

## Chapter 2

# Institutions and the Nexus Approach

## Trade-Offs, Synergies and Methods for Governance of Environmental Resources

**Abstract** This chapter draws upon three published case studies covering different aspects of water, soil, and waste management to discuss issues that are crucial to an improved understanding of the nexus approach to management of environmental resources. Based on previous research, we identified three questions that can guide the discussion on the nexus approach (Kurian and Ardakanian in *Governing the nexus: water, soil and waste resources considering global change*, UNU-Springer, Dordrecht, 2015). (1) Question of intersectionality: What are the critical mass of factors at the intersection of material fluxes, public financing and heterogeneity, and changes in institutional and biophysical environment that define environmental outcomes? (2) Question of interactionality: How can feedback loops be structured to capture both vertical and horizontal interactions between legal and policy reform, structural changes in economy and society, and variability in the biophysical environment? (3) Question of hybridity: What role can transdisciplinary methods play in supporting integrative analysis of biophysical and institutional processes that have a bearing on the use and management of environmental resources?

**Keywords** Data • Monitoring • Environmental resources • Risks • Governance • Public services • Case studies • Nexus observatory • Index • Visualization • Benchmarking • Scenario analysis • Trade-offs

### 1 Introduction

“The Nexus Approach to environmental resources’ management examines the inter-relatedness and interdependencies of environmental resources and their transitions and fluxes across spatial scales and between compartments. Instead of just looking at individual components, the functioning, productivity and management of a complex system is taken into consideration” (UNU-FLORES 2015). The emphasis on moving away from a focus on “individual components” is evident from the Integrated Water Resources Management (IWRM) approach. The IWRM approach emphasizes the following issues: (1) Inter-sectoral competition for surface water

resources; (2) Integration of water management at farm, system, and basin scales; (3) Conjunctive use of surface and groundwater resources; and (4) Prioritizing water for human consumption and environmental protection (Turrall 1998; Schreier et al. 2014). However, some have pointed out in previous analyses that IWRM approaches neglect the political dimension through a reification of “natural boundaries” and emphasis on “neutral planning and participation” (Wester and Warner 2002: 65).

The novelty of the nexus approach to management of environmental approaches is that it considers the above critique of IWRM seriously by engaging with scientifically problematic concepts of *trade-offs* and *synergies* (Kurian and Ardakanian 2015). The concept of a trade-off by signifying a compromise involves negotiation. Similarly, the concept of a synergy by signifying inter-connection necessitates collective action. What portfolio of mixed methods can capture the relationships between naturally available environmental resources (*flows and fluxes*), the demands that are made on them as a result of resource extraction strategies (*budget allocation*) of public agencies and individual behavior of resource users (*example: crop choice*), and environmental outcomes (*example: soil erosion or water quality*) (Poteete et al. 2010)? This question underscores the need for integrated analysis of *resources, services, and risks*, which constitute important components of poverty and well-being (Dasgupta 2001). Without a robust analytical framework, the science-policy divide will continue to support a disconnect between development and achievement of outcomes in terms of well-being and/or environmental sustainability (Kurian and McCarney 2010).

Advancing the nexus approach to management of environmental resources necessitates the development of a methodological framework that integrates analysis of biophysical processes with political structures and behavior that shapes environmental outcomes (Veiga et al. 2015; Reddy et al. 2015). Further, the nexus approach demands the delineation of *boundary* and *scale* conditions to be able to distinguish between the effects of human intervention and ecological change on management outcomes (Scott et al. 2015). The example of groundwater is illustrative: the objective of watershed management is to facilitate recharge of aquifers for which a number of human interventions are possible, such as construction of water harvesting structures or delineation of safe zones. After a few years, recharge of aquifers may become evident, but the important question is how much of this change has resulted from management when an improvement in rainfall or precipitation patterns during the same period could have also played a crucial role (Kurian 2010).

This chapter draws upon three published case studies covering different aspects of water, soil, and waste management to discuss issues that are crucial to an improved understanding of the nexus approach to management of environmental resources. Based on previous research, we identified three questions that can guide the discussion on the nexus approach (Kurian and Ardakanian 2015). (1) *Question of intersectionality*: What are the critical mass of factors at the intersection of material fluxes, public financing and heterogeneity, and changes in institutional and biophysical environment that define environmental outcomes? (2) *Question of interactionality*: How can feedback loops be structured to capture both vertical and horizontal interactions between legal and policy reform, structural changes in

economy and society, and variability in the biophysical environment? (3) *Question of hybridity*: What role can transdisciplinary methods play in supporting integrative analysis of biophysical and institutional processes that have a bearing on the use and management of environmental resources?

The first case study employed by this chapter focuses on soil and water management in the Mekong river basin of Laos. The second case study examines the issue of wastewater reuse for peri-urban agriculture in India. The final case study examines the issue of “collective action” through longitudinal analysis of self-organization for management of watershed resources in the Indian Himalayas. The three case studies highlight issues of complexity, heterogeneity, and uncertainty, as well as the trade-offs and synergies that make robust management regimes possible. The case studies also elaborate upon the methodological innovations that are required to enhance the credibility of research results for decision makers.

## 2 Understanding the Nexus: Approach, Concepts and Methods

### 2.1 Approach: Inter-dependence, the Commons and Collective Action

The nexus approach highlights the importance of inter-dependence involving environmental resources. Concepts of system fluxes and flows between compartments and across land uses capture the aspect of inter-dependence. However, inter-dependence could also be extended to include interactions across resource management boundaries potentially covering rural and urban, central and provincial governments and departments. We have argued previously that the literature on new-institutional economics uses the concept of *externalities* to elaborate upon the complex issues relating to human and agency behavior, and inter-dependence (Kurian 2010). As an example, the rapid expansion of piped and non-piped water supply resulted in exponential rates of wastewater generation. In many instances, wastewater in a developing country context is discharged into water bodies—rivers or groundwater aquifers. Rivers and groundwater are characterized as Common Pool Resources (CPRs) because they are *non-excludable* and *non-rival* in nature. This is very much like the argument that purported that “before Chlorofluorocarbons were invented, the stratospheric ozone layer was a public good; and since it was provided by nature, there was no under-provision. Now it is a CPR, subject to human depletion” (Keohane and Ostrom 1995: 15). Public choice theory has argued forcefully that it may indeed be possible to reverse the “degradation trap” we face by designing robust institutions<sup>1</sup> that can be effectively aligned horizontally (*involving*

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<sup>1</sup>Institutions are understood here as rules covering potentially constitutional, collective choice and operational rules (Ostrom 1990).

