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Water Innovation Centre

GWSP Global Water System Project

Water-Energy-Food Security

New Challenges and New Solutions for Water Management

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Conference Proceedings

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IISD contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, measurement and assessment, and natural resources management, and the enabling role of communication technologies in these areas. We report on international negotiations and disseminate knowledge gained through collaborative projects, resulting in more rigorous research, capacity building in developing countries, better networks spanning the North and the South, and better global connections among researchers, practitioners, citizens and policy-makers.

A founding principle of GWSP is the notion that physical, biological, chemical, as well as economic, political and cultural factors all shape the character of the global freshwater resource base. GWSP coordinates and supports a broad research agenda to study the complex global water system with its interactions between natural and human components and their feedback processes. Our mission is to understand the ways in which humans use the resources and influence the dynamics of the global water system and to advise decision makers on how environmental and social consequences of these impacts can be mitigated.

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Executive Summary

RIO+20 aspires to create “the future we want,” an epochal economic transformation to sustainable production and consumption. The international water community shares this aspiration, though it requires major innovation in the way water is managed. The fundamental requirement of the green economy is that it delivers food, water and energy security for all, a requirement challenged by climate and land-use change and its key impact—more volatile and less secure water supplies.


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Water security underlies all dimensions of human health and well-being, and is fundamental to both food and energy production. The green economy is inconceivable without diligent and highly efficient stewardship of this precious resource from raindrop to tap and back to raindrop.
Water is the practical entry point for integrated solutions to linked water, energy and food security challenges. Integrated Water Resources Management (IWRM) is a proven process for balancing societal, environmental and economic requirements, and provides a logical starting point for conceiving, implementing and managing the climate-resilient green economy. These points were underscored at the recent Oxford Conference on Water Security and the Bonn 2011 conference, "The Water, Energy and Food Security Nexus: Solutions for a Green Economy".

The "Water-Energy-Food Security: New Challenges and New Solutions for Water Management" conference hosted by the Global Water System Project (GWSP), the International Institute for Sustainable Development (IISD) and the National Aeronautics and Space Administration (NASA) in Winnipeg, Canada, in May 2012, reinforced these key messages and pushed further on three key implications:

1. Setting water targets works, as evidenced by recent reports that the Millennium Development Goal on improved access to water has been achieved—a major and commendable accomplishment. Other key water targets related to supply, quality, use and resilience to climate change should now be established, with appropriate investments in standards and monitoring to provide systematic and coherent advice to governments on planning and management. Earth observations are crucial, increasingly low-cost and ubiquitous sources of monitoring data.

2. The flow of water does not conform to political boundaries and thus challenges conventional governance models. Innovative polycentric governance models will be key to the new partnerships necessary for water-energy-food security. Furthermore, agreements on water science and observations can often provide a basis for new partnerships that can expand to address the policy dimensions of water security. Collaborative, fully

integrated water management respectful of unique cultural and historical patterns of resource tenure builds trust and is therefore a critical entry point for transboundary peacebuilding, and it should be prioritized.

3. The green economy is a vision for a sustainable world economy. It will likely evolve from the ground up through bioeconomies that provide renewable supplies of energy, fibre and chemicals to industry until it transforms national market economies. Innovative water management will be crucial to balance and optimize the flows of these ecosystem services and to remediate environmentally stressed regions. The Lake Winnipeg bioeconomy project demonstrates how innovative water management can link hydrologic and nutrient cycles, generate renewable feedstock for industry, produce ecosystem benefits and increase food security. Integrated water and land management that produces public and private benefits will be crucial for jointly mitigating and adapting to climate change—the crux of the green economy. This is the future we need.

Summary of the Conference

1. Introduction

On May 1–4, 2012, more than 80 experts participated in a conference in Winnipeg, Manitoba, Canada on the Water-Energy-Food (W-E-F) security nexus. This conference, sponsored by the International Institute for Sustainable Development (IISD), the Global Water System Project (GWSP) and the National Aeronautical and Space Agency (NASA), addressed the W-E-F nexus in preparation for the United Nations Conference on Sustainable Development (Rio+20). The W-E-F security nexus refers to the tightly interwoven cluster of risk that links global water, energy and food systems. It includes issues such as: water use for oil extraction and power generation, irrigation, biofuel production and the consequences of agricultural fertilizers and livestock for water pollution. According to the 2011 World Economic Forum this risk cluster will be critical to the global economy over the next few decades.

