E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

UNIVERSITY OF OXFORD

Water Security, Risk and Society

Findings, Gaps and Opportunities for Social and Economic Research

June 2012

"We need a coalition of the willing and the capable, beginning to move an agenda that includes interdisciplinary science, business, civil society and government"

Professor David Grey
University of Oxford

"Decisions under uncertainty are politically evaluated by their consequences, not by their wisdom"

Professor Jerson Kelman
CEO of Light S.A.
Federal University of Rio de Janeiro

"Transformation towards adaptive governance and enhanced water security requires polycentric governance, knowledge management and innovative ways for dealing with uncertainty"

Professor Claudia Pahl-Wostl
University of Osnabrück

This report is one in a series of outputs from the Water Security, Risk and Society conference which was held at Oxford University on 16-18 April 2012. For further information and materials, visit http://www.water.ox.ac.uk/events/water-security-risk-and-society/.

Acknowledgements

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Contents

1. Summary

Oxford University hosted the first International Conference on Water Security, Risk and Society on 16-18 April, which brought together over 200 of the world's leading thinkers and practitioners from science, policy and enterprise communities. The aims of the conference were to i) assess the emerging evidence base about the status of and pathways to water security, and ii) debate a risk-based framework as an approach to understand and achieve water security across scales and contexts.

This report identifies social and economic research challenges based on conference findings to inform UK Research Council thinking in relation to a global water security agenda. The emerging research priorities and science questions have clear linkages to the Economic and Social Research Council strategic priorities: Economic Performance and Sustainable Growth; Influencing Behaviour and Informing Interventions; A Vibrant and Fair Society. The UK Water Research and Innovation Framework provides further impetus and context to this agenda, emphasising linkages across science, policy and enterprise.

Water security as a 21st century challenge for science and society

Water security is a defining global challenge in the 21st century. The enduring struggle to cope with water access and shocks is now magnified by global change to societies, economies and climate at multiple scales. Living in poverty has long been synonymous with the precarious struggle for water security. Absent or unreliable water and sanitation services, unpredictable floods and droughts, and degraded ecosystems threaten the lives and livelihoods of a third of the world's population. Rapid change – in populations, economies, geopolitics and climate – will make achieving water security by countries that are currently water insecure much more difficult, and could threaten the water security of long-secure nations. Escalating water competition, deteriorating water ecosystems, intensified flood and drought shocks, and related social tensions are all predicted. Current and future costs, in terms of human suffering, sustained poverty, constrained growth, migration, and social unrest are unacceptably high and largely avoidable.

Eighty percent of the global population face a high level risk to water security[1]. Many low-income countries face greater risks but have the least ability to mitigate such risk through appropriate and sequenced investments in infrastructure and institutions. The poorest live in the most vulnerable areas, such as urban slums, rural hinterlands and floodplains, yet have the least capacity to invest in resilient and flexible measures to mitigate risk. Private investors are risk averse, crowding in investment where water security is already largely achieved. Recent global assessments of climate extremes, infrastructure and economic growth illustrate that water security risks are not being effectively addressed by current responses from science, government or enterprise[2].

1 Vörösmarty, C.J. et al. (2010), Global threats to human water security and river biodiversity, Nature, 467(7315): 555-561.

2 See: Banerjee, S.G., and Morella, E. (2011), "Africa's Water and Sanitation Infrastructure: Access, Affordability and Alternatives", World Bank, Washington, DC.; IPCC (Intergovernmental Panel on Climate Change) (2012), "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation", A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, NY, USA.; WEF (2012) Global Risks 2012. Seventh Edition, World Economic Forum, Geneva.

2. Water security risk and society

2.1. Social dimensions of water security risk: data gaps, uncertainty and vulnerability

Risk offers a unifying framework to link across multiple water security challenges. Global initiatives at the OECD, the World Economic Forum Global Risks Report and the UN World Water Assessment have converged on risk as a crosscutting theme. Debate about a risk-based framework identified opportunities and limits to applying risk analysis in response to water insecurity.

