, 2006; Jägerskog, 2008). Progress which is made is largely due to specific individuals; and at times they pay the price for proceeding too far down Cooperation Boulevard.

It is argued here that politics must be included in all analysis of transboundary water management – whether it is on local, national, regional or even global levels (Zeitoun & Jägerskog, 2009). Understanding and addressing political realities opens the door to creative bargaining approaches potentially offering multiple gains and trade-offs for all parties.

Face 5: Water is economics

If politics deals with the central question of "who gets what, where, when, why and how?" then economics provides the tools to manage the allocation of water resources and water services. In addition, it opens the door to recognising the vital contribution made by ecosystem functions; and valuing these in decision-making. Economics enables policy-makers to assess trade-offs between choices; in so-doing they can pursue cooperative policies which maximise benefits for all. By quantifying the benefits, costs and risks (social, economic, and environmental) derived from a specific water use, trade-offs can be made between different users – be it sectors or countries. It is important to recognise that the allocation of resources is not guided primarily, or exclusively, through economic considerations. Economics provides the tools through which political objectives can be attained. If political decisions are taken which seek to maximise the benefits from water across society in an equitable and (environmentally) sustainable way, then economics is part of the tool-box available to policy-makers for the implementation of these political decisions.

The recognition by the international community that "water is a social and economic good" (Rio Summit 1992) would seem to be in opposition to considerations of waters' role in promoting social equity and justice, as well as environmental considerations. However this apparently schizophrenic view is to miss the bigger picture – first; water is scarce (in some places more than others, but in all places when quality is taken into account), second; water is vital for human existence. By assigning an economic value to water resources it is possible to manage them in a way which maximises welfare for society overall. The economic value of water allows a comparison between benefits which accrue at the private level from a water use (to an individual or a company or a country) with the risks and costs which may result at the public level – to society and environment as a whole. Being able to ascribe economic costs and benefits to water uses and their impacts and then link these to the water security objectives of a society is an enabler of cooperative management approaches. If money is the ultimate transaction-cost reduction mechanism; then being able to establish incentive structures for the conservation, provision and use of water resources and services is a vital part of promoting effective, efficient and sustainable water management regimes. In so doing the various water-use sectors at local, national and regional levels can identify benefits, risks and costs and then agree on mechanisms for distributing these equitably in ultimate pursuit of water security objectives.

Face 6: Water is environment

Solving the final face of the Rubik's cube is always the most challenging and frustrating to get in place, with each move of the blocks upsetting the careful layout of the other faces – but vital if the puzzle is to be deemed solved. Humans can choose to do what they want in the areas described under the five faces above; but if ecosystems and their associated services stop functioning, all development objectives are placed at risk. Services provided by water-based ecosystems are numerous – nutrient and pollution cycling and dispersal, flood protection, soil conservation, water retention, water purification; and the provision of products such as reeds, fish, clay and water. In addition there is a range of social and cultural services provided by a healthy environment; such as aesthetic and religious values of water landscapes.

The absorptive capacity and resilience of natural ecosystems is, on average, astoundingly resilient. Species and habitats seem to adapt to human encroachment with niche populations flourishing in the midst of large-scale urban development. However, the risk is that the average level masks a plethora of local and regional environmental catastrophes. Biodiversity (aquatic as well as terrestrial) is plummeting in most parts of the world. Part of what makes the environment so resilient is this almost-infinite variation of species, precipitating adaptation and survival. With many ecosystems now becoming dominated by only a few well-adapted species of fauna and flora this inherent characteristic of resilience through diversity is being threatened.

The damage being done to aquatic ecosystems, through human activities, is immense and in most parts of the world increasing; with a few notable exceptions. The situation is compounded through the impacts of climate change – a reality for which our past systems of water resources management has ill-prepared us to cope.

Conclusion: Cooperation is the solution

More often than not cooperation and conflict coexist at various scales and levels (Zeitoun and Mirumachi, 2008). There can be political conflict; while cooperation at the technical level works relatively well (Jägerskog, 2003). Academic debates on the nature and extent of cooperation are of little consolation to a Palestinian farmer tending parched crops in the West Bank, or a parent raising a family amongst the drained Mesopotamian Marshes in Iraq, or the Cambodian fisherman striving for a catch in the Lower Mekong. The fundamental issue is to assess the quality of the outcomes and impacts of cooperation – across social, economic and environmental parameters. The process of cooperation may look different from one basin to another, but the result should be easily recognisable to all.

Photo: Håkan Tropp, SIWI

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Thirsty Energy: Water for Power Generation – It's not Only Hydropower

By Diego J. Rodriguez and Anna Delgado-Martin, World Bank

Energy and water: Intrinsically linked

Water and energy are both interdependent and indispensable for sustainable economic growth. Water is needed in almost all energy generation processes and energy is needed to extract, treat and distribute water. Water is required for hydropower generation and for cooling and other purposes in most thermal power plants. Water-intensive thermal and hydropower account for 90 per cent of total global power generation (IEA, 2012). Moreover, water is used to extract or process fuels (oil, coal, gas, uranium) and for hydraulic fracturing processes, which are expanding rapidly. Only open cycle power plants, which are usually used to meet peak load demands, wind and photovoltaic power require little to no water, and thus have minimal impacts on the water-energy nexus. In addition, both energy and water are used in the production of crops and some crops are used to generate energy through biofuels.

Several regions of the world are already experiencing water and energy security challenges. 783 million and 2.5 billion people remain without access to safe drinking water and sanitation, respectively (WHO/UNICEF, 2012) and over 1.3 billion people still lack access to electricity worldwide, with most of them located in Sub-Saharan Africa and East-Asia (IEA, 2012).

The International Energy Agency (IEA) estimates that global energy consumption will increase nearly 50 per cent by 2035 (IEA, 2012), which in turn will put additional pressure on already constrained water resources. Within two decades, roughly half of the world's population may live in areas of high water stress (WWAP, 2012). In 2010, water withdrawals for energy production were estimated at 583 billion cubic meters (bcm), from which 66 bcm were consumed. This demand is predicted to increase by 20 per cent by 2035, with consumption increasing by 85 per cent (IEA 2012). Population growth and climate change, which will cause longer dry periods and exacerbate water scarcity problems, will intensify the challenges faced at the core of the nexus.

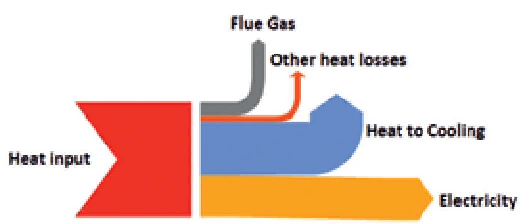

Figure 1. Simplified Visualisation of Heat Balance of a Fossil Fuel Power Plant. (Delgado, 2012)

Water for electricity generation

Thermal power plants generate around 75 per cent of the electricity produced in the world (IEA, 2012). These plants convert heat into power in the form of electricity. Most of these plants use steam as the prime mover. The heat, which is generated from a diverse range of sources including pulverised coal, natural gas, uranium, solar energy, and geothermal energy, is used to turn water into steam. The steam spins a turbine which drives an electric generator. After passing through the turbine the steam is cooled down and condensed to start the cycle again (closing the so-called steam cycle). In other words, all the heat put into the plant that is not converted into electricity is "waste heat" and has to be dissipated into the environment. Most of this heat (blue arrow in figure 1) is rejected to the environment through the cooling system, which usually uses water as the heat transfer medium (UCS, 2011). Thus, the more efficient the power plant is (yellow arrow in Figure 1 becomes thicker), the less waste heat needs to be rejected; and therefore, less cooling water is required per kWh produced.

