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The Water–Energy–Food Security Nexus: Towards a practical planning and decision-support framework for landscape investment and risk management

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February 2013

Written by Livia Bizikova, Dimple Roy, Darren Swanson, Henry David Venema and Matthew McCandless

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Table of Contents

Preface 1

Introduction 3

Motives and Drivers to Integrate WEF 4

International Dialogue on WEF 5

Review of Existing Water–Energy–Food Security Conceptual Frameworks 7

WEF Framework: Bonn2011 Nexus Conference 7

WEF Framework: World Economic Forum 2011 8

WEF Framework: International Centre for Integrated Mountain Development, 2012 9

WEF Review Summary 10

IISD's Water–Energy–Food Security Analysis Framework 12

Operationalizing a Planning and Decision-Support Process for Landscape Investment and Risk Management 16

Stage 1: Assessing the Water–Energy–Food Security System 16

Stage 2: Envisioning Future Landscape Scenarios 17

Stage 3: Investing in a Water–Energy–Food-Secure Future 18

Stage 4: Transforming the System 18

Conclusions 20

References 22

Preface

The concept that water, energy and food (WEF) securities are interdependent—not easily disentangled—is now part of the modern development canon. The World Economic Forum brought the issue of risk correlation between these sectors to full political attention at the Davos Summit through the *Global Risks 2011* report.

The world's poor are invariably the most threatened and most severely impacted by water, energy and food insecurity, but the risks are systemic and felt at the highest geopolitical levels as well. The World Economic Forum described the "water-food-energy" security problem as follows:

> 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.** (World Economic Forum, 2011; emphasis added)

The global resource scarcity fears that propelled the first wave of 20th century sustainable development are still clearly evident in the second decade of the 21st century. A key geopolitical (and typically narrowly focused) response to the WEF problem is the well-known "land-grab" phenomenon: the contentious issue of large-scale land acquisitions in developing countries, usually by domestic and transnational companies, for agricultural and bioenergy production, as well as access to water. Land acquisition has occurred throughout the colonial era; however, "land-grabbing" accelerated dramatically after the 2007–2008 spike in world food prices, sparking both criticisms over community disenfranchisement in the process and accolades for the agricultural productivity investments—especially in sub-Saharan Africa—regarded by many as long overdue.

Recent reviews (such as Allan, 2012; Keulertz, 2012) have emphasized that the critical asset sought in the land grab process is usually water because it is instrumental to higher land productivity. Other reviews of Foreign Direct Investment in Agricultural Land (FDIAL) have noted that local livelihoods, ecosystem services, and improved water management are typically neglected. According to Williams (2012), "FDI-induced large-scale biofuel and food crop plantations have not yet provided new farming opportunities, fair wage employment or allowed the benefits of installed agricultural water management infrastructure to be extended to displaced farmers." The critical observation is that although the potential livelihood and environmental co-benefits have not yet been realized from FDIAL, they could in principle emerge with a higher standard of investment design and management. Williams, for example, argues that a broader watershed/catchment-scale perspective is important for understanding impacts, synergies and benefits. This watershed/ecosystem approach was supported by the Millennium Ecosystem Assessment, which presented a future scenario where regional watershed-scale ecosystems are the focus of political and economic activity and allow for a strongly proactive approach to the management of ecosystems. The Earth Security Initiative has reached a similar conclusion and has noted the need to prioritize human rights and livelihoods while improving management of the landscape.

> International investments in land are firmly in the spotlight of global scrutiny, but progress depends on moving from a "land-grabs" debate to "land stewardship" solutions. This shift, which we call a *Land Security Agenda*, requires an improved understanding by investors and political leaders of three priorities: managing soil erosion, protecting human rights, and keeping within ecological—especially water—limits. (Litovsky & Villalpando, 2012, p. 2)

The emphasis on the need for a sustainable approach to land investments suggests an integrative framework to manage and govern land investments is required and that the design of such investments should explicitly take natural and social systems into account. From an investor perspective, a key hypothesis is that land investments made with broader social, environmental and economic objectives will perform better due to improved socio-ecological risk management. In this paper, we review the literature and develop a conceptual framework and offer implementation guidance for land investments that increase water, energy, and food securities, a key element of which are spatially explicit design and monitoring features to develop, implement and manage high-quality land investments.

Introduction

In recent decades, researchers and policy-makers have increasingly emphasized the importance of the complex relationships between water, energy and food (also called the WEF nexus)[1] that are often overlooked in narrowly focused actions, investments and policies. Overall, the concerns expressed in the literature emphasize the relevance of WEF linkages presently and in the future for both poor people who have limited access to water, energy and food in sufficient quality and for fast-developing regions with rapidly growing demand for all elements of WEF (Bazilian et al., 2012; Hoff, 2011; International Centre for Integrated Mountain Development [ICIMOD], 2012; World Economic Forum, 2011). While the interconnected nature of WEF has been recognized and supported by a number of examples around the globe, there is a relatively limited understanding of how to tackle these complex relationships when conducting assessments and taking action. Recently, more attention has been devoted to developing frameworks that will help in describing the linkages in the WEF nexus, as well as assisting in conducting case studies and, ultimately, identifying policies and actions. Many of these frameworks were developed through a number of international and regional initiatives in 2011–2012, especially in preparation for Rio+20 in June 2012.

The International Institute for Sustainable Development (IISD) has been engaged in research and policy development for water, energy and food security through its participation in international dialogues and commentaries. In May 2012, IISD hosted an international workshop on WEF in Winnipeg. This workshop targeted solutions for optimizing water security while maintaining a balance with aspects of food and energy security. IISD's Water Innovation Centre highlighted its work on harvesting nutrient-laden biomass for energy production while using nutrients extracted from biomass for fertilizers as a regional demonstration of the WEF nexus in practice. IISD is also engaged in identifying actions and financing to support the "triple dividend," which aims to promote food security, climate change mitigation and climate change adaptation in agriculture primarily in poor and vulnerable areas (Murphy, 2011; Parry & Boyle, 2012). Finally, in the context of future projects, the WEF approach is crucial to providing a land-use investment framework for increased food productivity, while enhancing natural and social capital as a hedge against long-term WEF security risks. We consider it critical to ground the framework in ecosystem goods and services that are crucial to ensuring food, energy and water security locally and regionally.