"Water security is tolerable water-related risk to society"

Professor David Grey
University of Oxford

Risk-based principles for defining and managing water security motivate interdisciplinary research to investigate: (i) the framing of decisions in risk-based terms; (ii) non-stationarity and uncertainty; (iii) tradeoffs and valuation of risks across multiple and often competing objectives; (iv) working across scales to address social, environmental and economic externalities.

Decision-makers across science, policy and enterprise emphasised these points about low probability, high impact events:

i. Decisions made under uncertainty are evaluated by their consequences, not their wisdom, and people expect protection against extreme drought scenarios.

ii. Low probability, high impact events are particularly challenging because expected costs trend to zero due to low probability, yet consequences are very large in practice. Political ideology and hydrology will clash under a pure risk-based approach.

Opportunities stem from insights from social theory of a risk society where modern society has manufactured risks, such as water pollution, closed river basins and groundwater over-abstraction, beyond or amplifying natural risks of floods or droughts. This leads to a self-reflexive examination by society of the nature and process of modernity – a process that is in constant flux and contestation. Natural risks from extreme hydrological events offer significant opportunities for change through policy windows (Hall, Kelman, Blackmore, Muller). Limits stem from the poor or contested understanding of the socioeconomic aspects and politics of risk, as well as the high levels of residual uncertainty associated with rapid global change.

Decision-making under uncertainty drives attention to multiple, interacting risks, particularly linked to the social and economic dimensions of extreme events, which have a low probability and high impact. A focus on risk requires attention to its corollary: vulnerability. Vulnerability depends on the ability of affected actors to "anticipate, cope with, resist, recover from" water security risks[3]. Vulnerability, like exposure, is linked to biophysical, social and policy conditions; the poorest parts of society are often the most vulnerable to water security risks, a theme echoed by experiences in Kenya's water service delivery (Gakubia), Africa's 'four-fold' vulnerability (Falkenmark) to famine, drought risk and natural blue and green water deficits (see also Muller). Data coverage and measurement technology is often weakest in areas exposed to high levels of variability and

3 IPCC (Intergovernmental Panel on Climate Change) (2012), "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation", A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, NY, USA.

uncertainty, yet mobile and remote technologies present novel opportunities (Hope, Mikkelsen, Annerose). Data is necessary but insufficient for mitigating water security risks, and also can incur significant costs. In sum, the social dimensions of water insecurity highlight the impacts of data gaps, uncertainty (particularly low probability, high impact events), perceptions and behavioural responses to risk and vulnerability.

2.2. Building a coalition of science, policy and enterprise: evidence-based decision-making

Water security risks have a growing profile in society, governments and business. Society faces risks of inadequate water and sanitation, vulnerability to extreme events, and political unrest over inequitable access and use of water across borders and sectors. Governments and civil society have identified water security risks to development and livelihoods; water insecurity has therefore become an important constraint on private investment and innovation in water supply and sanitation (O'Brien). Water security risks have cascading impacts across private investment and supply chains in a globalised economy; the business sector has responded by implementing system-scale programmes to identify and manage multiple, interacting risks (Bell, Koch, O'Hagan). The private sector prioritises and demands certainty over the long term, which requires early investments in the data and institutional framework to manage risks (Bell). Demand for evidence-based decision-making has grown, requiring science leadership and investment to advance understanding of the social and behavioural dimensions of water security risk in a context of global change.

Priorities for economic and social science research:

1. **Social construction of water-related risks** and vulnerability, understanding the gap between rich and poor societies.
2. **Behavioural responses to water-related risks,** including factors influencing behavioural change.
3. **Decision-making under and communication of uncertainty.**
4. **Politics and economics of extreme events and everyday risks** for the vulnerable and socially-excluded.
5. **Roles and contestations of knowledge** providers and users in risk analysis.
6. **Policy frameworks to mitigate medium- and high-probability events** through improved knowledge systems, cooperation and leadership.