For a power plant with a given amount of heat to be dissipated (i.e. with the same or similar efficiency), the amount of water required (withdrawn and consumed) for cooling will depend on the type of cooling system being used in the plant. The cooling system that power plant operators choose will also have an impact on the power plant efficiency, capital and operation costs and the environment. These trade-offs have to be evaluated case-by-case, taking into account the regional and ambient conditions (see Table 1). Water is also needed in smaller quantities for other purposes besides cooling, such as to generate steam to drive the steam turbines, ash handling and flue gas desulfurisation systems.

The thermoelectric power generation sector accounts for 40 per cent (USGS, 2005) and 43 per cent (Rubbelke and Vogele, 2011) of total fresh water withdrawals in the United States and Europe, respectively. The two main water risks that the power generation sector faces are increased water temperature for cooling (van Vliet, 2012) and decreased water availability due to climate change and increasing demand for competing uses. These risks have already had some repercussions on the energy sector (UCS, 2011). Although the water energy nexus problems are regional specific, given the growth of many developing countries, we can anticipate that these problems will increase in the near future.

In hydropower plants, most of the water is not consumed but diverted to generate electricity. This water can be used downstream of the dam for other purposes, such as irrigation or for urban use. Hydropower plants consume water through evaporative losses from the reservoir and through seepage. The amount of consumption will depend on the site selected, how the project is designed, and the average weather conditions. Depending on their scale and design, hydropower plants can have significant impacts on land, water and social environments. With a changing climate and increasing water variability, hydropower may be affected in two ways: increasing demand for greater amounts of storage in hydropower projects, and possible reduced power output from some projects depending on the nature of variability. Additional uncertainty due to changes in surface water temperature, flows and availability are encouraging some companies to develop more sustainable practices to ensure the long-term viability of their operations and infrastructure. More recurrent and longer droughts have already reduced the hydropower capacity of some countries, such as Sri Lanka, China and Brazil during the past years.

Water and energy for the 21st century

Despite clear linkages, the water and energy sectors have historically been regulated and managed separately.

Table 1. Summary of Cooling Systems Trade-offs (modified from Delgado, 2012)

Cooling Type	Water Withdrawal	Water Consumption	Capital Cost	Plant Efficiency	Ecological Impact
Once-Through	Intense	Moderate	Low	Most Efficient	Intense
Wet Cooling Towers	Moderate	Intense	Moderate	Efficient	Moderate
Dry Cooling	None	None	High	Less Efficient	Low

Decision makers often remain ill-informed about the drivers, possible outcomes, and the merits of different technical options. The need to understand the interactions between energy and water use is growing, and in addition to energy and water, planning and development challenges are likely to involve land use, food production, urbanisation, demographics, and environmental protection. Existing publicly available models are not equipped to properly evaluate and compare different energy investment alternatives given potential future water constraints and other trends that may create competition for resources. Current publicly available models possess neither the capacity to consider the wider social, economic and environmental impacts of the energy-water nexus, nor the ability to identify the potential implications of water and energy policies and investments at the required resolution to adequately inform decision makers. These challenges and complexities can no longer be addressed in the conventional way, with each sector taking decisions independently, guided by separate regulations and different goals. A more systematic approach is required; one that takes into account all the existing interactions and dependencies between sectors.

Breaking convention

Conventional water supply planning is primarily concerned with developing water resource systems to manage the distribution of water in time and space, and focuses on the allocation of water supplies to meet a specific set of objectives or demands. Most water allocation modelling assumes that there are always adequate energy supplies available to facilitate the diversion, pumping, and treatment of water. Few, if any, of the water allocation models quantify the imposed energy consumption associated with different water demands. This approach does not adequately reflect the dynamic interplay between energy and water, including the potentially large energy requirements to transport and treat water.

Conventional energy planning is primarily concerned with siting and cost requirements for energy generation and transmission to population centres. Aside from hydropower-dominated systems, the availability of water supply necessary for power generation is typically presumed to exist and is often not considered to be a limiting or guiding factor at the upstream planning stage. When water resources are assessed, it is primarily done in the front-end of projects, through environmental assessments. However, the quantity of water required for operation is not considered dynamically within models. In these situations, there is an inherent multiplier on both energy and water demands that may be overlooked when employing the traditional approach to modelling and analysis. While this effect may be quite marginal in regions with ample supplies of both water and energy, it could become a central cross-sector constraint in regions with resource scarcity and will require accurate evaluation and analysis.

Projected climate change and impacts on water availability are also not commonly factored into conventional energy planning and operations. Global warming will likely cause increased competition for water resources among economic sectors, such as agriculture and water recreation. The usual methodological approach to assess climate impacts on hydropower resource endowments consists of translating long-term climate variables into runoff, although this involves great uncertainties. One of the greatest challenges when assessing impacts of climate change is to do so in an integrated way so as to fully take into account the many complex interrelationships not only within the energy sector, but also in other sectors.

Seeking smarter models: Integrated energy and water planning

To date, energy-planning tools have not been regionally developed that are linked to water-related risks and trade-offs. The tendency for traditional planning is to be narrowly focused and exclusionary (Grigg, 2008). Risk avoidance and control of resources is a paramount consideration in traditional electrical utility and water resources planning. A more open and participatory decision-making process with strong coordination between the actors that govern water and energy resources is needed for successful and sustainable resource planning. In many places, a recalibration of institutional roles and processes will be needed in addition to new analytical tools. Consensus building and dispute resolution are also key to this process.

There are several publicly available modelling frameworks under development that aim to provide integrated energy-water planning capability. The integrated LEAP energy model and WEAP water model, currently present the most in-depth representation of both the energy and water sectors in the short-term but does not yet have the capability to optimise either sector. The MARKAL-Water (based on the optimisation model MARKAL with an added module in water) and EPWsim models provide the capacity to optimise across the energy-water nexus. MARKAL/TIMES can also include multiple objectives (e.g., minimise cost and water consumption while still meeting energy and water demands).

Addressing the nexus will require further development of professional capacity and modelling tools to understand and evaluate the merits of different energy and water investments and policies taking into account future constraints and their wider social, environmental, and economic implications. Economic analysis is also necessary to assess trade-offs and to assess if tightening resource constraints may inhibit economic activities. Increasing water demand and scarcity has potential to increase market prices for water and energy and lead to redistributions of these increasingly scarce resources between sectors.

