

# T16P04 / Responding to Water Scarcity and Quality in the Nexus: Effects on the Water, Energy and Food Sectors

**Topic :** T16 / Sustainable Development and Policy

**Chair :** Cecilia Tortajada (Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore)

**Second Chair :** Quentin Grafton (The Australian National University & National University of Singapore)

**Third Chair :** Jamie Pittock (The Australian National University)

## GENERAL OBJECTIVES, RESEARCH QUESTIONS AND SCIENTIFIC RELEVANCE

**PANEL PROPOSAL – Responding to water scarcity and quality in the nexus: Effects on the water, energy and food sectors**

Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore

The Australian National University, UNESCO Chair in Water Economics and Transboundary Water Governance

In an increasingly globalized and interconnected world, societies are becoming less resilient with respect to shocks to water, food and energy resources. Long term developments such as population growth, urbanization and industrialization in emerging markets, as well as the impending threat of climate change, are increasing the impacts on these critically important resources. Private, public and civic institutions must respond to these challenges.

The complexities of water, food and energy sectors must understood in relation to each other as well as within their own social, economic, natural, political and cultural environments, and not in isolation. Water is a critical resource for global sustainability and has a fundamental role in every sector. The effective governance of water can offer very large benefits to people and ecosystems, but typically water is not used or allocated to reflect its scarcity value. Water is also essential for crop production, be this for food, feed, fibre or fuels.

Food sustainability depends on the resilience of related agro-ecosystems, of which water is a fundamental component. Water, and its proper management, are indispensable for energy production and power generation. Water is used extensively in energy extraction, refining, processing and transportation; and energy is essential for transporting water over long distances, for treating water, and distributing it to end users, and for collecting and treating wastewater. Policies that take into account trade-offs, complementarities and resource constraints between water, food and energy are not yet effectively developed despite the urgent need.

In this session the speakers will discuss the effects of water scarcity (both in terms of quantity and quality) on food and energy needs today and tomorrow. Particular attention will be given to the policy framework and institutional underpinnings required to respond to the needs of the water, energy and food sectors. Case studies of projects, cities and regions will be discussed along with a framework to understand the complex interdependencies across the sectors and pathways to sustainable governance of water.

## CALL FOR PAPERS

**Panel proposal – Responding to water scarcity and quality in the nexus: Effects on the water, energy and food sectors**

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## Session 1 Responding to the Water Nexus

Friday, June 30th 10:30 to 12:30 (Block B 1 - 1)

### Discussants

Jamie Pittock (The Australian National University)

Stuti Rawat (Education University of Hong Kong)

### Singapore: No ordinary nexus

Cecilia Tortajada (Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore)

In the present changing global environment, policy-making and the management of development and governance of natural resources are increasingly based on policies and economic priorities of various sectors that do not always take each other into consideration. As a result, their interconnections, interdependences and impacts are still not fully realised; planning and implementation are mostly based on individual sectors that operate in silos and that do not always consider the overall economic, social, physical and political environments; and decision-making is normally impracticable. This would intuitively mean that complexities of water, energy and food sectors would have to be analysed in close relation to each other in all the cases, as decisions on each one of these sectors are assumed to have direct implications in the other ones due to the complex interdependence among them.

Singapore, however, has developed a different type of trade-offs and synergies. Interdependence among the several sectors is not direct in all the cases. This is because the city-state relies heavily on the imports of food for the population (90%) from numerous sources; fuels to ensure a secure, reliable and diversified supply of competitive priced energy (100%); and water resources (nearly 50%). This presentation argues that the trade-offs and synergies, or nexus - an approach that supports water, food and energy security- has taken a unique form in Singapore. It also analyses the risks in the short, mid and long terms.

### Impacts of hydropower dams, dikes and rice intensification on the water and food nexus in the Mekong Region

Jamie Pittock (The Australian National University)

The need to increase food and energy supplies globally are driving construction of hydropower dams, dikes and intensification of agricultural production, particularly on the fertile floodplains of major rivers. This policy study in the Mekong highlights the risk of perverse impacts if infrastructure development and intensification are undertaken poorly. Food security is about access to both calories and good nutrition. Water security is about access of both quality and quantity of water.