In order to further our work—including the practical application of the WEF nexus at the local, regional and national levels—we summarized key arguments, approaches, frameworks and lessons learned from global WEF initiatives. From this summary, we built on the information and experiences to develop a framework that would enable future developments to operationalize the WEF nexus in order to guide investment and design policies in context. This paper first summarizes key motives and drivers, initiatives and conferences on integrated approaches to the WEF nexus: it also explores suggested frameworks and their applications. We synthesize that information and present a theoretical framework with key elements and potential applications. This paper is intended to serve as a basis for discussion among experts working on the theoretical approaches and practical applications of WEF in order to gather feedback and assist in improving approaches to integrating water, energy and food.

[1] Focusing on water, food and energy security simultaneously is often referred in the literature as the water–energy–food (WEF) nexus.

Motives and Drivers to Integrate WEF

In the literature, a number of authors emphasize that the world's food, water and energy resources are already experiencing significant stress and shortfalls (Waughray (Ed.), 2011; Bazilian et al., 2012; Smil, 2000), and yet we anticipate rapidly increasing demands for these resources in the coming years (Hoff, 2011). This anticipated increase is specifically put forward in the literature in the context of growing population, increasing rates of urbanization, expanding middle-class lifestyles and diets, and overall increased demand for resources (Hoff, 2011; van Vuuren et al., 2012; World Economic Forum, 2011). That growth will come with significant challenges to security issues because the resources in the WEF nexus are fundamental to the functioning of society (Bazilian et al., 2011). Beyond focusing on the use of resources by fast-growing countries, a comprehensive approach to the WEF nexus is also important because of the need to improve the well-being of the poorest and most vulnerable populations by securing access to WEF (Bazilian et al., 2012; ICIMOD, 2012). Finally, a number of scholars point out that the challenges in balancing elements of the WEF nexus will be exaggerated by climate change and its impacts on the availability of water for drinking, food production and ecosystems, in addition to changes in energy consumption (Thirlwell, et al., 2007; Waughray (Ed.), 2011; Bazilian et al., 2012; van Vuuren et al., 2012)

When it comes to providing specific data, information and examples to support the WEF nexus, many scholars emphasize the challenges in each sector individually and in relationships within the nexus, especially water/energy and water/food. Specifically, they stress the importance of each of the elements of the WEF nexus in improving the well-being of people by addressing the following: the lack of access to clean water, globally and regionally, especially in rapidly growing areas; the lack of food security and resultant hunger; and the lack of access to modern fuels and appliances for cooking and electricity (Bazilian et al., 2012; Rasul, 2012; Thirlwell et al., 2007; van Vuuren et al., 2012). Rather than focusing on the challenges of ensuring WEF security separately as individual elements, a number of authors emphasize the interconnected nature of WEF, which results in challenges that cross two or even all three of the domains. These overlapping challenges include: the significant quantities of water needed for energy-processing activities, such as refining oil products or manufacturing synthetic fuels (Thirlwell et al., 2007; Organisation for Economic Co-operation and Development [OECD], 2006); larger amounts of water used in food production for irrigation (see e.g., Gerbens-Leenes, Hoekstra & van der Meer, 2009; Chaves & Oliviera, 2004) and for industrially produced meat (World Economic Forum, 2011); energy used in food production in post-harvest stages (Canning, Charles , Huang, Polenske, & Waters, 2010); and negative environmental impacts of deforestation, overgrazing, and (often) low-productivity agricultural methods as a consequence of ensuring energy and food (Bazilian et al., 2012).

With the recognition of the relationships among the elements of WEF, there are challenges that require considering all three elements when assessing consequences and planning for investments, policies and actions. Such cross-cutting challenges include, for example: a strong push for using biofuels, which could impact water and land availability for other purposes, especially for food production (Hellegers, Zilberman, Steduto, & McCornick, 2008; Bazilian et al., 2012); increasing need for drinking water, while water demand is rapidly expanding for food production, for energy-processing activities and for cities (Rasul, 2012; Hellegers et al., 2008); irrigable land areas using water that is important for food production and hydropower (McCornick, Awulachew, & Abebe, 2008); and increasing dependence on energy-intensive water desalination as a source of potable water and irrigation, especially in fast-growing areas (Bazilian et al., 2012).

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 allocation may easily be seen as (or actually become) a zero-sum game where intense competition for resource access can easily become conflict.

TABLE 1. REVIEW OF WEF SECURITY NEXUS

Food security	The elements of food security are: (1) **food availability**: influenced by production, distribution and exchange of food; (2) **access to food**: including affordability, allocation and preference; (3) **utilization**: nutritional value, social value and food safety (4) **food stability** over time (see e.g., Ericksen, 2008; Schumidhuber & Tubiello, 2007).
Water security	The elements of water security are: (1) **water access**; (2) **water safety**; and (3) **water affordability** so that every person can lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced (Global Water Partnership, 2000).
Energy security	The elements of energy security are: (1) **continuity** of energy supplies relative to **demand**; **(2) physical availability of supplies**; and (3) **supply sufficient to satisfy demand at a given price** (Department of Energy & Climate Change [DECC], 2009; International Energy Agency [IEA], 2001).

International Dialogue on WEF

In order to advance the notion of the WEF nexus, a number of global and regional conferences, workshops and meetings were held in 2011–2012, especially during the preparation phase for Rio+20 in June 2012. An overview of these initiatives is listed in Table 2. Conferences and workshops that focused on elements of the WEF nexus at the global level included: 6th World Water Forum, Bonn 2011 Nexus Conference, World Congress on Water, Climate and Energy, and Water–Energy–Food Security: New Challenges and New Solutions for Water Management. At the regional level, gatherings included: the Mekong2Rio International Conference on Transboundary River Basin Management; Asian Irrigation Forum; South African Water, Energy and Food Forum: Managing the Mega-Nexus; and 10th Gulf Water Conference in Doha. The key focus of these initiatives was to promote the WEF nexus by raising awareness, emphasizing the urgency of challenges related to WEF, providing forums for international dialogue, and suggesting policy and investment recommendations.

Focus: To emphasize the urgency of taking the nexus approach, the conferences, workshops and other recent initiatives focused on the challenges of rural poor people in securing enough food, modern energy and clean water; worsening water quality in poor rural areas with significant health implications; and addressing challenges of water availability.

Policy recommendations: These frameworks cover a number of issues and provide a large range of policy recommendations. These include, for example, taking a multipurpose approach to dam development to provide water supply, energy, flood protection and economic development; enhancing the storage capacity of reservoirs and promoting transboundary data collection/sharing and governance; and identifying investments needed to revitalize private and public sector programs.

Outcomes: The outcomes also stressed the need to focus on actual actions—such as innovative solutions and investments—and resource governance, such as regional and transboundary water and land governance.