Actual outcomes will depend on the capacity of a community to adjust, the rate of technological progress in development of water efficiency in energy and food production, and knowledge provision, institutional, governance, and planning arrangements to facilitate efficient investment and synergies in water and energy planning. One of the more difficult issues to manage is the fact that the economic value of water to the energy sector, at the margin, will generally be greater than its economic value to agriculture, while the implicit political power of the agricultural sector can sometimes be greater than that of the energy sector. This implies that the energy sector will generally be willing and able to pay more for water than competing agricultural uses – with the associated risk that some agricultural groups may seek to use their political power to redress this difference in economic power, such as by portraying the energy sector as damaging agricultural interests and threatening food security. The output from the different energy and water planning models will be have to be incorporated into an economic model that will enable them to look at different policy options.

Photo: Manfred Matz

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Photo: Jakob Granit, SEI

Unpacking the Water-Energy-Food Nexus: Tools for Assessment and Cooperation Along a Continuum

By Jakob Granit, Madeleine Fogde, Holger Hoff, SEI, John Joyce, SIWI, Louise Karlberg, Johan Kuylenstierna and Arno Rosemarin, SEI

This article argues that, in order to achieve sustainable development goals, there is a need to develop and implement systematic approaches that increase understanding of the Water-Energy-Food (WEF) nexus, both at different scales and across multiple sectors. Applying a WEF nexus analysis at different scales would strengthen collaboration between stakeholders, and would also help to identify measures for cooperative governance and management that support outcomes along multiple value chains within the nexus. It would also help to maintain and restore ecosystem goods and services. This article aims to encourage further work in this area by presenting examples of methods and tools to unpack the nexus along a continuum, ranging from qualitative approaches to more data-driven and quantitative modelling approaches (see Figure 1).

Understanding the links between water, energy and food, from local to global scales

At the same time as the availability of natural resources has decreased, due to growing demand for water, food, energy and other goods and services, understanding has increased about the inherent links between these resources (e.g. Hoff, 2011). Projections show that by 2050 the demand for more nutritious and better-quality foods will almost double (FAO, 2009) and the demand for primary energy will increase by almost 80 per cent (IEA, 2010). Furthermore, it is an on-going challenge to provide a sufficient supply of water and adequate sanitation to the world's population, notwithstanding global progress on sanitation targets. Not only is effective water resources management at different scales central to the functioning of water-dependent value chains,[1] it also supports broader socio-economic-ecological services.

As societies look to meet the growing demand for goods and services, new pressures are mounting to decarbonise the energy production chain and reduce greenhouse gas emissions in all sectors. Global efforts to create jobs, support innovation, and secure livelihoods run parallel to these pressures, and are also linked in the WEF nexus. The World Bank (2013) estimates that about 600 million new jobs will be needed by 2020 just to keep

[1] Value chains in this context relate to the full range of activities that are required to bring a product or service from conception, through the different phases of production, delivery to consumers and disposal after use (Kaplinsky & Morris, 2002).

Photo: Jakob Granit, SEI

the ratio of employment to working-age population constant (World Bank, 2013). These coupled environmental and social challenges in the WEF nexus have now entered the on-going debate on an evolution from the Millennium Development Goals to Sustainable Development Goals in the post-MDG (2015) period. However, more work is needed to unpack the WEF nexus at different scales in order to tackle the multiple and interlinked development challenges. By increasing our understanding of the complex links between water use, energy, and food production, including of sustaining ecosystem services, it may be possible to avoid future supply bottlenecks and to provide equitable access to these services for all people, now and in the future (Granit & Claassen, 2013).

There is a lack of data on water use in the context of WEF nexus value chains at local and regional levels. At the sectoral level, however, there is much information on efficiency measures in agricultural water management, water supply and sanitation, and desalination, although the energy production sector lags behind in assessing the impacts of water withdrawal and use for producing power. In most fuel extraction and refinement processes, assessments of consumptive water use are not systematically accounted for. Patterns of water consumption and abstraction vary greatly between different fuel and power generating technologies, depending on the context (IPCC, 2011). Biofuels are consistently water intensive, and hydropower reservoirs may evaporate large volumes of water depending on location, and in many parts of the world, such as in India, China, the Southeastern United States and France, there are already signs that water constraints are set to add additional costs on the energy sector (IEA, 2012). Energy is also used for water management and service delivery, including water treatment. For example, it requires large amounts of energy to keep conventional water supply and sanitation services operating.

A continuum of assessment tools at different scales

Water, land and energy assets are spatially unevenly distributed, often across political boundaries in all the regions of the world, and all geographic regions have different endowments of natural resources, as well as different political and economic contexts. Hence, in order to allocate these resources to their most productive uses and to maintain life supporting ecosystems, it is necessary to improve our understanding of the availability of (and competing demands for) these resources. Concrete analysis needs to be undertaken at the appropriate geographic scale, and should include macro-economic forecasts that cover trends in production and consumption from global to local scales. Sound assessment tools can provide the basis to support innovation throughout the WEF value chains, as well as create incentives to strengthen collaboration at macro-regional,[2] national and local levels. Such innovation and incentives can generate regional and global benefits by improving food and energy security, reducing greenhouse gas emissions, and supporting job creation and economic growth in a more resource efficient economy.

The WEF nexus can be assessed using methodologies in a continuum, running from qualitative approaches at the start of the continuum, to more data driven and quantitative modelling approaches further along it. A range of factors can determine which approach is chosen, including the goal of the analysis, the level of capacity and trust between competing stakeholders at different scales, sectoral integration, access to data, and capacity for analysis. If common issues and barriers to cooperation were jointly identified, this could help to build collaboration and trust between multiple countries in a macro-region or between sectors. More in-depth fact finding and detailed assessment could then be developed at a later stage to support common policy approaches and investment.

Governance and management solutions that are adapted to different countries and macro-regions must be context-specific, and can only be identified through collaborative partnerships. WEF security in a given transboundary context could be built within the framework of a macro-region, with ecosystem services and climate conditions acting as constraints. In order to achieve WEF security within a macro-region, it is important for actors to identify market-based transactions that add value. Such transactions can occur bilaterally between countries (e.g. flood protection and hydropower generation), at the regional level (e.g. power and food trade), and at the global level (e.g. mitigating and adapting to climate change through the deployment of renewable energy sources). Water underpins the nexus as an intermediary function in all of these examples.