This paper draws on empirical research to examine the links between infrastructure development, agricultural and aquaculture development and nutrition in farming communities in the Mekong Delta. In particular it argues that the recent development of dams, high dikes and the focus on the intensification of rice production, upland crops and cattle rearing in the upper part of the Vietnamese Mekong Delta has significantly diminished wild fish catch, an important food source for poor and middle income rural residents. Rice production has increase four times in An Giang Province due to dikes and rice intensification; however, fertilizer and pesticide use has increased three fold. The paper reviews changes during three periods in Vietnam. The first period was before 1975 when the canal

network that is used for drainage and transport throughout the delta was established. During the second period, the time of the Doi Moi reforms of the 1980s, the agricultural system based on low or August dykes was widely introduced. This allowed farmers to switch from one rice crop of traditional floating rice per year to two rapid growth high yielding crops using new plant varieties while still providing a viable habitat for wild fish. The third period since 1996 has seen a further intensification of the market economy and more investment in high dikes, partly in response to severe flooding and other changes in river flow due to hydropower dams. Farmers are now using the high dikes to produce three crops a year by the intensive use of fertilizers, pesticides and new pumping technology to irrigate and drain water to and from their fields on demand. In parallel commercial aquaculture has also expanded. The expansion of high dikes and aquaculture in the delta has, however, severely reduced the habitat available to wild fish and other food sources. This has severely impacted on the livelihoods of landless families that were previously dependent on wild fish caught in the commons, and diminished affordable access by low and middle income residents to nutritious foods. Further intensive, triple crop rice production is less profitable for farms than floating rice – fish – dry season vegetable cropping.

Further, while Vietnam has succeeded in exporting more low value, high volume rice, it has been at the cost of importing expensive, protein-rich foods. To address these water – food security nexus concerns, Vietnamese governments have begun to change their agricultural policies. The extensive development of water and agricultural infrastructure in Vietnam holds policy lessons for countries, such as Cambodia and Myanmar that have invested less in intensification to date.

### **Irrigation policy in Africa: Lessons on the water-food nexus for sustainable development**

Jamie Pittock (The Australian National University)

Bjornlund Henning (University of South Australia)

To achieve the United Nations Sustainable Development Goals for 2030, effective policies are required to reduce poverty, increase food security and conserve freshwater resources. These challenges are crystalized in the policies of many African Governments to greatly expand irrigated agriculture. Yet across Africa small holder irrigation schemes have performed very poorly leading to calls for their ‘re-vitalization’ or ‘reoperation’ or ‘rehabilitation’. Generally this leads to another donor or government funding costly repairs to failed infrastructure, which then fails again.

In this paper we present knowledge generated through a four year research for development project (supported primarily by the Australian Centre for International Agricultural Development) at six irrigation schemes in Mozambique, Tanzania and Zimbabwe. Socio-economic data is presented to highlight the initial problems of entrenched poverty, food insecurity and water wastage, then the impact of interventions. We present our understanding of what has worked to turn five of these schemes around, from a situation where: the infrastructure was poorly maintained or broken, the farmer organizations were weak, soil fertility was low, water was failing to reach the tail end of irrigation canals, a large number of plots were under-utilized or abandoned, crop yields were very low, and most worryingly, the farmers were living in poverty.

Instead, we argue that small holder irrigation schemes are complex systems which only function profitably and sustainably when there is a substantial investment in the capacities of the farmers and their institutions, in the formal and informal governing rules. Broken infrastructure is usually just a symptom of a failed socio-economic and socio-ecological system. We argue that no one intervention will make these irrigation schemes work, but rather, multiple complementary interventions are needed to achieve the potential of the farmers to use their irrigation schemes to generate good livelihoods sustainably. We draw lessons from this research on how to respond to the water - food nexus more widely.

### **Opportunities for Nexus-Oriented Policy Design: The Case of Singapore’s Transboundary Haze Pollution Act (THPA)**

Ishani Mukherjee (Singapore Management University)

Transboundary environmental pollution presents a critical policy problem in the ASEAN region due to the tripartite nature of its inherent environmental, health and political risks. While transboundary pollution can take many forms, it has been witnessed repeatedly in the region in the form of smoke pollution from fires caused due to unsustainable land-clearing practices in one nation severely deteriorating the air quality of adjoining countries, and often creating erratic spikes in water and energy use. Formulating national policies that deal with these local effects from pollution originating from outside of state jurisdictions has been a significant regulatory priority over the last few years as the pollution episodes have become more and more frequent.

Risks from widespread forest fires in the region include not only the local damage to terrestrial and aquatic ecosystems but also have global climate implications from greenhouse gas emission and the destruction of

carbon sinks. According to the World Resources Institute, the haze that has resulted from forest fires of Indonesia in the first half of 2015 alone, has emitted an estimated 20 times more carbon than that of the United States. [1]

In Singapore, the task of devising robust policy solutions has become even more pertinent as domestic water use and energy demand can spike as a way to deal with episodes of haze - that although may occur at predictable times of the year- are happening with increasingly unpredictable and often unprecedented intensities. Therefore, not only does the haze result in health implication due to air quality deterioration, it also has had a distinct impact on water demand and electricity use. News authorities in Singapore have reported water and power consumption levels reaching record highs during the most intense periods of haze over the last few years.[2] This trend is indicative of the compromising effect of the haze on the sustainable use of domestic water and energy supply that can in turn, take away from and at times undo parallel policy efforts for water and energy demand management and resilience.