TABLE 2. EXAMPLES OF EVENTS ON THE WEF NEXUS HELD DURING 2011–2012

TITLE/NAME OF THE CONFERENCE/WORKSHOP	LOCATION
Bonn2011 Nexus Conference[2]	Bonn
Mekong2Rio International Conference on Transboundary River Basin Management[3]	Vientiane
6th World Water Forum (water, energy and food are all included in the conference's priorities)[4]	Marseille
Water–Energy–Food Security: New challenges and new solutions for water management[5]	Winnipeg
Water, Energy, Environment and Food Nexus: Solutions and adaptation under changing climate[6]	Lahore
South African Water, Energy and Food Forum: "Managing the mega-nexus"[7]	Sandton
Powering Progress Together: Forum on Energy, Water and Food[8] Forum sponsored by Shell and the City of Rotterdam	Rotterdam
Corporate Sustainability in Africa 2012: "Living in the water, food and energy nexus"[9]	Johannesburg
Water Food Energy Nexus—Blue aquaculture as an integrative part to minimize use of resources for animal and plant production[10]	Berlin
"Food Energy Water (for all)" (organized by ReSource)[11]	Oxford
Managing Water, Energy, & Food in an Uncertain World (Universities Council on Water Resources UCOWR)[12]	Santa Fe
World Water Week (theme for 2012 was water and food security)[13]	Stockholm
10th Gulf Water conference[14]	Doha

[2] http://www.water-energy-food.org/en/whats_the_nexus/bonn_nexus_conference.html
[3] http://www.mrcmekong.org/assets/Uploads/M2R-report-address-water-energy-food-security.pdf
[4] http://www.worldwaterforum6.org/en/commissions/thematic/priorities-for-action-and-conditions-for-success/
[5] http://www.iisd.org/pdf/2012/role_of_water_green_eco_rio20.pdf
[6] http://www.cewre.edu.pk/News%20&%20Events/events.html
[7] http://sawef.co.za/
[8] http://www.shell.com/home/content/future_energy/events/forum/
[9] http://www.water-energy-food.org/en/calendar/view__470/corporate_sustainability_in_africa_2012_johannesburg_south_africa.html
[10] http://www.water-energy-food.org/en/calendar/view__712/water-food-energy-nexus--blue-aquaculture-as-an-integrative-part-to-minimize-use-of-resources-water-nutrients-energy-for-animal-and-plant-production.html
[11] http://www.reversethefuture.org/resource2012/
[12] http://www.water-energy-food.org/en/calendar/view__564/managing-water-energy-_-food-in-an-uncertain-world-santa-fe.html
[13] http://www.worldwaterweek.org/
[14] http://www.gwcdoha2012.org/Conference/Agenda.aspx

Review of Existing Water–Energy–Food Security Conceptual Frameworks

Our review of the literature demonstrates a number of attempts at frameworks that define the relationships between the WEF elements and the character of potential responses within the WEF nexus. In this chapter we review some of these frameworks to help us better understand their applicability for our core interests: guiding land investments and policy development.

The overview of current and future challenges in water, energy and food security (individually and across relationships) indicates that the WEF nexus needs to be integrated and addressed in tandem to improve our knowledge of the following:

- 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 securities.

Specifically, the literature suggests that a new nexus-oriented approach is needed to address unsustainable patterns of growth (Hoff, 2011) and to proactively address the causes, rather than the symptoms, by identifying effective points for intervention in underlying structures and systems (World Economic Forum, 2011). However, an actionable framework should not only focus on WEF, but should take a holistic (rather than narrowly sectoral) approach to reduce unintended consequences (World Economic Forum, 2011) and trade-offs (ICIMOD, 2012), and generate additional benefits. It should also address other landscape elements that are directly dependent on WEF or mediate between them and human well-being, such as the diversity of natural or cultivated species.

Our literature review considered a number of published frameworks, including those by Hoff (2011), Rasul (2012) and the World Economic Forum (2011). Many of the current frameworks have been developed by academic institutions such as the Stockholm Environment Institute (SEI); International Food Policy Research Institute (IFPRI); University of Pennsylvania; University of Montreal; Stockholm International Water Institute (SIWI) and The Energy and Resources Institute (TERI); international organizations, including United Nations agencies, the World Bank and Organisation for Economic Co-operation and Development (OECD); World Economic Forum (WEF); and private entities such as the Swiss Reinsurance Company.

WEF Framework: Bonn2011 Nexus Conference

One framework relevant to our work was developed as a part of the Bonn2011 Nexus Conference on the Water, Energy and Food Security Nexus: Solutions for the green economy (Hoff, 2011).

Purpose and goals: The purpose of this framework is to represent "a new nexus-oriented approach which is needed to address unsustainable patterns of growth and impending resource constraints and, in doing so, promote security of access to basic services. It is an approach that better understands the interlinkages between water, energy and food sectors as well as the influence of trade, investment and climate policies" (Bonn2011 Nexus Conference, 2011, p. 3). The framework is centred on water supply, energy and food security, all connected to available water resources. It accounts for global trends including urbanization, population growth and climate change. Using finance, governance (i.e., enabling factors and incentives) and innovations, the goal is to promote water, energy, food security for all; equitable and sustainable growth; and a resilient, productive environment. This goal could be achieved through action fields

and specific measures by accelerating access and integrating the bottom of the pyramid (society), by creating more with less (economy), and by investing to sustain ecosystem services (environment; Figure 1). Hoff (2011, p. 5) also suggests specific measures to support the transition to sustainability by reducing trade-offs and generating additional benefits that outweigh transaction costs associated with stronger integration across sectors required for taking the WEF approach.

Policy recommendations/relevance: Specific policy areas include: 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; and capacity building and raising awareness.