The GWSP has also identified this nexus as a critical science-policy interface and has conducted a survey of a number of major transboundary basins around the world to see how river basin management responds to W-E-F issues. To provide a basis for comparisons among the basins, information was gathered on the characterization of land cover and land use by basin, the drivers and basin-scale impacts of global change, water availability, water quality issues and impacts, agricultural and energy drivers, potential impacts of biofuels, maintenance of biodiversity, and extremes and risk management. This conference was an opportunity for GWSP to validate its conclusions through interactions with experts and policy-makers. IISD's Water Innovation Centre was interested in extending these discussions to clarify options for solutions through new technologies and economic frameworks such as the bioeconomy, which provides an integrated framework for responding to linked water, energy and food system risks.

The bioeconomy[1], which is a foundational component of the Green Economy, is typically defined as an economy where the basic building blocks for industry and energy production are the raw materials derived from plant/crop-based (i.e., renewable) sources. Within the bioeconomy, water is the principal mechanism that cycles resource flows including energy and agricultural nutrients across multiple value chains. For example, a functional bioeconomy would intercept and recycle non-point source nutrient loads through watershed-based biomaterial production, and would recycle wastewater for its water, nutrient and energy value. Large river basins concentrate water, energy and nutrients and thus are functional ecological units operating at scales that have a significant influence on global water, energy and food security.

2. Governance

The conference highlighted the critical role of governance issues and the need to pursue innovative and integrated options and solutions for the W-E-F nexus. While it was recognized that progress has been made on governance for water, food and energy security (though not necessarily as linked concerns), a key message that emerged was that innovative polycentric governance models are essential to provide the resilience necessary to deal with future uncertainties. This requirement applies to many spatial scales and it is valid for basins that are within countries; it applies to basins that are regional in scope as well as to water problems that are global in scope. The connection of governance issues across scales and across sectors will be important for the Rio+20 debate on global governance and for strengthening an integrated discussion of water, food and energy, especially with regard to equity (see Box 1).

Barriers to progress for achieving security through conventional governance include a tendency towards centralization, simplistic solutions (i.e., not enough integration), a lack of stakeholder engagement, persistent inequities, transboundary issues (e.g., between provinces/states, between countries), fragmentation, entrenched and unsustainable land-use systems, poor recognition of environmental flow needs, inadequate monitoring of existing attempts at water governance reform and inflexible regulations. These barriers are likely to slow the rate of adaptation to global change. Planetary boundaries are being exceeded in a number of areas raising concerns about the weak abilities of current governance systems to direct human activities towards safe operating parameters. Many positive steps towards better governance were also highlighted. On an international scale, steps toward global water governance processes have included the development of institutions and projects such as the World Water Council, the World Water Fora, the UN Conventions on Water, the World Water Scenarios Project and the European Water

[1] A bioeconomy is an economy in which the basic building blocks for industry and the raw materials for energy are derived from renewable resources.

Box 1

Equity

Equity was one of the issues most frequently and intensely discussed throughout the conference. For all human beings, water and food are vital and are considered a right under international law. The access to these resources as well as to energy is a major driver for human development, yet the access to water, energy and food is inequitably distributed at all scales, both within countries and between countries and regions.

This situation is becoming increasingly pressing due to global change and its impacts on demands for water, food and energy. The effects will be felt most keenly in developing countries and among vulnerable populations. This is largely due to the fact that the inequitable access to power and decision making fora as well as financial, institutional and human resources reflects back on the access to food, water and energy. When for example a river basin is a net food exporter while at the same time people living in the basin are suffering from hunger, Amartya Sen`s statement that "there is no such thing such as an apolitical food problem" is vividly illustrated. Similarly, the Consultative Group on International Agricultural Research (CGIAR) Challenge Program on Water and Food concludes in a recent report on 10 major river basins that water scarcity is not necessarily about the inability to grow enough food today or in coming decades. Rather, the "challenge is to make efficient and fair use of the water available. And this, ultimately, makes it an institutional and political challenge, not a resource concern"[3]. This statement underlines the fact that water, energy and food security can be achieved, but achieving it will demand drastic transformations in governance structures on all scales to react to the complex changes in the intertwined systems of water, food and energy.