As a response to the haze crisis, the design of the Singapore Transboundary Haze Pollution Act (THPA) represents a first-of-its-kind individual country policy response in Asia for governing pollution emanating from sources outside of its jurisdiction. Customized to address the management of haze impacts on local environmental contexts, it is a policy package that at present is centred on using indicators such as the air-quality index to govern the magnitude of the state's response to haze events.

In corresponding to the 'nexus' theme of this panel, the proposed paper will examine the opportunity that the THPA presents to address and strengthen the state's water and energy resilience policy targets. This distinction of the THPA as a 'customized' policy response, also makes the formulation and implementation design of the Act a promising case for the advancement of academic research on policy design studies. The paper will present findings collated using primary qualitative data and secondary data through publically available databases and documents.

[1] <http://www.wri.org/topic/indonesia-forest-fires>

[2] <http://news.asiaone.com/news/singapore/record-power-consumption-hot-hazy-june>

<http://www.todayonline.com/singapore/daily-water-usage-exceeds-level-during-haze-last-year>

## **The global struggle for water – for food, feed, fibres, fuels or flowers – for the rich or the poor**

Arjen Hoekstra (University of Twente / National University of Singapore)

In its annual Global Risks Reports 2012-2017, the World Economic Forum consistently lists water crises in the top-3 of global risks in terms of impact. Still, however, water doesn't receive the political and public attention it deserves, partly because water risks are obscured by the complexity of the global system. Most water risks are indirect: the operational water footprint of companies is generally a factor hundred smaller than their indirect water footprint, so that their water risks generally concentrate in their supply chain. Many countries have significantly externalised their water footprint, importing water-intensive goods from elsewhere, often from countries where water resources are overexploited. Water is too bulky to be traded, so water seems like a local resource. However, water is intensely used for commodities traded on the world market: cereals, cotton, sugar, soybean, biofuels. Hence, increasing consumption of milk in China translates to increasing water use for producing feed for the Chinese cows in the Americas, contributing there to the overexploitation of rivers and aquifers. Competition over water thus happens not only locally between different water-demanding sectors but also between countries – hardly visible though because there is no water trade, only virtual trade of water, in the form of food, feed, fibres and energy. With increasing dependence on bioenergy, global water demand will quickly rise and rich and water-poor countries will increasingly externalize their water footprint, thus aggravating water scarcity in other countries, depriving others from using the water for domestic purposes and thus raising issues of equitability. Given the projected increase in global water demand, the pressure on valuable untouched water streams will inevitably increase and the intensity of use of already overexploited water reservoirs is unlikely to stop, which means that worldwide biodiversity decline is likely to continue. Global coordination in reducing the water footprint of humanity is a precondition for a sustainable future. National water footprint reduction targets need to be agreed upon and plans to achieve these targets will need to address both water use efficiency and consumption patterns. There are many lessons to learn from the way governments and companies have struggled and are still struggling to develop effective plans to reduce our carbon footprint.

## **Food-Energy-Water-Environment-Development Nexus in China and India: Opportunities and Challenges**

Asit K. Biswas (Lee Kuan Yew School of Public Policy)

China and India will face different types of challenges during the post-2025 world. Both will then still be the world's two most populous countries but India's population will overtake China's by around 2022, and will continue to overshadow China. Because of economic, cultural, social, institutional and legal differences, the nexus-related problems and solutions of the two countries are likely to diverge more. The presentation will be future-oriented. It will assess the likely implications, both positive and negative, if the current policies and institutional arrangements change only incrementally over the next 15 years. It will then review what are likely to be the benefits if public policies are formulated on the basis of a nexus "business unusual" approach in the two countries.