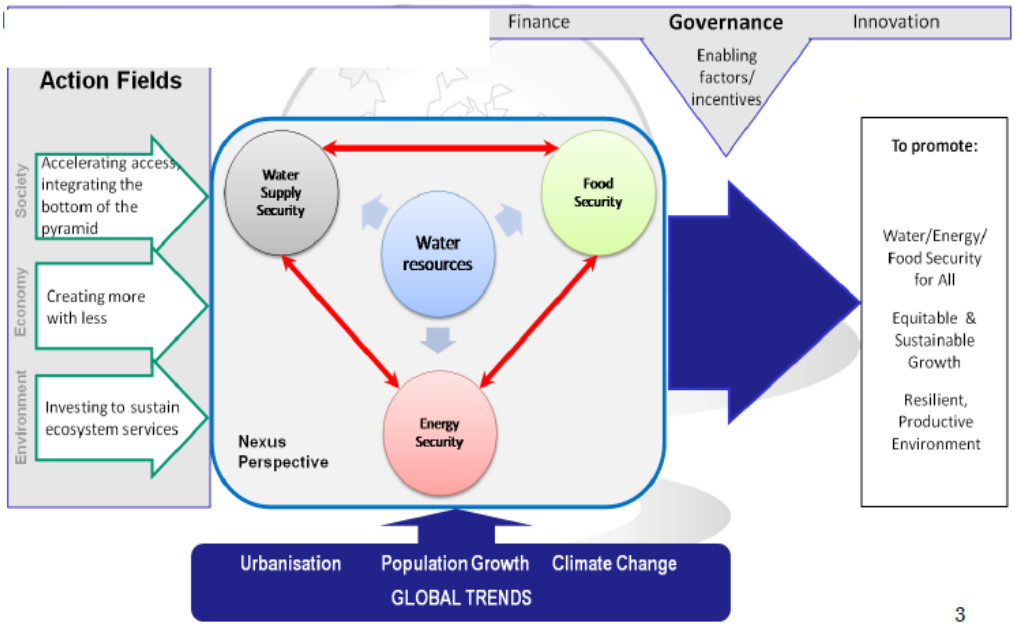

FIGURE 1. FRAMEWORK SUGGESTED FOR THE BONN2011 NEXUS CONFERENCE: THE WATER, ENERGY AND FOOD SECURITY NEXUS

Source: Hoff, 2011.

WEF Framework: World Economic Forum 2011

Another approach to WEF was presented by the World Economic Forum in 2011 (Figure 2). This framework aims to help decision-makers better understand risks so they are able to respond proactively and mobilize quickly in times of crises. The WEF nexus is presented as a major global risk area, together with macroeconomic imbalances and the illegal economy. In terms of the WEF nexus, the following environmental risks were considered: air pollution, biodiversity loss, climate change, earthquakes and volcanic eruptions, flooding, ocean governance, storms and cyclones. In this framework, food and water security are linked to economic disparity and global governance failures causing chronic water and food shortages and crises. Energy security is linked to economic risks in the form of energy shortages with impacts on growth and social stability. This framework also includes population and economic growth as well as environmental pressures affecting the nexus. In addition, it identifies specific relationships among the elements of WEF, such as intensity of energy use in food production as well as water use in both food and energy production.

Policy recommendations/relevance: It outlines a number of areas to explore as levers, including integrated and multistakeholder resource planning, regionally focused infrastructure development, market-led resource pricing, community-level empowerment and implementation, and technological and financial innovation for managing the nexus (World Economic Forum, 2011).

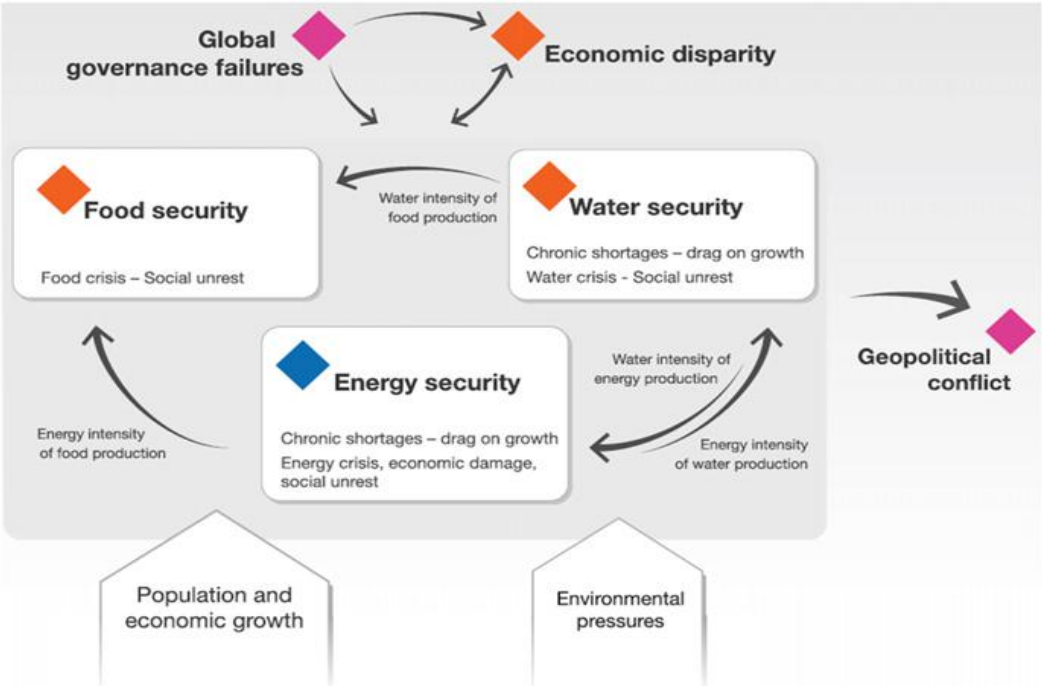

FIGURE 2. APPROACH TO WEF SUGGESTED BY THE WORLD ECONOMIC FORUM

Source: World Economic Forum, 2011.

WEF Framework: International Centre for Integrated Mountain Development, 2012

A third framework centres on ecosystem services (Figure 3). This framework was developed by ICIMOD with a focus on the Himalayas and South Asia (ICIMOD, 2012). Within this framework, the nexus approach is seen as a system-wide, rather than a sectoral, approach; it can help in reducing trade-offs and generating additional benefits. In South Asia, such an approach inevitably needs to take Himalayan ecosystem services into account (ICIMOD, 2012, p. 4). Key parts of the framework are ecosystem goods and services that contribute to a connected triangle representing WEF and agriculture, towards enhanced security in all three elements of WEF. Ecosystems are the crucial part of this framework, and the authors stress that they must be protected and enhanced to ensure their resilience and their support for production (ICIMOD, 2012).

Policy recommendations/relevance: The paper introducing the framework also presents policies and strategies to enhance food, water, and energy security in South Asia, such as: restoration of natural water storage capacity; development of climate-smart, environmentally and socially sound infrastructure; and incentive mechanisms for managing Himalayan ecosystems.