[2] The Indian economist Amartya Sen is best known for his research on poverty and welfare economics for which he received the Nobel Prize in 1998. His work on the causes of famine demonstrates that it results not merely from a lack of food, but rather from inequalities within the mechanisms for distributing food. See also: Sen, Amartya (1982): „The Food Problem: Theory and Policy." Third World Quarterly 4(3):447-459

[3] CGIAR Challenge Program on Water & Food (n.d.), Water, food and poverty: Beyond the limits. http://waterandfood.org/2011/10/01/water-food-and-poverty-beyond-the-limits

Initiative. One multi-country study was the Twin2Go Project (Coordinating Twinning partnerships towards more adaptive Governance in river basins), which identified best practices for governance for water issues at the basin scale. Findings included the fact that adaptive capacity (e.g., to climate change) is strongly related to polycentric governance, and that economic development leads to better fulfilment of needs of human populations but may not increase consideration of environmental needs. Governance of water issues in North America relies on collaborative arrangements.

Box 2

IWRM characteristics for success

- Convening power
- Multi-stakeholder participation
- Skilled facilitation
- Sophisticated decision support systems
- Iterative decision-making
- Monitoring and adaptive management
- Stable and adequate financial resources

For instance, the Red River Basin Commission, which works within a transboundary context, seeks multistakeholder collaboration by involving stakeholders at all levels for their many shared concerns (e.g., floods, droughts, nutrient loading, food production, fisheries, invasive species, human health). Similarly, the International Joint Commission plays a role in helping Canada and the United States plan for adaptation to climate change through joint studies. In spite of this progress, an overall lack of global coordination and leadership was noted by presenters. IWRM was also emphasized as a governance model that, while not yet perfect, offers a positive way forward. Many of its central tenets are believed to be essential to good water governance (see Box 2). The

Intergovernmental Panel on Climate Change has recognized the critical role IWRM must play, and has written that "Integrated Water Resources Management should be an instrument to explore adaptation measures to climate change, but so far is in its infancy"[4]. The World Health Organization concluded at a May 2012 expert meeting attended by IISD that investment in and legislation for IWRM was a public health indicator for sustainable water management. Alternate approaches for increasing food, water and energy security were also discussed.

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Soft path approaches in which the goal is to decrease water use and demand, rather than seek new supplies, offers one promising approach. The testing of policy options using indices and economic measures (e.g., water stress, Gross Domestic Product, food production) and modelling was also featured; modelling can illustrate and help plan for the complex nature of water-energy-food interactions and feedback loops.

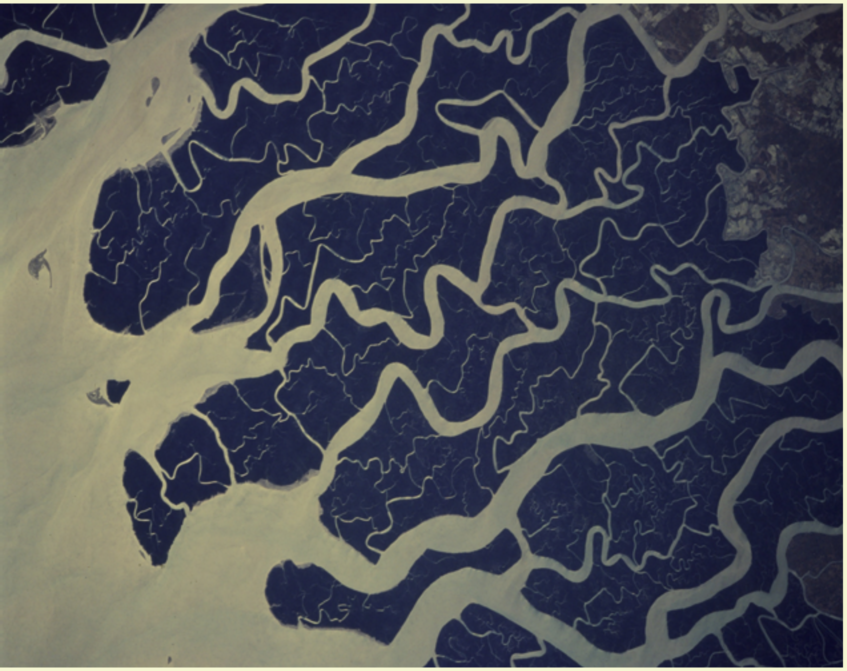
[4] Intergovernmental Panel on Climate Change (2007), IPCC Fourth Assessment report: Climate Change 2007. Retrieved from: http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch3s3-6.html

3. Earth Observations and the Water-Energy-Food Security Nexus

The Earth Observations session focused on the range of information needs that exist and the approaches that are used for making data available for the decision-makers who deal with W-E-F security. These approaches range from the provision of basic Earth Observation data products in the form of global satellite data and in-situ time series at specific locations, to tools that facilitate the access and use of these data, to systems that integrate these data with other information to facilitate decision-making.