*departments such as forestry or agriculture*) and vertically (*involving ministries such as finance or community irrigation management cooperatives*) (North 1990; Ostrom 1990). Collective action that emerges when rules are properly aligned and monitored over time and space, can result in effective management of multiple environmental resources and uses (Kurian and Dietz 2013). Robust collective action strategies in turn may advance principles of subsidiarity, accountability, and autonomy (Veiga et al. 2015).

## 2.2 Key Concepts

The nexus approach emphasizes the fact that effective management of environmental resources can in many instances necessitate the mitigation of trade-offs. For example, an afforestation program to restore soil fertility at basin scale may increase uncertainty in terms of downstream water flows. Further, increasing spatial and temporal scale may break the causality between poverty and environmental outcomes because of the amplification of effect of exogenous factors such as seasonal differences in farming practices, fluctuations in factor and product markets, and divergence in strategies of extension agencies (Kurian and Ardakanian 2015: 4–5). Some have referred to this as a Poverty-Environment (P-E) nexus (Lal 2015). Depending on the strength of the causal relationship between poverty and environment, public programs may have different impacts. For instance, a sector-wide approach assumes that the P-E nexus is strong while a budget support approach assumes the P-E nexus is weak (Dasgupta et al. 2005).

New Institutional Economics (NIE) has also been instrumental in shifting the focus away from a world of only two possibilities—centralized/hierarchically organized public sector departments and privatization of publicly owned assets with the aim of improving service delivery (Kurian 2010: 10). In this context, scholars have drawn upon public choice literature to introduce the concept of co-production defined “as a process through which inputs used to produce a good or service are contributed by individuals who are not in the same organization” (Ostrom 1996: 1074). Ostrom’s analysis of condominium sewers in Brazil illustrates issues that pertain to the role of community participation for management of environmental resources:

1. Centralizing infrastructure provision at the national level keeps local governments from access to decision-making responsibilities;
2. Excessively high engineering standards by distant bureaucracies were inadequate for bringing better services to poorer regions and neighborhoods; and

3. Citizens were themselves helpless to do anything about squalid conditions although they possessed resources like skills and time.

Co-production as a concept can help improve our understanding of the design of interventions that aim at improving delivery of public services such as irrigation or water supply. Here NIE scholars have argued that effective co-production involving public and private sectors and individual citizens can result from a multi-level and nested framework of rules (Ostrom 2009). Ostrom provides an overview of this framework by delineating four levels of rules, the proper alignment of which necessitates synergies:

1. Resource systems (*example, covering specific territory containing a water system*);
2. Resource units (*example, amount and flow of water*);
3. Governance systems (*example, organizations responsible, specific rules related to use of environmental resources and how these rules are made*); and
4. Users (*individuals, households, groups who use an environmental resource*).

A major insight offered by Ostrom's framework relates to the nesting of rules: "All rules are nested in another set of rules that define how the first set of rules can be changed" (Ostrom 1990: 51). Whenever one addresses questions of *institutional change*, it is essential to recognize the following: Changes in rules used to order action at one level (example, community water user association) occur within a currently "fixed" set of rules at a higher level (for example, constitution). Further, changes in higher-level rules are usually more difficult and costly to accomplish when compared to collective choice and operational rules.

The literature on New Institutional Economics has made an important distinction between institutional environment—policy and legal environment (*including property rights*)—and institutional arrangements. Institutional arrangements refer to access to markets, information, technology, financial resources, and skilled staff with clearly defined roles and responsibilities. The dispersion of institutional arrangements will most certainly differ across space (village, town or watershed). Here, *process variables* like connectivity to critical infrastructure such as roads, power or internet or motivated agency staff may mediate access to institutional arrangements. Interestingly, realization of higher order service outcomes like delivery of affordable and reliable water/wastewater services are often mediated by market forces. In this context, availability of disaggregated data can hamper planning aimed at improving access to basic services relating to water and soil resources (Kurian 2010). The big institutional question that can be posed is: How are resource allocation practices (transfers, taxes, tariffs, and functions and functionalities) advancing optimization of environmental resource use? An examination of this question has implications for design of research covering methods for data

generation, collection, sharing, analysis, decision-making, and coordinated action (Kurian and Turrall 2010). This is why transdisciplinary methods offer a number of benefits, an issue we examine in greater detail in the ensuing discussion.

### 2.3 *Studying the Nexus: The Role of Transdisciplinary Methods*

“Transdisciplinarity is used for research that addresses the knowledge demands for societal problem solving regarding complex societal concerns” (Hirsch Hadorn et al. 2006: 122). Because the nexus approach to the management of environmental resources typically includes such complex, inter-dependent processes and approaches to problem solving, transdisciplinary methods can assist with advancing the nexus approach and bridging the gap between science and policy.

Transdisciplinarity is characterized by crossing disciplines, scales, boundaries, and geographies as well as sectors, space and time. “As the prefix *trans-* indicates, *transdisciplinarity* concerns that which is at once *between* disciplines, *across* different disciplines, and *beyond* all disciplines. Its goal is understanding the present world and the unity of knowledge” (Bertea 2005: 6). Compared with other forms of research methods, such as interdisciplinarity or multidisciplinary, transdisciplinarity introduces a new openness and coordination between hierarchical levels of science and sources of knowledge, including institutional perspectives (Max-Neef 2005). In this way, as argued by Bertea, transdisciplinarity moves beyond specialization in isolation, also hyper-specialization (disciplinarity), multiple disciplinary perspectives of a given theme (multidisciplinarity), and hierarchical research coordination (interdisciplinarity). It rejects an artificial separation of knowledge, instead permitting a holistic assessment (Bertea 2005) that is reflective of reality<sup>2</sup> and integrates rational thought (the true or false paradigm) with relational thought (the right or wrong paradigm) (Max-Neef 2005; Lang et al. 2012). Additionally, transdisciplinary research helps with giving structure to complexities of societal challenges by considering four levels of knowledge/evidence in both their horizontal and vertical interrelations and interdependencies. These levels consist of the following: (1) The empirical level (what exists), (2) The pragmatic level (what is possible), (3) The normative level (what is desired/needed), and (4) The purposive/value level (what should be done and how) (Hirsch Hadorn et al. 2006; Max-Neef 2005).

