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Water, Energy, Food and People Across the Global South

'The Nexus' in an Era of Climate Change

Edited by Larry A. Swatuk and Corrine Cash

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Editors

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'The Nexus' in an Era of Climate Change

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Acknowledgments

The genesis of this project stems from a one-day workshop organized by Peter Mollinga, Laura Hammond and Anna Lindley in the Centre for Water and Development at the University of London's School of Oriental and African Studies (SOAS) and by Lyla Mehta, Jeremy Allouche and Alan Nicol of the IDS and STEPS Centre at the University of Sussex. The title of the workshop was 'Not Another Nexus? Critical Thinking on the "New Security Convergence" in Energy, Food, Climate and Water'. This was in 2012 (See: https://www.soas.ac.uk/water/event/26oct2012-not-another-nexus-critical-thinking-on-the-new-security-convergence-in-energy-food-climate.html). At that meeting, a plan was hatched by a few participants to hold a follow-up meeting at the University of Waterloo. This workshop happened two years later, over two days in the Northern Winter of 2014, and was titled 'Healthy Climates: Governance in the Water, Energy, Food and Climate Security Nexus'. The Waterloo meeting was funded by a grant from The Water Institute and co-hosted by The Water Institute and the School of Environment, Enterprise and Development. During this period, Larry Swatuk tasked his Master of Development Practice graduate class in Water and Security to write papers generally focused on 'the nexus'. These papers were presented in New York in the fall of 2014 at the annual International Conference on Sustainable Development, hosted by Columbia University's Earth Institute.

The core of the chapters collected here are derived from this process. Over time, however, some authors have come and gone, and others have been invited to be part of the project. The main criterion for inclusion, aside from quality, was a critical eye regarding received wisdoms about the causes and effects of water resources access, use and management challenges. What the reader finds here is an eclectic mix of chapters, each of which demonstrates what we call a 'nexus sensibility': how could sustainable, equitable and efficient resource use be otherwise? This sensibility is quite different from the nexus being discussed at high-level forums such as that held annually in Davos, Switzerland. Indeed, we remain quite skeptical of this 'nexus', which appears to us as yet another attempt to commodify nature at a grand scale (see, in particular, Chap. 1 and the Afterword). In the three years since the Waterloo meeting, there has been a great deal said and published about 'the nexus'. We hope that this collection helps further debate and discussion, not only about the water-energy-food-climate-security nexus but about the most appropriate ways and means for governing and managing the world's resources for just and sustainable ends as well.

The co-editors would like to thank The Water Institute for their ongoing and generous support of this project. We also thank Marion Brown, Karen Robertson and Marina Jozipovic for their assistance with the Waterloo meeting and the good people at SOAS, IDS and the STEPS Centre for initiating this exercise. Larry Swatuk would also like to thank Corrine Cash for agreeing to participate as the co-editor. Editing a collection is never easy, especially one with more than 20 authors! He hopes that this is just the beginning of many joint projects. Corrine Cash would like to thank Larry Swatuk for the invitation and, on behalf of both of them, also thank Timothy M. Shaw, Christina Brian and James Safford for their encouragement and assistance in bringing this manuscript to completion.

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List of Acronyms

ACWUA	Arab Countries Water Utilities Association
AFD	Agence Française de Développement
AFED	Arab Forum for Environment and Development
AFEX	Arab Future Energy Index
AGCare	Agricultural Groups Concerned About Resources and the Environment
AHIPAR	Paraguay Waterway Administration
AIDS	Acquired Immune Deficiency Syndrome
ASEAN	Association of Southeast Asian Nations
AWC	Arab Water Council
AWM	Adaptive Water Management
BDP	Basin Development Plan (Mekong)
BGR	Federal Institute for Geosciences and Natural Resources (Germany)
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BRAC	Bangladesh Research and Development Organisation
CBD	Convention on Bio-Diversity
CCA	Canadian Council of Academies
CDA	Chilika Development Authority
CFFO	Christian Farmers Federation of Ontario
CIC Plata	Intergovernmental Coordinating Committee for the Rio Plata
CLEW	Climate Change Land-Use Energy and Water
CLTS	Community-Led Total Sanitation
CPRs	Common Property Regimes
CWA	Clean Water Act (Canada)
DEA	Department of Environmental Affairs (Botswana)
DfID	Department for International Development (UK)

DOS	Department of Statistics (Jordan)
DWA	Department of Water Affairs (Botswana)
ECLAC	Economic Commission for Latin America and the Caribbean
ECS	Energy Charter Secretariat
EFP	Environmental Farm Plan
EIA	Environmental Impact Assessment
ENGOs	Environmental Non-Governmental Organizations
EU	European Union
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
FONPLATA	Financial Fund for the Plata Basin
FUME	Framework for Urban Management of the Environment
GAM	Greater Amman Municipality
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIZ	Gesellschaft für Internationale Zusammenarbeit
GM	Gender Mainstreaming
GranD	Global Reservoir and Dam Database Project
GWA	Gender Water Alliance
GWP	Global Water Partnership
GWP-SA	Global Water Partnership—Southern Africa
HIV	Human Immunodeficiency Virus
HOORC	Harry Oppenheimer Okavango Research Centre
IAEA	International Atomic Energy Agency
ICIMOD	International Centre for Integrated Mountain Development
IDB	Inter-American Development Bank
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IISD	International Institute for Sustainable Development
IJC	International Joint Commission (North American Great Lakes)
IPCC	Intergovernmental Panel on Climate Change
IRC	International Red Cross
IUCN	International Union for the Conservation of Nature
IWM	Integrated Waste Management
IWMI	International Water Management Institute
JAAH	Jordanian Alliance Against Hunger
JEA	Jordan Electrical Authority
JEPCO	Jordan Electrical Power Co.
JPRC	Jordan Petroleum Refinery Co.
JVA	Jordan Valley Authority
LAS	League of Arab States

LDCs	Least Developed Countries
LHWP	Lesotho Highlands Water Project
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MEMR	Ministry of Energy and Mineral Resources (Jordan)
MENA	Middle East and North Africa
MERCOSUR	Southern Common Market
MMR	Mixed-Methods Research
MoEnv	Ministry of Environment (Jordan)
MOPIC	Ministry of Planning and International Cooperation (Jordan)
MRC	Mekong River Commission
MWI	Ministry of Water and Irrigation (Jordan)
NCA	Natural Capital Accounting
NCCC	National Climate Change Committee (Jordan)
NCDs	Non-Communicable Diseases
NGOs	Non-Governmental Organizations
NPV	Net Present Value
NRC	National Research Council (United States of America)
NWDC	North West District Council (Botswana)
O&M	Operation and Maintenance
OAS	Organization of American States
OCSCSA	Ontario Chapter of the Soil Conservation Society of America
ODMP	Okavango Delta Management Plan
OECD	Organization for Economic Cooperation and Development
OFA	Ontario Federation of Agriculture
OFAC	Ontario Farm Animal Council
OFEC	Ontario Farm Environmental Coalition
OMAF	Ontario Ministry of Agriculture and Food
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMOE	Ontario Ministry of the Environment
ORASECOM	Orange-Senqu River Basin Commission
PICs	Pacific Island Countries
PLUARG	International Reference Group on Great Lakes Pollution from Land-Use Activities
POU	Point Of Use
PPWP	Paraguay-Paraná Waterway Project
R4D	Research For Development
RBOs	River Basin Organisations
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEEA	System of Environmental-Economic Accounting

SIWI	Stockholm International Water Institute
SNV	Netherlands Development Organisation
SPPs	Source Protections Plans (Watershed-based)
SPR	Source Protection Region
SSA	Sub-Saharan Africa
TEEB	The Economics of Ecosystems and Biodiversity
TGLP	Tribal Grazing Land Policy (Botswana)
UAE	United Arab Emirates
UCLG	United Cities and Local Governments
UN	United Nations
UNCED	United Nations Commission on Environment and Development
UNDESA	United Nations Department of Social and Economic Affairs
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Economic, Social and Cultural Organisation
UN-ESCWA	United Nations Economic and Social Commission for Western Asia
UNFCCC	United Nations Framework Convention on Climate Change
UN-Habitat	United Nations Human Settlements Program
USAID	United States of America Agency for International Development
VWT	Virtual Water Trade
WAJ	Water Authority of Jordan
WASH	Water Sanitation and Hygiene
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WB	World Bank
WEF	World Economic Forum
WFD	Water Framework Directive (European Union)
WFP	World Food Program
WHO	World Health Organization
WIC	Waterway Intergovernmental Committee
WLE	Water Land and Ecosystems
WRI	World Resources Institute
WUC	Water Utilities Corporation (Botswana)
WWTP	Wastewater Treatment Plant

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CHAPTER 1

Perspectives on the Nexus: Water, Energy and Food Security in an Era of Climate Change

Larry A. Swatuk and Corrine Cash

Introduction

This collection is centered on the so-called nexus. According to the Merriam-Webster online dictionary, a 'nexus' may be defined as: (a) connection, link, and also a causal link; (b) a connected group or series and (c) center, focus (see www.merriam-webster.com/dictionary/nexus). There is a well-known trend in policymaking circles toward integrating water, energy and food policy—the WEF nexus—within an overarching climate change and security 'nexus' (see *Water Alternatives* special issue guest edited by Allouche et al. 2015 and *International Journal of Water Resources Development* special issue guest edited by Allan et al. 2015). This is reflected in the policy frameworks of the Department for International

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Development (DfID) and the German Development Agency (GIZ) where the 'nexus' is the new operating framework. In addition, significant forums such as the Stockholm World Water Week, hosted by the Stockholm International Water Institute (SIWI), and the World Economic Forum have drawn concentrated attention to the linked security issues surrounding water, energy and food, largely from a management perspective (WEF 2009; 2011a, b; 2015). The basic argument is that treating water resource management discreetly—even if within an Integrated Water Resources Management (IWRM) framework—is incomplete, because all water decisions impact possibilities for 'energy security' and 'food security', particularly within an era of globalization under the overarching context of climate change. According to Stern and Öjendal (quoted in Leese and Meisch 2015: 695–696), a nexus 'can be understood as a network of connections between disparate ideas, processes or objects; alluding to a nexus implies an infinite number of possible linkages and relations'. However, water, in the words of the WEF (2011a), is the 'gossamer' strands that hold the web of resource use together. In other words, water is at the heart of the nexus. So, water resource use decisions—even if biased toward blue water (defined as flowing surface water and accessible groundwater)—should at minimum take into consideration the role and place of water across key sectors, especially energy and food (and vice versa). There is also a sense of urgency about the nexus: the FAO (2014) highlights that agriculture accounts for 70 percent of global water withdrawals and that food production accounts for 30 percent of global energy use, so linkages are already significant. Moreover, it is anticipated that the rising global population will require 60 percent more food by 2050, that energy demands will increase by 50 percent by 2035 and that irrigation itself will use 10 percent more water than it does now. Thus, it is imperative that management practices 'get it right' sooner rather than later (see, also, Leese and Meisch 2015: 698). A nexus approach, it is argued, will enable the crafting of better policy and practice. For Al-Saidi and Elagib (2017: 1137), the WEF nexus is a 'new kind of environmental policy paradigm', and the nexus focus has, in their estimation, been quite successful in changing policy debates.

Outside of policy circles, there exists a critical and somewhat skeptical perspective on the 'nexus'. It seems clear that, as a policy discourse, 'the nexus approach' is elite driven, drawing together state and private sector actors in a concerted attempt to deal with—through marketization and commoditization of essential goods—the hypothesized negative impacts of increasing resource demands across water, food and energy 'sectors'

(Allouche et al. 2015; Leese and Meisch 2015: 704). On one level, the nexus is simply a fact: since water and energy availability affects food production, and methods of food and energy production affect water supplies, and since climate change adds uncertainty to existing supplies of freshwater, then food and energy 'security' will inevitably be impacted by water availability and so on, resulting in mutual vulnerability. To say that we should recognize these interlinkages and build them into resource use policy and practice is, in fact, to say nothing new. Al-Saidi and Elagib (2017), in their important review of the literature pertaining to the nexus, show how nexus thinking extends back to at least the 1980s across different disciplines in the sustainability sciences. Matthew, in his afterword to this collection, suggests that the nexus was first flagged in the Brundtland Commission Report, *Our Common Future*, with one essential difference: back then, the focus was on inter-governmental cooperation as the driving force behind sustainable development. In the current iteration, at least as it is articulated by groups such as the World Economic Forum, the key to sustainability lies with markets and the private sector. To systematically build this recognition into private sector practice, given current path dependencies related to physical supply chains and metaphysical objectives such as 'profit', is, however, both new and extremely difficult (Allan et al. 2015: 303–304). It is also highly problematic, particularly for those at the bottom of the global economic pyramid (Leese and Meisch 2015).

On another level, however, the 'nexus' may be read as an over-simplified and apolitical approach to resource management. For example, in her remarks made at the Waterloo workshop where these ideas and several of the chapters included here were first presented, Jennifer Clapp worried about the implications of 'resource reductionism', pointing out that food security has many dimensions beyond 'supply': for example, availability, access, stability and utilization. At the same time, she argued, there are many (global) drivers to water, energy and food insecurity that force us to look beyond 'management of scarce resources' as an adequate approach: for example, subsidies, trade agreements/trends, financial markets, global investment patterns, aid policies, geopolitical/economic considerations and so on. In his remarks made at the Waterloo meeting, Simon Dalby was equally skeptical, reminding us that when security moves into the conversation, other lenses such as 'democracy' or 'equity' or 'sustainability' tend to get squeezed out (cf. Leese and Meisch 2015). Dalby also points out the fact that climate change as a phenomenon is not a consequence of scarcity but of production: over-production and over-consumption leading to certain types of resource scarcity. In Richard Matthew's words, 'systems of scarcity generate big winners and big losers'. When scarcity and security are brought together in political discourse, the outcome is generally an attempt to secure, that is, to capture the available amount of, a resource perceived to be essential but increasingly scarce.

In his remarks made at the Waterloo meeting, Richard Matthew highlighted the ways in which 'the nexus', 'the green economy' and 'natural capital' all go together as a means of enabling business and governance elites to think about the interrelationship of things most often dealt with discretely: through separate ministries, departments and so on. Drawing on the 'evidence' provided by the World Economic Forum, for Matthew, it is quite astounding how swiftly business and policy elites have been able to (a) reduce complex and interrelated phenomena to a simple equation: growth puts pressure on linked resources, and therefore increased efficiency will reduce such pressure and (b) render 'scarcity' to a market-led, one-size-fits-all solution: since water is at the heart of the nexus, and since water is underpriced, the answer is to price water accordingly. Put differently, governance oversight combined with private sector entrepreneurial capacity will ensure that resources are allocated efficiently, so ensuring resource security. According to Matthew, 'it is breathtaking how WEF can move to a solution in seconds' (See his formal remarks on the Nexus here: https://www.youtube.com/watch?v=rIM0tJ1AkZQ; also, see his blog on the nexus here: http://isn.ethz.ch/Digital-Library/Articles/Detail/?lng=en&id=179227). For Dalby, however, not all nexuses are the same, and we would do well to engage rather than ignore the nexus dialogue despite both our misgivings about its current characterization and our skepticism regarding our ability to alter its form.

The remarks highlighted above from Clapp, Dalby and Matthew were made at an international workshop entitled 'Healthy Climates: interrogating the water-energy-food-climate security nexus' held at the University of Waterloo in the winter of 2014. Several of the chapters in this collection were originally presented at this meeting and have undergone extensive revisions, while the balance has been specifically recruited because of their particular approach to understanding key questions relating to water within and beyond the 'nexus'. It is clear from the papers presented at the Waterloo meeting and in this collection that scholars of resource development, governance and management are already 'nexus sensitive', utilizing a sort of 'nexus sensibility' in their own studies, whether it concerns the ways and means of achieving water security in rural villages in Tanzania or Botswana or rehabilitating land in Vietnam or lagoons in India and

Ghana. It is painfully clear that where municipal water managers ignore the needs and behaviors of non-urban stakeholders across the watersheds they inhabit—as has been the case at times in the Mackenzie and Grand River basins in Canada—they create as many new problems for themselves as they have solved. Similarly, crafting food security policy based on yield while ignoring nutrition, or health policy while being 'gender blind', will exacerbate rather than ameliorate important problems. Thus, connection matters.

A key learning from the workshop and highlighted across all chapters in this collection is the importance of information, knowledge and the particular ways and means of creating knowledge and engaging in its dissemination. Accurately modeling electricity prices, measuring and mapping the effects of water quality on nature and economy, determining collaborative approaches to integrated surface and groundwater management, developing appropriate watershed discretization approaches in order to more accurately represent the heterogeneity inherent in nature and reconceptualizing key concepts such as 'food security' and 'sustainable diets' in order to create more space for better and more informed policy options are diverse subjects interrelated by their desire to provide a more nuanced understanding of the ways in which we access, allocate, use and abuse resources in the daily pursuit of human endeavor.

It is clear that 'the nexus' as currently conceptualized is 'high level', 'goal-oriented' and 'management-centric' either excluding or determining the direction of local processes and issues. In this way, the nexus is a tool rather than a theoretical framework, and those using the tool are elite actors (Leese and Meisch 2015). It is perhaps for this reason that most workshop participants were initially skeptical of the relevance of a nexus approach. But over the course of the two days, it came to be seen that 'the nexus' was flexible; like most concepts in global governance, it is as much discursive space as it is a real approach to practice. As a discursive space, we are all drawn into the nexus to argue over its meaning and its content. Currently, the 'high ground' is occupied by those framing 'the nexus' as a response to real or imagined resource scarcities, their increasing interlinkages and persistent 'failures of sector-driven management strategies' (Al-Saidi and Elagib 2017: 1132).

Regarded differently, the nexus presents academics and practitioners with the potential to proactively engage. As stated by one participant at the Waterloo meeting: 'the first step toward solving a problem begins with its conceptualisation'. Academics in particular can shape the nexus, through research, particularly at the local level, where many researchers felt a bigger impact can be made. For example, 'sustainability' can be appropriated by corporate power but can be used as a powerful tool by local people too; 'food security' is also a dynamic concept, as in 'community-based natural resources management'.

Clearly, power is central to the nexus wherever you are. Decision makers cannot be ignored. At the same time, those of us who are not involved in decision-making processes cannot ignore or delink from them. Therefore, what is needed are innovative rules and ways of engagement in order to deepen and improve nexus understandings. Clearly, what is most needed is critical thinking on the nexus (Allouche et al. 2015).

Most water scholars are in agreement that the 'big framing', that is, the meta-narrative of scarcity, is false. Scarcities may be seasonal or location-specific—particularly in 'global drylands' (Allan et al. 2015)—but these shortages may be compensated in a number of ways, such as through virtual water (Allan 2011). At the same time, the abundance of water is no guarantee of 'water security' when gender, race, class and caste are factored in, not to forget choice and taste of what to eat and where to live. In this way, scarcity is socially constructed (Mehta 2001). Thus, in our view, the real nexus questions are about access and distribution and about targeting food, energy and water security, not because we lack for those things but because there is so much injustice and inequality (not to mention waste) created by our current systems and approaches to resource management (Middleton et al. 2015).

For Richard Matthew, therefore, the role of the academic is important. The academic exercises forms of power through knowledge, expertise and legitimacy across social scales that no one else can. According to Matthew, 'it is a remarkable sort of power we have'. In making his remarks at the workshop, he drew on the example of Thomas Homer-Dixon (1999), who through his project on environmental security was very effective at putting an argument in a way that speaks to everyone and in marketing his ideas and making them relevant to policymakers. In the end, academics would do well to recognize that they have capacity to engage at all levels.

Perhaps the nexus calls for a renaissance of the academic in public life because how you tell the story matters so much. Researchers, academics and practitioners often act as a bridge between local people and policymakers/businesspeople. Activist academics, such as those included in this collection, try to make sure that the voices of 'real people'/citizens get heard. We can theorize a complex world and render it understandable: we can highlight the limits of the global norm entrepreneurs such as WEF and McKinsey; we can highlight the benefits of certain connections and shape the story from the ground up, not necessarily to displace but most definitely to complement as well as contest that which is being delivered to us from the top down. There are many risks inherent in the top-down approach, not the least of which is the attempt to simplify the environmental challenge through catchy ideas such as ‘green economy’, ‘natural capital’, ‘integrated water resource management’ and ‘the nexus’. Such an over-simplified approach paves the way for elite-pacting around what is to be done, and what is to be done appears at present to be both technocratic and market-centered (Leese and Meisch 2015).

What we need, in Simon Dalby’s words made at the Waterloo workshop, is a ‘nexus for the next-us’. That is to say, an alternative nexus approach that is, among other things, grounded in local experience, illustrating whenever possible the benefits of citizen-led community action and the dangers of ‘totalizing narratives’; consists of a terminology that is consistent, transparent and is able to resonate with a risk-averse public; derives from an iterative process drawing in a wide variety of expertise and life experience; seeks to empower people at the local level while engaging those at the highest levels of global governance; and finds an appropriate means to collect and disseminate relevant information in such a way that helps bridge the abiding time-frame gap that exists between longer-term academic research and a decision-maker’s need to know now.

Themes

Knowledge, Information, Public Engagement

Benson et al. (2015: 759) demonstrate the many different ways in which the ‘nexus’ concept has been invoked. In our view, it seems clear that the World Economic Forum would like it to serve as ‘a nirvana concept’ (Molle 2008), offering a positive vision of the future while also fostering integrated policy and planning via a negative articulation of the dangers of ‘business as usual’. In their recent article, Benson et al. (2015) compare the nexus to another ‘nirvana’ concept: integrated water resources management (IWRM), reaching the conclusion that they share a great many similarities. At minimum, it seems each provides a means for systematically approaching a resource use issue: what to consider, how to collect information, who to engage and so on. Scholars and policymakers do this all the time, some dressing up their actions in terms of 'objective science', others being more forthright about normatively constructed 'action-based research' for meaningful change. All claim to be working in support of sustainable development. Al-Saidi and Elagib (2017) are wary of such nirvana concepts and highlight the many failures of past grand ideas. In their view, it is better to situate the nexus 'as an update and renewal of the paradigm of "integrated management"' (Al-Saidi and Elagib 2017: 1133).

In this collection, contributors employ a wide variety of concepts, conceptual approaches, theoretical frameworks and so on, each in the endeavor to arrive at a clearer understanding of the (socio/eco/political) dynamics underlying a particular problem with a view toward its resolution. The chapters vary somewhat in length. Most of them are single-case or single-issue studies, whereas Chaps. 2, 4 and 11 present detailed comparative cases informed by rich theoretical frameworks. In Chap. 2, Maha and Keough explore the utility of a nexus approach to water-food-energy security in the Middle East and North Africa, coming to the conclusion that an urban focus may best facilitate integrative policy and practice. Tang-Kai, in Chap. 3, suggests that for a nexus approach to be most useful, relevant tools for resource valuation and decision-making are necessary. In this regard, she explores the potential utility of natural capital accounting. Chapter 4 (Jensen, Lange, Refsgaard) focuses on governance, especially the role of stakeholder participation, with case studies drawn from Vietnam, Denmark and India. In discussing the means for sustainable environmental management of the Korle Lagoon in Ghana, Jeffrey Squire (Chap. 5) puts forward a Framework for Urban Management of the Environment, while leaving the question of likelihood of implementation open to interpretation. Da Silva in Chap. 6 also focuses on governance but within the framework of the river basin scale. An interesting finding here is that both physical and conceptual scales matter in resource governance and management. In the case of the La Plata river basin, far from the IWRM ideal, the basin itself embodies the practice of regional political and economic relations, so central is it to the wealth and power of riparian states. Thus, the basin reinforces the status quo orientation of water governance in terms of territory (the sovereign state), authority (government) and knowledge (expert) (see Conca 2006 for an elaboration of these concepts).

Chapter 7 (Leo, Lougheed, Swatuk and Fatch) presents an alternative 'nexus', that of gender-water-health, arguing that without a gender focus, any 'nexus' perspective will be partial and therefore limited in its capacity to derive appropriate resource access, use and management policies. Chapter 8 (Webber, Baker, Gaudry, Swatuk) complements the previous chapter, in emphasizing the importance of gender in water management, this time with a focus on WASH—water, sanitation and hygiene. Chapters 9 and 10 focus on Botswana and present bottom-up perspectives on resource access, use and management. Kujinga and his colleagues (Chap. 9) examine household water security in Ngamiland and Magole and Kgomotso (Chap. 10) interrogate planning models and practices in the Okavango Delta. Simpson, Rudolph and de Loe (Chap. 11) present an interesting case of the importance of stakeholder networks and collective action in achieving sustainable resource governance within the water-food nexus in Ontario, Canada. Lastly, in Chap. 12, Dunkelman, Kerr and Swatuk use examples from Eastern Africa to argue that food security must move beyond yield toward an analysis of and emphasis upon nutrition. If nutrition becomes the emphasis, there may be a renaissance for so-called 'orphan crops' and localized water harvesting practices that contribute simultaneously to both food and water security.

Governance and (Discursive) Power

What this eclectic mix of cases and approaches shows is that governance matters. For Al-Saidi and Elagib (2017), this is precisely what is missing from the nexus. In their words, 'nexus governance is the missing link in the nexus debate' (Al-Saidi and Elagib 2017: 1137). Most chapters in this collection also demonstrate the power of discursive frameworks: what gets hammered out in global settings by powerful actors then gets delivered to and reworked at lower levels (regional, national, sub-national, transboundary) and at different scales (communities, cities, river basins)—IWRM, gender mainstreaming, CBNRM (community-based natural resources management), WASH, IRBM (integrated river basin management), stakeholder participation, green economy, MDGs (Millennium Development Goals), SDGs (Sustainable Development Goals), good governance and, of course, 'the nexus'. How these concepts are realized in policy and practice reflects the social relations of particular national and regional political economies. Put differently, each of these purported global goods finds poor purchase in highly securitized regions and/or poorly governed, fractured, failing or authoritarian states. At the same time, 'well-governed' states and 'well-functioning' markets make very poor resource use decisions (Allan et al. 2015). So, while a nexus sensibility is necessary, in the absence of appropriate socio-political and socioeconomic conditions, it is no more likely to succeed than any other 'nirvana concept' that has come before it.

The Importance of the Local Scale

There are several reasons that 'climate change' and 'water scarcity' discourses have so little popular and party political motivating forces despite ongoing attempts at securitization. An obvious fact is that those with the most power have all the water that they need and are best insulated from the negative impacts of climate change. They are 'inside the limousine', to borrow an image from Robert Kaplan (1994). A second, perhaps equally obvious, fact is that their impacts are felt unevenly: water problems and climate variability are geographically specific. Given this specificity of effect and event, generic understandings of system dynamics and their hypothesized outcomes will have more or less relevance across both time and space. Moreover, their impacts will be differently felt according to socio-political (e.g. degree of democracy) and socioeconomic (e.g. resource-based vs. diversified economies) variables as well as race, class, caste and gender. Where there are commonalities, such as the shared climate vulnerabilities for those least empowered across the tropical and sub-tropical zones, those most seriously affected are least able to have their voices, interests and concerns heard and seriously considered in policy and practice.

What does this mean for the nexus? In our view, it means that, like IWRM, a nexus perspective is, at best, a useful way of keeping the 'big picture' straight in one's mind, that is, to be able to see clearly the general dynamics of what Tony Allan et al. (2015: 304) label the 'sub-nexi' of 'water-food-trade' and the sub-nexi of 'climate change-energy', as well as their interrelationships within 'the grand nexus' comprising them both. Granted, as Allan et al. (2015: 304) say, these interrelationships are at present poorly understood. But from our point of view, this is fine. It is enough to see the big picture as you work within your own research area or field of study and draw your own conclusions about the value of 'the nexus' based on your own conceptual and theoretical understanding of human-nature interrelations.

At worst, however, the nexus may distract policymakers from pressing issues, particularly those at the local scale. In particular, and based on recent research in Ethiopia and Ghana, the 'climate change' narrative is having a profoundly disempowering effect on local groups and rural communities: dismal yields are thus the result of 'nature' not (highly politicized) 'nurture'. All of the chapters in this collection focus on local level dynamics—from Amman, Jordan to Accra, Ghana and from Maun, Botswana to Chilika Lagoon, India. Several focus on the watershed—for example, La Plata, Okavango and Lower Mekong—while others examine networks and communities operating at sub-national scales. Several of the chapters emphasize the importance of 'vernacular knowledge' or 'traditional ecological knowledge', while those that focus on gender and health and on food security emphasize local knowledge for sustainable practice. In each of these chapters, we can see the operationalization of nexus thinking primarily at the local level: for example, water-land, water-ecosystems, water-food-climate and water-land-regional security. At the heart of all of these chapters is the too-often unstated nexus of political power—local-national-regional-global—that transcends concepts, issues, communities and categories. It is this nexus that requires exposure and direct engagement, for it is here that powerful actors are most capable of mobilizing around the 'water-energy-food-climate security' nexus.

Conclusion

We would do well to remember that water is everywhere and in everything, and that, in the words of Huub Savenije (2002), it is 'not an ordinary economic good'. Thus, how water is used by whom and for what purpose reflects back to us the very nature of our social systems. If we have water problems, therefore, we must begin by looking at the specific social relations of production in that place where the rain falls (or not) and the rivers flow (or not) (Swyngedouw 2007). We must also examine the flows of goods in and out of that space, what Allan (2011) calls 'virtual water'. Once we have adopted this perspective, we are more likely to see the true nature of our various resource 'scarcities' and less likely to believe that equity, sustainability and efficiency will result automatically from a nexus-based management perspective.

In our considered view, we regard the 'nexus' with some skepticism, but acknowledge that it is, at present, an influential framework for policy-making, political action and resource mobilization. This collection highlights the many and varied ways of analyzing and understanding the outcomes of particular resource access, allocation and use decisions. It provides insight into the political economy and political ecology of water, energy and food across different socio-political landscapes so that we may be better able to understand the context within which 'nexus-oriented' resource use decisions are being made. It therefore counsels critical engagement not only with important issues but influential discourses about planetary tipping points and what might be done where, how, by whom and for what reason.

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CHAPTER 2

Water, Energy and Food: The Problematic Aspects of the Transition from 'Silo Approach' to 'Nexus Approach' in the Arab Region

Maha Al-Zu'bi and Noel Keough

Introduction

There always has been debate on the significant role of natural resources for socioeconomic development (IUCN 1980; UNCED 1992; UNDP 1994; WCED 1987). Scientists argued that the carrying capacity of the earth no longer could continue supporting current and projected levels of demand from already depleted resources. For them, resource scarcity may compromise the welfare of future generations and pose a threat to sustainable development (Malthus 1970). Norgaard argued that as the extraction rates of resources increase, the horizon of scarcity shortens (Norgaard 1990). Until recently, resource scarcity was considered a local (or national) issue; however, lately, problems have scaled up (Adnan 2013).

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According to a discussion paper released in 2013 by the United Nations, five attributes characterize the recent perception of resource scarcity. The first attribute is the inability to exploit undeveloped resources due to geographic locations and human and financial capacities. The second attribute has to do with technical, social and environmental challenges to the exploitation of new resources in remote and marginal areas. The unprecedented demand for more and new natural resources makes the third attribute. However, the interconnectedness of price volatilities underlines the fourth attribute, with water, energy and food (WEF) resources attracting more attention in policy discourses. The fifth attribute has to do with governance, the inclusion of actors other than governments in resource scarcity deliberations (Adnan 2013).

Though the idea of resource 'limits' dates to at least the 1970s (IUCN 1980; WCED 1987), it is still inadequately addressed in public policy. Rather, it is becoming more complicated (Adger et al. 2001; Winter 2006). According to the United Nations, to achieve sustainable development, the following limits must be taken into account while developing and managing natural resources (UN 2011):

- Biophysical limits: What is possible within planetary limits and according to the laws of nature?
- Economic limits: What is affordable?
- Scientific-technical limits: What is possible technically?
- Sociopolitical limits: What is socially and politically acceptable?

Biophysical limits are considered the most significant, as WEF are most needed to sustain life on earth (Chua 2014; WCED 1987). These three resources share many comparable characteristics: There are billions of people without access to them, they have rapidly growing demand, they face resource constraints, each has different regional availability and variations in supply and demand and all three are global goods (Bazilian et al. 2011).

Given the global growing demand, scholars emphasize that the world's natural resources, especially food, water and energy resources, are already experiencing significant stress and shortfalls (Bazilian et al. 2011; Howells et al. 2013; UNCED 1992; WEF 2011a); the use of each affects demand for the others; and the use of all affects the climate (IAEA 2009). These interdependencies add extra pressure on planning and management practices (Siddiqi and Anadon 2011; Siddiqi et al. 2013). This interconnection is captured in the concept of the WEF nexus

(Bazilian et al. 2011). In simple terms, food production demands water; water extraction, treatment and redistribution demand energy; and energy production requires water. Energy inputs via fertilizers, tillage, harvest, transport, irrigation and processing have their influence on food prices. Moreover, the relations between WEF systems are made even more complex by external elements: population growth, governance, international trade, climatic changes and growing economies (as illustrated in Fig. 2.1) (Mohtar and Daher 2012). Moreover, these three resources have strong linkages with climate:

> You can't have food, water or energy security without climate security; they are interconnected and inseparable. They form four resource pillars on

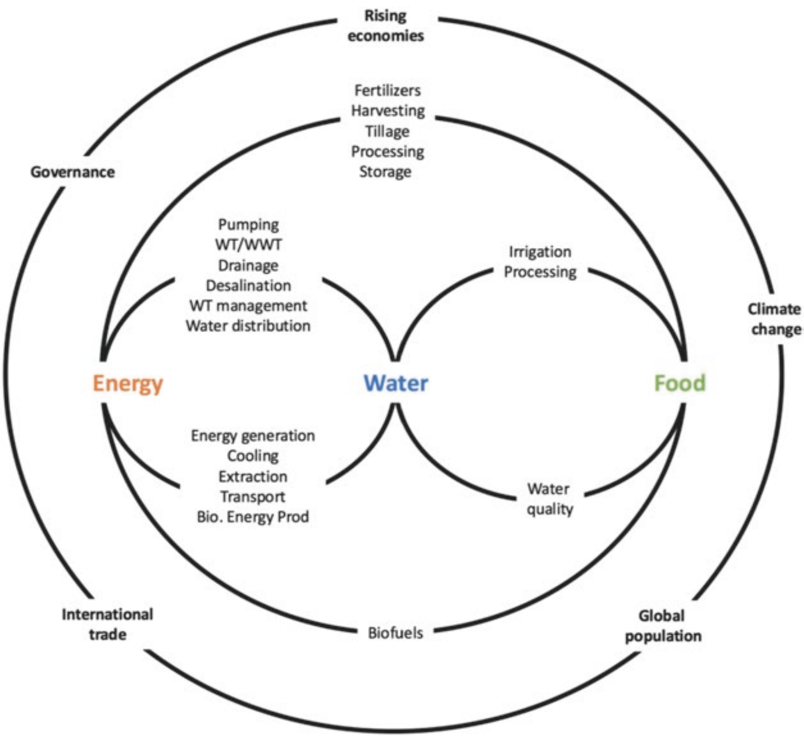

Fig. 2.1 WEF nexus with affecting parameters (Adapted from Mohtar and Daher 2012)

> which global security, prosperity and equity stand. Each depends on the other. Plentiful, affordable food requires reliable and affordable access to water and energy. Increasing dependence on coal, oil and gas threatens climate security, increasing the severity of floods and droughts, damaging food production, exacerbating the loss of biodiversity, and in countries that rely on hydropower, undermining energy security through the impact on the availability of water (Hague 2010).

While the interconnected nature of the WEF resources has been recognized globally, national and local policy planning for these resources typically proceeds as a silo approach (Hoff 2011), with relatively limited understanding of how to tackle these complex relationships when formulating policy, managing resources and taking action (Beddington 2009; Hoff 2011; WEF 2011b). Managing natural resources in isolation weakens synergies across sectors and hinders the transition to a more sustainable future especially in fragile ecosystems (Hermann et al. 2012; Hoff 2011; WEF 2011b). Although continued single-sector policymaking might temporarily result in an overall performance improvement of the sector concerned, it would be unlikely to persist over time (Bazilian et al. 2011; Siddiqi et al. 2013).

Many authors stress that future challenges will require integrating elements of the WEF nexus because decisions enhancing one area of security while compromising other areas will prove unsustainable. Without taking into account the interconnections among the sectors, resource allocations may easily be seen as a zero-sum game where intense competition for resource access can easily become conflict (Bizikova et al. 2013). Business as usual is no longer an option (Hoff 2011). The nexus approach, according to Hoff, is 'an approach that integrates management and governance across sectors and scales'. This approach gained momentum after the Water, Energy and Food Nexus conference in Bonn in 2011 (Bonn 2011 Nexus Conference 2011; Hoff 2011) and the Annual World Economic Forum which brought the WEF security nexus to full political attention at the Davos Summit through the Global Risks 2011 Report. It described the interconnected WEF security problem as follows (WEF 2011a):

> A rapidly rising global population and growing prosperity are putting unsustainable pressures on resources. Demand for water, food and energy is expected to rise by 30–50% in the next two decades, while economic disparities incentivize short-term responses in production and consumption that undermine long-term sustainability. Shortages could cause social and political

instability, geopolitical conflict and irreparable environmental damage. Any strategy that focuses on one part of the water-food-energy nexus without considering its interconnections risks serious unintended consequences.

Similarly, the emerging fear of WEF crisis has escalated the importance of the nexus perspective onto the international policy discourse (Adnan 2013). This was clearly witnessed during the United Nations Conference on Sustainable Development (2012), which advocated the integrated resource management approach with special focus on the interrelationship between WEF security (UN-ESCWA 2014).

Many researchers argued that understanding and analyzing the WEF nexus creates opportunities to increase resource use efficiency, enhance policy coherence[1] (Nilsson et al. 2012), provide a comprehensive base for allocating scarce resources and enhancing security, reduce tradeoffs, build synergies and improve governance across sectors to accurately assess investment needs and enhance investment effectiveness (Bazilian et al. 2011; Hermann et al. 2011; Hoff 2011; Howells et al. 2013; UNDESA 2014; WEF 2011b).

Globally, the geographic areas most susceptible to WEF insecurities are drylands (40 percent of the earth's land surface) due to their biophysical conditions (Fraser et al. 2011). The challenges of severe water scarcity, harsh climatic conditions, soil infertility, desertification and food insecurity put sustainable natural resource management of these regions at risk (Fraser et al. 2011; Lioubimtseva and Henebry 2009). On top of that, ineffective governance, insufficient human and financial capacity, accelerated demographic trends, and social factors (including poverty, unemployment and income inequalities) remain the most frequent drivers (Stringer 2008).

This chapter explores the obstacles and opportunities in the transition from the current 'silo approach' to a 'nexus approach' of policy formulation and both project and program implementation and management in WEF (agriculture) sectors in the Arab Region (90 percent of which lies within arid, semiarid and dry subhumid areas) (Abahussain et al. 2002). The chapter aims to shed light on the unique WEF interlinkages, interdependencies and tradeoffs at three policy levels: (i) Arab Region, (ii) national (Jordan) and (iii) municipal (Greater Amman Municipality).

The next section discusses the WEF nexus analytical framework and knowledge gaps. We then turn to a brief outline of the current situation of the WEF sectors, future trends and related policies in the Arab Region and illustrate the three resource constraints that are likely to arise in the future. This section also explores the interlinkages between water, energy and food, while at the same time taking into account the impact of climate change, and discusses how different parameters such as international trade, emerging economies, governance, climate change and population growth affect the overall WEF nexus. Following this, we turn to Jordan as a case study to examine the interconnectedness between WEF sectors and climate change policies at the national level, shedding light on the current institutional governance. The Jordan case is followed by a WEF nexus investigation at the municipal level (Greater Amman Municipality). The chapter concludes with the most problematic aspects that hinder the transition to the 'nexus approach' at policy levels. The novelty of this study vis-à-vis the consideration of the nexus approach lies in the endeavor to balance supply-side and demand-side responses, to locate the municipality as the focal point of intervention and to explore the potential for bottom-up community engagement in policy formulation and adoption.

WEF Nexus Analytical Framework and Knowledge Gaps

Scholars emphasize that the WEF nexus approach is needed to improve our knowledge of the following (Bizikova et al. 2013):

- the nature of the relationships among the three elements
- the consequences of their changes and changes in other sectors
- the implications for policy development and actions for addressing the three sectors' securities

A review of the literature demonstrates a number of published frameworks (Bizikova et al. 2013; Hoff 2011; ICIMOD 2012; WEF 2011b) that outline the relationships between the WEF sectors, level of interaction, governance and potential responses to guide the development of coherent policy (Bizikova et al. 2013). All frameworks aim to provide an informed and transparent approach that builds on the system perspective, enables tradeoff assessments and promotes transition to sustainability (Bizikova et al. 2013).

In order to meet these expected benefits of taking a coordinated WEF approach, scholars also suggest that the WEF framework needs to account for the longer time frame and to consider different policy scales, policymakers' perspectives and governance (Bazilian et al. 2011; Bizikova et al. 2013;

Hoff 2011; WEF 2011b), as well as different regional availability and variations in supply and demand of the studied resources. Equally, the WEF nexus essentially focuses on system efficiency, rather than on productivity of isolated sectors (Hoff 2011), and will require the explicit identification and management of risks (Bazilian et al. 2011). In terms of key elements of the frameworks, they all focus on promoting security and consider involving different domains: society, by changing human behaviors; economy, by using different approaches to economic growth; and environment, by promoting ecosystem services (Bizikova et al. 2013).

According to the published literature, the ultimate focus of these frameworks is to promote action by providing policy entry points to reduce tradeoffs, explore synergies and promote the transition to a more sustainable future (Bonn 2011 Nexus Conference 2011; Hoff 2011; Thirlwell et al. 2007). For this reason, the frameworks also shed light on the types of policies, measures and investments that would be needed to achieve these goals (Bizikova et al. 2013).

Literature on the nexus approach, which has its roots in systems analysis, follows three core themes: the nature of the relationships between WEF; the consequences of change in one sector for change in the other sectors; and the implications for policy (Bizikova et al. 2013). However, there are still some knowledge gaps to be addressed in future work:

- **Implications for policy:** This theme is relatively unexplored and there is a lack of evidence and knowledge about governance, institutional and political economy factors that determine the effectiveness of the nexus approach.
- **Demand side:** Until recently, the global discourse and most national efforts have been invested in WEF supply-side policies and infrastructure. Such interventions tend to be top-down, centralized with limited public engagement in policy development and implementation. In our view, it is important to locate the municipality as the focal point of intervention and explore the potential for bottom-up community engagement in policy formulation and adoption of demand-side policies (e.g., efficiency, conservation, etc.). Furthermore, the municipal level is the most appropriate policy and political jurisdiction for bringing about crucial demand reduction, given that this level touches the majority of the population and is where most of the WEF are consumed. We argue that reaching the actual people who consume the resources helps in understanding

consumption. This, in turn, helps enhance understanding of how to change consumption, including motivators of change. The premise is that comprehending what people experience at a local level can enhance the understanding of the problem and its solutions. It may also be a way to guarantee buy-in from citizens to support the necessary changes to inappropriate supply-side policy.

- **Three-way nexus:** Most nexus literature is largely about two-way (e.g., water-energy, food-water) rather than three-way relationships like WEF. However, exploring the synergies between three sectors would lead to policy coherence and good governance.
- **Integrating climate change:** Most nexus approach literature treats climate change as a contextual factor rather than a factor to be integrated into the nexus analysis. However, the current and near-term impacts and consequences of climate change include increases in sea levels, heatwaves and rainfall intensity, as well as increased energy consumption, reduced water availability and lower rain-fed agriculture yields. Country strategies to develop and keep emissions low will need to integrate climate change impact into sectors' policies to mitigate and to adapt to these impacts.
- **Local level:** Previous research has discussed the WEF nexus and related governance issues at the global and national levels, with limited attention to local level—the most appropriate policy and political jurisdiction for bringing about crucial demand reduction as described above.
- **Users' perspectives:** The developed nexus frameworks and analyses do not address the users' practice and behavior and the implications for resources consumption.
- **Public participation:** According to Kapoor (2001), environmental management practices tend to be centralized; however, there is a growing body of literature supporting a participatory approach in managing natural resources, which is decentralized, community oriented and holistic in its view of the environment (Kapoor 2001). While much has been written about the WEF nexus approach and the critical linkages between the sectors (Bazilian et al. 2011; Hoff 2011; Howells et al. 2013), relatively little attention has been paid to nexus relevant actors and the sociopolitical context in which further integration may be achieved (Stein et al. 2014). We argue that understanding how to engage the public and address their connections to the WEF nexus will lead to socially inclusive and environmentally sustainable decisions.

While the discussion in the previous sections was more generic, reflecting the overall context and perspective of the WEF linkages, the next sections will focus on WEF nexus in the Arab Region at three policy scales, where the WEF systems have many individual and collective layers of complexity.

Arab Region's Context

The Arab Region comprises 22 countries in the League of Arab States,[2] with a total area of 14 million km^2 representing 10 percent of the world's area. According to the United Nations estimates, with a population growth rate averaging around 2–3 percent, Arab countries will be home to 646 million people by 2050 (compared to about 357 million in 2010 and 172 million in 1980), increasing the urban share of population from 56 percent in 2010 to 68 percent in 2050 (UN-HABITAT 2012).

Arab economies have seen fragmented economic prosperity over the last three decades while inequality in the region has grown over time (El-Naser 2013; Habib-Mintz 2009). From an economic perspective, countries in this region span the spectrum from developed, through middle-income, to least developed countries (Habib-Mintz 2009). Poverty continues to affect 65 million people. Economic insecurity is further aggravated by disturbingly high unemployment rates of 14.8 percent for the general population, reaching 27.3 percent among the youth (AFED 2011). Despite the substantial progress in the socioeconomic and environmental indicators during the last three decades, the region's natural resources are experiencing significant stresses due to rapid population growth, urbanization, growing levels of consumption, commercial and industrial demand and climate change impact (Elasha 2010; Khoday 2011; UNDP 2011, 2013b).

In terms of WEF securities, the Arab Region represents an extreme case globally (Al-Zubari 2013). It has two-thirds of the world's proven oil reserves, up to 40 percent of world's proven natural gas reserves (IEA 2008) and imports 50 percent of its food (FAO 2008). It has only 1.4 percent of the world's fresh water supplies (Khater 2010), and up to 60 percent of surface water resources originate from outside the region. On top of that, the region is considered highly vulnerable to climate change impact (Verner 2012) and the attendant threat to the region's socioeconomic and environmental development and stability (UN-ESCWA and BGR 2013; UNDP 2013b).

Water-Energy Overview and Linkages

The Arab Region is characterized by great disparities in wealth, differently structured economies (Sowers et al. 2011) and heterogeneity between and within countries in terms of water and energy availability as illustrated in Fig. 2.2 (Hamhaber and Haering 2011). This creates significant divides between the Arab countries to adequately plan, manage and finance development of new sources of water and energy. This includes questions regarding equity and fair distribution of water and energy at both national and trans-national scales, and consequently leads to significant potential for conflicts (Hamhaber and Haering 2011; UNDP 2013b; Waterbury 2013). The diverse resource endowments and economic realities result in very different and divergent national priorities, development plans and

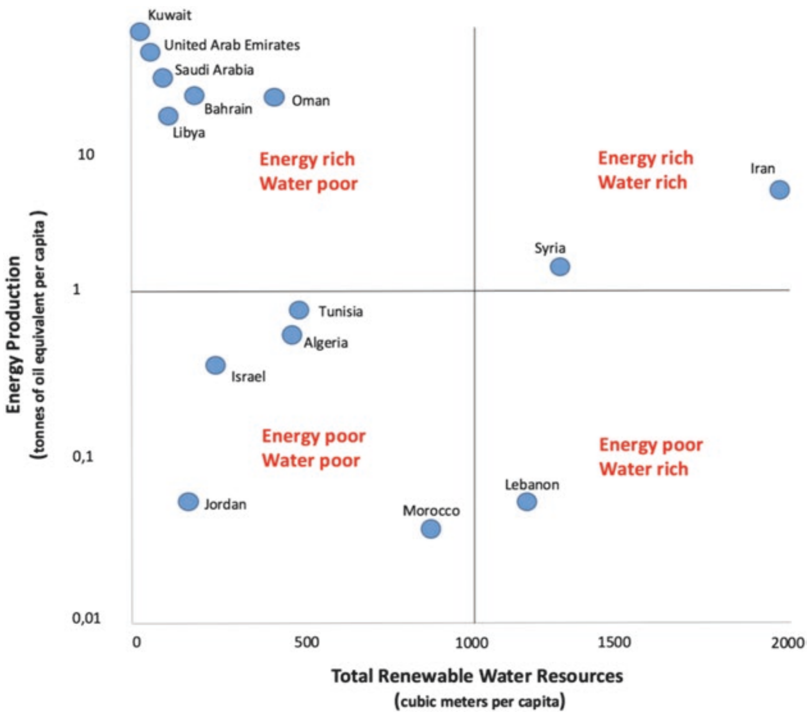

Fig. 2.2 Distribution of water and energy resources across the Middle East region (Adapted from Hamhaber and Haering 2011)

policies across the region and fewer collaboration opportunities (UN-ESCWA 2014).

Energy policy in today's world is directed mainly by three main common objectives: supply security, efficiency of supply and social and environmental sustainability (Mocarquer and Rudnick 2011). However, relying heavily on fossil fuels means that current trends in the Arab energy sector are unsustainable (Myrsalieva and Samborsky 2013). The socioeconomic development of the Arab Region is crucially affected by the energy sector. The region constitutes around 57 percent of the world's reserve of oil and 29 percent of its natural gas (UN-ESCWA and LAS 2009). Currently, energy consumption in the Arab Region is growing at an annual rate of 3–4 percent, which is twice the average global rate, while electricity demands are increasing at rates of 6–8 percent in almost every Arab country, compared to 2.6 percent global growth (IEA 2010). According to the OECD, to embed sustainable, long-term economic growth in the region, countries must diversify their energy sources. The Arab world contains 1 percent of the world's water resources (UNDP 2013b). Water scarcity is alarming in the region, since it has the lowest freshwater resource endowment in the world (Mirkin 2010; Verner 2012). The average water availability in the Arab world is 1700 cubic meters per capita per year (m^3/cap/y), with 15 countries out of the 22 having less than the recognized minimum endowment of 1000 m^3/cap/y and 8 countries having less than 500 m^3/cap/y and experiencing absolute water scarcity (AWC 2011; FAO 2008; UNESCO 2012). With rapid population growth, increasing per capita use and fast urbanization, the per capita availability of water is likely to be reduced in the Arab countries by about 50 percent by the year 2025, and by 2045, the demand is projected to increase by 60 percent (Gober 2010; UNEP 2013; Verner 2012).

In the Arab Region, the main segments of water use along the energy value chain are fossil fuel extraction and refining and electricity generation (Bazilian et al. 2011). The region is a large producer of oil and petroleum products, so the collective effects on water consumption can be significant. However, water consumption in oil extraction is much lower than what is consumed through evaporation in cooling processes in power plants (Siddiq and Anadon 2011). Energy is required in all segments of water value chains. Water extraction, conveyance, desalination and wastewater treatment constitute some of the most energy-intensive processes employed in this region (Bazilian et al. 2011; Siddiq and Anadon 2011). It is estimated that in most Arab countries, the water cycle demands at least 15 percent of national electricity consumption and it is continuously on the rise (Khatib 2010).

Groundwater and desalinated water are the significant sources of water in the region—both are energy intensive (UNDP 2013a). Groundwater appears to be the largest source (contributing to over 50 percent of total country withdrawals) in Bahrain, Jordan, Lebanon, Libya, Oman, Saudi Arabia, Tunisia, the UAE and Yemen. In the Gulf Cooperation Council (GCC), it accounts for 84 percent of total water withdrawals, while desalination accounts for 8 percent of water supply (Siddiq and Anadon 2011; Zyadin 2013). Siddiq and Anadon (2011) found that in the case of Libya, up to 14 percent total fuel consumption is due to groundwater pumping. In Saudi Arabia, 5 percent or more of the total electricity consumption is attributed to water pumping (Siddiq and Anadon 2011).

Energy needs for desalination are projected to grow rapidly, especially in arid regions like the Arab Region (Al-Zubari 2010; Fath et al. 2013). The desalination capacity is projected to grow from 8 million m^3 to around 15 million m^3 in 2030 (Bazilian et al. 2011), much of which is in the countries of the GCC. For instance, the UAE may be using up to 22 percent of its total electrical energy for desalination and Qatar up to 13 percent. Desalination of sea water and brackish groundwater has become a strategic option for meeting increasing drinking water demands in many countries in the region, particularly in the GCC countries due to their financial and energy capabilities (Al-Zubari 2010, 2013; Droubi and Al-Zubari 2011; Fath et al. 2013).

Non-conventional water resources have become a key option for most Arab countries particularly in light of climate uncertainties and increasing water demands among different sectors (AbuZeid 2012; Choukr-Allah 2012; Mairesse 2012; WB 2011). The reuse of treated wastewater (energy-intensive source) for irrigation, industrial applications, urban landscaping or aquifer recharge has become a progressively viable option (WB 2011). Reused treated wastewater contributes considerably to the water budget in some Arab countries, particularly those suffering from water scarcity like Jordan, Morocco and Tunisia (Guardiola-Claramonte et al. 2012).

With increasing population, urbanization and improved living conditions, a considerable amount of wastewater will be generated and require treatment across the Arab Region (Choukr-Allah 2012; Guardiola-Claramonte et al. 2012). Energy represents a substantial cost to wastewater utilities, as it is typically required for all stages in the treatment process, from the collection of raw sewage to the discharge of treated effluents (Daw et al. 2012). Energy accounts for 15–30 percent of the operation and maintenance (O&M) budget at a large wastewater treatment plant (WWTP) and 30–40 percent of O&M costs at a small WWTP (Moore 2012). More and more, WWTPs are not conceived of as waste disposal facilities but rather as resource-recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen) and produce renewable energy (Hoff 2011; Mairesse 2012). The caveat is that these alternative water resource procurement options are both capital and energy intensive and come at heavy economic and environmental costs (Siddiq and Anadon 2011; Siddiqi et al. 2013).

Water-Food Linkages

Water use within the Arab world has been growing at more than twice the rate of population increase. At the same time, there is an increase in the number of Arab countries which are reaching the limit at which reliable water services can be delivered (AWC 2011). Basically, demographic growth, economic development and climate change are putting unprecedented pressure on renewable, but finite, water resources (UNDP 2013a, b). This scarcity makes the problem of food production even worse due to the increasing competition for water within and between sectors, which result in transferring water out of agriculture and leaving less water for food production (UNDP 2009c, 2013b; Verner 2012). Over the last four decades, the Arab world has experienced a development boom, with rapid population growth (UNDP 2011). To meet the accompanying rising demand for food, many Arab countries have prioritized food security and socioeconomic development through policies to expand agricultural land and irrigated cultivation. But they have not carefully considered water's limited availability and the need for conservation and demand management (AFED 2010; El-Naser 2013; UNDP 2013b). Water scarcity has become a critical constraint to agriculture activities in the region (AFED 2010).

The current total cultivated area in the Arab Region makes up about 5 percent of the total global cultivated area, and it represents about 5 percent of the total area of the region (FAO 2008). The agriculture sector is the prime water consumer at the regional level, with annual average consumption up to 90 percent of the total water available (AWC 2010, 2011). Water use efficiency is as low as 30–40 percent (FAO 2008). Irrigated agriculture is widely represented in the Gulf countries and Egypt, where fully irrigated agriculture makes up 100 percent and 95 percent of the total cultivated area, respectively. Surface irrigation is the most widely used method in the region and is practiced on 80 percent of the irrigated area (UNDP 2013b).

In the absence of other economic opportunities in rural areas, poverty reduction is closely linked to water development for irrigated agriculture. Wise management of water is going to be crucial for food security and sustainable agriculture. Presently, the provision of water and food in the Arab Region is highly unstable, driven by individual or combined global, regional and national dynamics in energy prices, poor harvest, biofuels production, rising demand from a growing population, climate change, economic crises and political tensions (Abdel-Dayem and McDonnell 2012; Breisinger et al. 2012). For example, water is a fundamental part of the social context in the Arab countries. Along with subsidized food and fuel, governments provide cheap or even free water to ensure the consent of the public. However, recently as a result of the oil price increase, most subsidized commodities have been cut in the region; instability has followed accordingly (UN-ESCWA 2014).

Trading in agricultural products also means trading of the 'virtual water' embedded in the agricultural products (AFED 2010). Therefore, careful consideration must be given to capacity for each country to supply water and produce food and energy. These different capacities may exist within one particular country and certainly they exist to different degrees across the Arab Region. Regional strategies for the sustainable (from an ecological, economic and equity perspective) provision of energy, water and food across the region are worth pursuing. Agriculture is a major yet sensitive sector of the Arab Region's economy (UNDP 2011, 2013b). Although up to 90 percent of the region's water is extracted for agriculture as illustrated in Fig. 2.3, most countries in the region import more than 50 percent of their caloric intake (Abdel-Dayem and McDonnell 2012) as shown in Fig. 2.4. The agricultural performance indicators show that irrigation management is weak, characterized by deteriorating infrastructure, centralized administration, large irrigation bureaucracy, low irrigation service fees and limited participation of water users in maintenance tasks (UNDP 2013b).

Agricultural production in Arab countries is projected to grow by more than 60 percent between 2001/2003 and 2030 and more than double by 2050 (FAO 2006). Exactly how much water will be needed to meet

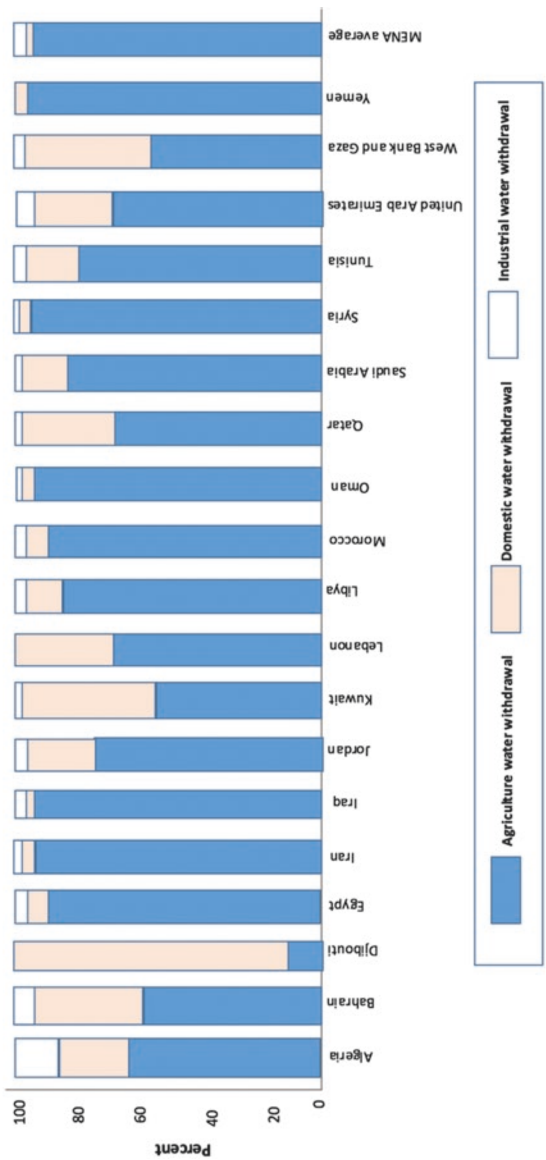

Fig. 2.3 Water withdrawal per sector in the Arab countries (Adapted from Abdel-Dayem and McDonnell 2012)

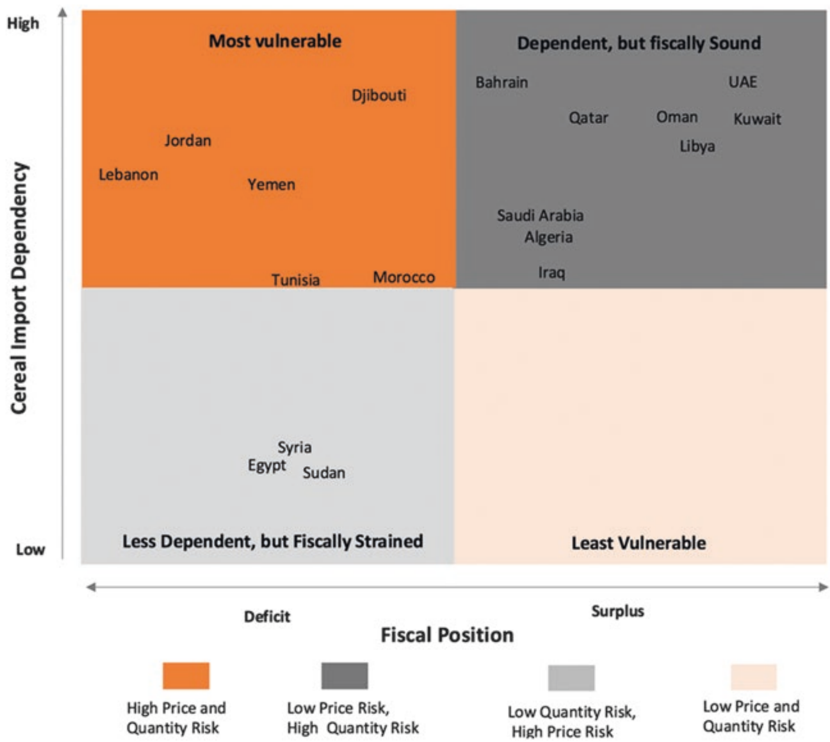

Fig. 2.4 Arab countries with high cereal import dependence and large fiscal deficits (Adapted from Lampietti et al. 2011)

projected food demand is still debatable; however, studies suggest that at least 20 percent more irrigation water will be needed by 2025 (Abdel-Dayem and McDonnell 2012; FAO 2006). This will represent a great challenge to water-scarce countries with limited surface water resources and non-renewable groundwater aquifers depleted at unsustainable rates, such as Saudi Arabia and Jordan (Kfouri 2013).

Energy-Food Linkages

As Fig. 2.4 illustrates in the case of cereal imports, the ability to purchase food is considered a fundamental reason for food insecurity in most of the Arab countries (Lampietti et al. 2011; UNDP 2013b). The large fiscal deficits and high rates of cereal importation make countries such as Yemen, Jordan, Lebanon, Tunisia, Morocco and Djibouti the most vulnerable countries. While GCC countries are dependent on imports, they enjoy fiscal surpluses that render them much less vulnerable (Lampietti et al. 2011). For instance, in Yemen, it has been estimated that 70–80 percent of cereal requirements alone are imported.

Energy availability is also a significant factor in food security. In 2010, Yemen's food security worsened due to soaring international food prices and fluctuations in energy prices. Low incomes meant that people could not purchase imported food but were at the same time unable to adopt widespread use of better irrigation techniques (e.g., diesel-powered water pumps). As a result, local production is hampered as 38.8 percent of households rely on rainfall for crop cultivation (El-Katiri and Fattouh 2011).