NASA programs focus on the dissemination of basic data products, usually global in scope, and on the provision of tools to facilitate the access to these data. NASA is developing a range of tools to access these data based on recent studies being carried out in partnership with the California Department of Water Resources. Not only do these projects show the value of Earth Observations to support water management goals but they also demonstrate the value of partnerships in addressing multi-objective issues. An example of these systems is the United States Agency for International Development's Famine Early Warning Systems Network, which uses NASA satellite data and models as key inputs for monitoring food aid needs and supporting food deficit countries.

Within the framework of providing Earth Observations, there is a continual need to review the variables that are being collected and analyzed. Two variables with great potential benefit for the W-E-F nexus are soil moisture and evapotranspiration. Soil moisture is an integrated measure of climate variability because the storage of water in soil drives atmospheric, biogeochemical and hydrological processes. Earth Observations can contribute to integrated soil moisture monitoring system to capture spatial and temporal trends in moisture conditions at the surface and at different depths in the vadoze zone.



Ganges River Delta © NASA

Evapotranspiration is highly correlated to crop yield under water-limited conditions. It also feeds water vapour and energy into the boundary layer causing deep convection and severe weather (hail, tornadoes), purifies water and redistributes it from oceans to land masses, and cools and dries the earth's surface. Although soil moisture and evapotranspiration play such strategic roles, few countries have adequate networks in place to monitor these variables.

Efforts are needed to integrate data products into formats in which they will be more readily available and meaningful for practitioners and policy-makers addressing W-E-F issues. For example, drought monitors are being developed at the national, regional and global scales to incorporate Earth Observations into integrated products. These efforts show the value of the results in terms of warning society that they will need to take certain actions to sustain their livelihood from agriculture or to ensure they maintain a certain level of energy availability. New models, data, products and new understanding of physical processes present a huge opportunity to better monitor and predict droughts and floods leading to improved early warning systems.

However, studies also have shown that the relationships between physically-based indicators and impacts are often very complex and vary by region and sector. Furthermore, socioeconomic factors are not well understood and geopolitical factors, which tend to be global, are quite unpredictable.

Addressing W-E-F issues creates a need for "place-based" policies where site specific, geospatial information are used to support scientific decision-making such as evaluating programs. Satellite data provide a cost-efficient and effective source of information to support the sector in terms of programs, policies, market access and performance measurement. Linkages between world class Earth Observations research and operational services could provide an emerging capacity to apply this technology more widely. Linkages bring more rigour to operational information development, and ensure that the relevant science gets used effectively.

The Group on Earth Observations (GEO) has been encouraging the development of integrated systems that can address W-E-F issues. Recently, its GEOGLAM (Global Agricultural Monitoring Initiative) has received the support of the G-20. It is a coordination initiative aimed at providing key information on agricultural production using Earth Observations by supporting, strengthening and articulating existing national and international efforts and developing capacities and awareness at national, regional and global levels (e.g., to provide reliable qualitative and quantitative global crop production outlooks). GEOGLAM will provide better coordination and harmonization between existing global and regional monitoring systems. GEOGLAM is on target to provide enhanced agricultural monitoring based on EO, leading to better and more transparent information for markets and food security. This initiative will include the delivery of highly localized and timely weather intelligence as well as crop management tools to farmers. It will also expand the use of advanced agronomic decision aids based on accurate, timely and local information accessible to every farmer. This system will need to be supported by a sustainable and well-maintained network of weather stations that collects and stores very local and timely weather intelligence.

In many parts of the world, livelihood systems are based on subsistence agriculture and/or pastoralism, which have no resilience and hence are highly vulnerable to weather and other adverse conditions. These operations need to be supported by improved and more reliable conventional weather station networks. They should also be supplemented by satellite remote sensing and modelling, which can fill some of the data gaps in conventional networks, crop calendars, anomaly monitoring products, drought predictions and products for use by food aid agencies.

4. Addressing the Nexus through Bioeconomy Development

The concept of a “bioeconomy,” an economy in which the basic building blocks for industry and the raw materials for energy are derived from renewable resources, was highlighted as one breakthrough solution for the W-E-F security nexus. The idea of bioeconomies is taking hold globally. Both the European Union and the United States have bioeconomy strategies. In early 2012 the European Commission produced "Innovating for Sustainable Growth: A Bioeconomy for Europe"[5]. In April 2012 the United States "National Bioeconomy Blueprint"[6] was published. Different concepts of the bioeconomy are emerging around the world and, with research and development, could lead to the production of bioenergy and a variety of other high-value products such as cellulosic ethanol, bioplastics, biocomposites and pharmaceuticals (see Figure 1).