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<sup>2</sup>Reality includes a reflection of the diversity, complexity and dynamics of related processes, as was highlighted by Hirsch Hadorn et al. (2006).

In doing so, transdisciplinary methods attempt to overcome hierarchies of knowledge, fragmentation, and silo mentalities. This has also been emphasized by Gibbons et al. (1994: 163), who proclaim: “Though scientists remain the driving force in proposing areas for research, the research priorities will be generated within hybrid fora composed of many different actors”.

Any research process that engages actors from various backgrounds (scientists, policy makers, practitioners, civil society, etc.) and subsequently competing interests, approaches, and methods, must address a number of challenges throughout the research process. Brandt et al. are among those, who have identified key challenges that may jeopardize the success and impact of transdisciplinary research. Points of friction may arise from a lack of coherent research frameworks, non-integration of diverse methods, differences concerning research and knowledge production processes, as well as the nature of involvement of non-scientists, such as policy makers or practitioners. Additionally, the generation of impact is hampered by the lack of platforms for publication of results, both in the field of science and practice (Lang et al. 2012).

The abovementioned challenges to employing transdisciplinary methods bear certain implications for research that advances a nexus approach to the management of environmental resources. As Lang et al. concluded, a structural change enabling transdisciplinary research is a crucial step toward increasing collaboration, integrating the best available knowledge, and co-producing knowledge that offers solution options to real-world problems (Lang et al. 2012).

By taking a problem solving, collaborative approach attitudes may be transformed, competences, capacities and ownership developed, institutions reformed, and technologies developed (Hirsch Hadorn et al. 2006). This also involves depicting knowledge sites (e.g. local or scientific knowledge), different policy cultures as well as their interactions and power relations with regard to the production of knowledge and consequently the participation of relevant stakeholders (Gibbons et al. 1994; Pohl 2008; Lang et al. 2012; Jahn 2008). “We need to focus on the quality of the engagement process, and move away from reliance on using a science disciplinary filter to judge the quality of the information or knowledge we use” (Apgar et al. 2009: 269). By extension, this assertion raises questions as to where knowledge is situated and, subsequently, stimulates debates concerning social accountability frameworks and feedback loops, including social learning, environmental management, and participation.

By employing a hybrid form of research that is based on mixed methods, complex societal problems can be addressed more coherently. Transdisciplinary methods, thus, constitute a key step toward providing a more complete evidence-base when addressing nexus challenges. Most importantly, it forces researchers and other stakeholders involved in the process to look beyond their own interests and instead to rethink their approaches to knowledge generation, problem solving, social learning (especially between those involved), and means of communication.

### 3 The Nexus Approach to Management of Soil, Water and Waste Resources: What Lessons from Case Studies?

#### 3.1 Case Study 1: Soil and Water Conservation in Laos<sup>3</sup>

##### 3.1.1 Introduction

In recent years, significant reductions in levels of poverty in Vietnam, Lao PDR, and Cambodia have been accompanied by a shift toward market and trade liberalization (Kurian and Lestrelin 2004). Fallow periods under traditional slash and burn system of cultivation have been shortened as a result of changes in land tenure policies (Evrard and Goudineau 2004). One particular policy of relevance to the discussion relates to Article 17 of the Land Law of Laos. Article 17 stipulates conditions for allocation of land to farmers, but does not make allowance for individual family size. The decline in fallow periods however has increased weed infestation, heightened labor requirements, and intensified tillage practices in upper catchments of the Mekong river basin. The transformation of the slash and burn system has exacerbated soil erosion and reduced soil fertility and crop yields with adverse consequences for livelihoods of poor farmers in upper catchments (Roder 1997; MRC 2003). This case study, by reporting on the findings of the Management of Soil Erosion Consortium (MSEC) research project that aimed to identify technical options for soil conservation, focused on two research questions: (1) What are the potential socio-economic impacts of adoption of alternative soil conservation practices and management systems in the Mekong river basin? (2) What are the policies, legal, and organizational constraints to adoption of alternative technical options for soil conservation measures?

##### 3.1.2 Ex-post Evaluations: The Role of Transdisciplinary Methods

It is important to understand the relationship between human behavior (e.g. *land use, payments for services, crop or technology choices*) and their impact on the condition of environmental resources (*water, soil, waste*). Analysis of MSEC experimental field trials revealed that farmer adoption of technical options such as *improved fallow*<sup>4</sup> were yet to take place. We argued instead that preliminary results of studies on crop yields and soil and nutrient loss, when analyzed in tandem with results of studies on cost-benefit and crop production, can highlight potential for

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<sup>3</sup>See Kurian (2010) for more information on this case study.

<sup>4</sup>Improved Fallow (IF) option includes planting of pigeon pea and croton seeds in plots of annual crops like maize, Job's Tears and upland rice to enrich the poor bush fallow with additional biomass, early ground cover and extra litter to improve soil and suppress weeds in a short period (De Rouw et al. 2003: 17).

technology adoption by farmers (Kurian 2010: 198). We argue that the absence of data on actual adoption rates should not prevent attempts to understand the *potential* for technology adoption.

Studies on technology adoption based on time series data may improve our understanding of biophysical processes (erosion, nutrient load) but does not necessarily enrich our understanding of institutional factors that mediate technology adoption by farmers. Scott rightly points out, “schemes for introduction of new crops such as cotton, tobacco, groundnuts and rice as well as plans for mechanization, irrigation and fertilizer regimes were preceded by lengthy technical studies and field trials. Why, then, have such a large number of these schemes failed to deliver anything like the results foreseen for them” (Scott 1998: 288)? Scott suggests that the failure lies partly in the obsession with data generated by a narrow, experimental, and exclusively quantitative approach that drives out other forms of local knowledge and judgment posed by cultivators (Kurian 2010).

We envisage three particular benefits of prospective studies in supporting transdisciplinary approaches to bridging the science-policy divide. First, social learning based on consultations with farmers’ groups and field staff of parastatal agencies could enhance processes of information exchange, capacity building, and project cycle management (Biggs and Smith 2003). Second, even as technology development gathers pace, a number of institutional issues related to labor availability for farm operations and access to markets for agricultural inputs and commodities are flagged. Finally, a methodology that incorporates perspectives on distribution of costs and benefits of technology adoption among farmers of differing class and gender categories could highlight pro-poor impacts of technology adoption across different spatial and temporal categories (Kurian and Dietz 2005).