A 2009 study by Lampietti et al. confirmed this vulnerability. It points out that 'Arab countries are very vulnerable to fluctuations in international commodity markets because they are heavily dependent on imported food. Arab countries are the largest importers of cereal in the world [...] Most import at least 50 percent of the food calories they consume' (Lampietti et al. 2009). Moreover, the League of Arab States/UNDP study on food security and agriculture concludes that many of the underlying factors behind high and volatile prices are likely to persist

Water-Energy-Food-Climate Change Linkages

Based on Intergovernmental Panel on Climate Change (IPCC) estimates (2007), which were emphasized in the IPCC 2014 report, the Arab Region will be negatively impacted by climate change. The region will become hotter and drier. The higher temperatures and the lack of precipitation will jeopardize water quality and quantity, increase the occurrence of droughts and decrease agricultural productivity (IPCC 2007a; b; 2014a; b). Moreover, Verner (2012) argued that climate change also poses many challenges to the Arab cities, including warming temperatures (and associated heat waves and health hazards) and flooding (irregular precipitation combined with infrastructural inadequacies) (Verner 2012). Additionally, rising sea levels and coastal erosion could affect 43 port cities (UN-HABITAT 2012). For instance, in the case of Alexandria, Egypt, a 0.5-meter rise would leave more than 2 million people displaced, with $35 billion in losses of land, property and infrastructure, as well as incalculable losses of historic and cultural assets (WB 2013a).

The projected climatic changes will be among the most important challenges for agriculture in the twenty-first century, especially for developing countries and arid regions (IPCC 2007b). The Arab Region's WEF resources will be more vulnerable to climate change (Verner 2012). By the end of the twenty-first century, the Arab Region will face an increase of 2–5.5°C in the surface temperature (IPCC 2007b). This projected change will lead to shorter winters and dryer hotter summers, more frequent heat wave occurrence and more variability and extreme weather events. This increase will be coupled with a projected decrease in precipitation of up to 20 percent (IPCC 2007b; Verner 2012). Likely, the Arab Region's agriculture sector will be impacted by increasing water demand, decreasing crop productivity and reduced water availability in areas where irrigation is most needed or has a comparative advantage (Hermann et al. 2011).

According to the 2009 report of the Arab Forum for Environment and Development, based on the findings of the IPCC and hundreds of references, it is categorically stated that the Arab countries are in many ways among the most vulnerable in the world to the potential impacts of climate change, the most significant of which are increased average temperatures, less and more erratic precipitation and sea-level rise (AFED 2009). The region is highly vulnerable to the potential impacts of climate change because of their existing vulnerabilities, notably water scarcity and recurrent drought (Verner 2012). In addition, the current capacities and actions are inadequate, and effective strategies for mitigating and adapting to climate change are not yet developed (AFED 2009; Verner 2012).

Increased energy inputs will be required to satisfy water demand and offset reduced productivity. But of course, all things being equal, this will increase Arab countries' greenhouse gas emissions, which are currently less than 5 percent of the global emissions (IEA 2013) but are projected to rise to 9 percent by 2035 (Khatib 2010). In other words, climate change is expected to create a negative feedback loop of reduced socioeconomic development, sustainability and security in the region (Khatib 2010; Khoday 2011; UNDP 2011).

Yet according to some researchers, politicians in Arab countries have inadequately responded to the threat of climate change, as they have not given due consideration to adaptive governance policies and strategies for the WEF nexus, nor have they promoted the vital element of public participation in climate change decision-making processes (Verner 2012; Verner et al. 2013; WB 2012).

This section provided an overview and outlined the context of the Arab Region. However, Arab countries differ vastly in terms of their resource supply and demand, economic conditions, demographic trends and decision-making environment. There is a need to more closely examine some of these linkages in the context of specific countries. In the next section, we examine the case of Jordan and its capital city, Amman. The focus of this examination is institutions, policies and governance and three selected key layers of larger processes of interaction between WEF policies in response to climate change.

Jordan's National Context

Jordan is an Arab state located in western Asia. It covers an area of 89,297 km^2. Although a small country, Jordan has at least three different climatic regions: subtropical, Mediterranean, and desert (Badia). Approximately 91 percent of Jordan lies in arid and semiarid regions, which receive less than 200 mm of annual rainfall (MWI 2009). Only about 5 percent of Jordan's land mass is considered arable, while the country is among the world's four most water-deficient countries (MoEnv and UNDP 2013).

Jordan faces a number of overwhelming challenges as it attempts to address its development priorities. These challenges include a rapidly growing population and continuous influx of refugees, urbanization, high unemployment, water scarcity and reliance on expensive imported energy (McCornick et al. 2008; USAID 2012). Despite the government of Jordan's commitment to political reform and several positive steps that have been taken to contribute to sustainable development, there are remaining challenges to accountable, transparent and effective governance. Citizen participation in decision-making and public debate is low at both the national and local levels, and popular 'ownership' of Jordan's reform agenda is limited (USAID 2012).

Rapid population growth continues to pose a major challenge for Jordan's development. Between 1979 and 2012, the population grew from 2.1 million to 6.5 million (this does not include refugees), and at the current growth rate of 2.2 percent (DOS 2012), the population of Jordan is expected to double in about 30 years to 13.2 million (DOS 2012; MWI 2009; USAID 2012). In addition, the population density is concentrated in the governorates of the middle region (where the capital Amman is located) and the northern region (DOS 2012). This adds extra pressure on natural resource allocations, land uses and existing infrastructure (MOPIC and UN 2013). For example, the capital of Amman has grown dramatically from a population of around 2000 in the 1920s to 2.5 million in 2012—equal to 38 percent of Jordan's total population (DOS 2012). This population growth has been accompanied by economic growth and has resulted in growing demand on natural resources, especially water that must be conveyed from long distances. As of 2010, Amman receives around 50 percent of its water from the Jordan Valley. Water is pumped from 225 m below sea level in the Jordan Valley to a treatment plant, which is located at an altitude of 1035 m. The remaining water demands of the city are met from groundwater aquifers located 70 km east of Amman. To meet the growing demand on water, in 2013, Amman started receiving 100 million m^3 from the Disi aquifer—carried from southern Jordan through a 325 km pipeline. This results in an economically costly and possibly environmentally unsustainable misfit between where the majority of people live and where the natural resources are.

Water Sector Overview

Resources

Water is a scarce resource and a limiting factor to overall positive socioeconomic development of Jordan. In the year 2009, the renewable freshwater resources availability per capita was 130 cubic meter (m^3), which is well below the global water scarcity threshold of 1000 m^3 per person per year (MWI 2012b). Groundwater accounts for 57 percent of Jordan's overall water resources, surface water accounts for 30 percent, treated wastewater is at 11 percent and brackish water rests at 2 percent (Grover et al. 2010; MWI 2009). Interestingly, 68 percent of the supply is based on pumping groundwater or treating wastewater, both of which are generally more energy intensive than securing surface water supplies (MWI and AFD 2011; Siddiqi et al. 2013).

Historically, agriculture has had the highest share of water use in the country, but with rising population, the domestic (municipal) sector has increased its share over time. The water resources in the country are fully tapped, with the agricultural sector (irrigation and livestock) using

56 percent, the domestic (municipal) sector using 39 percent and the industrial sector using the remaining 5 percent of supply (MWI 2009).

Governance

Jordan's three important water-governing organizations are the Ministry of Water and Irrigation (MWI), Jordan Valley Authority (JVA) and the Water Authority of Jordan (WAJ). The MWI was created in 1988 to serve as a policy planning organization accountable for developing water and wastewater sector policies, strategies and long-term planning. The JVA was created in 1977 to manage the water supply in the Jordan Valley through dam construction, irrigation and drainage management for farmers, as well as the bulk supply of water for municipal and industrial users. At that time, the JVA was also responsible for land management and distribution outside of municipal boundaries and the development of touristic infrastructure around the Dead Sea. It currently acts primarily as a bulk water supplier to farmers in the Jordan Valley. Localized distribution and management responsibility is increasingly ceded to local Water User Associations. The WAJ was created in 1988 to focus on municipal and industrial water supplies as well as wastewater collection and treatment. Today, the WAJ continues to be responsible for these services in addition to supervising and regulating the construction of public and private wells outside of the Jordan Valley. The laws governing WAJ were amended in 2001 to allow for private-sector participation in the water sector. The utility sector was subsequently corporatized through management and service contracts but currently remains nationally owned (MWI 2012a).

Managing water resources in Jordan has been centralized and driven by supply-based strategy. Despite the significant improvements in water supply infrastructure, a critical and serious supply-demand imbalance remains. The key decision-maker in the water sector in Jordan is the Minister of Water and Irrigation. It oversees the JVA and WAJ (MWI 2012b; MWI and AFD 2011). Water demand in Jordan is divided across five major user sectors: (i) municipal water requirements, (ii) tourism, (iii) industry including new activities in oil shale and uranium mining, (iv) agriculture and (v) ecosystems and nature. Energy will add a sixth sector with the intended construction of nuclear power plants after 2020. Jordan's water demand policy entails various sectoral priorities, policies and development plans. Given the competing demands on a scarce resource, a coherent water demand management policy becomes necessary to reduce the overlaps in mandates, improve the cooperation between the stakeholders, increase water use efficiency and reduce conflicts (MWI and AFD 2011).

In response, the MWI developed its most recent comprehensive water strategy entitled 'Water for Life' for the period 2008–2022. It mainly focuses on effective water demand management, effective water supply operations and institutional reform. The strategy was updated in 2012 to include climate change as one of its principles and part of its vision (MWI 2009, 2012b).

Energy Sector Overview

Resources

Jordan has extremely limited oil and natural gas resources. In 2012, the local production share of total energy requirements was only 3 percent, while 97 percent of total primary energy supply was imported. Total spending on energy imports was equivalent to around 21 percent of the gross domestic product (GDP). Jordan's primary energy sources were 7,979 kilotonnes of oil equivalent (ktoe), crude oil and products 88 percent, natural gas 8 percent, renewable energy 2 percent and imported electricity 2 percent (MEMR 2014).

Jordan imports the majority of its oil from Saudi Arabia and secondarily from Iraq. Some processing of the crude oil is done at Jordan's only oil refinery at Zarqa. The country previously imported 80 percent of its gas needs from Egypt to generate electricity. The continued disruption of Egypt's natural gas supply, caused by bombings targeting the gas pipeline to Jordan in Egyptian territory, resulted in a 64 percent drop in the gas supply and a marked increase in the cost of energy imports in 2011. Jordan is therefore seeking to increase oil imports from Iraq and to import oil from the Gulf States and Saudi Arabia (Reegle 2012).

Primary energy consumption is expected to grow at a rate of 4–5 percent during the period of 2012–2020 (MEMR 2014; Reegle 2012), though oil price fluctuations will have an effect on the country's energy demands. Additionally, electricity consumption is predicted to grow at a high rate of 6 percent (MEMR 2014; Reegle 2012).

While Jordan is short of conventional crude oil reserves, it accommodates extremely large proven oil shale, uranium and renewable energy resources (ECS 2010; Saeedan 2011). One of Jordan's strategic objectives as outlined in the most recent national energy strategy (2007–2020) is to 'develop and utilize the local conventional and renewable sources of energy, oil shale, and uranium' (MEMR 2007). The government of Jordan anticipates the following energy primary resource mix by 2020: 40 percent crude oil and products, 30 percent natural gas, 10 percent renewables, 13 percent oil shale and 7 percent nuclear (MEMR 2014).

Governance

The Ministry of Energy and Mineral Resources (MEMR), established in 1984, is responsible for the energy sector in Jordan. The role of the MEMR is to define policy, fix tariffs and regulate all activities that have an impact on the energy sector. Moreover, the MEMR is responsible for all activities related to the exploration and development of minerals and hydrocarbons. In the oil sector, the Jordan Petroleum Refinery Company (JPRC) is responsible for crude oil refining, storage, transportation and distribution. It was established in 1957 as a private company with the exclusive right to invest in and operate petroleum refining and derivative industries, including the right to market, store and distribute all such products. JPRC's operations are regulated by MEMR in accordance with a concession agreement. The Jordan Electricity Authority has been responsible for the generation and transmission of electrical energy throughout Jordan since 1967 (Saeedan 2011).

Food (Agriculture) Sector Overview

Resources

Slightly less than 10 percent of Jordan's total land area is cultivated, but only 3 percent is used for agricultural production, and only 1–2 percent is irrigated—mainly in the Jordan Valley and highlands (Grover et al. 2010). This leaves the country heavily dependent on rainfall, a factor that has hindered agricultural growth and lead to unreliable production and the conversion of most rain-fed land to other uses (Verner et al. 2013).

Jordan's agriculture sector significantly contributes to the water crisis in Jordan through high water allocations, water overuse and pollution of surface and groundwater (Shatanawi et al. 2007). Over the last 30 years, there has been an increase in irrigated land area, along with a parallel increase in permanent crops such as fruit trees (Grover et al. 2010).

However, the total area of Jordan cultivated with vegetables has decreased from 49,000 ha in 2010 to 36,000 ha in 2012 as a result of the cessation of irrigation water supplies (FAO 2014).

There are several central challenges facing the food and agricultural sector in Jordan. These include food insecurity, rural poverty, the critical role of water-related constraints, urbanization and the resulting loss of farmland and the vulnerability of rural populations to the impacts of climate change and price volatility (Verner and Breisinger 2013). The primary crops are citrus and other fruits and vegetables, such as tomatoes, eggplants, cucumbers, cauliflowers and cabbages. Though small, and operated on a nomadic or seminomadic basis, livestock is also an important subsector. Animal production accounts for about one-third of agricultural output value, and sheep and goats account for about 90 percent of livestock output (Beintema et al. 2006).

Jordan is a food-deficit country with almost 85 percent of its food imported (Daher 2012). The country imports almost all of its cereals, pulses, vegetable oil and sugar requirements. It also imports between 20 and 50 percent of its beef and lamb meat, in addition to some fruits and vegetables. However, Jordan has self-sufficiency in dairy products, poultry, eggs and most of its fruit and vegetable requirements (Daher 2012; Forbes 2008; Verner et al. 2013).

Jordan's per capita external water footprint (1303 m^3/cap/yr) is slightly higher than the global average of 1243 m^3/cap/yr. However, Jordan's domestic, internal agricultural and industrial footprints are all lower than the global average. The balance is offset by higher external agricultural and industrial footprints, reflecting the fact that Jordan imports a lot of agricultural and industrial goods for local consumption (Grover et al. 2010; Mohtar and Daher 2012). Jordan is considered as highly dependent on virtual water; it imports around 6 billion m^3 of virtual water—mainly in wheat, barley, maize and meat (Magiera 2006).

According to a World Food Program Survey (2008), food prices in Jordan have witnessed an unprecedented increase as a direct result of the soaring global food prices. The country produces barely 3 percent of its annual cereal requirements and is totally dependent on oil imports for energy needs and, thus, was considered among the most affected by the crises as the consumer price index reached 168 in September 2008. Despite the fact that food prices declined substantially during early 2009, food security has emerged at the top of the government of Jordan's priorities. Food utilizes almost 37 percent of the Jordanian family's expenditures, and the impact is most felt by the poor with food being the major constituent of their consumption profile (WFP and JAAH 2008).

Governance

The Ministry of Agriculture is responsible for the formulation and implementation of national policies and programs aimed at achieving rapid agricultural growth through optimum utilization of the country's land, water, soil and plant resources (MOPIC and MoEnv 2009). However, the Ministry of Water and Irrigation oversees the supply of water to Jordanian citizens, municipalities, industry and agriculture. Within the Ministry, the JVA provides water to agriculture and oversees development within the Valley to ensure that water demand does not exceed availability (MWI and AFD 2011).

The government of Jordan has defined agricultural development as the core of integrated development of Jordan's rural areas (Isikil and Yercan 2005). In general, the last update (in 2009) to Jordan's agricultural policy aimed at contributing to the country's development, based on principles of efficiency, sustainability and equity while maintaining the objectives of increasing agricultural production and preserving the environment (FAO 2014).

Climate Change Impact and Governance

Climate Change Impact

Jordan depends mostly on rainfall as its main water resource. Recent years have witnessed rainfall shortages in different parts of the country. As a result, numerous streams have dried out, underground water levels have fallen to critical levels and most water aquifers are experiencing low water quality, which makes them unsuitable for domestic or irrigation uses. In addition, extreme weather conditions such as flash floods during winter and heat waves during summer are becoming more frequent in the region (Al-Bakri et al. 2010; Hamdi et al. 2009).

According to Jordan's recent, 'Jordan faces vulnerability and potential serious impacts on its natural ecosystems, on its river basins and watersheds, on biodiversity – then cascading to impacts on agriculture and food security/production, water resources, human health, public infrastructure, human settlements and socio-economic framework' (MoEnv and UNDP 2013: 12). Water and agriculture are the most climate change vulnerable sectors in Jordan (Al-Bakri et al. 2010; MoEnv and UNDP 2009).

Climate Change Governance

The Ministry of Environment (MoEnv) is the national focal point for the United Nations Framework Convention on Climate Change (UNFCCC). The Ministry operates under the mandate of Environment Protection Law which does not make a direct reference to climate change (MoEnv and UNDP 2013).

Though a National Climate Change Committee (NCCC) was formed by a decree issued by the prime minister in 2001, a climate change response is not yet fully mainstreamed within Jordan's development agenda. Climate change was not mentioned in any national sectoral policies until MoEnv's 2013 comprehensive national policy for climate change. This policy reflects priorities and objectives of various environmental and development sectors in Jordan. To make this policy effective, in 2014, MoEnv officially established within its structure a dedicated department for climate change to implement the policy (MoEnv and UNDP 2013).

Water-Energy-Food Linkages in Jordan

Jordan's most significant challenge is securing WEF to sustain socioeconomic development (FAO 2014; Siddiqi et al. 2014; Verdeil 2014). The significant and most sensitive components of the WEF equation in Jordan are water and energy: Water is extremely scarce, energy resources are limited and both are extensively and unsustainably used (Siddiqi et al. 2013). Additionally, food security cannot be achieved without both resources (Bazilian et al. 2011; FAO 2002, 2006, 2011).

Jordan is energy-poor, relying on fuel imports for 97 percent of its consumption (Scott et al. 2003; Verdeil 2014), and suffers extremely limited water resources (El-Naser 2013; MOPIC and UN 2013; Potter et al. 2010). Energy is needed for conveying, treating and lifting surface water, especially from the Jordan Valley (fresh water needs to be lifted 1400 meters), and for pumping groundwater, desalination and treating wastewater. Since almost all of this energy is supplied by imported oil, there are major consequences extending far beyond the water sector, not least of which is the massive carbon footprint (Siddiqi et al. 2013; Telfah 2012). Adding to that, there are few opportunities for alternative sources of water and energy, and energy imports come at a significant cost, both financially and from a foreign policy perspective (Scott et al. 2003). Thus, the water-energy challenge in Jordan relates to securing energy for water to meet the increasing water needs and demand of an expanding population, including the mass influx of refugees (McCornick et al. 2008; Scott et al. 2003).

According to Scott et al. (2003), energy and water pricing is another major issue in Jordan. Even prior to the recent increases in energy prices, Jordan used 25 percent of its electricity, primarily generated from oil imports, to manage its limited water resources (Scott et al. 2003). The annual energy bill has been rapidly escalating over the past few years and exceeded US$ 3 billion in 2006 due to high rates of population and economic growth combined with the successive increase in oil prices (Awad and Al-Mofleh 2012). It was estimated that 68 percent of the water supply is based on pumping groundwater or treating wastewater, both of which are generally more energy intensive than securing surface water supplies (Siddiqi et al. 2013). Water pumping consumed around 15 percent of Jordan's total electricity consumption (ECS 2010; Telfah 2012).

The water and food linkages in Jordan are complicated. The production of food in semiarid countries like Jordan is hardly possible without irrigation. In 2007, Jordan's irrigated agriculture consumed 64 percent of the annual water use (MWI and AFD 2011), and almost half of this percentage was groundwater, which is energy intensive (MWI 2012b). Recently, Jordan's government reduced the share of water allocated to irrigation and increased the allocation to domestic use. Jordan imports were close to 90 percent of its food (Forbes 2008). Importing 5–7 billion m^3 of water in virtual form per year is in sharp contrast with the 1 billion m^3 of water Jordan withdraws annually from its domestic water sources. Yet by externalizing its water footprint, Jordan places itself in a position of water dependency, which could be costly on economic, political and social levels (Haddadin 2003).

Jordan's future development scenarios will differently reshape the equation between water, energy and food. For instance, adopting an energy policy to develop unconventional energy resources such as oil shale and nuclear energy will intensify water demand, since both resources are water intensive (MEMR 2007; Siddiqi et al. 2013). Supplying adequate water is an avowed priority for Jordan's government (MWI 2009, 2012b). Both major supply-side options are energy intensive: The Disi Project involves the construction of a 325 km pipeline from the Disi aquifer, which lies on Jordan's border with Saudi Arabia (100 million m^3/year) (Potter et al. 2010), and the Red Sea–Dead Sea Project proposes building a 180 km pipeline to transfer 2000 million m^3/year of brine water from the Red Sea to the rapidly evaporating Dead Sea. There are also plans for desalination facilities to supplement other fresh water sources (Nortcliff et al. 2008; WB 2013b). Reducing the water allocations to irrigation will either promote growing less water-intensive crops or result in the importation of more food products. Both scenarios will have consequences for food policies and prices (MWI and AFD 2011).

Jordan's Local Authority: Greater Amman Municipality

Jordan's Law of Municipalities, which was amended in 2011, defines a municipality as 'a local institution vested with financial and administrative independence'. This definition alludes to some level of decentralization. Municipalities have 29 areas of responsibility which relate to standard urban services, such as cleaning, spraying insecticides, street lighting, construction and maintenance of roads, slaughterhouses, markets, public parks, libraries and town planning. Municipalities also have a general local development mandate (MOPIC and UN 2013; SOFRECO 2010).

Local administration in Jordan is composed of 100 municipalities and they are all connected to the central government. There is no hierarchal relationship among municipalities nor with other government agencies (MOPIC and UN 2013). Municipalities are subject to supervision by the Ministry of Municipal Affairs. The Greater Amman Municipality (GAM) is an exceptional case. It reports directly to the prime minister and possesses a statute different from those of other municipalities (SOFRECO 2010). In all municipalities, except GAM, the mayor and municipal council members are elected. In GAM, the mayor and half of the council members are still appointed. The municipalities have limited influence on political issues, given that most of their responsibilities are limited to service-oriented tasks. In addition the central government does not allow them to intervene in political debates (UCLG 2013).

The GAM is a financially independent private corporation divided into 27 administrative districts. GAM functions are administered by the GAM Council, which includes the mayor of Amman (council president) and is the municipality's highest governing body. Amman's mayor is considered to be at the top of the administrative pyramid in the municipality's organizational structure (SOFRECO 2010).

GAM covers an area of 1680 km^2 and has a population of 2.5 million (DOS 2012). GAM is situated in the highlands of northwest Jordan, with an elevation ranging from approximately 800 to 1000 meters above sea level. Its Mediterranean climate is defined by cool, wet winters, during which almost all of its annual 250–480 mm precipitation occurs (including occasional snowfall), and hot, dry summers (UNDP 2008).

Managing WEF Resources at Municipal Level

The world's urban population has multiplied tenfold during the past century, and within the next decade, there will be nearly 500 cities of more than a million people, including several 'megacities' with populations exceeding 20 million (UN-HABITAT 2011). Cities are also the center of economic, social and political activities, and there is a growing resonance in considering the city level as a means to effectively manage natural resources (Alber and Kern 2008; UNDP 2006).

Though the global discourse does not explicitly identify a role for cities and local governments in managing natural resources and responding to climate change (UN-HABITAT 2011; WB 2010), national governments will not be able to meet their international commitments for addressing mitigation and adaptation without localized action (UN-HABITAT 2011). Rosenzweig et al. (2010): 910) argue that 'compared to national politicians, city leaders seem willing and able to take action to protect their cities against these threats and to help make a global difference.'

Arab cities face rapid urbanization which is often unplanned (Verner 2012). This results in the creation and expansion of informal settlements, which are highly vulnerable to climate events; the destruction of natural environments which act as a buffer to climate change impacts; and the design of inadequate drainage and wastewater management systems, which can make the consequences of extreme weather events more severe (UN-HABITAT 2012; Verner 2012).

In many Arab countries, the history of state-centered management is being challenged (UN-ESCWA 2009) (UNDP 2011). The Arab Spring illustrated that social groups are demanding democratic representation (Breisinger et al. 2012; El-Naser 2013; UNDP 2011) after years of unequal and inconsistent access to political power and wealth (UNDP

2009a). At the Arab regional level, relying for a long time on powerful national governments has meant that local governments and municipalities have an underdeveloped capacity to manage natural resources and mitigate and adapt to climate change (Verner 2012). Some analysts argue that increasing climate resilience in the Arab Region requires a diverse set of policy actions focused on different time horizons and different actors, including all levels of government, private sector, civil society and households (UNDP 2011; Verner 2012).

According to the Law of Municipalities in Jordan, there is no hierarchal relationship between municipalities and other government agencies. Planning is done mostly through vertical lines with top-down control and centralized budgets (Siddiqi et al. 2013). For instance, managing natural resources are functions of the central government in Jordan (e.g., water and energy supply are not municipal functions). Water resources are managed by the MWI, food (agriculture) resources are managed by the Ministry of Agriculture and energy resources are managed by the Ministry of Energy and Mineral Resources (MOPIC and UN 2013).

In the case of the Greater Amman Municipalities, Jordan Water Company-Miyahuna, a limited liability national company, operating under a mandate agreement with the WAJ, is responsible for the management of water and sewage services within the GAM boundary (Miyahuna 2012). Likewise, urban agriculture activities within the GAM boundary are administered by the Ministry of Agriculture. Also, electrical energy planning, forecasting and distribution is the responsibility of the Ministry of Energy and Mineral Resources and the publicly owned Jordan Electric Power Company (ECS 2010; MEMR 2007).

The example of Greater Amman Municipality demonstrates the limited role that local governments play in Jordan's policy formulation, natural resources planning and management. However, cities are responsible for the major consumption of WEF, and this consumption is expected to grow further with population, urbanization and economic growth (WEF 2011b). Yet, patterns of consumption of energy, water and food in cities have conventionally been addressed independently (Walker et al. 2014).

The WEF nexus or interconnectedness is the subject of increasing attention in research and practice, yet scholarly attention has been on addressing global and national levels with limited focus on urban or local levels, whereas cities can also provide solutions for reducing consumption and emissions because of their population density, potential efficiency and ability to adopt innovations and new technologies (Hoornweg et al.

2011). Governance at the city scale matters, as do the links and relationships with institutional and governance arrangements at other spatial scales. Given that cities are concentrated centers of population and economic activities, any impact or disruption, whether natural or human induced, has the potential to affect vast numbers of people (Chua 2014; Walker et al. 2014). Cities require balanced assessments of nexus security over the many flows of pre-consumption resources into the city and of post-consumption resources out of the city (Beck and Walker 2013).

Therefore, understanding the synergies among many elements of the urban system increases the scope for maximizing the benefits of innovation, technology and policy implementation. On the other hand, ignoring these interactions can reduce the positive impact of initiatives that are implemented in an uncoordinated, isolated fashion and focused on a single technology or innovation.

Water-Energy-Food Nexus Problematic Aspects

Despite the strong relationship between the three, the WEF nexus approach has not been fully addressed or considered while planning and managing these resources in most Arab countries (Al-Zubari 2012). However, in recent years and as water scarcity and demands increase, many Arab countries have started to realize the growing importance of such an approach and have started initiatives calling for integration across these three sectors (Al-Zubari 2012; Raouf 2013). Nevertheless, the following aspects still significantly hinder the transition from a 'silo approach' to a 'nexus approach' in the Arab Region.

Ineffective Governance

The World Bank has defined good governance as 'epitomized by predictable, open and enlightened policy making; a bureaucracy imbued with a professional ethos; an executive arm of government accountable for its actions; and a strong civil society participating in public affairs; and all behaving under the rule of law' (WB 1994: vii). As a whole, the Arab Region lags behind other regions in most governance indicators, which indicates poor governance. For example, the Arab countries undergoing political transitions rank low in terms of voice and accountability index (the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association and a free media) (UN-ESCWA 2014).

The absence of good governance in managing the natural resources is perhaps the most serious long-term development challenge facing the Arab Region (UNDP 2011). Ineffective governance institutions, corruption and lack of transparency prevent Arab governments from providing adequate protection against increased water scarcity and food and energy insecurity (El-Naser 2013). Similarly, The United Nations Development Programme Report (2013a, b) on 'Water Governance in the Arab World' concluded with some guiding principles and recommendations that can help realize effective water governance in the Arab world. These included decentralization, reorienting policies, instituting reform, addressing inadequate and weakly enforced legislation, empowerment, sustainability and addressing water-related challenges and nexuses (UNDP 2013b).

Undoubtedly, without good governance, most Arab countries cannot address the environmental, social and economic barriers that undermine sustainable development (UN-ESCWA 2013; UNDP 1994, 2011, 2013b). Good governance is key to sustainable development (UNDP 2011). Improving the mechanisms, processes and institutions, and supporting the ability of individuals to participate in developing their own societies, can ensure accountability and transparency in how natural resources are managed, while addressing the shortfalls and gaps of current Arab governments' policies (AFED 2011; UN-HABITAT 2012; UNDP 2011).

The local governance system in Jordan has been in a slow but inconclusive transition toward decentralization. The government has mainly approached administrative de-concentration from the local development planning angle. Governorate administrations still have limited executive and financial powers. Attempts have been made to reconcile vertical and horizontal planning streams, but there are unresolved issues regarding the distribution of roles between main ministries. There have been numerous efforts to establish participatory local development practices at the municipal level over the last ten years, but since they were mostly externally driven by donors, they have lacked consistency and institutionalization (MOPIC and UN 2013).

Jordan's Law of Municipalities falls short of establishing viable institutionalized mechanisms for citizen participation in policymaking and in holding local authorities accountable, other than through regular elections. There are no strong incentives for a more inclusive, transparent and more accountable governance style by local officials. Participation schemes are usually donor-driven, and there have been few efforts to develop a national policy in this area. However, the Greater Amman Municipality has set up neighborhood committees, which it uses to consult with local residents and increase their role in decision-making (MOPIC and UN 2013).

Fragmented Institutions and Incoherent policies

Most Arab countries have developed independent WEF institutional and legislative frameworks, with limited integration and coordination between these institutions (Raouf 2013). For example, many Arab countries have implemented institutional reforms in their water and agriculture sectors by separating water authorities from agriculture authorities (UNDP 2013b). In most cases, this leads to duplication in institutional mandates and conflicts between policies (Jubeh and Mimi 2011; Kfouri 2013; Mirkin 2010; UNDP 2009a, 2013b; Urwin and Jordan 2008). For example, lack of effective coordination between water and agriculture sectors during the last three decades resulted in government's policies ignoring water scarcity and strongly encouraging agriculture development via subsidies on water and fuel and low interest rates on loans for digging new water wells or securing equipment (UNDP 2011, 2013b). This led to unsustainable agricultural growth and practices and has serious negative implications on water resources (UNDP 2011).

Nilsson et al. (2012: 396) defined policy coherence as 'an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives'. Work on policy coherence has identified different types of coherence, such as horizontal, vertical and internal coherence (Nilsson et al. 2012). Greater emphasis on synergies between policies is needed to create win-win scenarios and engage other policy actors beyond those involved in development (OECD 2014). The emerging policy coherence challenges are shaped by a number of major global trends and population dynamics, including changes in food consumption patterns, urbanization, natural resource scarcity and climate change (OECD 2014). Moving from a sectoral to a cross-sectoral policy approach, and from identifying competing objectives to identifying common challenges, is fundamental to understanding the diverse dimensions of development challenges (OECD 2014; UNDP 2011). For instance, water demand competition is growing among other sectors, including those of expanding urban centers, industry, energy production, electricity generation and aquatic systems (UNDP 2013b). The aforementioned water uses leave nations with serious water security challenges and may raise conflicts between stakeholders. Therefore, balancing water supply particularly in countries with limited water resources and fast-growing populations is a big challenge requiring better horizontal and vertical coordination (Verner 2012; Verner and Breisinger 2013).

Most Arab countries' WEF policies are incoherent. Additionally, most Arab countries' governments have invested in WEF supply-side policies and infrastructure such as developing new resources, improving accessibility, securing reliable supply, while the focus on demand-side policies (e.g., efficiency, conservation, etc.) is still limited (Sowers et al. 2011). For instance, the current WEF policies (e.g., subsidization, low tariff, etc.) are meant to address equity issues but result in low efficiency and productivity, depletion of resources and unsustainable practices. The sustainability of any natural system depends on the dynamic interactions among the users and the policymakers (Aljanabi 2012).

Centralization and Limited Social Actor Participation

Decentralized governance of natural resources is considered one of the key strategies for enhancing efficiency, equity and justice in the management and use of natural resources (UNDP 2009b). Most Arab countries are characterized by a top-down, personalized, highly concentrated mode of governance (Kaufmann 2011). The policy development and planning processes in the Arab countries are highly centralized (central governments develop national, regional and local policies and plans, while municipal authorities implement local plans) (UN-ESCWA 2014; UN-HABITAT 2012). Decentralization entails the process of transferring some of the decision-making powers and responsibilities (fiscal, administrative, legal and technical) from central government down the geopolitical and administrative hierarchy to lower levels. It improves the flow of information and resources between and among various levels of government (UNDP 2009b).

Central governments are often blamed for being too far from the realities of people (Saito 2008). Thus, transferring various forms of authority and functions to subnational units of government for timely adaptation to locally specific conditions is considered to be an effective solution to today's compounded problems. Doing so is said to encourage genuine participation and representativeness of end users of local resources in development planning and practices while fostering local ownership and sustainable use of natural resources (UNDP 2009b). This should allow local governments to utilize limited resources more effectively than central governments (WB 2000).

For example, water management in the Arab world is centralized (UNDP 2013b). Richards (2001) argued that decentralization and devolution would be essential for future strategies for coping with water scarcity. Ultimately, there is simply no other choice. The inefficiencies of large, top-down, supply-enhancing approaches cannot continue to deliver the same volumes of water as in the past. Strategies of managing water scarcity certainly pose political implications. All responses to the crisis will provide opportunities for cooperation and creativity, but will also contain consequences and potential for conflict (Richards 2001).

Most Arab country governments have thus far seen little reason to seriously engage with societal actors in policy development and dialogue. Legacies of centralized systems of planning, taxation and revenue distribution have rendered multi-scalar governance mechanisms. Cities, provinces and other subnational levels of government are not significant players in identifying vulnerable populations or planning and managing WEF resources (Sowers et al. 2011).

Conclusion

Research shows the significance of the WEF nexus approach in increasing resource use efficiency, enhancing policy coherence, providing a comprehensive base for allocating scarce resources, enhancing security, reducing tradeoffs, building synergies and improving governance across sectors. However, there are knowledge gaps still requiring research and exploration such as: implications for policy, supply-side versus demand-side solutions, the three-way nexus, the integration of climate change, the urban nexus and users' perspectives and public participation.

Exploring the relationships between WEF resources in the Arab Region through the nexus lens emphasizes the strong linkages among the three sectors and shows how any strategic decision in any sector strongly influences the others. This chapter emphasizes that the Arab Region's development priorities and policies were shaped by the inherited, cartelized government systems and driven by largely reactive and modernization-centered responses to social, economic and climatic conditions over the last three decades.

The newly introduced WEF nexus approach to the region's policy dialogue highlights challenges for further research and investigation: disjointed policies and institutional fragmentation, limited social actor participation, limited cross-sectoral (vertical and horizontal) strategic planning and incoherent sustainable development policies.

Notes

1. 'An attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives' (Nilsson et al. 2012).
2. Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, State of Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen.

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CHAPTER 3

Natural Capital Accounting and Ecosystem Services Within the Water–Energy–Food Nexus: Local and Regional Contexts

Natasha Tang Kai

Introduction

The demand for water, food and energy is steadily increasing; growth is expected at 30–50 percent in the next two decades (WEF 2011). Economic interests favor short-term responses in production and consumption but, in turn, undermine long-term sustainability. Shortages in water, energy and food could cause social and political instability, geopolitical conflict and irreparable environmental damage (WEF 2011). A further complexity is balancing the elements of the water, energy and food nexus with climate change and its impacts on the availability of water for drinking, food production, ecosystems and changes in energy consumption (Thirlwell et al. 2007; Waughray 2011; Bazilian et al. 2012; Van Vuuren et al. 2012). The interconnections between water, energy and food are central to management and sustainability.

Current environmental impacts are measured in terms of tonnes of carbon and cubic meters of water while business performance is measured in

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dollars and cents. Measuring and integrating sustainability is difficult as decision-makers are comparing apples to oranges. Natural capital valuation is one way to help knock down this barrier by putting a monetary value on environmental resources, from pollution impacts to water dependency and land use (Richens 2014). 'This gives clarity on how much they depend on nature to generate revenue, what its pollution and natural resource consumption is costing the planet and society, and provides a common metric to truly embed sustainability in decision-making' (Richens 2014: 1).

In this chapter, the concept of natural capital accounting for ecosystem services in the context of the water, energy and food nexus is explored. Natural capital accounting current thinking and applications within the nexus is identified, including a look at its usefulness in future planning and development decisions, particularly at the local and regional level.

Natural Capital Accounting (NCA) and Ecosystem Services

The concept of natural capital accounting has been around for several decades and was brought to the forefront at the 1992 Earth Summit. However, it did not gain much traction largely due to a lack of widely agreed methods for putting monetary values on nature and its services. In the past decade, the concept of measuring natural capital has gained credibility through methodologies developed by The Economics of Ecosystems and Biodiversity (TEEB), the United Nations System of Environmental-Economic Accounting (SEEA), and the World Bank through the Wealth Accounting and Valuation of Ecosystem Services (WAVES).

'Natural capital is the land, air, water, living organisms and all formations of the Earth's biosphere that provide us with ecosystem goods and services imperative for survival and well-being. Furthermore, it is the basis for all human economic activity' (IISD 2013: 6). Natural capital includes 'visible' resources such as minerals, energy, timber, agricultural lands, fisheries and water. It also includes nature's vital services which are 'invisible' to people, such as air and water filtration, flood protection, carbon storage, pollination for crops and habitats for fish and wildlife (WAVES 2012). These invisible services performed by nature's ecosystems are called ecosystem services. Natural capital accounting is the measurement of the visible and invisible forms of nature. The Natural Capital Approach therefore enables the 'identification, quantification and valuation of ecosystem services leading to better decision-making for managing, preserving and restoring natural environments' (Voora and Venema 2008: 8). The United Nations Statistics Division developed the 'System of Environmental and Economic Accounts' (SEEA), 'an internationally agreed upon set of standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics, on the environment and its relationship with the economy' (UN 2012). Within this framework are a number of sub-accounting systems to measure different components and services of nature such as water and land accounts.

Ecosystem services are categorized into four groups—provisioning, regulating, supporting and cultural services—which are illustrated in Fig. 3.1. Ecosystem services have direct and indirect dependencies. For example, within the water, energy and food nexus, 'Land is needed for food, for energy (e.g., to grow biofuel crops), for hydropower (reservoirs), and for ecosystem conservation. Water is needed for food and for energy, and energy is needed for water (to secure, deliver, treat, and distribute it). Energy is needed for agriculture and for processing, transport, and cold storage of food while, energy and water resources are used for the collection, treatment, and disposal of wastewater and solid waste' (ICIMOD 2012: 2). These types of interconnections are not only difficult to measure but present many management challenges.

Approximately 60 percent (15 out of 24) of the ecosystem services examined during the 2005 Millennium Ecosystem Assessment were

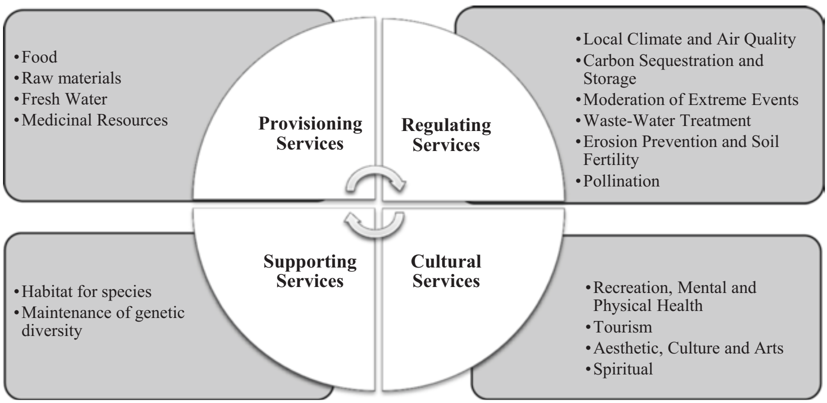

Fig. 3.1 Types of ecosystem services (based on information presented in MEA (2005); see http://www.millenniumassessment.org/documents/document.300.aspx.pdf)

degraded or used unsustainably, including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards and pests (MEA 2005). The full cost of the loss and degradation of these ecosystem services are difficult to measure, but available evidence demonstrates that they are substantial and growing (MEA 2005). Many of these resources directly support the livelihood of 90 percent of the 1.2 billion living in poverty (World Bank 2004), 500 million people who depend on coral reefs (Wilkinson 2004) and 80 percent of the population in developing countries who rely on traditional medicine from local plants (WHO 2008). Many efforts are underway across the globe to foster more sustainable management of natural resources, for example, ecosystem services are built into five Millennium Developments Goals (MDGs) and across most of the Sustainable Development Goals (SDGs) (Table 3.1).

For those of us living in developed nations, the connection with nature can be largely indirect since much of our food is purchased in a supermarket, we buy pre-built homes, water comes through our taps, and electricity is derived at the flick of a switch. Whether direct or indirect, our reliance and dependence on nature (the seen) and its ecosystem services (the unseen) is a vital relationship. Understanding its true value

Table 3.1 Ecosystem services linked to the MDGs and SDGs

SDG and MDG	*Ecosystem services linked to targets*
SDG 1: No poverty SDG 2: No hunger MDG 1: Eradicate extreme poverty/hunger	The availability of food, fuel wood, water and biodiversity directly influences the minimum standard of living and hence the incidence of poverty and hunger
SDG 5: Gender equality MDG 3: Promote gender equality and empower women	The availability of fuel wood and water reduces the burden that falls mainly on women and helps to improve gender equality. Women's income is often directly dependent on ecosystem services (e.g., collection of non-timber forest products)
SDG 6: Clean water and sanitation MDG 4 and 5: Reduce child mortality. Improve maternal health	Availability of clean water, clean air, plants for medicinal use and biodiversity can reduce the spread of diseases. Healthy ecosystems help to provide all the above
SDG 14: Aquatic sustainability SDG 15: Terrestrial sustainability MDG 7: Ensure environmental sustainability	The natural capacity for wastewater treatment, soil formation and other regulating and supporting ecosystem services help maintain the resilience of ecosystems and biodiversity

Source: TEEB 2010:15 and UN 2015

may encourage more informed decision-making. Unfortunately, in few economic discussions are the values or potential values of nature understood. According to TEEB (2010), some of the issues associated with a lack of understanding of the full cost of natural ecosystems include:

- The role of nature and its intrinsic value are underutilized. Development strategies therefore focus on economic growth.
- Due to its invisibility, the full value of nature is not well understood (e.g., wetlands as a source of wastewater purification and regulation).
- An intensified use of natural ecosystems from too many competing demands on nature.
- The degradation of nature is most times not immediate, there is a time lag (e.g., the loss of vegetation that stabilizes slopes and retains rainwater in soils is only noticed when landslides and flooding occur).
- Incomplete understanding of the natural cause and effect of our actions (e.g., clear cutting a tropical forested area could lead to a loss in biodiversity and species displacement).
- The return on private investment from exploiting nature is quantified more easily, while the public benefit can be taken for granted.
- Those concerned with natural resources lack the power and money in decision-making circles; decision-making is often fragmented.
- Collaboration among various stakeholders and agencies, levels of government and interest groups, is important for collective interests and issues to be addressed, to strengthen institutional capacity and governance.

At the local scale, policy makers can influence the benefits that natural assets provide through local development. For example, enhancing forested water catchment areas provides water for both drinking and irrigation, increasing green spaces in cities improves urban climates and air quality, securing mangrove belts supports coastal protection against floods and protecting beaches improves local quality of life and attract tourists (TEEB 2010; FAO 2007). The key challenge is balancing economic growth, biodiversity and quality of life for residents. Protecting natural resources and biodiversity is sometimes perceived as an impediment to local development when, in fact, it could enhance it. A municipality for example, 'can save money by securing water provision, waste-water treatment, and protection against erosion or floods more effectively and efficiently through natural rather than technical solutions' (TEEB 2010: 13).

At the regional scale, many resources such as water from transboundary rivers are governed by many local, regional and national stakeholders. The food, water and energy nexus has a strong regional element where upstream actions often have downstream impacts (Rasul 2014). Taking into account the transboundary nature of ecosystems offers opportunities to enlarge planning horizons, increase economies of scale, identify trade-offs and maximize synergies in food, water and energy (Bach et al. 2012; Grey and Sadoff 2007).

Ecosystem Services Within the Water, Energy and Food Nexus

There are several conceptual frameworks that simplify the complex and interconnected nexus. The International Center for Integrated Mountain Development (ICIMOD) whose regional focus is the Himalayas and South Asia, developed a framework where ecosystem services are a critical component, offering a system-wide approach. This approach presents policies and strategies to enhance food, water and energy security in South Asia. Examples include the restoration of natural water storage capacity, development of climate-smart, environmentally and socially sound infrastructure, and incentive mechanisms for managing Himalayan ecosystems (ICIMOD 2012). The premise of ecosystem services here is a holistic one, whereby, all ecosystems naturally produce multiple ecosystems but they all work in harmony with each other. The ICIMOD conceptual framework builds this system-wide approach at its core to achieve sustainable water, energy and food security given scarce resources (see Fig. 3.2).

Water

Within the context of water, wetlands in particular are a fundamental part of local and global water cycles and at the heart of the water, energy and food nexus. Wetlands provide many ecosystem services such as clean water for drinking, water for agriculture, cooling water for the energy sector and regulating water quantity for flood regulation (TEEB 2010). Despite these and many other benefits, wetlands are continuously being degraded or lost due to intensive agricultural production, irrigation for food provision, water extraction for residential and industrial use, urbanization and pollution (TEEB 2010). Since 1900, the world has lost around 50 percent

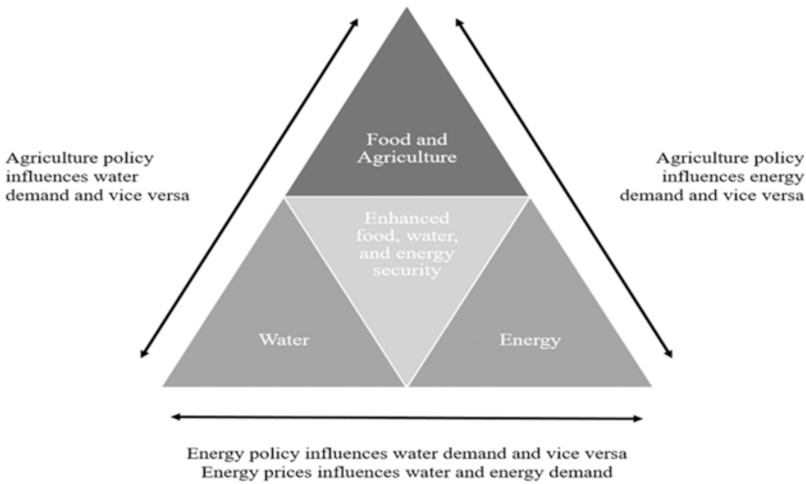

Fig. 3.2 Ecosystem services within the food, energy and water nexus (Source: Adapted and simplified from Rasul 2014).

of its wetlands (UNWWAP 2003). Recent coastal wetland loss in some places, notably East Asia, has been up to 1.6 percent per year (TEEB 2012). A key reason wetlands are slowly being degraded is lack of knowledge of their full value in order to make more informed social, economic and environmental decisions. The United Nations valuation method 'System of Environmental-Economic Accounting for Water' (SEEA-Water) is a systematic tool for collecting and collating biophysical water-related data into monetary and non-monetary terms. According to the UN (2012: 7–8), the SEEA-Water accounting system is made up of the following five categories:

- Category 1: *Physical supply and use tables and emission accounts* comprise hydrological data on the volume of water used and discharged back into the environment by the economy, as well as the quantity of pollutants added to the water.
- Category 2: *Hybrid and economic accounts* align physical information recorded in the physical supply and use tables with the monetary supply. For example, it links volumes of water used with monetary information on the production process, such as value added, and derives indicators of water efficiency.

- Category 3: *Asset accounts* measure water resource assets in mostly physical terms. These accounts are particularly useful because they link water abstraction and return to the availability of water in the environment, thus enabling the measurement of the pressure on physical water induced by the economy.
- Category 4: *Quality accounts* describe the stocks of water resources in terms of quality. They show the stocks of certain qualities at the beginning and the end of an accounting period, describing only the total change in an accounting period, without further specifying the causes. This category is currently experimental.
- Category 5: *Valuation of water resources* is also currently experimental as no agreed standard method for compiling this information has been established.

The World Bank's Wealth Accounting and Evaluation of Ecosystem Services (WAVES) program is a global partnership to mainstream natural capital accounting in countries across the world, with a particular focus on the Global South. WAVES already has established extensive working relationships in Botswana, Colombia, Costa Rica, Madagascar, Rwanda, Guatemala, Indonesia and the Philippines. At a local level, Box 3.1 presents an example of the utility of natural capital accounting in the Credit River watershed in Ontario, Canada.

Box 3.1 Estimating the Value of Natural Capital in the Credit River Watershed

The Credit River watershed is situated in a very densely populated part of the Greater Toronto Area in Ontario Canada. The river and roughly 1500 km of its tributaries drain almost 1000 km^2 of land. With a growing population and increasing land use intensification within the watershed, a 2009 report prepared by the local conservation authority and an environmental think tank set out to educate and build awareness of natural capital and to demonstrate the importance of natural capital and ecological service values when making land-use decisions in the watershed. The evidence-based report found the minimum total value of ecosystem services in the watershed was estimated at \$371 million per year, with waste treatment being the most valuable ecological service provided by the watershed at \$137 million per year. Annual water supply was valued at \$100 million, climate regulation $41 million and a number of riparian services valued at $35 million. The report provided several recommendations for research and policy, such as a need to invest in a robust framework for measuring and tracking natural capital, to invest in natural capital education and awareness, as well as the need to provide incentives for the conservation of ecological services.

(Source: Kennedy and Wilson 2009)

Energy

'The goods and services provided by ecosystems through their supporting, provisioning and regulating services underpin most of the energy services we use daily' (IUCN 2008:5). Some of these provisioning services in the form of raw materials include biomass and biofuels, and regulating services such as soil formation, climate and water regulation and pollination. Water is an especially important ecosystem service in many energy production options. Box 3.2 presents an example of a sustainable energy-based initiative in small island states.

Box 3.2 Rural Electrification from Copra in Pacific Island Countries (PICs)

'Many Pacific Island Countries (PICs) are dependent on imported petroleum for commercial energy. However fuel supplies are often erratic and costs rise as the distance between fuel source and use increases. High fuel costs relative to the small economies of these PICs limits socio-economic development. Copra, the dried meat, or kernel of the coconut is a potential fuel source. Once processed the efficiency and power output of copra oil is roughly equivalent to that of diesel. Moreover its impact on the fragile island ecosystem is less than that of imported diesel fuel. Using copra as a local fuel source can lead to higher energy independence, a decrease in real costs and greater local value added to the crop. The rehabilitation of coconut groves can contribute to adaptation strategies by stabilizing erosion and providing local income through harvesting and processing. As coconut grows in coastal areas, valuable land is not removed from agriculture. Ecosystem preservation can be encouraged through coconut grove management'.

(Source: IUCN 2008: 6)

The energy sector impacts to ecosystem services are complex and require a more detailed review. They are simply referenced here to highlight their importance. Some examples include the ecological footprint of energy operations and infrastructure leading to significant habitat degradation. The Keystone XL project—a proposed 1879 km pipeline to transport oil from Alberta, Canada, through the United States to join an existing pipeline in Steele City, Nebraska, and then on for export at Port Arthur, Texas—is a good example of this issue, particularly regarding the costs versus benefits of large-scale, carbon-based infrastructure projects (see http://www.bbc.com/news/world-us-canada-30103078). It is important to note, however, that large-scale renewable energy options, such as solar and wind, can also be problematic given their extensive demand on nature for land and water. According to the IUCN (2010: 1), 'Energy security is the reliable supply of affordable energy, of which there are two dimensions – reliability and resilience'. Energy is a key provisional service of ecosystems but unsustainable use can undermine the integrity of ecosystems. Energy reliance on water is inextricably linked. For example, hydropower facilities at every scale rely on water flows; biofuels depend on healthy soils, water and pollinators; fuel wood and charcoal is derived from forest systems; fossil fuels require water for processing; and power facilities rely on water for cooling. Agricultural-based energy production of corn and soy for products such as biofuel development, is very water intensive.

Energy reliability is closely linked to ecosystems, and in nature, there are limiting factors for energy development. For example, water availability is linked to rainfall patterns and water table levels, and biomass-based energy systems are vulnerable to ecosystem degradation, particularly the forests which also provide fuel, wood and charcoal (IUCN 2010). Similarly, since industrial-scale biofuel markets turn to next-generation technologies, marine and freshwater environments will be limiting factors (IUCN 2010). Energy reliance 'is the ability of the system to cope with shocks and changes' (IUCN 2010: 3). The traditional approach to energy security has been securing reliable supplies of energy. Current thinking on energy security has to now factor climate change into generation and supply-side issues. Impacts from climate change to energy producers can include agricultural disruption, changes in the growth rates of biomass for fuel use, increased runoff and siltation from land degradation (affecting hydro-generation) and losses or fluctuations in hydropower production due to increased stresses on water supply systems and changing rainfall patterns (IUCN 2008). Energy systems have to move beyond securing supplies of energy and move to building resilience in light of the many complexities associated with this sector, such as climate change. To be resilient, energy systems should be designed based on an integrated approach which considers environmental, economic, technical and social aspects. Several of the most well-known mechanisms and approaches to understanding the relationship between energy systems and ecosystems include tools such as ecosystem valuation, environmental impact assessments, stakeholder engagement and community engagement.

Food

Food is discussed in the context of agricultural commodities. 'Agriculture is the single most important sector in providing the basic necessities for human existence' (TEEB 2010: 132). By 2050, with expected economic growth, increased purchasing power from income growth, new food preferences and population estimated at 9 billion people, there inevitably will be an increase in nutritional demand and strain on the resources used for food production (Kruse 2010). For agriculture to continue to supply the growing demand, it must rely on a set of complex interdependent and functional relationships between soil, crop production and animal husbandry. Other key dependents include its relations with forestry, wetlands, pollinators and natural predators (Kruse 2010). According to the 2005 Millennium Ecosystem Assessment, 'both the intensity of production and growth in the area cultivated are increasingly affecting ecosystem services', with soil and water quality deterioration centrally impacted. Ecosystem services likely to be affected include air quality from livestock stables and feedlots emissions, water and aquatic systems from animal effluent and runoff from agricultural fields, which contain fertilizers, pesticides, hormones and nitrates (TEEB 2010). Biodiversity may also be threatened by intensive agricultural systems, while climate change may be impacted from deforestation of tropical forests (TEEB 2010).

For local policy makers, agricultural development requires a whole-system approach, one that brings together an integrated ecosystem perspective to agriculture. It needs to be 'tailored to the particular opportunities and requirements of the ecosystem' (TEEB 2010: 86). Local policy support can range from advisory services such as land-use alternatives, long-term investment supports to poor farmers or invest-

Box 3.3 Utility of the Ecosystem Approach to Water Management in Agriculture, Sri Lanka

Early rice production irrigation systems used tanks that retain river runoff for irrigation agriculture. The tanks also provided goods such as fish, lotus flowers and roots, diversifying household incomes. Given water demands through modern large-scale agriculture and hydropower, traditional management practices diminished leading to increase sediment load and siltation with negative consequences for downstream users. Local authorities raised the spill to restore water storage capacity but the siltation problem did not improve. The IUCN together with the local authorities conducted an economic valuation of the goods and services the traditional tank system provided for the livelihood of local communities. The ecosystem services perspective revealed that only 16 percent of households obtained benefits from paddy rice cultivation, the most prominent purpose of the tank, while 93 percent benefited from access to domestic water. The analysis suggested that the scenario of rehabilitating tanks and continuing the 'traditional management' provided the highest economic return for local communities. It had a net present value (NPV) of US$ 57,900 per tank (over 30 years, 6 percent discount rate), as a broad range of services can be secured.

(Source: TEEB 2010: 86)

ments toward improvements such as agro-forestry (TEEB 2010). Creating incentives for maintaining ecosystem services across multiple scales and users as well as collective action is required in managing and maintaining ecosystems and its services. Thus, coordination to enhance efforts and ideas by all users such as farmers, developers, residents, conservationists and municipalities is integral to success. Box 3.3 highlights the utility of an ecosystem approach using NCA to manage water in Sri Lankan agriculture.

Conclusion

Economic discussions in growth planning and development are fragmented. The services of nature (ecosystem services) are a key information gap. Putting a monetary value on nature's services may not appear to be a suitable approach at valuing nature, but in growth planning, this is the type of information that may garner support and leverage in environmental-economic debates. It can reveal cost-saving opportunities allowing nature to exercise its regulating services to manage common environmental issues such as air pollution (through carbon sequestration) or water pollution (through the wastewater treatment capacity of wetlands). There are many tools currently in place and still being developed. A key tool in measuring and capturing natural capital data is the United Nations System of Environmental-Economic Accounting (SEEA). The Economics of Ecosystems and Biodiversity (TEEB) has a number of well-researched, expertly written and, in some cases, evidence-based papers to help decision-makers recognize, demonstrate and capture the values of ecosystems and biodiversity, including how to incorporate these values into decision-making. In terms of application, WAVES is at the forefront of rolling out natural capital accounting across the globe at a national scale. This global partnership which brings together UN agencies, governments, international institutes, non-governmental organizations and academics to implement natural capital accounting (NCA), aims to enable more informed decision-making to ensure genuine green growth and long-term advances in wealth and human well-being (WAVES 2012). There are currently eight WAVES NCA-implementing countries.

At the local and regional levels, the Himalayas and Credit River watershed studies are just a few of many initiatives. It is at these levels where NCA may have the biggest impact as key decisions are made about where to site a new residential development, a new factory or new green space. Stakeholders from across a community, city or region can have input into local decisions that directly or indirectly affect them. At the local level, local government, mayors, councillors, planners and developers are key decision-makers; citizens can act as advocates, conservationists and protestors; regulating agencies approve projects or monitor health and environmental compliance against regulations; and the legal system provides support in planning and dispute resolution (TEEB 2010). It is therefore at the local and regional scale where people can have discretion over the landscape in which they live, work and play. Local decisions however, need to be more inclusive of the visible and non-visible parts of nature to achieve sustainability. This is particularly true given current population, industrialization, urbanization, economic and income growth rates that result in growing demands for and pressures upon nature and its services. Within the water, energy and food nexus, natural assets need to be better integrated into the local and regional policy framework to realize and maintain the benefits already provided by ecosystems and biodiversity. The 2011 Bonn Conference on 'the nexus' states that governance needs to 'assess and acknowledge the value of ecosystem services directly and indirectly for water, food and energy security and their contribution to local and national economies; encourage conservation and use of natural capital through a framework of economic analysis and incentives; develop and adapt sustainable financing mechanisms to maintain ecosystem services; strengthen measures to protect critically important ecosystems and biodiversity; reduce sources of pollution to water bodies, soil and air; and recover and maintain a balance between productive ecosystems and intensive farming systems' (see https://www.water-energy-food.org/about/bonn2011-conference/). Developing robust systems of natural capital accounting, in order to determine the contribution of ecosystem services to human well-being, is important if we are to realize the stated goals and targets of the UN's Agenda 2030.

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CHAPTER 4

Pigs, Prawns and Power Houses: Politics in Water Resources Management

K.M. Jensen, R.B. Lange, and J.C. Refsgaard

Introduction

When the global water expert community joined the heads of state for the Rio+20 summit in 2012, they celebrated 20 years of promoting the concept of sustainable development, now enshrined within the Sustainable Development Goals (SDGs). Under this umbrella, a range of normative management ideals and methods have been developed and advocated. These include the holistic concepts of Integrated Water Resources Management (IWRM) and Coastal Zone Management, as well as their 'tool room' management instruments and methods, such as environmental impact assessments and Environmental Flows. These ideals designate elaborate approaches to 'good environmental governance'

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aimed at replacing 'bad' and unsustainable practices. Sustainable water management is included in SDG 6 which aims to 'ensure availability and sustainable management of water and sanitation for all' (see https://sustainabledevelopment.un.org/sdg6). Target 6.5 of SDG 6 states 'By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate'.

Experts across different institutional contexts have sought to evaluate the merits of the various approaches and extract important lessons learned from their empirical applications. Consequently, we now have a broad range of more or less scientifically validated ideals and models ready for decision-makers and practitioners to implement. Among these, IWRM has achieved iconic status in the water community and has gained ground in national water policies and development interventions in both developed and developing countries. Indicator 6.5.1 of SDG 6 will measure the 'degree of integrated water resources management implementation (0–100)'.

Yet, progress with IWRM is faced with the harsh reality of everyday water governance. Despite considerable efforts by governments, donors and other water-sector stakeholders, the effects of the IWRM approach have been mixed. Unambiguous stories of success are scarce, and the cleavage between IWRM plans and policy papers and water resources management practices on the ground remain a challenge. Whereas this implementation deficit has led some critics to question the universal relevance of normative ideals such as IWRM, others point to the shortcomings of the predominant technical and managerial approaches employed by governments and international donors (cf. Biswas 2004, 2008; Butterworth et al. 2010; Lenton and Muller 2009; Molle 2008; Saravanan 2006; Shah and van Koppen 2006; Öjendal et al. 2011). As one of the keynote speakers at the Brisbane River Symposium in September 2005 noted on the global progress of IWRM:

> Globally we have considerable knowledge and many lessons learned on the technical, engineering and managerial aspects of IWRM and river basin management. What remains to be achieved is a better understanding of the political constituents of water governance.