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## Session 2 Water Allocation and Governance

Friday, June 30th 13:45 to 15:45 (Block B 4 - 6)

### Discussants

Edoardo Borgomeo (University of Oxford)

Cecilia Tortajada (Institute of Water Policy, Lee Kuan Yew School of Public Policy, National University of Singapore)

### Pathways to Improved Water Allocation

Quentin Grafton (The Australian National University & National University of Singapore)

The presentation provides: (1) an overview of water misallocation at a global level with multiple examples of misallocation whereby water use (including in situ use) at a particular place and time is not allocative inefficient or inter-temporally inefficient or inequitable, as determined by the locally established norms of distributive justice; (2) barriers to water reallocation, or a reassignment of physical volumes of water or changes in water quality or in terms of the timing and location of water delivery to achieve specific goals and/or particular outcomes; and (3) policy responses to water misallocation. To guide water reallocation the benchmark of a Just, Allocative and Dynamically Efficient (JADE) water allocation is presented to which existing water allocations can be compared. To help move towards JADE and overcome water misallocation a Three-Step Approach is proposed that includes: (1) Scoping or a diagnosis of the type of water misallocation and the barriers to reallocation; (2) Risk assessment and a prioritization of options and sequencing of actions; and (3) Evaluation and adaptation that implements responses and measures outcomes. Two illustrations are provided to show how the Three-Step Process could work and contribute to improved water allocations.

### Sustainable water governance in agriculture: The case of Gangetic plains of South Asia

Stuti Rawat (Education University of Hong Kong)

In the Gangetic plains of South Asia, located in Pakistan, India, Nepal and Bangladesh, agriculture is a major activity. Agricultural production from this region contributes significantly towards the overall agricultural output of the respective countries, making it critical for food security and sustainability. Tied closely to the agriculture systems of this region is a dependence on groundwater aquifers for irrigation. Scarcity of water as evidenced by falling groundwater levels, has led to the increasing use of motive power such as electricity or diesel to pump out water. Free or heavily subsidised electricity, which is predominantly the case in India, when supplied to the agriculture sector, disincentivises economising on groundwater and energy by farmers. The operation of diesel pumps on the other hand, is directly responsible for carbon emissions in the region. Differences in the regulatory regime and policies related to agricultural power (whether electricity or diesel) have a crucial role to play in the manner in which the irrigation-energy nexus plays out. Thus, drawing on secondary literature and national datasets, this paper undertakes a comparison of the state of irrigation, agricultural-energy policies and the ground-water regulatory regime among the countries of the Gangetic plains of South Asia (Pakistan, India, Bangladesh and Nepal). The paper aims to understand the role played by the current institutional framework and identify changes in the policy sphere that would contribute towards sustainable water governance in the agricultural sector for the region.

## **Diversity within unity: State, market and community approaches to water allocation in China**

Jesper Svensson (School of Geography and the Environment, Oxford University)

Water, energy and food systems are increasingly interlinked and presents challenges of institutional coordination. Allocating water to different users and sectors implies trading off the benefits perceived by the water, energy and food sectors. In China, competition for water between agriculture, industry and the environment has elevated this challenge to the top of the policy agenda, culminating with “the strictest system of water resource management”, called the “Three Red Line Policy” (santiaohongqian ???). The defining challenge is how to design institutions to effectively allocate water to different users and sectors and how to manage trade-offs related to water allocation. Despite its authoritarian political system, China is characterized by a diversity of water allocation institutions. The design features of a water allocation varies depending on the characteristics of water rights entitlement and coordination institutions. The latter is particularly important to maintain infrastructure and to allocate and distribute water among users, and settle disputes. China features stark regional variation in coordination institutions with regards to horizontal relationships between sub-national jurisdictions as well as vertical relationships between central and local levels of government. This poses several questions: 1) why have diverse water allocation institutions developed?; 2) how are features of administrative, market-oriented and community approaches combined?; 3) and how has this affected the management of trade-offs in water reallocation? This paper builds on the Coupled Infrastructure Systems, Institutional analysis and Development Framework to undertake a diagnostic study of water governance arrangements for water allocation in semi-arid basins of northern and northwestern China. The Yellow river, Black river and Shiyang rivers are compared because they face upstream-downstream competition and increasing competition among different users, leading to a ‘Tragedy of the Commons’ problem. These rivers confront trade-offs between economic development and protecting ecosystems, epitomizing many of the tensions linking the nexus of water, energy and food with water reallocation. The paper uses document analysis, supplemented by interviews, to diagnose governance arrangements in managing trade-offs in the nexus of water, food and energy. It is a diagnostic study of a multi-method research project that will involve content analysis, field surveys and regression modelling to understand the design, evolution and performance of water allocation institutions in China.

## **Considering a whole of resource approach: Underground resources policy in Australia**

Sara Bice (The University of Melbourne)

Sedimentary basins provide 90% of Australia's primary energy and water for agriculture and rural populations. But information to support management and governance decisions is lacking. Community outrage and anachronistic regulation complicate things further.

Today's decisions about how Australia's sedimentary basin resources are used will have major effects on tomorrow's

environment, economy, and communities. And they exemplify key policy challenges at the energy-water nexus.