In our analysis of soil conservation in the Mekong river basin, we found that it was imperative that we measured gross margins and costs that farmers experience from crop production under a given set of technological practices. In our case study location, we found that farmers do not incur costs on fertilizers and transportation. Therefore, gross margins we ascertained were most likely influenced by per ha yields and labor costs. Others have pointed out that daily wages for agricultural labor are normally paid at the rate of 4–6 kg of rice plus free meals (Roder 1997: 4). Therefore, in calculating labor costs, we assumed that every employable member of a household would offer his or her services on farms of at least three households. Depending on family size of the household hiring out labor, the same household can expect to receive three times the same number of labor to help with farm operations. This figure when added to the number of members of employable age in the household would give us the total number of laborers available to perform farm operations free of charge. We assumed that every additional laborer required would incur a wage of US\$1.50 per day.

Transdisciplinary perspectives also influenced our approach to calculating yields for Job’s Tears under the improved fallow system. In this case, we allowed for a 20 % increase in per ha yields over the slash and burn system for plots in higher reaches of the catchment, a 30 % increase for plots in the middle reaches of the catchment, and a 40 % increase for plots in lower reaches of the catchment. These

categories fit well with the range of figures of yield increase for Job's Tears as reported by agronomic studies in Houay Pano catchment (see De Rouw et al. 2003). Potential constraints to generating gross margins were size and quality of farm plots, quality of output (*for example rice or Job's Tears*), and differences in price received by farmers for sale of agricultural crops.

Our analysis of food security benefited from nutrition studies in Lao PDR. We found that an average person would consume 535 g of rice daily yielding approximately 1900 kcal, which gives a 90 % adequacy of daily intake (Aree et al. 2003: 10). Sen (1999: 81) makes a strong methodological case for assigning evaluative weights to different components of quality of life (forests, soils or household incomes) and then to place the chosen weights for open public discussion. Others emphasized the need to examine issues of intergenerational equity in tandem with generating and analyzing data on biophysical change to understand potential for farmer adoption of alternative technologies and management practices (see Dasgupta et al. 2005). Based on group discussions, we found that balanced nutritional requirements come normally from consumption of vegetables, crabs, rats, and forest products. The population at the study site consumed meat, eggs, and poultry products less frequently. By combining information on household size with 1999 market price for a kilo of rice, we calculated household food requirements. We then calculated the extent to which gross margins derived from sale of Job's Tears would meet household food sufficiency requirements of poor households.

We found that on average, each household comprises three members of employable age. The availability of members of employable age within households is crucial in determining potential for cultivation of commercial crops like bananas and pineapples. In the case of pineapples, two years after initial planting the crop is available for harvest annually in August. However, since the weeding operations for pineapple coincides with similar operations for rice, Job's Tears, and maize, there is intense demand for farm labor. Most households prioritize achieving household food security based on production of rice and maize or sale of Job's Tears to purchase food items. On average, we found that each household could sustain its food production from domestic production for up to nine months. Therefore, using nine months as an average, we found that about 30 % of households did not meet the average figure and we classified them as food insecure.

### 3.1.3 Issue of Trade-Offs in Management of Soil Resources

Erosion rates are higher especially for short rotation systems under the traditional slash and burn agriculture system practiced in large parts of the Mekong river basin. Interestingly, agronomic studies in our study area revealed that although erosion rates were highest under the slash and burn system, crop yields were highest under this system, averaging between 1900 kg per ha for rice and 1400 kg per ha for Job's Tears. By contrast, crop yields of Job's Tears under the improved fallow system (*known to lower erosion rates*) averaged only 400 kg per ha (Kurian 2010: 202). Another alternative to the slash and burn system, known as mixed cropping of Job's

Tears and Pigeon Pea (*with no tillage*), caused a yield reduction of between 26 and 53 % (De Rouw et al. 2003). This analysis highlights the importance of trade-offs between efficiency and conservation that operates at the plot or farm scale.

Transdisciplinary research approaches improve our understanding of trade-offs in environmental management. We found in our discussions with farmers the importance of topographic features like slope and soil erosion in influencing crop yields on individual plots. For example, on erosion plots that are located on steep plots, Job's Tears yields were more likely to be in the range of 400–500 kg per ha under the slash and burn system. Job's Tears yields under the slash and burn system were likely to be still lower and in range between 200 and 300 kg per ha respectively on erosion prone plots that are located on land with moderate to lower slopes. Therefore, an improved fallow system has the potential to increase per ha agricultural yields on erosion prone plots with diverse slope characteristics (Kurian 2010: 204).

Improved fallow system has the potential to improve per ha yields and gross margins from production of Job's Tears. However, another trade-off needed examination: Would improved fallow be socially and politically acceptable as a technological alternative? In other words: 1. How would adoption of improved fallow technology affect the distribution of gross margins from production of Job's Tears among different categories of farmers and 2. How would adoption of improved fallow technology affect food security among different categories of farming households? It was revealed that farmer adoption of improved fallow technology had the potential to reduce levels of income poverty. Gross margins from production of Job's Tears increases by US\$73 and US\$33.20 for middle and low-income households respectively. As a result, the number of farmers in the low-income category declines since gross margins from production of Job's Tears using improved fallow has the potential to move them into a middle-income category. Transdisciplinary approaches to data collection and analysis revealed that for households most likely to improve their food security, intra-household decision-making related to food and expenditure patterns would ensure that benefits would be distributed more evenly irrespective of gender or age status.

### **3.1.4 The Institutional Environment and Scope for Synergies in Environmental Management**

Transparent policy processes as reflected in information exchange between MSEC scientists and field staff of parastatals were assumed to have an important influence on farmer adoption of alternative practices at different scales: experimental plot, farm, catchment, watershed or river basin. The predictability of the legal and policy framework as reflected in, for instance, stability of market prices for some crops or flexibility of land-tenure reform process could also influence farmer adoption of alternative practices. The sensitivity of cropping patterns to changes in market prices was evident, for example in the 1990s, when the decline in price of coffee on the international market resulted in a sharp decline in the area under coffee cultivation in Luang Phabang from 313 ha in 1990 to 90 ha in 2000 (State Planning

Committee 2000). It is also important to recognize that fluctuation in export volumes of agricultural crops has been accompanied by a steady devaluation of the Laos currency (*Kip*) against the US Dollar between 1999 and 2004.