In this chapter, we seek to address this knowledge gap by analyzing three cases from developed and developing countries: India, Denmark and the Mekong region. The cases provide illustrative examples of the political processes involved when some actors try to introduce normative ideals like

IWRM into water governance practices. We analyze the process of translating normative ideals into action as a process of social learning in which public and private stakeholders engage in deliberations and negotiations on the appropriate way to manage and allocate water resources according to certain governance practices. Our point of departure is that water governance is an inherently political process. Actors not only pursue normative and holistic ideals, their partial interests in the distribution of water resources are also based on the existing relationships of power. Consequently, social learning processes are always embedded in the prevailing political economy of water, which has significant influence on how water governance unfolds in the contexts of each of the three case studies.

In the water sector, the concept of Adaptive Water Management (AWM) has recently been introduced as an answer to the challenges of implementing IWRM (Pahl-Wostl and Sendzimir 2005; Pahl-Wostl et al. 2005). AWM emphasizes the contextual nature of water management and situates social learning through a 'best-practice' approach, continuous 'reality checks' and 'polycentric water governance', these being the mechanisms of change. Polycentric governance refers to the vertical and horizontal integration of stakeholders, institutions and sectors within hydrological units. As such, the AWM approach dives more directly into the political aspects of water resource governance.

However, in this chapter we argue that the IWRM and AWM concepts both represent normative ideals for how water resources may be best managed and governed. Their strengths are the provision of a holistic analytical and strategic approach to water resources management (Ravnborg and Jensen 2011). Their weakness is their exclusion of the larger context of politics and political economy.

Analytical Framework: Normative Ideals, Politics and Social Learning

Saravanan and his colleagues discern two discourses on the character and importance of power and politics in water governance in the current debate on the implementation problems of IWRM (Saravanan et al. 2009, Saravanan et al. 2008). Proponents of IWRM tend to portray politics in line with Jürgen Habermas' (1984) thinking. Politics is a communicative process in which actors seek to build common understandings and coordinate action through reasoned argument, consensus and collaboration, rather than self-interested strategic action. Resting on the normative concept of communicative rationality, this approach emphasizes the establishment of enabling environments and democratic institutions, which allows for the participation of all relevant stakeholders and enables decision-makers to make informed and rational choices between alternatives (cf. Lenton and Muller 2009: 214). In this context, power is a property that can be negotiated though mutual and cooperative agreement.

Conversely, critics of IWRM have made the case for the opposite conception of politics as a conflict-loaded process in which stakeholders compete over limited resources based on a particular set of interests. Decision-making is dominated by asymmetrical power relationships, which are deeply enmeshed in the wider sociopolitical and economic context of water governance. In short, the struggle for water is often equal to the struggle for power, meaning that water resource management is inherently political. In such a setup, democratic institutions are no 'quick fix', as patterns of participation tend to reflect power asymmetries rather than change them. Drawing on Michel Foucault (1990) and Pierre Bourdieu (1977, 1991), power is understood as a relational concept that is continuously produced and reproduced through interactions and negotiations between actors.

Whereas the critics of IWRM tend to exclude the possibility of consensual decision-making a priori and leave little room for stakeholders to reach cooperative agreements, its proponents tend to treat the content of normative ideals as the obvious common good (Öjendal et al. 2011). As François Molle (2008: 132ff) has pointed out, proponents assume such normative ideals as representing the water governance Nirvana that we should all be striving to achieve and thus as the natural center of gravity for all stakeholders involved in political processes. This assumption seems to have fueled the supply-driven agenda and social engineering approach that has governed the way IWRM has been implemented in many developing countries (Mollinga et al. 2007: 714).

Social Learning as an Analytical Middle Ground

In this chapter, the intention is to establish a 'middle ground' between these two discourses on politics and power through the concept of social learning (e.g. Molle 2008; Mollinga 2008; Pahl-Wostl et al. 2007a, b; Lebel et al. 2010; cf. Armitage et al. 2007, 2008; Leeuwis and Pyburn

2002; Argyris and Schön 1978; Flood and Romm 1996). Politics is about both collaboration and conflict, and power can inhibit or promote change, depending on the larger context, the institutional setup, the constellation and behavior of actors and other features of the processes of the actual water governance situation at hand. We argue that a realistic and strategic approach that leaves a space for the analysis of both types of political dynamics to influence water governance, and not exclude any possible outcomes in advance, is required for the analysis of the translation of normative ideals into practice.

Theoretically, the concept of social learning departs from the notion that policy-making can be framed as a kind of collective puzzle war that involves experimentation, negotiation and deliberation over problems and their solutions between various stakeholders (Pahl-Wostl et al. 2005; Pahl-Wostl 2009; 355). Through continuous interaction, actors may produce new knowledge, shared understanding and eventual trust that can facilitate collective action and change in governance frameworks, actor relationships and the distribution of water resources (Lebel et al. 2010: 334).

However, social learning does not occur in a vacuum. Formal and informal institutions define the rules and roles that structure actors' interactions and establish a normative foundation for their behavior (Saravanan et al. 2009: 82). As such, they give rise to a certain set of social practices that influence the outcome of water governance processes. Institutions do not act themselves, nor do they account for all aspects of the political processes involved in water management. State and non-state actors act strategically inside and toward the existing institutional frameworks to influence policy-making and implementation according to their perceptions of their interest.

In these dynamic governance processes, actors deploy power to transform existing social practices (e.g. through institutional change) or secure the status quo (Saravanan et al. 2009: 82ff). Importantly, we define power as both a relationship and a property. Power comes from everywhere (Foucault 1990: 93). Power denotes a relationship between the actors involved that is continuously negotiated through interactions. Power is also a property embedded in and legitimized by the prevailing institutions. Institutions accumulate bias and contribute to the creation of sociopolitical positions, giving some actors more power than others, for example, through better access to information, resources, authority or boundary setting. It is this dynamic interplay between actors using various sources of power strategically in negotiations on the management, distribution and allocation of water resources that may eventually generate social learning. The result of such social learning may then result in institutional change or alterations in water management practices. Hence, politics is an integral part of social learning, which is neither value-free nor politically neutral, and power is built into such processes of change (Armitage et al. 2008: 96).

Social Learning and Normative Ideals

How, then, does social learning occur with reference to normative ideals? To achieve relevance on the ground, normative ideals need to be adopted, interpreted and adapted to the actual water governance situation by stakeholders in the local context. However, the agents of change, whether experts, international organizations, local NGOs or state agencies, will be confronted with a muddy setup of stakeholders and advocacy coalitions, some of which will have a vested interest in the status quo, others an interest in change. Power relationships are most often asymmetrical, and problem perceptions may also differ considerably. Consequently, the actual process of translating normative ideals into practice often involves tradeoffs between different policy goals (e.g. the three E's of IWRM: economy, environment, equity) that need to be negotiated between stakeholders (Molle 2008: 132ff; also Biswas 2004: 253). The outcome denotes a negotiated order, which typically represents a suboptimal outcome, from the perspective of both the proponents of normative ideals and the perspective of most stakeholders, who have to relinquish something in painful political processes (Barret 2004; Molle 2008; Swatuk 2008; see also Warner 2007; Mollinga et al. 2007).

However, that does not render social learning with reference to normative ideals impossible. When some stakeholders adopt these ideals and advocate their implementation in negotiations and deliberations with other stakeholders on the appropriate mode of water governance, new knowledge can inform water governance processes and generate new outcomes in the form of changes in governance frameworks and practices. Actors may collectively learn to do things differently. Advocates of the social learning framework often point to a reasonable degree of democratic governance, transparency and participation by relevant stakeholders as a necessary condition for the social learning process to unfold (Mostert et al. 2007; Armitage et al. 2008). Social learning needs a political space in which to occur (Armitage et al. 2008: 10). This should not be contrasted or confused with the mechanisms of representative democracy

(Pahl-Wostl 2009: 357). Rather, participation refers to the issue-specific inclusion of stakeholders in deliberations and decision-making on policy content and implementation. While participatory processes may be expensive and less controllable for policymakers and experts, they expand the scope of learning to a broader range of stakeholders (Pahl-Wostl et al. 2007a). This may qualify the outcome of the political processes in terms of stakeholder ownership and acceptance, as Lebel et al. (2010: 336) pointed out: '[D]eliberative processes bring together alternative perspectives and forms of knowledge reducing the likelihood that collective responses are based solely on relative influence and power of the actors involved'.

Again, participatory governance is not a universal fix that removes power from politics (Swatuk 2008). Participatory processes provide a forum for negotiations, conflict resolution and identification of synergies, but can also be stalled by strong conflicts of interest and partisan agendas. Stakeholder behavior may produce a situation in which the deliberative process ends up by merely reinforcing positions of opposition. Additionally, powerful stakeholders may also manipulate participatory processes. This may result in de-politicization and/or elite capture of participatory institutions in water resource management. As Biswas (2004) and Molle (2008) have pointed out, the adoption of normative ideals like IWRM can be strategic and/or symbolic and not denote any real intention to change the prevailing system of water governance or approach. Rather IWRM may be adopted to acquire recognition, legitimacy and funds from the international epistemic community of donors and authoritative water experts.

Learning Loops, Power and Politics

In order to leave analytical space for social learning to occur without neglecting power and politics, we conceptualize the process in terms of the 'learning loops' identified in organizational theory (Pahl-Wostl 2009: 258ff; Armitage et al. 2008; also, Flood and Romm 1996; Argyris and Schön 1978). Single-loop learning refers to the incremental refinement of action strategies without revising underlying assumptions. Improved goal achievement is the aim of eventual changes in governance practices. In double-loop learning, assumptions (e.g. cause and effect relationships) within the prevailing normative framework are questioned. Actors start to reflect on goals, problems and priorities and on how the goals can be achieved. Eventually, the actor networks involved in resource governance are changed. Triple-loop learning entails reconsideration and, eventually, transformation of underlying structures, values and worldviews. Such paradigmatic changes entail the inclusion of new actor groups in governance processes, the alteration of power structures and relationships and the introduction of new regulatory frameworks (see Pahl-Wostl 2009 for details).

Politics and power play an important role in the learning cycles. Firstly, they involve elements of policy-making, implementation and evaluation, regardless of depth (i.e. single, double or triple loops). Social learning is thus intimately related to large-scale and micro-scale political processes, where actors deploy power in the pursuit of their interests. Secondly, the deeper the loop, the higher transaction costs in terms of institutional and behavioral change. Theoretically, this places certain expectations on the behavior of actors involved in collective decision-making processes. They tend to choose the 'low-hanging fruits' associated with single-loop learning and only enter the deeper double- and triple-loop learning if they face constraints at the shallower levels. Hence, change is more likely to occur when social or environmental problems become seriously aggravated and cannot be solved within the prevailing governance framework (Lenton and Muller 2009: 11). However, the potential stakeholder conflict grows proportionally and aggravates the political struggles over decision-making. Thirdly, power relationships can be utilized strategically by actors either to resist learning or to enhance it (e.g. in support of the implementation of a normative ideal; see, e.g. Swatuk 2008; Saravanan et al. 2009; Mollinga et al. 2007). Here, the prevailing political economy of water plays an important role in defining the pattern of power asymmetries that typically vests the stronger actors with an interest in resisting change and maintaining the status quo.

Analytical Framework

In the following, we apply the concept of social learning as an analytical tool to understand the process of translating normative ideals into practice. The central question we seek to address is to what degree has social learning occurred in the cases with reference to normative ideals. The key analytical categories are the governance framework (formal institutions—e.g. policies, laws, modes of governance and informal institutions—e.g. caste, patron-client relations) and the governance processes (strategic actions by state and non-state actors). Similarly, the role of normative ideals vis-à-vis partisan power politics in deliberations and decision-making on problems of environmental governance forms an important analytical focus in the discussion of whether or not social learning has occurred. Through this line of analysis, we aim to discern the preconditions that can be identified as critical for the translations of normative ideals, such as IWRM, into action.

Methodological Approach

The concepts of social learning and the political economy of water are applied as the analytical framework for the comparative analysis of three cases of water governance processes. The objective in taking this approach is to demonstrate that, in spite of the three empirically very different cases, there are structural similarities in the way social learning and governance processes unfold (or not).

The three cases in our water governance research have been selected from both developed and developing countries. They vary in terms of the primary governance level—that is, sub-national (India), national (Denmark) and transnational (the Mekong). Similarly, transparency and stakeholder participation in the governance processes vary, with Denmark being the most open and inclusive. Equally important, asymmetries of power between stakeholders differ. Discrepancies are huge in India, more equal in Denmark and formally equal in the Mekong case (between sovereign states). However, in all cases, the stakeholder setup is complex, as both sub-national and international actors influence negotiations.

The cases function as illustrative examples of social learning across different governance contexts. The social learning approach provides an opportunity to analyze the discrepancies between normative ideals for water management ('what should be') and the governance limitations imposed by political realities ('what is') in a comparative perspective (Ravnborg and Jensen 2011). Additionally, the analysis has considerable time depth, as IWRM has influenced water management and governance processes in all three cases for more than 15 years. This allows us to analyze the evolution of the governance frameworks, discuss the social learning involved and identify situations when 'politics take over'. Ultimately, the analysis leads us to identify situations when strong economic and political interests—the political economy of water—override scientific knowledge and social learning.

Prawn Politics: Integrated Management of Chilika Lagoon, India

The brackish waters of Chilika Lagoon on India's east coast have been contested for more than 30 years (Dujovny 2009, 2010). From the middle of the 1980s, the catches of local fishermen and the lagoon's hitherto rich biodiversity started to decline. The ecological crisis gained international attention in 1993 when Chilika was placed on the Montreux Record of endangered wetlands under the Ramsar Convention. The Odisha state government responded by creating the Chilika Development Authority (CDA), which set out to restore the environment and build an integrated approach to lagoon management (Ghosh and Pattnaik 2005, 2006; Chilika Development Authority 2011a; Chilika Development Authority and Wetlands International 2010). The CDA's activities have subsequently been highlighted by international NGOs as a best-practice example of a holistic and integrated approach to water resource management (see, e.g. the Global Water Partnerships 'Toolbox' at www.gwptoolbox.com).

However, the lagoon has simultaneously been the scene of a bitter conflict over rights and access to fishery resources (Samal 2002; Samal and Meher 2003; Ghosh and Pattnaik 2005, 2006; Pattanaik 2006, 2008; Dujovny 2009, 2010; Mishra and Griffin 2011; Nayak and Berkes 2010, 2011). Traditional low-caste fishermen have increasingly become marginalized, as local non-fisher communities from higher castes in alliance with local and political elites have encroached on large areas of the lagoon for prawn aquaculture and instigated controversial changes in fishery policy. Hence, the integrative nature of government activities can be contested. Multiple demands on the lagoon's productive capacity are now levered by its stakeholders in a highly polarized setting, which impedes social learning processes.

Governance Frameworks: Integration, Conservation and Aquaculture

In the analysis of the governance frameworks, we concentrate on the two most important policy regimes related to water governance in the lagoon: conservation and fisheries (both capture and culture). Prior to the establishment of the CDA in 1991, the Odisha state government was only marginally engaged in the management of natural resources in Chilika Lagoon (Ghosh and Pattnaik 2005; Ghosh et al. 2006; Pattnaik 2009).

Designed as an 'apex organization', the CDA was meant to serve as a coordinating body between the stakeholders in the basin (Ghosh and Pattnaik 2005; Ghosh et al. 2006; CDA 2011a). The CDA was given the mandate (1) to conserve the lagoon's ecosystem, (2) to conduct socioeconomic development activities, and (3) to prepare an integrated management plan. These loosely defined policy goals delegated significant powers to the agency to translate policy into action. However, the organization was not vested with any regulatory power (e.g. granting fishery leases), and only few human and financial resources were transferred from the Odisha state government (Controller and Auditor General 2008: 94ff). Consequently, the CDA has had to rely on its ability to foster stakeholder cooperation and raise funds from other sources to gain an impact on lagoon management (Ghosh and Pattnaik 2005: 122ff; Controller and Auditor General 2008: 94ff; CDA and Wetlands International 2010; World Bank 2005). Political and bureaucratic control of the organization also remained strong, as the governing body of the CDA is composed of high-level politicians and bureaucrats from various departments and districts (Ghosh and Pattnaik 2005; Pattnaik 2009; CDA 2011c). Representation of other non-state stakeholders is weak.

The Odisha state government's integrative ambitions are being jeopardized by the simultaneous development in fishery policy. Here the critical juncture also occurred in 1991 when the Revenue Department changed the leasing policy (Samal 2002; Ray and Ray 2007; Dujovny 2009; Nayak and Berkes 2010, 2011; Pattanaik 2006, 2008). Firstly, it introduced aquaculture as a legal fishery technology. Previously only various traditional methods of capture fishing were allowed. However, prawn aquaculture had been promoted by the government since the beginning of the 1980s, when increasing global demand made prawn farms a lucrative export business, with the prospect of a 'blue revolution' comprising poverty alleviation and foreign earnings in Chilika Lagoon (Samal 2002: 1714; Pradhan and Flaherty 2008: 65ff; Nayak and Berkes 2010, 2011). Trade liberalization in the 1990s only made the industry even more attractive. Secondly, it allowed higher caste non-fisher communities and outsiders to lease fishing territories, although this actually just reflected the de facto situation. These communities had taken up aquaculture in large parts of the lagoon without any legal rights in previous years. Before this, fishing rights were granted only to traditional low-caste fisher communities. Thirdly, it nearly tripled the annual increase in the cost of a lease. Fourthly, the management of leases was centralized in the form of a new state-level apex organization, which deprived the local fisher organizations of their key role in the existing community-based fishery resource management framework.

While the changes in fisheries policy have clear benefactors (i.e. non-fisher communities), the conservation and development goals of the CDA apparently posit a win-win situation for all stakeholders. However, the political commitment to the normative ideal of integration embodied in the CDA is weakened by the lack of coordination with the fishery policy. This makes the governance framework somewhat paradoxical, especially when we consider the way the governance processes unfold.

Governance Processes: Prawn Politics

The governance processes are dominated by the antagonistic and asymmetrical relationship between traditional fisher communities and newcomers. In the face of the changes in the governance framework discussed above, fishermen have tried to lever their interest through legal action and public protest (Samal 2002; Pattnaik and Trisal 2003; Nayak and Berkes 2010, 2011). Success has been limited: despite a Supreme Court ban on shrimp aquaculture in 1996 and subsequent promises by the state government to enforce this decision (through the CDA and local administrations), it has never been implemented (Supreme Court of India 1996; also, Odisha High Court 1993). Repeated public rallies and violent confrontations between fishermen, non-fishermen and the police have produced similar government reactions: vows of action but little enforcement on the ground. Attempts to solve the conflict through a new fishery policy (the Orissa Fishing in Chilika [Regulation] Bill) have been met with equally fierce resistance, as it reifies the division of rights and introduces a rubber-stamp paragraph to legalize shrimp aquaculture (Ghosh and Pattnaik 2005: 128; Dujovny 2010: 259ff). The bill has not been approved as yet, despite multiple relaunches.

The political stalemate is commonly attributed to the existence of an alliance of politicians, bureaucrats and business interests involved in aquaculture—the so-called shrimp mafia (Nayak and Berkes 2011). Through patron-client relationships and informal networks, the interests of these stakeholders dominate the de facto outcome of the governance processes. Consequently, the (illegal) encroachments on fishing grounds, high leasing costs and corruption networks continue systematically to marginalize the traditional fishermen politically and economically (Mishra and Griffin 2011).

Equally important, the unabated practice of aquaculture is producing negative environmental impacts (pollution, increased silting and loss of biodiversity), which are jeopardizing the health of the lagoon's ecosystem and the integrative policy goals (Mishra and Griffin 2011; Das et al. 2003; Supreme Court of India 1996).

The CDA's role in this political landscape has been ambiguous. As the champion of the integrative ambitions, the organization has engaged other stakeholders in its activities. However, priority has been given to government agencies, research institutions and international organizations, as well as to the execution of less controversial technical-managerial development interventions. The CDA dug a new sea mouth to the Bay of Bengal in 2000 to establish 'a more beneficial hydrological regime' (Ghosh and Pattnaik 2005: 122). The experts ascribed the ecological problems to increased sedimentation, choking of the existing sea mouth and, consequently, a drop in salinity. The CDA also claims that the intervention was 'the long standing demand of local communities', which were consulted in the decision-making process (Ghosh et al. 2006: 248). This is contradicted by independent studies, which claim that the degree of participation of local stakeholders was limited and that the research conducted prior to the intervention was biased (Nayak and Berkes 2010: 559; Dujovny 2009: 195ff). The CDA-sponsored reports uniformly identify the shifting position of the existing sea mouth as the key problem for the lagoon's ecology. Consequently, the new sea mouth was perceived to be the optimal solution. This analysis runs contrary to both historical evidence of the stability of the sea mouth and local debates on the importance of upstream flood control measures (dams) for the lagoon's ecosystem (Dujovny 2009). The official narrative of success, that is, ecological rejuvenation and livelihood improvement (e.g. a tenfold increase in fish catches) has also been questioned. For example, Chilika was removed from the Montreux record at the request of the Indian Ministry of Forests and Environment (see Ramsar Advisory Mission No. 50, India, 2001). Critics claim that, a decade after the intervention, the ecosystem and fishery resources continue to decline, primarily due to the continuous proliferation of aquaculture (around 60 percent of the lagoon's waters remain illegally encroached upon for this purpose) (Nayak and Berkes 2010: 558; Dujovny 2009: 199ff). Additionally, the new mouth has changed the distribution of resources in the lagoon and created a more saline environment which, primarily, is better for prawn aquaculture (Controller and Auditor General 2008; Dujovny 2009; Nayak and Berkes 2010).

However, upstream deforestation, untreated sewage and pollution, dams and irrigation projects and so on also pose severe challenges for sustainable management of the lagoon (Dujovny 2009; Ghosh and Pattnaik 2005). Despite attempts to deal with these issues, such as through a World Bank-sponsored Environmental Flow Assessment and participatory IWRM schemes in catchments, the CDA's ability to facilitate cooperation between different government departments and stakeholders has been weak (World Bank 2005; Controller and Auditor General of India 2008; Hirji and Davies 2009; CDA and Wetlands International 2010). Hence, the actual governance processes continue to follow sector divisions, effective participation in decision-making processes lingers in the shadows, and the conduct of the CDA has been dominated by interventions that do not conflict with the interests of the strong 'shrimp mafia'.

Shallow Social Learning in Chilika

The discrepancy between the formal and informal governance processes in Chilika poses some challenges for the assessment of the degree of social learning. On the one hand, the establishment of the Chilika Development Authority has led to a change in the governance framework for Chilika Lagoon. Despite its biases, the conservation strategy applies a scientifically informed approach to the whole hydrological unit and represents an improvement to the management perspective, which now formally includes a broader array of goals. At face value, this would qualify as double-loop learning. On the other hand, it is difficult to talk about such deeper degrees of social learning when the actual practices are taken into account, and even the incremental improvements of first loop learning are hampered by the prevailing sociopolitical dynamics. The integrative ambitions embodied in the Chilika Development Authority have to a large extent been subsumed by the interests of the stronger stakeholders involved in aquaculture, who have had an important influence on its conduct. Official political and institutional adherence to the goals of conservation, holistic management and sustainable development are contradicted by other parts of the governance framework and the prevailing governance practices, where little effective coordination occurs. As such, this case points to the general problem of corruption in policy-making and implementation, and to the specific problem of patron-client relationships embedded in the social structure of Odisha. Both problems are severely hampering the possibility of social learning, as official deliberations and decision-making succumb to power politics conducted behind the scenes. Similarly, the discrepancy between public policy goals, legal decisions and the de facto situation on the ground erodes trust between the actors involved, confining eventual learning to be represented only by the ink on policy plans, rather than becoming a lived experience. The present 'modus operandi' is far from the normative ideal of integration. Evidence from independent studies suggests that it is more likely that the governance of Chilika Lagoon approaches that of a scientifically managed 'prawn pond'.

Power House Politics: Dams and Integrated Management of Lower Mekong River

Cambodia, Laos, Thailand and Vietnam have cooperated over the Lower Mekong River since the 1960s, when a series of dams on the Mekong mainstream appeared on the drawing board. The intention was to develop hydropower as the power house for economic development. It was also seen as a measure undermining the communist insurgencies in the region. The subsequent Indochina wars and instability into the early 1990s put the dreams of turning the Lower Mekong into a power house for economic growth on hold. In 1995 the four Lower Mekong countries signed an agreement to establish the Mekong River Commission (MRC). The agreement—brokered by the UNDP with the assistance of water experts and experts in international environmental law—represented state-of-the-art thinking on transboundary water resources management including international water law and many IWRM principles. The agreement also represented a considerable degree of river basin management learning at the time and is often referred to as a 'development agreement' translating normative ideals for sustainable development into specific plans and programs.

In the 1990s, the Mekong River was largely considered an open-water regime with unlimited quantities of free flowing water. There were few contentious transboundary issues between the four countries. However, at the national levels, including upstream China, hydropower projects were implemented, with many social and environmental consequences. The controversies over the Pak Moon dam in Thailand and the Nam Theun 2 dam are well known. Dams have also been built in Vietnam's Central Highlands on the '3S' tributaries (Srepok, Sesan, Sekong) shared by Cambodia and Vietnam. Although there has been increasing NGO and civil society involvement in the environmental and social impacts of the

Vietnamese dams, they have not attracted regional and international attention comparable to the Pak Moon and Nam Theun 2 dams.

As water management in the Mekong was until recently largely a national affair, there was limited social learning at the transboundary level. Knowledge production and capacity development within the MRC was implemented according to the mandate of the 1995 Agreement—primarily in its technical support Secretariat. In parallel to these largely self-confined national and transboundary levels, there was growing civil society and NGO engagement in the environmental and social aspects of water management in the Mekong.

Thus, until around 2007 social learning was limited to single-loop learning, largely based on scientific learning, within the confines of the major Mekong stakeholders—that is, the MRC, national governments, civil society, academia and NGOs. The study on 'National Interests and Transboundary Water Governance in the Mekong' (Hirsch and Jensen 2006) was an attempt to pull together social learning by Mekong stakeholders including national governments, the MRC, civil society, NGOs and donors. However, recent developments in the Mekong case are now inviting more stakeholders to meet and engage at the transboundary level. Economic development is the driver. Accelerated economic growth in China and the Lower Mekong countries over the last 10 years has increased the need for energy. Consequently, hydropower is being considered as the power house fueling further growth. The pressure on the Mekong is increasing and its image as 'the Shangri-La of rivers' is under threat. Stakeholders are becoming engaged as the space for transboundary power and politics unfold. Social learning is being taken to another level.

Governance Framework: The MRC as a Mechanism for Transboundary Water Management and Development

Cooperation on water resources management and development in the Mekong dates back to the 1940s. It has overcome setbacks caused by the Indochina wars, the Khmer Rouge in Cambodia, the structural challenges of the Cold War and historical animosities between the riparian countries (Öjendal 2000). Cooperation between the four Lower Mekong countries was first formalized in 1957 under the Mekong Committee. During the 1960s cooperation was reinforced politically as a united front against communism, meaning, in this case, China and North Vietnam. The 1957 agreement was changed under the Interim Mekong Committee in 1975, which excluded Cambodia under the Khmer Rouge and subsequent conflict until the recognition of a democratic government in Cambodia in 1993. The current MRC agreement was signed in 1995 after 3 years of negotiations.

Because of its emphasis on sustainable development and environmental balance, the 1995 agreement has been acclaimed as a 'model among multilateral efforts in international river basin development' (Radosevich 1996). According to its emphasis on approaches to integrated water management, the agreement covers not only water allocation but also 'irrigation, hydropower, navigation, flood control, fisheries, timber floating, recreation and tourism, in order to optimize the multiple use and mutual benefits for all riparians' (Mekong River Commission 1995: Art. 1). However, according to international environmental law experts, the agreement falls in the 'soft law' category, as 'its legal mechanisms for implementation and enforcement at regional and national levels [are] generally weak' (Hirsch and Jensen 2006: 43). Hydrological flows and water allocation are not mentioned in quantitative terms but left to be resolved as policy harmonization among riparians in the implementation of the agreement. The agreement is couched in a consensus spirit of 'Asian cultural values', 'the ASEAN way' and 'the Mekong Spirit'. There is no right of veto in cases of difference or dispute. Instead a number of restrictions on development interventions apply according to various circumstances ultimately aimed at mutual understanding and consensus among the member states. The detailed text on the 'Procedures for Notification, Consultation and Agreement' was agreed by the MRC member countries in 2003.

In the absence of a formal legal framework, and as the ultimate power remains with the individual member states, the MRC's governance framework, including the decision-making support by its technical Secretariat, has become crucial in addressing transboundary tensions and maintaining cooperation. The MRC's three tiers of governance are geared to doing precisely that. The MRC's technical Secretariat develops the necessary knowledge capacity in member countries to implement the 1995 agreement. The Secretariat provides technical services and decision-making support to the MRC's Joint Committee (JC) of senior civil servants, representing the four member countries. The JC meets twice a year and is mandated to take decisions (by unanimous vote) on matters as specified in the agreement. The MRC's Council of Ministers meets once a year to confirm JC decisions or decide (also by unanimous vote) matters of higher political importance. In the event of differences and disputes that cannot be solved within the MRC governance framework, governments have to resort to diplomatic channels or invite mediation by another party (Mekong River Commission (1995): Art. 35).

Governance Processes: Expanding Stakeholder Participation

Major development interventions along the Mekong are largely synonymous with hydropower and only to a lesser extent irrigation development. Until recently, governance processes linked to such infrastructure-based developments were largely a national affair, as they occurred on tributaries within national territories. Governance regimes around hydropower projects have been narrow and under state control in China, Laos and Vietnam. (Thailand's Pak Moon dam from the 1980s is the only Mekong tributary dam in Thailand.)

With its Basin Development Plan (BDP), the MRC has taken steps to widen the Mekong governance regime to include other stakeholders. The BDP is considered the MRC's 'flagship program', and it attempts to be the umbrella approach to water management and development in the Lower Mekong according to the 1995 agreement's Article 2. The BDP is a management and planning process exploring and analyzing likely development scenarios in the Mekong basin. The scenarios and their assessments include existing, ongoing and planned development interventions (largely hydropower and irrigation infrastructure development, including upstream China). Assessments are based on the MRC's extended knowledge production from many programs and projects. Assessments on development impacts also follow a number of agreed MRC guidelines, such as environmental impact assessment (EIA), social impact assessment (SIA), environmental flows and so on. The BDP started in 2002 and is now running into its third phase.

The BDP process as it has unfolded since 2007 represents a general shift toward greater participation and greater MRC openness toward other Mekong stakeholders. In a number of arranged meetings with regional civil society and NGO stakeholders, the MRC has presented the BDP work undertaken, including the assessment of development scenarios and an overall IWRM-based development strategy for the Mekong basin. Although the development scenarios may have limitations in terms of being largely hydrologically defined, they did open up a space for dialogue, though they also generated controversy over the assumptions, scope and impact of management and development interventions

(Lebel et al. 2010). The MRC's dialogue with a wider public was also supported by more transparency and access to the MRC's knowledge production. Assessment reports and policy documents are now easily accessible on the MRC's official website and open for comments (see www.mrcmekong.org). The MRC's technical secretariat has supported this participatory mode of engagement, resulting in much friendlier stakeholder attitudes toward the MRC. This is due partly to a more engaged and conducive leadership in the MRC's technical secretariat, and partly due to Vietnam's widened perspectives on NGOs, civil society and environmental consequences on upstream hydropower development. Although the expanded involvement of stakeholders has generated social learning on approaches to transboundary management and development of the basin, it did not enter the more controversial national regimes for water development plans and projects.

However, the recent controversy over the Laotian government's plan for the Xayaburi mainstream dam and hydropower project has stirred up controversy at the regional and international levels, as well as within the MRC's own governance framework. Export of hydropower is the major foreign exchange earner for Laos. It is expected to increase considerably, turning Laos into the 'battery of Southeast Asia'. Laos has plans for up to nine mainstream dams, Cambodia for two, and China for several more in the upper reaches of the Mekong in China. Dozens of tributary dams are being considered all over the lower basin, most of them within Laos. Several of these are in an advanced stage of planning and financing (see Öjendal and Jensen 2011). The Xayaburi controversy illustrates the extent to which scientific and social learning has developed and is able to influence (or not) the governance processes within the MRC and national political decision-making. The Xayaburi dam proposal and the unilateral interests of Laos are testing the MRC's governance regime. Laos argues that exports of energy will generate government income to be invested in poverty alleviation measures benefiting the whole country. The proposal has presented the MRC with its first real governance challenge, namely, the engagement in controversial mainstream development. It has also given the MRC the opportunity to demonstrate the value of its knowledge-based assessments, as well as assess how these assessments can support political decision-making by each MRC country.

The Xayaburi dam is seen as the key to the potential for mainstream dams or otherwise in the Lower Mekong. It has generated widespread discussion over the future of the Lower Mekong. Activists, NGOs, villagers and the Thai and Vietnamese media are opposing Thai commercial interests and the Laotian government.

Hydro-politics thus play a role in determining the positions of the MRC member country governments toward the Xayaburi dam. Upstream Laos, the proponent of the project, has the best geographical conditions for hydropower development. With few other alternatives, Laos considers hydropower a national asset for economic growth and poverty alleviation. Thailand is also upstream, but in a complex and ambiguous situation. On the one hand, it has commercial interests in the project and needs the electricity it will generate. On the other hand, as a vibrant democracy, Thailand needs to consider politically that there is widespread public opposition to the project. Vietnam has expressed strong concerns over the project's basin-wide environmental impacts in general and its impacts on the Mekong Delta in particular. Cambodia is also downstream and wary of the project's environmental impacts, not least on fisheries and the Tonle Sap flow system. But the Cambodian government's position is complicated by its own interest in mainstream dams on the one hand and public opinion against not only the Xayaburi dam but mainstream dams in general on the other.

According to the MRC Agreement, large infrastructure developments with a transboundary impact, particularly mainstream dams, have to follow a process of notification, consultation and agreement before being implemented (see earlier section on the 1995 MRC agreement). As a first step in this process, Laos submitted the Xayaburi project for assessment by the MRC in early 2011. The assessment concluded that there were a number of uncertainties and negative impacts from the project. Public hearings on the project were also held, with opposition expressed by the Thai public. Perhaps most significant was the criticism of the project by downstream Vietnam's official media, environmental authorities and Vietnamese scientists and environmentalists. Critics in the region, and internationally, warn that the project could open the door to the ten other dams being considered for the Lower Mekong, thus turning the river into a cascade of engineered lakes.

At a JC meeting of the MRC in April 2011, Vietnam, Thailand and Cambodia raised doubts over the project, which was referred to a MRC Council in December 2011. The apparent importance of the Xayaburi controversy led to diplomatic engagement on the matter between the prime ministers of Laos, Thailand and Vietnam during the ASEAN Summit in Jakarta in May 2011. After closed meetings, the Laotian Prime

Minister announced that Laos would temporarily suspend the project. It was agreed to engage 'prestigious international scientists to seek firm scientific ground for future decisions' (Radio Voice of Vietnam, 8 May 2011). In defiance of the MRC and its three neighboring countries, Laos informed the Thai project developer in early June 2011 that all necessary impact assessments had been made and the regional decision-making process had been completed (Reported by the International NGO International Rivers based on a leaked letter from the Laotian government to the Thai investor, the Xayaburi Power Co. Ltd.) Disagreement over the results of the existing scientific impact assessments of the dam remains.

The differing views on these assessments appear ultimately to be embedded in the political economy of water in Laos, whose national economic imperative of hydropower development is challenging scientific impact assessments and social learning. However, geopolitics is also playing a role here. Closer commercial and political ties with China may also be a factor behind the Laotian government's determination to go ahead with the Xayaburi project in defiance of the opposition from other MRC member countries, particularly Vietnam.

Discussion: Unfolding Social Learning Where National Sovereignty Reigns

Until recently, social learning in the Mekong was limited to single-loop learning in largely self-contained circuits. For many years, the MRC and its member country governments were operating in a rather closed governance regime. Donor-supported knowledge production in the MRC represented single-loop learning and was mainly oriented toward science and management. In parallel, and largely outside the MRC framework, a civil society and NGO network dominated by national and regional NGOs located in Thailand and Cambodia has created its own space for alternative dialogue and single-loop social learning. Thai and international media have voiced criticism and concerns over the Mekong and MRC developments, thereby participating in this alternative circuit of single-loop learning. From time to time, the relationship between the two circuits has been tense.

But as the MRC has opened up a space for participation and transparency around its knowledge production, social learning is being enhanced within a wider governance framework. This has created room for double-loop learning based on dialogue and discussions over the BDP process of formulating development scenarios, including the conditions for and impact of hydropower development. Also, the sharing of the development space by inviting stakeholders for consultation and dialogue and the MRC's more open and transparent management of its considerable pool of knowledge represents social learning. The MRC's transparency around the notification, consultation and agreement process linked to the Xayaburi dam has been an icebreaker for double-loop learning. Mekong stakeholders outside the MRC have been able to voice their views and concerns over the dam, including having direct access to and dialogue with the MRC. Also, the openness around the MRC-sponsored independent strategic environmental impact assessments (SEA) of Mekong mainstream dams in general appears to have widened the space for double-loop learning and given the MRC considerable credit. The NGO, civil society and scientific community have largely been supportive of the quality of the MRC's impact assessment of the Xayaburi dam. Although the chapter on mainstream Mekong dams remains open, the events surrounding the Xayaburi dam have had significant positive social learning effects, widening and deepening the governance regime of the MRC to include all stakeholders in shared social learning. In addition, it has given a boost to the legitimacy of the MRC as a relevant knowledge and governance institution.

It remains a question whether the MRC and cooperation in the Lower Mekong is ready for triple-loop learning. If, for example, the MRC decides to postpone the Xayaburi dam or have a 10-year moratorium on mainstream dams in general, as has been suggested, it would represent a paradigm shift that amounts to triple-loop learning (Trandem 2011). Although such a decision would be possible within framework of the current 1995 agreement, it would infringe upon national sovereignty and thereby represent a transformation of the political context and governance practices.

Pig Politics: Integrated Management of Water Resources in Denmark

Conflicts of interest between agriculture and the environment have been topics of a continuous political struggle in Denmark during the last three decades. The most fundamental problem has been related to the leaching of nitrogen from agricultural land, which has contributed significantly to the dramatically increased eutrophication and poor ecological status of lakes, estuaries and coastal waters.

Agriculture has been the dominant sector in Denmark, and export of agricultural products formed the backbone of the national economy until the 1960s. During the first two thirds of the twentieth century, the paradigm among the population and the politicians was that 'What is good for the agricultural sector is good for Denmark'. During this period, the majority of wetlands and other marginal land areas were converted into agricultural land with heavy subsidies from the Danish government, so that agricultural land today constitutes 61 percent of the entire land area, which is among the highest in the world (Statistics Denmark 2009).

During the 1960s, the use of agrochemicals such as fertilizers and pesticides increased dramatically, and a process of industrialization, specialization and centralization was started. Thus, the 200,000 farms before 1960 had been reduced to 40,000 farms in 2009. The largest growth in agricultural production occurred for pork meat, with an increase in the pig population from 4.6 million in 1955 to 12.4 million in 2009 (Statistics Denmark 2009; Statistical Yearbook 1960). As a result of the increased use of fertilizers, crop yields increased significantly, but so did the leaching of surplus nitrates and to a lesser extent phosphorous to the aquatic environment. Today a major part of the fertilization comes from pig manure, from which the nitrogen uptake in plants is much more difficult to control than from mineral fertilizers, and which therefore contributes significantly to nitrate leaching.

The main water stakeholders are the agricultural and environmental sectors. The interests of the two sectors are to a large extent promoted by their respective sector ministries. The ministries have managed these interests in the classic manner of having their own research institutes and research programs and having close contacts with their respective stakeholder groups. The key stakeholder in the agricultural sector is the farmers' association—the Danish Agriculture and Food Council—which has its own research organization, the 'Knowledge Center for Agriculture', and runs the agricultural extension service. The environmental stakeholders are organized into several green NGOs, with the Danish Society of Nature Conservation being the most powerful in this context.

Governance Framework: National and EU Legislation

The governance framework has evolved in three stages: (1) before 1987, (2) 1987–2003 and (3) after 2003. During the 1970s and 1980s, it became clear to the scientific community that the leaching of nitrates and phosphorus from agricultural land was the dominant source responsible for the increasing eutrophication of coastal waters that periodically resulted in oxygen depletion and dead fish in coastal waters. After a number of severe episodes and heavy campaigning by the Danish Society of Nature Conservation, in 1987 the Danish Parliament adopted an act (VMP1) with the overall objective of improving the aquatic environment. An important instrument in the VMP1 was regulations on Danish agriculture aiming at reducing nitrate leaching by 50 percent. Two other elements of the VMP1 were a major research program aimed at improving knowledge about nitrates and phosphorus in agricultural and environmental systems and the establishment of an environmental monitoring system to assess the impacts of the regulations.

VMP1 was executed during the period 1987–1998. The objective of reducing nitrate leaching by 50 percent was not achieved, so the Danish Parliament revised the plan in a new act (VMP2) with a strengthening of the regulations, an additional research program and so on. (Grant et al. 2002). By the completion of VMP2 in 2003, the target of a 50 percent reduction has been officially achieved and the aquatic environment improved, albeit not nearly to the extent originally envisaged (Ministry of Environment and Ministry of Food, Agricultural and Fisheries 2004).

With the adoption of the EU Water Framework Directive (WFD) in 2000, the legislative framework changed significantly (European Commission 2000). Most importantly, the objective was shifted, as the WFD requirements for 'good ecological status' were much stricter than the soft objective in VMP1 of improved water quality. As a result, the target of nitrate reduction was changed to the reduction of a further 50 percent—that is, down to about 25 percent of the amount before 1985. The measures to achieve the new WFD objectives are described in the politically much disputed river basin action plans from the Ministry of Environment, which were delayed for 2 years (www.naturstyrelsen.dk/Vandet/Vandplaner/).

The normative ideals behind the VMP1 and VMP2 legislation were dual. On the one hand, the ideal was to ensure environmental sustainability in line with the principles outlined in the Dublin Statement on Water and Sustainable Development of 1992 (ICWE 1992). On the other hand, the ideal was to ensure good framework conditions for an economically sound agricultural sector. The EU WFD introduced new principles with close similarities to key IWRM principles, such as the requirements to manage surface water and groundwater in an integrated manner, to involve stakeholders in the planning and management process and to make economic assessments, including all cost aspects. The WFD can be seen as a European adaptation of IWRM, but with some important differences: (1) the WFD gives a priori preference to environmental objectives, while the IWRM in itself is neutral, only emphasizing the triple bottom lines (economy, environment, equity), and (2) the WFD has a built-in implementation mechanism, including the transfer of national powers to the EU.

Governance Processes: Low-Hanging Fruits and Stagnation

The adoption of VMP1 in 1987 represented a paradigm shift. Until then the agricultural sector had not been subject to environmental regulations, and the general thinking among most farmers and many of their advisors in the agricultural extension service was that the water quality problem was not being caused by the agriculture. The cooperation between environmental and agricultural researchers had until then been very limited, and when these water quality issues emerged, there was a considerable degree of mistrust ('we cannot be sure that foreign groundwater equations also apply under Danish conditions'). This lack of trust was naturally even greater among private stakeholders in the two camps.

Therefore, the government intentionally designed the VMP1 so that the interactions between scientists, professionals and stakeholders from the two camps were increased. Thus, it was prescribed that both the research and the monitoring programs should be run jointly by research institutes from the two ministries of agriculture and environment. This gradually resulted in the building up of trust, so that the inevitable political battles could take place with a minimum level of disturbing misunderstandings. Another outcome of this process was that scientific evidence became important arguments in the political struggle. Conditions for the knowledge-based management process were favorable during this period because it was possible to identify solutions where the conditions for one part (environment) could be improved substantially without severe costs for the other part (agriculture).

By the time the environmental objectives had been strengthened with the WFD, all the low-hanging fruits had been harvested, and the agricultural stakeholders argued that it was not possible to achieve the WFD goals without devastating costs for the agricultural sector. Environmental stakeholders like the Danish Society of Nature Conservation likewise argue that the only way to preserve an economically sound agriculture in

Denmark is for it to give up some of the marginal agricultural land. If this idea of converting land from agriculture back to nature is implemented, it would be a major paradigm shift requiring new legislation.

Agricultural stakeholders have been heavily engaged and have strongly influenced this evolution. The environmental NGOs were very active in the 1980s and at the beginning of the 1990s, but as the Ministry of Environment gradually adopted their agenda during the 1990s, they have played a less significant role since.

The transition from the national VMP1 process with significant progress to the EU WFD process with, so far, rather limited progress coincided with a change of government in Denmark in 2001. During the 1990s, environment was high on the political agenda, the Minister of Environment was a powerful member of the cabinet, and Denmark often played a role as environmental frontrunner internationally. The new government had lower environmental ambitions and agenda and the once powerful Ministry of Environment lost influence.

Discussion: Social Learning Up to the Threshold of Pain

The paradigm shift with the adoption of the VMP1 in 1987 was a reframing of the regulatory framework (double-loop learning), including new legislation, though without undermining the conditions for the agricultural sector. The developments between 1987 and 2003 can be seen as a single-loop learning process that started with two fundamental different knowledge frames among environmental and agricultural stakeholders. The results were very successful because there was room to improve environmental conditions without sacrificing agriculture. Thus, the 'low-hanging fruits' were gathered in a process of intensive stakeholder involvements and dialogues, and the water management process was truly knowledge-based during this period.

Today there are no low-hanging fruits left, and achieving further improved ecological conditions, as required by the WFD, will in the short term be very painful for the agricultural sector. This will require a transformation implying a completely different paradigm for the role and importance of agriculture in society, corresponding to triple-loop learning. Such a transformation is obviously not possible without a major political struggle. An indicator of this ongoing struggle is the fact that Denmark, once perceived to be among the environmental front-runners, has had to delay the adoption of the WFD river basin action plans, due in December 2009, by 2 years, with the result that in June 2010 the European Commission (EC) issued a notice to the Danish government that it may take legal steps because Denmark is breaching the relevant directive. It remains to be seen how much muscle the EC will apply to enforce the WFD in Denmark and in other countries.

All the regulatory frameworks (VMP1, VMP2 and the EU WFD) included elements of normative ideals. While these ideals were higher than what could realistically be achieved in the short term because of the political struggles between stakeholders, they contributed to setting the agenda throughout the period. Progress toward achieving some of the ideals was influenced partly by the low socioeconomic and political costs—that is, the availability of 'low-hanging fruits' and the degree of resistance from stakeholder groups—and partly by the changing policies of the respective governments.

Discussion: Power, Social Learning and Normative Ideals

These three cases allow us to study the way social learning processes unfold in practice. Through our analysis, we approach '…the way integration actually takes place…' rather than idealized normative pictures of how actors should integrate (Saravanan et al. 2009: 77). Below we discuss the cases in a comparative perspective while investigating the links between social learning with reference to normative ideals, the political economy of water and principles of democratic governance.

A Comparative Perspective on Social Learning

In the three cases, social learning has occurred with reference to different normative ideals ('what is learned'). IWRM includes both a sustainability dimension (e.g. the balancing of environmental, economic and social goals in water management) and a process dimension (e.g. the coordination and participation of stakeholders in a governance process), which are intimately linked.

The learning loops in the Danish case primarily refer to tackling the environmental problems created by the limited regulation of an industrialized agricultural sector. Conversely, the Chilika and Mekong cases emphasize the problems of transparency and inclusion in decision-making processes, as well as the ability of the key integrative agencies (i.e. the CDA and MRC) to secure effective implementation of the normative ideals involved. In Denmark, these processes have been framed by an enabling environment characterized by a transparent and highly institutionalized governance system, which to a lesser degree is present in the other two cases.

Despite the democratic character of the Indian state, the outcome of governance processes in Chilika is structured by informal patterns of power and influence producing contradictory policies, which erodes trust between the non-state stakeholders involved and jeopardizes the legitimacy of government interventions. This complicates and expands the scope of social learning processes, as both the sustainability and process dimensions are involved; there is no enabling environment in place.

At first sight, the intergovernmental character of the MRC sets a different scene, with the sovereign Mekong countries as the key stakeholders. Nevertheless, the integrative institutions in Chilika and the Mekong cases are structurally similar in the sense that both the CDA and MRC have been designed as facilitating institutions meant to perform a support function for political decision-making, act as mediators between stakeholders and build a scientific knowledge base. Neither of the organizations have been mandated with any formal regulatory capacity.

Consequently, they both depend on their ability to build shared understandings and create a sense of common interests if they are to achieve the cooperation of state and non-state stakeholders. The capacity to implement political decisions is formally stronger in the Danish case, as integrative policy plans have been accompanied by adaptation of the regulatory frameworks and close links to well-established government institutions (i.e. the Ministry of Environment and Ministry of Agriculture). With the adoption of the EU's WFD in 2000, the role of the various actors changed in Denmark. Water management goals are now defined multilaterally, and member states, including Denmark, are given the task of implementing the directive according to a specific timetable. Implementation by member states will be carried out under the supervision and ultimately the legal pressure of the European Commission. This strengthens the water governance framework even more compared to the Chilika and the Mekong cases.

Social Learning and the Political Economy of Water

Despite their differences, the three cases point to the importance of the political economy of water for social learning processes (see Swatuk 2008). In Denmark, Chilika and the Mekong, the interests of strong economic stakeholders or specific national interests intervenes and challenges the implementation of the IWRM-based frameworks that have been created. Social learning has been an incremental affair, where the 'low-hanging fruits' of single-loop learning have been picked first. Deeper and more controversial transformations of double- and triple-loop learning have been avoided, as they typically challenge the distribution of power, interests and benefits among stakeholders within the prevailing water governance system. In the three cases, actors with vested interests in the status quo have tended to resist transformative changes. These findings largely reflect points made by several other authors, namely that change is 'generally not the result of the triumph of rational science over ignorance' (Swatuk 2008: 25; also, Warner 2007; Molle 2008; Mollinga 2007). Rather, change occurs when powerful actors see a benefit in change, or when costs are minimal. As Jeroen Warner (2007) has also argued, realizing mutual interdependence does not in itself pose a sufficient condition for actors to engage in social learning: they also need to be willing to search for solutions and take joint responsibility.

Consequently, the translation of normative ideals like IWRM into practice is mediated by the context-specific political economy of water. The translation process typically involves hard negotiations, trade-offs and asymmetric power struggles between stakeholders over the use and allocation of water resources. A willingness to learn, cooperation, trust and shared understandings between stakeholders are not easily achieved, especially when problems continue after less costly and uncontroversial solutions have been implemented. When the persuasion of normative ideals requires changes beyond clear-cut win-win situations, as in the conflicts over prawn aquaculture in India, mainstream dam construction in the Mekong or the environmental effects of industrial agriculture in Denmark, the links between social learning, politics and power become even more important for the outcome of water governance processes. In such situations, social learning in the realm of water governance may require a shift in the wider sociopolitical context—and in the power relationships, norms and perspectives of key stakeholders—to approach the second- or third-tier learning loops (Pahl-Wostl et al. 2007a).

Possibilities and Limitations of Normative Ideals in Water Governance

Whereas deeper degrees of social learning with reference to normative ideals may be controversial and difficult to achieve, the three cases illustrate some of the possibilities that emerge when these concepts inform the political processes of water resource management. The three cases also underline the importance of democratic governance for social learning to occur.

Firstly, the introduction of normative ideals in Denmark and the Mekong region has contributed to setting the agenda for policy-making and created a political space for contestation of the prevailing practices. In spite of the controversies and shortcomings of their implementation, the normative ideals have provided a frame of reference for the agents of change, which is utilized to exert pressure on the existing management systems and challenge the stronger or emerging stakeholders. This is exemplified in the Danish case, where normative ideals have provided a vehicle for the environmental sector to seek a transformation of the agricultural sector and in that sense contributed to the politicization of water management practices. In the Mekong region, this is illustrated by the Laotian government's determination to go ahead with the mainstream Xayaburi dam, which has accelerated social learning (on water management and environmental principles) and widened the space for more transparent and inclusive governance. The Indian case is muddier, as the official claim to integration stands in grave contrast to the actual practices. In this context, the normative ideals play a somewhat dubious role in providing legitimacy to the official government policy, but in effect they contribute to the de-politicization of water governance in the lagoon. Thus, normative ideals may provide a direction for social learning processes, or else become symbols in which stronger stakeholders may base their interests.

Secondly, the cases point to the role of scientific knowledge in processes of social learning (Pahl-Wostl et al. 2007b; Pahl-Wostl and Sendzimir 2005). Provision of scientifically validated and context-specific information is a key part of the integration strategy designed. Despite the political and contestable character of scientific knowledge, such knowledge has ultimately evolved into 'soft' constraints on political decision-making, especially in Denmark and the Mekong region. Here the actors have developed some sense of shared understanding, exerting pressure on actors who are tempted to resort to unilateral decision-making. For example, it may become politically costly for Laos to build the Xayaburi dam if commonly agreed scientific knowledge identifies serious social or environmental problems. Consequently, the significant amount of scientific knowledge-generation in the key water management institutions in these two cases also contributes to the exposure of stakeholders giving priority to political or economic self-interest over the shared knowledge base and shared social or environmental concerns.

Thirdly, water governance processes in the Mekong and Danish cases have been relatively transparent and have involved government, business, media and civil society actors. This makes decision-making susceptible to public scrutiny and debate, thus influencing room for maneuver and the legitimacy of outright power politics. In India, formal decision-making and knowledge-generation subsumes to the informal and power-ridden political logics of corruption and patron-client relations. Whereas the principle of democratic governance is no magic bullet that guarantees social learning, evidence from these cases suggests that general features of the governance system—those outside the 'water box'—such as transparency, the rule of law, participation, free media and so on work as facilitating conditions for social learning with reference to normative ideals (see Armitage et al. 2008; Pahl-Wostl et al. 2007a).

This corresponds to the common notion among proponents of normative ideals like IWRM and AWM that stakeholder participation and democratic institutions are the key tools in moving water governance processes toward their respective 'nirvanas' of integration or enhanced adaptiveness (Lenton and Muller 2009; Pahl-Wostl et al. 2007a). Despite the attention given to the necessary transformations in prevailing practices, the AWM ends up in the same position as IWRM: as a normative model of how water management systems should be created to maximize the possibility of social learning and stakeholder involvement. Hence, AWM portrays an idealized picture of how water governance processes should be orchestrated. Whereas AWM provides an important supplement to IWRM, it does not escape the fact that normative models need actors to be implemented locally. AWM processes, like the integration processes of IWRM, are likely to produce suboptimal, political and highly power-infused outcomes. Moreover, the institutionalization of new water management arrangements is likely to fall short of the adaptive ideals and their social learning imperatives. Consequently, agents of change—whether governments, NGOs, water experts and international donors—need to qualify the prevailing social engineering approach to IWRM and AWM with a strategic action approach based on careful contextual analysis of the current situation. This would entail identification of the options for change, the benefits and costs involved for various stakeholders, vested interests and potential allies and opponents in political struggles for change (cf. Mollinga et al. 2007; Saravanan et al. 2009). Such an approach deals directly with the inherently political and power-ridden character of water management, as well as seeking to create political spaces of contestation that may increase the chances that social learning processes with reference to normative ideals can be pushed toward more inclusive and deeper loops and therefore more profound changes.

Conclusion

The social learning processes involved in the translation of normative ideals into actual governance practices inevitably comprise the political economy of water—the reality of 'what is'. Consequently, social learning does not occur independently of power politics and does not occur with any self-enforcing necessity. Normative ideals require some actors to adopt and advocate them in the local context. In this process, open, inclusive and transparent decision-making and implementation, as well as political support by authoritative actors, are crucial. Positively, political power can push social learning processes toward the normative ideals if it is used to build shared understandings, trust and regulatory capacity. Negatively, political power can impede social learning if actors use it to resist the changes envisaged and pursue partisan interests. Whatever the outcome, it is determined by the way the political processes unfold in the actual context in which the normative ideals are applied.

Despite the effect of the normative ideals on the water governance practices identified in the three cases, the simultaneous impediments related to the political economy of water suggest that more IWRM or AWM in itself does not suffice to take the social learning processes above the low-hanging fruits. Rather, the eventual accumulation of shared knowledge among stakeholders, significant political shifts and the alteration of power structures constitute the windows of opportunity that may make deeper degrees of social learning with reference to normative ideals possible. It remains to be seen whether implementation of the EU WFD will be lifted out of the current stagnation and the social learning process pushed toward a paradigmatic transformation of the Danish agricultural sector. However, political struggles are inevitable and important determinants of such social learning processes.

Consequently, sober-minded and realistic expectations regarding the ability of normative ideals to solve the present water governance challenges should inform future attempts to design integrative or adaptive water governance systems. Whereas they may provide a frame of reference for agents of change, the eventual transformation toward their 'Nirvana' visions will be the result of long-term political processes, where strategic action, negotiations and trade-offs between the stakeholders involved in the micro- and macro-decisions of water governance on the ground provide the vehicle of change. Otherwise, they will remain misty mirages on the horizon of public policy-making.

Finally, we see the discourse on the relationship between normative water management ideals and politics or political economy as having universal application. It is relevant for most development priority areas, including climate change mitigation and adaptation, as well as for overall development policies.

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CHAPTER 5

Mitigating the Korle Lagoon Ecological Pollution Problem in Accra, Ghana, Through a Framework for Urban Management of the Environment

Jeffrey Squire

Introduction

This chapter examines the Korle[1] Lagoon ecological pollution problem in the Accra Metropolitan Area, the capital city of Ghana, with a view toward putting forward feasible policy recommendations that might be used to mitigate the problem, using a Framework for Urban Management of the Environment (FUME). Located in the Ghanaian capital city of Accra, the Korle Lagoon overlooks the Gulf of Guinea and covers a total surface area of 0.6 km^2 (Karikari et al. 2006). The Korle Lagoon used to be a freshwater ecosystem that once boasted an abundance of fish, crab and other forms of aquatic biota that contributed to food security and also provided a means of livelihood for residents around its vicinity. In the past few decades, however, the lagoon has become heavily polluted and an environmental

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disaster due to the combined effects of uncontrolled urbanization, politics and mismanagement. The banks of the Korle Lagoon have been transformed into human habitats by migrants, mainly from the northern parts of the country, whose activities largely contribute to the problem. These migrants engage in commercial and other activities that contribute to the generation of massive amounts of waste including dangerous pollutants that end up in the lagoon.

The situation is compounded by the absence of effective sanitation and waste management systems in the metropolis, which contributes to indiscriminate littering and unauthorized dumping on the banks of the lagoon. In addition, there is not a single wastewater treatment facility in the metropolis, and as a result, effluents from adjacent households, industries and institutions including healthcare facilities are emptied directly into the lagoon. This has caused the lagoon to lose its functions, diversity and carrying capacity. A study by Karikari et al. (2006) found extremely low dissolved oxygen levels in the lagoon leading to a high biochemical oxygen demand (BOD). A major contributing factor to this problem is the presence of wastes including high fecal coliforms in the lagoon. Boadi and Kuitenen (2003) also reported rapid proliferation of water hyacinths and other vegetation, depriving the lagoon's ecosystem of oxygen. This has had a dwindling effect on the lagoon's biota and, in some cases, contributed to the complete disappearance of some species. There have also been studies that show high concentrations of pesticides and heavy metals including lead, copper and cadmium in the Korle Lagoon (Essumang et al. 2009; Nyarko and Evans 1998). In particular, heavy metals found in the lagoon exceeded the World Health Organization's recommended limits, and there was evidence of biomagnification of zinc and copper along the food chain, raising concerns around public health (Nyarko and Evans 1998).

Attempts by various governments to restore the lagoon to its original state have been largely unsuccessful, despite significant capital investments. This chapter posits that the failure to restore the Korle Lagoon ecology is largely a result of the top-down scientific approach taken by decision-makers to addressing the problem. Field studies have been mainly scientific and quantitative and have taken the form of topographical and bathymetric surveys, digital mapping, geotechnical investigations, sampling and laboratory analysis, offshore surveys and measurements. This approach is purely technical and devoid of any meaningful consultation and collaboration with all relevant stakeholders including the squatters who inhabit the banks of the lagoon. Effective environmental governance requires ecological 'literacy', and meaningful citizen participation (Hempel 1996). In other words, addressing the Korle Lagoon ecological problem requires both scientific and collaborative approaches. This is in line with the concept of good environmental governance which requires interaction between power structures and civil society in an atmosphere of power sharing, flexibility, tolerance and respect for each other's views, especially those of local groups and communities (Swilling 1997). Against this backdrop, the fundamental objective of this chapter is to explore the applicability of the Framework for Urban Management of the Environment (FUME) to mitigating the Korle Lagoon ecological problem.

Dissecting the Framework for Urban Management of the Environment

The FUME is an eclectic concept designed purposely for understanding and addressing complex environmental problems characterized by high degrees of uncertainty such as the Korle Lagoon environmental disaster. It draws upon relevant aspects of numerous important concepts often aligned with the notion of good environmental governance: the precautionary principle; adaptive management; co-management; risk management; integrated waste management (IWM); ecosystem approach; and advocacy, transactive and communicative planning models (CPMs). Each of these is briefly articulated below. It is worth emphasizing that the FUME model does not reject or negate the usefulness of existing environmental planning and management concepts such as the Water-Energy-Food Nexus. Rather, it is predicated on the need for the selection of suitable intervention strategies to address specific environmental challenges. A conceptual representation of the FUME model is shown in Fig. 5.1 and described further below.