At the local level, nexus assessments might focus on integrated waste management, energy generation, or reuse in agricultural production, actions which if applied could save water, reduce emissions, recycle nutrients, and increase energy and food security. Such approaches respond to the need to develop sustainable and resilient energy and sanitation systems at the local level.[3]

Methodological examples in the water-energy-food continuum

Index building is an example of an assessment that could be carried out in the initial parts of the WEF continuum. Index building addresses the macro-regional scale using a core set of representative parameters for key sectors, thus identifying insecurities within the nexus. The index could be built using well-defined surveys that country representatives can respond to, drawing on national data sets that could be combined with publicly available indicators. Specialists could then carry out an initial analysis to determine which issues are important for country stakeholders to consider. A version of such a methodology is described in the Transboundary Waters Opportunity Analysis (TWO) (Phillips *et al.*, 2008). TWO assesses key development opportunities in the nexus, taking into account qualitative assessments of water resource constraints. By collaboratively exploring the positive gains that can be generated and shared, stakeholders can identify barriers to development as well as preferred development options. For example, this approach has been applied in the Orange-Senque River basin in Southern Africa.[4] It added value because it allowed stakeholders to identify key WEF insecurities and how to mitigate them, or to turn them into development opportunities by using limited water resources more efficiently and in innovative ways. This kind of assessment would be a first step towards

[2] A macro-region in the context of the WEF nexus is defined as a territory spread over two or more countries that are connected to a transboundary freshwater system. Such a territory might experience linked energy and food insecurity because of the connective role of water as an intermediary good traded bilaterally or in regional and global market places.

[3] Sustainable sanitation systems protect and promote human health, minimise environmental degradation and depletion of the resource base, are technically and institutionally appropriate, socially acceptable, and economically viable in the long term (Rosemarin *et al.* 2008).

[4] Case study available at: www.waternet.co.za/SADCRBO/two.html (accessed April 2013).

more quantitative analyses of resource use, as well as assessments of common policy and institutional options for collaboration, thereby helping to build trust between riparian countries in a macro-region.

Tools further along the continuum at the macro- and in-country levels might include linked, sector-specific, data-intensive modelling approaches. An example of this is SEI's work on integrating its Water Evaluation and Planning (WEAP) and Long Range Energy Alternatives System Planning (LEAP) models with GIS-based models of land-use (Purkey, 2012). This approach provides quantitative outputs on water resources, food production, land-use, power production and concurrent environmental impacts, as illustrated by the application of the approach in California. If stakeholders are included in the process of setting up these kinds of tools, as well as in developing scenarios and analysing the outcomes, there is an increased likelihood that the tools will provide relevant information. The WEAP-LEAP integration lends itself to exploring trade-offs between water, land and energy needs for agricultural intensification and food, and biofuels and hydropower production in relation to other sectors, such as tourism and water for industry and domestic use. This kind of quantitative and stakeholder-driven approach can provide sustainability criteria for investments and support national and local planning, as is currently being tested in Lake Tana and the Upper Blue Nile basin in Ethiopia (Hoff & Karlberg, 2013).

Hydro-economic modelling is a further example of a nexus assessment approach, as demonstrated in a pilot study for the Euphrates and Tigris region (Granit & Joyce, 2012). This study was carried out by four countries using only publicly available data and remote sensing, and by assessing the nexus in a macro-regional context beyond the transboundary river basin. Its hypothesis was that marginal benefits can be generated by a cooperative approach to managing and developing water resources in relation to hydropower, irrigated agriculture and ecosystem goods and services. To test the hypothesis, the study designed a basic hydro-economic simulation model. The model assessed the extent to which different efficiency measures could save water in hydropower and irrigated agriculture, and put a monetary value on these savings. Shadow values were used for environmental flows. Alongside in-depth dialogue with stakeholders, the model supported a process to identify opportunities for cooperative governance and management in the nexus at different scales. These opportunities included developing power and agriculture markets, and other benefit sharing mechanisms that could support steps towards regional integration.

The World Bank has spearheaded a modified Strategic Environmental Assessment (SEA) approach to explore regional power planning and water resources management in a multi-country perspective, which has been applied at full-scale in the Nile Equatorial Lakes Region (Granit *et al.*, 2011). The approach takes the form of a pre-investment tool that facilitates broad participation by governments, sector experts and civil society. In the initial stages of the planning process the tool combines standard power planning and water resource modelling with data on the cumulative impacts of environmental, economic and social development programmes. Such an approach supports cooperative infrastructure planning that incorporates sustainable energy production for socio-economic development and environmental management. In this process, social and environmental factors are considered to be equally important as technical and economic factors. The modified SEA supports a macro-region development agenda linked to the East African Community (EAC), and provides information to potential investors from domestic, regional and global markets on major development initiatives.

Poor infrastructure for water and wastewater, water scarcity and limited energy supply all hold back potential for human wellbeing and sustainable economic growth at the local and national level. Releasing this potential is the key driver for exploring linked systems of water use, sanitation services, and energy and food production for sustainable urban development (Rosemarin *et al.*, 2008). Innovation in a range of global markets over a period of several years has demonstrated the value of resource-based and productive sanitation techniques at the local level. These techniques show promising potential for decentralised system solutions that focus on safe resource recovery in sanitation.

Figure 1 shows the different methodologies and tools described in this article along a continuum,

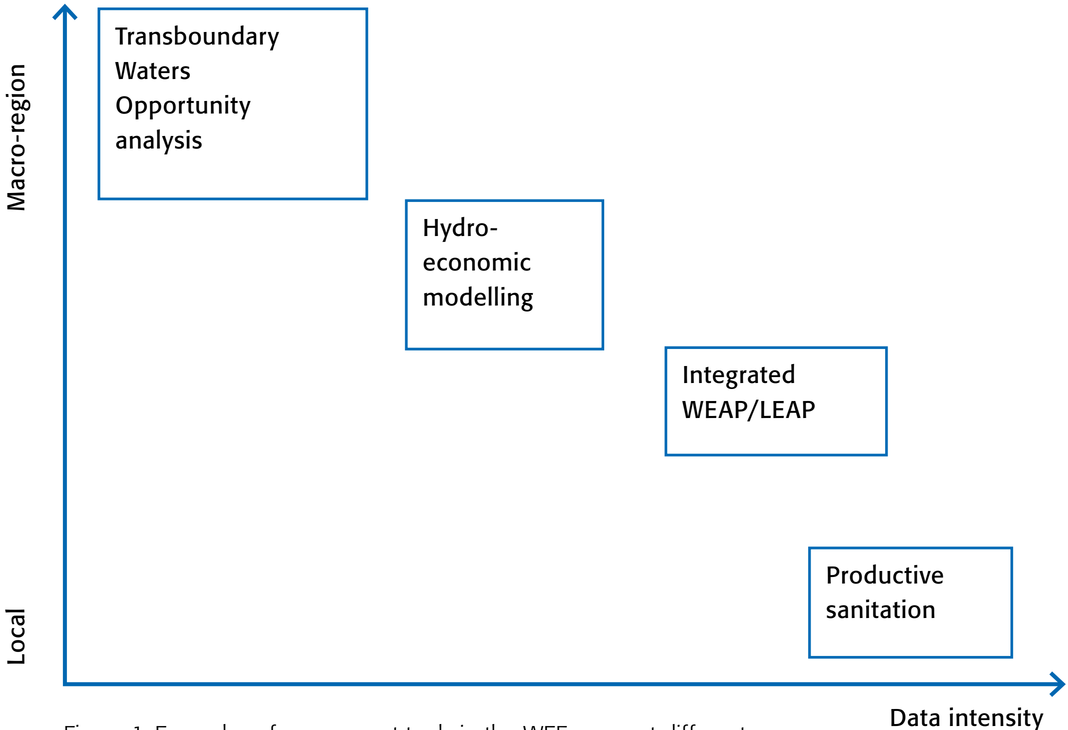

Figure 1. Examples of assessment tools in the WEF nexus at different scales and with different levels of data intensity

ranging from qualitative approaches to more data-driven and quantitative modelling approaches and in the context of the local to macro-region scale. By unpacking the WEF nexus at different scales using different methodologies it is possible to identify measures for cooperative governance and management that support outcomes along multiple value chains within the nexus.