Our case study revealed the importance of institutional environment (*policy and legal framework*) and institutional arrangements (*markets, labor, land*) in influencing environmental management (Kurian 2010: 205). With regards to institutional arrangements, three factors were highlighted by our analysis.

1. Rigid land tenure reform process apparent from Article 17 of the Land Law makes no allowance for changes in plot size due to population growth. Rigidity of the land-tenure process constrains farmers from benefit of the potential yield increases offered by alternative technological practices.
2. Poor access to information on sources of good quality seeds affects quality of crop production reflected in different prices that farmers received for their output. Further, inaccurate information on market conditions was responsible for government extension workers persuading farmers to cultivate Job's Tears as a cash crop. However, prices fluctuated due to regional constraints as private companies reneged on their purchase agreements with farmers. This left farmers with insufficient cash to make food purchases.
3. Technical capacity of the government extension agencies and departments affected the quality and reliability of advice farmers received on seeds and crop varieties. Limited access to nationwide data sets on issues such as trends in land cover change limited the capacity of local government departments to identify resource management priorities and plan future investments.<sup>5</sup> Adequate staffing levels were another issue that constrained the ability of government departments in undertaking effective management of environmental resources.

## 3.2 Case Study 2: Wastewater Reuse in Peri-Urban Agriculture in India<sup>6</sup>

### 3.2.1 Introduction

One of the consequences of urbanization is land modification. Land modification combined with gradient dynamics, can alter the intensity and direction of water flows in urban areas. Wastewater usually enters storm drains, and rainfall variability can result in increased frequency, intensity, and duration of storm drain overflows. Inadequate source separation of domestic wastewater from rainwater and solid

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<sup>5</sup>The issue of data—its generation, collection, aggregation and analysis—is extremely important in framing of policy-relevant dialogue, an issue we discuss in greater detail in Chaps. 3 and 4.

<sup>6</sup>See Kurian and Dietz (2013) for more information on this case study.

waste followed by necessary treatment can result in transport of contaminants into surface and groundwater sources that are important sources of water supply (Kurian and McCarney 2010). Over time, with deposition of solid waste, storm drains can silt up with consequences for public health because of mosquito breeding due to stagnant water, inundation of low-lying slum localities, and destruction of crops under peri-urban agriculture. However, on the flip side, when wastewater is better managed, significant economic benefits can be derived through reuse that advances multiple uses of environmental resources in sectors as varied as agriculture, poultry rearing, and homestead gardens (Jimenez and Asano 2008).

Double cropping and lower input costs for agriculture could be some of the direct benefits of wastewater collection and reuse (Rijsberman 2004). There could also be important economy-wide benefits of supporting freshwater swaps through use of treated domestic wastewater for agriculture. Source sustainability of urban water supply could be enhanced, agricultural productivity may increase and farm incomes can rise. However, climate-induced risks posed by variability in climatic, soil, and groundwater conditions can influence biophysical processes (*example, material flows*) and potential for cooperation thereby impacting upon realizations of hypothesized benefits.

This case study reports on the findings of a secondary review of 121 towns in India combined with a case study of a small town in the 0.2–0.5 million category. The study posed three key questions: (1) What are the economic benefits and costs of wastewater reuse in the context of hypothesized links to climate variability. (2) What is the role of local farming practices, market conditions, and crop variety in influencing wastewater reuse in agriculture? (3) What is the role of inter-governmental financing in influencing selection of technical adaptation options for collection, treatment, and disposal of wastewater?

### **3.2.2 The Idea of Risks for Wastewater Management in Urban Agriculture**

Wastewater reuse for irrigated agriculture has often been viewed as a pathway to advance the nexus approach to management of environmental resources—water, soil, and waste. However, climate, market conditions, and technical options can seriously affect the translation of potential into actual economic benefits. A serious examination of inter-dependencies in resource use patterns cannot overlook sanitation challenges in peri-urban regions, public health risks, economic value of wastewater, and variations in climate. This case study based the assessment of wastewater reuse for peri-urban agriculture by considering off-site sanitation options (Kurian and Dietz 2013):

- Eco-san: Composting toilets with/without urine diversion;
- Settled sewerage: Involving sewer system receiving solids-free effluent from a septic tank, secondary wastewater treatment, and effluent reuse in aquaculture, agriculture, and horticulture; and

- **Simplified sewerage:** Systems receiving unsettled domestic wastewater. Simple junction boxes are used rather than manholes thereby reducing unit costs of systems.

We consider urbanization, notably growth of small towns in peri-urban regions, to be an important policy consideration, especially in developing countries and emerging economies. In light of rising population densities in peri-urban regions with adoption of simplified sewerage systems, a 20–50 % cost reduction may become possible when compared to conventional sewerage. Simplified sewerage offers benefits in the form of simpler technologies, lower unit costs, possibilities for wastewater reuse, scope for cost-recovery, and possibility to do away with on-site water supply for flushing of toilets. However, it is important to note that citizen participation combined with political support from mayors and public sector agencies is crucial for adoption of simplified sewerage technologies (Allen 2010).

Climate variability poses new challenges to advancing wastewater reuse schemes in peri-urban regions. Regional climate change scenarios predict major shifts in climate zones, although with much uncertainty about regional specificities (Kurian and McCarney 2010: 50). Where shifts are predicted from sub-humid to semi-arid conditions, particularly in areas with a dense population and intensive water demands, major problems can be expected (Dietz et al. 2004). However, what is more disturbing is the temporal aspect. All climates have an element of variability: between seasons, between night and day, between quiet and stormy conditions. Seasons are changing and variability is becoming more extreme the literature suggests. Periods of drought are feared to happen more often, but particularly periods of extreme rainfall and storms are likely to increase, and become more extreme, with a higher concentration of rainfall in fewer days (or hours). From a nexus perspective, these trends could imply the need for adaptation mechanisms to cope with lower predictability and more extremes. Adaptation could mean a shift to more water sources, from a wider geographical environment (*more inter-dependence*). What institutional and technical mechanisms are available to predict and respond actively to risks posed by climate-change?