The Precautionary Principle

The precautionary principle is a decision-making tool that implores stakeholders to implement effective management action to mitigate environmental and human health threats characterized by uncertainty (e.g., deFur and Kaszuba 2000; Jordan and O'Riordan 1999). The principle states in part that 'when an activity raises threats of harm to

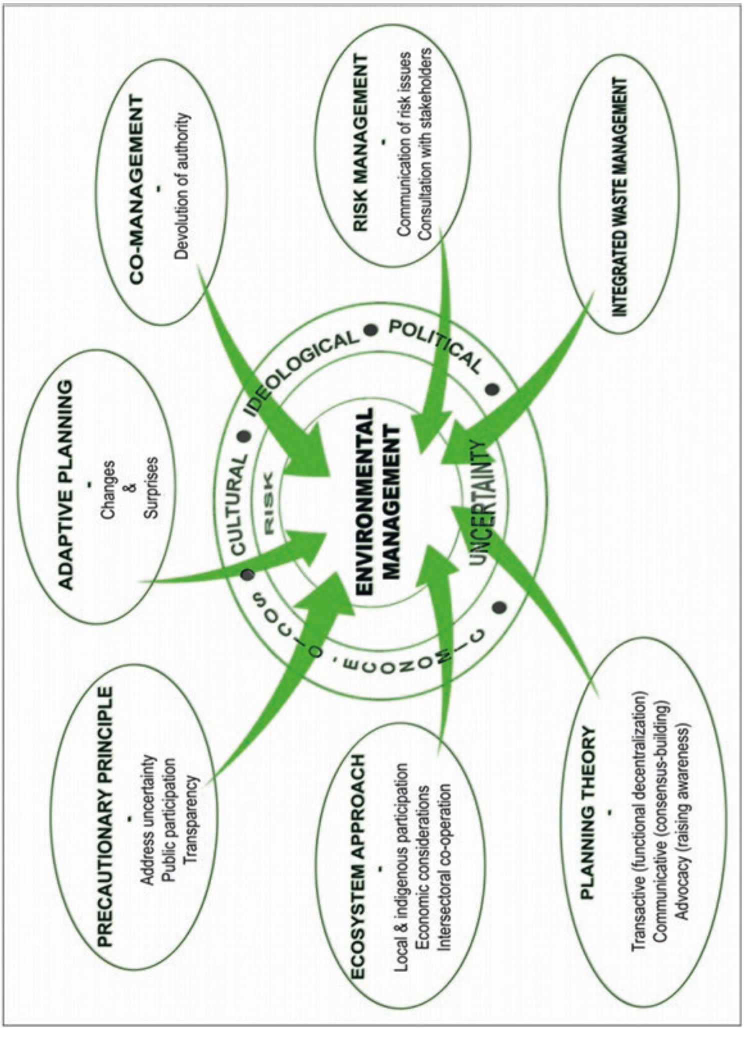

Fig. 5.1 The FUME model

human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically' (Wingspread Conference 1998: 2). It is widely believed to have originated in Europe in the 1970s in response to growing environmental problems and has since been adopted by a number of countries, agencies, organizations and international institutions. In France, for example, the precautionary principle is invoked in the country's environmental charter. The precautionary principle has also been cited in a number of international agreements, protocols and frameworks including the Basel Convention (1992), the North Sea Ministerial Declaration (1987), the Rio Declaration (1992), Convention on Biological Diversity and the Bamako Convention on Hazardous Wastes in Africa (1992), among others. Embedded in the core premise of the precautionary principle are a number of essential elements including a duty to act, shifting the burden of proof to proponents of an activity, consideration of a wide range of alternatives when exploring management action for environmental problems, and public participation and transparency in the planning and decision-making process (e.g., deFur and Kaszuba 2000; Jordan and O'Riordan 1999; Kriebel et al. 2001; Quijano 2003; Rogers 2001).

The Ecosystem Approach

The underlying crux of the ecosystem approach entails the integration of scientific (systems-based) methods with collaborative (holistic) processes in understanding and solving complex environmental problems (Heissenbuttel 1996; Szaro 1998). The concept is widely believed to have originated in North America, where it was used as a framework for managing the natural resources of the Great Lakes Basins (Caldwell 1994). The ecosystem approach has since been ratified by 150 countries under the Convention on Biological Diversity (CBD 2000; Government of Canada 2008). This approach recognizes the role of humans as both central to the causes of problems facing ecosystems and pivotal to solving such problems (Cooperrrider 1996; Forget and Lebel 2001). Thus, the ecosystem approach is predicated on the notion that sustainability in any given society cannot be achieved without consideration of the larger ecological system of which society is a part (Waltner-Toews et al. 2005).

Co-Management

The co-management approach involves a process of co-operation and partnership between central governments and local-level stakeholders in the management of environmental resources. Thus, a fundamental premise underlying the co-management approach is the devolution of authority, one where central government authorities share responsibility for the environment with local communities (Persoon and Van Est 2003; Timko and Satterfield 2008). The co-management approach thus holds a pluralistic view of society, one where local solutions are sought for local problems and government intervention is solicited when necessary (Plummer and Fitzgibbon 2004). Effectively, the co-management approach advocates for fairness, transparency and equity in environmental planning and decision-making by creating linkages between local and national-level actors (Borrini-Feyerabend et al. 2007; Fisher and Jackson 1998).

Proponents of the co-management approach tout several benefits associated with its use. These include an informed and democratic decision-making process, resolution of conflicts and stakeholder participation (Armitage et al. 2007; Castro and Nielsen 2001). This can lead to increased efficiency and good governance of the environment (Armitage et al. 2007). The process can also assist in the allocation of resources as well as the exchange and sharing of tasks, risks and power (Carlsson and Berkes 2005). Further, a co-management approach can lead to the effective gathering and analysis of data (Pinkerton 1989). Conversely, a number of questions have been raised about the efficacy of the co-management approach as a viable environmental management tool. Critics argue that stakeholder participation in environmental planning and decision-making may generate new conflicts or even aggravate existing tensions (Castro and Nielsen 2001; Carlsson and Berkes 2005). In some instances, co-management strategies also may reinforce and even intensify class and gender inequities within the community (Colchester 2003).

Adaptive Planning and Management

Most environmental problems are characterized by high degrees of uncertainty, and the principle of adaptive management is predicated on the need to address uncertainty. The concept is widely believed to have evolved during the Gulf Island Recreation Land Simulation Study in the mid-1980s

(Gunderson et al. 1995). Adaptive management operates on the premise that eradicating uncertainty in environmental problems is unfeasible, and as such, the implementation of intervention strategies must be seen as experiments, leaving open the opportunity to accept, acknowledge and learn from mistakes (Briassoulis 1989; Holling 1978). This is due to the possibility of sudden changes in socio-economic, environmental, social and political systems. Subsequently, adaptive planning and management urges planners, decision-makers and all stakeholders to design and implement flexible management strategies that can be modified to accommodate sudden changes and surprises (Briassoulis 1989; Holling 1978; Marttunen and Vehanen 2004). Public participation is deemed an essential component of adaptive planning and management (Lessard 1998). This allows for the tapping of information from different stakeholders including scientists, planners, decision-makers and the general public when designing management strategies (Grayson et al. 1994: 246; Holling 1978: 8).

Advocates maintain that the greatest strength of adaptive planning and management lies in its ability to accommodate sudden changes and surprises. This may curtail the tendency to delay management action while research is conducted to reduce uncertainty (Harremoes et al. 2002). The emphasis on public participation may also lead to transparency in the planning and decision-making process (Weterings and Eijndhoven 1989). On the other hand, some critics argue that the idea of monitoring and making adjustments when new information becomes available can be expensive and expansive (Mitchell 1997). This might constitute a problem for poor developing countries, especially in instances where the nature of the problem supersedes resource availability. Adaptive planning and management also requires decision-makers to acknowledge mistakes, which they may not be willing to do (Mitchell 1997). Furthermore, some critics argue that adaptive planning and management principles lack a clear means of implementation (Briassoulis 1989).

Advocacy Planning

Advocacy planning involves a process of planners immersing themselves in the political process and acting as advocates for stakeholders who have a stake in the planning outcome (Davidoff 1965). This approach recognizes that society is constituted of diverse groups with opposing goals and interests and therefore seeks to facilitate the democratization, inclusion and empowerment of marginalized stakeholders in the planning process

(Clavel 1994; Davidoff 1965; Harwood 2003; Peattie 1968). This model views the top-down approach to ecological planning as an affront to pluralism and, therefore, charges planners to democratize the process as a way of dealing with inequalities and bringing marginalized groups into the process (Checkoway 1994; Davidoff 1965).

Communicative Planning

The CPM is predicated upon the need for communication, consensus building, negotiation and conflict resolution in the planning process (Healey 1997; Taylor 1998). This is necessary for dealing with a contentious environmental problem such as the Korle Lagoon pollution issue involving stakeholders as differently empowered as squatters, private sector actors and the government (both as a direct stakeholder—i.e., state-owned hospital—and as a regulator). The communicative approach involves a process of 'practical deliberation involving dialogue, debate and negotiation among planners, politicians, developers and the public' (Taylor 1998: 71). Essentially, the CPM places practitioners in the role of experiential learners vested with the responsibility of ensuring agreement among multiple stakeholders (Healey 1996). The objective is to ensure that whatever the position of participants within the social economic hierarchy, no group's interest will dominate (Healey 1996: 176). This ensures the consideration of the views, values, knowledge and experience of local stakeholders in the planning process (Mitchell 1997). Ultimately, this can give local stakeholders a sense of ownership over the outcomes of planning decisions. Additionally, effective dialogue within the communicative planning process will facilitate agreements and consensus in an atmosphere of mutuality which can contribute to personal growth among stakeholders (Innes and Booher 1999; Healey 1997; Sager 1994; Buchy and Race 2001).

Transactive Planning

The transactive planning model is rooted in the premise of communicative rationality which fosters dialogue between planners and people affected by planning practice by taking a situation-specific, process-oriented approach. Essentially, the transactive model aims at providing an alternative to the centralized norms of planning practice by seeking diverse solutions at the local and regional levels of society (Friedmann 1993; Mitchell 1997).

Such reasoning is based on the assumption that various interests in society exist, and all these interests have to be considered. Within the transactive model, populations assist in planning through the contribution of socio-cultural and traditional beliefs and practices as well as experiences (Friedmann 1993). Typically, the transactive planning model assumes five main dimensions: normative, innovative, political, transactive and social learning (Friedmann 1993).

According to Friedmann (1993), as a planning theoretical concept, the transactive model has several advantages. The application of the transactive model, for example, can make the planning process more decentralized. Decentralization in the planning process may give voice to marginalized sections of the populations from the onset when planning problems are being identified. This may strengthen communal responses and potentially lead to a sense of collective security. Transactive planning may also bring more detailed and specific knowledge to bear on a situation than would be possible if only expert knowledge were used.

Environmental Risk Management

Environmental risk management refers to the steps taken to control, prevent, reduce or eliminate the release of potentially harmful contaminants into ecosystems (Government of Canada 2008). It involves a process of identifying, assessing, communicating and taking the best possible course of action regarding diminishing risks, using both scientific and non-scientific information (McColl 2000). Thus, most typical environmental risk management frameworks and strategies involve an assessment of risks which generally involve a process of determining the presence of contaminants in the environment through scientific and quantitative means (Lave 1987; Wilson and Crouch 1987). The process assists in measuring levels of acceptable harmful substances in the environment as well as the consequences of past exposures (Wilson and Crouch 1987). Analysis of environmental risks typically assumes ecological as well as human health dimensions. Ecological risk assessments address issues relating to the structure, functions and processes within ecosystems as well as the fate of ecosystem species. It aims at assessing the effects of contaminants on the food web, habitat and behavior of living organisms within ecosystems (Dobson 1993). Human health risks assessment, on the other hand, analyzes human health risks brought about by exposure to environmental contaminants (Kavlock et al. 1996).

Risk assessment encompasses four main areas. These include hazard/problem identification, dose–response relationship, exposure analysis and risk characterization (Quijano 2000; Russell and Gruber 1987). Hazard/problem identification determines whether available scientific information adequately addresses the causal relationship between a contaminant (e.g., biodegradable municipal solid waste—BMW—residue) and an established impact on the environment or human health (Guidotti and Gosselin 1999). This process is essential for setting planning and management goals (Patton and Sawicki 1993). Dose–response assessment addresses the quantitative relationship between exposure and response in circumstances where adverse environmental and human health effects have been observed. Guidotti and Gosselin (1999) describe exposure assessment as a process whereby qualitative insight and quantitative data are sought on the degree, duration, frequency, sources and routes of exposure of contaminants into the environment. Risk characterization interprets the potential risk based on the relationship between exposure, dose–response and other relevant information (Quijano 2000).

Although risk assessments cannot establish full scientific certainty, quantification can provide a basis for estimating the magnitude of an effect of exposure to contaminants (Russell and Gruber 1987). An environmental risk assessment will also help to identify potential threats, set priorities, design suitable intervention strategies or provide a basis for further study (Lave 1987; Russell and Gruber 1987). Conversely, analyzing risks can be subjective and value laden and can contribute to polarization of views (Slovic 2001). Experts and scientists can inject personal goals and interpretations during risk analysis (Lave 1987). Further, risk assessment can be a costly and time-consuming process.

Integrated Waste Management

The IWM approach involves a process of applying a variety of techniques to service delivery with the objective being the selection of appropriate methods for different types of wastes. In so doing, the IWM approach considers the environmental, energy, socio-economic and political impacts of waste management techniques and seeks to incorporate options with the potential to cause less harm (Tchobanoglous et al. 1993). Public participation is a cardinal feature of the IWM, and it requires effective coordination and partnership among various agencies.

While the IWM concept is considered ideal for ensuring sustainability, its demand for substantial financial, technical and human resources makes it difficult to be adopted in developing countries (Ali et al. 1996).

Applying FUME to the Korle Lagoon Situation

In addressing the Korle Lagoon pollution problem in Accra, applicable aspects of FUME include public participation and stakeholder consultation, consideration of local knowledge and risk communication/public education.

An Integrated Approach to Waste Management

A shift from the current 'collect and dispose' approach to waste management service delivery is perhaps one of the most crucial ways of addressing the Korle Lagoon pollution problem. Under the current approach, emphasis is laid on collection and disposal, while other aspects of the management process such as minimization, reuse, recycling and composting are ignored. There is virtually no distinction between hazardous and non-hazardous wastes in the management process, and in most cases, significant amounts of toxic waste end up in the lagoon, leading to pollution. Moreover, the current approach is heavily centralized, and there is no public participation, collaboration and consultation with key stakeholders including the squatters who occupy the banks of the lagoon. This has set decision-makers and squatters on a collision course whenever they interact, resulting in massive policy failures. The integrated waste management approach, as embedded in FUME, would require policy-makers to consider the application of multiple techniques while considering potential environmental as well as socio-economic and political impacts (Tchobanoglous et al. 1993).

In line with the integrated approach, waste storage and collection arrangements must be improved not only in the vicinity of the Korle Lagoon but also in the broader metropolis. Standard and accessible storage containers must be provided for the squatters who occupy the banks of the lagoon in order to drastically reduce the problem of indiscriminate littering. Informal sector waste collectors must be involved in the management process since they are able to navigate these squatter settlements with non-motorized means of transportation.

Consideration of Indigenous Beliefs and Practices

Consideration of indigenous knowledge in the design of strategies is one of the major ways in which the Korle Lagoon pollution problem might be addressed. In Ghana and other West African countries, traditional religious practices permeate all aspects of life including environmental governance. In many parts of Ghana, including Accra, aquatic ecosystems are regarded as sacred entities inhabited by gods and spirits, and therefore, it is considered a taboo to engage in acts that undermine the sacredness of water bodies. Aquatic ecosystems are not to be degraded or polluted in any way for fear of incurring the wrath of God, the gods and the ancestors.

There are also traditional practices that contribute to the diversion of waste from dumps including the reuse of discarded bottles, cans and plastics as storage receptacles; the use of dried sugarcane peels and coconut husks for smoking fish; feeding domestic livestock with food leftovers; the use of discarded broken bottles as security on fence walls; and the use of old and unwanted automobile tires as raw materials for making sandals. Such acts of ingenuity can be harnessed and incorporated into the design of strategies in line with the FUME concept.

Public Participation, Stakeholder Consultation and Transparency

Public participation and consultation with stakeholders are cardinal features of many environmental management tools such as those described above. Public participation is imperative in good governance and helps to ensure a legitimate relationship between civil society and the state (Masaki 1997), allowing for the harnessing of social capital as well as the development of negotiation and organizational skills (Plummer and Fitzgibbon 2004). A fundamental step will be public consultation and deliberation forums, where ordinary citizens and other stakeholders can participate and share ideas relating to waste management. Invitations can be sent out via mass-mediated messages such as press releases, radio broadcasts and television announcements. Policy-makers can also take advantage of social media sites such as Facebook and Twitter to encourage and promote public participation.

It is worth emphasizing that while public participation and consultation is vital for good governance, one must be cognizant of the need to address subjectivity and bias in the process. Hempel (1996: 53) notes that, '[I]n elevating an environmental condition to the status of a problem, scientists, policy-makers, and ordinary citizens typically construct their diagnosis or definitions on a foundation of preconceptions and predispositions that direct their attention to particular factors of causation, change and response'. This statement underscores the possibility of subjectivity being injected in the participation process due to multiple stakeholders having divergent views (Bowonder 1984).

Risk Communication and Communicative Planning

Communication of environmental and public health risks associated with the Korle Lagoon pollution problem is an essential step in the mitigation process. In general terms, the purpose of risk communication in environmental management is to disseminate information to relevant stakeholders with the objective of making informed decisions. Risk communication is therefore a vital component of environmental management and can determine the success or failure of policies and strategies (CSA 1997; Slovic 1993; Weterings and Eijndhoven 1989). For risk communication to be feasible, there is a need for communicators to understand societal perceptions, values and concerns regarding risk issues (Hance et al. 1989; Covello 1989). A major way of achieving this goal is through two-way communication processes, where information, knowledge and experience are exchanged by all parties in order for informed decisions to be made (Leiss and Krewski 1989). Essentially, two-way communication can build public trust in government and decision-makers, whereas one-way (scientific and technical information from experts to the public) communication can generate misunderstanding, confusion, apathy and distrust (Covello 1989; Jardin and Hrudey 1997). It is also imperative that risk communicators are cognizant of the language used in risk communication since reliance on technical jargon and quantitative analysis may be confusing as well as exacerbate fears and raise suspicions (Covello 1989; Jardin and Hrudey 1997; Weterings and Van Eijndhoven 1989). Further, risk communication must be facilitated in an atmosphere of honesty and transparency in order to quell skepticism and suspicion among the public (Hance et al. 1989).

Conclusion

Aquatic ecosystems serve as important agents of development by providing essential necessities required for the sustenance of life including food, water, medicine, esthetics, recreational and even spiritual outlets. Although such ecosystems are naturally resilient and have the ability to bend and flex with various stressors while retaining their integrity, preserving and maintaining their integrity, carrying capacity, diversity and functions is vital for sustainability. In other words, mismanagement can result in the transformation of pulse disturbances into chronic or even compounded perturbations which can ultimately result in the dilapidation, alteration and, in some case, removal of such ecosystems (Bengtsson et al. 2003; Paine et al. 1998). The Korle Lagoon pollution problem represents a clear example of the devastating effects of poor environmental governance on ecosystems. A systematic approach to remediation, such as that offered by FUME, is necessary for mutually beneficial outcomes for all stakeholders.

Notes

1. The Lagoon is believed to be inhabited by a female water spirit called *Naa Korle*, hence the name. Naa is the English translation of Miss or Ms. This is in line with the traditional religious beliefs of the chiefs and people of the Ga Traditional Area, where the Korle Lagoon is located.

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CHAPTER 6

La Plata River Basin: The Production of Scale in South American Hydropolitics

Luis Paulo Batista da Silva

Introduction

Transboundary waters are a great challenge to water governance in a context framed by the sanctioned discourse (Allan 2001) of water crisis (e.g., Gleick 1993; Camdessus et al. 2005) and the predictions of increasing disputes over water resources in the future (Wolf 1998; Giordano et al. 2002). This situation is sharpened by the great importance of surface river basins shared by two or more countries, which cover almost half of earth's land surface and provide water for around 40 per cent of the world population (Wolf 1998; UN-Water 2008; Earle et al. 2010). In South America, a continent with three of the largest transnational river basins in the world, in area, flow and stream length—the Amazon, Orinoco and La Plata (Castillo 2011)—transboundary water security issues do not seem so acute compared to other regions such as the Middle East and North Africa, where water availability is already an urgent matter (Allan 2001). Nevertheless, in South America processes such as agricultural frontier

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expansion, increasing urban populations and climate variability raise questions on water politics in the continent and the production of scales to address water governance (Tucci 2004).

The argument developed in this chapter is that the outcome of regional hegemonic disputes within La Plata during the twentieth century, between Brazil and Argentina, produced a geo/hydropolitical scale in South America. During this period, attempts of both countries to develop their hydroelectrical capacity using La Plata's waters gave rise to socio-political tensions that resulted in the creation of institutions that, still to this day, influence water governance at the river basin scale. Put differently, these institutions shaped political discourse and confirmed the river basin as the appropriate geographical scale to address transboundary water governance.

La Plata's resulting regional hydropolitics have been analysed through different lenses. For example, Gilman et al. (2008), Castillo (2011) and Pochat (2011) assessed the effects of institutional constructions, through international law and signature of treaties, on regional foreign politics. Queiroz (2012a, b) analysed how hydrological interdependence between riparian countries influenced the construction of water as a security issue and built a regional security complex. The perspective presented in this chapter derives from geographical discussions about production of scales and multi-level governance in transboundary waters. In other words, how actors situated at different levels move towards transnational or subnational levels setting up a frame in the governance of transboundary waters (e.g., Lebel et al. 2005; Sneddon and Fox 2006).

Within the spectrum of actors involved in the governance of transboundary water resources, more prominent attention had been paid to the sovereign state. This predominance is due to a dominant view of water as a national security issue, in which national states intend to maintain the quantity and availability of surface water within their sovereign territories. Regarding water and other environmental resources, this process was coined as 'securitization' (Dalby 2009; Mirumachi 2013; Mason and Zeitoun 2013).

Nevertheless, even from a state-centred perspective, there are divergences about the hydropolitical effects of national-level interactions regarding transboundary waters. Catastrophical premonitions, such as in the influential paper of Robert Kaplan (1994), affirm that a combination of population growth and water scarcity will be the driver of twenty-first-century wars. Another set of studies asserts that controlling and accessing natural resources might create conflicts through structural scarcity (Homer-Dixon 1999) or by negatively impacting the national economies (Klare 2001). On the other hand, Wolf (1998) and Uitto and Wolf (2002) conclude that the prognosis of future water wars do not seem strategically rational, hydrographically effective or economically viable; instead, historical records and recent treaties made these authors affirm that the outcome of water disputes usually are cooperative initiatives. Finally, another set of contributions tries to detach the political outcomes in transboundary hydropolitics from conflict/cooperation poles, arguing that elements of both categories can co-exist within the political interactions. Negotiations over river basin agreements can conceal hydro-hegemonic strategies or the exercise of 'soft' power to achieve compliance of weaker nations (Zeitoun and Warner 2006; Zeitoun and Mirumachi 2008; Zeitoun et al. 2011; Mirumachi 2015).

Assessing the production of La Plata river basin scale for transboundary water governance in South America enlightens the relation among water politics and different processes across the region. Such processes firstly include evidence of different spatial frames adopted to enforce water paradigms within the Southern Cone of South America (e.g., hydraulic mission, Integrated Water Resources Management (IWRM) and environmental concerns). Secondly, the development of water resources infrastructure follows distinct moments of regional foreign policies (e.g., hegemonic disputes between Brazil and Argentina, attempts to enhance regional physical integration and the formation of the regional bloc of South Common Market—Mercado Común del Sur—MERCOSUR). Moreover, analysing the path towards the production of the river basin scale contributes to assessing how La Plata's scenario, seen as less confrontational and accusatory when compared to similar Asian and African bodies (Biswas 2011: 423), encompasses power relations and background tensions.

The first section of this chapter discusses the concept of scale derived from distinct theoretical backgrounds: human geography and ecology. The understanding is that attributes from both conceptualizations are fundamental to assess how river basins are used to compose transboundary water governance, structuring distinct 'river basin trajectories' (Molle and Wester 2009). The second section presents the La Plata river basin trajectory identifying three distinct moments and issues within the river basin: 1) conflicts to define South American boundaries, which adopted rivers as natural boundaries; 2) the control of waterways navigation, a sensitive matter to guarantee inland access and facilitate commodity production and 3) the use of La Plata's hydroelectricity capacity to foster competing national development projects, bringing the advent of the 'hydraulic mission' (Molle et al. 2009) all over La Plata. The chapter ends by discussing the contributions of these different moments to produce a hydropolitical scale in South America.

Scaling Hydropolitics: Scalar Analyses Within Interdisciplinary Perspectives

A wide variety of scholars stress how a particular set of actors interact politically to produce and change spatial scales used to frame water governance and the scope of water politics (e.g., Swyngedouw 1999, 2007; Sneddon 2002; Sayre 2005; Lebel et al. 2005; Cash et al. 2005; Sneddon and Fox 2006; Norman and Bakker 2015). Regarding water resources shared by sovereign states, one salient issue is the interplay between non-state actors, which permeate water governance and influence scalar production, towards sub-national and/or supranational levels.

There are manifold definitions of and methods for discerning and describing multi-scalar and multi-level governance. Environmental geography scholarship on environmental and water governance usually adopts concepts derived from physical and human geography, from near fields such as ecology and landscape ecology and from debates about the new world political economy stemming from globalization processes (Sheppard and McMaster 2004; Reed and Bruyneel 2010). It is not my intention to either produce a unified definition or assess extensively their limits; other works have done this more comprehensively (e.g., Gibson et al. 2000; Sheppard and McMaster 2004; Sayre 2005, 2009; Reed and Bruyneel 2010; Moss and Newig 2010; Cohen and McCarthy 2014). The attempt here is to show how different theoretical approaches to scale can help us illuminate the production of La Plata river basin scale.

The history of the river basin framework vis-à-vis water governance is well described in the literature (Barrow 1998; Molle and Wester 2009; Moss and Newig 2010; Cohen and Davidson 2011). Despite numerous criticisms regarding possibilities for operationalizing water governance at the river basin scale (Budds and Hinojosa 2012; Davidson and Loe 2014), the river basin remains an attractive concept to water politics. Its appeal is related with its physical and natural justification. This geomorphological unit had taken its place as a conceptual tool to assess the processes in landscape evolution at the beginning of the twentieth century, developed by the works of Robert Horton and Arthur Strahler (Linton 2010). Besides its origin in physical sciences, the river basin has turned into an object of differing political interests and multiple possible territorializations, depending on the political objectives of the moment, be they local, regional, national or sectoral. Therefore, the river basin can be conceivable also as a hybrid territory (Ghiotti 2006), a hybrid socionature (Swyngedouw 1999, 2007) and a concept developed to be a technical tool that has been taken up as a political framework (Cohen and Davidson 2011).

Despite the apparent rigidity of the river basin scales—that is, as a geomorphological/hydrological structure, delimited by watersheds that divert water flows, nested within the hierarchical organization of subunits, resembling the scalar metaphor of the Russian doll—within a river basin, there are different arrangements of politics. The nested structure is just one of the scalar possibilities of water governance. For instance, Lebel et al. (2005) present different spatial possibilities of politics for water resources within a river basin: politics of scale, politics of position or politics of place. Observing the nested organization of a river basin, Lankford and Hepworth (2010) use the metaphor of the cathedral and the bazaar to compare different perspectives on water management. On the one hand, the cathedral emphasis is on basin-wide and monocentric governance. On the other, the bazaar model stresses polycentric management in a nested set of sub-catchments within the biggest frame of the cathedral management.

In ecology, particularly in landscape ecology, scale has been used very often to define the size of observable phenomena. Within this perspective, landscapes can be assessed through their mosaic composition, whether composed by corridors, patches or matrices. Each one of these spatial forms has their own process and internal structures; therefore, they can be isolated and studied as a specific unit and can be defined as a study scale (Forman 1995; Wiens 1989). Following this approach, scale is defined as the size of a discrete phenomenon over the terrestrial surface. Hence, Forman (1995) states that ecological studies could be made at several scales: a region, a landscape patch, a local ecosystem or in a river basin. This definition is strictly connected with the cartographical approach to scales, which corresponds to a relation between an area in the terrestrial surface and a representation on a map. Sayre (2005, 2009) asserts that a corollary of this definition is an epistemological moment to any study, due to limited aspects that can be observed, given a specific scalar grain (e.g., spatial and/or temporal resolution available within a given data set) and extent (e.g., the size of the study area or the duration of study). Therefore, any scale chosen to be studied has inherent constraints to your reasoning. However, an attribute to landscapes or ecological systems studies is the key concept of an open system, one that entails energy exchanges with other systems by inputs and outputs. This character is responsible for features like the diversity and population of an ecosystem.

Theory has been formulated to deal with this scalar diversity and interactions hierarchy. In this theory, each scale interacts with another as levels and specific units called *holons* (which in Greek means whole), so each *holon* is a discrete sub-system. The interactions among *holons* could be horizontal—between *holons* of the same hierarchical level—or vertical—between *holons* situated above and below (Koestler 1970). This conceptual organization enabled ecological analysis to focus on at least three levels in order to realize a multi-scalar analysis: the analysis level, one upper and one lower level (McMaster and Sheppard 2004). Sayre (2005, 2009) argues that the definition of scales as levels entails a scalar ontological moment, defined by the assumptions made to justify interactions among levels and their boundaries as an objective reality.

Understanding scales as extension and levels also brings consequences to its temporal process. Theoretically, on the one hand, a phenomenon occurring in a level above the level of analysis occurs in a slower temporal scale; therefore, their characteristics are constraints. On the other, a phenomenon occurring on a level below the level of analysis happens at a faster pace; hence, they bring diversity and stability to scalar analysis (Wiens 1989; McMaster and Sheppard 2004; Forman 1995).

Gibson et al. (2000) shed light over some flaws of hierarchical theory. The factors they identify as misleading derive from the fact that the theory does not address the emergence of constitutive hierarchies (e.g., hierarchies that have their structures marked not only by the union of different levels). In constitutive hierarchies, raised in complex systems, the aggregation of lower levels does not mean the union of their functions and processes but creates emergent proprieties. In complex, constitutive hierarchies, characteristics of larger units are not simple combinations of attributes of smaller units but can show new, collective behaviours (Gibson et al. 2000: 221). Hence, within environmental geography the concerns about the distinctiveness of every scale and level became a prominent issue. Moreover, the distinctiveness and emergent properties is not just a feature of environmental processes, it is a concern of how political structures are built to cope with human-environmental systems. Problems of multi-level governance (Cash et al. 2005; Lebel et al. 2005) or of scale fitness (Moss and Newig 2010) occur when organizations and institutions misguide in taking account issues specific to their level.

Finally, the works that intend to explore the challenges to implement an effective governance in multi-level environmental systems try to cope with the definitions of scale and level. Scales are generally defined as the spatial, temporal, quantitative or analytical dimensions to study any phenomenon, and levels as units of analysis that are located at different positions on a scale (Gibson et al. 2000; Cash et al. 2005; Moss and Newig 2010). The character of a constitutive hierarchy brings serious consequences to the conceptualization of scale because the processes and structures of any level upon analysis do not reflect only on their upper and lower levels but propagate through the system. Human geography, through different methods and debates, came to similar theoretical conclusions: that a scale is not only the aggregation of different levels or given containers; instead, each scale presents a distinct character built on social and political processes. Moreover, it undertook severe critique of the hierarchical thinking within scalar organizations, proposing more networked and flat spatial arrangements of scales.

Human geography knowledge, during the last 30 years, has been seeing a great debate over the concept of scale and its limits. Some critiques have been made to the conceived idea of scales structured as nested hierarchies in social sciences—exemplified by the metaphors of the 'Russian dolls', the 'Chinese boxes' or (scales as a) 'ladder' (Herod 2011). One of the most well-diffused perspectives about how the scales were structured, in a nested sense, was proposed by Peter Taylor (1982) who stated that the political economic organization of the contemporary world was driven by an urban to global structure, going through the national level.

The comprehension of scales as nested hierarchies generated another dissensus, whilst it conflated the notions of scales and levels, which became more evident in the work of Yves Lacoste (1988). Lacoste identifies scale issues within human geography as the matter of choosing an adequate level of analysis, a level of generalization, appropriate to the phenomenon being tasked, and, further on, the dimension through which you can address the reality of the world. Therefore, the choice of an appropriate level of study would be one of the most important roles of geographical endeavours, depending on the conceptualization of space made by geographers and the objective of their works (e.g., public policies or scientific analysis). The notion of a nested hierarchy of scale was also addressed when geographers attempted to identify and delimit patterns in space by quantitative and nomothetic methodologies. The attempt was to discover by statistical methods which phenomena would be more relevant at each scale (for instance, tidal currents, frost action and soil creep at the local scale; tectonic activity at the regional scale and solar radiation activity at the global scale) (Harvey 1968).

The human geography literature about scales shows that while the geographical scientific field is still far away from a conceptual general definition and operational consensus, some approximation between different perspectives are possible, and perhaps desirable (Brenner 2001; Howitt 1998; Marston et al. 2005; Swyngedouw 2007). Despite the harsh criticisms of nested conceptualizations of scale, one of the most distinguishable benefits of scalar thought is to emphasize relations among levels. Instead of disregarding vertical connections, one of the most challenging efforts would be seeking to uncover the power relations that produce scalar structures and which different levels make up this structure. In environmental governance, movement between levels seems more intricate regarding the intertwining of natural and jurisdictional scales of governance in socio-natural systems (e.g., Cohen and McCarthy 2014). Hence, in our case of the La Plata river basin, the analysis must pay attention to the different kinds of interactions—political, economic or ecological—that produce scales of water politics.

Transnational La Plata Hydro(Geo)Politics and the 'Hydraulic Mission'

La Plata river basin, which encompasses Brazil, Argentina, Paraguay, Uruguay and Bolivia, has a total area of 3.1 million km^2, making it the second biggest river basin in South America. The river flux at its mouth is the third largest in the continent, surpassed only by the Amazon and Orinoco Rivers (Castillo 2011). In fact, what is commonly known as La Plata is the ensemble of three main river basins that drains South America inland: the Parana River basin, with 1.5 million km^2; Paraguay River basin, with 1.09 million km^2; and Uruguay River basin, with 365 thousand km^2. These three river basins converge to the Plata river estuary, located at the boundary between Uruguay and Argentina, which drains an area of 130 thousand km^2; altogether, these river basins outline the most known La Plata basin (Elhance 1999; Pochat 2011; Queiroz 2012).

Brazil owns the biggest area of the river basin, at 46 per cent, and the sources of the main rivers within the basins are in Brazilian territory. Argentina has 28 per cent of the basin area, Paraguay has 13 per cent and the last 13 per cent is shared between Uruguay and Bolivia (Elhance 1999). Although Brazil has the control of the biggest area and the main water springs, it does not have control of the river mouth, which was first within Spanish domain, and, after Latin American independence, within Argentinian and Uruguayan rule. The outcome of this spatial arrangement was that throughout the colonial period and state independence process, disputes concerning the river streams were related primarily to boundary demarcation and control/access to the ports at the river mouth, in La Plata estuary.

Navigation and Boundary Demarcation: The Aftermath of the Colonial Period

Fluvial navigation was one of the main diplomatic affairs involving countries within the basin and foreign trade powers, that is, Great Britain, France and the USA. Controlling the waterways and the port activities was strategic to access and exploit South American inland resources, especially the mining in the Mato Grosso and Goiás provinces, in Portuguese America, Bolivian silver and the livestock hordes—cattle, horses and mules—which were located extensively in the continental inland. The La Plata rivers were the main, if not the only, way to move products and communicate with those areas since the terrestrial pathways entailed huge dangers and long travels. Economic and geopolitical demands to open the waterways to free navigation were the primary reasons to Portuguese and Brazilian governments' endeavours to control the river mouth. To achieve this, distinct strategies were used, like taking leadership over the trade of silver, slaves and basic goods—through legal ways or smuggling—within the Buenos Aires port, as well as the invasion, building and dominance of Colonia del Sacramento, and the attempt to annex Cisplatina province, both on the north margin of La Plata estuary, which is today located in Uruguay territory (Puiggrós 2006; Bandeira 2012).

Free navigation of the La Plata rivers was accomplished after several conflicts during the nineteenth century. These conflicts involved the City of Buenos Aires, the Argentinian Mediterranean provinces (Entre Rios, Corrientes and Misiones provinces), Uruguay, Brazil, Paraguay, and also France and the UK. The Buenos Aires port had a monopoly over the custom taxation on La Plata River and its tributaries. This went against the interests of other riparian states, foreign powers and other provinces within the Argentinian confederation. Those players were willing to extract a bigger income from the beef jerky and meat trade. Therefore, the first free navigation treaties were de facto rather than de jure signed by the City of Buenos Aires during Juan Manuel Rosas's government (1835–1852). At that time, Brazil signed bilateral treaties with all the other riparian governments to assure their access to the La Plata main waterways—Parana and Paraguay rivers: with Uruguay in 1851, with Paraguay in 1856 and, finally, with Argentinian Confederation (without Buenos Aires) in 1856. Afterwards, the free navigation principle was reaffirmed through different deals and agreements among the countries. The principle was then 'solemnly consecrated' in the Triple Alliance treaty, in 1865, which united Brazil, Argentina and Uruguay in an alliance against Paraguay (Puiggrós 2006; Zugaib 2006; Bandeira 2012).

Although Brazil has no settled domain over the mouth of La Plata River, since both Colonia del Sacramento and Cisplatina province do not stand within the Brazilian state, the arrangement of the international boundaries within the river basin nonetheless guarantees Brazil access to the three main waterways (Paraguay, Paraná and Uruguay Rivers). Brazil also has demarcated boundaries with every country in the basin. Furthermore, the rivers are, most times, the boundaries among the riparian states (Table 6.1).

Table 6.1 Brazil's boundary extension with riparian states in the La Plata basin

Boundary extension (Km)	*Total*	*Rivers and channels*	*Lakes*	*Geometrical lines*	*Watersheds*
Bolivia[a]	3.423,2 (100%)	2.609,3 (76. 2%)	63 (1.8%)	750,9 (21.9%)	
Paraguay	1.365,4 (100%)	928,5 (68%)			436,9 (32%)
Argentina	1.261,3 (100%)	1.236,20 (98%)			25,1 (2%)
Uruguay	1.068,10 (100%)	608,4 (56.9%)	140,1 (13.1%)	57,6 (5.4%)	262 (24.5%)

Source: Second Commission on Boundary Demarcation (SCDL, Segunda Comissão Demarcadora de Limites acronym in Portuguese)

[a]Brazilian boundaries with Bolivia are also inserted within the Amazon River basin. This data does not differentiate between the two river basins

Hence, as a consequence of this territorial arrangement, Brazil interacts with any country within the basin, even in bilateral and multilateral ambit.

Setting Up the La Plata Treaty to Initiate the Hydraulic Mission Within Brazil-Argentina Geopolitical Disputes

Following the demarcation process and the settlement of the international boundaries of countries situated within the La Plata basin, the waterways continued to be used as the main routes for national and international trade. Due to its Mediterranean position, Paraguay and Bolivia have a keen interest in the waterways since it is their only sovereign way to the sea. Otherwise, Brazil and Argentina, the two main players in regional politics, used their control to access the waterways and other transport networks to gain more influence over other South American countries. The regional waterways were employed as a bargain asset with the smaller countries and were a dispute arena between the two regional powers.

Brazilian and Argentinian initiatives to improve navigation conditions were a frequent diplomatic issue in the region over the mid-twentieth century, but it was the driver to develop the first institutional attempts regarding water issues on the continent. During the 1960s, international organizations such as the Organization of American States, the Inter-American Development Bank (IADB) and the Economic Commission for Latin American and the Caribbean supported the discussion over a treaty regarding the La Plata basin watercourses. The outcome of this process was the signing of the La Plata Basin Treaty, in 1969, which established benchmarks on the use of water resources and the development of regional infrastructure projects. Therefore, this treaty is seen as one of the first steps to create a cooperative hydropolitical scenario (Elhance 1999; Castillo 2011; Biswas 2011; Pochat 2011).

The La Plata River Basin Treaty accomplishment builds the institutional framework to regulate the hydropolitical interactions between the countries (Pochat 2011). The influence of the treaty over the hydropolitical initiatives is made through two institutions created to articulate and develop the policies regarding the development of the basin: the Intergovernmental Co-ordination Committee (CIC Plata) and the Financial Fund for the Plata Basin (FONPLATA). The CIC, created even before the La Plata Treaty signature, is responsible for the execution of projects regarding water issues. The FONPLATA, created in 1976, is responsible for the financing of development projects within La Plata countries. It receives funds from the treaty signatory countries and from other international institutions. As of 2011, FONPLATA had approved US$ 1.04 billion in development projects.

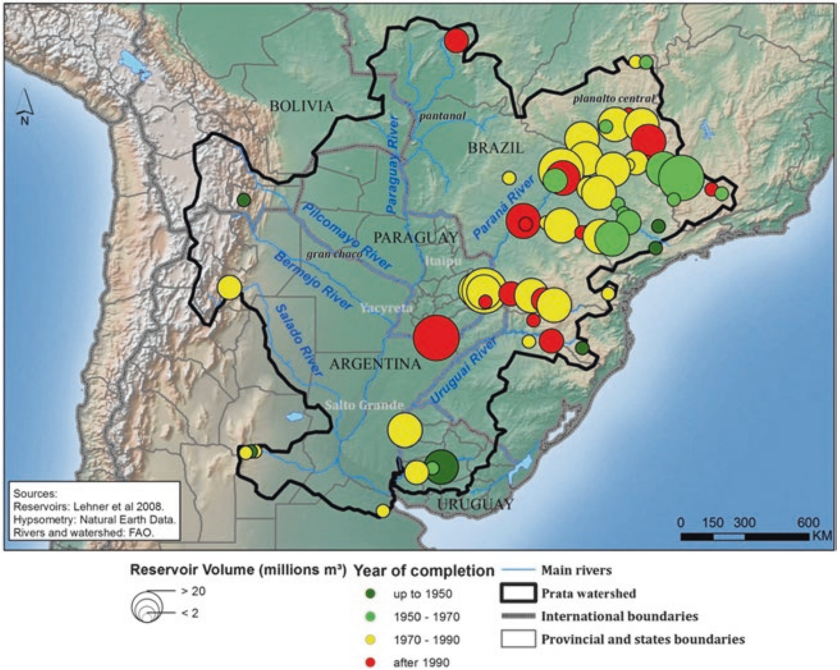
The treaty ratification did not end tensions among the countries within the La Plata basin. Ferres (2004) argues that the treaty constituted an Argentinian diplomatic victory, which could assemble the downstream (*rio abajo*) countries to cooperate about the uses of water resources for development purposes, in a movement to antagonize the Brazilian position. Initially, the Brazilian military government regarded a treaty with downstream neighbours as a possible restraint upon Brazil's upstream and economic power. Brazil succeeded to interpose the inclusion of a prior information clause that countries must inform other riparian countries ahead of any intention of work on La Plata's rivers. Essentially, Brazil more likely agreed to sign the treaty to prevent loosening their hegemonic influence over the countries in the region to Argentina. The 'prior information' clause became a sticking point among riparians in regard to dam developments on the Parana River (see below).

From 2001 onwards, environmental concerns, particularly those arising from the effects of climate change and variability, began to be integrated into CIC Plata policies through the creation of the Sustainable Management of Water Resources in the La Plata Basin programme. This regional research programme, sponsored by the Global Environment Facility (GEF), aims to produce a social and environmental diagnostic over the La Plata basin, in order to facilitate the construction of local programmes to mitigate environmental degradation and support resource preservation. Moreover, the Framework Program, as it is known, intends to integrate and articulate the projects already in motion within the river basin, as well as propose new ones. It is worth noting that ideas and inspiration for this programme came from the Water World Fora, especially the second, held in the Netherlands in 2000 (Tucci 2004; CIC 2011). Although the La Plata Treaty is open to adaptive policies depending on local issues, one of the treaty's main goals was to implement a common vision for water resources within the La Plata river basin. In that sense, the initiation of the Framework Program shifted the trajectory of river basin initiatives regarding the environment towards concerns with the regional effects of climate change.

Transnational Disputes over La Plata Water Resources: The Settlement of Hydraulic Mission and Construction of Big Dams

During the second half of the twentieth century, the construction of big hydropower projects started to dominate the disputes over the uses of the La Plata's water resources. Since the main urban and industrial centres in South America are within the basin, its energy potential came to be seen as the possible source to foster national development. The surface waters of the La Plata basin are used to achieve two goals: hydroelectricity and navigation. This mid-twentieth century water governance period can be defined as the state hydraulic paradigm, characterized by state power being used to harness and allocate water in support of modernization projects (Bakker 2003; Gleick 2000). Given the nature of state boundaries, the frontier of resources available to be exploited was in the border regions. Hydropower projects were developed upon the initiative of riparian national governments, with financial resources from international agencies and banks, such as the World Bank and IADB. On the one hand, these projects were the trigger of conflicts among the countries. On the other hand, the resolution process had strengthened the dialogue spaces and the cooperation on hydropolitical issues.

The worst disputes among the countries were about the hydropower plants of Itaipu and Yacyretá, resulting in skirmishes between Brazil, Argentina and Paraguay (e.g., http://www.transboundarywaters.orst.edu/research/case_studies/La_Plata_New.htm). The La Plata basin's hydroelectric potential is one of the biggest in the world because of the topographical gradient that has an abrupt rift between the Central Brazilian plateaus with the Chaco depression (Map 6.1). The basin's rivers provide 55.5 per cent of the energy demanded by the countries within the La Plata region, producing a volume of 309.503 GWh, in 2010. Paraguay, for instance, is completely dependent on the energy generated in the Paraná River (Popescu et al. 2012). The energy is produced for domestic use and export. Currently, around 60 per cent of the basin potential is already exploited through more than 100 hydropower plants working, or in construction (CIC quoted in Pochat 2011: 499). Within Brazil, the bulk of hydropower construction happened during the mid-twentieth century, beginning on the main tributaries of Paraná River, such as Tietê River, near the biggest southeastern cities. Furthermore, they expanded to the proper Paraná River, following the urban and agricultural frontier (Elhance 1999). Parana River is cur-



Map 6.1 The La Plata river basin: Main reservoirs, by volume and year of completion (constructed by author)

rently the most important contributor to energy supply in Brazil, supplying approximately 49 per cent of Brazil's energy (Pochat 2011).

The reservoirs and dam distribution shown in Map 6.1 reflect the ever-increasing post-1950 demographic, with considerable urban and industrial development in the region, particularly after 1970 (yellow and red dots). Of the 68 dams identified by *Global Reservoir and Dam Database Project* (GRanD), 20 started to produce energy in the 1970s, with most of them in Brazil (Lehner et al. 2011). It is noteworthy that three of the biggest dams were bilateral projects: Salto Grande (Uruguay and Argentina), Itaipu (Brazil and Paraguay) and Yacyretá (Argentina and Paraguay).

Disputes about the construction of the Itaipu Dam between Brazil and Paraguay once more related the use of the watercourses with boundary demarcation issues. Similar to the nineteenth century, when boundary demarcation guaranteed the rights of certain countries to navigate through waterways, in the twentieth century, these same sovereign boundaries gave states the right to exploit the hydropower potential of the rivers. During the Itaipu negotiations, Paraguay's pleas to revise the boundaries with Brazil ensured their right, in condominium with Brazil, to use Parana River waters to produce electrical power.

At the beginning of the 1960s, during Brazil's João Goulart government (1961–1964), the first inventories of hydropower potential were made: along the Paraná River, in the region of Sete Quedas (Seven Falls), and on the border between the Brazilian state of Paraná and Paraguay. At the time, the proposal was to develop a joint energy resource exploitation project on the river. However, following the 1964 coup d'état that removed the Goulart government, negotiations were stopped and the Paraguay government requested a review of their boundaries with Brazil. The Paraguayan allegation was that in Sete Queda's region, the boundary treaty was not clear about the limit position, whereby Paraguay could gain some territory over Brazil. In 1965, both the Brazilian and Paraguayan armies seized on the banks of the river, upstream at the first of the seven falls, near the towns of Mundo Novo, in Brazilian Mato Grosso do Sul state, and Guaíra, in Brazilian Paraná state. The contest was settled the next year, with the signing of the Itaipu accord, where it was agreed that future condominium energy projects on the Paraná River course, from the mouth of Iguacu River (a southern tributary of Paraná River) up to the Sete Quedas, must share the yield between the two riparian countries. The accord was enforced in 1973, with the Itaipu Treaty, and at the same time, the binational company was created to build and manage the hydropower plant.

Finally, the boundary question within the reservoir area was solved by the flooding of the contentious area and the creation of an ecological reserve on the left bank of the river, on the international boundary (Oliveira 2012).

In the same year that the Itaipu Treaty was agreed upon, Paraguay signed a similar treaty with Argentina. This treaty was to build another dam, the Yacyretá, downstream of the Itaipu on the Paraná River. The proximity between the agreements of those two diplomatic treaties was not a coincidence. Both resulted out of disputes between Brazil and Argentina to exert political and economic influence over Paraguay, which did not have resources to develop hydropower projects. Paraguay used its geographical position within the continent to bargain investments and engage in regional politics. Nowadays, Itaipu and Yacyretá are still the biggest hydropower plants within the La Plata basin and turned Paraguay into the largest energy exporter in the world. Both treaties are very similar: there are instituted binational companies to manage the undertakings and sell energy production. Most of the enterprises' expenses were taken on by Brazil and Argentina, and the treaties stated that Paraguay had to sell the energy surpluses below market price, therefore leaving Paraguay with a big foreign debt (Elhance 1999; Pochat 2011).

The negotiations leading towards the Itaipu and Yacyretá binational treaties were happening almost at the same time as the terms of the multilateral La Plata Basin Treaty were being defined. On the one hand, the Paraguayan bilateral treaties put Brazil and Argentina on opposite sides, since the Itaipu position along the Parana River gave Brazil privileges to dam its waters. On the other, the La Plata Basin Treaty was the first attempt to create a diplomatic mechanism to negotiate the technical parameters to exploit the river resources. However, as argued by Candeas (2010), the La Plata Treaty does not attenuate tensions among signatory countries because it was firstly focused to improve, politically and technically, the navigational conditions of the river basin, not to cope specifically with hydropower issues. Argentina maintained a strong mistrust of Brazilian intentions to dam Paraná River, thereby jeopardizing downstream energy projects.

It was just after the 1976 Argentinian coup d'état that the governments of the biggest countries in the region searched for an agreement regarding the hydropower technical questions and more broadly concerns about integration within the southern region of South America. At the time the Itaipu Dam was being built, Argentina joined Paraguay to launch another hydropower plant on the Paraná River: the Corpus Dam. Because of the proximity of these two dams, their performance would be intertwined (Map 6.2).

Map 6.2 Sites of the hydropower plants of Itaipu, Corpus (planned) and Yacyretá, which are located along the Paraná River, and the contentious region (constructed by the author)

If the Corpus reservoir was too big, it could decrease the Itaipu's slope, therefore decreasing its hydropower potential. However, if the Itaipu Dam were bigger, the Corpus would not have enough water to run its turbines. At the beginning of the construction, whereas Brazil was not keen to limit their capacity to produce energy at the Itaipu, Argentina tried to establish an agreement with Brazil diplomatically and through media campaigns about the negative impacts of the Itaipu on the Argentinian economy (e.g., by alleging that the Brazilian works on the Itaipu were an attempt to exert regional hegemony). In 1979, Brazil, Argentina and Paraguay signed the tripartite Itaipu-Corpus Treaty, defining the level that each country could keep in its reservoir without negatively affecting downstream neighbours. Some authors argue that the agreement reflected the Brazilian military government's foreign policy interests at the time. In particular, they acceded to the hydrological limits in Itaipu, thereby ensuring Corpus' feasibility as part of a new focus on strengthening regional ties in order to become more independent of the USA. This policy culminated in the formation of the Southern Common Market (MERCOSUR) in 1991. Since the Corpus Dam project was not held by Argentina and Paraguay, because of further economic and political reasons, the tripartite treaty is the institutional dispositive that determines the amount of water that can be dammed by each country and that guarantees multi-purpose use of water on the Paraná River, such as navigation (Ferres 2004; Candeas 2010; Queiroz 2012).

Recent Projects and Conflicts Within the La Plata Basin

Recently, the Itaipu treaty, agreed upon by Brazil and Paraguay, was submitted for debate and revision. This was initiated by the Government of Paraguay, which wished to review the clauses that 1) established the price paid by Brazil for the Paraguay energy surpluses and 2) gives leverage to Brazil over other potential energy buyers. In 2008, the heretofore Paraguayan presidential candidate, Fernando Lugo, was trying to settle on a new value that would be paid by Brazil. Lugo used this as a campaign platform in the national election. He argued that for each US $45.31/ megawatt that Brazil paid, the Paraguayan government did not receive approximately US $42.50. Instead, these funds were retained by the Brazilian government to amortize Paraguayan debt undertaken with Brazil to build the dam. This retaining mechanism was articulated in the treaty and would be submitted to a revision only in 2023. However, in 2009, the presidents of both countries—Fernando Lugo (Paraguay) and Luis Inácio

Lula da Silva (Brazil)—agreed on a threefold increase to the price per megawatt to be paid to Paraguay. At the same time, other important changes were established, including the revoking of the Brazilian state electricity company's—Eletrobrás's—exclusive right to purchase Paraguayan energy. This allows Paraguay to look for private companies to sell their energy to the Brazilian market,and, from 2023 onwards, Paraguay can search for different markets to export their energy. Brazil also has committed to funding construction of a 348-km-long 500-kV transmission line between Itaipu and Asunción, which was launched in 2013. This facilitates an increase in Itaipu's domestic energy use (Blanco 2012; Planalto 2013).

Another recent transnational issue within La Plata was the improvement of fluvial navigation. Since the beginning of regional groupings in the 1980s, in particular MERCOSUR, countries have sought ways to increase joint investments on regional transport infrastructure. The Paraguay-Paraná waterway navigation project was portrayed as an important means to improve physical integration. It would enable a logistical alternative to transport commodities exports from the Brazilian centre-west and maintain a feasible autonomous way to the sea for Bolivia and Paraguay (Zugaib 2006).

The Paraguay-Paraná Waterway Project (PPWP) has a goal of extending perennial navigation by 3395 km, from the La Plata estuary up to the Cáceres port, in the Brazilian state of Mato Grosso. Although those rivers are already largely used to transport industrial goods and agriculture commodities, they have a huge volume variation throughout a year, especially in the Paraguay River. This requires the reduction of the length and weight of the vessels. To tackle this obstacle, PPWP proposes extensive river works, including dredging, rock removal, rectification of the riverbed channel (on Paraguay River) and improvements on ports' structure. In 1989, the Waterway Intergovernmental Committee, comprising stakeholders from the five La Plata countries and with financial support from IADB and the United Nations Development Programme, was created in order to organize this project. Up to now, just a few projects have been executed. Numerous local, regional and international civil society groups are concerned about negative environmental impacts from this project, mainly citing changes that the hydrological regime would cause in the vulnerable Pantanal region (Elhance 1999; Zugaib 2006; see https://www.internationalrivers.org/campaigns/paraguay-paran%C3%A1-hidrovia).

This waterway segment extends from the Paraguay River's heads—in Cáceres—to the City of Corumbá, along the Brazilian-Bolivian border. It is the biggest tropical wetland in the world and has a huge hydrological variation among the wet and dry seasons. Moreover, Pantanal works as a valve which regulates the volume of the run-off along the Paraguay River up to their joining with Paraná River, therefore affecting the amount of water which reaches important cities, like Asunción, the Paraguayan capital. Among other things, the canalizing works needed to improve navigation in this segment would increase risks for Pantanal's biodiversity, result in unpredictable changes to the river outputs and increase the erosion ratio in the Brazilian Central Plateau (Elhance 1999; Pochat 2011).

The ongoing projects dealing with navigation are the result of national initiatives, such as harbour improvements in Brazil, Paraguay and Argentina, as well as signalling corrections along the rivers, made by the Brazilian state agency, the Paraguay Waterway Administration (AHIPAR). Among the suite of intended investments supported by the IADB, up to now, only the purchase of vessels to transport iron ore from Corumbá (Brazil) to Puerto Palmira (Uruguay) has taken place. These vessels were funded by a US$ 100 million loan to the Brazilian Vale S.A Company. To its backers, this is no doubt a huge disappointment, especially in light of the grandiose intentions of the project.

Another conflict developed in 2005 over the use of water between Argentina and Uruguay. This conflict flared up following the installation of two pulp industries along the Uruguayan banks of the Uruguay River, near the City of Fray Bentos. One of the pulp companies was owned by the Finnish company Botnia and the other by the Spanish company Energía y Celulosa. The escalation of the conflict started when doubts arose over the environmental impact evaluation made by both companies. The main contenders were NGOs, the Argentinian departmental government of Gualeguaychú and the Argentinian federal government. Locally, the most common demonstration tactic was the closure of the international bridge General San Martin, therefore blocking the boundary between Argentina and Uruguay (Beloqui 2013).

The conflict between the two countries manifested in two different international courts. Uruguay lodged a complaint in the MERCOSUR Court regarding the constant closures of the international bridge and the failure for the Argentinian government to avoid it. In Uruguay's view, Argentina was not honouring the Asunción treaty that guarantees the free movement of goods. Argentina lodged a complaint to the International

Court of Justice in The Hague, arguing that Uruguayan industrial plants contravene the Uruguay River statute, wherein it is required that intended developments impacting the river must be subject to timely information interchanges between the countries and the shared effort to maintain good environmental conditions of the river. In 2006, Spain was appointed as mediator of the conflict; however, the third-party mediation strategy was not very effective to settle down the contention.

Finally, in 2010, following closure of Botnia's industrial plant, the dissension was settled when research conducted by Uruguayan and Argentinian institutions demonstrated that the production of pulp does not affect Uruguay River water quality in a relevant way. The International Court of Justice condemned Uruguay for not informing the Argentinian government about their development projects, even though Argentina was not impaired by those industrial plants. At that time, Argentina committed to attempting to avoid any more closures of the international bridge but demanded that Uruguay comply with the Uruguay River statute to inform Argentina of any further industrial project. However, three years later, in 2013, tensions once again escalated because the Uruguay government, led by Pepe Mujica, announced its intentions to increase pulp production within Botnia. This decision was made without any prior discussion with the Argentine government (Beloqui 2013). Up to now the distress has been contained, since the intended increase in pulp production had not materialized.

This section describes how the use of La Plata waters to produce hydroelectrically, transport goods and support economic development are the main themes in South American regional hydropolitics during the twentieth and early twenty-first centuries. The projects, agreements and treaties resulting from these hydropolitical interactions were the outcome of national political arrangements, with the support of supranational organizations. The scale chosen to undertake these hydropolitical interactions is the river basin; nonetheless, water governance is intertwined with other geopolitical and economic issues, as well as other scales, such as MERCOSUR.

Conclusion

This chapter presented the transboundary river basin trajectory within La Plata, in South America. The argument is that along different moments of political interactions in South American foreign politics, mainly during the twentieth century, the river basin was developed as the main arena of transnational hydropolitics. Even though not every transboundary issue encompasses all riparian countries (they can be, e.g., binational or trinational) or are spread all over the river basin (some problems are point specific, such as the case of the pulp mills), the institutional arrangements are framed by this scale. Not just national policies but the interests of transnational funding banks, regional economic blocs and NGOs are expressed at the river basin scale. Therefore, regarding transboundary waters, it may be observed that an array of different levels interacting throughout the river basin result in a politics of scale, a politics of place and a politics of position.

Along the timeline of hydropolitical interactions, different actors and levels were more salient, depending on the political goals of the moment. In each case, however, the primacy of the sovereign state is apparent. Hydropolitics in South America have been considered a matter of national interest, in which states pursue a self-defined hydraulic mission, made possible through the support of international financial institutions. During the advent of regional integration projects, programmes and institutional arrangements such as MERCOSUR, La Plata is seen as an infrastructural asset to support transport integration. Due to this reason, it is not surprising that waterway project dismay coincided with MERCOSUR hardships. Nevertheless, river basin institutional arrangements, such as CIC Plata and FONPLATA, endure as spheres of water governance and dialogue at the transnational political level and gather international funding in a moment of increasing environmental concerns.

Another process of levelling hydropolitics is the use of the nested structure of the river basin. Stemming from climate change uncertainties, raising concerns about water crisis and initiatives of devolved water governance, sub-basins most recently have been adopted as the scale for hydropolitics within La Plata. Given regional, ecological and social diversity, fostering cooperative initiatives in sub-catchments is regarded as an appropriate way forward in both the La Plata Treaty and the Framework Program. Such a perspective has been gaining momentum with support from international NGOs, awareness of local ecological and social water needs, and increased participation of border region dwellers in environmental governance. This downward rescaling can be a new opportunity to improve local participation in environmental policymaking. At the same time, this chapter shows how other issues are addressed together with water issues, such as regional development and trade cooperation among border cities. In demonstrating interaction between traditions of transnational hydropolitics (i.e., the national state in pursuit of the national interest via the hydraulic mission) with more local initiatives (e.g., from civil society organizations to subnational governments in support of sectoral interests), as well as the integrating role played by water geographically/politically/socially, the La Plata experience suggests the value of hybridity in hydropolitics. Thus, it seems the cathedral and the bazaar models of water management demand more comprehensive evaluation.

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CHAPTER 7

The Social Flows of Water in the Global South: Recognizing the Water-Gender-Health 'Nexus'

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Introduction: The Right to Water and Gender Imbalance

Water is vital to human life. With it, we thrive, along with our crops, our domesticated animals, our societies and our civilization. Without it, we die in as few as three days. For humanity, water is both a biological and social imperative, and both our history and our current geopolitical landscape are shaped by it to an extent that is seldom recognized or acknowledged.

What makes water unique among all other natural resources is its universality: whether a person is rich or poor, they nonetheless require access to water on a daily and continuing basis. Unlike food, it cannot be easily stockpiled, hoarded or condensed for long-term storage against a time of

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need. Instead, it is a quintessence in and of itself: forever necessary, forever renewing itself, forever beyond our ability to fully comprehend or control. It was with this idea in mind that the UN Human Rights Council adopted a binding resolution in 2010 that affirmed that access to safe, clean drinking water is a right due to all humanity, and that it is incumbent upon all governments, societies and peoples to do their utmost to uphold this provision (see http://www.un.org/waterforlifedecade/human_right_to_water.shtml, accessed 8 March 2016).

As water is vital to human life, water management is an issue that necessarily concerns all people equally. However, water resource management has historically been afflicted by a gender imbalance that has impacted the development of both its management discourse and practices. Although women and men interact with water in different ways and at different times in water use and management processes, water resource management has generally failed to acknowledge or compensate for this fact. Consequently, women have frequently been marginalized from the process, resulting in a gender imbalance. The differences in the ways women and men are involved with water are indicative of deeply rooted, systemic power relations that have significant implications for the ways in which the resource is handled. As such, any discussion of the 'nexus', however defined or delimited, is incomplete without a thorough gender analysis.

Since the relationship between water and gender has different effects at different governmental levels, any review of the problem must necessarily incorporate examples from global/supranational, national, local and household levels. An analysis conducted in this fashion is advantageous because it clearly highlights the ways in which water issues are addressed at different socio-political levels, as well as how they are impacted by various social and governmental structures. In this chapter, issues of economic water, formal water management institutions, water politics, and localized and domestic water management are addressed, and case examples are discussed in order to illustrate the scope and significance of the challenges and opportunities related to gender and water.

In addition to these three divisions, the relationship between water, gender and health is addressed in a fourth section, which discusses how this differently articulated but no less important 'nexus' is embedded in all levels of the socio-political system. The fourth section also illustrates the nested and mutually reinforcing levels of water use and management and provides important lessons in best practice through the successes and failures of current management efforts. As with the previous sections, water and health-related case examples are explored. Lastly, the analysis presented within these sections is used as the framework for a set of recommendations for best practice that address the most effective points of intervention.

The evidence is clear: current water management practices in the Global South are defined by pronounced gender imbalances, and those imbalances inevitably tend to favour men. What is less clear is the best means of conceptualization, the best point of intervention and the best practices to use to rectify the situation.