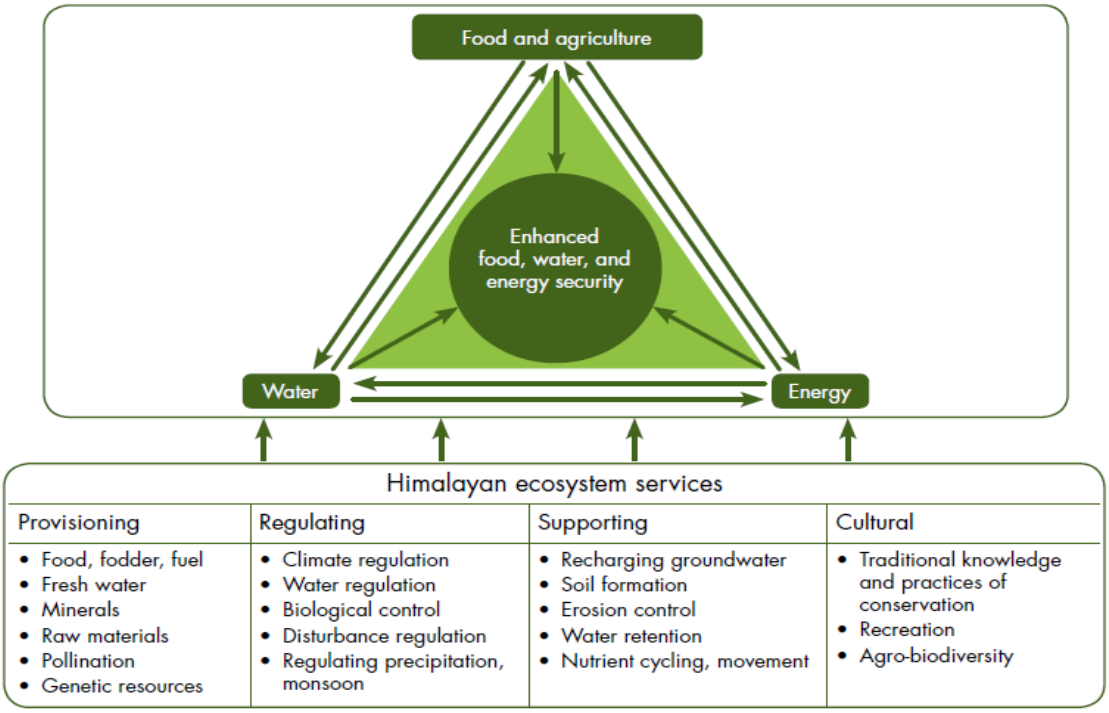

FIGURE 3. WEF FRAMEWORK DEVELOPED BY ICIMOD

Source: ICIMOD, 2012.

WEF Review Summary

Overall, all the reviewed frameworks aim to provide an informed and transparent approach that builds on the system perspective, enables trade-off assessments and aims to promote transition to sustainability. In order to meet these expected benefits of taking a coordinated WEF approach, they also suggest that the WEF framework needs to account for the longer time frame (World Economic Forum, 2011), as well as different regional availability and variations in supply and demand of the studied systems, and will require the explicit identification and treatment of risks (Bazilian et al., 2012). In terms of key elements of the frameworks, they all focus on promoting security and consider involving different domains: society, by changing human behaviours; economy, by using different approaches to economic growth; and environment, by promoting ecosystem services.

Finally, according to the published literature, the ultimate focus of these frameworks is to promote action by providing policy entry points to reduce trade-offs, explore synergies and promote the transition to a more sustainable future (Hoff, 2011; Bonn2011 Nexus Conference, 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. Specifically based on the revised frameworks, we identified the following areas for interventions in promoting WEF:

- Engaging stakeholders to build awareness and capacities about the interconnected nature of the elements of the WEF nexus, share ways to minimize trade-offs, explore synergies and suggest actions for changing behaviours with regard to the nexus and with regard to other actors whose well-being relies on services and products associated with elements of the nexus. This includes community-level empowerment and implementation to incent local actors that are actually using core resources to focus on more sustainable consumption (World Economic Forum, 2011).
- Improving policy development, coordination and harmonization to account for trade-offs and build on the increased interconnectedness of WEF. Part of this process is promoting, identifying and eliminating contradictory policies (World Economic Forum, 2011).
- Governance, and integrated and multistakeholder resource planning to promote cross-sectoral and cross-departmental approaches to planning and working with stakeholders at different levels to improve public sector-led governance, planning and information flows (World Economic Forum, 2011; Bonn2011 Nexus Conference; 2011).
- Promoting innovation to identify technological choices and investments that explore WEF synergies and could be implemented to achieve desired changes on the ground.
- Influencing policies on trade, investment in environment/climate by focusing on improving ecosystem management to increase resource productivity, thus contributing to poverty alleviation and green growth. Specific investments could include:
    - Market-led resource pricing to account for local impacts (social and environmental costs of resource exploitation) and global impacts (contribution to climate change) (World Economic Forum, 2011).
    - Investments in "smart" environmentally and socially sound infrastructure, especially that which is adaptive and focused at the regional level. A key part of these investments should be investing in natural infrastructure. Specific attention is being devoted to climate-related infrastructure development in irrigation, hydropower generation and flood management (Hoff, 2011; World Economic Forum, 2011; ICIMOD, 2012).
    - Promoting more effective waste management by reducing waste and using it in more diverse ways in production (Hoff, 2011).
    - Stimulating development through economic incentives, including working with local stakeholders, and poor and rural populations to provide incentives to manage ecosystems.

IISD's Water–Energy–Food Security Analysis Framework

Based on our review of existing WEF literature, we offer a framework relevant for work centred on ecosystem management. Crucial in our development of this framework were gaps in existing WEF frameworks, including the need for a stronger focus on making the case for an integrated approach to research, policy, investment and other action. We identified the following key elements as central to achieving WEF security in communities and watersheds.

- Our WEF framework emphasizes implementation. While other global agencies have successfully made the case for WEF integration and articulated some of the linkages, our framework builds on these and provides practical implementation guidance for communities and decision-makers on desirable future investments and policies.
- Ecosystem goods and services (EGS) provide an appropriate starting point for an implementation focus. Ecosystem services provide water, food and energy and influence their supply, availability, and access in many ways. Restoring and managing EGS provides a practical means to optimizing WEF security.
- The focus on EGS fills a gap in previous WEF frameworks by emphasizing the importance of the biotic components of the landscape as a direct source of human well-being and as a common connection between food, water and energy.
- Our WEF framework is place-based. A geospatially explicit framework would allow for complementary analytics centered on specific elements of water–energy–food quality, quantity, and supply. Our framework is replicable in other similar contexts. Our implementation focus on ecosystem services implies that our context is ecosystem-based.
- The framework guides a process of implementation through collaboration, visioning and planning at various levels of decision making most relevant to the context. The process builds in measures of success to ensure that WEF security is in fact being improved. While some WEF frameworks are directed in part at good governance and management systems, our research on ecosystem management and complex adaptive systems has shown that collaborative and adaptive planning approaches ensure that governance challenges are met in the best possible manner to create resilience.
- Finally, our goal is to inform investment, decision making and associated risk management to ensure optimization of water, energy and food security. In this respect we take into account the fact that ecosystems and decision-making systems are nested and act at different spatial and temporal scales. An effective WEF framework will take this into account and delineate the linkages between natural and human systems.