3. Informing tradeoffs to manage water security risks

3.1. Understanding resource interdependencies and complexity across agricultural, energy and water systems

Water insecurity affects people, livelihoods, agriculture, energy and cities from the local to the global levels. Challenges and driving forces include population growth, urbanisation, food security and climate change, which have important interactions and consequences for the most water insecure (Obeng). Concepts of peak water and peak energy refer to approaching limits (and tradeoffs) to water and energy use (Gleick); there is increasing potential for energy scarcity to act as a fundamental barrier on economic performance (Reinhardt, Ibanez). There is a limited, but growing, understanding of interactions between water and energy risks. There is significant opportunity to enhance water security by improving understanding of the resource intensity of different water and energy technologies (Froggatt). Food security and agriculture are fundamentally linked to water security; agriculture uses 70 times as much water as households and faces several key water-related risks tied to green (too little and variable rain) and blue water (competition) at both the regional (carrying capacity) and global (planetary boundaries) levels (Falkenmark). Inadequate water and sanitation cost up to 7% of GDP; benefits of well-designed interventions outweigh costs up to 34 times. Improvements in water and sanitation provision requires a combination of incremental and transformational change at multiple scales (Bartram). In transboundary rivers, divergent perceptions about water resources can fuel conflict and knowledge controversies (Leb) as exemplified by Palestinian-Israeli interim agreement on managing shared waters (Fischhendler). In these contexts, physical, social and technical influences on water negotiations are subject to inherent uncertainties, interpretations and incomplete knowledge.

3.2. Adaptive capacity and global change: informing tradeoffs through coupled systems modelling

The dynamics of global change and resource interdependencies require adaptive capacity and tradeoffs (Hall, Ibanez). Systems modelling has advanced understanding of natural and social dynamics of global change, including potential to identify dominant drivers (physical, social, economic and demographic) of vulnerability at multiple spatial and temporal scales (Brown). Systems models decompose complexity to identify the key interactions, trajectories and vulnerabilities across social and ecological dimensions of global change (Garrick[a]). Global change requires adaptation strategies that limit regrets and counterproductive approaches (Pittock, Garrick[a]).

Coupled models therefore inform decision-making and can be used to evaluate management options that build adaptive capacity. For example, scenario development and visualization techniques are increasingly used to downscale processes to local impacts to inform mitigation and adaptation investments (Conway). Such techniques are also useful for characterising the feedback effects of water and land management decisions on global change (Dadson). Uncertainty raises challenges for science to inform decision-making, as evidenced by the use of hydrologic projections based on historic observations (Wagener). Simulation and optimisation-based hydroeconomic models are one example of modelling to inform policy design, infrastructure investment and technology change by linking hydrologic processes and economic impacts in a context of uncertainty. Hydroeconomic

modelling tools have been useful for strategic basin assessments to guide development (Grey) and have also examined the impacts and interactions of water scarcity under scenarios of local and regional water trading (Harou). Modelling and scenario development is not strictly about risk, but rather the deep uncertainties in the status and driving forces of human and physical systems. These dynamics require careful attention to the communication of uncertainty to decision-makers (Gober).

Priorities for economic and social science research:

1. **Informing tradeoffs about resource interdependencies.** Role of incentives and information to promote water and energy efficiency; inform tradeoffs through transparent and accessible data in each sector; and examine the impact of energy and water scarcity on economic growth and security.
2. **Adaptive capacity to manage climate risks and global change** in fragmented political systems (e.g. federations and multi-level governance arrangements like the EU Water Framework Directive).
3. **Managing and decision-making in a context of 'deep uncertainty'** when parties cannot agree on forces driving change, probability distribution of key variables and value of outcomes.
4. **Resilient and robust institutional and infrastructure pathways** to water security that limit maladaptive outcomes.
5. **Integrated modelling to dispel myths about river basins and food-climate-energy linkages,** particularly dissemination and co-production of scientific knowledge.