There are a number of risks associated with considering reuse options for off-site sanitation in urban areas. Three main reuse risks include: (1) pathogen transfer through contamination of groundwater based water supply sources, (2) pathogen transfer through contamination of food chain-crop quality, and (3) pathogen transfer through disposal of untreated wastewater into rivers. The 2008 revised World Health Organization (WHO) guidelines identified indicators for environmental, soil, and geo-hydrological parameters that address various reuse risks from water source to waste disposal. An attempt was made to identify reuse possibilities together with associated risks for a range of agro-climatic contexts, including high or dry regions. The WHO guidelines identified parameters for monitoring water quality depending on type of use (water for drinking or irrigation) and by levels of crop resistance to effluent pollution (WHO 2008).

### 3.2.3 Making Trade-Offs Explicit to Promote Accountability for Wastewater Collection, Treatment and Disposal

#### Rationale for Wastewater Reuse in Indian Context

Land area devoted to wastewater farming in India is estimated between 6900 and 100,000 ha (Scott et al. 2000). Apart from reducing water scarcity, especially in drought prone areas, wastewater could be highly beneficial for agricultural purposes due to its high nutrient concentrations. This nutrient value with proper management can be transferred to crops and reduce the application of fertilizers. Revenues generated by farmers could then be used to treat wastewater to mitigate its negative health impacts. Given the magnitude of wastewater generated, the extent of area irrigated could be more than 1.2 million ha in all class I cities and more than 0.35 million ha in cities with populations between 2 and 5 hundred thousand. The total revenue generated with proper water pricing (*water + nutrient value*) is US\$48 and US\$14 million respectively, for the two categories of towns (Kurian and Dietz 2013: 51).

The health risks involved for humans and livestock and the returns from crops make it disadvantageous, especially in comparison to crops grown under open well or river/tank/canal irrigation. This case study revealed that wastewater irrigation is characterized by low investment, low yields, and lower market price. Due to the higher nutrient value of wastewater, farmers do not apply pre-sowing fertilizer, which results in savings of approximately US\$10 per ha (Kurian and McCarney 2010: 55). On the other hand, average yield under wastewater irrigation is lower by about 7 quintals per acre. This factor coupled with a lower market price for paddy cultivated using wastewater results in gross returns that are lower by approximately US\$200 per acre. However, our case study revealed that better management of wastewater can improve returns by approximately six times based on the ability to double crop and lower expenses on pesticides.

#### Implications for Policy: A Normative Focus

Public choice theory has emphasized that if sufficient autonomy is granted to local authorities, it may be possible to deal with the challenge of cost-recovery by mobilizing local finances and skills to address regional environmental challenges like wastewater pollution of rivers. However, on the contrary when central fiscal transfers do not allow for sufficient autonomy, it may be difficult to hold local authorities accountable for their revenue and expenditure practices (Veiga et al. 2015). For example, our case study revealed that when the local government at our study site was presented with technical options ranging from oxidation ponds (*with highest cost-benefit ratio*) to up flow anaerobic sewage blanket (UASB—*lowest cost-benefit ratio*), the authorities chose the UASB option. This was because central funds were readily available for its construction. Central transfers will only encourage dependence of sub-sovereign entities without emphasizing a search for

cost-effective and efficient means of service delivery as long as central transfers are not tied to accomplishment of policy outcomes like connection of poorer households to a sustainable source of water supply or connection to a sewer network (World Bank 2006).

A search for sanitation options that promote pollution prevention rather than control, waste separation at source rather than end-of pipe treatment, and reuse of valuable nutrients rather than wasting by discharging into the environment can be supported by greater accountability in allocation of fiscal resources. In peri-urban regions, source separation of urine and rainwater are known to have the best prospects for improving water management (Wilsenach 2006). Urine separation could improve the efficiency of treatment processes, which would support the philosophy of “closing the loop” and recovery of nitrogen and phosphorous. Another futuristic option is to promote separation of feces where full separation occurs at the source through separate collection, handling, and treatment of yellow, grey, and black water. The wider applicability of this approach in developing countries remains to be seen. In institutional terms, the challenges that arise in developing countries could relate to the following:

- Identifying norms that would facilitate integration of water resource management from source to reuse by addressing issues of sectoral water allocation.
- Identifying norms for costing of water supply and sanitation interventions that would reflect the costs of separating waste at source.
- Identifying norms for billing of water supply and sanitation services, especially in contexts where multiple service providers from public and private sectors are involved (Salome 2010).

### ***3.3 Case Study 3: Collective Action for Watershed Management in India<sup>7</sup>***

#### **3.3.1 Introduction**

The Shiwalik hill forests comprising approximately 6.5 % of the land area of the North Indian state of Haryana perform an important ecological function of mitigating the effects of soil erosion. Open cattle grazing and fuel wood collection by local communities had endangered the soil erosion function of the Shiwalik forests. Forest degradation was manifested in the increasing rate of siltation of the Sukhna reservoir in the state capital, Chandigarh (Arya and Samra 1995). The reservoir was an important source of tourism revenue and analyses indicated that the source of the risk lay in rapid deforestation of the catchment areas located in proximity to the village of Sukhomajiri (Dhar 1994: 20).

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<sup>7</sup>For more information on this case study, refer to Kurian et al. (2013).

A community-based forest management initiative that involved construction of water harvesting dams to arrest movement of silt was initiated. However, when villagers destroyed check dams that were constructed and continued to open-graze cattle in the forests, a substantive dialogue was initiated that resulted in usufruct sharing agreements between the forest department and local communities (Hill Resource Management Societies (HRMS)). The usufruct sharing agreements that initially covered fuel wood, fodder, and fiber grasses was later extended to include water from dams constructed by the Haryana Forest Department (HFD) with in-kind contribution of labor by the HRMS. The dams, by providing supplemental irrigation for the winter wheat crop, proved a powerful incentive in encouraging forest dependent communities to change their behavior from open grazing to stall feeding of livestock (Grewal et al. 1995). Multiple benefits emerged as a result of the Sukhomajiri model: increased fodder production on private fields and increased production of cattle dung used as cooking fuel in the area. As a result of increased production of fodder grass and cattle dung, a dramatic reduction in open cattle grazing and harvesting of fuel wood from forests was noticed, which in turn lead to forest regeneration and lower levels of soil erosion.

The case study that follows describes the importance of higher-order institutional rules in shaping environmental outcomes. More importantly, the case study is the first of its kind because it adopts a longitudinal approach to study the effect of institutional change on environmental management. By combining a survey approach with a comparative case study, the methodology adopted by the study emphasizes the importance of quantitative and qualitative approaches and its implications for benchmarking strategies that attempt to examine organizational performance.