Ecosystem goods and services are benefits we receive from well-functioning ecosystems. They are key elements of WEF security and play a crucial role in the quality and quantity of the supply and maintenance of water, energy and food (see Figure 4). Provisioning services provide food and water; supporting services ensure supply and quality of resources; regulating services can mitigate uncertainties from climate variability and other uncertainties; cultural services include aesthetic and spiritual enjoyment. The main goal of the framework is security of water, energy and food, and these components create the foundation of the framework. The first step in implementing the framework is to understand each security component in itself and "unpack" it to understand individually how water security, food security or energy security might be achieved and maintained in the future. The temporal perspective is important to avoid trading off security today for security tomorrow—pushing externalities to the future.

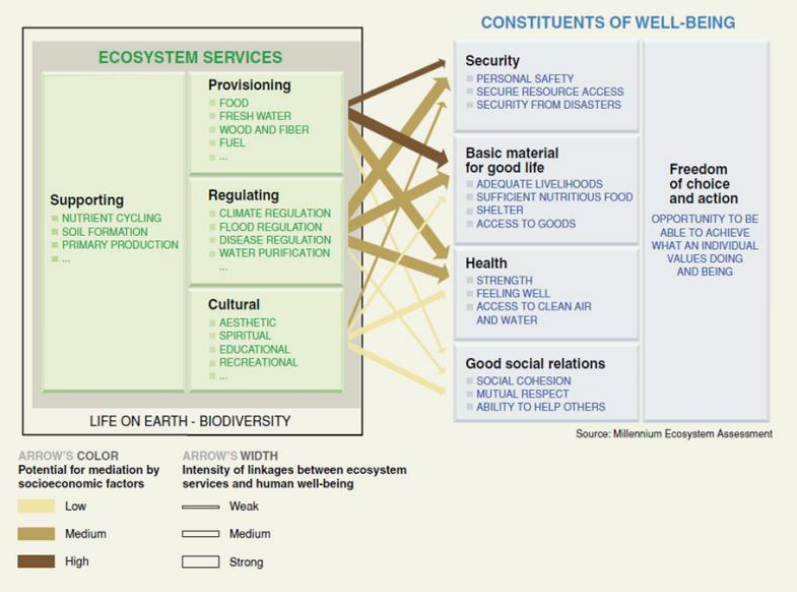

FIGURE 4. LINKS BETWEEN ECOSYSTEM SERVICES AND HUMAN WELL-BEING

Source: Millennium Ecosystem Assessment, 2005.

Because the focus of our framework is ensuring optimal water–energy–food security, we start by building three independent security frameworks, one around utilization of each component. The next layer of analysis is identified as access. This layer describes how watershed communities access their water, energy and their food. This includes mechanisms such as purchase, barter, and self-production. Access to water, food and energy is determined by their availability, e.g., water flow, irrigation infrastructure, agricultural production, food processing, energy production, and energy supply. These are in turn influenced by two overall contextual systems that influence availability and access:

- Natural systems and built systems—we regard ecosystem goods and services as specific elements of natural systems. Built systems include aspects such as irrigation pipes, hydroelectric generators, food production and storage facilities.
- Human systems are institutions such as markets, transportation infrastructure, and communication networks, including the rules that govern their behaviour.

To represent these relationships, we used a series of circular diagrams (Figure 5). This approach is based on a previously developed conceptual framework that seeks to identify critical elements of the food system for ensuring food security (Tyler et al., 2013). We extended this framework by applying it to water and energy security. Like the framework developed by Tyler et al., (2013), water, energy and food utilization are central, and so appear in the centre. Outside these, we identify additional elements that affect the three securities independently; these included access and availability. Beyond these three circles we identify those factors with significant overlaps that affect one or more of these independent systems. These are the three "external" elements described above.

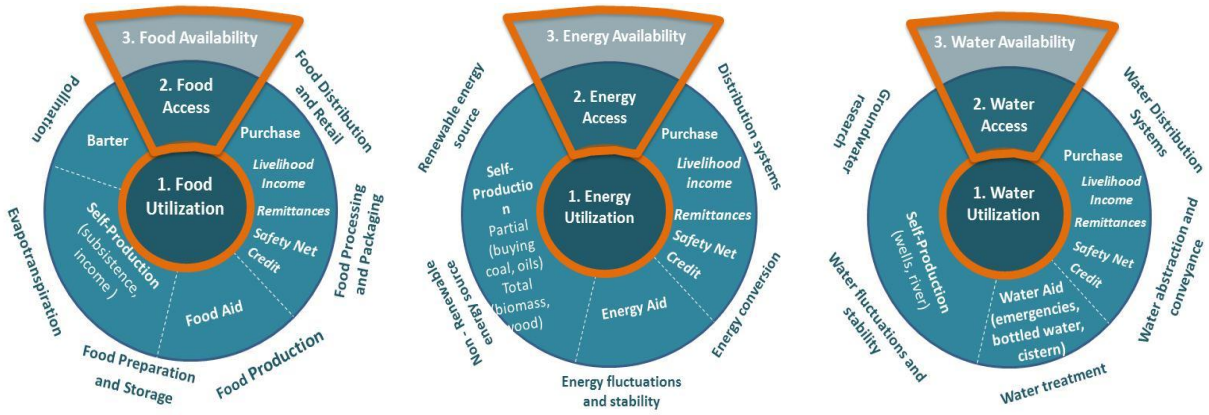

FIGURE 5. DEFINING KEY SECURITIES AS CORE ELEMENTS OF WEF

To implement the framework for any of these independent securities, we can start with the "utilization" aspect (1), and move through the "access" (2) and "availability" (3) rings. The process is described and clarified through a collaborative process because it varies considerably among contexts. Progressing from the inside to the outside of the framework, it is possible to identify different aspects of use, access and availability. Rotating the rings articulates different combinations of elements influencing water, energy and food use and security. Analysts and decision-makers can explore and clarify relationships and draw attention to particular combinations of elements.

Going forward from this representation of the three securities independent of the nexus concept, we add concentric rings to symbolize natural and built systems that provide resources, and that influence access and stable supply of water, energy and food (Figure 6). We combine natural and built systems, since they are often interchangeable in practice. For example, natural wetlands can provide water quality improvement functions as can a built water treatment facility or a constructed wetland. Similarly, riparian buffers might provide similar soil erosion prevention functions as engineered berms and riprap.