4. Linking risk and response to enhance economic performance and achieve a fairer society

4.1. Risk and response to water insecurity: the role of behavioural change, institutions and technology

The conference sessions identified the need to connect water security risks and their driving forces with responses at multiple levels from individual behaviour to investment in institutional and technology platforms for water security. Influencing behaviour to inform transformative interventions for water security was illustrated through institutional innovation and mobile technologies in Africa and Asia. The transformation of Uganda's National Water and Sewerage Company (Muhairwe) and the 24/7 model in India (Jalakam) revealed that good institutional performance depends on realigning incentives and investments to overcome political economy hurdles from powerful and sometimes ill-informed interest groups. The expanding mobile network architecture in Africa provides a framework to address the system information deficit that limits accountability and increases investment and management risks in rural water supply (Hope, Annerose, Mikkelsen). Decision-making is improved for all actors in 'open societies' where risks are revealed and reduced, and accountability is increased.

"Donor support is only one part of the story; it is vital that the private sector steps up to seize the opportunity presented by investment in water"

Stephen O'Brien

Parliamentary Under-Secretary of State for International Development, UK

Stressed river basins in semi-arid regions provide another example of the need to link risk and response through behavioural change, institutional reform and technological innovation (Cox). Economic innovations may enhance water security through water rights trading by capping extractions, defining water rights and supporting trading in response to shifting preferences and supply-demand conditions. The Australian experiences in the Murray-Darling basin illustrate the role of water reform to incentivise behavioural change and enable social and economic gains from water trade (Bjornlund). Although institutional development does not follow strict blueprints (Pahl-Wostl), broad principles have emerged about the need for property rights reforms and supporting infrastructure (Young). However, institutions are not free; transaction costs include the resources required to define, change and manage property rights. Water security and transitions to more adaptive and sustainable water allocation systems may impose significant short-term transaction costs that can lead to long-term payoff, as illustrated in the Columbia Basin of western North America (Garrick[b]).

Context matters and will shape the design and sequencing of institutional and technological investments to match local and regional factors. In the UK context, rising demand and diminishing resource variability have spurred reforms to water abstraction licencing and planning under uncertainty; hydroeconomic modelling tools support decision-makers through supply-demand portfolio investment optimisation and the simulation of water rights markets across alternative trading scenarios (Harou). Research progress must link the natural and social dimensions of water security risks and responses to support the design, testing and evaluation of alternative policy options, incentives, information and technological innovations and economic instruments.

4.2. Governance and technology to enhance cooperation and economic performance

Strategic investments in a platform of information, institutions and infrastructure can unlock positive feedbacks between water security and economic performance. Don Blackmore identified the role of river system models to support water reform by providing the hydrological and technical evidence base to inform complex tradeoffs at the basin scale. The link between water security and economic growth becomes fundamental in a context of climate variability and change. For example, analysis of hydroclimatic risk by Casey Brown identified variability as the most relevant climate risk to economic growth. Robert Gakubia warned that poor governance and regulatory risk contribute to a chain of insecurities in water services provision. The role of economic instruments is to identify the incentives that influence behavioural change in order to manage water demand and recover costs of water services (Cox). Water security requires multi-level governance arrangements with adaptive capacity and social learning to foster incremental and transformational change. A systematic comparison of water governance systems failed to identify panaceas or detailed blueprints to strengthen adaptive capacity; however, broad principles and patterns identify the role of polycentric governance (Pahl-Wostl).

Priorities for economic and social science research:

1. **Effective institutional design, governance capacity building and sequencing,** including strategies to reduce transaction costs and address social equity issues. Context-sensitive comparative research can move beyond the notion that there are no panaceas.
2. **Understanding corporate water risks and responses (i.e. opportunities).** Water risks to business have increased reliance on metrics to measure and manage corporate water risk. Science priorities include questions about the validity and robustness of metrics, including investment strategies and outcomes for the private sector.
3. **Strengthening positive feedbacks between water security and economic development** through behavioural change, institutional reform, and technological innovation, e.g. water services and sustainable cost recovery.
4. **Opportunities to channel (or transform) securitisation tendencies towards cooperation in management of international waters.**