Theoretical Framework

When discussing gender, it is first necessary to define the terms being used. Although *gender* may seem, at first glance, to be a clear and unambiguous term, there have been varying conceptualizations of what *gender*, as a term, represents. For our purposes here, *gender* refers to the socially constructed expression of behaviour, most commonly expressed through the self-identification of 'man/men' or 'woman/women' (Fausto-Sterling 2000). While it is acknowledged that gender exists on a spectrum and is often expressed outside of this dominant binary, in terms of the societies in question herein, it is the traditional male/female dichotomy that generally applies. Accordingly, this chapter works within the framework of the dominant gender binary, as it pertains to how women and men interact in water use and water management processes.

This foundational understanding of gender is complemented by the utilization of an analysis that frames women as a class of people whose oppression is linked to categorization of women as a class similar to the Marxist conception of the proletariat as a class. As such, women and men have had different experiences with water as a result of class formulations based on socially defined genders rather than being rooted in biological sex distinction (Kennedy and Lapidus 1980). This analytical framework is adapted from the work of socialist feminists such as Zillah Eisenstein, who argued that the liberation of women would have to be accompanied by the social liberation of all people (Kennedy and Lapidus 1980).

Gender and Water at the Supranational and Global Level

The recent history of the relationship between women and water has been one of considerable change on a global level. Prior to the 1980s, policies tended towards a welfare approach, wherein women were the primary beneficiaries of improved water supplies. During the 1980s, this began to move towards a focus on efficiency, effectiveness and reducing the role of the state. In the 1990s, this evolved into a focus on managing water at the lowest appropriate level and involving women in the process (UN 2005). This was accompanied by an increased emphasis in all global forums on the need for mainstreaming gender into water management.

Since the turn of the millennium, water has become increasingly gender inclusive. The Second World Water Forum in 2000 identified women as prime users of 'domestic water', crucial users in food production and, along with children, as the population most vulnerable to water disasters. Furthermore, it proclaimed that as women were the primary victims of poor water management, they should be empowered to more effectively participate in the process (UN 2005). This idea of a gendered approach was reiterated at the 2001 International Conference on Freshwater and at the 2003 Third World Water Forum in Kyoto. At the United Nations Conference on Sustainable Development, in 2004, water was described as having a woman's face, a somewhat poetic acknowledgement of the role that women play in sustaining households, communities and economies.

Today, the idea of female inclusion in all water management discussions is normative, and gender mainstreaming (GM) has advanced to the point that women necessarily play an important role in all global forums on the issue. In fact, from about the mid-1990s, 'gender mainstreaming' became a development buzzword for how to achieve equality in the water sector. It is an approach that looks at the implications at all levels of a project, from design and implementation through monitoring and evaluation (Cap-Net/GWA 2006). GM holds that when projects are implemented through a participatory process that is gender-sensitive, it is more likely than not that they will be technically appropriate, well used and maintained. It allows for both genders to bring different concerns and knowledge to the discussion, which, in turn, can lead to better health outcomes, more productive potential and less time spent on water-related activities (Cap-Net/GWA 2006).

Perhaps the most well-known recent initiatives for water access are Millennium Development Goal (MDG) 7C of halving the number of people without sustainable access to safe water by the year 2015 and Sustainable Development Goal (SDG) 6 which aims to ensure availability and sustainable management of water and sanitation for all. In international policy, women without sustainable access to water are identified as 'a group traditionally facing difficulties in exercising the right' to water (Singh et al.

2008: 186). Dublin Principle No. 3 states that 'Women play a central part in the provision, management and safeguarding of water'. In elaborating this point, Principle 3 states 'This pivotal role of women as providers and users of water and guardians of the living environment has seldom been reflected in institutional arrangements for the development and management of water resources' (http://www.wmo.int/pages/prog/hwrp/documents/english/icwedece.html accessed 10 May 2017). Targets 6.1 and 6.2 of SDG 6 focus on ensuring equitable access to appropriate forms of water and sanitation, so implying gender equality. Target 6.2, which focuses on sanitation and hygiene, notes the need to pay 'special attention to the needs of women and girls and those in vulnerable situations' (https://sustainabledevelopment.un.org/sdg6; accessed 10 May 2017; see also Chap. 8 in this collection).

An example of improved practice in integrating gender in water policy and practice at a regional level that is more focused than these global conventions can be seen in the Southern African Development Community (SADC) (See Box 7.1). There has been a movement from gender-blind and/or gender-neutral to gender-inclusive and integrated policies, protocols and budgets at the SADC level since the reformation of the regional organization in 1992. For example, in September 1997, the SADC adopted the Declaration on Gender and Development. This paved the way for the SADC Protocol on Gender and Development (PGD) of 2008 which entered into force (following ratification by two-thirds of the member states) on 22 February 2013. Article 3 of the PGD articulates the aim of attaining 'empowerment of women' and of putting an end to gender-based discrimination. With regard to water, Article 18 focuses on Access to Property and Resources within which Article 18(a) aims to 'end all discrimination against women and girls with regard to water rights and property such as land and tenure thereof' (SADC 2008). While there is considerable criticism of approaches to and claimed achievements of mainstreaming gender in water resources management in the region (Derman and Prabhakaran 2016), it is without doubt that the ratification of the PGD has mobilized a great deal of action around GM (Box 7.1; for details see SADC/SARDC 2016).

Recognizing that water resource management is lacking equality in power relations, that there is low participation of women in decision-making, and limited control over water resources and information about water, various regional initiatives have been formed. SADC has determined that the most serious issue is that women are the main managers of environmental resources, so women are instrumental in water and sanitation projects and should be included at all levels. In order to carry out this involvement, regional activities include strategic partnerships between networks and organizations, capacity building for stakeholders such as gender training, and consultative forums. A great deal of this activity involves civil society, which Debusscher and Hulse (2014) argue is a good thing since there are only two full-time staff employed in the SADC Gender Unit. They also regard extensive civil society involvement as reflective of SADC's foundational roots as a social justice-oriented organization. For example, the Global Water Partnership-Southern Africa (GWP-SA), a network of organizations involved in water management, carries out affirmative-action-oriented strategies, and forces an improved balance in representation by mandating that 30 per cent of those participating are women (Kwaramba 2001). Another GWP-SA initiative is working with the Zimbabwe Ministry of Water Resources to coordinate mainstreaming efforts at the regional level (Kwaramba 2001). Ultimately, the role of women as users of water and part of the decision-making process is an integral focal point if regional efforts for water management are to be successful. However, persistent gender inequalities remain difficult to displace, irrespective of the declarations, policies and plans made by regional organizations and national states in both the Global North and South (Ghosh 2009; Prugl 2009). Derman and Prabhakaran (2016) are particularly critical of the fact that whereas it is clear that women are more involved at local levels, their presence is limited as money, power and technology become the focal point of water management. Debusscher and Hulse (2014) observe that 'gender' is almost always translated as 'women', so GM is most often about involving women rather than critically reflecting upon and possibly working to transform structures that place women and men in fossilized social positions.

Box 7.1 Gender Mainstreaming in SADC

The SADC Treaty of 1992 placed gender firmly on the SADC agenda, and this was followed by the Declaration on Gender and Development of 1997, the SADC Gender Policy of 2007 and SADC PGD of 2008. Specific to the water sector, the SADC Regional Water Policy and Strategy (2007) proposes that all SADC water institutions implement principles, goals and objectives of GM in their administration and implementation. In line with this objective, the GM in the Transboundary Water Management (TWM) project was developed and implemented in an effort to integrate a gender perspective into policy and programmes in the regional and national water sector. The project was commissioned through the SADC Secretariat with support from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the Government of Germany in delegated cooperation with the Government of Australia and the Government of the UK and Northern Ireland.

The GM in TWM project was a two-year project launched in August 2013 and completed in July 2015. The project was aimed at ensuring that decision-makers and water specialists at different levels demonstrate the relevance of gender and social inclusion in TWM and integrate them into policy and programming. In order to achieve its objective, the project was guided by the following five outputs:

(1) **Gender Sensitivity:** Relevant stakeholders improve their sensitivity and capacity for GM.
(2) **Strategy:** SADC provides strategic advice and policies on GM in TWM to Member States and River Basin Organizations (RBOs).
(3) **Coordination:** RBOs involve relevant stakeholders in a gender-balanced way in the management of shared watercourses.
(4) **Piloting:** RBOs demonstrate regional gender and social inclusion benefits in Integrated Water Resources Management (IWRM) initiatives through infrastructure pilot projects.
(5) **Methods:** SADC provides water resources management products for GM to assist RBOs and Member States.

The project achieved the following:

(1) **Output 1**: Gender focal persons were nominated in all 15 SADC Member States and are serving as spokespersons and entry points for GM in the water sector at the country level. Furthermore, GM Action Plans have been developed, the Regional Capacity Building Plan has been elaborated on and cooperation between the SADC Gender Unit and the SADC Water Division has been enhanced.

(2) **Output 2**: The project recommendation for the introduction of gender-disaggregation of data and gender-based reporting in the SADC water sector was approved.
(3) **Output 3**: Gender has been mainstreamed in the Orange-Senqu River Basin Commission (ORASECOM) IWRM Plan with the approval of the ORASECOM Council, and GM support was provided to the Okavango River Basin Organization (OKACOM) and the Zambezi Watercourse Commission (ZAMCOM).
(4) **Output 4**: Priority GM entry points for three IWRM Pilot Projects were identified in Bokspits (Botswana), Mafeteng (Lesotho) and Mariental (Namibia), and GM training workshops were conducted at all sites in February and March 2015. Experiences from these projects have been documented.
(5) **Output 5**: The SADC Guidelines for Strengthening RBO: Mainstreaming Gender in RBOs in SADC, The SADC Handbook on Mainstreaming Gender and the Pocket Brief for Policy-makers in the SADC Water Sector were developed, published and disseminated.

This marks progress with regard to gender in water in the region, although one will have to continuously check on the project achievements against real changes on the ground at different levels—the regional, basin, national and local levels.

Gender and Water at the National Level

The power of the sovereign state to make decisions that impact all water stakeholders is largely unparalleled. As an authority, sovereign states rarely acknowledge any structure as being more powerful than the state itself. State actions and national-level policy decisions have a significant impact on gender dynamics of the country due to the oft-times structural nature of these policies. Within policy-making processes, government bodies are central in the creation and implementation of programmes and policy efforts that, while they may be designed for the benefit of the citizenry, often do not adequately address gender inequalities inherently present within the national context.

Large-scale development projects have a significant environmental and social impact on the communities where they are implemented. This is particularly true of water-related projects like dams and reservoirs, which can have national or even international effects. As such, governing bodies often consider these impacts as a way to establish a compensation package designed to offset the losses sustained by members of local communities (Braun 2010). At a national level, however, existing gender inequality is often not considered. As a result, these projects can intensify the challenges associated with gaining access to water for household use as well as water as a productive resource (Braun 2010).

In Lesotho, the Lesotho Highlands Water Project (LHWP), for example, shows how the systemic inequality that exists in patriarchal societies impacts even the most well-intentioned national policy efforts. The multi-level dam included a mitigation policy that was intended to offset the material losses of households. In Lesotho, however, society is patrilineal and patrilocal which results in household finances being organized around the lineage of men, and women's access to money being limited (Braun 2010). Given that a woman's primary responsibilities are to take care of the household and to be the main farmer in the family, this represents a significant obstacle. As such, women's access to water is imperative for the health of families as well as a way to earn an income through selling surplus crops (Braun 2010). When the LHWP took effect, households that lost agricultural income received a lump sum compensation package. Consequently, men were made responsible for monies that rightly should have gone to women, given their respective relationships to the lost water in question (Braun 2010). This is an example of how national policy decisions often neglect existing gender dynamics and result in an unintended worsening of gender inequality (Braun 2011). It is also an example of how a development project that would appear by all outward measures to be an unqualified success can nonetheless contribute to limited opportunities for women and a reinforcement of the traditional male-dominated power structure.

National water policy can also impact women's access to clean water and adequate sanitation at the most basic level. In Brazil, national water policy has been largely inadequate in working towards achieving gender equality. In a similar situation to that in Lesotho, Brazil's national water policy has done nothing to address the differences in the ways in which men and women interact with water (Leite 2010). At all levels of Brazil's national water and sanitation policy, there is typically no consideration for how programmes and policies will have different implications for men and women (Leite 2010). The water needs of men and women are often different, and in Brazil, economic and social power are dominated by men, leaving women's interests to be largely overridden in rural communities where water is scarce (Leite 2010). Economic and politically driven scarcity has become a primary obstacle for many Brazilians, as power remains in the hands of men and national policy does little to counteract this. However, some smaller efforts in Sao Joao D'Alianca and Sertao Central have shown that when there is a conscious effort to give women leadership positions, water has been more equitably managed. Fostering women's active participation is, therefore, expected to improve the efficacy of Brazil's national water and sanitation policy (Leite 2010). Brazil's case is important as it highlights the role of national policy in ensuring equal access to water.

Brown (2010) makes a similar argument in relation to water policy in Tanzania, where water privatization has become a national discussion. She argues that the Tanzanian government has to make a more concerted effort to ensure access to water as a human right (Brown 2010). Privatization, she argues, has not improved access for poor women and girls. Consequently, the state should work to implement a water policy that takes a human rights approach to guaranteeing access to safe, accessible and affordable water for every man, woman and child (Brown 2010). The Tanzanian case is interesting, and builds upon the idea of women as a social group facing challenges often perpetuated by national policy.

While there continue to be significant challenges related to gender and water on a national level, there have been cases where progress has been made and lessons for best practice can be learnt. Building on the argument that water privatization has had negative impacts for women, the case of the Bolivian so-called water wars is an important one. This case demonstrates how social movements can empower women to change their national context. The water wars took place from November 1999 to April 2000, when women in Cochabamba, Bolivia, initiated a social movement in response to their dissatisfaction with the government's water policy. In just six months, they trigged a real change, in which women took on more leadership positions and promoted a more equitable gendered perspective (Laurie 2011). The result of this movement was the overthrow of a newly privatized water company, and the consequent easing of gender imbalances with regard to water in the region (Laurie 2011). The class-consciousness displayed in the Bolivian case illustrates an important lesson for best practice: the power of a unified and progressive stance can lead to action that improves equality in water use and water management (Assies 2003). The durability of the outcome, however, is questionable, particularly when improved governance depends on social movement activism (Friedman-Rudovsky 2008).

A different case of mixed outcomes—partly positive but mostly negative—in water policy reform and practice can be found in Zimbabwe. Mainstreaming gender at the ministerial level in Zimbabwe has been a considerable part of a water sector reform programme that began in 1995 (Manase et al. 2003). Two of the programme's goals were to broaden women's access to water and to enhance their participation in water management. While the progress has not been entirely successful in creating a gender-sensitive water management scheme, this case illustrates important ways in which national policies have attempted to integrate gender issues (see Derman and Prabhakaran 2016 for details). The Zimbabwean national policy was successful in its mandate to articulate the goal of gender equity and made goals that addressed unequal access to water as well as encouraged all stakeholders to be more participatory (Manase et al. 2003). To be certain, these goals are admirable and are illustrative of a desirable national policy; however, Zimbabwe's government fell short by failing to reach these goals through the active participation of most poor men and women and by failing to address strategic gender needs. Derman and Prabhakaran (2016) reach similar conclusions in relation to policy and performance in Mozambique, South Africa and Tanzania. Lessons for best practice can be taken from the willingness to mainstream gender and the continued commitment to do so. On the one hand, then, the Zimbabwean case exemplifies a move towards increased awareness and fewer obstacles to discussing and implementing gender provisions in national policy, and that represents an important step forwards. On the other hand, however, the complete unravelling of the Zimbabwean economy over the last 15 years illustrates how poor men and women are most vulnerable to macro-social/political/economic changes and how progress in one part of a society/economy (i.e. gender and water) can be undermined by regress in another part (i.e. politicized land reform leading to widespread economic collapse): an equally important step backwards.

Gender and Water at the Local and Household Level

The relationship between gender and water is particularly relevant at the local and household level in the Global South. Unfortunately, the household is also the most complicated site of intervention, and it is unclear if other interventions—including those at the local level—have any effect on household norms (Panda 2007). In particular, water management at the local level is far more driven by traditional gender roles and expectations than are regional or national policies. Consequently, it is necessary to focus on the ways in which gender roles within the familial, household structure impact the distribution of water management tasks.

In most parts of the Global South, women are less likely to have rights or ownership over resources, including water. As this is both an indicator and an underlying cause of inequality, it has led to recent moves by many states to give resources back to local groups and communities. The hope is that this will allow cooperatives and associations to compensate for some of the state failings that have happened in recent years. As decentralization often opens doors for women, feminist and mainstream water management scholars generally view this trend in a positive light. It also leads to women promoting both social and environmental sustainability through their role as key users (Zwarteveen and Meinzen-Dick 2001). Unfortunately, this is still not a complete fix: both those scholars like Shiva who view women as symbolic keepers of the Earth ('gender and environment') and those who are more development focused ('participation') agree that privatization and nationalization of land ownership generally favours men. Worse, since land has been divided, as such since colonial times, these practices now have some degree of historical legitimacy (Zwarteveen and Meinzen-Dick 2001).

This problem is compounded by the fact that women and men have different uses for water. Makoni et al. (2004) surveyed 16 villages in Zimbabwe and found that men and women rank uses and priorities for water differently. In keeping with their role as local managers of water, men prioritize clean drinking water; on the other hand, women tend to prioritize reducing the distance necessary for water transport and improving health and hygiene, which reflects their role as managers of household water and family hygiene (Makoni et al. 2004). However, despite the fact that women generally transport, use and dispose of far more water than men, it is the men's priorities that have tended to take precedence. This is partly due to the patriarchal tendencies of traditional societies in the Global South and partly a result of the 'managerial' role that men maintain.

There is also some complication created by the fact that there is no clear consensus on just what the exact role of gender should be, in terms of water projects. Over the years, water projects have focused on different aspects of gender involvement, with mixed results. For example, some projects have used participation methods, where the water knowledge of both genders is collected to better the project. Other projects have focused on efficiency by incorporating women as a means of garnering free labour for the project. Only occasionally has there been true gender empowerment resulting in lasting social change through the participation of women in water projects (O'Reilly 2006). Ultimately, the most common driver in most situations is economics: as water becomes commodified, women move from household caretakers to village-level participators and modern consumers (O'Reilly 2006). However, this change does not necessarily represent progress as women remain consumers, not managers, and modernization serves to crystallize, not alter, the underlying gender imbalance. This runs counter to modernization theory, which enshrines the ideals of women's empowerment and the restructuring of inherently disadvantaged traditional systems.

There are numerous lessons for best practice that can be taken from examples at the local and household level. Gender sensitivity has often meant involving women in water projects and in management institutions such as community water committees, but it is also clear that this is no panacea (Cleaver and Hamada 2010). For example, at the local level, hierarchies among women mean that even when interventions are aimed at women, they are not necessarily meeting the needs of all women. When high-caste women in India are on water committees to represent marginalized women, they frequently meet the needs of just their social class rather than those of all women and may even deliberately exclude the poorest caste, the Dalit (Cleaver and Hamada 2010). From this example, we learn that perhaps gender-sensitive water policies are not enough unless accompanied by an understanding of the wider social structure.

In order to understand how to intervene at a broader level, it is imperative to understand how gender roles and expectations are created and negotiated at the household level among family members. In Peru, ethnographic studies of women illustrate the challenges relating to accessing and controlling water and land without the help of men. In the town of Coperaque, Delgado and Zwarteveen (2007), describe the case of Lupe and Illa, two women separated from their husbands, who struggle to get the water rights for their land. Local cultural norms dictate that even when women inherit land, it is typically registered to their husbands (Delgado and Zwarteveen 2007).

One example of poor practice in the Hile Village of Nepal was in the construction of tube wells and tap stands right by a major road. Because women did not want to be seen bathing publicly, this project increased by several hours women's time spent fetching water and bringing it home to bathe, simply because they were not consulted on location or design (UN 2005). This example shows that without minimal consultation, projects frequently fail.

Meanwhile, there are also true local successes. In El Salvador, Watersheds and Gender, a CARE project, helped to not only incorporate women into water management but to empower them. They trained women as managers of small companies and to be leaders and sit on boards. They gave them the technical knowledge to fully participate and speak in water discussions (UN 2005). This is a useful example of women's empowerment through water management.

Additionally, men and women have different tasks and perspectives at the household level. Domestic water provision, particularly in household farming systems, remains a key gender issue, and women and men experience this household economic activity differently. Men's roles frequently involve construction and maintenance of water wells, tanks and reservoirs, while women bring water into the home and use it for multiple purposes including backyard gardening. Obviously this is not true of all places. For example, in Punjab, Pakistan, during canal closures, water cannot be accessed locally, so men are responsible for biking and getting water from further away (Van Koppen 2001). In the majority of developing areas, however, women tend to play the bigger role in domestic water. One lesson from Punjab is that female-managed and dual farming systems can be a viable solution if the barriers to accessing land and water resources can be adequately addressed. The International Water Management Institute (IWMI) has undertaken important work in relation to developing multiple-use systems in rural settings. In this way, while not necessarily altering traditional gender roles in relation to water access, use and management, these interventions do make an important contribution by helping to not set men (as irrigators and large livestock keepers) and women (as domestic, backyard garden and small stock-keepers) against each other in a zero-sum game. Multiple-use systems may then provide the necessary socio-economic space to rethink dominant gendered models of resource use (Van Koppen et al. 2014).

The Water, Gender and Health Nexus

The importance of addressing the relationship between water and health as a gendered issue is so significant that it warrants a separate analysis. This is especially so, since one could argue that all of the 'nexus' talk regarding water-energy-food and so on has once again shunted the most important relationship—in our view, the primary 'nexus' if you will—to the sidelines. So, global policy discourse about 'big issues' involving mostly men, money and machines sidesteps the thorny issue of women's (and children's) persistent water-related ill health and burden of disease. Within the Global South, women often face obstacles in accessing water at the expense of their health. These health factors are often inherently gendered, and as a result, women are faced with health concerns that are directly and indirectly related to their access (or lack thereof) to water. Women have a unique experience with health issues due to the combination of biological differences and a male-dominated system of power relations.

Women's reproductive healthcare and menstruation are experiences that are uniquely feminine and have direct links to water. Women are also frequently constrained by social structures that define acceptable feminine behaviour (Water and Sanitation Program 2010). For instance, social pressures often relegate women to defecating only before dawn and after nightfall to maintain privacy (Water and Sanitation Program 2010). As such, women often drink and eat less during the day in order to avoid the need to urinate or defecate, which can lead to other health problems (Water and Sanitation Program 2010). Furthermore, women in the global South are often tasked with the collection of water and providing for the household which can cause indirect negative health effects such as stress and injury due to travelling long distances for water collection (Stevenson et al. 2012). These women's health realities are shaped by policy decisions and systemic social norms that are influenced by every level of policy-making and management, from the global to the local, and therefore require a discussion that cross-cuts these various levels. One of the most pressing concerns facing women and girls is having access to water and sanitation services to manage menstruation in a hygienic and dignified manner (Mahon and Fernandes 2010). The needs of menstruating women have been neglected by the dominant water, sanitation and hygiene development sectors, which are often brought together as Water, Sanitation and Hygiene (WASH) (Mahon and Fernandes 2010). While WASH programmes have acknowledged the link between access to water and sanitation and achieving health development goals, women and girls have often been excluded from meaningfully participating in decision-making processes and the management of programmes (Mahon and Fernandes 2010). By not being able to participate in WASH programmes, millions of women and girls struggle to realize their rights to gender equality, education, health and dignity. Focusing WASH projects on menstrual hygiene can significantly contribute to achieving global health targets, and WaterAid in India is an example of how this can occur. In 2007, WaterAid site visits resulted in the realization that women and girls in rural India were being denied access to communal sanitation services during menstruation, and that there was a lack of feminine hygiene products (Mahon and Fernandes 2010). Consequently, WaterAid collaborated with regional NGO partners to assess prevalent local beliefs, behaviours and the prevalence of diseases related to poor menstrual hygiene (Mahon and Fernandes 2010). The results of the assessment concluded that approximately 14 per cent of women reported suffering from menstrual infections, 89 per cent of women used cloth for the absorption of menstrual blood, and the majority of respondents gave responses that reflected a lack of correct information that was influencing how menstruating women could manage their hygiene (Mahon and Fernandes 2010). WaterAid then worked to develop community strategies that attempted to reduce the stigma surrounding menstruation and raised the level of discussions on menstruation while also empowering women to access community self-help groups that help women learn about themselves and their unique health and sanitation needs (Mahon and Fernandes 2010).

This initial work has led to all participating NGOs to formally include menstruation in their WASH efforts (Mahon and Fernandes 2010). WaterAid has since integrated menstrual hygiene within their Indian programmes at various levels while targeting different groups including men and boys (Mahon and Fernandes 2010). This WaterAid initiative is an exemplary model of how to address menstrual hygiene within WASH projects. WaterAid was effective in opening up a dialogue that improved women's health while working to reduce the stigma and shame that has been associated with menstruating women and girls.

The WaterAid case study is illustrative of the need for best practices to be active in local communities. As an example of best practice, this action-based case is an important model for development projects. Best practice, however, can also be found through researching new ways to understand how women experience water scarcity and what that means for their health. In Ethiopia, women have been found to suffer psychosocial distress due to the stress of water insecurity (Stevenson et al. 2012). One study was concerned with how women's experience with water scarcity influenced their mental health in addition to the largely emphasized impacts on physical health. Stevenson et al. (2012) established that most Ethiopian women were responsible for collecting water. This task increases the likelihood of women experiencing greater physical and health problems than men.

The longer distances women travel to access water, the use of heavy earthenware containers and the rugged terrain make water collection an extremely physically demanding task. When water is scarce, women's health risk is increased. Stevenson et al.'s (2012) study found that while women were still at risk for physical health issues, women who experienced water insecurity challenges reported more symptoms of common mental disorders. This type of research into quantitatively conceptualizing and scaling water insecurity experiences in cultures is warranted to measure and predict the effect of water insecurity as has been done more widely for nutrition interventions to measure effectiveness.

Towards a Gender Mainstreamed 'Nexus'?

As has been evidenced through the discussion of numerous case examples, there are important differences in how men and women are expected to use and manage water. This difference in behaviour is attributed to the decisions made by people, most often men, who have been given social and structural power. The case examples shown throughout this chapter are indicative of how entrenched this power system has become. The case studies were chosen as they illustrate how the roles and behaviours of individuals are defined within a gendered and inherently unequal framework. As a class of people, women have been defined in relation to men in a way that has negatively influenced how women are able to access and manage water for their optimal use. This construction of women as domestic labourers and caretakers has resulted in women being cyclically relegated to these tasks and being largely excluded from any formal management or leadership positions. It is important to note, however, that men are also defined by the construction and dissemination of normative gender roles. Within this chapter, the case examples have illustrated how men and boys have been largely defined as the breadwinners and therefore have been given a managerial role in establishing how and when water is used. As such, men have been responsible for many of the large decisions made at each socio-political level. This expectation placed on men can be just as limiting as the constructions of gendered behavioural norms that define women, especially given preferences for techno-economic interventions which are almost in every case gender blind.

While these gender norms have been entrenched in the foundation of each socio-political level, this chapter has emphasized how incorporating a gender-sensitive analysis to water management policies can improve how women, and men, interact with water. At each level, there have been examples of how this gender imbalance is beginning to be addressed. While there is still a long way to go, each case study illustrates the ways in which progress is being made. Highlighting these examples is imperative to continuing progress towards mainstreaming gender in water resource management circles, since by opening up a dialogue, a new discourse can form.

In addition to the socio-political divisions, this chapter has emphasized how women are often removed from discussions entirely, and their gender-specific needs are largely ignored in water policy development. The focus on women's health in relation to water reflects the manifestation of multiple sources of exclusion on women's experience. The cases discussed within this section emphasize how the experience of women can be vastly improved by the mere consideration of how women need water in a different way than men. Furthermore, by including men and boys in the education of health needs and how access to water impacts health, the stigma and ignorance surrounding women's health issues can be dissipated.

The focus on emphasizing examples of best practice throughout this chapter has made a gap in existing literature identifiable. Much of the current literature pertaining to gender issues in water use and water management conceptualizes the relationship as problematic, yet does not frame these challenges as opportunities. In order to effectively and progressively address the deeply rooted, systemic and cyclical nature of the power dynamics which shape the ways men and women access and use water, a new discussion that promotes what is working and why these efforts are effective must develop. Put differently, gender and water is not simply 'a women's issue'; rather, it is the essence of any nexus, be it water-land-food or water and health. The current nexus discourse is painfully silent in regard to gender and water; this is hardly surprising since it is a discourse dominated by men operating at the highest levels of political and economic power (WEF 2011). The fact that a few influential women, such as Germany's Angela Merkel, may be present in the room does not alter the fact that the current 'nexus' discourse is gender blind.

The importance of a discussion of an alternative nexus—gender-water-health—is ultimately to help us determine how to move beyond gender blindness. The recommendations herein have been categorized in terms of the major sections identified in this chapter.

Global

Given that the majority of water policy decisions occur at the regional level and below, there is no single specific policy that should be enacted at the global level. Rather, existing international forums should take a leadership role in gender equity by expanding their current levels of support, promoting the creation of linkages between existing networks, creating further forums and emphasizing gender equity whenever possible.

National

Best practices at the national level are highly dependent upon regional gender and economic norms. In those areas such as Yemen, where gender equity is all but non-existent, almost any policy encouraging a more balanced approach to gender and water would be beneficial; in those areas such as Brazil, where development is progressing apace and the gender gap is closing rapidly, policies need to be more specific. Generally speaking, all nations should further the best practices mentioned at the global level: encouraging dialogue, establishing forums and promoting—through policy, legislation, implementation and enforcement—internal equitable access to water for both genders whenever possible.

Local and Household

Because local interventions are generally the most feasible and the most successful, more attention should be paid to best practices at this level. An obvious first step is the inclusion of both men and women in decision-making. Zwarteveen and Meinzen-Dick (2001) found that often one of the challenges in determining rights and access over time is a lack of documentation tracking gender and socio-economic information. In many instances, simply collecting this type of information would do much to accurately identify what the differences and challenges truly are. Furthermore, since water intervention policies are necessarily data driven, these collection practices can help policy-makers drive broader intervention strategies at both the regional and national levels. That SADC has mandated gender-disaggregated data is a step in the right direction.

Gender-Water-Health

Given the inextricable linkages between public health and clean and accessible water supplies, the establishment of gender equity in water policy is of particular importance. Currently, there are a number of interventions being undertaken, and they all have some merit. However, many of these practices overlook the fundamental differences in the water needs of the two genders, and they especially overlook the additional personal needs that women have for clean water due to their unique physiological demands. With this in mind, the recommended best practice in this area is to balance gender norms with personal needs. Particularly, it is necessary to take into account the additional burdens that water frequently imposes on women, such as the need to transport water long distances, the risks entailed in that travel, and the stress and psychological burdens created by being forced to work in a framework that does not take their needs into account. These hurdles need to be overcome at all levels, but the first step is most easily enacted at the local and public health levels.

Furthermore, there is also a need for data. Rather than discuss a specific best practice, it is more important to recognize that there is a need to quantify water insecurity experiences in cultures to predict the effects of water scaling. This type of research into quantitatively conceptualizing and scaling water insecurity experiences in cultures is warranted to measure and predict the effect of water insecurity, as has been done more widely for nutrition interventions to measure effectiveness.

Conclusion

Although women and men interact with water in different ways and at different times in water use and water management processes, water resource management has generally failed to compensate for this fact. Instead, men have held disproportionately dominant roles, while women have frequently been shut out of the process and suffered the worst consequences of mismanagement. All this, despite the fact that women utilize and manage most water resources at most levels in those societies. These imbalances are indicative of deeply rooted, systemic power relations that have significant implications for the ways in which the resource is handled.

Fortunately, there are opportunities to change the systemic problems. At the global, national and local levels, there are interventions that are effectively creating systemic change that can be adapted and replicated to other contexts. The example of WaterAid's menstruation intervention in India demonstrates how one good idea can be multiplied. Ultimately, there is potential for sustainable global change in the gendered dynamics of water management with a comprehensive action plan and understanding of what has worked.

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CHAPTER 8

Water as Threat and Solution: Improving Health Outcomes in Developing Country Contexts

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Introduction

Water is a determinant of health and health forms the very basis of human well-being. Water, like health, forms the very basis of human survival and thus the right to life. In many instances water is both a solution and a threat to human life. In the case of maternal and child health, water poses great risks for pregnancy and childbirth as well as to young children. Increased mortality and morbidity of developing country populations have tremendous implications for development outcomes as not only single individuals, but whole swaths of the population fall into the cycle of poverty. A significant threat to health is poor water and sanitation, specifically low or no access to clean water as well as poor sanitation practices and conditions (Rautanen et al. 2010). According to UN estimates, 'at least

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1.8 billion people globally use a source of drinking water that is fecally contaminated', so resulting in a nexus of cyclic poverty and disease (see http://www.un.org/sustainabledevelopment/water-and-sanitation/ accessed 9 May 2017).

Poor hygiene practices, water quality and sanitation contribute to ill-health particularly the health of women and children. Proper hygiene, point-of-use (POU) water treatment and community-led total sanitation (CLTS) are all innovative methods within the water, sanitation and hygiene (WASH) sector that directly and indirectly improve health outcomes and quality of water. In this chapter, we explore the effectiveness of these various methods in their applications in developing country contexts.

Water as Threat: Maternal and Child Health

As poor water and sanitation is considered less visible than other global threats such as famine and HIV/AIDS, many governments of the Global South simply do not prioritize water and sanitation even though it is a major development and public health issue (Whittington et al. 2012). For girls and women in developing countries, pregnancy and childbirth are a leading cause of disability, morbidity and mortality (IRC 2012). Although maternal mortality rates have been reduced by 50 per cent from 1990 to 2010, 99 per cent of all maternal deaths occur in developing countries, particularly in South Asia and sub-Saharan Africa (IRC 2012; Pruss et al. 2002; UN 2006). Additionally, the countries with the lowest access rates to water and sanitation also have extremely poor maternal health (IRC 2012). Remarkably, current literature is only just beginning to demonstrate evidence-based, causal relationships between the water, sanitation and hygiene (WASH) sector and maternal and child health. Findings have shown that further research of WASH and maternal and child health combined with programmes that develop behaviour and health-seeking attitudes can substantially improve water-related health outcomes for mothers and children (Benova et al. 2014; Bryce 2008; IRC 2012; van Wijk and Murre n.d.).

The correlations between WASH and maternal and child health are substantial. Improving WASH results in improved health benefits by reducing risks of viral, bacterial and parasitic infections, as well as other diseases such as scabies and upper respiratory infections such as trachoma (Bryce et al. 2008; Cheng et al. 2012; Herzer 2013). In fact, rates of diarrhoea can be reduced by as much as 48 per cent by hand washing with soap (IRC 2012; UN 2006). Maternal and child health outcomes are the most negatively impacted by poor water and sanitation as well as hygiene practices. Further, this demographic is most responsible for the overall use of water at the household level. Therefore, this demographic must be prioritized in any WASH intervention and the subsequent adoption of behaviour will determine sustainability and replicability of methods to ultimately improve this vulnerable group's health outcomes.

Water as Solution: Hygiene

There are tremendous burdens associated with maternal mortality. What happens to a family upon the death of a mother as a result of pregnancy or childbirth reverberates through not only her immediate relations but the community and, to a wider extent, leads to deprived families. While World Bank data shows that the ratio of maternal deaths per 100,000 live births has fallen dramatically worldwide over the last 25 years, from 385 to 216, UNICEF reports that a total of 303,000 women still died from complications of pregnancy and birth, 88 per cent of whom were in sub-Saharan Africa and South Asia (see http://data.worldbank.org/indicator/SH.STA.MMRT and https://data.unicef.org/topic/maternal-health/maternal-mortality/# accessed 9 May 2017).

The children of mothers who have died have lower chances of reaching their sixth birthday and if they do survive, more difficulty breaking out of the cycle of entrenched poverty (IRC 2012; World Health Organization 2012). Additionally, mothers who suffer ensuing disability and morbidity will face greater health challenges with subsequent pregnancies, as well as be disadvantaged in terms of compounding poverty due to reduced opportunities as a result of ill-health. In fact, 10–20 million women worldwide bear the burden of complications resulting from pregnancy and the birthing process (Bryce 2008; IRC 2012).

There are many direct and indirect causes of maternal mortality related to water and sanitation. In terms of vulnerability, the birthing process itself accounts for between 11 per cent and 17 per cent of deaths, while 50–70 per cent of maternal deaths occur within 24 hours of birth (Bryce 2008; IRC 2012). According to Say et al. (2014: e323), '[a]n estimated 287,000 maternal deaths occurred worldwide in 2010, most of which were in low-income and middle-income countries and were avoidable'. The leading causes of maternal death according to data collected and analysed by Say et al. (2014: e326) are as follows: haemorrhage (27.1 per cent), hypertension (14 per cent), sepsis (10.7 per cent), abortion (7.9 per cent), embolism (3.2 per cent) and other direct (9.6 per cent) and indirect causes (e.g. HIV/AIDS) (27.5 per cent).

Hygiene during the birthing process is essential as these infections are often caused by unhygienic practices during childbirth. WASH directly affects health outcomes and maternal survival from pregnancy to birth and beyond via improved WASH and particularly with the use of safe hygiene practices (Benova et al. 2014; Bryce 2008; Cheng et al. 2012; IRC 2012). Recent epidemiological and ecological evidence suggests a causal relationship between WASH and improved maternal health outcomes (Benova et al. 2014; Cheng et al. 2012; IRC 2012). For example, in Tanzania women who bathed before giving birth and had clean clothes for themselves and their children were found to be three times less likely to develop puerperal sepsis (infection of the genital tract) than those who did not bathe (IRC 2012). The one major technique to improve hygiene is what the World Health Organization describes as ‘six cleans’: clean hands of mother and attendant, clean perineum, clean delivery surface under mother, clean blade for cutting cord, clean towels to dry and wrap mother and baby (IRC 2012; Pearson et al. 2006). Additionally, hand washing reduces tetanus, mortality and cord infection for babies and reduces risk of infections for the mother (IRC 2012). Hand washing and improved hygiene practices in rural/urban and home/facility settings are contingent on increased access to safe water sources such as protected wells, pumps, boreholes, public taps and piped water (Benova et al. 2014; Cheng et al. 2012; Rautanen et al. 2010; United Nations 2006).

Best Practices: Health Outcomes from Hygiene

Use of clean water and hygienic birth processes with trained attendants can halve all infection-related maternal deaths (United Nations 2006). For example, in Nepal universal provision of low-cost interventions could reduce infection rates by 70 per cent (Rhee et al. 2008). Universal access to improved water and sanitation is estimated to save $134 billion in avoided health costs, lost productivity and reduced morbidity and mortality (Toro 2014). The major challenge is dealing with implementation of interventions in resource-poor settings that address the needs of both rural and urban women as well those that deliver at home or in facilities. The MaiKhanda (Chichewa for mother-baby) project in Malawi has demonstrated itself to be an innovative approach that increases demand for health care services via community mobilization as well as improvement of health care facilities resulting in substantial reductions in neonatal mortality (The Health Foundation 2013). Although maternal mortality rates for Malawi have certainly reduced over the years, there is less evidence for links between WASH and significant reductions in maternal mortality. In this case, improved transportation options for pregnant mothers improved neonatal survival, but the study found that a hygiene-based continuum of care versus single hygiene interventions was more impactful on maternal health outcomes (The Health Foundation 2013). In Malaysia and Sri Lanka, maternal mortality rates decreased by 70 per cent as a result of programmes aimed at health care combined with education and WASH components (United Nations 2006). There are many examples of hygiene interventions, especially hand washing, that result in direct improvements in maternal health outcomes. However, there still exists many challenges, foremost of which are scalability and replicability of WASH and maternal health projects, especially in the long term. Aside from the central problem of affordable access to water of sufficient quality and quantity, the predominant issue surrounding long-term results rests ultimately with behaviour change and adoption of WASH methods.

Behaviour and Adoption of Hygiene Practices

Simply providing knowledge of the risks or benefits of hygiene for mothers does not necessarily translate into adoption of those methods, even though the mothers (and their children) would be direct beneficiaries. There are often many other factors contributing to behaviour such as history, culture, social hierarchy and accepted norms of behaviour. These cultural coordinates are contextually determined and impact both behaviour change and demand creation by mothers. Often, maternal health and WASH interventions focus on, for obvious reasons, pregnant women; however, it is important to discern that they may not have control over their health. Pregnant women frequently do not have a large share of decision-making power, especially when it comes to allocating resources associated with both the birthing process and water, sanitation and hygiene (IRC 2012; van Wijk and Murre n.d.). Different contexts may determine varying hierarchies, and thus ultimately decision-making power may be shared regarding expenditures, birthing process, seeking and choosing transportation for emergencies and the provision of water and sanitation amenities (IRC 2012). For example, in Zambia 47 per cent of women decided themselves where to deliver, 14 per cent the parents, 11 per cent the husband, 9 per cent relatives and 3 per cent traditional birth attendants (Stekelenburg et al. 2004). In other cases the importance of elder women and grandmothers may be predominant regarding maternal and child health.

Men play a huge role in both maternal health and WASH even though they are often not directly involved in the birthing process, but because they are responsible for both resource allocation and decision-making (IRC 2012). In Nepal men are predominately involved in decisions regarding investment in and location of water points, latrines and, importantly, soap purchases (Krukkert et al. 2004), and it stands that any subsequent hygiene promotion should include them as major stakeholders. As a result WASH projects in Bangladesh (BRAC) and Nepal (SNV) are specifically targeting men (Krukkert et al. 2004).

Hygiene behaviour change and especially communication must be sustained over time, initiated and devolved to the local level by and for stakeholders. Additionally, recognizing and utilizing existing knowledge capacity and frameworks is essential for not only the deployment of hygiene programmes and projects but ultimately for any concept of benefit sharing to be adopted. Numerous organizations have developed frameworks for facilitating hygiene behaviour change. Perhaps the most well-known is the IRC/SNV supported FOAM (for hand washing) and SANIFOAM (for sanitation) approaches where FOAM is an acronym meaning Focus, Opportunity, Ability, Motivation (see SNV/IRC 2015 for details).

Dreibelbis (2015) and colleagues, with a focus on India, articulate the extent of the problem but also the complexity and difficulty of engendering attitudinal change towards poor water and sanitation (WATSAN) practices. Hulland et al. (2013), with a focus on Bangladesh, illustrate the many barriers to better WATSAN practices, including psychosocial factors. Each study illustrates the potential for positive outcomes deriving, in part, from proximity to a latrine or hand washing station, and the demonstration effect of people using and benefiting from these interventions within the community, be it rural or urban.

Water as a Solution: Point-of-Use (POU) Water Treatment

The health consequences of poor access to water and sanitation services cause almost 4 billion cases and nearly two million deaths from diarrhoea each year, primarily among children in the developing world (WHO and

UNICEF 2000; Fielbelkorn et al. 2012). Infants and young children suffer the highest rates of mortality because they are vulnerable to even minimal exposure to waterborne pathogens which would be unlikely to cause illness in adults (Montgomery and Elimelech 2007). Further, long-term effects from diarrhoeal diseases cause indirect health impacts like malnutrition and a reduction in cognitive function in children (Montgomery and Elimelech 2007). The gathering and provision of water largely rests on women and children in the developing world as they are primarily responsible for domestic work. It is of fundamental importance that access to safe drinking water prior to consumption be made available to all vulnerable populations, particularly women and children. Traditionally, access to improved drinking water has been concentrated on centralized water treatment systems (Bakker 2010). However, these types of systems make it difficult to provide water to dispersed rural populations in the developing world as well as unplanned urban areas (Mintz et al. 2001). In rural areas, these centralized approaches regularly require large capital investments as well as proper operation and maintenance which can be extremely costly for governments, donors and the private sector (Carlevaro and Gonzalez 2011). Furthermore, in urban areas, rapid urbanization can put heavy strain on existing infrastructure and cause issues for planning and construction of this new infrastructure (Mintz et al. 2001). This casts doubt on the sustainability of implementing large centralized systems and whether even large investments in this area would lead to overall health improvements (Mintz et al. 2001). Therefore, when proper functioning centralized systems are not available and water sources are contaminated, an alternative must be available to treat water prior to consumption. A current option to these centralized systems is POU water treatment which consists of various household treatment methods to reduce contamination of water prior to consumption.

POU water treatment provides a locally modified solution to these centralized systems. A main advantage of POU treatment is that it reduces pathogen exposure immediately before consumption. Therefore, even when water is clean at the source, if it is exposed to contamination during collection, transport or storage, POU treatment can reduce exposure to pathogens before consumption (Montgomery and Elimelech 2007). There are various approaches to POU water treatment including chemical treatments such as flocculant-disinfectant and sodium hypochlorite as well as solar disinfection. Many studies have evaluated the effectiveness of POU water treatment and consistently conclude that, ‘in settings where diarrhoea is a leading cause of death, persons who live in households that regularly treat their drinking water with an approach that is microbiologically effective have less diarrhoea than persons living in households that do not treat their drinking water at the point of use' (Luby et al. 2008: 382). Further, if water is to be stored after treatment, safe storage must be included alongside POU treatment.

Flocculant-disinfectant is a chemical powder sold in sachets to be used on small volumes of water. The brand often associated with this technique is Purifier of Water (PUR), a product manufactured by Procter and Gamble Company consisting of a powder of ferric sulphate (a flocculant) and calcium hypochlorite (a disinfectant) (CDC 2012). This chemical disinfectant is the most effective at removing bacteria and viruses (Montgomery and Elimelech 2007). In a study conducted in rural Guatemala, it was found that of 257 households who received flocculant-disinfectant (measured against 257 control households who did not), an approximate 39 per cent decrease in cases of diarrhoea occurred (Luby et al. 2008). However, as PUR is manufactured by a private company and not locally produced, this tends to impede widespread adoption and distribution (Montgomery and Elimelech 2007) as well as increase cost in comparison to other chemical treatments. Sodium hypochlorite is another form of POU chemical treatment; however, it is not as effective in treating bacteria and viruses particularly in water that is turbid or in removing chlorine-resistant pathogens such as various protozoan cysts (Montgomery and Elimelech 2007). Yet, sodium hypochlorite is the least expensive type of chemical disinfectant and has the potential to be produced locally through electrolysis of salt water (Mintz et al. 2001). Additionally, a major benefit of the above chemical disinfectants is that they leave residue behind which can protect against recontamination and also be measured to determine adoption rates of the POU technology to determine future objectives (Mintz et al. 2001).

A form of non-chemical POU treatment is that of solar disinfection where the removal of active pathogens in water occurs by way of ultraviolet radiation with or without an increase in temperature or solely due to an increase in temperature (Montgomery and Elimelech 2007). This inactivation will only occur when the water's temperature is above 45 °C as this heat intensifies the bactericidal effects of ultraviolet radiation (Montgomery and Elimelech 2007). This is usually done using clear plastic bottles which will be painted half black or laid against a dark surface (Montgomery and Elimelech 2007). A disadvantage of this treatment method is that turbidity also significantly decreases the ability of the ultraviolet radiation to penetrate the water (Montgomery and Elimelech 2007). However, evidence from South Africa shows that straining water through something like cheesecloth is effective in removing a significant amount of particulate matter. A study in Southern India provided both field and laboratory validation that solar disinfection decreases contamination of drinking water and the resultant morbidity and mortality of children (Rose et al. 2006). After a six-month follow-up, it was found that there was greater than 50 per cent reduction in diarrhoea in children under 5 in this community (Rose et al. 2006). Interestingly, the field evaluation demonstrated that solar disinfection's ability to reduce diarrhoeal episodes was 'statistically significant despite the fact that most children were not using solar disinfected water as their sole source of drinking water' (Rose et al. 2006: 141). The use of ultraviolet radiation as a POU treatment is a simple method to implement and, along with being inexpensive, does not alter the taste or odour of water as do chemical disinfectants (Montgomery and Elimelech 2007).

As mentioned, the inclusion of proper storage with these methods helps to reduce the risk of contamination. According to Mintz et al. (2001: 1567), '[t]he risk of diarrhoea due to the contamination of drinking water during household storage, first noted in the 1960s, has since been repeatedly observed'. This study conducted a review of the principles of safe water storage and features required for safe water vessels, alongside an analysis of the effectiveness of these vessels (Mintz et al. 2001). The results signified that safe water storage vessels should have tight-fitting lids and narrow mouths so that water may be drawn by pouring or through spigots to prevent collection by dipping into the collected water which may cause contamination (Mintz et al. 2001).

Best Practices: Health Outcomes from Point-of-Use Water Treatment

It has been noted that POU treatment methods remove or inactivate pathogens at varying rates. However, there is no conclusive evidence stating which POU method is the most effective at reducing diarrhoeal rates, thereby improving health (Montgomery and Elimelech 2007). The results of POU methods are highly contextual and very much related to adoption rates and consistent use. Though POU methods have the ability to decrease contamination before consumption and reduce occurrences of diarrhoea, '[d]ecentralization has not solved perhaps the largest problem facing water and sanitation projects – sustaining long-term use and operation' (Montgomery and Elimelech 2007: 22). Fielbelkorn et al. (2012)

noted the evidence that exists surrounding attrition in use and a reduction in health impacts of POU treatments over time. The reduction in health gains is related to the fact that POU treatment is only beneficial if it is used consistently (Fielbelkorn et al. 2012). When considering the above study in Guatemala, a questionnaire was administered six months after the trial to assess the frequency of purchase and use of flocculant-disinfectant (Luby et al. 2008). It was found that of 462 households who participated in the survey (out of the 514 who participated in the study), only 22 households (5 per cent) had purchased the treatment in the previous 2 weeks and used the product in the preceding week (Luby et al. 2008). Therefore, even after the effectiveness of the treatment was demonstrated alongside a marketing campaign, a small number of households had adopted and consistently used the product (Luby et al. 2008). These household treatments require time and effort on the part of the householders, primarily women and children, to treat their water properly and ensure that treated water is steadily accessible but also to discontinue drinking untreated water (Clasen et al. 2007). Each of these tasks requires compliance, and it was found that the more opportunity for non-compliance the less effective are household treatments (Clasen et al. 2007). Therefore, assessing whether the target populations will use these POU treatments and which type is best suited is central to long-term consistent use and health gains. As Fielbelkorn et al. (2012: 632) state: 'If vulnerable populations are not using point-of-use water treatment interventions, then it is of little consequence that these measures have proven effective in reducing diarrhoeal disease'. Ergo, the ability of POU water treatment to reduce diarrhoeal diseases depends not only on the effectiveness of the technologies but factors associated with consistent use such as affordability, time constraints, preferences, interpersonal communication and behaviour change.

Behaviour and Adoption of Point-of-Use Water Treatment Methods

When centralized systems are unavailable or inefficient, the burden of water treatment falls on to the consumer, including ability to pay. A study conducted of mothers in Malawi with regard to usage of a sodium hypochlorite treatment found that there was a gap in usage between mothers who were aware of the treatment and had previously used it and those who were current users when the survey was conducted (Stockman et al. 2007). The difference was a sizeable drop from 52 per cent to 12 per cent, meaning there was an overall dropout rate of 78 per cent and the primary reason given by mothers who had stopped using the treatment was cost (Stockman et al. 2007). In the majority of efficacy studies and programmes conducted for POU water treatment, the treatments are often provisioned at no cost or are heavily subsidized which can explain the high rates of use during these periods. It is well-known that offering free products by no means ensures continued use or purchases in the long run. For example, as a 'free water for all' policy once existed in Tanzania, this has made cost a major obstacle to POU treatment adoption and consistent use (Montgomery and Elimelech 2007). However, an antenatal care programme also conducted in Malawi, and also using a sodium hypochlorite technique, found that current users were more likely to weigh the cost of the product against its benefits such as reductions in future medical expenses (Wood et al. 2012). In addition, in the same study, the extended free trial of the sodium hypochlorite solution allowed women and their families to experience the health gains from the product, realize its value and importance and also to become accustomed to the taste and odour (Wood et al. 2012).

Time constraints also play a role in consistent use as women are already burdened with the majority of domestic work and treating water contributes to this work. It may happen that women treat the water but will not do so consistently if there is a lack of time to do so. Further, as mentioned, the taste and odour associated with chemical disinfectants also deter consistent use of these POU treatments. It has also been noted that less than needed use of the chemical is used to treat the water as to minimize the disagreeable taste associated with chlorine within these treatments. However, solar disinfection has the ability to overcome both affordability and preferences with regard to taste and odour. Mothers in the study in Southern India believed solar disinfection to be a practical water treatment method due to its cost effectiveness and 'because the taste and smell were not changed' (Rose et al. 2006: 141).

An important component to improve adoption and use is related to behavioural change and interpersonal communication. In the antenatal care programme in Malawi, it was found that 'positive, ongoing contacts with health care workers, especially during home visits, raised awareness of the need to treat water, encouraged trial use, and supported continuing use' (Wood et al. 2012: 634). Further, social support from immediate family, relatives and health care workers was found to be a very important component of behavioural change towards adoption and consistent use of POU techniques (Wood et al. 2012). The hardware of POU treatment projects are just a component of the overall programme, what is truly important is the process and ability to promote the use of POU water treatment and storage behaviours (Mintz et al. 2001). It is clear that POU treatments are effective at reducing diseases due to diarrhoea, but this proven efficacy is not enough to ensure use of treatments. The understanding of each target population's perceived value of the product is essential to adoption, consistent use and sustainability of POU treatment techniques.

Water as Threat: Sanitation

While 1.8 billion people gained access to improved sanitation facilities between 1990 and 2010, 2.5 billion people mostly in developing countries and predominantly in rural areas still lack access (UN Water 2014). Sanitation coverage in developing countries (49 per cent) is only half that of the developed world (98 per cent) (UNICEF and WHO 2014: 221).

Open defaecation (OD) rates have declined globally from 24 per cent in 1990 to 15 per cent by 2011; however in 2011, there were still nearly 1.1 billion people practising OD around the world (UN Water 2014). The decline in OD rates differs between regions, with a steady decrease in the practice in Eastern, Southeastern and South Asia, as well as in Latin America and the Caribbean (UN Water 2014). In sub-Saharan Africa, however, OD rates are increasing (UN Water 2014). A contributing factor has been the lack of access to toilets or other facilities (UN Water 2014) that ensure hygienic separation of human excreta from human contact such as flush or pour-flush toilet/latrine to a piped sewer system, a septic tank or a pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab; or a composting toilet (UNICEF, n.d.).

According to the United Nations, 80 per cent of diseases in developing countries are caused by unsafe water and poor sanitation, including inadequate sanitation facilities (UN Water 2014). While 88 per cent of diarrhoeal diseases are attributed to unsafe water supply and inadequate sanitation and hygiene (WHO 2004), one of the main causes of diarrhoea specifically is open defaecation (OD), which results in more than 750,000 deaths per year in children under the age of 5 (UN Water 2014). Open defaecation (OD) is responsible for a number of endemic infections aside from diarrhoea, including tropical enteropathy, malabsorption of nutrients in the gut ascaris, tapeworms and other intestinal parasites, hookworm, hepatitis, liver fluke, schistosomiasis, trachoma and zoonoses. Infant and child undernutrition and stunting are also aggravated as a result.

The most effective way to prevent faecal-orally transmitted diseases is the sanitary disposal of human faeces in pit latrines or other improved sanitation facilities (UNICEF and WHO 2014: 230); any form of improved sanitation such as a basic hygienic latrine can prevent globally important infections such as helminthiases and giardiasis (Bartram and Cairncross 2010). Similarly, cholera outbreaks often spread in large populations of people relying on a contaminated water source, where wastewater is not separated from drinking water (Yacoob and Whiteford 2008). Parasites can be transferred to humans when they come in contact with water contaminated with snails that have schistosomiasis or guinea worms (Singer and Erickson 2011). Infections can be contracted through bathing, swimming, washing clothing or drinking contaminated water (Singer and Erickson 2011). Diseases further spreads through bodies of still water, lack of access to indoor plumbing and inability to separate wastewater from the water used for consumption, bathing, irrigation of crops and washing of clothes (Singer and Erickson 2011).

Adequate treatment and disposal of wastewater causes a sharp decrease in environmental contamination by faeces, which thereby contributes to better ecosystem conservation and reduces pressure on scarce freshwater resources (UNICEF and WHO 2014: 221). Illnesses caused by unsafe drinking water and inadequate sanitation generate high health costs relative to income for the poor. Access to safe drinking water and adequate sanitation helps reduce household expenditures on health care (UNICEF and WHO 2014: 221).

In many cultures around the world, women and girls can only defaecate after dark when there is no latrine. The walk to the defaecation field, often in the dark, increases the risk of sexual harassment and assault. The lack of separate sanitation facilities in schools often prevents girls from attending school, particularly when they are menstruating (UNICEF and WHO 2014: 230).

Water as Solution: Community-Led Total Sanitation (CLTS)

Developed in Bangladesh, community-led total sanitation (CLTS) arose in the late 1990s in response to an unsuccessful sanitation initiative by UNICEF, WHO and the Department of Public Health Engineering in the 1970s (Mehta and Movik 2011). The construction of latrines had been introduced as an attempt to improve sanitation; however, the initiative failed as it was rejected by the community due to lack of affordability (requiring hardware subsidies upfront), ineffective training on the use of latrines, improper use (often used as storage) and local perceptions surrounding the highly Westernized top-down approach that had been used for implementation (Mehta and Movik 2011). As a result, the initiative failed to motivate behavioural change and uptake did not occur. CLTS, in contrast, was successful as it came about through local mobilization and facilitation, enabling villagers to analyse their own sanitation and waste situation in order to foster collective decision-making towards reducing and preventing open defaecation (Mehta and Movik 2011).

CLTS is a participatory methodology that uses facilitation instead of teaching or preaching and emphasizes behavioural changes with the community as the unit of action (Mehta and Movik 2011). Rather than focus on individual empowerment, CLTS empowers entire communities to do their own analysis and take steps to become open defaecation free (ODF). The main difference between CLTS and other similar projects is that the method rejects hardware subsidies and acknowledges that the introduction of latrines alone does not result in improved sanitation and hygiene (Dreibelbis et al. 2013, 2015). CLTS concentrates on ending open defaecation (OD) as a first significant step and entry point to changing behaviour. It starts by enabling people to do their own sanitation profile through appraisal, observation and analysis of their practices of OD and the effects these have (Mehta and Movik 2011).

CLTS occurs in three phases: pre-triggering, triggering and post-triggering (Kar and Chambers 2008). In the pre-triggering phase, a community is selected and rapport building begins prior to triggering the appraisal. The triggering phase involves the launching moment—in this phase, shame and disgust are used to induce collective revulsion among community members as they face the negative effects related to open defaecation (OD). During the post-triggering phase, the community develops an action plan to tackle OD and ideas for follow-up (Kar and Chambers 2008).

Although CLTS has been successful in a number of areas, it has also been widely criticized. CLTS uses a community view of shame and disgust to motivate behavioural change (Mehta and Movik 2011). Through the triggering phases, shaming and disgust are used to strategically provoke strong emotions where the impulse to change arises from the shock of realizing the implications of one's actions. Many critics feel that this is an unethical way to create or promote change; however, some supporters maintain that 'disgust' is a healthy, life-protecting emotion and thus beneficial for creating positive change.

Best Practices: Health Outcomes from Sanitation

Sanitation improvements allow women and girls to enjoy private, dignified sanitation, instead of embarrassment, humiliation and fear from open defaecation and menstruation. Research shows that separate school sanitation facilities for girls and boys increase girls' attendance, particularly in adolescence (UNICEF and WHO 2014: 221). In Bangladesh for example, a gender-sensitive school sanitation programme increased girls' enrolment by 11 per cent (UNICEF and WHO 2014: 230). Moreover, water sources and sanitation facilities closer to home reduce the risk of assault for women and girls collecting water or searching for privacy.

CLTS has led to rapid and sustainable behavioural changes and has been successful in creating livelihood improvements in many parts of the Global South (Mehta and Movik 2011; Dreibelbis et al. 2014). While mobilizing community members towards collective action, CLTS promotes empowerment through good sanitation and self-developed participatory initiatives. In many cases, CLTS initiatives helped by promoting dignity for women and girls especially, who were forced to defaecate after dark in search of privacy prior to this initiative. Women and girls previously suffered further discrimination as a result of a lack of privacy surrounding menstruation. According to Mehta and Movik (2011), CLTS was successful in Bangladesh because it was a participatory approach that had the support of local leadership but was not imposed using a top-down approach. Mobilization and community support came from a wide understanding of the negative side effects of open defaecation and the willingness to change behaviour at the community level. Additionally, children and women were instrumental in the success of CLTS in Bangladesh (Mahbub 2011). Through empowerment, CLTS helped to create a culture of good sanitation, and can reduce and mitigate the incidence of disease through rapid and sustainable behavioural changes.

In Vietnam, however, a CLTS initiative in nine villages did not achieve the same success (Brown 2009). While attempts were made and certain villages experienced some positive outcomes, in general, CLTS was not adopted as there was an atmosphere of top-down enforcement of simply building latrines as opposed to focusing on behavioural change (Brown 2009: 40). Even where temporary latrines were owned, a high percentage of people admitted to practicing OD (Brown 2009: 40). In the case study area, according to Brown (2009), understanding of disease causation related to OD varied: hand washing was not widely practised and people routinely leave infant faeces to be eaten by dogs and pigs. While most people simply stated that they had 'no choice' but to practise OD, the next largest category stated that OD was, in some comparative measure, a positive experience. Research conducted by Hulland et al. (2013), also in Bangladesh, reached similar conclusions.

Behaviour and Adoption of Sanitation Practices

While the participatory process of CLTS directly involves communities, it has been criticized for imposing globalized sanitation norms and a dominant external worldview. Pomerantz-Kasper (2013), for example, argues that CLTS structurally advocates for continuing local hierarchies, promotes external technologies, enforces the power of outside development facilitation and creates a new sanitation paradigm. He further argues that communities resist sanitation initiatives such as CLTS because of its top-down structure, which was the case in the example of Vietnam (Brown 2009). Nevertheless, water and health are related in a number of important ways and reducing OD through instances where CLTS has been successful has resulted in improved health and sanitation. There are multiple, often conflicting relationships between water and health that CLTS can help to improve. Health is as much social as it is biological. Similarly, reduced access to water changes people's behaviours towards water. As a result, participatory methods derived from local perceptions, mobilization and facilitation can lead to some improvements.

Investing in community mobilization instead of hardware has been key to the success of CLTS initiatives. This triggers the community's desire for change, fosters innovation and local solutions and encourages mutual support leading to greater ownership and sustainability. Change is essentially implemented through education using methods design by and for the local community. As shown earlier, several models have emerged to address WASH; however, many suffer a number of limitations and ignore the contextual, psychosocial and technological dimensions of WASH practices. The success of interventions to improve WASH practices ultimately depends on the ability to foster and maintain behavioural change at the individual, household, community and structural levels to ensure that the programme is sustainable, practical and replicable.