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Photo: Getty Images

Reducing Greenhouse Gases While Building Resilience – Cooperation towards Climate Mitigation and Adaptation Coherence

By Karin Lexén, SIWI, John Matthews, CI and Mats Eriksson, SIWI

There is a clear scientific consensus that humans heavily contribute to climate change. Furthermore, there is a clear political consensus that there is an urgent need to "mitigate" this climate change by reducing the concentration of greenhouse gases in the atmosphere. However, the transition from need to action by the international community is lagging. International negotiations are stalled by nearsighted political and economic interests. While there is an urgent need to reach a binding global agreement, effective mitigation measures cannot wait. Given that climate change is already happening, approaches are needed that help climate mitigation methodologies adjust to shifting climate conditions. Adaptation to adverse changes is also necessary, as acknowledged by the climate and water community. There is a need for more coherence between these two approaches as well as improved cooperation across boarders and disciplines, thereby working towards coherent climate measures. This paper aims to explore the opportunities for more targeted work in this interface.

Reducing greenhouse gases has remained high on the agenda of policy- and decision-makers since the United Nations Climate Change Convention (UNFCCC) was established at the UN Conference on Environment and Development in Rio de Janeiro in 1992. Two complementary climate mitigation strategies have been developed: lowering the rate of emissions of greenhouse gases and reducing carbon emissions from degraded ecosystems as well as increasing potential carbon storage in plants, wetlands, and soils.

Reducing energy demand, increasing energy efficiency, and shifting from fossil fuels to renewable energy sources such as solar, wind, hydropower, and biofuels have been critical elements of climate mitigation that result in lower greenhouse gas emissions. Natural gas and shale gas have also been introduced as alternatives, despite the fact that they are slowing down the investments in non-fossil alternatives. Forests, soils, and wetlands are important reservoirs of carbon, and climate mitigation policies have targeted methods to stabilise and/or expand these reservoirs by reducing their degradation and destruction as well as managing them in order to maximise greenhouse gas sequestration.

Most of the impacts of climate change are expressed via the water cycle. These include long term shifts in the amount and frequency of precipitation as well as increased variability, which may lead to increased floods and droughts, challenges to food production, and difficulties in maintaining ecosystem sustainability, infrastructure development, and water dependent manufacturing (IPCC, 2008). Gradual sea level rise poses an additional real threat to coastal communities, cities and mega-cities, as well as many vulnerable coastal food production systems. It has become clear that livelihoods and economies must adapt to current and future impacts from climate change, even in a state of uncertainty about the magnitude of changes to come. We need to plan for today and tomorrow with an understanding that the future may be significantly different than the past, even the recent past. Confronting uncertainty calls for an increased emphasis in applying risk management approaches and that we do not shy away from making decisions and the responsibility for action to be taken.

Resilient land and water management is clearly a critical strategy for climate adaptation. A less obvious but equally important point is that water is often a key dimension for climate mitigation as well. For example, biofuels need vast quantities of water to grow and process; large hydropower dams store vast quantities of water, especially during dry seasons; and shale gas extraction poses serious threats to groundwater quality. Nuclear power is a climate friendly alternative. However, in addition to unsolved problems with the environmental impacts associated with the extraction of uranium and storage of radioactive waste, this energy source is highly dependent on water for cooling; there are already instances where nuclear facilities have had to shut down as a result of cooling water that was too warm from extreme air temperatures. Similar concerns have also been raised with so-called concentrated solar power (CSP) facilities, which evaporate high levels of water for cooling, which has led to conflict in water scarce regions (see, for example, New York Times, 2009). More generally, water for energy also often means less water for other uses, such as food production, cities, fisheries, and ecosystems. Water is also a critical component in ecosystems that store and sequester carbon – increasing drought can trigger massive losses of ecological carbon through forest fires or wetland destruction.

Some approaches to climate adaptation may also exacerbate climate mitigation. For instance, desalinisation methods to produce potable or irrigation-quality freshwater are – at least to date – an energy intensive process. When that energy derives from fossil fuels such as petroleum or coal, creating desalinated water supplies to compensate for declining freshwater availability can ultimately exacerbate climate change.

On the other hand, water has the potential to serve as a bridge to support both climate adaptation and mitigation. For instance, in addition to capture and store carbon, reforestation and watershed management can reduce or prevent destructive surface runoff and debris flows from intense precipitation by stabilising hill-slopes and promoting groundwater recharge.

The acknowledgement of the potential threats and opportunities between cooperation and competition for climate mitigation and adaptation is new, as is recognising the role of water as a means of securing the success of both approaches. As such, water provides one of the best entry points and means for negotiating a coherent pathway between global, national and local level priorities for mitigation and adaptation.

Adaptation and water

While energy, food production, and manufacturing are considered fundamental to economies, water should be considered elemental. Water quality, quantity, and timing (i.e., the seasonality of water) have historically determined many aspects of human livelihoods and behaviour, including agricultural patterns, cities' locations, and even the evolution of humans as a species (e.g., Scholz *et al.*, 2007). Indeed, for most of our history, humans have adapted to shifts in climate by altering cropping patterns, supplementing rainfed with irrigated agriculture, and adjusting livelihoods to areas where reliable water resources existed. The "elemental" aspect of freshwater as a part of many essential biophysical processes means that we need to prepare for futures that come with an increased uncertainty in all aspects of the water cycle, such as less reliable timing of monsoon precipitation and high inter-annual variability (IPCC, 2008). Given the sensitivity of the water cycle to climate change, the past is no longer a reliable guide for future planning, infrastructure design and operations, and the development of national economic strategies (Milly *et al.*, 2008). New methods to balance uncertainty and risk are needed (Kundzewicz and Stakhiv, 2010; Matthews *et al.*, 2011). If water represents the "teeth" in climate change's bite, then more effective water management can mean reducing the damage from that bite – or even converting threats into opportunities.

Mitigation and water

Reducing greenhouse gas emissions requires a radical shift towards energy efficiency and cleaner energy sources. A well-known stumbling block for climate mitigation discussions is fear for high transition costs in the shift towards renewable energy and possible lifestyle changes. The climate mitigation discussion has until recently neglected water resources as an important element for success, but there is an increasing recognition of the need to combine water, food, energy, and climate securities in order for them all to be effective (Ebinger & Vergara 2011; Hoff, 2011). Therefore, there is a strong need for integration of water and energy when discussing greenhouse gas emission policies and technology developments (World Energy Council, 2010).