5. Priority actions: strengthening UK leadership on the global water security agenda

- Establish a UK-based water security programme for global scientific excellence
    - UK Water Resource and Innovation Framework and Partnership (UK WRIP): Informing cross-research council investments and strengthening the interface between researchers, government and the private sector
    - UK Collaborative on Development Sciences: Linking the development agenda with improved understanding of perceptions of risk, behavioural and institutional response
- Leverage existing UK science investments across social and natural sciences to establish strategic water secure river basin observatories in the UK (Thames) and internationally
    - Belmont Forum: Linking the Economic and Social Research Council and the Natural Environment Research Council through advances in dynamic coupled systems modelling

5.1. UK Water Resource and Innovation Framework and Partnership (UK WRIP)

UK Chief Scientific Adviser Sir John Beddington highlighted the risks of water insecurity due to climate change, population increase and urbanisation. Innovations in technology and science-business-society partnerships offer pathways to address these threats. The UK WRIP process exemplifies these pathways and is built on strategic engagement with multiple stakeholders to develop common goals within a shared framework and international context. The risk framework advanced at the Water Security, Risk and Society conference contributes to this effort and builds on the recent December 2011 UK WRIP strategy on Taking Responsibility for Water[4].

4 UK WRIP (2011). Taking Responsibility for Water: United Kingdom Water Research and Innovation Framework 2011-2030. Available at: http://www.bis.gov.uk/assets/goscience/docs/t/11-1390-taking-responsibility-for-water

"We need to advance the UK science and engineering capacity and we need to think about this in an international context; if we are going to address these fundamental problems of the 21st century, we are going to need enormous amounts of science and engineering innovation. We are going to need companies and governments to invest money very substantially"

Professor Sir John Beddington
UK Government Chief Scientific Adviser

5.2. ESRC-DFID

Water security is a fundamental condition to promote economic performance and sustainable growth. New and transformative information media in open societies and open economies have significant potential to influence individual and institutional behaviour to inform more effective and fairer interventions. Risk offers a unifying framework to understand and address new and emerging water security challenges. The contested dialectic between 'manufactured water risks' and 'natural water risks' is a fertile and critical ground to engage in water security challenges in the UK and globally.

5.3. Belmont Forum

The Belmont Forum is an international consortium of research councils formed to convene multi-country research partnerships to deliver integrated science responses to society's pressing challenges of global change. The Belmont International Opportunities Fund has identified freshwater security among its initial priorities. Risk-based concepts and analytical frameworks have significant potential to bridge across multiple contexts and regions internationally, providing an opportunity for integrated assessment. The conference confirmed that the water security risks of resource interdependencies and differential vulnerability to water insecurity require adaptive capacity and tradeoffs across multiple objectives at multiple levels from the household and farm to the river basin and global arena. Systems modelling has advanced understanding of physical and social dimensions of global change at multiple, nested scales, including the river basin level. This opportunity allows UK and international science teams to harness advances in dynamic coupled systems modelling to understand the interactions, impacts and effective adaptation strategies across physical, biological and socioeconomic processes of global change.

6. Appendix – Alphabetical list of conference speakers

All presentations are available online at:
http://www.water.ox.ac.uk/events/water-security-risk-and-society/programme/

Akanda, Ali Shafqat. Regional water security and public health implication in the Bengal Delta. In Water security, human development and governance.

Annerose, Daniel. Rural water supply management and monitoring innovations from West Africa. In Mobile technology innovations and rural water security.

Bartram, Jamie. State of water and sanitation: how secure is water for people? In Water security and the global development challenge.

Beddington, John. Catalysing sustainable water security – role of science, innovation and partnerships.

Bell, Robert. Addressing water security risks: can we leapfrog carbon? In A risk perspective on water security.

Bjornlund, Henning. Water security and the irrigation sector. In Economic innovations to manage risk through water trading.

Blackmore, Don. River basin management pathways to water security. In Pathways to enhance water security.

Bradley, David. Water and sanitation planning: concepts, institutions and action. In In WASH: goals, targets and metrics for the next 25 years.

Brown, Casey. Water security and economic growth – an imperative for climate change adaptation. In Pathways to enhance water security.

Calow, Roger. A global water crisis? Conceptual and practical insights from an analysis of water security. In Water security in Africa.