Conclusion

Poor hygiene practices, water quality and sanitation contribute to ill-health particularly that of women and children. Proper hygiene, POU water treatment and CLTS are innovative methods within the WASH sector that directly and indirectly improve health outcomes and quality of water. The field of study recognizing the considerable importance of aligning maternal and child health with WASH is in its infancy and is only now emerging as an important cross-sectoral connection to improve health outcomes. While there is evidence to support the effectiveness of proper hygiene and POU water treatment techniques, what needs to be considered is their application in various environments and the contexts of target populations. Ultimately, the recognition that these techniques are beneficial is null if the importance of addressing behavioural change towards adoption and consistent use of WASH methods is not acknowledged.

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CHAPTER 9

Household Water Insecurity in Different Settlement Categories of Ngamiland, Botswana

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Introduction

The availability, accessibility, usage and quality of freshwater resources around the world have been central issues on the international agenda since the late 1970s (Bigas 2012; Gleick 2009; Jury and Vaux 2007; Prud'homme 2011). The objective of organizations such as the United Nations has been to ensure that the 1.1 billion people, mostly in developing countries, lack-

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ing access to safe and clean water, have potable water available and accessible to them, thereby enhancing water security (Jones et al. 2009; UNDP 2006; United Nations 2003). There is growing recognition that the urgent and deepening crisis in water stewardship worldwide is a particularly acute problem in developing countries (Rosegrant and Cline 2003). The problem is being exacerbated by ineffective water governance and lack of financial and material resources to invest in water supply (UNDP 2006).

An estimated 100 million people in Southern Africa lack access to clean water supply, while about 120,000 children die annually as a result of waterborne diseases (Provost 2014). There has been slow progress in Southern Africa in terms of increasing coverage to safe and clean water supply services through improved water sources (Ainuson 2010). By 2013, only Botswana and Seychelles out of the 15 Southern African countries were expected to meet Millennium Development Goal (MDG) Target 9 which aimed at halving the proportion of people without access to safe water through improved sources by 2015 (UN 2013a). According to the UN's country report for 2015, Botswana did indeed achieve this target (UN 2015). Coverage for improved water sources in Southern African countries is still low, for example, Malawi at 60 per cent coverage, Tanzania at 60 per cent and Zambia at 61 per cent (WHO/UNICEF 2013). Few countries in the region have high coverage of improved water sources, for example, Botswana has 97 per cent, Seychelles reached 100 per cent and South Africa is at 95 per cent (WHO/UNICEF 2013). However, having improved water sources does not always translate to or guarantee reliable water supply as a number of households with such sources go for prolonged periods of time without water supply services (WHO/UNICEF 2013). While 88 per cent of households in Ngamiland, Botswana have improved water sources, 74 per cent of them encounter water supply challenges (Kujinga et al. 2014). In Malawi, where an estimated 50 per cent of the population do not have access to safe and clean water, households in urban and peri-urban areas are forced to buy water from kiosks and neighbours with running water or fetch from unprotected points (Manda 2009). A decade-long economic decline (1999–2009) in Zimbabwe reversed the previous gains achieved in enhancing access to clean water in urban and rural areas, a situation which led to 98,000 cases of cholera and 4000 deaths in 2009 (Manyanhaire and Kamuzungu 2009). Harare and Bulawayo have been facing chronic water shortages and households have been forced to collect water from unsafe sources (Manzungu and Chioreso 2012).

The purpose of this chapter is to enhance understanding on the extent of household water security challenges in Botswana in general and Ngamiland in particular by (a) analysing water supply and quality challenges being encountered by households in different settlement categories and (b) offering policy directions and focus for future research with regard to water security in semi-arid countries such as Botswana.

Conceptual Framework

The chapter is underpinned by the concept of security (Baldwin 1997; Buzan 1983, 1991; Buzan et al. 1998; Soroos 1994) in general and water security and human security in particular (Alkire 2003). Security refers to freedom or protection from serious risks and threats (Buzan 1983; Soroos 1994). Achieving water security by ensuring access to clean and safe water is a priority for all developing countries including those in Africa (World Bank 2010). Water security reflects a country's ability to guarantee to its citizens access to safe water for both domestic and productive purposes in the face of water vulnerability (World Bank 2010).

When households experience water insecurity, this becomes a pervasive threat to human security as it threatens the core of human lives since water is essential to the extent that it has no substitute to human survival (UNDP 2006). A state of water insecurity becomes an existential threat (Buzan et al. 1998) to households and their members and this has to be prevented by ensuring that households have access to adequate water of good quality for both domestic and productive purposes. Human security is thus a process of safeguarding the vital core of all human lives from critical pervasive threats, in a way that is consistent with long-term human fulfilment (Alkire 2003). The human security concept has two main aspects, that is, firstly safety from chronic threats such as hunger, disease and repression, while the second aspect refers to protection from sudden and hurtful disruption in the pattern of daily lives in homes, jobs and communities (Paris 2001; UNDP 1994). Human security is people centred as it is concerned about how people live in a society and how they access critical resources such as water of adequate quantity and quality for use at the household level (Buzan et al. 1998).

Water security has multiple definitions depending on the definition of need (human and/or environmental). This chapter focuses on the provision of water for basic human needs while conscious of the fact that other water uses for agriculture, industry, livelihoods, ecosystem services and the environment are important and closely interlinked. Water security can be defined as access to enough safe water at an affordable cost to lead a clean, healthy and productive life while ensuring that the natural environment is protected and enhanced (GWP 2000b). Household water security refers to 'accessibility, reliability and timely availability of adequate safe water to households to satisfy basic human needs' such as drinking, cooking, sanitation and bathing (Ariyabandu 2001: 8). The household concept denotes an institution of two or more people (not necessarily permanent) whose primary feature is co-residence, eating and pooling resources together as well as involvement in the provision of essential resources required for a living (Beall and Kanji 1999; UN 1976). A settlement is a community of households occupying a particular geographical space (Lamprey and Reid 2004).

Water security is aimed at addressing threats and risks associated with lack or shortage of water for domestic purposes (e.g. drinking, cooking, bathing and general cleaning), food production or food security and energy production (Cook and Bakker 2012; Grey 2012; Vanwey 2003). Risks and threats to water security include unreliable or lack of water supply, surface water contamination, submerging of water supply sources by floods, saline or contaminated groundwater resources and degraded ecosystems (Grey 2012). The term 'security' implies that there is a threshold below which households and individuals become water insecure (Cook and Bakker 2012). As a result, individuals and households should not live below a certain threshold for water.

Important dimensions of water security which also have implications on human security include quantity, quality, reliable access, improved water sources, availability and affordability (Ariyabandu 2001). Water sources for domestic water can be affected by factors such as rainfall, floods and decreased flow (Kujinga et al. 2014). Water supplied to households in a particular settlement is usually abstracted in bulk from particular sources before being distributed. The sustainable management of water supply sources is critical since this is where water supply institutions abstract bulk water for households. Proper governance structures such as policies, laws and institutions are required for the management of water sources. Financial resources are required for investment in infrastructure as well as in operation and maintenance. Human resources are required in different sections of organizations responsible for the supply of water.

Reliable water supply entails having functioning facilities providing safe water within a reasonable distance from the home, within safe physical reach, being affordable and accessible without exclusion on grounds of race, tribe, religion, disability and gender (UN, 2003). An individual needs to have access to at least 20 litres of water per day to meet minimum requirements (WHO 1997; WHO/UNICEF 2000a). This has to be from a source within 1 km of the user's dwelling (WHO/UNICEF 2000a).

The quality of water should be such that no significant health risk arises from its use and it should be acceptable to users in appearance, taste and odour (WHO/UNICEF 2000a). Contaminant levels should not exceed the accepted water quality standards of the region or the country where it is consumed. Water for household use should be free from microbiological contaminants (i.e. pathogenic bacteria, viruses and parasites) and inorganic contaminants such as arsenic, fluoride and nitrate (WHO 2011).

A minimum capacity of infrastructure and institutions, backed by robust policies and legislative frameworks is needed to ensure basic national water security as well as human security (World Bank 2010). Water governance affects the quantity and quality of water supplied to households as well as the sources through which the households access water (Tortajada 2010). Effective water governance ensures water availability, accessibility and affordability, allocation, distribution and operation and maintenance of the water supply system.

Materials and Methods

Study Area

The study was undertaken in Botswana's North West District, (also known as Ngamiland) (Fig. 9.1) which has a population of 158,104 (Central Statistical Office 2011). The North West District Council (NWDC) (subdivided into Ngami and Okavango Administrative Authorities) administers the district. The main administrative centre of the district is Maun Village which has a population of 60,263 (Central Statistical Office 2011).

Ngamiland receives low and variable rainfall averaging 425 mm per annum with a coefficient of variation of 35 per cent, which is characteristic of a semi-arid environment. The region's main surface water resources are found in the Okavango River, shared between Angola, Botswana and Namibia. On the Botswana side, the river forms a large in-land delta-like feature (actually an alluvial fan), the Okavango Delta, a world heritage site. Ngamiland experiences high temperatures, up to 40 °C, as well as frequent droughts and periodic/variable flooding (Mendelsohn et al. 2010; Wolski and Murray-Hudson 2008). The Delta loses 14,600 Mm^3 of water per annum as a result of evapo-transpiration against an inflow of 10,000 Mm^3/a and a rainfall of 5,000 Mm^3/a (HOORC 2007).

Two broad settlement categories, that is, gazetted and ungazetted, are found in Botswana (Government of Botswana (GoB) 1998). Gazetted settlements are formal settlements entitled to service provision, that is,

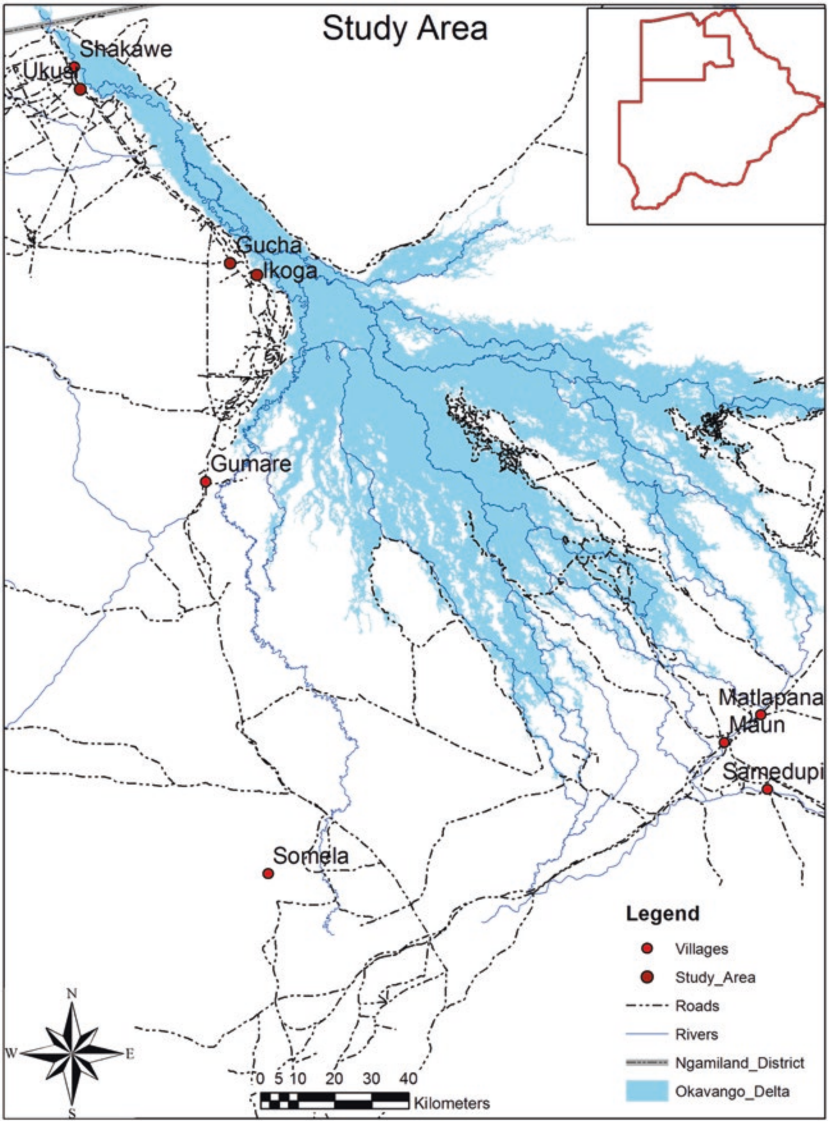

Fig. 9.1 Study sites

water supply, education, police, electricity and roads (GoB 2009). Three levels, that is, Primary (sub-divided into I, II and III), Secondary and Tertiary (sub-divided into I, II, III and IV) centres make up gazetted settlements (Government of Botswana 1998). Primary centre I settlements are cities whose population is at least 100,000. Primary centre II settlements have a population range of between 50,000 and 99,999 people, while Primary centre III settlements are large villages (e.g. Maun) whose population is between 20,000 and 49,999 (Government of Botswana 1998). Secondary centre settlements (e.g. Gumare) have a population range of 10,000–19,999 people (Government of Botswana 1998).

Tertiary centre settlements have different population ranges, that is, Tertiary centre I, 5,000–9,999; Tertiary centre II, 1,000–4,999; Tertiary centre III, 500–999; and Tertiary centre V, 250–499 (GoB 2009). All other Tertiary centre settlement categories are found in Ngamiland except Tertiary centre I (GoB 1998). Ungazetted settlements are informal and have populations of less than 250 people (GoB 1998). These settlements are not entitled to any social services provision.

Water Supply Services in Botswana

Three institutions used to be involved in water supply: the Water Utilities Corporation (WUC) supplied water to towns and cities, the Department of Water Affairs (DWA) supplied water to large villages and District Councils supplied Tertiary centres. Water reforms, which commenced in 2009, identified the WUC as the most appropriate institution to supply water to all settlements nationally. The WUC took over the provision of water to all settlements in Ngamiland on 1 April 2013.

Data Collection Methods

The study employed qualitative and quantitative data collection methods. Qualitative data collection methods included focus group discussions (FGDs) with ordinary community members, key informant (KI) interviews (i.e. ward councillors, traditional leaders, officials from the NWDC, DWA and WUC). Participant observation was done in all the sites, including Matlapana where one of the researchers lived for 3 years. This enabled close interaction with households experiencing water insecurity and enhanced a deeper understanding of the phenomenon. Participant observation helped the researcher to be engaged in informal discussions related to water security issues with people from different households. Information collected through qualitative methods include household water sources, water supply services and quality challenges encountered by households. Qualitative data was collected between February 2012 and March 2014.

A structured household questionnaire was used to collect quantitative data which include general household characteristics, types of water sources, distance to the sources, quality and water supply challenges. The questionnaire was administered by trained enumerators between May and August 2012.

Water samples were collected from different water sources used by households for microbiology testing (Table 9.2). The samples were tested for three parameters, that is, faecal streptococci, faecal coliforms and total coliforms. According to Botswana Bureau of Standards (2009) water quality standards for drinking, water should not have any of these in 100 ml of water.

Sampling

The study was undertaken in eight purposively sampled settlements from gazetted and ungazetted villages for the following reasons: (a) Maun Village was sampled by virtue of being the only Primary centre settlement in Ngamiland and also experiencing water security challenges; (b) Matlapana was sampled as a Tertiary centre settlement whose households experienced water insecurity (one of the authors resided in this village for 3 years and this allowed for participant observation to be undertaken); (c) Somelo was sampled in order to understand water supply challenges in a gazetted settlement that does not have surface water resources nearby while its groundwater resources are saline; (d) Ikoga was sampled to understand water supply challenges in a village receiving its supply from a surface water treatment plant; (e) Ukusi settlement was sampled to analyse water security challenges in an ungazetted settlement which receives water supply services contrary to policy provisions; and (f) Gucha, Samedupi and Xobe, which are all ungazetted settlements, were sampled to understand and analyse household water security challenges in settlements which do not receive any water supply services.

The settlement and household were the units of analysis of the study. A 30 per cent sample size in the settlements was adopted (Table 9.1) using population lists obtained from the national census, district council and local village leadership. Households in each settlement were listed during the survey. Each household was assigned a number and a random number generator was used to select households which were interviewed. Trained enumerators administered the questionnaires to household members from the age of 15 with knowledge on household water issues. A total of 554 questionnaires were administered.

Key informants were purposively sampled while FGDs were attended by at least 16 people, that is, males and females of age 15 years or above from each settlement. Participants for FGDs were randomly sampled from different areas of each settlement. At least one FGD was held in each study settlement.

Water samples for water quality testing were collected from sources mainly used by households (Table 9.2). Public standpipes in Ikoga did not have water at the time of sampling. The water samples were mainly collected to give an indicative idea of the microbiological quality of the water.

Table 9.1 Sample sizes by settlement

Settlement	*Settlement category*	*Population size (2011)*	*Total number of households listed*	*Number of households sampled*
Maun	Primary centre III	4105[a]	933	295
Matlapana	Tertiary centre II	1449	329	99
Ikoga	Tertiary centre III	673	153	46
Somelo	Tertiary centre IV	600	41	41
Gucha	Ungazetted	88	20	20
Samedupi	Ungazetted	286	65	20
Ukusi	Ungazetted	261	60	19
Xobe	Ungazetted	260	60	20
Total		7722	1571	554

[a]Two wards in Maun (Boyei and Wenela) represented the village

Table 9.2 Number of water samples collected from different settlements

Number of samples collected→ Sampling areas↓	*Gucha*	*Ikoga*	*Maun*	*Matlapana*	*Samedupi*	*Somelo*	*Ukusi*	*Xobe*
Private standpipes	n/a	1	9	2	n/a	2	n/a	n/a
Public standpipes	n/a	0	n/a	2	n/a	2	1	n/a
Borehole	n/a	n/a	n/a	n/a	n/a	2	n/a	n/a
Untreated source	1	1	n/a	2	2	n/a	n/a	2

Data Analysis

Data collected through the structured household questionnaire were analysed using the Statistical Package for Social Sciences (SPSS) version 21. In the analysis, the independent variables were settlement category, household, income and main sources of water. The data were not normally distributed; as a result, non-parametric tests in general and Kreskas-Wallis one-way ANOVA in particular were used to determine differences between attributes of non-parametric variables. The Pearson's chi-square test was used to determine association between variables, which include income and settlement category, settlement category and type of water source and water shortages or lack of supply and the amount of water used for different activities by households. Data from FGDs, key informant interviews and participant observation were analysed using the thematic approach. Thus, data were categorized into broad themes of socio-economic background of households, type of water sources used in different settlement categories, household water supply challenges and water insecurity in Primary and Tertiary settlements, as well as ungazetted settlements.

Water samples from different sources and sites were analysed in the laboratory for three microbiology parameters, that is, faecal coliforms, faecal streptococci and total coliforms, and the results were compared against the requirements of drinking water specifications for Botswana (Botswana Bureau of Standards 2009).

Results and Analysis

Socio-economic Profiles of the Households

The average household size across all the settlements is 5.9 people. There is no significant difference on the average number of household members across the different settlement categories. There are slightly more female-headed households (53 per cent) than male-headed (47 per cent) households.

There is a statistical association between settlement category and monthly household income (Pearson's chi-square, degrees of freedom = 10, $p = 0.000$), significant at 5 per cent level. Households with relatively higher incomes, that is, above BWP1,000,[1] are from Maun, while households from Tertiary centres, that is, Ikoga, Matlapana and Somelo, are mainly in the BWP100–500 category with some in the relatively higher categories of BWP501–1000 and BWP1001–5,000 (Fig. 9.2). The majority of ungazetted settlement households (63 per cent) (i.e. Gucha, Samedupi, Ukusi and Xobe) are in the BWP100–500 monthly income category, while the remainder (24 per cent) is in the BWP100 and below category.

Sources of Water for Households

The Government of Botswana's policy over the years has been to ensure that all households in gazetted settlements have equitable access to safe water for domestic purposes from improved sources within a distance of 400 m (Department of Environmental Affairs 2008). This enabled the country to achieve 97 per cent coverage for the population. Data from the study show that 88 per cent of the households have improved domestic water supply sources (Fig. 9.3). Households access water from public standpipes (23.1 per cent), standpipes in yard (46.8 per cent), taps inside the house (10.8 per cent), neighbour's standpipes (7.2 per cent) and untreated sources (12 per cent). There is a statistical association between settlement category and type of main water sources used by households (Pearson's chi-square, degrees of freedom = 12, $p = 0.000$) significant at 5 per cent level. Households from the Primary centre (Maun) and Tertiary centres (Ikoga, Matlapana and Somelo) have improved water sources,

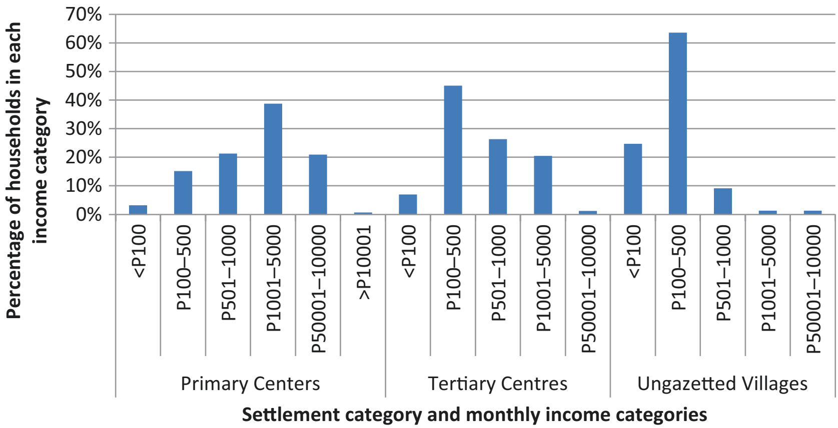

Fig. 9.2 Household monthly income ranges

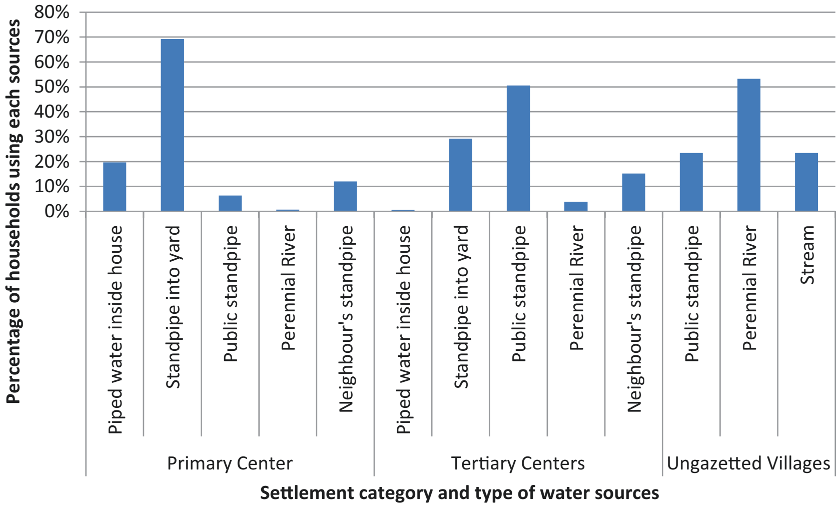

Fig. 9.3 Main water sources for households

while ungazetted settlements (Gucha, Samedupi and Xobe) access water from untreated sources such as rivers and/or streams. Ukusi, an ungazetted settlement, is an exception as the households receive water supply services which they access from public standpipes.

Household Water Supply Challenges

Despite the fact that the majority of households from gazetted settlements (i.e. Primary and Tertiary centres) in Ngamiland have improved water sources, they experience frequent water supply shortages which date back to 2000 and in some cases earlier. As a result, household members interviewed through the household survey and informal interviews highlighted that they are water insecure due to prolonged periods of time experienced without water supply services. Such a scenario is comparable to the situation in countries like Ethiopia, Kenya, Malawi and Zimbabwe (Manda 2009; Manyanhaire and Kamuzungu 2009; Manzungu and Chioreso 2012). Water security is viewed by households from different settlement categories as the continuous availability of water of good quality from improved water sources. On the other hand, water insecurity is seen as the lack of availability of water from improved water sources for a period ranging from one hour to days/weeks/months/years. In ungazetted settlements, water insecurity entailed absence of improved water sources, forcing households to fetch water from untreated sources.

Between 2005 and 2011, 60 per cent of gazetted settlement households across the different settlement categories faced serious episodes of water shortages. The situation got worse as 74 per cent of gazetted settlement households faced water supply problems from June 2011 to June 2012. Across the gazetted settlements, 32 per cent of the households did not have water supply during the time of the survey.

The study established that during times of water shortages or lack of supply, all households across the different settlement categories use an average of 11.6 L per person per day. This is opposed to an average of 69 L per person per day which households use when water supply is available. There is a statistical association between water shortages or lack of supply and the amount of water used for different activities by the households across the different settlement categories (Pearson's chi-square, degrees of freedom = 7, $p = 0.000$) significant at 5 per cent.

All (100 per cent) households across the gazetted settlements highlighted that when water is available and accessible from their main sources, they are usually not sure about how long it will be available. As a result, they always fill containers with water and keep them in their houses for use during times of shortages. The households do not have proper means of communicating with service providers about the unavailability of water from their main sources. This is sometimes done by either the ward councillors or the Village Development Committee members.

Water Insecurity in Different Settlement Categories

Water Supply to Primary Centre Settlement, Maun

Prior to 1 April 2013, Maun Village was supplied with water by the DWA which managed 30 boreholes located along the Shashe, Kunyere and Sexaxa floodplains. Out of the 30 boreholes, managed by the DWA, 14 were functional by the time the WUC took over water supply to the Village. These functional boreholes yielded 5760 m^3 of water per day (Kujinga et al. 2014). Sixteen of the boreholes either broke down or were submerged by floods which took place between 2008 and 2013. The DWA also managed a water treatment plant located in Maun which produced 700 m^3 of water per day instead of the designed 2000 m^3 per day mainly due to the size of the electric pump that was used.[2] The functional boreholes and the surface water treatment plant for Maun Village yielded at least 6460 m^3/day, and when overstretched, this could go up to 7830 m^3 against a daily demand of 8319 m^3/day. The situation was complicated by limited storage capacity since only 5365 m^3 of storage was available for the village. However, this was increased by 6000 m^3 at the beginning of 2014 following the completion of a water storage and treatment plant in Maun Village. Though storage increased from 5365 m^3 to 11,365 m^3, there was no increase in the yield. The increased storage is still below the desired 16,000 m^3 which would allow Maun to store water for at least 2 days supply. Ten months after the takeover of water supply to Maun Village by WUC, 90 per cent of households felt that nothing much had changed in terms of water supply.

Households in Maun Village (57 per cent) faced episodes of water supply problems between 2005 and May 2009. During this time, households would experience cut-offs in supply that would last for more than 24 hours. As from 2009, the frequency of water shortages started increasing to 3 days or more. Households (73 per cent) identified the period from June 2011 to 2012 as being the worst period in terms of water supply. In October 2011, the whole of Maun experienced acute water shortages resulting in most residential wards going for more than a month without water supply. Maun further experienced another acute water shortage which lasted from mid-April to the end of May 2012. Fifty-one per cent of the households experienced water supply shortages within the previous 24 hours of the survey. During the time of the survey, 63 per cent of households in Maun were not receiving water supply services from their main sources.

In March 2011, some of the residents of Maun Village staged a demonstration and handed a petition to the District Commissioner who was asked to forward it to the Minister of Minerals, Energy and Water Resources. The petition reminded the Minister that access to water is of paramount importance to the achievement of Goal 7 of the MDGs, especially the targets on water and sanitation and eradication of extreme poverty and hunger. It went further to highlight that the supply of adequate drinking water is enshrined in Botswana's Vision 2016. The residents reminded the Minister in the petition that they are being denied access to safe and clean water by the DWA. The petition stated:

> In contravention of these binding international and national commitments, the DWA in Maun has failed to reliably provide adequate domestic water to residents. For well over ten years now, we have been subjected to deteriorat-

> ing quality and constant interruptions in the supply of water… Therefore, we kindly seek and pray for the Honorable Minister's presence in Maun in order to appreciate the extent of the problem from the people's perspective. We believe this will provide further impetus for immediate resolution of this problem.

Different media outlets captured the water problem in Maun in different issues: *Maun water woes worsen* (Voice 2013); *Excuses, Excuses, But Maun Still Without Water* (www.ibotswana.co.bw, 15 May 2012); *Minister reveals plan to address water problems in Maun* (Writer 2011); and *Maun goes for days without water* (The Voice 2011).

Households from Maun identified what they considered to be factors behind the water shortages that they experience. Two of the major factors identified were (a) an increase in the amount of water each household uses (90 per cent of the households have private standpipes) and (b) changes in lifestyles. Households also identified management challenges on the part of the DWA as a result of the old water infrastructure (especially pipes) and the limited funding from the government for water supply services. However, according to key informants from the DWA and WUC, flooding was a major factor in Maun's water shortages since boreholes located along the floodplains were periodically submerged.

Besides poor water supply for Maun Village, the quality of water supplied is also a major water security issue. Water from private standpipes has some microbiological counts, something not allowed under Botswana water quality standards (Fig. 9.4) (Botswana Bureau of Standards 2009). However, the microbiology counts for the water are relatively low compared to those of other settlement categories.

However, 56 per cent of households from Maun regard the quality of the water from their main sources as being of good quality. Eighty-nine per cent of the households do not treat (e.g. boiling) drinking water from their main sources. Though chemical analysis of the water was not done, sometimes the water from the taps in Wenela and Boyei has a brownish colour.[3]

Water Security in Tertiary Settlements

Sixty-seven per cent of households in Tertiary settlements (including Ikoga, Somelo and Matlapana) experienced water supply shortages between 2005 and May 2011. Kruskal-Wallis 1-Way ANOVA test shows significant differences ($p = 0.000$, significant at 5 per cent level) between Matlapana and Ikoga and Matlapana and Somelo in terms of the extent of

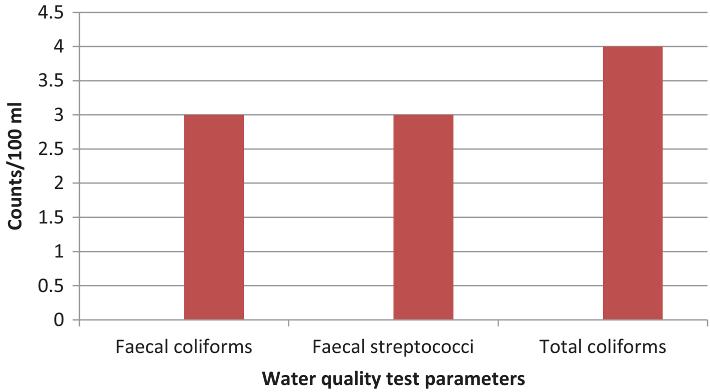

Fig. 9.4 Microbiological water quality for Maun

water supply challenges faced by households during the period 2005–2011. Water shortages in Tertiary settlements worsened as 94 per cent of households were not receiving reliable water supply from June 2011 to June 2012. At the time of the survey, 70 per cent of Tertiary centre households were not receiving any water supply services.

Ikoga, Somelo and Matlapana used to be supplied with water by the NWDC prior to the takeover by WUC. Matlapana village's water source is a borehole located along the Thamalakane river channel which was submerged by floods in 2009. By July 2014, Matlapana village households still experienced water shortages. This resulted in 86 per cent of the households accessing untreated water direct from Thamalakane River for household use. Household members at focus group discussions said that there is no motivation for installing private standpipes since they last had a reliable supply of water in 2009.

Somelo village was supplied with water from a borehole situated 40 km away on the channel of Komana River which was submerged by floods in 2009. Efforts to repair the borehole failed. There are no other surface water resources nearby in Somelo. Groundwater sources within the village are saline. The NWDC started hauling water to Somelo on a daily basis since 2009 using a tanker, a practice which the WUC continued to do. However, the hauled water is not sufficient for all the households. The hauled water is offloaded into the village's 20 m^3 storage tank. Household members throng public and private standpipes with containers from which they usually access water. In most cases, the water gets finished before all the households get an opportunity to fill their containers. Part of the water is accessed by the Somelo Primary School which needs the water to cook food for the children for mid-morning porridge and lunch. The health post in the village also requires water for use.

The boreholes for the supply of water to Matlapana and Somelo villages, located on the channels of Thamalakane and Komana Rivers, respectively, were installed between 1987 and 2005 when the river channels were not flowing. This enabled pumping of groundwater without encountering any major challenges. The two channels started flowing in 2005, and the floods, which occurred in 2009, submerged the boreholes which supplied water to both Matlapana and Somelo, thereby negatively affecting water supply services to the settlements. Households from Matlapana were forced to rely on untreated water from Thamalakane River, while those from Somelo had to use saline water as well as the water hauled by a tanker from Maun Village.

Ikoga is supplied with water from the Sepopa treatment plant located approximately 25 km away. The plant's location along the banks of the Okavango River makes it susceptible to flooding. Between 2009 and 2012, the Sepopa treatment plant was flooded every year. Households from Ikoga could go for up to three weeks without water mainly due to technical challenges at the Sepopa treatment plant. In February 2014, Ikoga village went for two weeks without water supply services.

The water transmission line from Sepopa treatment plant to Ikoga village passes through ungazetted villages such as Gucha which did not receive water supply services. Some of the villagers from ungazetted villages sometimes illegally open sluice valves of the transmission line using vice-grips and access the water. This results in loss of pressure for the water leading to households experiencing water supply problems. Such a problem can last for up to three days or more. The transmission line also experiences bursting in some sections caused by pressure surges. In a single month, there could be as many as six pipe burst cases which usually takes six hours to three days to fix.

Ikoga village has nine public standpipes and only four are functional. Prior to the takeover by WUC, 38 per cent of households accessed water from public standpipes, while 20 per cent did so from their neighbour's private standpipes who did not have water meters. The owners of such standpipes paid a monthly flat fee of BWP5.75 to the NWDC. In February

2014, the WUC installed water meters on all private standpipes in Ikoga, resulting in the owners refusing to allow their neighbours access to water from their standpipes fearing huge bills.

The majority of households from the Tertiary centres (98 per cent) said that WUC does not have the capacity to ensure reliable water availability to their areas. Households from all the Tertiary centres argued that surface water resources were plentiful in the Okavango Delta and the infrastructure was available, but their service provider has no capacity to ensure the availability of water for household use at all times.

Water Quality in Tertiary Settlements

Water from a number of improved sources in Tertiary settlements is not suitable for drinking as microbiological test results showed unacceptable levels of contamination of water from private standpipes (e.g. in Ikoga, Matlapana and Somelo), public standpipes (e.g. Somelo), borehole (in Somelo) and harvested rainwater (in Ikoga and Matlapana) (Fig. 9.5). Despite this being the case, 66 per cent of Tertiary settlement households said that water from their main water source was safe for drinking. As a result, no prior treatment is done to the water before consumption by household members.

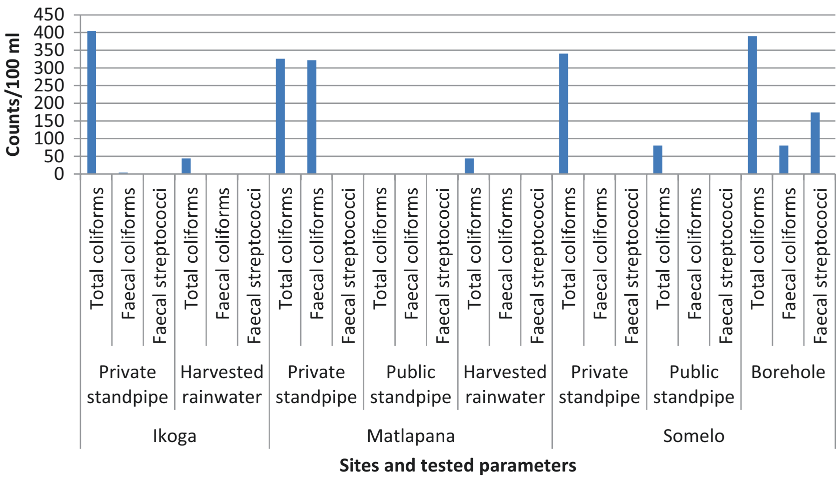

Fig. 9.5 Water quality in tertiary settlements

Water Security Challenges in Ungazetted Settlements

Ungazetted settlement households (100 per cent), that is, Gucha, Samedupi and Xobe, do not receive water supply services. As a result, the households mostly access untreated water (from perennial rivers and seasonal streams) which is of poor quality (Fig. 9.6). Households from Samedupi and Xobe access water directly from the Boteti River, while those from Gucha did so from the Kwenookore stream. Xobe and Samedupi are located 15 and 20 km from Maun, respectively, while Gucha is located along a water transmission line from Sepopa treatment plant. Households (100 per cent) from these settlements feel that it is feasible for them to receive water supply given their proximity to other areas receiving water supply and water transmission lines.

The households share their water sources with domestic and wild animals. The water makes some of them susceptible to contracting diarrhoea and to developing a skin rash after bathing. Some villagers from Xobe said: 'We fetch water from this point but our domestic animals also come to drink water from the same point. This is not safe at all as this water definitely has negative effects on our health. But we do not have a choice since this is the only freshwater source that we have which we can use' (interview: Xobe, 3 August 2012).

Though Botswana's policy provisions do not allow service provision to ungazetted settlements, the Okavango Sub-district Authority supplies water to 20 ungazetted settlements which are located along water transmission lines. Ukusi village is one of the ungazetted settlements which receive such a service. The political leadership in the area lobbied the sub-district authority to supply these settlements since they are already located along water transmission lines. With regards to Ukusi, two 5 m^3 tanks were installed in 2002 and 2003, respectively, by the NWDC. The WUC continued to supply water to settlements such as Ukusi. However, households from Ukusi said that on a monthly basis, they could go for at least 7 days without water due to problems encountered at the Mohembo West treatment plant, such as mechanical breakdowns and electrical power cuts. In March 2012, the village went for a month without water as a result of a breakdown at the treatment plant. The village had no water supply for the whole of February 2014.

However, not all ungazetted settlements located along water transmission lines are connected to water supply systems. Gucha settlement, located along the transmission line from Sepopa treatment plant, does not receive water supply services. The Sub-district Authority realized that more settlements such as Gucha were mushrooming anticipating water supply services. This forced the authority to stop connecting more ungazetted settlements to water supply systems. Households from Gucha fetch water from Kwenookore stream which is 4 km away for most of the households. Water from this stream was described by all the respondents (100 per cent) as being discoloured and with a bad taste. Kwenookore stream flows only during the rainy season. As a result, during the period that it will be flowing, the households access what they termed 'better' quality water because the flowing water carries away dirt. During winter when the stream stops flowing, only stagnant and dirty water in some portions of the stream become accessible to households. When the stream is completely dry, the households dig in the streambed for water.

Water Quality in Ungazetted Settlements

Water quality in ungazetted settlements is generally poor due to higher counts of microbes (Fig. 9.6). Seventy per cent of ungazetted settlement households are aware that they access water which is unsuitable for drinking. There is a statistical association between water sources used in ungazetted settlements and quality (Pearson's chi-square, degrees of freedom = 6, $p = 0.008$) significant at 5 per cent level.

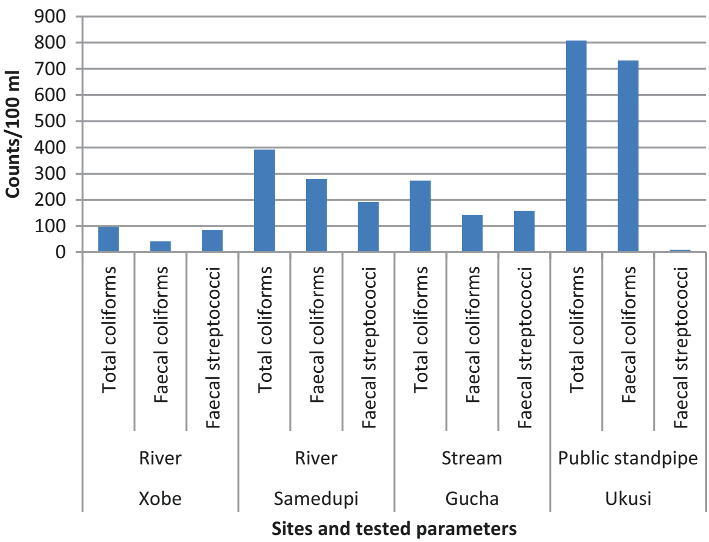

Fig. 9.6 Water quality results for ungazetted settlements

Though the households are aware of the quality of the water that they access for drinking purposes, 87 per cent of ungazetted households do not treat the water in any way to make it safe to drink. Water quality test results for Ukusi village are shocking given the fact that the village's water comes from a treatment plant.

Discussion

Developing countries are facing water security challenges as 1.1 billon people lack access to clean water (Hanjra and Qureshi 2010). Developed countries managed to achieve water security through policy changes, effective water governance, financial investments in water infrastructure, human capacity and technological solutions to water supply (UNDP 2006). Developing countries have not been able to come up with strategies that enhance water security in the same way that developed countries managed to do (UNDP 2006). As a result, Africa and South Asia continue to lag behind other regions in satisfying MDG 7, Target 9 and now Sustainable Development Goal 6 (Swatuk 2015; UN 2013b; see also https://sustainabledevelopment.un.org/sdg6).

Data presented in this chapter has shown that there is water insecurity, that is, inadequate access to enough safe water to lead a clean healthy and productive life, for the majority of households in Ngamiland. Water insecurity experience by households in Ngamiland negatively affects human security (Alkire 2003). Households in gazetted settlements which have improved water sources are not having access to enough water of good quality, while those from ungazetted villages are not receiving any water supply services forcing them to access untreated water. The situation in gazetted settlements shows that the presence of improved sources does not always guarantee access to water all the times. Thus, the presence of improved sources cannot be used as an effective measure for access to water. Water security which considers issues of accessibility, availability, quantity, quality, reliability and affordability could be a good measure for access to water (GWP 2000b). Households in Ngamiland are constantly at risk of water shortages and face the abiding threat of poor water quality. Results in this chapter on water security in Ngamiland buttress what other studies found in the same area (Kgomotso and Swatuk 2006; Kujinga et al. 2014; Mazvimavi and Mmopelwa 2006). Water security challenges in Ngamiland pose an existential threat to the life of individual household members (Buzan et al.

1998). Human life is under threat globally since 1.6 million people, mainly children, die each year as a result of waterborne diseases, while over 4 million are affected by waterborne diseases (UN 2013b). Cases of devastating impacts of waterborne diseases in Southern Africa include 4,000 deaths as a result of cholera in Zimbabwe between 2008 and 2009 (Mason 2009).

Water security challenges in areas such as Ngamiland result in households using less water per capita per day (i.e. 11.6 L) than what is acceptable. The same has been observed in countries such as Zimbabwe, Malawi, Nigeria and Kenya where water security challenges are experienced by households (Adeniji-Oloukoi et al. 2013; Manda 2009). This is in sharp contrast with countries such as the USA where an individual uses 101 L of water per day as opposed to 5 L in developing countries (UNDP 2006). Households facing water security challenges are unable to use the recommended 20 L of water per person per day (Gleick 1996; Manzungu and Chioreso 2012; WHO/UNICEF 2000b). Failure to provide water supply when infrastructure is present demonstrates management failure on the part of service providers. In the case of Botswana, WUC was supposed to engage in research which delves into the factors which resulted in the DWA and the NWDC failing to supply water to households in different settlement categories. Research can assist WUC to understand and deal with water supply challenges faced by DWA and NWDC to enable proper water governance and planning.

Botswana's policy of not providing water supply services to ungazetted settlements contributes to water insecurity and human security challenges to households in these settlements. This can be regarded as social exclusion (Atkinson 1988; Bowring 2000; Jordan 1996) which is underpinned by policy since a section of the population is denied water supply services, a public good that is essential for human survival (Kleiner 1999; Postel and Ritchter 2003). This demonstrates a policy shortcoming which is unable to recognize the existence of ungazetted settlements which play a critical role to Botswana's social, political and economic development (Kgomotso and Swatuk 2006). There is a need for the country to put in place a water policy that enhances social inclusion by recognizing all settlement categories as requiring priority in the provision of clean water. Such a policy has to make water accessible to all households as highlighted in the Vision 2016 (Presidential Task Force Group 1997). Such a move will greatly enhance human security in Botswana. Ungazetted settlements are critical for Botswana as livestock farming mainly takes place in these areas

(Republic of Botswana 2003). The country needs to put in place policies which discourage the mushrooming of more ungazetted settlements. This will allow the government to formalize ungazetted settlements that are currently in existence.

South Africa now recognizes the existence of informal settlements and has embarked on programmes which ensure service delivery in such settlements, including water supply and sanitation. The Municipality of the City of Cape Town set 2008 as the time by which all 220 informal settlements in its area would have access to clean water and sanitation services (Mels et al. 2010). Botswana can give due recognition to ungazetted settlements by recognizing their existence and the need for service delivery including water supply. Research can be undertaken to come up with viable options of supplying water to households in these settlements. The approach being adopted for Ukusi village can be replicated in other villages. The Federal Australian government faces similar challenges of supplying water to remote Aboriginal communities, but it managed to formulate the Remote Area Essential Services Program aimed at supplying domestic water to such settlements (Shepherd 2012). The programme allows the community members in remote communities to operate and maintain their own water supply systems (Shepherd 2012).

Household water security and human security challenges for gazetted and ungazetted settlements is further worsened by the poor quality of water which households in settlements such as Maun, Matlapana, Somelo, Xobe and Samedupi are accessing. Accessing water that is unsuitable for drinking puts individuals at health risk (Bigas 2012). Poor water quality can be blamed for the outbreak of diarrhoea in Ngamiland which claimed the lives of 18 babies in June 2012.

The major water security challenges in developing countries are related to availability, accessibility, quality and reliable supply (GWP 2000a). Cost is not a major issue since water is mainly provided as a social good (Budds and McGranahan 2003). Households accessing water from public standpipes in Botswana do not pay for the service, while those with private standpipes pay nominal charges. In South Africa, the first monthly block consumption of 6 m^3 is free for each household (Muller 2008). It has been argued that water in sub-Saharan African countries which cost an average of USD0.67/m^3 is underpriced as it is below the cost recovery threshold of over USD1.00/m^3 (World Bank 2010). This underpricing of water results in sub-Saharan Africa foregoing at least \$1.8 billion per year in potential revenue (World Bank 2010).

In order for developing countries to achieve household water security, there is need for relevant frameworks that include appropriate and effective water policies, governance and management structures which result in the sustainable provision of good quality water in appropriate quantities that is accessible, reliable and affordable through improved household water sources. Water policies for developing countries need to put water security and human security at the centre of the development agenda. This entails putting in place proper and appropriate water governance structures as well as laws and institutions that enhance water security. In such an endeavour, financial investments in appropriate infrastructure as well as human resources have to be another priority. Though Botswana managed to make investments in water infrastructure which resulted in all households in gazetted settlements having access to improved water sources, more still needs to be done since households still experience water insecurity despite having access to improved water sources (Kujinga et al. 2014; Swatuk and Kgomotso 2007). Improved sources in gazetted settlements have helped in reducing time taken to fetch water as well as the distance to water sources. However, the governance of water supply, especially ensuring that the improved infrastructure provides water on a reliable and sustainable basis, is not effective in developing countries (Cooley et al. 2013). Frameworks for household water security need to be informed by scientific research.

Conclusions

The majority of households in different settlement categories of Ngamiland experience water insecurity despite the fact that gazetted settlement households have access to improved water sources which do not provide water for domestic use regularly. Water security challenges in Ngamiland depict the situation of water insecurity at the global level in general and in developing countries in particular. The majority of developing countries including Botswana are unable to guarantee their citizens water security in the context of any vulnerability. Due to water supply problems and lack of water supply in ungazetted settlements, the majority of households are forced to access water from unprotected sources. Due to water insecurity being experienced by the majority of households in different settlement categories of Ngamiland, human security is being threatened.

Ineffective water governance for gazetted settlements and policy shortcomings related to service provision in ungazetted settlements are the major factors behind water security challenges in Ngamiland. The Government of Botswana has to improve water supply by ensuring that households in gazetted settlements access water from their improved water sources on a sustainable basis in order to enhance water security. There is need for policy changes in order for the state and other actors to provide water supply services to ungazetted settlements.

Scientific research could greatly contribute to water security and human security in developing countries. Further research is required on how the Government of Botswana can supply water on a sustainable basis to all settlement categories including those settlements that are categorized as ungazetted. Research has to focus on water governance, especially on ensuring sustainable provision of water to households in the context of vulnerabilities such as floods, limited water resources and increasing variability in the context of climate change.

Notes

1. USD1 = BWP 8.6, August 2013 when data was collected; USD1 = BWP 10.4, May 2017.
2. Personal communication with the DWA Water Supplies Manager.
3. This was picked up from informal interviews and observations by the researcher.

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CHAPTER 10

Evolution or Illusion? The Okavango Delta Management Planning Process Versus the Conventional Planning System in the Face of Climate Change and Variability in Botswana

Lapologang Magole and Phemo K. Kgomotso

Introduction

Land and water management in Botswana has evolved as have all other sociopolitical and development processes, through pre-colonial, colonial and post-colonial eras. As the evolution took place, the country's land resources ownership and use transformed from a traditionally managed communal system throughout the country to a mix of land uses and proliferation of land resources authorities. Figure 10.1 shows the location of Botswana and illustrates the different land uses that have come to exist through the land management evolution, each pretty much with its own

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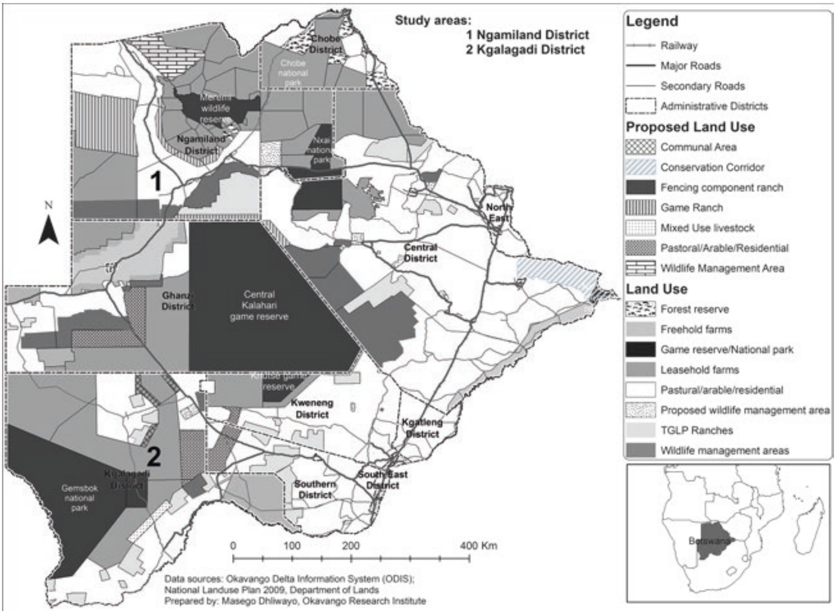

Fig. 10.1 Botswana location and land use map (Source: Okavango Research Institute)

institutional authority. It is argued and demonstrated in this chapter that the fragmentation of land uses and takeover of land management from community leaders have practically reduced the land available for community livelihoods and rendered them vulnerable to and unable to adapt and cope with global and climate variability and change conditions. In this map illustration, the white areas indicate land left for communal use. Judging by the white shading shown in the study sites (1 and 2), they are among the most affected districts by the systematic reduction of communal land.

Initial transformation took place during the colonial era. While the colonial administration used commands and directives to effect changes, the post-colonial government evoked land use planning models evolving through the classical, sustainability and integrated development concepts. The classical model of planning or policy development is an expert-based situation analysis and policy recommendation process. The sustainability model usually follows the same process; thus, it is expert (consultant) based, but considers the three traditional pillars of sustainability of social, economic and environmental objectives in policy development. To support this concept, appraisal tools such as cost-benefit analysis, environmental impact assessments and strategic environmental assessments were developed. Integrated natural resources management is a concept meant to enhance the chances of achieving sustainable development by integrating all knowledge (including indigenous knowledge) and all stakeholders including rural dwellers. The application of this concept is expected to improve policy processes and ensure that everyone's issues and interests are addressed and facilitate equity in access. The evolution of land resources management in Botswana has followed all these concepts, and each has had a distinct impact on rural communities' vulnerability and adaptability to climate variability and change.

This chapter traces these conceptual and practical changes in land use planning and presents their impact on two case study communities in Kgalagadi and Ngamiland Districts (see Fig. 10.1). It shows that regardless of the supremacy of the planning concepts adopted over time so far in Botswana, a sustainable development win-win situation has not been achieved due to unequal power relations of the land resources stakeholders. It appears that those who have the decision-making (e.g. government) and or financial power (e.g. international donors or wealthy individuals or private sector actors) are the 'winners' and those who possess neither (rural communities) can be considered the 'losers'.

This chapter traces the evolution of land resources management from the pre-colonial period but focuses more on post-colonial reform processes and their results. It presents the results of an analysis of Botswana's land resources management policy over a decade. The work involved policy and other materials perusal, key informant interviews with policy makers, top government workers, land resources management technical staff, community leaders and members in general, as well as researchers and experts working in the area of natural resources management in Botswana. Research also involved participation in land use activities such as pastoralism and in policy processes in order to enter and acquire knowledge of the life worlds of stakeholders. Complementary to the policy analysis work was stakeholder analysis to appreciate the variety of stakeholders and their interest in land resources.

While, earlier in the evolution, issues of degradation and conservation of land resources were important, the existence of multiple stakeholders and interests, access and distribution has added other variables to consider and so has climate risk (comprising climate variability and change). Being a semiarid region, the latter factor cannot be ignored in Botswana. Vulnerability and ability to adapt to changes brought about by changing and variable climatic conditions are key issues in rural development where communities are still highly dependent on natural resources. It is therefore important that any reforms or policy development process ensures that vulnerability of rural communities is curbed and their ability to cope and adapt is enhanced. It is within this context that the evolution of land resources management reforms in Botswana and their consequences were analyzed.

Initial Reforms: From Pre-colonial to Colonial Land Resources Management

Pre-colonial Land Management: Customary Land Tenure

In Botswana, all natural resources access and user rights are embedded within the land rights. Land tenure is therefore of paramount importance when it comes to equity and access issues of natural resources management.

Pre-colonial land use and management in many areas of Botswana was based on a multi-land-usage settlement system where each household had access to land at three different levels which defined the settlement pattern (Hardie 1985). A typical *Setswana* settlement was made up of the village or town (*motse*) in the center, the agricultural fields or 'lands' (*masimo*) on the immediate outskirts of the town and land further afield was left for livestock grazing or 'cattlepost' (*moraka*) and temporary structures used by those looking after the livestock. This structure was popular with agro-pastoral communities whereas strictly pastoral communities settled in dispersed homesteads surrounded by grazing areas. Hunter-gatherers settled in temporary home structures surrounded by their hunting and gathering grounds.

The organizational structure for land management and administration was similar to that of other sociocultural and political activities. It was headed by the *Kgosi* (village chief) and his advisors for agropastoralists and by elders for pastoralists and hunter-gatherers. The *Kgosi*'s advisors would not only consider and advise on political issues but also had a say on how the land was allocated and used. The *Kgosi*, headmen and elders administered land, thus ultimately controlling its distribution, use and access to resources therein. Headmen/land overseers were placed in charge of land use in wards. These were to ensure that land and other natural resources were used for what they were designated and by the people to whom it was allocated. Land overseers had the responsibility to report to the senior leaders including, and especially, the *Kgosi*, any land resource use issues and problems in their area. However, ownership of the land rested with the clan (Schapera 1943; Hitchcock 1985; Mathuba 1992; Kalabamu 2000) and thus it was held by the community as a common property resource (CPR). As Hitchcock (1985: 92) argues, '[I]t was sometimes said that the chief "owned" the land, but in actual fact the chief held that land in trust for the people of the tribe.' After studying *Setswana* land use custom and practice, Koma (1984) concluded that the *Kgosi* could not make major decisions on land use and allocation without first consulting the public or at least his advisors. The system demonstrated one of the strengths of common property regimes (CPRs), which is that they are participatory in nature (Berkes et al. 1989; Gibbs and Bromley 1989; Jacobs 1989).

Apart from the role of the *Kgosi* as the custodian of the land, another important feature of customary land tenure was the right of access to land enjoyed by all members of the community. All rights, individual or communal, were incorporated under the customary rights (Kalabamu 2000). Individual rights were enjoyed for residential and arable land uses. Land not allocated for these purposes was available to all members of the community for grazing, collecting veld products such as firewood, timber, thatching grass, food products and supplements, medicinal products and hunting. Water sources such as ponds, dams and pans could also be accessed by all. The system promoted equity in land resource use and access, as well as security of livelihood, other features for which common property regimes are hailed (Gibbs and Bromley 1989; Berkes and Farvar 1989).

Although all members of the community had access, the common property system was—as argued by Bromley (1992)—far from open. Land management did not only involve allocation. Usage was subject to various controls. Different land uses were kept strictly separated, such that people were not free to settle, grow crops or graze livestock wherever they wanted. Only under special circumstances, and where proper arrangements were in place, could people operate outside the allocated areas and set rules. Thus, land divisions established by the *Kgosi* or elders were binding and user member's rights and obligations were clearly defined.

While everyone had access to land and members of the community participated in decision-making processes governing the use of land in their locality, women and youth only had decision-making powers at the microlevel in the use of land holdings for residential and arable agricultural use, while the macrolevel land use decisions (zoning and siting) were the domain of senior males as represented by the *Kgosi* and his advisors who were rarely female or youth. This excluded key stakeholders as in rural communities women and youth play an important part in household production and subsistence. In the context of global and climate change, a land management and allocation system that discriminates against women and youth could increase the vulnerability of many households. It is partly for this reason that the search for a win-win situation is justified.

Colonial Land Tenure and Management

The changes introduced by the colonial powers at the end of the nineteenth century did not help to resolve the discriminations inherent in the traditional management system. Instead they introduced more polarization in land resource distribution and access. Together with the broader sociopolitical changes which took place during the colonial era, changes were introduced specifically to the tenure and land management systems. These changes laid a foundation and direction for the current land management policies in Botswana. Schapera (1943) notes that when Botswana became a protectorate, certain areas were set aside for 'Natives', others were alienated for Europeans and the remainder was appropriated by the Crown.

Unlike in the Union of South Africa (now the Republic of South Africa), South West Africa (Namibia) and Southern Rhodesia (Zimbabwe), the colonial administration did not claim ownership of the land that made up Native reserves. However, the status of the reserves in the protectorate was never formally defined. On the one hand, the official view was that land in the Native reserves belonged to the *Kgosi* and the people occupying these areas. This implied that along with the *Kgosi*, the people would retain control over land usages. On the other hand, Schapera (1943: 39) indicates that 'the administration, nevertheless, has restricted in various ways the use that the natives may make of their land, which means that their ownership of the reserves is not absolute'. It is important to note though that the colonial authority did not interfere with the traditional system of land administration. The use of the land and its resources was indeed controlled by the *Dikgosi* (chiefs), 'subject to the limitations imposed by the administration' (Schapera 1943: 40). Hence, just as was the case with political power, where the colonial administrations ruled through directives given to chiefs, the administration assumed powers over the use of land. *Dikgosi* were encouraged to make rules and restrictions on veld-burning, hunting of certain big game, cutting of trees, watering of livestock and cultivating crops at cattle posts (Magole 2003).

By the end of the colonial era, 47 per cent of all land in Botswana was held communally by 'Native' communities under the control of *Dikgosi*, 48 per cent was held as Crown land and the remaining 5 per cent was held privately by private companies and European individuals (Dickson 1990). The partitioning of land according to 'race' under colonialism set in motion a process of dispossessing the Batswana of land resources. It will be shown below that the post-colonial government inherited these discriminatory and unsustainable land resources management practices which have rendered rural communities increasingly vulnerable to climate change and variability.

Post-colonial Land Reforms in Botswana

At independence, Botswana retained the three main tenure systems set up by the colonial administration: communal (sometimes referred to as tribal or customary), state (formally Crown) and freehold land. However, the proportion of land held under the communal tenure system increased to 70 per cent of all land (because half of state land was reverted to communal land at independence). No new freehold land has been established since 1978 (Kalabamu 2000). Arguably, this was to avoid the accumulation of land in the hands of an elite, thereby creating a situation of deepening landlessness. As a result, freehold land currently stands at 7 per cent of all land in the country and the remaining 23 per cent is held by the state.

Furthermore, since independence the government has enacted new laws to guide land administration and management, which in some instances has exacerbated land access problems for rural communities and rendered them vulnerable to poverty and variable climatic conditions. According to Mathuba (1992, 1994, 1996), government land reforms were necessary to accomplish improved land administration, introduce other forms of tenure such as leasehold which could accommodate the demands of the cash economy, ensure easy access to land for all Batswana, reduce complaints that some chiefs were abusing their powers in land administration and decentralize controls over communal land by creating local institutions to administer land. Reviews and appraisals of the land reforms however show that the new system has failed to deliver on all of the above, especially ensuring easy access to land (see, e.g. Reilly 1983; Hitchcock 1985; Peters 1994; and Magole 2003).

The Tribal Land Act of 1968

The first of the land reforms was the enactment of the Tribal Land Act of 1968 to provide written law to guide allocation and management of tribal land. The Act provided for the establishment of 'modern independent institutions' (Mathuba 1992: 8) referred to as Land Boards to take over the role of the *Dikgosi* as custodians, administrators and distributors of land. While *Dikgosi* allocated land under customary law only, Section 23(1) of the Act provides for Land Boards to be able to allocate tribal land under common law. Initially common law provided leases for commercial and industrial purposes in rural areas; however, since the late 1970s, such leases have been extended to cover both arable land, as in the Pandamatenga area in the Chobe District (see Fig. 10.1) and grazing land through the Tribal Grazing Land Policy (TGLP).

This alteration of communal land management has been met with widespread criticism. First, it has been criticized for creating inefficiency in land management by centralizing the management of this fairly local resource (Reilly 1983). As stated above, one of the aims to be achieved by the land reform was to decentralize land management. This is, however, only true insofar as the level of operation (district level) of the Land Boards is concerned. Otherwise, the Boards are set up by and are accountable to central government and not the local authorities such as the Tribal Administrations or District Councils (Clayton 1995; Magole 2003). Moreover, the Minister directly or indirectly nominates 10 out of the 12 members of the District Land Board, appoints the chief executive who is the Land Board secretary and chief advisor and may, according to Section 6(3) of the Tribal Land Act, dismiss any member of the Board. This shows total control by central government and none by local government. It is this monopoly of power which has caused for other stakeholders' interest to be ignored in land policy decision-making. The situation is exacerbated in the area of reforms in the use and management of grazing land.