The role of water in energy production

Assuming current practices continue, by 2030 humanity's demand for water could outstrip sustainable supply by as much as 40 per cent (UNEP, 2011). Currently, water withdrawals for agriculture represent the main share of global water extraction, but in many regions of the world the energy sector is one of the largest users of water. In developing countries, 10–20 per cent of withdrawals are used to meet industrial needs, including for energy (Boberg, 2005).

Water security is thus ultimately essential for achieving energy security, and is embedded in many steps of the energy production, including nuclear, coal, natural gas, hydropower, geothermal, and solar technologies. Generally, biofuels require more water per unit energy than extracted fuels, and unconventional fossil fuels require more water than conventional fossil fuels. A recent World Bank study suggested that shifts in the water cycle represented the biggest climate vulnerability in energy production in the future, excluding wind generation (Ebinger and Vergara, 2011).

Photo: Daniel West, SXC

Photo: Jesper Baerentzen, SXC

Both water (availability and consumption) and energy (demand and production) are states of flux. While water availability reflects allocation and choices, energy production requires strategic, long-term, and large-scale institutional and financial investments. These take time, and the results of both good and bad decisions may not be visible for decades.

Recognising the urgency in combating climate change, growing energy demands will require addressing trade-offs between water and climate change mitigation. This need to be addressed through coherent policies that also mainstream adaptation and resilience building measures in development planning.

The role of water for carbon sequestration

Soils and plants, especially long-lived plants such as trees, contain abundant carbon that is harvested directly from the atmosphere through the process of photosynthesis and converted into cellulose. Currently referred to by the UNFCCC as "REDD+" (reducing emissions from deforestation and degradation "plus" conservation), forest carbon management has evolved into a strategy that protects existing forests, reduces soil erosion, and stops the loss of peatlands, while also attempting to expand forests globally to increase carbon storage, using a combination of public policy and private sector carbon investment market mechanisms (Tollefson, 2013). Many REDD projects are located in the developing world, particularly in the tropics, where the conversion of land for agriculture is rapid and has often come at the expense of intact forests.

However, much of this policy has failed to account for these forests as dynamic ecosystems that have always responded to shifts in climate, particularly precipitation regime. Thus, the impact of how forests adjust to climate change and their capacity to act as a carbon reservoir or sink has not been widely studied. For instance, two recent extensive droughts in the Amazon Basin may signal a shift – perhaps even a tipping point – in the Amazon that may result in it evolving into a drier forest or even a grassland, which would shrink its capacity to store carbon (Lewis *et al.*, 2009; Davidson *et al.*, 2012). These ecosystems are adjusting to changes in climate, and it is possible that the Amazon has already become a net carbon source (Lewis *et al.*, 2011). In effect, water is the "lock" for the Amazon's carbon "vault," and in some ecosystems carbon is becoming unlocked and may leave the vault, quickening the rate of climate change and undermining REDD.

In northern regions, such as in Canada and Russia, with large areas located north of the tree line, new carbon sinks may be fostered through afforestation (IPCC, 2008). The same may refer to some high altitude areas as global warming pushes the tree-limit upwards. We must learn whether there is a way to secure forests as healthy, dynamic ecosystems, while we also use them as a long-term storage mechanism for our atmosphere's excess carbon.

Wetlands such as tropical and temperate lakes and peatlands can also store carbon. However, these carbon sinks can also be turned into sources. For instance, there is an imminent threat of potential release of large amounts of carbon dioxide and methane, which is a very potent greenhouse gas, triggered by desiccation from climate change or land use conversion. The role of storage dams as sources of methane in the tropics, deriving from the decomposition of organic material under anaerobic conditions, has also been debated lately. This serves as a prime example of the difficult trade-offs posed by hydropower and the tension between climate mitigation and adaptation (UN-WWDR, 2013).

Mitigation and adaptation coherence – water as a bridge

Mainstreaming climate mitigation and adaptation into national development strategies is an important and largely unresolved challenge for many countries. In most places, climate mitigation should better factor in linkages to resilience and adaptive capacity, but positive examples exist that highlight useful lessons. For instance, in Durance, France, the energy utility company EDF partly reimburses farmers' investments in water-efficient irrigation technologies upstream of a hydropower reservoir to contribute to water and energy efficiency simultaneously (World Water Forum, 2012). This approach demonstrates the importance of business models that create synergies through cross-sectorial approaches.

In the Middle East and North Africa (MENA) region, a recent study points at the need to make clear, coherent trade-offs between climate mitigation and adaptation measures (Hoff, 2013). This region has some of the world's lowest water availability per capita and is projected to see even less precipitation in future. Efforts to deal with increasing water stress, such as desalination and irrigation, are both water and greenhouse gas intensive. Three pilot countries, Lebanon, Jordan and Egypt, are sharing experiences on water-related adaptation and energy-related mitigation interventions through the Arab Strategy for Water Security, a new platform for transboundary cooperation (Hoff, 2013).

Northeast India is severely affected by increasing variability. The region's weak capacity to buffer the effects of hydrological variability has severe consequences for food production and sustainable growth. "Climate-smart" agriculture is needed to achieve both food security and green growth objectives (Sharma, 2013). The challenge here involves the control of energy intensive fossil fuel based systems for pumping ground water to compensate for surface water scarcity. Better adaptation to seasonal water shortages through improved water management can potentially reduce the need for fossil fuels for pumping, and also lower greenhouse gas emissions.

Conclusions

Climate change is a major challenge to economic development and human well-being. It highlights a key dilemma; there are no shortcuts in meeting the needs of a growing population and securing welfare to all in a way where the needs for natural resources are balanced with current availability and long term sustainability. The potential conflict between using water for climate friendly energy sources and building resilience is one example. Further, the lack of coherence between mitigation and adaptation interventions also mirrors the need for more efficient integration of land and water resources management in energy, infrastructure, and food production.

Ultimately, climate driven shifts in the water cycle are connected to changes in carbon production, emission, and sequestration. In many cases freshwater is the glue that binds our desire to reduce the rate at which climate change is occurring and the choices we have available to adapt to climate change impacts.

Our dilemma is delicate and difficult, but our greatest obstacle to date has been ignoring the need to find coherence and cooperation between mitigation and adaptation. However, with the challenge comes new opportunities. In the light of the International Year of Water Cooperation, declared by the UN General Assembly, we conclude that effective cooperation will enable us to reach future-oriented decisions and force implementation. Only by building partnerships among actors and working across geographical levels and disciplines will this be possible.

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Photo: Scott Pollard, SXC

Bridging Divides Between Land, Water, Coast and Sea

By Jan Lundqvist, SIWI, Peter Koefoed Bjørnsen, UNEP-DHI
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The link between river basins and coastal areas has been highlighted as a critical area of concern for more than two decades. In 1992, at the Earth Summit in Rio de Janeiro, it was pointed out that neither freshwater nor coastal ecosystems will be able to function properly and provide essential services to a growing world population if fragmented governance of land, water, coastal and marine resources is allowed to continue unabated. While the high social, environmental and economic costs of the disconnected management of land, freshwater, coastal and ocean systems may be well-known, resolving these divides remains a considerable governance challenge around the world. There are a number of examples where different approaches have been taken that can be learned from to guide future action. Improved coordination and cooperation between a wide range of actors, including freshwater and coastal experts, are pivotal to success.