Closas, Alvar. Solar water – ecosystem implications of the food/water/energy nexus in La Mancha, Spain. In Water and energy security.

Conway, Declan. Securing water in a changing climate. In Impacts of global change on water security.

Cook, Christina. Approaching water security from a risk perspective. In Informing decision-making.

Cotton, Andrew. Joint Monitoring Programme Sanitation Working Group. In WASH: goals, targets and metrics for the next 25 years.

Counsell, Chris & Nicholson, Kit. Water security, climate change and agriculture: a simple framework for rapid assessments. In Informing decision-making.

Cox, Anthony. Economic innovations to manage water security risks and tradeoffs. In Pathways to enhance water security.

Cubillo, Francisco. Coping with risk-managing distribution networks. In Urban water services delivery.

Dadson, Simon. Changing land-atmosphere feedbacks in tropical African Wetlands. In Impacts of global change on water security.

Day, St John and Casey, Vincent. Managing water locally: the role of community based institutions in the management of water resources. In Water security in Africa.

De Stefano, Lucia. Measuring transparency in the water sector: the Spanish case. In Water security, human development and governance.

Falkenmark, Malin. Growing water scarcity in agriculture – future challenge to global water security. In Global change and the evidence base for strategic policy and business decisions.

Farrington, Robin. Lessons from public-private-civil society partnerships to address shared water risk. In Corporate water security risk: harnessing science-enterprise partnerships.

Feitelson, Eran. The water security implications of water securitization: an Israeli-Palestinian perspective. In Water: a fault line of international conflict in the 21st century?

Fischhendler, Itay. The impact of uncertainties on cooperation and conflict in transboundary water management. In Water: a fault line of international conflict in the 21st century?

Franks, Tom. Water governance and security in the Usangu Plains, Tanzania. In Water security in Africa.

Froggatt, Antony. Resource implications of the move to non-conventionals in the energy and water sectors. In Water and energy security.

Fung, Fai. Designing robust water supply systems in the UK. In Informing decision-making.

Gakubia, Robert. Water services regulation and water security. In Pathways to enhance water security.

Garrick, Dustin. Water reform in a transaction costs world: concepts, metrics and lessons learned. In Economic innovations to manage risk through water trading.

Gleick, Peter. Peak water and peak energy: implications for security. In Water security as a 21st century challenge.

Gober, Patricia. Decision making under uncertainty: a new paradigm for water security. In Global change and the evidence base for strategic policy and business decisions.

Goulden, Marisa. Scenario based elicitation of expert perceptions of water security and climate change adaptation in the Nile Basin. In Water security in international affairs: transboundary waters.

Grant, David. SABMiller's perspective on corporate water risk. In Corporate water security risk: harnessing science-enterprise partnerships.

Grey, David. Framing the agenda: the global case for science, policy and enterprise. In Water security as a 21st century challenge.

Hall, Jim. Risk-based principles for defining and managing water security. In A risk perspective on water security.

Harou, Julien. What's the national economic value of water trading? In Economic innovations to manage risk through water trading.

Hepworth, Nick. Embracing failure: diagnosing the causes of water insecurity to improve the design of future interventions – results of multiple case study research in East Africa. In Water security in Africa.

Hirvi, Marja. Does privatisation increase water security in the global South? Evaluating the findings and methods of empirical literature. In Sustainable water infrastructure.

Hope, Rob. Smart handpumps and rural water security risk. In Mobile technology innovations and rural water security.

Howarth, Simon. Infrastructure and incentives for water security in North-west China. In Sustainable water infrastructure.

Ibanez, Carles. Water security, energy scarcity and sustainable development. In Water and energy security.

Islam, Shafiqul. Water diplomacy: a networked approach to understanding, measuring and managing water security. In Water security in international affairs: transboundary waters.

Jalakam, Anand. Continuous water supply – an essential component for achieving water security. In Urban water services delivery.

Kelman, Jerson. Small probability events that could cause water supply collapse – how to deal with them? In A risk perspective on water security.