Grazing Land Reforms: The Case of Kgalagadi District

Tribal Grazing Land Policy of 1975

The Tribal Grazing Land Policy (TGLP) of 1975 was the first land reform to directly target communal rangeland use and management. The policy was developed using the classical policy development model where experts/consultants undertake a situation analysis to diagnose the problem and prescribe a solution. The diagnosis for which TGLP was prescribed was an alleged land degradation condition especially 'near large villages, on communal grazing, and on some freehold farms which have been mismanaged' (Chambers and Feldman 1973: 122). A consultancy report by Chambers and Feldman (1973: 124) warned that 'if nothing were done, overgrazing and deterioration of communal land would become even more serious'. The policy argued that fencing off parcels of communal grazing land for exclusive use by individual farmers would be the answer to the alleged land deterioration problem and that 'without fencing, the development of commercial ranching would be held back' (Chambers and Feldman 1973: 124). This marked a turning point at which semi-privatization of communal land and commercialization of agriculture was recommended as a rural development strategy in Botswana. It was argued that this strategy provides for good management of land, implying that such was not the case under communal land use and management.

Agriculture was at that time the most important contributor to the country's Gross Domestic Product (GDP) and the most important source of rural livelihoods. For this reason, the government put great effort into convincing the nation that everyone, rich or poor, stood to benefit from TGLP. However, the implementation of TGLP had negative impacts in many areas. For example, in the Kgalagadi District, local people—especially small stock owners and non-livestock holders—were displaced (Hitchcock 1985), localized environmental damage continued to occur and levels of agricultural production did not increase (Harvey and Lewis 1990). Through implementation of TGLP, land available for communal use was reduced significantly, causing communities to lose access to land for grazing and other uses such as gathering of veld products (Magole 2003). In the Lake Ngami area of Ngamiland, district pastoral communities have lost their livestock migration routes and hence the capacity to adapt to variations and long-term changes in climate (Magole 2009). Farmers argue that their livestock is unlikely to survive

Table 10.1 Amount of land available for communal use in Kgalagadi District 1960–2001

Year	*Land available for communal use (km^2)*	*% of total district land*	*Reasons for reduction of communal land*
1960	10, 6940	100	All land under communal use
1961	74, 350	70	Protected areas established: Central Kgalagadi and Khutse Game Reserves
1979	27, 538	26	Wildlife management areas and commercial ranches established (TGLP)
2001	26, 162	24	More commercial ranches and WMAs as the 1991 agricultural policy and the conservation policy were implemented

Source: Magole (2003)

a drought should a major one occur in their area as they would have nowhere to move the stock.

Table 10.1 shows that land available for the rural communities in Kgalagadi District has reduced from 100 per cent before 1960 to 24 per cent in 2001 due to the introduction of land use changes over the years. The area is part of the semiarid Kgalagadi Desert which receives less than 300 mm of rainfall most years. Pastoral and hunter-gatherer communities in the area had adapted to the environment by developing a migratory system which took advantage of the vastness of the area (Magole 2003). However, with the new land policies, the land has been fragmented (as shown in Fig. 10.1) and now less and less migration is possible. This has generally made the communities more vulnerable to climate variability and change. The case of Ngamiland, discussed below, shows a similar situation as land is fragmented mainly for conservation reasons.

The Second Evolution: Sustainability and Conservation Land Reforms: The Case of Ngamiland District

As stated earlier, Botswana has adopted the dominant conceptual frameworks in land resources management, including the sustainability concept. Frustration with the classical model which has tended to yield undesirable results such as in the case of Kgalagadi and other districts has caused a rethinking of natural resources management philosophy, resulting in the sustainability movement. Theoretically, the sustainability concept requires that any development process takes into account social, economic and environmental needs. In Botswana, the concept of sustainability was used to push a conservation agenda which alienated local communities, especially minority groups such as the San who tended to live in remote, wildlife-rich areas. The need to reserve land for wildlife conservation and tourism development took the position of a moral high ground of conservation that could not be challenged. However, in some parts of the country, it has paralyzed rural production and compromised rural livelihoods and adaptation strategies by severely reducing land available for communal use. It has not only contributed to the reduction of communal grazing land and loss of access to land by the poor but has also been responsible for controversial evictions (Magole 2007). The evolution of land reforms regarding conservation and tourism development in Botswana is briefly described below.

The Establishment of Protected Areas

The Bechuanaland Protectorate Game Proclamation was passed in 1925. The law provided for the creation of national parks, game reserves and wildlife sanctuaries, where wildlife species and areas were to be protected. This proclamation led to the establishment of Gemsbok National Park (1948), Chobe Game Reserve (1961), Central Kgalagadi Game Reserve (1961) and Moremi Game Reserve (1965). Other national parks and game reserves were later established, including Nxai Pan National Park (1967), Makgadikgadi National Parks (1971) and later several private and community parks. The establishment of national parks and game reserves in Botswana has resulted in over 17 per cent of the country's surface land being designated as national parks and game reserves.

One issue of concern is that many national parks and game reserves in Botswana have been established in the hunting and gathering grounds of local people (Moganane and Walker 1995). As a result of the establishment of these parks and reserves, local groups have been pushed to live on the fringes of protected areas and are denied access and benefits from their former homelands and hunting areas. This has had the general effect of reducing their livelihood sources, pushing them into poverty and making them vulnerable to the effects of variable climatic conditions. Their adaptive capacity which was based on a strategy of juggling several sources of livelihoods has also been greatly altered. The communities of Khwai and

Gudigwa were removed from the Moremi Game Reserve area and in the process lost access and control of their hunting and gathering grounds (Bolaane 2004). Instead, the communities live with high poverty levels, depending on government aid on the outskirts of the reserve (Magole 2007).

The other concern in the establishment of protected areas is that local people were never involved in the decision-making or policy formation processes that resulted in the establishment of national parks and game reserves (Magole 2007). Mordi (1991: 89) put it elegantly when he stated that in Botswana, 'wildlife management laws were parachuted fully formed into society and literally imposed by government on local people'. In Ngamiland, the people of Khwai and Gudigwa whose case is stated above were relocated from Moremi Game Reserve to their respective sites without their consent (see Taylor 2000; Bolaane 2004; Mbaiwa 2005). In the Kgalagadi District, the people of Kaudwane and Xade were also relocated from the Central Kgalagadi Game Reserve without their consent (Magole 2007). The relocation of these *Basarwa* (San) group without their agreement caused international outrage and led to one of the major land court cases at the Botswana High Court which, unusually, was won by the San group (Magole 2007). Such 'top-down' strategies in land resource decision-making have caused land use conflicts between the wildlife and tourism management (government) and business (private) sectors on one side and communities living in wildlife areas on the other side. At the same time, they have increased these communities' vulnerability to climate variability and change and reduced their ability to adapt to these conditions.

The end result and main impact of the conservation and sustainability reforms in Ngamiland, and indeed the whole country, has been to severely reduce land available to be accessed and used by rural communities (see Table 10.2 below).

Table 10.2 shows that land available for communal use has declined from 100 per cent before independence to 41 per cent in 2008. While 41 per cent appears like a substantial amount of land, it should be noted that in some localized areas such as in the Lake Ngami area, the effect of indiscriminately annexing community land for other uses is more severe. Here the community claims that their pastoral migration route has been reduced from 40 kilometers to 10 kilometers from their homesteads. They claim that the land served as their wet season grazing area and also areas where they could move their livestock during droughts. Their ability to adapt to climate variability and change is thus partly constrained.

Table 10.2 Amount of land available for communal use in Ngamiland District in 1960–2008

Year	*Land available for communal use (km²)*	*% of total district land*	*Reasons for reduction of communal land*
1960	111, 650	100	All land under communal use
1981	102, 423	92	Protected areas established: Moremi, Chobe, Nxai-Pan, Makgadikgadi
1991	58, 508	52	Wildlife management areas and commercial ranches established (TGLP)
2001	58, 508	52	No Change from the 1991 status
2008	45, 870	41	More commercial ranches and wildlife management areas established (1991 agricultural development policy)

Source: Magole (2009)

The Third Evolution: Integrated Natural Resources Management

Flaws and problems with both the classical and sustainability policy models have evoked a further paradigm shift. While sustainability remains the goal, the process of achieving it has been reviewed and revised by adding the concept of integration. Of particular importance is integration of all stakeholders, their ideas, issues and interests. The question remains as to whether this ideal can be achieved. An attempt to integrate multiple stakeholders into the decision-making process has been made in Botswana through the production of the Okavango Delta Management Plan (ODMP). Due to the inherent hydro-ecological variability and resource use conflicts which exist in the Okavango Delta area, the government decided that the area is perfect for an integrated approach to coming up with a policy tool for management of the land and water resources. It was expected that this would bring poor communities on board to access resources and help improve their livelihoods. Another anticipated benefit of such an approach was that it would promote co-learning. This was because the government rationalized that after life-long residence in the area, communities have acquired both adaptive skills and knowledge about the system.

The Okavango Delta Management Plan

The ODMP is an integrated water and land resources management plan for the Okavango Delta Ramsar site. According to the plan proposal document, the ODMP aims 'to develop a comprehensive, integrated management plan for the conservation and sustainable use of the Okavango Delta and surrounding areas' using the ecosystem approach which includes advocating stakeholder involvement in the management of natural resources (Government of Botswana 2002: 12).

Firstly, in the background to the ODMP planning effort, Botswana listed the Delta as a Ramsar site—that is, a wetland of international importance—in 1997. Among other obligations, Botswana as a contracting party to the Ramsar Convention had to develop plans to promote 'wise use' (Swatuk 2003: 898) of the listed wetland system. Thus, the planning initiative was the fulfillment of Article 3.1 of the 1971 Ramsar Convention which states that 'The Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the List, and as far as possible the wise use of wetlands in their territory.'

The ODMP is also a challenge to the existing sectoral planning and resource managing system of Botswana. It is believed that most of the resource use conflicts in the Okavango Delta occur because government departments responsible for managing different components of the ecosystem neither communicate with each other nor with other stakeholders. Conflicting policies are also a problem due to lack of cooperation and coordination in the management of the Delta resources and natural resources in the country as a whole.

The ODMP process therefore followed the now popular integrated water resources management (IWRM) approach. IWRM comprises a potential solution to many natural resources management and use problems. The approach is hailed by many (Bellamy et al. 1999; Al Radif 1999; Dungumaro and Madulu 2003; Jonch-Clausen 2004; Van der Zaag 2005) as having the potential to bring about successful and sustainable water resources management by providing a platform for stakeholder dialogue, cooperation and negotiation for access to scarce resources. According to paragraph 20 of the Ramsar Convention on Wetlands' New Guidelines for management planning for Ramsar sites and other wetlands, 'the aim of Integrated River Basin Management or Integrated Water Resource Management is to bring together stakeholders at all levels, from politicians to local communities, and to consider water demands for different sectors within the basin' (see: http://www.ramsar.org/key_guide_mgt_new_e.htm).

Two things seem to make this approach very attractive: the promise of sustainability of the ecosystem and the goods and services that it provides as well as the potential for conflict resolution. It should be noted, however, that IWRM is not magic or a quick solution or a generic answer to all natural resource use and management issues (Lovell et al. 2002; Jonch-Clausen 2004). As Dungumaro and Madulu (2003) argue, how much success IWRM brings about to a particular water or natural resources management initiative depends on numerous factors. These include the nature and extent of the natural resources conflicts involved, interpretation of the approach and also the sociopolitical and cultural environment upon which the approach is applied (Bellamy et al. 1999; Swatuk 2005).

Basic planning requirements of financial and human resources are very important and were considered when the ODMP was created. Yet there is a tendency in planning to ignore the role played by political power and political will as well as institutional arrangements and their role to support or discourage IWRM. IWRM requires institutional arrangements which provide equal opportunity for all to negotiate their stake. By implication, IWRM is unlikely to happen if institutional arrangements remain empowering to some and disempowering to others. The question remains as to whether or not Botswana has an institutional framework for natural resources planning which provides an enabling environment for an IWRM approach such as that attempted by the ODMP.

Swatuk (2005) rightly points out that the prerequisites of IWRM are much tougher than those of the traditional or classical natural resources management system. Its most difficult prerequisite is that the last be put first (Chambers 1983), that is, that the voiceless rural communities be given a platform to speak and be listened to by resource managers who may not have the culture, attitude and will to speak. In particular, the IWRM approach promises to tackle the real water resources problems of power, equity and access (Van der Zaag 2005). Herein lies the problem, according to Swatuk (2005: 878), who argues that 'this is a profoundly political act which challenges the very basis of power in many societies'. Leveling the playground in this way is likely to be met with resistance by those who hold power. Within these limits, however, IWRM has supporters in Botswana and other Southern African countries (Swatuk 2005) as evidenced by such efforts as the ODMP.

IWRM in Botswana: The ODMP Planning Process

As a production strategy, the ODMP was initially divided into 12 components, each representing a prominent resource use sector, such as water, fish, land, plants and range, wild animals, livestock, tourism and so on. It is important to mention the existence of a less conventional planning component of 'stakeholder participation, research strategy and data management'. In most planning processes, these are considered cross-cutting issues and hence to be treated within and across each of the other sectors/ components. Too often, the end result is that these cross-cutting issues are starved of resources as dominant sector-specific issues (e.g. mining, agriculture) take precedence in terms of time and resource allocation. In the ODMP process, however, these together formed a substantive sector which was complete with a budget and allocated to an equally unconventional but appropriate planning partner, the University of Botswana's Harry Oppenheimer Okavango Research Centre (HOORC, now reorganized and renamed the Okavango Research Institute, ORI). Planning processes in Botswana also often miss out on the contribution of academics.

Sector participants were tasked with situation analysis within their sector. They had to answer questions such as: What is the state of the resource? Who is using the resource? Who is managing the resource? Who else has interest in the resource? Are there any conflicts in the use of the resource?

Integration sectors were organized into task forces with members from all the other professional areas. Thus, multidisciplinary teams were formed in accordance with the requirements of IWRM (Al Radif 1999). These allowed for a rare opportunity for the sectors to communicate their views and plans, learn from other sectors and to negotiate their stake in other sectors. For example, the tourism sector was able to negotiate its land and other resources requirements from the Land Board and Wildlife sectors.

Communities were also brought in through community leaders and resource use group's representatives as well as community focal persons who became members of task forces and acted as the intermediary between the ODMP planning team and the communities. Workshops were organized to provide a forum for the community representatives to contribute their perspective on the situation of the resources, their suggested solutions and to appraise solutions suggested by the technical planning team.

The strategy for managing and/or supervising the plan production also had elements which are unconventional to the country's planning system. The planning process was led and coordinated by the Department of Environmental Affairs (DEA) under the Ministry of Wildlife, Environment and Tourism. The coordinators of the DEA reported to a Steering Committee of Permanent Secretaries and Directors of involved departments. At the district level, the coordinators and the planning sectors reported to the Okavango Delta Wetland Management Committee of all district-level stakeholders and task forces of experts as described above. Last but not least, the coordinators and the sectors had to report every milestone achievement to the communities in the village *Kgotla* (the traditional meeting place and the seat of the *Kgosi*). Altogether this strategy gave the ODMP a significant stakeholder involvement profile, possibly unmatched elsewhere in Botswana.

Were All the ODMP Stakeholders Able to Negotiate Their Stake Successfully?

We attempted to answer the question stated in the subheading by use of the analysis matrix shown below. The matrix (Table 10.3) traces the interests declared during the planning process and using the results of interviews with stakeholders to find out whether the stakeholders according to their level, primary (living with and depending on the resource), secondary (controlling or managing the resource), and tertiary (benefiting directly or indirectly from the resource) have achieved their goals. Generally, we found that while secondary and tertiary stakeholders have had most of their interests met, the primary stakeholders, who are mainly local communities, have not been as successful. Most of their issues remain unresolved.

We explain this by analyzing the power relations that exist between the stakeholders. We argue that the secondary and tertiary stakeholders have both political and financial power and are hence able to push their agenda with much more success. Primary stakeholders should either have a broker (advocate or dedicated supporting agency) whose power matches that of the other stakeholders or the process facilitators should have an intense empowerment session with the primary stakeholders at the beginning of the planning process.

Table 10.3 Analysis matrix for the ODMP stakeholder interests and achievement

Primary stakeholders	**Interests**	**Issues raised during the ODMP consultations**	**How the issues were addressed through the ODMP or national policy post-ODMP**	**Current status (results)**
Fishers	Access to fishing for livelihoods *(small-scale commercial sector and household subsistence)*	Conflicts between different fishing sectors (mainly recreational vs. small-scale commercial) over fishing grounds Need to control the sizes of boats used by recreational fishing sector as they disturb spawning fish and bird's nests	Introduction of Fish Protection Regulations (May 2008) Introduction of fishing licenses and permits, and a closed fishing season Revival of the Okavango Fishing Association for different sectors to discuss issues of concern (stakeholder platform)	Issue of conflict over fishing grounds not addressed by policy, no fishing grounds zoning. Boat sizes only partially regulated (*Fisheries officers not able to enforce the regulation due to political influence)* Commercial fishermen still denied access to traditional fishing grounds
Subsistence farmers	Access to agricultural land for food production and pasture for livestock	Human-wildlife conflicts (elephants raiding crop fields and predators killing livestock both at the river front and in the dry-land grazing areas)	DWNP pepper project only implemented in some parts of the human/elephant conflict area (Mohembo-Gudigwa stretch) due to limited resources Government aid announced in late 2008 (just before 2009 elections) to, among others, fence farmers' fields for free (program never implemented)	Human-wildlife conflict remains high as very few farmers have adopted/know about the chili pepper strategy More farmers exiting arable agriculture and falling into poverty (e.g. abandoning of fields after elephant raids)

(*continued*)

Table 10.3 (continued)

Community-based organizations (CBOs)	Access to the tourism industry for local people	Citizen participation and benefits from tourism currently non-existent or insignificant Inequitable benefits from community-private sector partnerships	Community-Based Natural Resource Management (CBNRM) Policy introduced in late 2007 to promote community participation in tourism Decision by central government to direct 65 per cent of proceeds made by CBOs to a government-controlled environment fund	Policy not yet implemented CBOs still largely disempowered to negotiate for an equitable stake with the private sector players in the tourism industry as there is no protection from policy Threat of more loses from 65 per cent levy
Secondary stakeholders	**Interests**	**Issues raised during the ODMP consultations**	**How the issues were addressed through the ODMP or post-ODMP initiatives**	**Current status (results)**
Tourism business/tour operators	Access to the Delta resource for business (profit) and conservation	Conflicts in the fishing sector (lodge/camp owners complain about small-scale commercial fishermen fishing too close to their properties and overfishing)	Introduction of fishing licenses prohibiting small-scale fishermen to access traditional fishing grounds without permission	The tourism sector has managed to influence policy changes within the fishing sector that maintains their access to the resource Introduction of fishing licenses Introduction of fishing closed season

(*continued*)

Table 10.3 (continued)

Policy-makers (politicians and top civil servants)	Regulation of the use of resources Personal access to resources	The need for better understanding of the Delta system and impacts of changes to better manage use of resources	Collaboration with the University of Botswana (UB) Sector policy instruments produced. For example, land use plan and tourism policy in place	Okavango Delta Information System (ODIS) set up at UB giving access to socio-economic, ecological and hydrological information Some policy instruments being implemented. More government control in the tourism industry
Government institutions	Resources management Promotion of tourism sector	Need to carry out institutional mandate Implement government policy and carry out directives	Institutional strengthening; Department of Environmental Affairs has set up office in Maun to coordinate the implementation of the ODMP and other environmental management instruments	Several regulatory instruments put in place. Fisheries regulation in place Tourism development key component in national and district development
Tertiary stakeholders	**Interests**	**Issues raised during the ODMP consultations**	**How the issues were addressed through the ODMP or national policy post-ODMP**	**Current status (results)**
Government institutions from upstream countries	Technical collaboration, co-management, benefit sharing	Need for cooperation and communication on management of the basin. Need to share benefits from use of the basin resources	ODMP products used in the development of the basin Transboundary Diagnostic Analysis (TDA)	Technical collaboration continues through specific programs/ projects though generally weak and could be improved

(*continued*)

Table 10.3 (continued)

International donor agencies (USAID, SIDA , DANIDA, DED)	To promote specific management approaches	Need for primary stakeholder participation and sustainable natural resources management and use	Donor-initiated interventions supported. For example, DANIDA sponsored ODMP summary booklet (Setswana and English) to improve communication and implementation	International approaches to use and management of the Delta resources through ongoing projects
Tourists	Access to recreational and aesthetic products of the Delta	Need to maintain the pristine and wilderness state of the Delta	Conservation: a key theme of the ODMP. Land use promotes tourism	Tourism (and conservation) remains the main focus of resource utilization in the Delta
International NGOs (Ramsar Bureau, IUCN)	Conservation ideology	The need to adopt the ecosystem approach and IWRM as planning and management approaches in the Okavango Delta	Ecosystem approach and Ramsar Planning Guidelines used as planning tools during the ODMP	Conservation (and tourism) continues to be the main focus of Okavango Delta resources management

Source: Adopted and adapted from Magole and Kgomotso (2009)

Conclusions

The benefits promised and expected from the evolution of land management in Botswana have been something of an illusion for rural communities in Kgalagadi and Ngamiland Districts. As shown in Tables 10.1 and 10.2, implementation of new land use and conservation policies fragmented the land and caused the communities to lose the vastness of their area as well as the adaptive capacity to climate variability. Communities also lost access to key livelihood resources and the power to make decisions about the use of their land resources. The newer ODMP process provided a rare platform for stakeholders, especially the primary- or community-level ones to raise their issues, air their views and give their opinions. However, as shown above, it was not empowering enough for all stakeholders to successfully negotiate their stake in the resource. Local communities (at least for now) remain on the margins of the resource access and utilization arena. Of particular concern is the fact that they remain vulnerable and unable to adapt to global and climate variability and change situations. While the solution lies mainly with local processes and frameworks, which should change to accommodate and protect the poor and vulnerable, it is recommended, in conclusion, that international partners who usually provide financial assistance should consider financing empowerment phases for the local communities or acting as brokers and improving their ability to negotiate their stake.

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CHAPTER 11

Evaluating an Agri-Environmental Network and Its Role in Collaborative Problem-Solving

Hugh Simpson, Rob de Loë, and David Rudolph

Introduction

Complex problems that cannot be resolved using a traditional problem-solving approach guided by expert science are becoming more common (Turner 2004). Complex environmental problems, many of these associated with contemporary water management, are particularly challenging because they are set within a broader societal context that includes financial, institutional, economic, political, social and technical considerations (Patrick et al. 2008). This has led to the recognition that an alternative

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approach is necessary for making decisions about water management, one that incorporates the knowledge and perspectives of different stakeholder groups (Functowicz and Ravetz 1993; Wynne 2002). In this chapter, the focus is on a particular alternative approach—collaborative approaches to environmental problem-solving—that brings diverse stakeholders together to integrate different forms of knowledge with community beliefs and values, and to engage in problem-solving using a consensus-based approach (Lemos and Agrawal 2006; Paavola 2007).

The contribution of stakeholder networks to collaborative approaches to problem-solving involving complex problems has received growing attention. Stakeholder networks can help encourage the development of relationships between and within groups (Blanco et al. 2011). Stakeholder networks are particularly useful for helping diverse interests to work together to share and integrate knowledge (Sørensen and Torfing 2009; Taylor et al. 2012) and for promoting communication and cooperation among stakeholders concerning issues across vertical and horizontal scales and administrative, physiographic and political boundaries (Paquet 2001; Peters and Pierre 2004; Reed and Bruyneel 2010).

Given their potential significance for collaborative approaches to problem-solving, it is important to better understand what stakeholder networks are, how they function and how they contribute to the creation and sharing of knowledge. In this chapter, a mixed-methods study is used to explore two related questions. First, what form of problem-solving process—traditional or collaborative—is used within a stakeholder network to reconstruct and reconcile new and existing ideas (Peters 1998; Torfing 2007; Bevir and Richards 2009)? Second, do such closed networks resist or facilitate the integration of new and existing ideas and information with the beliefs and values of network members as part of internal problem-solving processes (Peters 1998; Torfing 2007; Bevir and Richards 2009)? This case study examines these questions at the watershed and provincial scale by interpreting a network that is involved in a mandated collaborative problem-solving process in the Canadian province of Ontario. The case study focuses on the involvement of a network of farmers who were elected to represent their local farming communities. This network is situated within the broader context of agricultural and agri-environmental networks in Ontario. The chapter begins with a brief review of the related literature. This is followed by an overview of the methodology. The results of the research concerning these two questions are then presented. The chapter closes with a discussion that relates the research results to the literature presented, and provides insight into the theoretical and empirical literature.

Challenges and Opportunities

Complex Problems and Problem-Solving

There is growing consensus that an expert-driven approach is not adequate for dealing with complex problems concerning the environment and risk (Lach et al. 2005; Renn 2008). On its own, expert science is not suited to the growing and increasingly complex needs of the contemporary state (Functowicz and Ravetz 1993; Ravetz 1999). Complex problems are characterized by different forms of risk: complexity, uncertainty and ambiguity. They also have no clear end point or obvious solution, involve many state and non-state interests and have an unknown risk of adverse outcomes (Gough 1997; Ravetz 1999; Wynne 2002; Turner 2004; Lach et al. 2005; Dilling 2007). Indeed, complex problems have been characterized as 'quasi-scientific' because more than scientific knowledge is required to make competent decisions (Turner 2004: 253). They have proven to be a particular challenge because traditional risk analysis and expert science have difficulty rationalizing and incorporating local knowledge and societal beliefs and values—which tend to be qualitative and subjective in nature (Jasanoff 1998; Slovic 1998; Smith 2004). In large part, because of these challenges and despite associated limitations, expert science continues to be the primary basis for addressing complex questions (Turner 2004).

The disconnect between expert science and the complex problems that it is intended to help society resolve has been the subject of growing concern within both the scientific and broader communities. This concern has led to the development of a number of alternative scientific approaches, including 'Mode 2', 'Post-Normal' and 'Reflexive' science (Nowotny et al. 2003; Functowicz and Ravetz 1993; Ravetz 1999; Wynne 2002). These alternative approaches share a number of common requirements, including greater accountability; expanded involvement of citizens in research planning, practice and implementation; increased reflexive engagement on the purpose and use of knowledge; and incorporation of expert science and local knowledge through a formal and deliberate forum that involves the concerns of the broader community. An alternative problem-solving approach is needed that can incorporate these requirements in order to deliberate and find solutions to complex problems in a more efficacious manner.

Collaborative Approaches and Vernacular Knowledge

Environmental problem-solving approaches have been linked to good governance. Governance includes the mechanisms, processes and structures through which society makes or influences decisions and shares power (Lemos and Agrawal 2006; Innes and Booher 2010). Growing interest in governance is part of a shift from problem-solving primarily or solely by governments, where the state mandates change primarily through regulation, to one where stakeholders play key roles, and where other ways of making decisions are used alongside traditional approaches (Glasbergen 1998; Gunningham 2005; Jordan et al. 2005).

A collaborative approach to environmental problem-solving has been identified as well suited for addressing complex problems because it can involve stakeholders and incorporate their knowledge and concerns into the problem-solving process (de Loë and Kreutzwiser 2007; Lemos and Agrawal 2006; Paavola 2007). Collaborative approaches to environmental problem-solving bring diverse stakeholders together, often including government representatives, to make decisions collectively using a consensus-based approach where power and responsibility are shared (Innes and Booher 2010). Collective action is a critical part of collaborative problem-solving because no single interest, public or private, has all the knowledge required to solve complex problems (Stoker 1998; Lach et al. 2005; Blackstock and Richards 2007).

An important aspect of collaborative problem-solving is its potential to integrate expert science, local knowledge, community beliefs and values (Lee 1993; O'Riordan and Rayner 1993; Fischer 2000). Local knowledge in this context is defined as knowledge that has been gathered by the community through experience, rather than through scientific observation or measurement, over one or more generations (Folke 2004). This process of integration involves stakeholders in generating vernacular science or knowledge during their deliberations and negotiations of solutions to problems (Orr 1991; Lach et al. 2005; Bartel 2013). Vernacular knowledge can provide stakeholders with 'a much more accurate form of knowledge … that is more relevant to their problem than is scientific expertise' (Wagner 2007: 14–15). As a consequence, vernacular knowledge can empower participants involved in collaborative processes and enable them to move beyond the limitations of expert science by providing a mutually relevant foundation for deliberating complex environmental problems in several ways.

First, the process helps scientists, state representatives and stakeholders to engage in sharing and integrating scientific and local knowledge, discussing value-based issues and building relationships that promote trust, common rules, shared values, inclusion and empowerment (Carr 2004; Turner 2004; Cash et al. 2006; Van Wyk et al. 2007). This process helps participants adjust their perspectives and expectations so that they can make concessions that are necessary for efficacious problem-solving involving complex problems (Lach et al. 2005; Falkenmark 2007). Moreover, this will help promote more rigorous outcomes by incorporating local perspectives (Carr 2004; Cash et al. 2006; Van Wyk et al. 2007).

Second, the process helps overcome questions regarding what constitutes valid knowledge for supporting the development of solutions to environmental concerns (Rogers 1997). Determining what valid knowledge is has been a key challenge associated with the transition to collaborative problem-solving because multiple forms of knowledge have historically been excluded from the problem-solving process (Rogers 1997; Montpetit 2003; Innes and Booher 2010). The co-production of knowledge allows the concerns of competing stakeholder groups to be acknowledged, can help resolve or avoid conflict between state representatives and stakeholders, and helps move them toward negotiating shared outcomes (Innes and Booher 2010).

Third, the process helps to reduce the perceived distinction between expert science and local knowledge. Scientific experts often insist that expert science is the only valid knowledge, and have dismissed the knowledge of stakeholder groups as invalid (Montpetit 2003; Innes and Booher 2010). This distinction has been difficult to justify with the recognition that some stakeholder groups have participated in formal scientific training and have incorporated this knowledge into their practices (Raymond et al. 2010). For example, farmers may integrate local knowledge about their specific farm operation with that of agricultural and environmental science that they have received through formal academic training (Tsouvalis et al. 2000; Moore 2006; Ingram et al. 2010).

Collaborative Approaches and Stakeholder Networks

Human communities comprise an overlapping network of networks (Wellman 1979; Crossley 2010; Brummel et al. 2012). A network is formed by a group of interdependent persons who typically have a mutual understanding and shared vision concerning some activity or interest (Stoker 1998; Paquet 2001). A key feature of a network is that the members are connected or linked by relationships through which resources can flow (Brummel et al. 2012). These resources can be tangible, such as assisting a neighbor to build a structure, or intangible, such as the sharing of information on a topic of mutual interest. In this way, networks can help to 'harness the energy and creativity of those with the greatest stake in successful environmental management: the people who live in or depend on the affected ecosystems' (WRI 2004: 2).

Networks can help promote the collective action necessary for collaborative approaches to environmental problem-solving. In particular, they can support the creation and sharing of vernacular knowledge. First, networks can promote the development of relationships through 'bonding', involving relatively close relationships and shared values within well-integrated and cohesive networks (Blanco et al. 2011). The development of relationships is important because it encourages a sense of responsibility, connectedness, shared values and trust among and between stakeholder groups, and helps them to develop common rules, equity and mutual empowerment, all of which are critical for collaborative approaches (Carr 2004; Turner 2004; Mitchell and Breen 2007; Van Wyk et al. 2007). The benefits of building closer relationships were demonstrated when a diverse group of stakeholders worked collaboratively to develop an approach to support the re-introduction of a threatened bird species in an intensively farmed part of Texas (Yaffee and Wondolleck 2000).

Second, interaction between networks can encourage stakeholders from different backgrounds to create 'bridges' by building connections between diverse stakeholder groups (Blanco et al. 2011), and to work together to co-produce knowledge (Van Wyk et al. 2007; Sørensen and Torfing 2009; Reed et al. 2010; Taylor et al. 2012). This can help to mitigate power differentials that often exist between different stakeholder groups, encourage reasoned debate and negotiation and promote the discussion of value-based issues (Innes and Booher 2010; Paquet 2001; Schusler et al. 2003; Carr 2004; Reed and McIlveen 2006; Lach et al. 2005). The benefits of building bridges between diverse interests were demonstrated in the Rural Water Quality Program in Ontario, Canada, which was designed and implemented collaboratively by representatives of farm and government agencies (Simpson and de Loë 2014).

Third, networks can also promote communication and cooperation between stakeholders concerning issues that cross horizontal and vertical scales (Paquet 2001) through a process of multilevel governance (Eckerburg and Joas 2004; Peters and Pierre 2004). Multilevel governance promotes the movement of power vertically (downward) from senior levels of government to local agencies, and shifts authority horizontally (outward) from the state to stakeholder groups, across different scales and administrative, physiographic and political boundaries (Paquet 2001; Peters and Pierre 2004; Reed and Bruyneel 2010). For instance, agricultural networks have been successful in sharing knowledge about better farming practices within the farming community and raising awareness about farming within the non-farming communities (Lubell and Fulton 2007; Tsouvalis et al. 2000).

Despite the existence of a growing body of scholarship, the circumstances and factors that give rise to networks—and how they form, evolve and function—are not well understood from both a theoretical and an empirical perspective (Hay 1998; Torfing 2007). Stakeholder networks have been characterized (and often dismissed) in the literature as closed and static entities that have actively resisted the entry and influence of external ideas and societal pressure to change (Daugbjerg 1998; Sørensen and Torfing 2007). It has, moreover, been alleged that stakeholder networks have acted to shield activities from environmental regulation, and representatives of environmental regulatory agencies and non-governmental organizations have been excluded from decision-making processes (Skogstad 1990; Daugbjerg 1998; Montpetit 2003). The result is a form of problem-solving that only includes members of the stakeholder network (Monpetit and Coleman 1999). Conversely, networks have also been portrayed as porous to external influence, allowing new ideas to enter through contact with broader society and by the inclusion of new members (Bevir and Richards 2009). For example, agricultural networks have been recognized as horizontally and vertically integrated entities (Lubell and Fulton 2007) through which knowledge can flow. Although agricultural networks in Western democracies have traditionally focused on issues related to optimizing agricultural production, they have expanded their scope of interest (and influence) in the last 30–40 years to include environmental issues associated with farming (Daugbjerg 1998; Marsh 1998; Montpetit 2003). Further, agricultural networks are now known to be important vehicles for distributing knowledge to their members about agri-environmental best management practices for protecting water resources (Lubell and Fulton 2007), and for helping the farming community share knowledge about farming with the non-farmer community

(Tsouvalis et al. 2000). As a consequence, agricultural networks have evolved to provide farmers, researchers and government representatives involved in agri-environmental and other issues with an outlet for creating and sharing knowledge as part of problem-solving processes operating at local, provincial/state and national scales (Skogstad 1990; Lubell and Fulton 2007).

These different perspectives suggest that there continues to be a lack of understanding concerning stakeholder networks. In particular, two questions stand out concerning the development and function of the role of stakeholder networks. First, do stakeholder networks adopt a collaborative or more traditional approach for reconstructing and reconciling new and pre-existing ideas (Peters 1998; Torfing 2007; Bevir and Richards 2009)? For instance, is problem-solving within a stakeholder network bound by historical norms and practices, or have problem-solving practices evolved to become more collaborative and open? Second, do stakeholder networks participate in the creation and sharing of vernacular knowledge, and if so, how does this occur? For instance, how does the problem-solving process within a stakeholder network promote the integration of new and existing ideas and information with the beliefs and values of network members (Peters 1998; Torfing 2007; Bevir and Richards 2009)? These questions are particularly relevant for networks that operate with little societal involvement and oversight, and whose membership and activities remain largely the subject of speculation (Daugbjerg 1998; Montpetit 2003). It is anticipated that the answers to these questions will provide insight concerning the operation of stakeholder–state networks that attempt to operate in a more open manner, and their contribution to collaborative approaches to problem-solving.

A Conceptual Framework

Collaborative approaches are an important emerging way of supporting the co-production of vernacular knowledge as part of a multi-stakeholder problem-solving process for finding robust outcomes concerning complex environmental problems. Six key interrelated attributes gleaned from the theoretical and empirical literature can be used to determine whether or not a problem-solving process conforms to a collaborative approach. These six factors are summarized in Table 11.1. The rationale for emphasizing these characteristics is provided in the next section.

Table 11.1 Key attributes of collaborative approaches

Attribute	*Significance*
Stakeholder involvement	Process should involve stakeholders in framing the process, and developing and implementing solutions
Reciprocal communication	Process should promote the multi-way sharing of information and interests that reflect different perspectives
Stakeholder capacity	Process should encourage stakeholders to develop capacity for action
	Process should provide an opportunity for stakeholders to develop capacity for self-interest
Stakeholder expertise	Process should provide opportunities for stakeholders to build contributory expertise in order to share local or scientific knowledge more effectively
	Process should help stakeholders build interactional expertise in order to understand, share and translate information between different (contributory) knowledge communities
Accountability	Process should encourage stakeholders to consider and represent interests and concerns of network members
	Process should encourage stakeholder representative actions to reflect broader interests of stakeholder network
Legitimacy	Process should provide an adequate forum in which diverse interests are adequately represented
	Process should promote outcomes that will contribute to the common good, will be effective and can be implemented

Stakeholder Involvement

Stakeholder involvement is important for influencing the manner and extent to which environmental problem-solving is undertaken. Specifically, it has been suggested that the limitations of expert science can be addressed by involving state representatives with other stakeholders in guiding environmental problem-solving initiatives through a front-end, reflexive questioning of the process (Wynne 2002; Jasanoff 2003). This is different from the traditional linear model of expert science where the public becomes involved once the scope and context of problem-solving process has been defined by the state. Reed (2008: 2426–27) envisions 'institutionally embedded' stakeholder participation where state representatives and stakeholders networks work collaboratively to solve problems that they could not solve independently of each other. Such a level of involvement is an important part of building trust and promoting the co-production of knowledge, where stakeholders discuss and develop an understanding of each other's positions. This can also lead to outcomes that are less divisive, are more likely to be accepted and have a greater chance of being implemented (NRC 2000; Lemos et al. 2010).

Reciprocal Communication

Promoting reciprocal communication helps to change the movement of information from a one-way flow, where state technical experts educate stakeholder groups about water concerns, to a multi-way flow, where state representatives and stakeholders share information from their different perspectives (Bellamy et al. 1999; Lach et al. 2005). Reciprocity can also encourage the collaboration of scientists, state representatives and stakeholders to engage in sharing and integrating scientific and local knowledge, and discussing value-based issues (Carr 2004; Turner 2004; Cash et al. 2006; Van Wyk et al. 2007). This helps state representatives and stakeholders to better understand conflicting and shared perspectives and concerns that can arise as part of the problem-solving process. Reciprocity also helps to build vernacular knowledge, which is important for encouraging greater public involvement in problem-solving concerning complex problems which have a societal context (Lach et al. 2005: 12). This improves problem-solving by incorporating the local perspectives of stakeholder groups—promoting greater rigor through the co-production of knowledge (Carr 2004; Cash et al. 2006; Van Wyk et al. 2007), and by helping participants to adjust their perspectives and expectations so that they can make concessions that will benefit society and the environment (Falkenmark 2007).

Stakeholder Capacity

Stakeholder capacity is necessary for stakeholder groups to participate effectively in problem-solving (Carr 2004; Van Wyk et al. 2007). Ivey et al. (2006) state that there are two potentially opposed forms of capacity. The first is 'capacity for action' where individuals or groups work to meet externally imposed objectives. The second is 'capacity for self-determination' where individuals or groups seek to 'establish and achieve their own goals and agendas' (Ivey et al. 2006: 946). Collaborative approaches to environmental problem-solving accommodate both forms of capacity, although the latter could be perceived by state representatives and stakeholders as an impediment to achieving consensus among stakeholder groups. However, Mitchell (2005: 1340) states that 'the reality is that individuals and agencies do have their own goals and mandates, and it would be unwise to ignore them, or pretend they did not exist'. As a consequence, although stakeholders have their own agendas, they can share and discuss perspectives. This can help stakeholders to work together to achieve a balance between their own and external motivations, and provide a forum to make concessions necessary for the success of the project (Lach et al. 2005). It is possible, at the outset of the problem-solving process, that stakeholder groups will be more interested in the latter form of capacity than in the former. However, stakeholder groups can support the overall goals of the problem-solving process, even though they may not completely agree with the process as envisioned by stakeholder groups, or required by legislation.

Stakeholder Expertise

Stakeholder expertise is an emerging concept in the theoretical and experimental literature that concerns the ability of actors to participate effectively in collaborative problem-solving. Contributory expertise has been described as the ability of stakeholders to share knowledge from a single perspective, either local or scientific. Alternatively, interactional expertise helps a stakeholder to understand and share information between different perspectives (Carolan 2006). A stakeholder with contributory expertise has and can share abstract/general or local/practical knowledge concerning a particular topic. A stakeholder with interactional expertise can facilitate the exchange of knowledge between contributory experts, which can facilitate a sharing of perspectives by participants (Collins 2004). However, an individual who has interactional expertise in two different knowledge communities does not have to have contributory expertise. As a result, a stakeholder with interactional expertise can help different stakeholder group members to share and understand each other's perspectives, assisting them to work together to integrate different types of knowledge in order to achieve a balance between their own and external motivations as well as to make necessary concessions as part of the collaborative process.

Accountability

Accountability is important for ensuring that the problem-solving process reflects the concerns of stakeholders and the broader community (Murdoch and Abram 1998; Stoker 1998; Blackstock and Richards 2007). Bringing together individuals and groups—often with different backgrounds, interests and expectations—can lead to accountability concerns of two types.

The first involves individual stakeholder group members who may not accept the arrangements agreed to by their representatives in the network, but who may not express or act on their concerns because of their loyalty to the group or the network (Stoker 1998; Carr 2004; Turner 2004; Cash et al. 2006; Mitchell and Breen 2007; Van Wyk et al. 2007). The second concerns individuals or groups who represent the network, but whose concerns do not represent those of the network. As a consequence, the decisions of the network may reflect only the self-interest of the network representatives, and decisions may be made at the expense of the stakeholder community (Stoker 1998; Carr 2004; Turner 2004; Cash et al. 2006; Mitchell and Breen 2007; Van Wyk et al. 2007).

Legitimacy

Legitimacy is important for ensuring that the efforts of collaborative approaches to environmental problem-solving are effective over time by striving to represent the interests of all affected stakeholders (Stoker 1998; Blackstock and Richards 2007). A key related challenge is how legitimacy can be maintained in a process where it is impossible for all interests to be represented (Montpetit 2003). It has been proposed that if an outcome results in a common good, then a collaborative approach that does not include all possible interests may be legitimate, particularly where specialized technical knowledge is involved (Scharpf 1997; Montpetit 2003). Process legitimacy issues include those that are internal, such as providing an adequate forum for resolving stakeholder issues, and external, such as ensuring adequate representation of interests and concerns of groups with the issue(s) under discussion (Blackstock and Richards 2007; Fawcett and Daugbjerg 2012). Both outcome and process concerns will require a balance to be struck between inclusiveness and efficiency (Dreyer Hanson 2007; Provan and Kenis 2007).

The Emergence and Evolution of an Agri-Environmental Network: An Example from Ontario, Canada

Collaborative approaches to problem-solving concerning complex problems involving the environment, such as those common in many water management situations, require the involvement of key stakeholder groups (WRI 2004; Lemos and Agrawal 2006; Ansell and Gash 2007; Reed

2008). One example relates to concerns about the potential impacts of agricultural practices on water resources at global, regional and local scales (CCA 2013). Impacts on water resources from agricultural practices have come under growing scrutiny and criticism as more intensive methods and technologies have been used to increase production to meet the food requirements of a growing global population (Jarosz 2000; Wilson 2009). With the global population estimated to reach nine billion by 2030, it is anticipated that food production will need to increase globally by a minimum of 70 percent compared to current levels, resulting in an estimated increased water demand of at least 25 percent over current needs (FAO 2009; WEF 2009; Hoff 2011).

Agri-environmental networks will continue to have a significant role in collaborative problem-solving processes involving this and other environmental concerns related to agricultural activities (Montpetit 2003). An example from Ontario, Canada, provides an opportunity to probe questions concerning the evolution of an agri-environmental network that includes representatives of the provincial Ministry of Agriculture, agricultural commodity groups, and provincial farm organizations and other interested individuals and groups, and its participation in policy and program initiatives at local and provincial scales. The Ontario example is significant in two ways. First, it demonstrates how a stakeholder network that has existed in one form or another for more than a century can evolve to address complex problems that lie outside of its traditional focus. Second, it is an example of how an established network can modify its approach and participate in emerging multi-stakeholder problem-solving processes. This evaluation is useful from an empirical and theoretical perspective for two reasons. First, the network provides insight for understanding how an agri-environmental network may emerge and function in situations where the agricultural community and state are beginning to work together to address environmental challenges such as water management. Second, it is an example of how an established agricultural network can evolve to address concerns that have been outside of its traditional focus—in this case the integration of environmental issues into a production-oriented mandate—and participate in collaborative approaches for addressing them.

The Ontario example is assessed in two ways. First, the conceptual framework presented and discussed earlier is used to guide the evaluation of the agri-environmental network in two ways. The key attributes presented in Table 11.1 serve as a rubric for evaluating whether the behavior of the network is consistent with the characteristics of a collaborative problem-solving approach. This provides an opportunity to explore how non-state actors in general, and farm organization representatives in particular, can work with the state to create a stable stakeholder network, and how this network has evolved and contributed to external problem-solving processes. Second, the manner in which this network has participated in the integration of expert science, local knowledge, and community beliefs and values, is evaluated. This provides insight into how a stakeholder network can create and share vernacular knowledge within the network as part of its involvement and contribution to multi-stakeholder problem-solving processes.

Ontario's Farm Network

Several related initiatives have contributed to the emergence of an agricultural network in Ontario that is integrated at the local, county and provincial scales, and includes farmers and representatives from farm organizations, a state agency and other local and provincial organizations that share an interest in agriculture. Local farming communities in Ontario began organizing as early as the mid-1700s in order to improve farmers' conditions, share agricultural knowledge and generally advance the interests of the rural community (James 1914; Fowke 1942; Dodds 1980; Fuller 1985). An example of this was a network of agricultural societies that was established to coordinate local-, regional- and provincial-scale activities (James 1914; Fowke 1942; Dodds 1980; Fuller 1985). Such voluntary efforts were promoted more formally by the Province of Ontario, when the Department of Agriculture (now known as the Ontario Ministry of Agriculture and Food [OMAF]) began working with the farming community in 1907. These efforts have included building leadership in the farming community by helping to organize local farm organizations (e.g. 4H clubs), and helping the farming community to establish elected entities, including county farm federations, provincial commodity groups, and educational associations (Reaman 1970; Veeraraghavan 1985; Biesenthal 1991).

Local agricultural networks became formally connected at the provincial scale with the formation of the larger Ontario Federation of Agriculture (OFA) in 1936 (Reaman 1970: Dodds 1980; Zwerver 1986), and the smaller Christian Farmers Federation of Ontario (CFFO) in the 1960s (Veeraraghavan 1985; Reaman 1970). These provincial farm organizations have a direct membership structure, with individual farmers electing provincial and local representatives who are supported by member services and policy staff. The province encouraged these efforts and provided support by implementing legislation in 1993 that required farmers to register their farms and pay an annual fee to either farm organization (Struthers 2007). Farm leaders have also increased leadership and capacity by serving within a network of farm, commodity and local organizations (e.g. municipal government, service organizations), by participating on agriculture-related committees and by helping to negotiate solutions to agriculture-related issues with state representatives at local, regional and provincial scales (Martin 1972; Dodds 1980; Veeraraghavan 1985; Biesenthal 1991; Monpetit and Coleman 1999).

The agricultural network has also supported a research and educational system coordinated by farmers, farm organizations and OMAF representatives, and researchers (Reaman 1970; Martin 1972; Haslett 1985; Biesenthal 1991). One key objective of this system has been to encourage the development and uptake of progressive agricultural science and practices that are suitable for Ontario conditions (Reaman 1970; Haslett 1985; Veeraraghavan 1985; Monpetit and Coleman 1999). This objective has been implemented by incorporating expert science and local knowledge through two complementary initiatives. The first initiative involved actively encouraging farmers throughout Ontario to participate in cooperative scientific agricultural research coordinated through the University of Guelph (James 1914; Reaman 1970; Fuller 1985; Haslett 1985; Milburn et al. 2010). The second initiative involved the incorporation of this emerging agricultural scientific knowledge into farming practices across the province (Reaman 1970; Biesenthal 1991). These initiatives were implemented initially through OMAF on-farm extension science programs and later supported by farm educational organizations and conservation authorities (James 1914; Reaman 1970; Haslett 1985; Milburn et al. 2010). On-farm extension efforts were replaced in the mid-1980s with a more centralized technology-transfer approach (Milburn et al. 2010), which has been integrated with regular education events such as farm demonstrations, workshops and conferences throughout the province.

Emergence of the Ontario Agri-Environmental Network

Efforts to mitigate impacts on the environment from agriculture in Ontario have been influenced by two social movements. The first was a conservation movement that began in the late 1800s (James 1914; Reaman 1970; Biesenthal 1991; Paehlke 1997). One objective of the conservation movement was making farmers aware of the need to voluntarily adopt progressive agricultural approaches, such as the implementation of alternative nutrient and soil management practices (Croil 1861; Reaman 1970; Fuller 1985). This objective was promoted through agricultural extension efforts, where extension workers helped farmers to identify and implement alternative practices (Cressman 1981; Paehlke 1997; Forkey 2012).

Broader societal awareness of the environment resulted in the 1960s and 1970s, following the publication of domestic and international research which demonstrated that land use activities were impacting the environment (Richards 1987; Monpetit and Coleman 1999; AGCare 2007). For instance, the International Reference Group on Great Lakes Pollution from Land Use Activities (also known as PLUARG) studies of the Great Lakes concluded that society was having a negative impact on water quality in the Great Lakes with agricultural and urban land use activities identified as significant sources of water quality degradation (IJC 1978; Cressman 1981; OCSCSA 1983). Conservation efforts were then intensified through a series of state-sponsored cost-share programs in Canada and the United States that were delivered to Ontario by conservation authorities in collaboration with farm organizations, the OMAF, and the newly established Ontario Ministry of the Environment (OMOE) (Cressman 1981; AGCare 2007; CCA 2013).

Increased environmental awareness in the 1970s also led to a second movement that contributed to the formation of non-government organizations and efforts of newly formed state environment regulatory agencies that shared an interest in protecting the environment (Paehlke 1997; Daugbjerg 1998; Forkey 2012). Environmental non-government organizations (ENGOs) and state regulatory agencies focused their early efforts on advocating or developing regulatory programs for eliminating pollution sources associated with industrial activities in urban areas (Paehlke 1997; Forkey 2012).

The scope of the environmental community broadened in the late 1980s to include agricultural land use activities. This new interest in agriculture led to a commitment by the newly elected provincial government in Ontario to follow through on an election promise to introduce environmental legislation that farmers considered draconian (Grudens-Schuck 2000; Skogstad 2008). In response to these pressures, 37 farm and commodity organizations formed a provincial agri-environmental network in 1991 called the Ontario Farm Environmental Coalition (OFEC). The

OFEC was created to develop and implement a province-wide program for addressing environmental concerns associated with agricultural production practices (Verkley et al. 1998; FitzGibbon et al. 2004; Morrison and Fitzgibbon 2014). The OFEC also provided farm and commodity organizations with a single organization that could negotiate with the provincial government and other organizations with an interest in agri-environmental issues (Grudens-Schuck 2000; Skogstad 2008).

Given the strong reticence and resistance to formal environmental regulations among farmers, the OFEC advocated, and eventually implemented, a non-regulatory alternative for addressing agri-environmental concerns (Morrison and Fitzgibbon 2014). The OFEC brought forward this alternative, the Environmental Farm Plan (EFP), during an impasse between the OMAF and the OMOE concerning agri-environmental legislation at this time (Verkley et al. 1998). A fundamental part of the EFP was that each farmer should develop and implement an environmental plan for their farm operation to address agri-environmental concerns associated with air, natural habitat, soil and water resources (OFEC 1992; Verkley et al. 1998). The EFP format was negotiated by a working group composed of representatives from the agri-environmental network, the OMOE and the Ministry of Natural Resources (Verkley et al. 1998). The outcome of the negotiations was the EFP program, which has been delivered since 1993 using a two-day workshop wherein farmers complete risk assessment worksheets for their farm operation, and then prepare a risk management plan for addressing the identified risks. The content of each worksheet was developed using a consensus-based process to negotiate risk assessment benchmarks by a working group that included farmers, researchers and representatives from the OMAF, conservation authorities, regulatory agencies and other interested groups such as ENGOs (Robinson 2006).

Walkerton: A Trigger for Collaboration

In May 2000, seven persons died and several thousands became ill, when the municipal water supply was compromised and contaminated water was distributed to homes and businesses in Walkerton, Ontario (O'Connor 2002a). Justice O'Connor, who led an inquiry concerning the Walkerton tragedy, recommended that future outbreaks could be avoided by implementing a five-part multi-barrier approach for municipal drinking water systems. A key component was a decision-making approach incorporating public involvement, based on the principles of risk analysis and guided by the precautionary principle (O'Connor 2002b). The second through fifth barriers concerned the operation of a municipal water supply (O'Connor 2002b), and have been implemented through the *Safe Drinking Water Act, 2002* (Province of Ontario; O'Connor 2002a; OMOE 2012). The first barrier addressed concerns with the raw water quality for municipal water systems, and included the development of watershed-based source protection plans (SPPs). In 2007, the Province of Ontario implemented the *Clean Water Act, 2006* (CWA) (Province of Ontario 2006) and first phase of regulations, which had the objective of preparing local SPPs for municipal drinking water systems (OMOE 2007).

Farm organizations had initially expressed support for source water protection during the Walkerton inquiry, and had offered to work with the OMOE during both the development and implementation of the SPP process. The intent was to build on past efforts by the farming community to protect water resources in Ontario (Armitage 2001). However, the OMOE implemented a prescribed form of collaboration that disregarded 'historical practices and shared understandings, especially in rural areas with long agricultural traditions' (Ferreyra et al. 2008: 318). This retreat to the familiar, centralized regulatory command and control response has been a predictable reaction of government programs when presented with a high-profile crisis (Jordan et al. 2005; Innes and Booher 2010). This action was also consistent with the behavior of environmental agencies such as the OMOE, which have promoted a policy approach in which the environment should be protected from land use activities using a regulatory approach (Montpetit 2003). This regulatory approach is also part of a historical trend in Canadian society to restrict land use activities in rural areas in order to protect natural resources on the part of, and for the benefit of, the majority urban population (Forkey 2012).

The responsibility for developing SPPs was delegated under the authority of the CWA to 19 Source Protection Committees (SPCs). Each SPC was responsible for a Source Protection Area, which consisted of a single watershed, or a Source Protection Region, which consisted of two or more watersheds. The chair of each SPC was appointed by the Ontario minister of the environment, with one-third of the members divided among representatives of municipalities, industry and the broader local community such as 'environmental, health and other interests of the general public' (Province of Ontario 2007: 2). Members also included First Nations representatives where a band has reserve lands located within the SPA or SPR. Municipalities and First Nations bands were given the authority to select their members. The authority for selecting representatives of other sectors was given to Source Protection Authorities, which comprised the Boards of Directors of pre-existing watershed-based conservation authorities (OMOE 2007). Administrative and technical support was provided by local conservation authority staff.

Unable to participate directly in the design of the SPP process, farm organizations initiated an advocacy process to encourage the province to align the SPP process with agri-environmental legislation and stewardship programs that promoted economically and environmentally sustainable farming (Legislative Assembly of Ontario 2006; OFA 2006). Moreover, the OFA contacted provincial legislative members directly by letter to make them aware of the farming community's support for source water protection in general, and to outline its outstanding concerns with the proposed SPP process. One outcome of these efforts was the creation of the Ontario Drinking Water Stewardship Fund by the Ministry of the Environment, which would provide seven million dollars (Canadian) per year for four years to help farmers and rural residents implement activities such as beneficial or best management practices (BMPs) that would reduce threats to drinking water (OMOE 2006).

To coordinate agri-environmental network efforts during the SPP process, the OFEC established an SWP working group that included representatives from the four major farm organizations—namely, the OFA, CFFO, Agricultural Groups Concerned About Resources and the Environment (AGCare) and the Ontario Farm Animal Council (OFAC). Two OMAF program staff with technical expertise and knowledge in extension education and source water protection also participated at the invitation of the OFEC and with the approval of their Deputy Minister.

Another outcome of the OFEC advocacy process was the agreement by the OMOE that any SPC with significant agricultural activity should include a minimum number of local agricultural representatives. The OFEC SWP working group had recognized the importance of having farmers participate in the SPP problem-solving process directly, and the OFEC and the local county federations of agriculture organized local elections to select agricultural representatives from within the local farming communities to sit as SPC members. Although the process for electing agricultural representatives was initially challenged by the OMOE and Conservation Ontario, an organization representing the 36 watershed-based conservation authorities in Ontario, 34 of the 37 candidates selected by the local farming community were eventually appointed as members of local SPCs. This outcome, farmers believed, provided parity with the provision in CWA regulations that permitted municipalities and First Nations to select their SPC representatives.

The OFEC SWP working group determined that agricultural representatives would need the support of the farming community to help them participate as effectively as possible in the SPP problem-solving process. The OFEC applied for and received funding from farm organizations and federal and provincial agencies to deliver six workshops. All 37 agricultural representatives—both those appointed by the Source Protection Authorities and those elected by the farming community—were invited to attend these workshops. These workshops were designed to increase the communications and technical capacity of agricultural representatives. Presentations were delivered by academic, municipal and provincial government and private sector speakers on a variety of topics (OFEC 2007, 2008b, 2008d, 2010a, 2011a, 2012a). An opportunity was provided at all meetings for agricultural representatives and OMOE senior management to share concerns and dispel misunderstandings concerning the SPP process. The workshops were also augmented with frequent teleconferences and online discussions concerning local and provincial issues.

Methods

A mixed-methods research (MMR) approach was used to combine qualitative data collected using different research techniques. Although MMR has been associated most commonly with integrating qualitative and quantitative data, it also provides a structured approach for integrating qualitative data collected using different research methods with different philosophical contexts (Johnson and Onwuegbuzie 2004; Hesse-Biber 2010). This data collection approach was consistent with the concurrent triangulation approach to MMR where the emphasis was on confirming, cross-validating and corroborating findings using different methods within a single study (Cresswell 2003). The MMR approach provided flexibility, allowing qualitative data collected, using different techniques, to be assembled concurrently and then integrated during the data interpretation portion of the study.

The example presented in this chapter required a flexible methodology because the primary source of qualitative data was observations collected using an unobtrusive participant observation approach (Crossley 2010) over a four-year period. These observations were organized, classified and interpreted using the conceptual framework presented earlier in Table 11.1.

This approach was appropriate in this instance because collecting data concerning networks from an internal perspective, particularly a network that has been largely inaccessible, can be challenging with more structured techniques such as interviews and questionnaires (Hesse-Biber 2010). An open-ended participant observation approach was advantageous because it facilitated the observation of changes in the attitude of participants—such as a change in body language or tone of speech—as the discussion on different topics progressed, and to observe when and how a group did or did not manage to find mutually acceptable solutions to any disagreements that arose (Crossley 2010). Such subtle group dynamics might have been overlooked by a researcher who was not present and, thus, had relied on a survey or interviews to collect data. An open-ended approach was also useful for identifying and assessing the influence of what Crossley (2010: 20) describes as the 'mechanisms of relationship formation', which include the 'identities, expectations, rituals, shared feelings and meanings' of the community. The use of participant observation was approved by the Office of Research Ethics at the University of Waterloo.

Qualitative data were also collected through the evaluation of 312 publicly available documents, and included provincial regulations, policy and program publications, position papers issued by various interested organizations and articles from non-academic publications. The interpretation of these documents was guided using the conceptual framework presented in Table 11.1, with the goal of developing a better understanding of how 'particular understandings, imageries or systems of knowledge' informed and/or shaped the network and its function (Esmark and Triantafillou 2007: 101). It was recognized that documents reflected the perspectives of the organizations that generated them, rather than providing factual records of what has transpired at the time of their writing (Esmark and Triantafillou 2007). However, the purpose was not to actively 'deconstruct' information to determine and analyze the underlying perspectives, but rather to be aware that perspectives may have existed and to account for these perspectives during analysis (Babbie 2001).

Results

Stakeholder Involvement

Stakeholder involvement has been a core activity within the agricultural network, at both the local and provincial scales (Reaman 1970; Veeraraghavan 1985; Biesenthal 1991), and was incorporated into the

OFEC SWP workshop process in two ways. First, agricultural representatives themselves were nominated and elected by the local farming community, with the dual purpose of representing their interests during the SPC problem-solving process and keeping them informed about how the SPP process would affect them. The OFEC SWP workshop process drew the local farming community into the SPP process through the election of agricultural representatives, and raised awareness about possible implications of the SPP process for them and their farm operations. Second, the OFEC SWP workshop approach was endorsed by the farm leadership, a point that was reinforced by the president of the OFA when he addressed agricultural representatives at the first OFEC SWP workshop in December 2007 (OFEC 2007). This signaled that direct farm participation was important for ensuring that the interests of the farming community were incorporated into the SPP process, both locally and provincially, and that the OFEC would look after their interests by supporting the involvement of agricultural representatives on behalf of the farming community.

The agri-environmental network had also contributed to the ongoing creation and sharing of vernacular knowledge by promoting the integration of top-down and bottom-up efforts across the province. This is consistent with the role of stakeholder networks in communicating knowledge vertically and horizontally across different scales and boundaries (Paquet 2001; Peters and Pierre 2004; Reed and Bruyneel 2010). In this instance, farmer involvement within these efforts has been central, with technical expertise provided by university researchers, the OMAF, the OMOE, conservation authorities, and local and provincial farm and environmental organizations. For instance, the OFEC SWP workshops provided a forum in which agricultural representatives interacted with each other and technical experts, and learned how agricultural and environmental science were related to source water protection, in general, and the SPP process, in particular. The workshops also provided a forum for agricultural representatives to discuss agricultural and environmental science, relating and reconciling it with local knowledge and concerns, with support from technical experts from academia and government. In this way, agricultural and environmental science could be integrated with local knowledge, beliefs and values held by agricultural representatives and their local farming communities to create vernacular knowledge that could be shared with their SPC colleagues. Agricultural representatives also acted to connect the agri-environmental network with the SPP process, by encouraging their SPC colleagues to participate in a similar process where expert science, local knowledge, beliefs and values could be shared to co-produce vernacular knowledge. Building of trust and the co-production of knowledge through bonding between network members, and through the act of bridging between the network members and representatives of different stakeholder groups and networks, is an important part of collaborative problem-solving (Blanco et al. 2011).