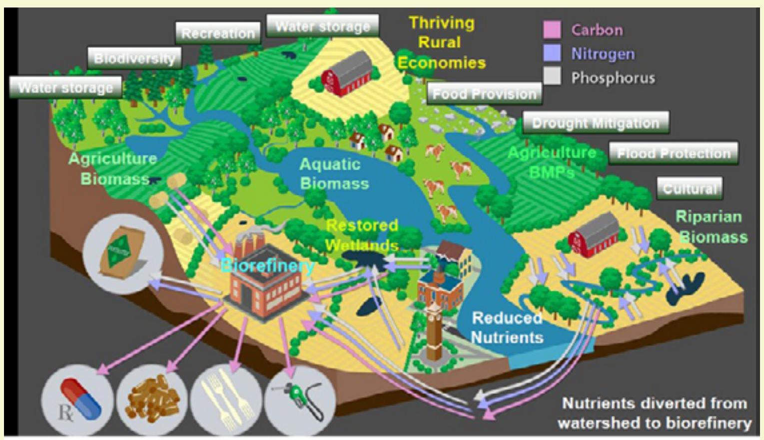


Figure 1: A conceptual illustration of a bioeconomy, © IISD

5 See: http://ec.europa.eu/research/bioeconomy/pdf/201202_commision_staff_working.pdf and: http://ec.europa.eu/research/bioeconomy/pdf/201202_innovating_sustainable_growth_en.pdf

6 See: http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf

The bioeconomy approach can create an economy that better balances environmental and social needs. This integrated systems thinking can be scaled up to a local, regional or basin scale and result in solutions with increased resilience and greater sustainability.

A multistakeholder initiative in the Lake Winnipeg Basin was featured that aims to use the bioeconomy to address both nutrient loading to Lake Winnipeg (the 10th largest freshwater lake in the world) and surface water management, namely floods and droughts. Other benefits include bioenergy production, carbon sequestration, the production of carbon credits, phosphorus recovery and habitat improvement (see Box 3).

5. Basin-Scale Implementation

Research undertaken by the GWSP has indicated that W-E-F security linkages issues will have important influences for river basin management responses to emerging global environmental change, risks and opportunities. The global trade of food and energy markets are linked and transmit embodied (“virtual”) water between remote basins, which otherwise might be linked only through teleconnections in the hydrological cycle.

GWSP is undertaking an assessment of 20 major river basins around the world, most of them transboundary, to analyze issues related to water, energy and food security.

Box 3

Lake Winnipeg Pilot Bioeconomy Initiative

IISD, in partnership with the University of Manitoba and Ducks Unlimited, has piloted the harvesting of the common wetland plant, cattail (Typha spp.) as an input into a bioeconomy. After harvesting, the cattail is condensed and burned for bioenergy, providing a low-carbon alternative to coal. The ash from the burned biomass contains phosphorus, which can be recovered and recycled for fertilizer (see Figure 2).

By capturing this phosphorus, rather than allowing it to run into the lake, the phosphorus loop is closed within the watershed, which contributes to increased food security. Phosphorus is a scarce resource on which food security depends, and most phosphorus used today in agriculture is from non-renewable mined rock phosphate. The production of carbon credits for sale on carbon markets are also a value chain in the bioeconomy. The habitat at the harvest site is also improved through the removal of the dense accumulation of dead plants, which opens the marsh to sunlight, spurring new plant growth. Bioeconomy projects such as the harvesting and processing of cattails for bioenergy production, carbon sequestration, eutrophication mitigation and phosphorus recovery can help diversify rural economic activity, while also providing increased energy security and access to phosphorus.

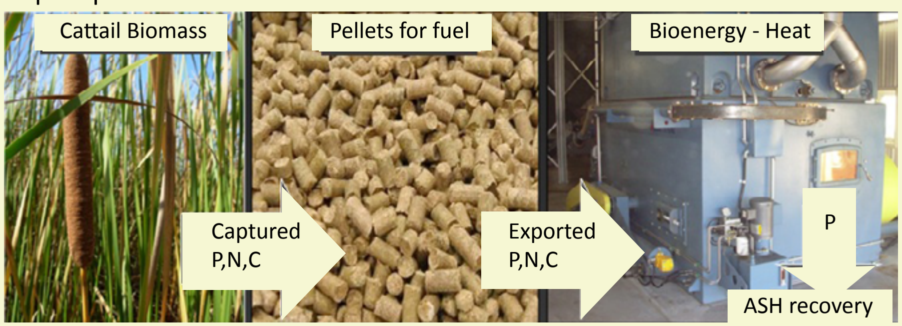


Figure 2: Harvesting cattails for bioenergy, nutrient and carbon capture, © IISD

The preliminary survey results available from 11 basins (see Box 4) illustrate the benefits of cross-border collaboration in balancing the needs of different nations for food, water and energy.