Thus, this fourth ring, combining natural and built systems, comprises both EGS from the natural environment and those from the built infrastructure that also provide services to consumers. Using this framework, we can identify EGS that affect WEF elements independently as well as collectively. For example, regulating services that protect against floods could potentially improve food production and stabilize water supply and assist with hydroelectric power generation capacity. For built infrastructure, highways and access routes built for food delivery to remote areas can also support water supply and energy grids. Another example would be waste management that could be specific to food or water or could benefit all three of the components.

Finally, a fifth ring encompasses all of the other rings, and represents the human and institutional elements of water, energy and food securities, both independently and together. This ring includes governance and management systems, policies, markets, agreements, etc.

Because natural, built and institutional systems often affect all elements of WEF security and we are most interested in those that intersect at least two of the three securities, these are placed as concentric rings that encompass all three of the individual security circles. This graphical representation and the notion that the rings can be "rotated" allows the

framework to provide a "menu" approach to watersheds and communities, allowing analysts and decision-makers to "choose" their priorities and risks, and to identify ways to optimize water, energy and food security. This framework also shows the nested nature of the securities and the linked nature of the elements that affect WEF security.

This framework is embedded in a process that allows watersheds/catchments and communities to identify the key ecosystem services that would optimize their WEF security. This process is described in the following section.

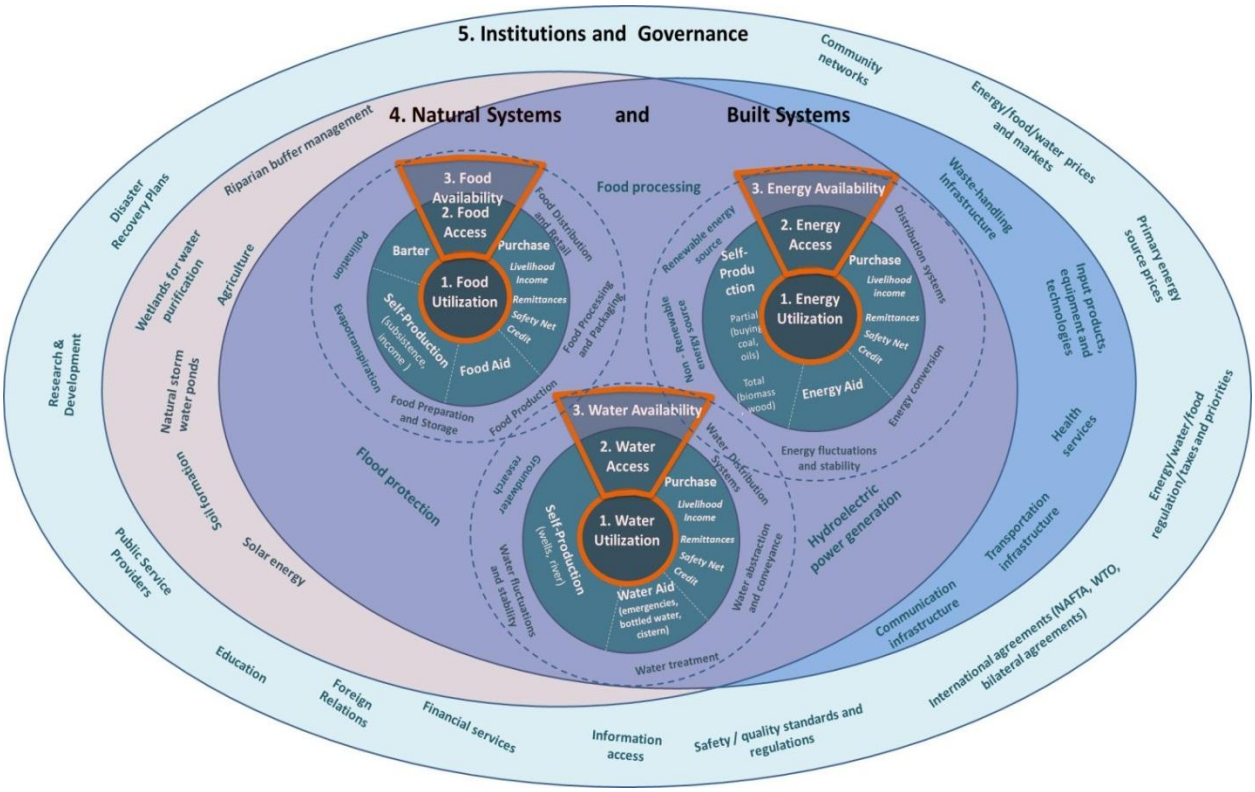

FIGURE 6. OVERVIEW OF THE FRAMEWORK LINKING WATER, FOOD AND ENERGY SECURITY

Operationalizing a Planning and Decision-Support Process for Landscape Investment and Risk Management

The analytical framework presented above offers a comprehensive integration of WEF security issues in a place-based context. It is a foundational step towards a planning and decision-support process for informing critical investments, policy design and adaptively managing opportunities and risks.

The next step is to embed the analytical framework within a practical participatory planning process. This section outlines such a process based on traditional scenario planning approaches (Ralston & Wilson, 2006; Kahane, 2012).

The basic participatory planning process is visualized in Figure 6, and includes four main stages:

- Stage 1: Assessing the Water–Energy–Food Security System
- Stage 2: Envisioning Future Landscape Scenarios
- Stage 3: Investing in a Water–Energy–Food Secure Future
- Stage 4: Transforming the System

Stage 1: Assessing the Water–Energy–Food Security System

Assess Current Status and Trends in Natural, Built and Social Capital. The process of bringing stakeholders together in a watershed or other landscape-defined place necessarily begins with an assessment and discussion of the current status and trends of key aspects of water, energy and food security. We say "necessarily" because a shared understanding of existing conditions and the most influential drivers of these conditions lays the foundation for all deliberations.

Undertaking such an assessment requires a clear picture of the system to be assessed; this highlights the importance of the analytical framework developed in this paper. This initial assessment stage actually accomplishes an additional objective: it will be the first time that stakeholders meet to discuss the water–energy–food security system, and this engagement opportunity can be used to tailor the generic analytical framework to local factors when original conditions are being assessed.

Understand Past Stresses and Adaptations. Before launching into the detailed assessment using the analytical framework, a broader historical analysis is necessary to understand the regional landscape with respect to how it has changed over time, as well as why and how stakeholders have adapted to change—and were drivers of change themselves—in the context of water, energy and food security issues (as well as other significant issues). This respect for history is fundamental to understanding complex adaptive systems because "adaptive systems are shaped by their past, and a knowledge of this history may suggest constraints on and opportunities for what can be done in the future" (Glouberman, Campsie, Gemar, & Miller, 2003). Such a historical analysis typically requires looking back several centuries, rather than just several decades—which is often the range of available data.