### **3.3.2 Synergies Foster Collective Action Between Government and Community Organizations**

#### **Institutional Environment**

Community-based forest management in the Shiwalik hills is not insulated from wider political economic trends occurring in Haryana in particular and India in general. Three trends are important. First, because of a secular decline in returns from pursuing a purely agricultural-based livelihood strategy, there has been a marked integration of farming populations in markets for non-farm labor and dairy products (Bhalla 1999; Varalakshmi 1993). Others have pointed out that given cultural norms in the region that prevent women from engaging in non-farm labor, women's workload in the domestic economy would have most likely risen to compensate for time spent away from the settlement by male members of households on account of their engagement in non-farm employment (Agrawal 1997). Second, imported paper and pulp have depressed demand for fiber grass sourced from the Shiwalik hill forests as a result of a larger trend of removal of import controls following the liberalization of the Indian economy (Kurian 1998). Finally,

in response to growing profits of community-based forest management cooperatives fiscal mechanisms have become regressive (Kurian and Dietz 2007).

### Public Auctions as Instrumental Basis of Co-production Contracts

The notion that public auctions could facilitate greater transparency gradually led the HFD to introduce auctions for sale of forest produce and rights to distribute water from earthen dams. Over time, a pattern evolved whereby contractors from outside the village bid higher than the HRMS at public auctions. Villagers preferred that contractors from within their village purchase rights to forest products and water distribution although no restrictions were placed on participation of outsiders. This preference is linked to their perception that a contractor drawn from within the village would be sensitive to individual household requirements for forest products and would likely accept instalment payments for services rendered. Further, local contractors were more likely to invest a share of the proceeds from sale of forest and water products in maintenance of the dam itself and indulge in gift giving in the form of donations to repair local schools and temples (Datta and Varalakshmi 1999: 117).

### Infrastructure, Decision-Making and Accountability

The success of the Sukhomajiri project provided the HFD with the legitimacy it needed to go on a dam construction spree. Between 1985 and 1998, 45 water-harvesting dams were constructed in the Pinjore forest division. Lower level functionaries of the HFD exercised considerable discretion over decisions regarding design, operation, and maintenance of the earthen dams. In many cases, faulty design was overlooked to justify expensive repairs to parts of the dam that were washed away in the rains. The institutional framework encouraged collusion because villagers desired a share of the spoils of public investment, which took the form of provision of wage labor for dam construction and contract awards for specific tasks such as transport of distribution pipes from government warehouses to dam sites. However, in response to rising costs of infrastructure construction and evidence of rent-seeking behavior by field staff, the HFD resorted to public auctions whereby the highest bidder would be granted contracts for specific tasks.

## ***3.4 Synergies for Community-Level Collective Action: The Role of Ecology, Power and History***

In 2000, we undertook a survey of 28 community-based watershed management groups known as HRMS responsible for management of 45 earthen dams. Our survey revealed the complicity of the HFD in the faulty infrastructure design, which

resulted in only 17 % of the dams functioning to their lifetime capacity of 20 years (Kurian and Dietz 2007). From a collective action perspective, we found that of the eight HRMS with functioning dams, those groups that exhibited successful cooperation were the ones characterized by heterogeneity in asset distribution and a higher interest in CPRs on account of: lower aggregate engagement in non-farm labor markets and limited access to private tube wells. To explore the relationship between group composition and collective action, we undertook a comparative case study of Bharauli and Thadion HRMS. The key findings of the study were as follows:

1. Land ownership, hierarchical social relations and labor market structure

Bharauli is a village with 80 households while Thadion is a village with 50 households. Delicate power relations are evident in Bhrauli because it is a multi-caste village with a skewed pattern of land ownership. Hierarchical social relations are reflected in occupational specialization and segregation. In Thadion, a neighboring village, by contrast such caste-based patterns of hierarchy, social segregation or occupational specialization were absent. The structure of the labor market reinforces hierarchical social relations. For instance, landless households who work as hired labor on other people's fields or as domestic hands in the homes of the wealthy are not always paid in wages but in kind, such as food or insurance during times of natural disasters like floods. From a gender perspective, cultural norms that prevent participation of girls in the nonfarm labor market can make families with limited supply of male children highly reliant on farm production.

2. Differences in local ecology and location of farm plots

Bharauli HRMS differed from Thadion HRMS with respect to local ecology (Wade 1988). Groundwater is relatively easy to find in Thadion while in Bharauli, the groundwater table is deep. The prohibitive groundwater drilling costs increased farmers' reliance on common pool resources in Bharauli where farmers also had access to kuhls for land irrigated by the dam. However, the kuhls run dry by early February and, if rains do not arrive by early March, the supply of the last round of supplemental irrigation for wheat depends on water from the earthen dam. Reliance on water from the dam becomes even more critical if rains fail altogether. Not surprisingly, we found that average land irrigated by earthen dams is the strongest explanation for understanding the degree of variance captured by household endowment scores.

3. Previous leadership experience

Differences in caste or wealth status need not necessarily prevent groups from working together in a society that values democratic governance. For example, between 1995 and 2000, the water contractor (farmer Y) was the Sarpanch (chief) of the Bharauli local government. He had developed experience successfully leading a disparate group of people drawn from the different caste groups. Although caste rules prevented groups from inter-marriage or sharing of public space, they were fully capable of collaborating based on common but secular interests.

In 2008, we returned to our study site to examine how collective action had evolved over an eight-year period since our initial study. We found that as a result of several years of failure to promote collective action, the dam in Thadion had silted up and resource users had moved toward private water provisioning from tube wells. On the other hand, we found that collective action for dam management had continued in Bharauli. In the ensuing discussion, we adopt a longitudinal approach to examine the institutional basis of effective leadership and its role in delivering irrigation services.

Our longitudinal analysis of collective action for irrigation management points to three conditions of successful leadership:

1. Moral basis of power and authority

An accurate description of power sources emerges when caste status is examined in the context of wealth differentials. Wealth ranking discussions revealed that irrigated land was considered a source of power. Interestingly, when we considered other factors such as land size or ownership of tractors, we were able to identify a different sub-set of individuals within the group. However, when we ranked households based on the composite endowment index that we developed, we were able to identify the water contractor as a powerful individual. He managed the largest acreage of irrigated land, owned a tractor, and possessed a small family, which implied fewer mouths to feed and potential to retain a large grain surplus that could be sold in local markets. Land sub-division at the time of marriage of male children has the potential to reduce levels of household wealth. However, the absence of male children in his family posed no secular threat to household wealth. Our focused group discussions revealed the contractor to be a benevolent patron despite his ability to control access to credit, land, and labor in the village.