Box 4

List of GCI II Basins

- Aral Sea Basin
- Danube River
- Elbe River
- Huai River
- Incomati River
- Jordan River
- Lake Winnipeg
- Mekong River
- Murray Darling River
- Volta River
- Yellow River

Although the influences of water management on W-E-F security vary by basin, this study brings GWSP to the science-policy interface in nearly every river basin in the world. In particular, the study addresses questions relating W-E-F issues to the characteristics of the basins, the way in which the basins are managed, the interactions between basins and the opportunities for improving governance and management.

Based on the results presented and the discussions that followed at the conference the preliminary conclusions outlined in Section 6 were drawn from the survey results.

6. Issues arising from the Workshop

6.1 The Challenge of Integration

River basins are a natural geographical and hydrological unit of our freshwater resources and are the spatial unit best suited for water management based on the principles of IWRM. River basins also provide a logical and beneficial framework for managing water data and for sharing the benefits among nations within the same basin.

However, surveys done by the Global Catchment Initiative and discussions at the workshop clearly showed that the implementation of IWRM at a basin scale is in its initial stages in many river basins, especially in developing countries. The intersectoral integration needed for a nexus approach is lacking at the national level, and even more so at the basin scale. At best, these issues are implicitly being addressed through water allocations for agriculture and energy production.

However, the water needs of different sectors such as agriculture, energy and industry are typically treated separately, leading to fragmented policies and often conflicting priorities among and within riparian nations. The institutional and political weakness of many river basin organizations (often arising from competing national interests) further complicates basin-wide implementation of water management. In most cases, the trade-offs resulting from such fragmented management approaches have adverse impacts on both the aquatic and terrestrial ecosystems that provide the services needed for water, food and energy security in the basin.

From a nexus perspective, the insight that the "water crisis" is foremost a political crisis becomes even more obvious and more pressing.

6.2 The Political and Water Security Interface

One of the clearest messages from the case studies was the connection between political security and water security. Political instability often has a major and long-lasting influence on basin development, as in the case of the Okavango Basin where military land mines have delayed the economic and social development of parts of the basin years after civil war has ended.

In many of the basins discussed, the extent of political integration between riparian nations is directly affecting the approach to water management and the related issues of energy and food security as well as aquatic ecosystems, either in a positive (as in the case of the European Union`s Water Framework Directive) or negative way (as in the case of the Aral Sea Basin or the Jordan River). Thus, in most of the basins, political and economic development have greater immediate impact on a basin`s ability to support water, energy and food security than environmental changes that likely have a longer-term impact. Those oftentimes rapid political, economic and social changes have in many cases also significantly changed the role rivers play within societies.

6.3 The Changing Roles of Rivers

As technology develops, economic forcings evolve and river conditions change. The use of rivers also changes; for example, the role of rivers in transportation has been changing over the past few decades. Some rivers have decreased flows due to increased withdrawals for agricultural and industrial purposes and can no longer sustain the levels needed for transportation. For example, the Yellow and Huai Rivers can no longer be used for transportation, while many European basins continue to play that role, navigability being one of the priorities for river management and a major driver for transboundary cooperation such as in the cases of Danube and Elbe.

6.4 Monitoring Change in the Basins

Climate change effects are being observed around the globe. Although the patterns of changes in precipitation and runoff are characterized by significant levels of uncertainty, it is anticipated that these effects will be magnified in river basins due to the multiple impacts that climate change will have on agriculture, energy demand and food production. Some of the basins have trends that appear to follow projected environmental change, while others are tracking differently. There is a need to benchmark basins to assess which are following the global trends and which are not, and to assess whether these differences can be used as indicators of the magnitude of tghe direct impacts of humans on the environment. Science and technology play a significant role in the management of some basins. In particular, Earth Observations are providing information for effective integrated management in some developed countries.