The big squeeze

For good reasons, the coastal zone is the most congested and dynamic part of the world. Nearly half of the global population is located within 200 kilometres from the coast, including 200 million people that live along the coastline less than 5 metres above sea level (Martinez *et al.,* 2007). With a majority of the mega-cities and economic centres located on or near water, coastal areas are the most valuable territories on earth. They are also the most vulnerable to pressures from human activities and an increasingly turbulent climate.

The attraction, function and the beauty of the coastline face growing risks from land and sea. An estimated three quarters of all commercially important marine fish depend on estuaries at some stage in their development (Olsen, *et al.,* 2006). In addition to marine fish resources, aquaculture is one of the fastest growing food production systems in the world. The resources that are part of the marine system are, of course, vital not only for communities who reside on the fringes of the terrestrial and freshwater systems but for national and international interests.

Coastal areas are also heavily influenced from land-based activities occurring upstream, which cause 80 per cent of nutrient- and chemical-based marine pollution (Jeftic, *et al.,* 2009). Globally, an estimated 65 million tons of nitrogen and 11 million tonnes of phosphorous flow from rivers into coastal areas each year and result in algal blooms and oxygen

Photo: William Picard, SXC

A six foot sea level rise (a possible projected climate scenario over the next century), would put 21 per cent of Lower Manhattan under water. Hurricanes can drive surges of water four times higher and flood more than 60 per cent of the area.

depleted 'dead zones' in the ecosystems (Syvitski *et al.,* 2009). The impacts of this pollution are compounded by reduced flows reaching the sea after much of the water is abstracted upstream. Salt water intrusion onto coastal lands and freshwater sources, is another growing stress for both water and coasts.

Warming of the oceans and climate change, in general, will also lead to more frequent and intense storms, typhoons and hurricanes that will hit coastal settlements on all continents. The potential costs in human, environmental and financial terms are enormous. A six foot sea level rise (which is a possible projected scenario over the next century), would, for instance, put 21 per cent of Lower Manhattan under water. Due to special character of the coast and the mouth of Hudson river, hurricanes can drive surges of water four times higher and flood more than 60 per cent of lower Manhattan (Bergdoll, 2011). Fisheries may face major changes under climactic shift, with potential increases of 30-70 per cent in high, temperate latitude regions and up to a 40 drop in the tropics. Considering that some 1,5 billion people rely on fish for essential nutrition and 200 million more depend of the fishery industry for livelihoods, such a shift would have a major impact on food supply and human development worldwide (FAO, 2009). It can also potentially threaten food security in tropical and sub-tropical regions, particularly for poor people.

Sinking deltas – A hotspot for humanity

Close to half a billion people live in deltas – low lying coastal areas that are often densely populated, heavily farmed and prone to floods. One survey of over 30 deltas found that 85 per cent experienced severe flooding over the last decade, and estimated that sea level rise over the next century would increase flooding by at least 50 per cent (Syvitski *et al.,* 2009). Compounding these risks, many deltas are sinking – due to natural and human causes – much faster than the sea is rising. This is, in part, due to increasing freshwater withdrawals which results in reduced flows of sediment that in turn augments downward soil compaction and ultimately causes the land levels to drop. Drainage and resource extraction, including groundwater, gas and oil, can further accelerate this process. For example, groundwater extraction in the Chao Phraya Delta, Thailand, have caused sinking at a rate 30-50 times greater than the concurrent sea level rise. In the Po Delta in Italy, methane gas mining has had similar impacts over the past century (ibid).

IWRM and ICM: Worlds apart?

Two key management approaches have been promoted over the past several decades to promote sustainable development within the river-coast continuum: IWRM (integrated water resources management) and ICM (integrated coastal management).

IWRM aims to provide a systematic and holistic approach to relevant and related issues within river basins such as upstream-downstream water allocation conflicts, economic and financial issues, involvement of stakeholder groups, the degradation of freshwater quality by water pollution upstream, or reduced water storage capacity of dams due to increased sediment loads resulting from poor soil conservation practices in upstream areas. ICM has addressed issues caused by activities in the coastal regions including overfishing, declining mangrove areas due to coastal shrimp ponds and cutting of mangroves for firewood or construction, degradation of estuarine water quality due to urbanisation and industrial development along the coastal zone.

The concepts of IWRM and ICM have been developed by and large independently from each other, typically by separate management bodies and organisations, frequently and logically with different objectives and modes of operation. As a result, the downstream impacts on coastal zones from activities in a river basin – such as the degradation of wetland ecosystems from agricultural pollution, or changes in salinity regimes and sediment profiles in estuaries and lagoons due to reduced river flows – may not be adequately accounted for in either IWRM or ICM plans. Both frameworks can face challenges for implementation, as shown in Table 1 (taken from Liss Lymer, 2012).

There have been promising advances in developing the framework for integrating watershed and coastal management, such as the national initiatives developed under the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) or Integrated Coastal Area and River Basin Management (ICARM) approaches. The ICARM guidelines (UNEP, 1999) prioritised the issues of coastal land-use planning, river basin development and resource management, legislation, enforcement, coastal and river banks protection and conservation. The capacity and resources dedicated to conduct these programmes or reforms are often lacking and insufficient in many regions, and impede their implementation.

Learning from practice and pragmatism

A number of regions have been successful in improving the coordination of freshwater and coastal management at different scales. There is a tremendous amount of experience to learn from around the globe from Small Island Developing States in the

Table 1: Common barriers to effective IWRM/ICM implementation

Key Issue	Barrier to Implementation
Links to national policy and legal system	Necessary for effective implementation, but often missing
Funding	Often short-term, project-based. May not extend over planning phase
Boundary definition	Unclear how to regulate relations between river basin and coastal zone
Institutional restructuring	Often pre-requisite for effective implementation – but this is a huge task
Strong focus on process and procedural integration	Few accepted evaluation frameworks; thee is a Gap between river basin and coastal management that has so far not been resolved by IWRM/ICM

(Source: Granit et al. 2012)

Caribbean and the Pacific (GEF, 2009), to the Orange Senqu River (UNDP-GEF 2012) or the Baltic Sea (Schernewski, 2005). This experience shows that there is no straightforward blueprint for success, but most good examples share in common a dedicated and sustained effort to build knowledge, capacity and coordination among a large range of actors. No matter what management framework that is used, any approach will need to include the ecosystem, be able to evaluate the economic and social benefits it can produce and deliver measurable outcomes.