Reciprocal Communication

Reciprocal communication has been a longstanding characteristic of relationships involving farm organizations and the OMAF within the agricultural network, as illustrated by the participation of both farm organizations and OMAF representatives during the development of policy and programs affecting the farming community (Skogstad 1990; Biesenthal 1991). It is not surprising, then, that reciprocal communication was incorporated into and promoted within the OFEC SWP workshop process. The workshops were designed to provide an opportunity for agricultural representatives to identify agenda items, and to make suggestions for modifying the workshop format, so that the learning process would better serve their needs. For instance, an exit survey was provided at each workshop for agricultural representatives and OFEC SWP working group members to rate the effectiveness of each topic on the workshop agenda, to identify additional topics that should be presented at the next workshop to meet their needs, and to suggest changes to the content and format of future workshops. Informal comments provided by agricultural representatives either during or after the workshops were also noted and discussed by the OFEC SWP working group members when evaluating the effectiveness and outcomes of each workshop as part of the planning process for subsequent workshops. As a result, the content and format of workshops changed to reflect the evolving needs of agricultural representatives as they and their SPCs progressed through the SPP process. In this way, collaboration was encouraged and the concerns and interests of participants were addressed (Carr 2004; Cash et al. 2006; Van Wyk et al. 2007).

Although OFEC SWP working group members facilitated the workshops, agricultural representatives were encouraged frequently by workshop facilitators to ask questions of technical speakers, and to discuss and relate expert science concepts presented during the discussions to their local knowledge, as well as individual and shared concerns. Time was built into the workshop between formal presentations to encourage bonding among agricultural representatives through informal discussions, relationship building and opportunities for reflection. Time was also scheduled at the end of each day of the workshop to revisit any topics that agricultural representatives wanted to discuss further. This was part of an overall objective of providing opportunities for agricultural representatives to share concerns as part of informal small group discussions, to encourage the sharing of information and opinions, to help each find solutions to their individual and shared concerns and to build a sense of community that would extend beyond the time spent together at the workshops. This sense of community was reinforced outside the workshops by encouraging agricultural representatives to take advantage of online and teleconference discussions, with or without the involvement of OFEC SWP working group members. The sharing and discussion of information and concerns can encourage members to make concepts and associated discussions relevant to their particular circumstances and needs (Yaffee and Wondolleck 2000; Carolan 2006), and promote the sharing and integration of expert science, local knowledge, and beliefs and values (Carr 2004; Cash et al. 2006; Van Wyk et al. 2007), which helps promote the co-production of vernacular knowledge.

Stakeholder Capacity

The building of leadership and technical capacity has been an ongoing activity within the Ontario agricultural network since the early 1900s (James 1914; Reaman 1970; Haslett 1985; Biesenthal 1991). The increased capacity enabled subsequent innovation, such as the establishment of the agri-environmental network and the development of the EFP process, which has helped build trust and promote the co-production of knowledge among farmers, farm organization representatives and OMAF technical specialists (Smithers and Furman 2003; Knierim 2007). As a consequence, the OFEC SWP working group recognized the need to enhance the leadership and technical capacity of agricultural representatives, which had been previously developed through involvement in local, provincial and federal initiatives. A training program was undertaken to help agricultural representatives increase their capacity to understand and discuss contentious and technical issues. Several key concepts that were deemed to be essential background information to prepare agricultural representatives to participate effectively in the SPP problem-solving process were emphasized. These included an overview of the history of agri-environmental actions in Ontario, the development of SWP principles from the perspective of the agricultural community, communications training on 'how to win friends and influence people', stakeholder mapping and the likely positions that other stakeholder groups would be bringing to the SPC problem-solving process, as well as technical aspects of the SPP process that could affect agricultural land use activities across Ontario (OFEC 2007). This information would help agricultural representatives to demonstrate that the farming community had been involved in agri-environmental initiatives for more than 30 years, help them to engage with and understand the concerns that other SPC members would have regarding the SPP process and give them the capacity to collaborate with other SPC members to develop vernacular knowledge through the problem-solving process (OFEC 2007, 2008b, 2008d, 2010a, 2011a, 2012a). As a result, agricultural representatives were prepared through the OFEC SWP workshops to develop the two types of capacity outlined by Ivey et al. (2006)—capacity for action and capacity for self-determination—enabling them to meet both the needs of the farming community and the SPP process.

Stakeholder Expertise

The development of stakeholder expertise within the farming community and agricultural network has focused historically on the development of contributory expertise, which is consistent with agricultural extension efforts in Ontario and elsewhere. There has also been an increasing need for interactional expertise with the emergence of the agri-environmental network and for the ability to engage and communicate with individuals and organizations that did not have a farming background. For instance, the importance of being able to share and integrate different types of knowledge was reinforced during the EFP process when representatives of organizations from the agricultural and environmental science communities came together to negotiate the contents of the EFP worksheets (Verkley et al. 1998). As a result, the OFEC SWP working group also concluded that it would be prudent to build contributory and interactional expertise among agricultural representatives in order to be able to participate as effectively as possible in the SPP problem-solving process. It was recognized that the level of contributory expertise varied among agricultural representatives, with some having had considerable experience with agri-environmental concerns such as climate change, nutrient management and water management, at either or both the provincial and federal level, whereas others had had fewer opportunities to develop contributory expertise.

Furthermore, many agricultural representatives had participated in formal post-secondary education studies that included both agricultural and environmental science, which had been supplemented with information and experience gained through formal and informal learning events. Technical presentations were provided during the OFEC SWP workshops to enhance the contributory knowledge of agricultural representatives. An example of this was a presentation by the Executive Director of AgCare, who provided a summary of the history of agri-environmental initiatives in Ontario (OFEC 2007). This was structured around different agri-environmental initiatives, such as the EFP program, which provided a provincial context for agri-environmental activities within which local initiatives and participation could be attributed. The development of contributory and interactional expertise has been recognized as a promising approach for facilitating the sharing of knowledge at different scales and from both an abstract and general perspective between researchers and stakeholders (Carolan 2006).

Some agricultural representatives also had previous opportunities to develop considerable interactional expertise through activities such as serving as elected officials in municipal government, volunteering on service organizations and representing the farming community on local and provincial initiatives. A common comment from agricultural representatives during informal discussion, both at and outside the workshops, was that they had been asked by urban and rural non-farm neighbors to provide explanations about agriculture, in general, and about their commodity, in particular. As a consequence, many agricultural representatives had some basic level of interactional expertise that they had developed by having to help share insight about agriculture with urban and non-farm neighbors who had little or no knowledge of the topic. Agricultural representatives who had participated in a formal capacity, such as serving as elected representatives on provincial and federal farm or commodity organizations, or as elected municipal or provincial government positions often had more advanced levels of interactional expertise.

This interactional expertise had been developed by communicating regularly with individuals and groups with little or no knowledge of farming, such as elected officials and staff members in municipal, provincial and federal government agencies. To help agricultural representatives enhance their interactional expertise, a number of technical presentations were provided by OFEC SWP working group members that introduced and explained SWP concepts and discussed how these concepts were related to agricultural science and practice (e.g., OFEC 2007). These presentations were also supported by plain-language technical publications that reinforced these concepts (e.g., Simpson et al. 2006a, b, c, d). Discussions at subsequent OFEC SWP workshops indicated that these presentations had provided agricultural representatives with a more comprehensive understanding of SWP concepts than their SPC colleagues, demonstrating the benefits of enhancing their interactional expertise, and prepared them to discuss and negotiate them effectively as part of the SPP problem-solving process. This is consistent with experience elsewhere where network members have become more confident in their ability to share their knowledge, and also serve as a bridge between the agricultural and environmental science communities, by increasing their contributory and interactional expertise (Carolan 2006).

Accountability

Accountability has been a strong theme in the agricultural network in Ontario, with an ongoing tradition of member-controlled farm organizations that have been overseen by an annually elected farm leadership (Reaman 1970; Veeraraghavan 1985; Struthers 2007). The process developed by the OFEC SWP working group promoted accountability in two ways. First, the agricultural representative was someone that the local community had known and had trusted to act in their interest, and they had chosen to represent their interests as part of the SPP process. Because agricultural representatives continued to be members of their farming community, accountability has been reinforced by the level of accessibility. This level of accessibility provided an opportunity for the agricultural representative to keep the local farming community informed about initiatives at the SPC table, and to seek ideas and support regarding how local concerns should be addressed. Conversely, this accessibility has provided an opportunity for the local farming community to share concerns and ideas with the agricultural representative regarding how their interests should be addressed as part of the SPP process.

Second, the OFEC SWP workshop process promoted accountability to the farming community because the actions of the OFEC have been overseen by the farm leadership, which was elected by, and represented the interests of, the farmers of Ontario at a provincial scale, and guided and supported by farm and commodity organization representatives. As a consequence, state and non-state organizations have been assured that the OFEC is accountable to and represents the concerns and interests of farmers and farm organizations across Ontario (Coleman and Skogstad 1990; Monpetit and Coleman 1999). This accountability has also empowered the OFEC with significant leverage during negotiations with state and non-state organizations, providing a unified voice for the farming community concerning agri-environmental matters (Veeraraghavan 1985; Verkley et al. 1998). Promoting accountability has helped ensure that broader community concerns and interests have been represented in the problem-solving process (Stoker 1998; Carr 2004; Turner 2004; Cash et al. 2006; Mitchell and Breen 2007; Van Wyk et al. 2007).

The OFEC SWP workshop process has also been accountable to, and reflects, agri-environmental knowledge at local and provincial scales through the involvement of representatives of farm and commodity organizations and the OMAF. The OFEC SWP working group brought together state and academic experts to present agricultural and environmental science within the workshops, and openly encouraged agricultural representatives to share and discuss their knowledge, beliefs and values. This enabled the local farming community to develop a vernacular knowledge that they then shared with their SPC colleagues. Agricultural representatives were also actively involved in the development of the OFEC SWP principles by debating and revising draft positions that were presented to them by members of the OFEC SWP working group (OFEC 2007). The SWP principles were developed to assist the different agri-environmental network members to provide a consistent position concerning the preferred outcome for the SPP problem-solving process. The SWP principles have also been used by agricultural representatives as part of their involvement with SPCs during the development of vernacular knowledge, and by OFEC SWP working group members when negotiating the desired approach and outcomes of the SPP process with state and non-state organizations. The process used to identify the broader interests of stakeholder network members is an important aspect of promoting accountability. Specifically, it is important to provide an opportunity for network members to raise their concerns and interests and have them incorporated into the problem-solving process where possible (Stoker 1998; Carr 2004; Turner 2004; Cash et al. 2006; Mitchell and Breen 2007; Van Wyk et al. 2007).

Legitimacy

Legitimacy, like accountability, has been a strong theme within the agri-environmental network, and both process and outcome legitimacy were incorporated into the OFEC SWP workshop process. Process legitimacy was incorporated by drawing on the tradition of stakeholder involvement in the farming community in two ways. First, once the agri-environmental network ensured the ability for the farming community to be represented on SPCs, the OFEC SWP working group implemented a process for the farming community to participate in the selection of agricultural representatives who would fill this role. This process included developing a list of qualifications and requirements for agricultural representatives, which were then circulated through local farm organizations and the farm press, and then a series of publicly advertised elections were organized by the OFEC in cooperation with the local County Federations of Agriculture. The use of an open and transparent approach has been identified as an important feature for enhancing the legitimacy of problem-solving processes (Montpetit 2003). In this case, all network members could not be directly involved with the SPP problem-solving process; therefore, the use of a democratic process to select agricultural representatives was valid. Second, the OFEC implemented a program to enhance the capacity and expertise of the agricultural representatives to help them participate as effectively as possible in the SPP problem-solving process. This helped ensure that the interests of the local farming community, and broader objectives of the agri-environmental network, were acknowledged and incorporated into the local SPP process. This is an example of how a stakeholder network contributed to a broader problem-solving forum by helping to identify and discuss stakeholder issues, and helping to ensure that the concerns and interests of the community were represented and incorporated into problem-solving processes (Blackstock and Richards 2007; Fawcett and Daugbjerg 2012).

Enhancing the capacity and expertise of agricultural representatives also contributed to outcome legitimacy by promoting the development of SPP policies that complemented existing farming approaches in the province, and built on existing agri-environmental policy and programs. Specifically, outcome legitimacy was promoted in three ways. First, the OFEC SWP working group provided ongoing technical support for agricultural representatives by participating in teleconference and internet discussion groups concerning general and specific concerns that were raised by agricultural representatives. This support outside the OFEC workshops helped agricultural representatives to relate their local concerns to the OFEC SWP principles, helping them to present a consistent message within and between SPCs. Second, members of the OFEC SWP working group provided presentations to many of the SPCs concerning the OFEC SWP principles that had been developed during the OFEC SWP workshops and were endorsed by the farm leadership. These technical presentations helped reinforce the OFEC SWP principles and assisted agricultural representatives to explain them to their SPC colleagues. Third, the OMAF issued technical guidance that explained how existing agri-environmental regulatory standards and voluntary BMPs supported the objectives of the SPP process (OMAF 2012). This bulletin helped provide legitimacy for complementary farming community policies, such as the OFEC SWP principles, which were built on a common foundation of agri-environmental science. As a consequence, the agri-environmental network contributed to outcome legitimacy by helping to incorporate vernacular knowledge that was based on agri-environmental science, practice and programs, in a consistent manner, into the problem-solving process, making it more efficient and technically sound from the farming community perspective. This helped increase the efficiency of the overall process, helped ensure that decisions provided for the common good and ensured that the outcomes were effective and could be implemented (Montpetit 2003; Dreyer Hanson 2007; Provan and Kenis 2007; Fawcett and Daugbjerg 2012).

Discussion and Conclusions

Stakeholder networks have been recognized as necessary participants for developing and implementing outcomes for complex problems, such as those involving the environment (Yaffee and Wondolleck 2000). This recognition has been due, in part, to a growing awareness that networks, and the members whose interests they represent, are entities that can support and contribute to collaborative problem-solving processes (Eckerburg and Joas 2004; Blanco et al. 2011). This is in contrast with earlier characterizations of networks as unable or unwilling to participate in collaborative problem-solving processes. Despite this growing awareness, the problem-solving process used to reconcile new and existing ideas within networks, and how networks integrate ideas and information with the beliefs and values of members, is not well understood (Peters 1998; Torfing 2007; Bevir and Richards 2009).

In this chapter, a Canadian example was used to explore the involvement and contribution of an agri-environmental network to a state-mandated multi-stakeholder problem-solving process. This agri-environmental network, and the broader agricultural network within which it has emerged and functioned, has been characterized as an entity that has been closed to external ideas and influences, and has been static and unable to evolve to address emerging concerns (Skogstad 1990; Monpetit and Coleman 1999). However, the results presented earlier suggest that the agri-environmental network did not behave in this manner. Rather, it demonstrated a more open and dynamic manner, adapting to problem-solving involving a complex problem using a non-regulatory initiative developed in a collaborative manner.

This example, therefore, provided insight concerning two related questions regarding the contribution of stakeholder networks to collaborative problem-solving. First, what form of problem-solving process, traditional or collaborative, is used within a stakeholder network to reconstruct and reconcile new and existing ideas (Peters 1998; Torfing 2007; Bevir and Richards 2009)? Second, do such closed networks resist or facilitate the integration of new and existing ideas and information with the beliefs and values of network members as part of internal problem-solving processes (Peters 1998; Torfing 2007; Bevir and Richards 2009)? These questions were explored in the context of the agricultural network, given that the contribution of circumstances and factors related to the formation, evolution and function of how stakeholder networks such as the one featured in the case study are not well understood in both the theoretical and empirical literature (Hay 1998; Torfing 2007).

Regarding the problem-solving approach observed, the results suggest that the agri-environmental network has operated in a manner that has been consistent with the attributes of collaborative approaches to environmental problem-solving (see Table 12.1). This consistency was demonstrated from two perspectives. From an internal perspective, the agri-environmental network, through the efforts of the OFEC SWP working group, developed a forum to support agricultural SPC members during a prescribed environmental problem-solving process. This reflected the importance of developing a process for promoting stakeholder involvement (Wynne 2002; Jasanoff 2003), accountability (Murdoch and Abram 1998; Blackstock and Richards 2007) and legitimacy (Blackstock and Richards 2007; Fawcett and Daugbjerg 2012). This process was promoted by supporting the election of agricultural representatives using a transparent approach that was endorsed and organized at the local and provincial level, and encouraging the participation of agricultural representatives in workshops and through email and teleconference discussion groups. However, accountability and legitimacy of agricultural representatives to the local communities could not be verified because this was not part of the research.

The process also demonstrated the benefits of promoting reciprocal communication between network members (Bellamy et al. 1999; Lach et al. 2005), and the importance of developing their capacity (Carr 2004; Van Wyk et al. 2007) and expertise (Carolan 2006) to participate effectively in local problem-solving processes. Unobtrusive observation at workshops and as part of email and teleconference discussion groups verified substantial reciprocal communication and stakeholder capacity. However, it was evident that the development of interactional stakeholder expertise was a challenge for some agricultural representatives, particularly with the more complex concepts that arose during workshop presentations and discussions, such as understanding the threat posed by different land use activities to water sources (OFEC 2008a, c, 2009, 2010b, 2011b, 2012b).

From an external perspective, the agri-environmental network demonstrated support for, and a willingness to work collaboratively with the OMOE in developing the SPP process. Unfortunately, the OMOE chose to impose the SPP process through regulation and overlooked the opportunities to build on past efforts and the existing multilevel approach to environmental governance that was available through the agri-environmental network (Ferreyra et al. 2008). However, when the OFEC's efforts to participate formally in the SPP process were unsuccessful, the OFEC developed and implemented a process whereby it could participate informally. This behavior is consistent with observations from other mandated problem-solving processes where informal networks have been established in parallel to formal problem-solving processes (Robins 2008).

The research results indicate that the agri-environmental network actively supported the creation and sharing of vernacular knowledge by facilitating the integration of expert science, local knowledge and community beliefs and values in two ways. Internally, the OFEC workshop process was designed to provide an opportunity for agricultural representatives to learn about and discuss agricultural and environmental science—provided by external experts, OFEC SWP working group members and agricultural representatives—and to reconcile this information with their knowledge, beliefs and values. A forum was encouraged for the creation and sharing of vernacular knowledge (OFEC 2007, 2008b, 2008d, 2010a, 2011a, 2012a), which was then summarized and shared as a series of OFEC SWP principles.

Externally, the OFEC SWP principles provided a consistent source of technical information that has been disseminated within the vertically and horizontally integrated agri-environmental network in two ways. First, the SWP principles provided a source of knowledge that agricultural representatives could share at a watershed scale during the creation and sharing of vernacular knowledge with their colleagues as part of the problem-solving process within individual SPCs. Second, the SWP principles provided a common approach for OFEC SWP working group members to advocate for during negotiations with OMOE and SPC staff representatives involved with the SPP process at a provincial scale. This demonstrates how networks can create an approach for communicating knowledge across and empower stakeholder members to engage in problem-solving at horizontal and vertical scales in an integrated manner (Paquet 2001; Peters and Pierre 2004; Reed and Bruyneel 2010).

The research also provided broader insight for the theoretical and empirical literature in two ways. First, the research demonstrated the importance of context for the function of networks: namely, what circumstances and factors led to the formation, evolution, and formation of the agricultural network. The historical literature indicates that the formation of the overarching agricultural network in Ontario was shaped by several-related factors, where the relationship between the state and farming community evolved from a traditional command and control to a more collaborative approach. It is important to note that the relationship between the farming community and the province prior to the formation of the OMAF was one that could be characterized by a lack of cohesion and distrust of the state on the part of the former, and lack of a strategic vision and consistent support for the farming community on the part of the latter (James 1914; Reaman 1970). Following the formation of the Province of Ontario, OMAF extension staff implemented a program to develop leadership and organizational and technical capacity within the farming community (Biesenthal 1991; Milburn et al. 2010). The OMAF reinforced these efforts by including farm organization representatives to participate on its problem-solving bodies, providing an opportunity for farm leaders to enhance their leadership capacity and participate in negotiating agricultural policy and programs.

In addition, the OMAF transformed its approach for supporting the farming community, moving from an agricultural extension to a technology-transfer approach once the agricultural network had attained a highly developed level of leadership, organizational and technical capacity (Milburn et al. 2010). As a result, the agricultural network has evolved to work collaboratively to resolve problems both internally and externally. The establishment of an agri-environmental network, which has involved representatives from farm organization, OMAF, and other interested agencies and organizations, is a recent example of how the agricultural network has been able to use a collaborative approach for addressing an emerging complex problem (Verkley et al. 1998; Robinson 2006).

Second, the capacity and interest of the agricultural network to create and share vernacular knowledge has increased along with its growth in leadership and organizational capacity. Specifically, the province, in cooperation with the University of Guelph, has actively promoted the development of a forum within which farmers have participated in the development of progressive agricultural science and practice across Ontario (Reaman 1970; Biesenthal 1991). Farmers have been involved in on-farm research programs starting in the early 1900s, and knowledge gained from the on-farm research process has been promoted systematically through agricultural extension and technical transfer programs to encourage its uptake by the farming community (Reaman 1970; Biesenthal 1991; Milburn et al. 2010). To ensure that the research undertaken is relevant and useful for farmers in Ontario, the province has ensured that farmers have served in key roles where they can influence agricultural research undertaken in Ontario. For instance, the Agricultural Research Institute of Ontario, which provides strategic advice directly to the Minister of Agriculture and Food concerning research on agricultural and other areas of interest, is currently chaired by a farmer (OMAFRA 2017). Consequently, the ability of the agricultural network to participate in the creation and sharing of vernacular knowledge, and the identification of new research themes necessary to improve agricultural science and practice in Ontario, has evolved over time. As a result, an agricultural network has evolved in which representatives from farm organizations, provincial government and university researchers have identified and negotiated mutually beneficial approaches to issues related to agriculture, such as complex agri-environmental problems like water management.

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CHAPTER 12

The New Green Revolution: Enhancing Rainfed Agriculture for Food and Nutrition Security in Eastern Africa

Adi Dunkelman, Meghann Kerr, and Larry A. Swatuk

Introduction

It is anticipated that by 2050, the global human population will reach nine billion (Rosegrant et al. 2009). Along with population growth, socio-economic shifts and changing dietary patterns will require global food production to double in the next 40 years to accommodate increasing levels of consumption (Sposito 2013). Most population growth will take place in developing countries, which is also where food insecurity is most prevalent. The growing demand for food production also creates challenges with respect to water resources. A total of 70–85 percent of available freshwater is used for agricultural production (Rosegrant et al. 2009; Nordin et al. 2013),

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and increased demand for food will exacerbate issues related to the degradation and depletion of water resources (Nordin et al. 2013). In line with these facts, the narrative surrounding food security is predominantly focused on increasing yields while ensuring sufficient water to do so. Some have argued that the 2008 and 2011 global spikes in food and oil prices initiated the entire 'water-energy-food nexus' discussion. In this discussion, these three 'systems' are said to be inextricably linked (http://www.unwater.org/topics/water-food-and-energy-nexus/en/). While this is true, the globalized nature of this discourse means that it is overwhelmingly dominated by powerful states and private sector actors, each fundamentally interested in the financial costs (and possible profits) of efforts to achieve energy, food and water 'security'. Efforts to increase food security through 'production' have resulted in myriad pathological practices, the most pernicious of which may be land-grabbing across the Global South.

Our concern here is with a different impact of this meta-narrative: the emphasis of caloric output over nutritional output. In our view, the drive to grow 'more' without asking whether it is a socially, ecologically and nutritionally sound decision increases rather than decreases the food insecurity of the most vulnerable—that is, impoverished rural farmers. At the same time, the focus on caloric production has also resulted in the cognitively dissonant fact of people being considered 'food secure' yet increasingly malnourished (Tanumihardjo et al. 2007). In this chapter, we investigate the neglect and importance of nutrition as a function of food security in rainfed agricultural production. In order to meet the growing consumptive needs of an increasing population as well as effectively use available water resources for agricultural production, we argue that there is a need for a shift in focus toward traditional rainfed agricultural practices to facilitate an emphasis on the local and nutritional dimensions of food security.

This chapter discusses how rainwater harvesting techniques for smallholder farmers can be undertaken in order to increase water-use efficiency and upgrade rainfed agriculture to enhance food and nutrition security. These issues are analyzed in the context of Eastern Africa, namely Ethiopia, Kenya and Tanzania.

Background to Food and Nutrition Insecurity

Food and nutrition insecurity results from the confluence of a number of factors such as population growth, widespread malnutrition and water scarcity. To feed increasing populations, conventional approaches have emphasized large-scale irrigated (blue water) agricultural practices (Yang et al. 2003; Rockström et al. 2004; Falkenmark and Rockström 2006; Enfors 2013). The corresponding focus has been on crop yield, resulting in a general perception of 'food security' in the context of caloric intake more than food's nutritional value (Falkenmark 2001).

Population and Diet Factors

The population of Eastern Africa is estimated to have doubled since 1980 (Funk et al. 2008) and, relative to 2000 levels, is anticipated to triple by 2050 (Thornton et al. 2010). Combined with a high rate of population growth, it is anticipated that food requirements in Eastern Africa will also triple by 2050 (Thornton et al. 2010). The region's increasing population has corresponded with shifts in the types of food that are produced to meet the increasing demand for food. Traditionally, the diet has consisted of primarily animal protein as well as native cereals such as sorghum and millet. Since the 1980s, however, diet has become characterized by predominantly maize and small quantities of animal protein (Kennedy and Reardon 1994; Rufino et al. 2013).

The widespread shift in diet has been attributed to various causes, such as climate change (Rufino et al. 2013) as well as economic and political factors (Raschke and Cheema 2008). The decrease in meat consumption has been associated with increased drought conditions the region has experienced (Rufino et al. 2013). Colonial influences have been associated with a shift toward agricultural practices that favor monocropping of non-traditional crops such as wheat, rice and maize over indigenous foods (Raschke and Cheema 2008). However, it should be noted that the general population of Eastern Africa—defined here as Kenya, Tanzania and Uganda—continue to rely on rainfed smallholder agriculture (Funk et al. 2008; Garrity et al. 2010; Enfors 2013).

Despite a shift toward non-traditional foods in the region, malnutrition remains prevalent (Rockström et al. 2010). Malnutrition results from insufficient provision of nutrients and energy to the body (Atinmo et al. 2009). Compared to indigenous foods of the region, non-traditional foods are of lower nutritional quality (Frison et al. 2006; Raschke and Cheema 2008); even if caloric needs are met, an individual may still be undernourished (Frison et al. 2006; Tanumihardjo et al. 2007). Increased consumption of wheat, rice and maize in the region has given rise to an upsurge in non-communicable diseases (NCDs) such as cardiovascular disease, type 2 diabetes and various cancers (Frison et al. 2006; Raschke and Cheema 2008). Increased prevalence of NCDs is related to malnutrition (Atinmo et al. 2009).

The definition of food security encompasses both the quantity and the quality of food (Rosegrant et al. 2005; Mwaniki 2006). However, the general shift away from indigenous crops and emphasis on crop yield suggests that, in practice, efforts to achieve food security appear to focus on meeting the caloric needs (quantity) rather than addressing the more complex dimension of nutrition (quality). The Food and Agriculture Organization (FAO) defines 'undernourishment' as when a person is unable 'to acquire enough food to meet their daily minimum dietary energy requirements, over a period of one year. FAO defines hunger as being synonymous with chronic undernourishment' (http://www.fao.org/hunger/en/, accessed May 9, 2017). According to 2015 data from the FAO, the percentage of people chronically undernourished in Eastern Africa is as follows: Kenya (moderately high, 15–24.9 percent); Ethiopia, Tanzania and Uganda (high, 25–34.9 percent). Across sub-Saharan Africa, among states for which there is data, only three—Central African Republic, Namibia and Zambia—fall into the very high (35 percent and over) category (see http://www.fao.org/hunger/en/, accessed May 9, 2017). Widespread hunger in developing countries, including the region of Eastern Africa, speaks to the need to consider nutritional value as a significant component of food security (Mwaniki 2006).

The Role of Water Scarcity

In addition to the challenge of meeting the nutritional requirements of a growing population, water scarcity is increasing, and there are higher and competing demands for water resources (Gleick 1993; Falkenmark 2001; Rosegrant et al. 2009). Agriculture is the most water-consumptive sector compared to water for industrial and domestic use (Rockström et al. 2010). Rockström et al. (2004) noted that the demand for agricultural water in sub-Saharan Africa is expected to triple by 2025 and increase fivefold by 2050. The challenge is to meet the increased demand for food without compromising water resources and optimizing the use of available water (Rockström et al. 2004; FAO and IFAD 2006).

To meet increasing demands for food, decision-makers have conventionally emphasized the development of large-scale irrigation infrastructure to harness blue water flows. Blue water is defined as surface water (e.g., rivers, lakes and wetlands) and accessible groundwater. Investment in blue water technology has proven costly, inefficient and ecologically unsustainable (Enfors 2013). Blue water practices have also been associated with land degradation, mismanagement, maintenance challenges and tensions related to water allocation at the watershed level (Rockström et al. 2004).

Blue water capture has increasingly sidelined the value of traditional water management practices as technology, finance and 'expert knowledge' have taken over. However, in our view, the use of indigenous knowledge is crucial to achieving food security (Atinmo et al. 2009). In addition to the nutritional superiority of traditional foods (Raschke and Cheema 2008), indigenous agricultural practices emphasize the use of green (rain) water over blue (irrigation) water (Rockström et al. 2004). Put differently, it focuses on resource management 'where the water hits the soil'. As described in the next sections, a shift toward local level and traditional practices has the dual benefit of meeting the nutritional requirements of a population without compromising the water resources (Rosegrant et al. 2002).

Relevance of Rainfed Agriculture and Green Water for Food

In the context of agricultural production, green water and rainwater are synonymous. Rainfed crops make use of the water that infiltrates into the soil and is taken up by plant roots (FAO and IFAD 2006; Rockström et al. 2010). Although blue (irrigation) water is often the focus of discussion related to agricultural water, green water (from rainfall) plays a more significant role in global food production (Falkenmark et al. 2001; Falkenmark and Rockström 2008; Rosegrant et al. 2009). In fact, according to Rockström et al. (2004: 1111), 'rainfed agriculture is today practised on 97 percent of the agricultural land in SSA'. Globally, 70 percent of countries grow more than half of their food through green water (Falkenmark et al. 2001), and approximately 60 percent of cereals produced worldwide depend on it (Falkenmark et al. 2001; Rosegrant et al. 2002).

In light of a higher demand for food due to rapid population growth, as well as increasingly pervasive malnutrition, rainfed agriculture offers the potential to contend with the challenge of food and nutrition insecurity because it is a more sustainable and feasible approach than the use of blue water (Rockström et al. 2004; Swatuk et al. 2015).

Rainfed Agriculture and Food Production

Compared to conventional blue water techniques, rainfed agricultural practices tend to be undertaken on a smaller scale (Rosegrant et al. 2002). To address the challenge of food security, it is also important to focus on small-scale farming since 'most rural households in developing nations are involved in agriculture and most food is produced and consumed locally' (Garrity et al. 2010: 197). Indeed, the majority of the food-insecure population of Africa participates in smallholder farming practices (Haile 2005; Mwaniki 2006; Pretty et al. 2006).

Rainfed agricultural practices tend to correlate with a healthier environment at a broader scale (Rockström et al. 2004; Rosegrant et al. 2009). Compared to large-scale irrigation techniques, rainfed agriculture does not jeopardize the complex relationship between hydrological and ecological systems (Rockström et al. 2004). There is a direct relationship between ecosystem integrity and the growing conditions for crops as well as quality of grazing land for livestock (Rockström et al. 2004). Related to the benefits of rainfed agriculture to environmental integrity, more effective use of rainwater can also generate higher crop yields (Rosegrant et al. 2009).

The use of green water for agricultural production is sometimes viewed as less efficient than irrigation water due to unpredictable variability in rainfall patterns. Indeed, despite sufficient annual rainfall for crop production in Eastern Africa, uneven annual distribution of precipitation creates periodic deficits of sufficient water (Haile 2005; Enfors 2013). Crop yields can be impaired by too much water, which can lead to excess runoff (Falkenmark and Rockström 2008), or too little water, which can result in high evapotranspiration instead of soil and root uptake (Rosegrant et al. 2002). Despite the challenge to increase agricultural production, in spite of variable precipitation levels, rainfed agricultural practices tend to maximize the uptake of agricultural water compared to irrigation techniques (FAO and IFAD 2006; Rosegrant et al. 2009).

Through investment in green water technology, there is an opportunity to simultaneously improve land use functionality, enhance agricultural water management and achieve food security (van der Zaag 2005; Rockström et al. 2009). This opportunity is particularly important to consider in light of the projected population growth and increasing demand for food in the coming decades (Rockström et al. 2009). Rainwater harvesting techniques and their benefits are described below and discussed in the context of Eastern Africa.

Rainfed Agriculture in the Context of Nutrition Security

Globally, the quality and quantity of irrigation water is expected to decrease in the coming decades (Rosegrant et al. 2002; Hoff et al. 2010), and as a result, green water is expected to play a more prominent role in agricultural practices (Rosegrant et al. 2009). Access to freshwater resources is imperative to contending with malnutrition (Rijsberman 2006).

As discussed above, in Eastern Africa, there has been a widespread shift away from traditional crops and toward the production of other staple crops such as wheat, maize and rice. Consequently, diets have lost their nutritional diversity, and malnutrition remains ubiquitous (Frison et al. 2006; Johns and Eyzaguirre 2007). Indigenous crops provide a suite of nutritional benefits such as micro-nutrients, fiber, healthy fats and antioxidants (Johns and Eyzaguirre 2007).

In addition to the ongoing prevalence of malnutrition, another disadvantage of these non-indigenous staple crops is that they are not as well-suited to the climatic conditions as are indigenous crops. For instance, rice and wheat are considered C3 crops, which continuously transpire and therefore require higher inputs of water in order to grow in arid (C4) environments (Swatuk et al. 2015; Falkenmark and Rockström 2004). In addition, Mula and Saxena (2010) found that maize fails three out of five years. Above and beyond their nutritional superiority, traditional crops such as millet, sorghum and pigeon pea are more drought tolerant and can better withstand the variable growing conditions typical of the region (Raschke and Cheema 2008; Mula and Saxena 2010; Mwadalu and Mwangi 2013).

As Wallace (2000: 105) noted, agriculture is highly water consumptive and 'the additional food required to feed future generations will put further enormous pressure on freshwater resources'. Rainfed agriculture is already an essential and significant component of food production (Rockström et al. 2010; Enfors 2013), but improving rainwater harvesting techniques as well as re-focusing on traditional agricultural crops and practices is imperative to producing sufficient food (Rockström et al. 2002). Rainwater harvesting techniques can address food and nutrition insecurity of Eastern Africa and are discussed in the next section.

Rainwater Harvesting Systems and Upgrading Rainfed Agriculture

The heavy spatial and temporal rainfall variability of arid and semi-arid areas of Eastern Africa creates major challenges for rainfed agriculture and food security. According to Rockström (2007), sufficient rainfall within arid and semi-arid regions exists to double current agricultural yields. However, due to high rainfall variability, many dry areas experience limited rainfall during critical periods of the growing season, resulting in dry spells and poor crop yields. Moreover, 70–80 percent of the annual rainfall is considered lost from agricultural production due to high soil evaporation, deep percolation and surface runoff. Therefore, only a small percentage of rainfall, approximately 15–30 percent, accounts for plant transpiration (Helmreich and Horn 2009). It is, therefore, essential to reduce the high risk of rainfall variability by maximizing rainfall infiltration and the water-holding capacity of soil to reduce excess runoff and enhance the productivity of rainwater for agriculture. This can be successfully accomplished through rainwater harvesting which helps manage the availability of water for crops to improve yields (FAO 2005). Rainwater harvesting enhances the productivity of rainwater by collecting and concentrating runoff to crops, thus reducing the high risks associated with rainfall variability. Rainwater harvesting is defined as methods of concentrating, diverting, collecting, storing, utilizing and managing surface runoff for productive use (Ngigi 2003). In order to effectively collect and utilize rainwater for agricultural production, rainwater harvesting requires a producing area known as a catchment, and a runoff receiving area such as cropped area and/or storage structures. Therefore, water storage can be achieved either directly in the soil profile through increased infiltration, known as in situ rainwater harvesting, or in small reservoirs, tanks and aquifers, known as ex situ or external rainwater harvesting systems, which can be used for supplemental irrigation (Ibraimo and Munguambe 2007).

In situ and ex situ rainwater harvesting systems are the two main practices of rainwater harvesting within arid and semi-arid regions. With in situ rainwater harvesting, there is no separation between the rainwater collection area and the storage area. Rainwater is trapped where it falls and is therefore collected and stored where it is utilized. This prolongs the time of infiltration and increases soil moisture for increased yields. In situ rainwater harvesting practices are achieved through the creation of bunds, ridges, broad-beds and furrows, microbasins, runoff strips, terracing, pits, contour cultivation, conservation agriculture, dead furrows and staggered trenches (Rockström 2007). In situ rainwater harvesting systems are predominantly based on indigenous knowledge and harvesting techniques and are the most common methods of rainwater harvesting within Eastern Africa. By collecting surface runoff and increasing soil moisture through intensifying and prolonging rainwater infiltration, in situ rainwater harvesting techniques contribute to reducing soil erosion which is partially caused by excessive runoff (Ngigi 2003). Conservation tillage is also considered a form of rainwater harvesting since it reverses the crust formation of the soil, which exacerbates excessive runoff. As shown by Ngigi (2003), through conservation tillage, soil water is increased, and therefore, more water can be stored in the crop root zone.

Rainwater harvesting practices can also further be categorized into three classifications based on the size of the rainwater catchment—micro, small and macro (Ngigi 2003). The varying sizes of the catchments yield different harvesting methods. Micro catchment rainwater harvesting is located within the cropped areas and collects small quantities of rainwater runoff for single crops or a row of crops. Small external catchments collect surface runoff in the root zone of an adjacent infiltration area. These systems are predominantly used for growing medium water demanding crops such as maize, sorghum, groundnuts and millet. Macro-catchments are used to divert floodwater from gullies and ephemeral streams. Rainwater is diverted through channels and earth structures and spread to the cropped area through spate irrigation. Macro-catchments with large storage structures are more common for community-based projects and require larger areas of land (Ibraimo and Munguambe 2007; Hatibu et al. 2006).

The use of the various rainwater techniques for capturing lost rainwater for agricultural production has significantly aided smallholder farmers in mitigating the negative effects of rainfall variability. Although ultimately farmers have no control over the time lines and quantity of rainfall, rainwater harvesting techniques optimize rainfall by capturing and storing rainwater in either the soil profile or storage systems. Therefore, rainwater harvesting minimizes the risk of crop failure during droughts, intra-seasonal dry spells and floods (Kibassa 2013). By supplying appropriate amounts of water to the cropped area, rainwater harvesting does not only reduce risk of crop failures as a result of rainfall variability but also increases yields. Effectively concentrating rainwater for crop production through the use of in situ methods has resulted in higher crop yields by 30–50 percent (Ngigi 2003; Pachpute et al. 2009). Increasing yields and reducing risk of crop failures are fundamental for increasing the productivity and ability of rainfed agriculture to provide the food and nutrition security for smallholder farmers. Therefore, upgrading rainfed agriculture can be achieved through rainwater harvesting to reduce rainfall shocks and increase yields and soil productivity.

Case Studies: Rainwater Harvesting in Tanzania, Kenya and Ethiopia

Overview

Rainwater harvesting methods based on indigenous practices have been used in arid and semi-arid areas of East Africa for over 4000 years. These indigenous techniques have been adopted, adapted and disseminated by farmers who rely on rainfed agriculture for their livelihoods. Although indigenous techniques of collecting rainwater for agriculture have been practiced for centuries, rainwater harvesting received significant attention from the international community during the widespread droughts in Africa during the 1970s and 1980s (Kibassa 2013). As a result, external rainwater harvesting projects have been established and supported by national governments and development organizations to support farmers engaged in rainfed agriculture. This renewed interest was also initiated by the increased marginalization of people to drier lands due to increased pressure and demand for commercially productive, large-scale agricultural land (Ngigi 2003).

The continual national and international support for rainwater harvesting interventions is a result of the increasing recognition of rainfed agriculture as the main form of food security for smallholders within the region. As many of the chapters in this collection attest, the correlation between an agriculture, water and food security 'nexus' is increasingly acknowledged due to rapid population growth, land degradation and strain on water resources, which limit farmers' and households' ability to achieve food security and increases their vulnerability to climate impacts on agriculture (Awulachew et al. 2005). More cynically, as 'land-grabbing' proceeds across Southern and Eastern Africa and into the Horn, smallholder farmers will need to make what little land they have remaining that much more productive (Arezki et al. 2011; Rulli et al. 2013; Salomão and Nhantumbo 2009; Vermeulen and Cotula 2010). Rainwater harvesting is considered a key strategy for improving food security through rainfed agriculture within the region. Thus, increased effort and support have been initiated within Eastern Africa, specifically Tanzania, Kenya and Ethiopia, to enhance the capacity of smallholder farmers to be able to adapt and adopt successful methods of rainwater harvesting. According to Kibassa (2013), few of the rainwater harvesting projects supported by governments have been successful in effectively reaching smallholder farmers. However, through farmer dissemination and local initiatives by smallholder farmers, rainwater harvesting practices to support rainfed agriculture are found throughout these countries.

Tanzania

In Tanzania, rainwater harvesting has become an integral part of their Agricultural Sector Development Strategy as a solution to the ongoing droughts that have been resulting in poor agricultural outputs and food insecurity among smallholder farmers and households (Rockström 2007). Despite this, rainwater harvesting has always been present within the country and developed through indigenous methods of collecting rainwater for crop production. The most common traditional rainwater harvesting techniques found throughout Tanzania include excavated bunded basins, *Majaluba*, for paddy rice production in the Lake Zone. Water storage structures, *Ndiva*, and charco dams, *Lambo*, are commonly found in the Kilimanjaro region. Tanzanian farmers have adapted the micro-catchment pitting technique, originally developed in Burkina Faso, by creating deeper and wider pits filled with manure and planting 15–20 seeds of maize per pit to achieve higher yields (Ibraimo and Munguambe 2007). The practice of *Mashamba ya Mbuga*, where farmers grow high water demanding crops in lower-lying cropped areas and use rainwater from surrounding high grounds to supplement irrigation for crop production, has been practiced for centuries within Tanzania and is an example of a macro-catchment rainwater harvesting system (Mbilinyi et al. 2005; Kibassa 2013).

Although in situ and micro-catchment techniques have traditionally been most commonly used to grow maize, sorghum and millet, macro-catchment systems are increasingly being adopted to grow paddy rice for market. The macro-catchment rainwater harvesting systems for paddy rice cultivation found in the central semi-arid parts of Tanzania, such as Dodoma, Singida and Sjinuaga, have predominantly been initiated, developed and financed by the local farmers with little to no external assistance (Hatibu et al. 2006). The surface runoff is diverted from gullies in steep hilly areas to the cultivated basins, *Majaluba*, by high earth bunds. These macro-catchment systems are responsible for approximately 32 percent of Tanzania's rice production (Rockström 2000).

Rainwater harvesting practices within the *Makanya* catchment in Northeastern Tanzania have helped improve smallholder livelihoods through increased crop production. This has been achieved through the use of microdams, *Ndiva*, and furrows and dugout ponds for lowland farmers that have protected vegetables and maize crops against dry spells (Pachpute et al. 2009).

Kenya

Techniques developed and widely used within the Arusha region of Tanzania such as *Fanya Chini* and *Fanya Juu* terraces have been promoted within the dry areas of southeastern Kenya through extension services (Rockström 2000). The *Fanya Chini* method consists of throwing soil downslope to form an embankment, whereas the F*anya Juu* terraces are made from digging trenches and throwing soil upslope to form an embankment. Between the 1930s and 1990s, Kenya's population experienced a fivefold increase. During this period, *Fanya Chini* and *Fanya Juu* terraces largely contributed to the reduction of soil erosion and helped to mitigate the potential degradation of land caused by increased pressure of population on land use (Rockström 2000). In both Machakos and Laikipia districts, conservation tillage in the form of constructing ridges and terraces have improved yields by approximately 50 percent (Ngigi 2003).

Similar to Tanzania, macro-catchments and floodwater harvesting systems are increasingly becoming more common in Machakos, Laikipia and Kitui districts and are implemented through both farmer initiative and project interventions. Floodwater harvesting entails the diversion of floodwater from gullies and roads close to cropped areas. This system includes diversion structures of deep trenches with check dams to direct surface runoff for agricultural production, particularly maize, through spate irrigation (Rockström 2000).

Most African governments have responded to the discourse and felt the reality of climate change and increased climate variability through policy and planning. Kenya is no exception in this regard. Of interest here is the fact that the Kenyan government's National Climate Change Response Strategy includes an increased focus on rainwater harvesting and conservation (RWHC). There are numerous academic studies emerging in response to this focus. Recha et al. (2015), for example, highlight the widespread use of RWHC techniques among farm communities in Tharaka sub-county. Importantly, they highlight the fact that most of these techniques are farm specific, so micro-catchment in nature. Their research also showed that key factors determining willingness to engage in RWHC activities are years in school, labor availability, land allocation and number of livelihood options. This corroborates evidence in Tesfaye et al. (2014) where, in the case of Ethiopia, labor and capital availability as well as education and awareness were key determinants in adoption of soil conservation practices.

Ethiopia

Rainwater harvesting systems of floodwater diversion and spreading through spate irrigation have also been introduced in parts of Ethiopia. Spate irrigation and the capturing of floods from the hilly terrains in Northern Ethiopia, in the Kobo plains, have allowed farmers to divert floodwater into basins in arid lowland crop fields. Spate irrigation is developed to distribute and apply water evenly to the crops once the rainwater has been diverted to the croplands. This is achieved through contour bunds that enable uniform application and therefore sufficient water to the root zone of each crop. These systems provide water for crop production to a part of the country that is extremely vulnerable to dry spells and droughts. These large rainwater harvesting systems as well as macro-catchment, small-scale catchment and storage schemes are increasingly dominating over the previously dominant in situ rainwater harvesting methods within Ethiopia, especially the Tigray region. Despite additional costs, smallholder farmers are increasingly adopting these methods. However, in situ rainwater harvesting techniques are still being used and, along with conservation tillage, have resulted in cereal yield increases. Within high potential cereal zones, a 15 percent increase in yields has been achieved, and within low potential cereal zones, a 7.5 percent increase has been reported (Awulachew et al. 2005).

Discussion

It is evident that rainwater harvesting practices through farmer initiatives and national and development programming are ubiquitous within the arid and semi-arid areas of Tanzania, Kenya and Ethiopia. However, the inability of interventions to effectively reach smallholder farmers is a significant challenge to increasing the use of RWHC for rainfed agriculture in these regions. The lack of inadequate training on the uses and benefits of different techniques and the lack of technical resources have been identified as one of the main reasons that smallholder farms are unable to adopt rainwater technologies and methods provided by external assistance. Moreover, it is crucial to note that a large majority of farmers within these areas do not own their own land and therefore are unable to incorporate these methods to enhance their agricultural production (Awulachew et al. 2005). This speaks to Recha et al. (2015) whose research suggests that while RWHC improves food production, poor rural people face multiple barriers to poverty alleviation.

There are also important biophysical limits. Despite the ability to improve soil moisture and crop yields, even in extremely dry areas, Ngigi (2003) emphasizes Rockström's argument that each rainwater harvesting technique is ultimately restrained by hydrological limits such as poor rainfall partitioning and in-field crop competition for soil water. In addition, low cumulative rainfall levels result in soil water availability below crop water requirements. Therefore, although rainwater harvesting can optimize rainfall and capture the water lost to surface runoff, the cumulative amount of rainfall still dictates the amount of water available for crop production: all the more reason to return to an emphasis upon crops best suited for the hydroclimate.

However, by capturing surface runoff and prolonging rainwater infiltration in the soil profile, rainwater harvesting prevents soil erosion by increasing soil moisture. Rainwater harvesting practice promotes improved land management, which, in turn, enhances crop yields. Poor land management within dry areas can potentially reduce crop yields to less than 1 ton per hectare. Poor land management leads to crust formation, which decreases infiltrations and increases surface runoff. Rainwater harvesting techniques break up the soil by constructing terraces, ridges, pits and bunds, for instance, to improve crop yields and reduce erosion. Therefore, rainwater harvesting practice not only provides 'more crop per drop' but also reduces land degradation (Ibraimo and Munguambe 2007).

In situ practices and internal micro-catchments, which still dominate Eastern Africa, are simple, have low implementation costs, can be implemented on various types of land and can be easily replicated (Ibraimo and Munguambe 2007; Rockström 2007; Recha et al. 2015). Moreover, methods of rainwater harvesting are decentralized, and therefore, smallholder farmers and communities can manage their own systems. Rainwater harvesting systems have significantly increased yields in typically dry regions in Tanzania, Kenya and Ethiopia, and, therefore, enhanced livelihoods and food security and nutrition security within those regions.

Conclusions and Recommendations

Rainwater harvesting practices found throughout Eastern Africa enhance soil moisture and water availability in the root zone and therefore help to mitigate variable rainfall, dry spells and droughts that are characteristic of arid and semi-arid regions. Thus, upgrading rainfed agriculture increases crop yields as well as land productivity. Because of these benefits, it is essential to promote the use of these techniques to support rainfed agricultural production. Upgrading rainfed agriculture through rainwater harvesting and soil conservation increases opportunities for crop intensification. Depending on crop choice and other relevant inputs as well as supports, such practices have the potential to significantly contribute to income increases and more secure livelihoods (Pachpute et al. 2009). The promotion of rainwater harvesting through external assistance has failed to reach its maximum potential, despite the recognized benefits of these practices (Recha et al. 2015). This is the major challenge to the wide-scale promotion and sustainable use of these technologies. Lack of proper assistance has been identified as one of the main reasons why a wider-scale adoption of these methods has failed to be upheld by smallholder farmers in the dry regions (Awulachew et al. 2005). Therefore, an obvious disconnect exists between rainwater harvesting interventions and the needs of smallholder farmers to successfully use these technologies. In order to address the issues related to the adoption of RWHC techniques, increased information and improved governance, policies and institutional support are needed to support smallholder farmers.

Access to support services such as credit and extension services as well as to market information can result in more effective interventions to support the out-scaling of RWHC systems. Effective support systems are crucial for guiding farmers for optimal application and understanding which methods are most appropriate, as well as the recognition of indigenous rainwater harvesting practices and their role in informing current interventions and extension services (Critchley 2000). Co-management between local communities and extension agents is essential to support effective out-scaling and knowledge sharing between users and extension officers, based on indigenous knowledge and traditional rainwater harvesting practices. Out-scaling rainwater harvesting through increased support and information sharing will ensure the widespread application and sustainability of these methods for upgrading rainfed agriculture. Rainfed agriculture is projected to increasingly become the dominant source of food and nutritional security of semi-arid and arid regions. Therefore, rainwater harvesting along with land management and an emphasis on nutrition security will allow rainfed agriculture to reach its full potential and focus on growing nutritious food to provide a new green revolution—that is, a green water revolution—across not only Eastern Africa but arid and semi-arid regions worldwide.

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CHAPTER 13

Afterward: Closing Thoughts on the Water–Food–Energy–Climate Nexus

Richard A. Matthew

In the space of a decade, the concept of the "nexus" has gained considerable traction as a holistic, and allegedly disruptive, approach to thinking about current environmental issues. The content of the nexus varies across reports and conferences and speeches—there is the water–energy nexus, the water–energy–food nexus, the water–energy–food–climate nexus and so on (e.g. McCornick et al. 2008; Perrone and Hornberger 2014; Poppy et al. 2014; WBCSD 2009; WEF 2009; for an annotated bibliography, see Williams 2014). But those embracing this concept appear less concerned about reaching broad agreement on what it does and does not include than they are about reaching an agreement that the concept itself is innovative, inclusive and useful for understanding and addressing contemporary environmental challenges.

Articulated and marketed by leaders from academia, business and government, the nexus is a response to at least three ideas: first, the idea that many current trajectories of resource use and ecosystem management are

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interactive and unsustainable; second, the idea that we must act quickly at scale to avoid crisis; and third, the idea that a successful response will require new partnerships between government and business and entail working outside the box of familiar mindsets, jurisdictions, behaviors and incentives. We need, in short, to recognize the urgency and interconnectedness of twenty-first century environmental stress and breakdown, and we need to bring different social actors together to reconceptualize social–ecological interfaces and design and implement new approaches to governing them.

Ironically, perhaps, at least part of the appeal of nexus thinking may be that it is in some important ways a very familiar concept. In particular, as an analytical discourse, it is closely aligned with the academic fields of ecology and biology. For example, a fundamental building block of these life sciences is a formula known to every high school student. This formula describes perhaps the most critical biogeochemical process on the planet.

$$6CO_2 + 6H_2O + \text{light energy} > C_6H_{12}O_6 + 6O_2$$

In simple terms: air, water and energy combine to produce food.

In terms of human activity, the earliest and most extensive operationalization of this formula is also familiar—it is farming. For millennia farmers have appreciated that crop yields depend upon the interaction of water, energy and soil nutrients. Farming is in large measure about developing a holistic understanding of the contextual dynamics of these interactions and about intervening wherever needed to optimize outputs. Irrigate. Expose. Fertilize.

Farming emulates natural systems of food production that are quite remarkable. Plants grow and replicate, defend themselves against predators and attract pollinators. Their root systems bring in water and nutrients, at times working in partnership with underground fungi. Their leaves absorb solar energy. They adapt to daily and seasonal changes in sunlight and temperature. They have found ways to flourish in radically different environments around the world. But plants can also die, quickly and in large numbers, and each year, a number of them go extinct. To survive and flourish, plants rely upon a natural water–energy–food–climate nexus that under certain conditions can break down. To cultivate plants, to farm, means replicating and managing this nexus and protecting it from breaking down.

In important ways agriculture has been a spectacular success over the last 10,000 years, producing vast quantities of nutritious and affordable food and allowing the human species to grow in numbers unique for higher order mammals. But today the water–energy–food–climate nexus assembled by humankind is experiencing multiple forms of stress and also disrupting the natural systems in which it is embedded. The new nexus thinking simultaneously reflects the ecological reality of interconnectedness, and the science-based conclusion that our interventions into this reality have become too disruptive and damaging, and therefore need to be transformed. And it also evokes some good news, because there is remarkable dynamism evident on the margins of agriculture today, such as the rich repertoire of experiments in urban farming, permaculture, agroecology and so on. These are all attempts to align agriculture with the ecological realities of the twenty-first century as expressed through science.

The concept of nexus embodies the reality of interconnectedness, the fear of breakdown and the promise of better management. Contemporary nexus thinking is also far more expansive than just agriculture, which I have used as a basis for understanding why it may be immediately attractive to many people. Indeed, the concept focuses on the need for a new approach to managing water–energy–food–climate interactions broadly conceived. Although this broader viewpoint does not have a single authoritative text, certain expressions of it have been widely influential. Among these various texts, the differences are as important as the similarities. Here I consider two of these, selected for their prominence in contemporary nexus discussions.

In 2011 the World Economic Forum (WEF) released a study entitled *Water Security: The Water-Food-Energy-Climate Nexus*. According to the authors of this report, humankind is trending toward catastrophe. Around the world, agricultural, industrial and household practices have degraded and depleted natural capital and destroyed ecosystems. But the demand for food, water and energy is poised to dramatically increase. Under these conditions, business as usual is unsustainable.

The ensuing analysis is quick and simple. The authors contend that understanding water is the key to understanding the challenges facing this failing nexus: water "is the gossamer that links together the web of food, energy, climate, economic growth, and human security challenges that the world economy faces over the next few decades". Focusing on water leads the authors to a quick explanation of why we are facing challenges:

"[W]hy have we got to this state? In many places around the world, we have consistently underpriced water'. The results of underpricing water are alarming: "This set of regional challenges becomes a fast-growing global crisis when placed against future needs for water" (WEF 2011: 1–2). Thankfully, there is an "emerging realization of the extent to which water security underpins and connects the food, fiber, fuel, urbanization, migration, climate change, and economic growth challenges the world system faces" (WEF 2011: 4).

Underpriced water leads to wasted water. Wasted water results in water scarcity. Water scarcity disrupts a range of human activities. Disruptions accumulate into crisis. Armed with this analysis, the authors are able to lay out the solution set with great clarity. By focusing on efficiency and innovation, the world can move onto a new trajectory, one in which burgeoning human needs and aspirations are met largely by eliminating waste. In order to realize this bold vision, the status quo must change. In particular, government must partner with business around a worldview that appreciates the interconnectedness of natural resources and an agenda that appreciates the need to act swiftly and decisively. Other stakeholders are welcome to participate.

A public–private partnership is necessary because "The recent financial crisis and its aftermath … shows us that, in today's world system, wide collaboration, although difficult, is the only effective way to address a widespread crisis" (WEF 2011: 2). Transforming water use "is a difficult agenda for governments to lead by themselves". Collaboration makes possible effective "market-based solutions" that are the key to successful transformation (WEF 2011: 2, 13).

Now this version of nexus thinking is very tightly focused on the subjects of efficiency and innovation and draws a very straightforward and perhaps compelling connection between these values and market forces, but it does not consider at all how issues of equity and security might be relevant here. In other words, higher water prices might stimulate efficiency and innovation—but is there any chance that they could also deepen inequality and division, conditions linked to violent conflict? For example, what are the possible implications of charging for water in a country like India, where there is extensive poverty in a vast population that regards water as a resource that is and should be free to all, a resource embodying spiritual and cultural significance that militates against the idea of turning it into a business venture (Asthana and Shukra 2014)? If nexus thinking generates solutions that run the risk of worsening the conditions of the most vulnerable and disadvantaged people on the planet, the bottom half of the human economic pyramid, then a discussion of this risk and how it might be managed is essential (for an overview of environmental security issues, see Floyd and Matthew 2012). Thus, while the nexus vision provided in the WEF report describes a reasonable approach to reducing waste and inefficiency, it does not address the possibility that the proceeds of higher water prices will aggregate mainly into the hands of the investors, deepening inequality, fostering corruption and creating conditions ripe for instability and violence. It might be wise, then, to explicitly integrate a discussion of equity and security into this rendering of the nexus.

Also in 2011, the Stockholm Environment Institute (SEI) released a report on the nexus as background material for the 2012 Rio Summit—a conference very explicitly focused on working with business to green the global economy. The authors of the SEI report contend that:

> Water, energy and food security can be achieved through a nexus approach – an approach that integrates management and governance across sectors and scales. A nexus approach can also support the transition to a Green Economy which aims, among other things, at resource use efficiency and greater policy coherence. Given the increasing interconnectedness across sectors and in space and time, a reduction of negative economic, social and environmental externalities can increase overall resource use efficiency, provide additional benefits and secure the human rights to water and food. Conventional policy- and decision-making in 'silos' therefore needs to give way to an approach that reduces trade-offs and builds synergies across sectors – a nexus approach. Business as usual is no longer an option. (Hoff 2011: 7)

In this report, the description of the global challenges we are facing and the need for nexus thinking to address them is in many ways similar to the arguments advanced in the WEF (2011) report. In particular, the SEI report emphasizes the fundamental importance of water security and argues for building energy security and food security through a dynamic relationship with water. This analysis provides a platform for arguing that there are enormous potential benefits to be achieved through integrated approaches to production, management, planning and governance. And the final section of the report, "Opportunities for Improving Water, Energy and Food Security through a Nexus Approach" (Hoff 2011: 36), organizes these benefits into seven categories:

- Increasing resource productivity
- Using waste as a resource in multi-use systems
- Stimulating development through economic incentives
- Governance, institutions and policy coherence
- Benefiting from productive ecosystems
- Integrated poverty alleviation and green growth
- Capacity building and awareness raising

One thing that stands out in and differentiates this report from the one prepared by WEF is the concern expressed for the poor. The authors caution, for example, that "[w]hile investment in agriculture is much needed in developing countries as it can bring innovation and production gains, the present sudden wave of FDI [foreign direct investment] poses significant challenges to local people's livelihoods, access to land and water, and food security" (Hoff 2011: 12). Moreover, they argue that a nexus approach can benefit the poor by strengthening "a wide range of ecosystem services and maintain[ing] a healthy environment – the human 'life support system' – on which the poorest depend most strongly. The provisioning of clean water and energy improves the health and productivity of the 'bottom billion'. Green agriculture can generate more rural jobs" (Hoff 2011: 40). But, as charming as this rhetoric might be, there is no real discussion of how the poor will benefit from a new management structure—rather the authors seem to espouse a variant of the trickle-down theory.

Overall, the SEI and WEF reports share an understanding of the challenges facing humankind, contend that a nexus perspective can clarify opportunities and trade-offs thus making it easier to address these challenges and endorse the idea that the private sector can and should play a significant role in addressing these challenges. They differ considerably in the degree to which they identify poverty alleviation and concern for the plight of the poor as critical to nexus thinking, with the WEF making a brief allusion to poverty and the SEI report weaving this concern throughout its analysis. Because of this, the SEI report is more explicitly allied to the discourse of sustainable development that builds from the 1987 Brundtland Report, *Our Common Future* (UN 1987). In fact, this association is so strong that it is not clear what, beyond the very particular emphasis on the key role of the private sector, a nexus perspective adds to the discussions of the past 30 years. According to the Brundtland Report (UN 1987: 13):

> Until recently, the planet was a large world in which human activities and their effects were neatly compartmentalized within nations, within sectors (energy, agriculture, trade), and within broad areas of concern (environment, economics, social). These compartments have begun to dissolve. This applies in particular to the various global 'crises' that have seized public concern, particularly over the past decade. These are not separate crises: an environmental crisis, a development crisis, an energy crisis. They are all one.

Its authors conclude that

> most of the institutions facing those challenges tend to be independent, fragmented, working t relatively narrow mandates with closed decision processes. Those responsible for managing natural resources and protecting the environment are institutionally separated from those responsible for managing the economy. The real world of interlocked economic and ecological systems will not change; the policies and institutions concerned must. (UN 1987: 17)

In a sense the nexus perspective reboots *Our Common Future* in a way that gives more attention to the role of the private sector than to intergovernmental cooperation. This might be a good way of reinvigorating the somewhat stale rhetoric of sustainable development and of marshaling all of the world's key actors—public, private and civil—into a shared understanding of global challenges and a shared agenda for change. Or, conversely, it may be tilting the global agenda toward a course of action that looks and feels familiar and right, retains the focus on environmental sustainability, but subtly shifts the key metrics of success away from human security and poverty alleviation and toward corporate spreadsheets and value propositions—hence threatening to deepen inequality and intensify the sorts of stress that historically have been associated with violent conflict (Collier 2008; Matthew 2014).

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NUMBERS AND SYMBOLS

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B

[1] Note: Page numbers followed by "n" refer to notes

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