King, Wendell. Water security – a matter of national defence. In Water security in international affairs: law and defence.

Koch, Greg. Risk and response: a business perspective on water security.

Lankford, Bruce. Water (un)control and water (in)security; theorising an infrastructural framework for water apportionment and access. In Sustainable water infrastructure.

Leb, Christina. A systemic legal response to water security: the responsibility to provide solutions beyond definitions! In Water security in international affairs: law and defence.

Lipponen, Annukka. Pan-European landscape of cooperation on transboundary waters: main issues and security implications. In Water security in international affairs: transboundary waters.

Magsig, Bjørn-Oliver & Moynihan, Ruby. The web of water security: Legal challenges in an interconnected world. In Water security in international affairs: law and defence.

McCulloch, Christine. Defining water security for heavy manufacturing industries in Teesside, North East England: from the perils of the 1959 drought to the burden of oversupply. In Water security, human development and governance.

Mikkelsen, Rasoul. LIFELINK - Reducing financial and operational risks to rural water security. In Mobile technology innovations and rural water security.

Money, Alex. Measuring what you manage: corporate water risk. In Corporate water security risk: harnessing science-enterprise partnerships.

Muhairwe, William. Sustainable urban water service delivery: focusing on efficiency and leadership. In Urban water services delivery.

Muller, Mike. Rocks, hard places and road blocks: challenges on the paths to water security in Africa. In Water security and the global development challenge.

Obeng, Letitia. The case of the water insecure: building a national, regional and global coalition. In Water security as a 21st century challenge.

O'Brien, Stephen. Water security and the global development challenge. In Water security and the global development challenge.

O'Hagan, Gerry. Diageo's approach to water – supporting business growth In Water security and the global development challenge.

Pahl-Wostl, Claudia. Enhancing water security for the benefit of humans and nature – a multi-level governance challenge. In Pathways to enhance water security.

Pittock, Jamie. Managing risk from climate variability and change: lessons from Australia's Murray-Darling Basin. In Global change and the evidence base for strategic policy and business decisions.

Rajeev, K.J. Mobile-enhanced handpump maintenance innovations in rural India. In Mobile technology innovations and rural water security.

Reinhardt, Walter. Three things for the water security community to know about the energy sector. In Water and energy security.

Roaf, Virginia. Joint Monitoring Programme Equity and Non-Discrimination Working Group. In WASH: goals, targets and metrics for the next 25 years.

Roberts, Carolyn. Flooding and professional dialogue: scientists and local decision-makers exchange ideas.

Rouse, Michael. Elements of sustainable urban water services. In Urban water services delivery.

Slaymaker, Tom. Joint Monitoring Programme Water Working Group. In WASH: goals, targets and metrics for the next 25 years.

Stahl, Dale. Building dams, building states: water, development and politics in the Tigris-Euphrates Basin. In Water security in international affairs: transboundary waters.

Tickner, Dave. Beyond metrics: can water footprinting improve water security? In Corporate water security risk: harnessing science-enterprise partnerships.

Wadsley, Johanna. Sustainable cost recovery: re-shaping the moral economy of 'Financing Water for All'. In Sustainable water infrastructure.

Wagener, Thorsten. How credible are hydrological projections in a changing world? In Impacts of global change on water security.

Wheater, Howard. Water security in the Canadian prairies: science and management challenges. In Informing decision-making.

Whitehead, Paul. Water scarcity, water quality and aquatic ecology: impacts of climate and land use change on the River Thames system. In Impacts of global change on water security.

Wirsing, Robert. Dust-up over the Brahmaputra: India, China and the impending encounter of river diversion mega-schemes. In Water: a fault line of international conflict in the 21st century?

Young, Mike. Designing water entitlement systems for an ever changing and ever varying future. In Economic innovations to manage risk through water trading.

Zawahri, Neda; Sowers, Jeannie; & Weinthal, Erika. Assessing household water security in the Middle East and North Africa. In Water security, human development and governance.

Zetland, David. The political economy of land and water grabs. In Water: a fault line of international conflict in the 21st century?