6.5 Implications of Energy and Food Production and Consumption

There is a strong W-E-F connection in many basins that tends to favour energy production in the upstream portions of the basin and agriculture in the downstream portions often leading to an imbalance in water availability and withdrawal as the case study of the Aral Sea basin showed. In addition, the downstream portion of the basin

© Richard Lawford

often has a delta supporting biodiversity and water storage for urban areas leading to the need for multi-objective planning. The diversity in the mix of energy sources is often greater in the downstream part of a basin so that the pollution production, with its impact on water quality, is often greater in the downstream portion of the basin. As comparisons between basins in developing and developed countries suggested, the impacts of energy production on water quality may also be complicated by ownership, development policies and environmental regulations.

6.6 Data Issues

The lack of data in many areas can lead to a "laissez-faire" approach to water management, particularly as it relates to groundwater and water quality. Groundwater is an issue in a number of the basins. Data on groundwater availability, quality and use are often minimal to non-existent. As a result, groundwater reserves are being depleted in a non-sustainable way without planning, regulation or monitoring. The situation is as bad or worse for water quality in many basins because the ambient levels of pollutants are difficult to measure on a regular basin and the range of pollutants multiply as the technologies for extracting energy expand. As a result, the primary sources of the pollution associated with energy production vary widely, while agricultural pollution tends to arise from fertilizer and pesticide use, and its consequences are more predictable. In developed countries, models are being applied to supplement field measurements and enable scientists to address many of these impacts. However, in developing countries the data for developing such models is missing, thereby allowing the exploitation of energy resources in non-sustainable ways to outstrip the development of regulations and controls. Satellite-based Earth Observations can provide some assistance in these areas, but appropriate investments are needed, and the roles of monitoring and sharing data need to be expanded to support a more integrated approach to the management of river basins.

6.7 Technical and Political Cooperation as a Way to Integrated Water Management

While a basin-wide framework for river management is absent in many cases due to lack of political will and integration, institutions addressing water problems on a technical level can provide knowledge and scientific data-sharing, which can lead to politically integrated approaches. In this way, scientific and technological cooperation on the basin scale can foster broader types of agreements, eventually resulting in more collaborative approaches to river management on the political level (for example, in the Jordan River Basin).

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6.8 IWRM in River Basins and the Difficulties of Scale

Although IWRM is widely accepted as a useful concept to achieve water security, the case studies confirmed earlier findings[7] showing that implementation is often hindered by inadequate financial, technical and human resources or incompatibility of concepts with existing legal, institutional and social structures within the basins.

In regions where such constraints are particularly significant, such as the Amudarya and Volta River Basins, the basin scale may be too large to effectively manage water resources with respect to the W-E-F nexus. Aiming for coherent national strategies and better communication between stakeholders can then be an entry point to gradual governance reforms, actually gaining quicker acceptance and leading to better progress than more ambitious plans. Therefore, the building of both national and transnational partnerships between and across different water users, political and private stakeholders, and sectors is crucial to address the complex issues resulting from the W-E-F security nexus.

[7] Examples of Twin2Go case studies can be found at: www.twin2go.uos.de

Recommendations

1. Water is affected by a wide range of stressors ranging from local and regional factors, such as economic development and human settlement pressure, to global factors such as climate change. Given the success of the Millennium Development Goals (MDG) in achieving improved access to drinking water, it is recommended that a similar process of setting targets and monitoring progress towards those targets be established for other critical water indicators. The targets should address water supply, water quality and water use in a balanced way. They should be developed in collaboration with an effective and well-funded monitoring plan that would follow international observational standards, adopt uniform monitoring procedures and implement interoperable analysis platforms to ensure systematic advice is supplied to governments in a sustainable way.

2. New partnerships are essential to enable the implementation of the goals identified for the water-energy-food nexus. The benefits of partnerships between the water and agricultural sectors have long been recognized because agriculture is the largest user of water. Partnerships need to be expanded to other sectors. Just as water management problems are multi-scale, the solutions are also multi-scale, which means that partnerships are needed among the public and private sectors and between national and municipal governments. Multi-scale polycentric governance is needed to address water security issues.

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3. The green economy is a broad term that describes a new paradigm for the world economy. An important vehicle for realizing this concept on a local or national level is the bioeconomy framework—a concept for using biological products as the basis for supplying many goods and services in a region. Large-scale environmental processes can be very effective in producing these products or feedstocks for bio-industries in large quantities. For example, demonstration projects in the Lake Winnipeg Basin show the value of these products for meeting energy needs. The management of water on the landscape is a central core activity for managing the benefits of this activity for local economies and for realizing basin-wide environmental objectives. The effective inclusion of water in evaluations of goods and services, full and transparent analysis and use of Earth Observations in the context of IWRM and innovative governance mechanisms will be central to success of the green economy.