When crops failed due to pests or drought, the water contractor has traditionally been a source of credit at times. He also is known to provide loans for weddings, thereby cementing his position in the moral economy of the village. In the past, when loans were not repaid on time, the ownership of land that was pledged as collateral was transferred to the water contractor after allowing for a sufficient grace period. During harvest periods when family labor is insufficient to perform harvesting and threshing tasks, labor from landless households is hired. Laborers are not always paid in cash. Our longitudinal analysis revealed that eight years later the same conditions of in kind payments for labor contributions was retained.

2. Political factions

In 1995, the water entrepreneur did not own the largest area of land in the village. That distinction belonged to another powerful person in the village, farmer X, who represents a powerful political faction. Political factions in the village are typically represented by members of the extended family of the patron (brothers, cousins) and clients (landless laborers). There are complex social norms that dictate behavior within factions. For example, an unwritten rule during a water auction is that members of a particular faction will not

compete once one of their members has decided to place a bid. Farmer X dominated politics in the village prior to arrival of irrigation in the village and he served as liaison with local government. There was intense jostling among farmers to get irrigation to their fields. While allowing for constraints imposed by topography, when the pipes were finally laid, the water contractor had the largest acreage under irrigation in the village. Farmer X, with the larger family and more mouths to feed, was no longer in a position to exercise his power as he once used to do. Power had shifted gradually to a new political faction led by the water contractor. Incidentally, the two entrepreneurs who attempted a leadership role but failed in 2004, did not belong to either of the two political factions in the village.

### 3. Calculus of profit

Our revisit in 2008 revealed that de-silting of the dam pondage area was a pressing requirement. However, the important question that arose in this context was what type of contract form (*group provision vs. entrepreneur*) was better placed to bear the political risks associated with required tariff increases to facilitate adaptive environmental management. The combined effect of increasing group size (*facilitated by land fragmentation*) and lower tariffs (*shaped by emergence of countervailing forces within HRMS*) has potential to alter the “threshold of entrepreneur led collective action.” The threshold is a function of: (1) marginal revenue derived from extending the irrigation network to accommodate new resource users who are paying a reduced tariff, and (2) availability of public subsidies that would enable the entrepreneur to retain the possibility of making a profit while charging poor consumers a lower tariff and undertaking de-silting of the dam pondage area.

### 3.4.1 The Usefulness of Transdisciplinary Methods

Our use of mixed methods advances transdisciplinary methods because: the composite index of interest and endowments based on food security assessments constitutes an improvement over single metric measures (*land and income*) of wealth distribution while allowing for benchmarking and comparisons over time; and forest vegetation analysis makes it possible to link dam management to condition of forest and soil resources. Such an approach is better placed to understand the institutional processes by which differential access to assets (*irrigated land, credit or labor*) at the level of individual households are translated into power (White 1989).

Power is understood here as the extent to which one could control the actions of others; from recourse to use of cultural symbols like gift-giving (Thapar 1994). Power is also exercised through patronage relations between landed and landless households that are embedded in labor-tying and informal credit arrangements that serve to insure groups against market and climate-based risks (Kozel and Parker 2003; Scott 1976).

## 4 Conclusions

At the beginning of this chapter, we pointed out that without a robust analytical framework, the science-policy divide will continue to support a disconnect between development and achievement of outcomes in terms of well-being and/or environmental sustainability. Based on the analysis undertaken of the three case studies in this chapter, we emphasize the importance of analyzing trade-offs and synergies involving different levels of government, private service providers, and communities. In this context, we underlined the principles of accountability, subsidiarity, and autonomy of decision-making. We therefore propose that the concept of co-provision can provide the basis for development of such an analytical framework that elaborates upon the following key elements (Kurian and Ardakanian 2015):

- Accountability in fiscal relations that facilitate identification of incentives for Operation and Maintenance (O&M) of infrastructure relating to water, soil, and waste services.
- Integrated analysis of *system* performance in terms of biophysical processes (e.g. *material flows*) or infrastructure operation (e.g. *dams or wastewater plants*) to cope with climate-induced risks posed by variability in climactic, soil, and groundwater conditions.
- Administrative culture and its influence on extent of discretion exercised by public officials in enforcement of rules relating to delivery of critical environmental services at different levels of government.
- Uncertainty in factor and product markets that influences incentives for cooperation in management of common pool resources.
- Contract forms that support the development of local leadership models to enforce rules for management of environmental resources.

Another major conclusion offered by analysis of three case studies relates to methodology. For the nexus approach to management of environmental resources to be advanced, it is important that transdisciplinary methods be used more widely. Combination of qualitative and quantitative methods, surveys and case studies are necessary to provide a robust analysis of the links between human and agency behavior, management regimes, and environmental outcomes. A major conclusion is that the relationship outlined above need not be a linear one (Scoones 1999). Complexity, heterogeneity, and variability characterize the relationship between biophysical and institutional domains when it comes to the nexus approach. The nexus approach could be advanced by adopting mixed methods and transdisciplinary approaches to research design, data collection, analysis, and presentation. Transdisciplinary approaches would entail finding innovative ways by which narrow disciplinary “silos” can be breached that would allow for social learning, trial and error, and incorporation of local insights in program planning and implementation. Transdisciplinary approaches would further support a rethink of the processes and structures that enable knowledge construction and dissemination with the potential to influence policy-making regimes.

The final conclusion this chapter offers is that with proper attention to evaluation design, important and generalizable principles can be gleaned from case studies of “success” and “failure” as they relate to management of water, soil, and waste resources. In Chap. 3, we discuss the role of data observatories and the potential role they can play in bridging the science-policy divide. We point out how the Nexus Observatory builds upon the principle of dispersed problem solving through access to a widespread network of project databases. Data observatories could potentially consolidate knowledge and support its translation into policy-relevant advice (Kurian and Meyer 2014). In Chap. 4, we demonstrate that the Nexus Observatory could support rapid scale up of nexus management approaches by facilitating the use of indices to advance evidence-based decision-making. Such a project would go a long way in demystifying concepts of trade-offs and synergies and provide a spatial and temporal context to application of nexus management tools to address challenges of environmental sustainability.

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Resources, Services and Risks

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