Economic tools are an important part of the equation to achieve this. While developments in coastal areas suffer risks and fall victim to pollution from their upstream neighbours, they also benefit from the higher values of land, concentration of economic activities, and tourism opportunities that come from locations close to the sea. In many cases, the most pragmatic approach involves channelling some of that prosperity to upstream neighbours to support clean development for the entire region. There are economic instruments and management approaches to do this that have been applied with varying success in regions across the world, such as payment for ecosystem (or watershed) services schemes. To apply these tools, however, local actors need to have the scientific capability to assess the economic values and returns on pollution prevention or alternate water allocation measures.

They also must have the governance capacity to enforce legal provisions and delivery compensation directly to the actors who will modify their behaviour. Trust between all parties so that they can agree on a fair level of compensation and processes to enforce regulations and deliver payments is likewise critical. As shown in the example of Xiamen, China, payment schemes have been effectively implemented and is now an integral environmental policy measure applied across the nation (see case study: The Xiamen Story).

Strategic Environmental Assessments are another method to evaluate the overall economic, social and environmental costs and benefits of development, investment and policy choices that can take into consideration their impacts across the continuum from land to sea. Spatial planning is another crucial process where the downstream impacts of potential land use plans should be assessed in order to take measures to prevent losses of natural, economic and social capital when taking development decisions (Granit *et al.,* 2012). Consultation and coordination with those working with freshwater and coastal planning can provide critical information on how water resources and ecosystem will be impacted by different development options. This requires, however, that a new set of actors (developers, spatial planners) learn how to utilise these assessments when making physical plans and, again, demands more collaboration between an even wider set of actors. Scientists, water and coastal management specialists will need to develop capacity to provide information and training to planners that they can readily understand and apply to ensure that this is done effectively.

Photo: Manfred Matz

CASE STUDY:
The Xiamen Story – Protecting the Jiulong River and Xiamen Seas

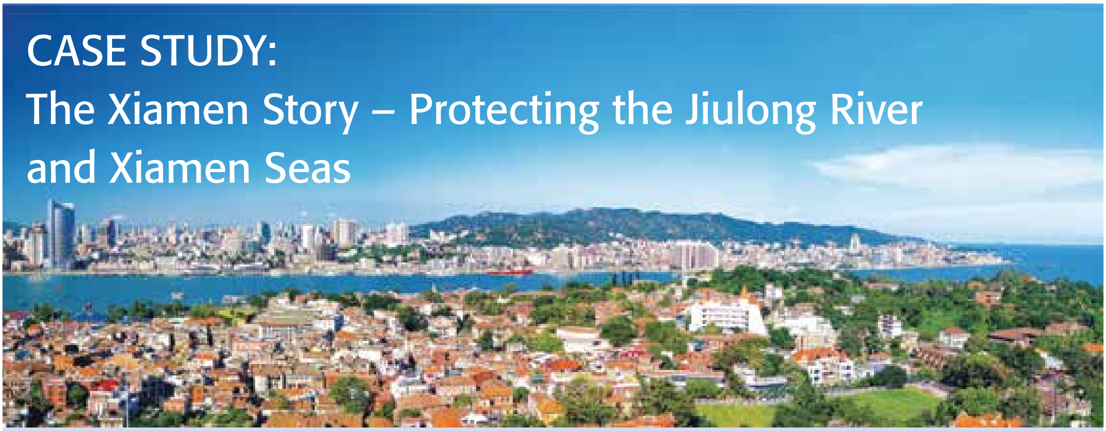

Photo: Chen Weikai

Xiamen, a coastal city in Southeast China, is home to 3 million residents and host to 40 million annual tourists. Roughly 80 per cent of water used in Xiamen (1.5 million tons per day) is provided by the Jiulong River, which serves 7 million people in Longyan, Zhangzhou and Xiamen. Industrial and agricultural production upstream in the watershed have led to heavy pollution (nitrogen and phosphate) which in turn cause eutrophication in the Jiulong river and more frequent red tides in the Xiamen seas. As a result of poor management, solid waste was often flushed downstream during storms and ends up in the Xiamen seas, damaging the local beach and coastal environment.

As a demonstration site on Integrated Coastal Management (ICM) supported by PEMSEA (Partnerships in Environmental Management for the Seas of East Asia), the concept of integration in ocean governance has been adopted by Xiamen since 1993. There were five essential components for success found in implementing ICM in Xiamen:

1) the establishment of coordinating mechanisms,
2) legislation and planning,
3) integrated enforcement,
4) science informed decision-making and
5) public participation.

The creation of effective cooperation with the upstream cities of Longyan and Zhangzhou has been a key to successful efforts to protect the Jiulong River and Xiamen Seas. One important development was setting up a regular "joint meeting of city mayors" to discuss watershed protection. Efforts were also made to better inform decision-making by strengthening scientific research of the watershed.

This included conducting water pollution inventories for point and non-point source sources; integrated models of river, estuary and coastal seas; and creating an environmental information sharing system.

An 'ecological compensation' scheme, similar to payment for ecosystem services (PES) in other places in the world, was also put in place. Each year, Xiamen has paid roughly 50 million RMB (USD 8.1 million) to the cities of Longyan and Zhangzhou to take actions that would reduce pollution loads sent downstream. This has been widely regarded as a win-win solution – the financial support from the downstream actor has provided economic incentives to upstream cities. It has also been cost-effective, as the marginal cost to raise the local wastewater treatment is much higher than the investment made to prevent pollution upstream (Granit *et al.* 2012). Consultation and coordination with those working with freshwater and coastal planning can provide critical information on how water resources and ecosystem will be impacted by different development options. This requires, however, that a new set of actors (developers, spatial planners) learn how to utilise these assessments when making physical plans and, again, demands more collaboration between an even wider set of actors. Scientists, water and coastal management specialists will need to develop capacity to provide information and training to planners that they can readily understand and apply to ensure that this is done effectively.

Rising to the challenge

Governments, sector professionals, and scientists in the freshwater and marine communities will benefit greatly from reaching across the divide between land, water, coast and sea. As demonstrated in this chapter, there is a great deal of knowledge and experience on effective ways this can be done and practical frameworks – whether they are adapted from ICARM guidelines, GPA national programme strategies, or focus on spatial planning approaches – are well developed but challenging to implement. Freshwater and coastal experts must connect more often and more effectively to inform decision makers on how to manage the complex dynamics between land, water, and coast in their development planning and decision making. Considering the scale and the complexity of the task, it is essential that the few actors and organisations that work with the explicit mandate to catalyse coordination and cohesion of land, water resource and coastal governance are given additional support. Of those that concentrate on this area, a large majority work primarily with coastal and marine issues. A much greater focus in needed in the freshwater community to prevent downstream impacts on coastal areas. The 2013 International Year of Water Cooperation is a perfect time to redouble our efforts to meet the challenge.

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Cooperation for a Water Wise World

– Partnerships for Sustainable Development

This report provides input into the discussions at the 2013 World Water Week in Stockholm, which is held September 1-6 under the theme of Water Cooperation – Building Partnerships. Through eight chapters authored by more than 25 leading thinkers in the field, it presents insightful analysis and diverse perspectives on some of the key opportunities and challenges to effective cooperation over water.

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