Appendix: Conference Participants

Marc Andreini*	University of Nebraska
Nicole Armstrong	Province of Manitoba, Conservation & Water
Guy Ash	Canadian Wheat Board
Pascal Badiou*	Ducks Unlimited Canada
James Battershill	Keystone Agricultural Producers
Armand Belanger	East Interlake Conservation District
Janos Bogardi*	Global Water System Project
David Brooks*	IISD Associate
Greg Bruce	Ducks Unlimited Canada
Jim Bruce*	Consultant
Paul Bullock*	University of Manitoba
Bruce Burnett*	Canadian Wheat Board
Catherine Champagne*	Agriculture & Agri-Food Canada
Xi Chen	IISD
William Cosgrove*	Consultant
Donna Dagg	Manitoba Lotteries
Bradley Doorn*	NASA
Leanne Dunne	University of Manitoba, volunteer
Kate Dykman	University of Manitoba, volunteer
Rosemary Dzus	MB Environmental Industries Association
Martin Entz	University of Manitoba
Balazs Fekete*	The City College of New York
Shane Gabor	Ducks Unlimited Canada
Ray Garnett*	Consultant
Bill Glanville	IISD
David Grimes*	Environment Canada
Richard Grosshans	IISD
Sharon Gurney	Manitoba Conservation & Water
Jamie Hewitt	Agriculture & Agri-Food Canada
Harvey Hill	Agriculture & Agri-Food Canada
Ute Holweger	Agriculture & Agri-Food Canada
Ted Horbulyk*	University of Calgary
Al Howard*	Agriculture and Agri-Food Canada
Dale Hutchison	Manitoba Hydro
Ian Jarvis*	Agriculture & Agri-Food Canada
Singjiro Kanae*	Tokyo Institute of Technology

Abdul Kashem	Water Stewardship
Erin Keating	Lake Winnipeg Foundation
Bartley Kives	Winnipeg Free Press
Bob Krull	Dutch Council
Curtis Krull	Guest
Josef Kuhn	Consulting Ecologist
Rick Lawford*	GWSP, Morgan State Univ., IISD Associate
Mel Lazareck*	Special Rep. for Manitoba/Israel Project
David Lobb*	University of Manitoba
Gord Mackintosh	Government of Manitoba
Doron Markel*	University of Calgary
Sina Marx*	Global Water System Project
Greg McCullough*	University of Manitoba
Rhonda McDougal*	Manitoba Water Stewardship
Tim McIsaac	Province of Manitoba
Jamshed Merchant*	AAFC (via Skype)
Dianna Meseyton-Neufeld	RHA Central Inc.
Magdalena AK Muir*	University of Calgary via Skype
Hans-Peter Nachtnebel*	Institute for Water Management (Vienna)
April North	Manitoba Agriculture, Food and Rural Initiatives
Bryan Oborne	IISD Associate, Alberta
Koert Oosterhuis	Agriculture Crop Production
Claudia Pahl-Wostl*	University of Osnabrück
Nona Pelletier	IISD
Selena Randall	University of Manitoba
Marla Riekman	Agriculture, Food and Rural Initiatives
Dimple Roy*	IISD
Jay Sagin	Red River Basin Commission
Ramon Sales	Manitoba Conservation and Water Stewardship
Alex Salki	Lake Winnipeg Foundation
Esther Salvano	Agriculture, Food & Rural Initiatives
Gabriel Senay*	USGS (South Dakota)
Bruce Shewfelt*	Agriculture & Agri-Food Canada
Slobodan Simonovic*	University of Western Ontario
Colleen Sklar	Lake Friendly
Darren Swanson*	IISD
Shelly Swidinsky	IISD
Kyle Swystun	IISD
Tony Szumigalski	Agriculture, Food and Rural Initiatives
Stuart Taylor*	iDE
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Efrem Teklemariam*	Manitoba Hydro
Anika Terton	Manitoba Eco-Network
Sara Thrift	Red River Basin Commission
Hank Venema*	IISD
Morgan Vespa	University of Manitoba, volunteer
Vivek Voora*	IISD
Heidi Walker	University of Manitoba, volunteer
Alf Warkentin*	Consultant
Howard Wheater*	Univ. of Sask. Institute for Water Security
Grant Wiseman	Agriculture & Agri-Food Canada
Lance Yohe*	Red River Basin Commission
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