Australia's Chief Scientist recently declared ‘the sustainable use of sedimentary basins’ a National Strategic Research Priority. As the national mining boom ends, ‘unconventional’ energy sources to support economic competitiveness, growth and energy security are being pursued. Many of these resources—including coal seam gas—reside in the underground ‘pore spaces’ also home to water, carbon storage and geothermal potential. Resource-use decisions are costly and afford few second chances. Estimates place groundwater losses from potential unconventional extraction at a \$6.8 billion GDP decrease and \$419 million in lost household use. Yet we lack vital information for basin management and governance. We know little about current choices' long-term socio-economic impacts. Understanding of how basins work and how new technologies may affect water resources is limited. Regulatory regimes are inefficient. Anger dominates public debate while certain governments and industry push for expansion. Geo-scientific data lag rapid industry growth.

This paper presents work from the Melbourne School of Government and Melbourne Energy Institute to map regulatory tensions and complexities concerning energy and water resource management as it has arisen from policies that govern underground resources in a ‘siloed’ way. The paper suggests a reconceptualisation of traditional, resource-by-resource approaches to basin management by advancing a ‘whole-of-resource’ approach. It argues that such an approach can contribute to more sustainable resource-use decision-making while also improving public understanding of resource interconnection.



## **Water scarcity and variability in the Awash basin, Ethiopia: economic effects and policy options for water and food security**

Edoardo Borgomeo (University of Oxford)

The economy and food security of the Awash River basin are strongly linked to water availability and variability. In this paper, we present an analysis of the direct and indirect effects of rainfall and extreme weather events on the economy of the Awash river basin in Ethiopia. The aims of the study are to (i) analyze how the relationship between agricultural production and rainfall varies over time, depending on the crop type and on the type of extreme event (flood or drought) and (ii) quantify the economy-wide effects of rainfall-related shocks in agriculture. This analysis has implications for understanding current and future vulnerabilities to climatic factors and for informing basin-wide adaptation strategies.

Using novel disaggregated data on agricultural production, we estimate the direct impacts of rainfall and extreme weather events on agriculture and then use a Computable General Equilibrium analysis to model the propagation of the agricultural shocks through the wider economy of the basin. Results show that agricultural impacts depend on season and crop type. The analysis also shows that the basin's food security and expanding agricultural sector are highly vulnerable to rainfall availability and extreme weather events, in particular to extended drought, suggesting that failure to adapt to climate change might result in significant damages. A four-year drought (two years longer than the 2015-2016 drought) could reduce basin's GDP by 20% compared to 2014 levels. The knock-on effects on other sectors in the economy tend to amplify losses related to rainfall availability and variability, as reductions in the supply of agricultural produce lead to a fall in productivity in other industrial and services sectors. The paper concludes by describing water policy options that could reduce the basin's vulnerability to water scarcity and variability. Options to reduce water resource variability as well as improvements in the capacity to manage water resources, including regulation and hydro-meteorological forecasting, are discussed.

## **Bringing multiple perspectives to water, energy and food systems in Pakistan**

Grigg Nicky

Toni Darbas (Commonwealth Scientific & Industrial Research Organisation (Australia))

Tira Foran (CSIRO (Commonwealth Scientific and Industrial Research Organisation))

The Indus Basin spans land in Pakistan, India, China and Afghanistan. It is a complex social-ecological system undergoing rapid social and biophysical change, influenced by a broader global change context with historical, socio-political and social-ecological dimensions. The coming decades in Pakistan will be critical because water, food and energy security in Pakistan relies on the Indus Basin and the water availability within it, which has been identified as particularly vulnerable in the face of anticipated future changes. Diverse analytical approaches to the water-energy-food nexus (and to the Sustainable Development Goals more generally) highlight contrasting insights and imply alternative courses of action in particular sectors and at different scales (e.g. household, basin or international level). Currently the water-energy-food nexus literature encompasses many different approaches, with little evidence of overlap between them. Our aim is to draw on these different perspectives to foster cross-disciplinary and cross-sectoral dialogue in support of more inclusive whole-of-system awareness. One purpose for doing so is to reveal counter-intuitive linkages and system feedbacks, so providing insights that can be used to reduce the likelihood of decisions in one sector undermining the goals of another sector (e.g. energy subsidies locking in unsustainable groundwater depletion). We will present preliminary findings from the Pakistan Indus basin, including: implications for gender, health and agrarian change dynamics; the nature of interactions between upstream drivers and downstream impacts; and a nexus view of trade settings and impacts. In doing so, we reflect more broadly on water-energy-food nexus analysis approaches and point to promising opportunities and future directions that benefit from contrasting views of the nexus.