Describe Future Risks. This task builds on the historical analysis and takes a prospective view of the key stresses of the past to assess their potential to manifest as key risks of the future. Existing projections from the literature are used as the basis for this forward-looking assessment of risks. Other potential future risks will be considered later in Stage 2 while envisioning future landscape scenarios.

This stage will inevitably be iterative and require follow-up as the other stages advance. This is because information on each of the key system components usually will be limited and some primary data collection often will be necessary.

Stage 2: Envisioning Future Landscape Scenarios

Develop Shared Principles for a Desired Future Landscape. The objective of this stage is to craft plausible scenarios of the future as framed by the most important and uncertain drivers of change in the region. The starting point for doing so is to build a shared set of principles that can guide a more refined articulation of a desired future and what benefits society can expect from it. This does not require detailed elements of the future landscape, such as a particular type of energy system, types of water use, or sources of nutrition; rather, we suggest participants deliberate to describe the desired characteristics of their landscape, such as efficient use of resources. It is during this task that the notions of excess natural capital (i.e., water and forests) and social capital (i.e., water user groups, soil conservation associations, etc.) are discussed as a hedge against future risks, as opposed to the more traditional economic approach of conserving enough resources to meet demand.

Identify Critical Uncertainties and Craft Plausible Scenarios. Crafting plausible stories of the future that are coherent across multiple trends and factors requires a narrative framework. In scenario planning, this is traditionally done using the **scenario axis technique**. For example, participants are asked what they believe to be the most important factors and high-level drivers that will influence water–energy–food security in their region over the next 50 years. Such trends and factors could, for example, include population growth, new technologies, urbanization, trade agreements and access to global/national markets, changes in legislation, and changes in water level, water quality or temperature. These factors and drivers are then ranked according to how important and uncertain their evolution is perceived to be over that period. Those factors and drivers that are the most important and uncertain represent the critical uncertainties. Often, these **critical uncertainties** can be grouped under two main types, or axes, with the ends of the axes representing different types of outcomes. The axes frame a four-quadrant visual space with four plausible future scenario stories of water–energy–food security for the region. Experience shows that it is difficult for groups to contemplate and manage more than four scenario stories, with participants typically choosing to focus on two or three to help guide strategies for the future.

Develop Adaptations and Transformations. The plausible stories of the future provide the context for participants to discuss actions for ensuring water–energy–food security. This is done by taking an adaptive and a transformative stance (Kahane, 2012). From an adaptive stance, participants are asked what opportunities and threats each scenario presents and what specific strengths and weaknesses this illuminates. From that information, adaptive actions can be identified to leverage opportunities or mitigate risks. From the transformative stance, participants are empowered to shape the actual realization of a given scenario and are asked which future scenarios are better for us and our community/organization/business. Within this context, participants can then deliberate prospective roles and responsibilities in making the desired future scenarios happen—essentially asking what does the future need of each person/group? This task provides a menu of robust actions (i.e., those that make sense in most scenarios and involve mostly no regrets) and those that are triggerable (i.e., those actions that make sense only for certain future possibilities and might need more information before being implemented) (Swanson, Barg, Tyler, & Venema, 2010). The shared understanding of a desired future scenario (or elements thereof) and menu of adaptive and transformative actions provide the foundation for the next stage, that is, for creating a practical investment strategy for the future.

Stage 3: Investing in a Water–Energy–Food-Secure Future

Create and Communicate a New and Shared Story of the Future Landscape. The purpose of this stage is to develop a specific investment strategy for ensuring the WEF security of the region or basin. This stage involves multiple engagements with various stakeholders as well as larger multistakeholder meetings. Central to these engagements is a shared, innovative and motivating story of a future landscape than can deliver water, energy and food security in a sustainable and resilient manner. This requires taking the desired scenario story from Stage 2 (or compiling desired elements across several scenarios), branding it, and actively communicating it across the region or basin. A modality for active communication of the desired future scenario is engaging more stakeholders in various sectors to better understand their adaptive and transformative roles and responsibilities.

Develop the Investment Strategy and Scaling Mechanisms. The purpose of this task is to develop a specific and pragmatic investment strategy that can deliver WEF security for the basin or region. This is a shared document meant to represent a strategy owned by the participants in the process, a document that ideally is representative of the aspirations of the basin and region as a whole. The strategy is implementation-orientated in that the adaptive and transformative actions are backed by specific financial and policy mechanisms to enable their implementation. The strategy must present a comprehensive business case that openly and transparently discusses risks and mitigating/hedging actions that are built into the strategy directly as specific forms of excess natural and social capital. The strategy must describe the implementation mechanisms that are adaptive and transformative for the basin or region as a whole.

Stage 4: Transforming the System

Communication. Transformation demands action, and action requires communication—and lots of it. While the very undertaking of the participatory scenario planning tasks of Stages 1 through 3 is a form of active communication in and of itself, a separate communication plan is imperative, one that can effectively market the investment strategy and build the necessary public, financial and policy support for scaling up actions. Experience shows that significance of this task cannot be overemphasized, though it is often poorly executed.

Implementation. Experience shows that there exists a hefty stack of strategies lying unimplemented on shelves, giving rise to what is called the **implementation gap**. There are many factors that help narrow the implementation gap, and many of these have been already incorporated in the process, such as active communication, ensuring that recommended actions are backed by financial and policy commitments and that scaling-up mechanisms are well thought out as part of the strategy. Implementation also requires capacity, in a broad sense of the term, including technical capacity, know-how and personnel. However, one of the most important mechanisms for implementation is the clear identification of an organization or formal consortium of organizations that is accountable for the implementation of the investment strategy. While it is certainly the case that action from a range of stakeholders is necessary to implement the plan, some defined entity must be identified as the steward of the plan so that it can report on progress to the broader public in a transparent and accountable manner.

Monitor, Adapt and Improve. Adaptive management of a complex and transformative process is fundamental to successful implementation (Tomar & Swanson, 2009). This is because it is not possible to predict what actions will work well (and which will not) in dynamically commingled economic, social and environmental systems. Therefore, a regular and formal process of monitoring progress, learning from successes and failures, and actively adapting and improving performance is required to change what is not working (and to abandon actions in certain situations) and

strengthen what is working (Pintér et al., 2012). The identification and monitoring of a suite of outcome and output indicators, and the continual and transparent communication of this information, is a critical part of the participatory planning process and the adaptive management of implementation.

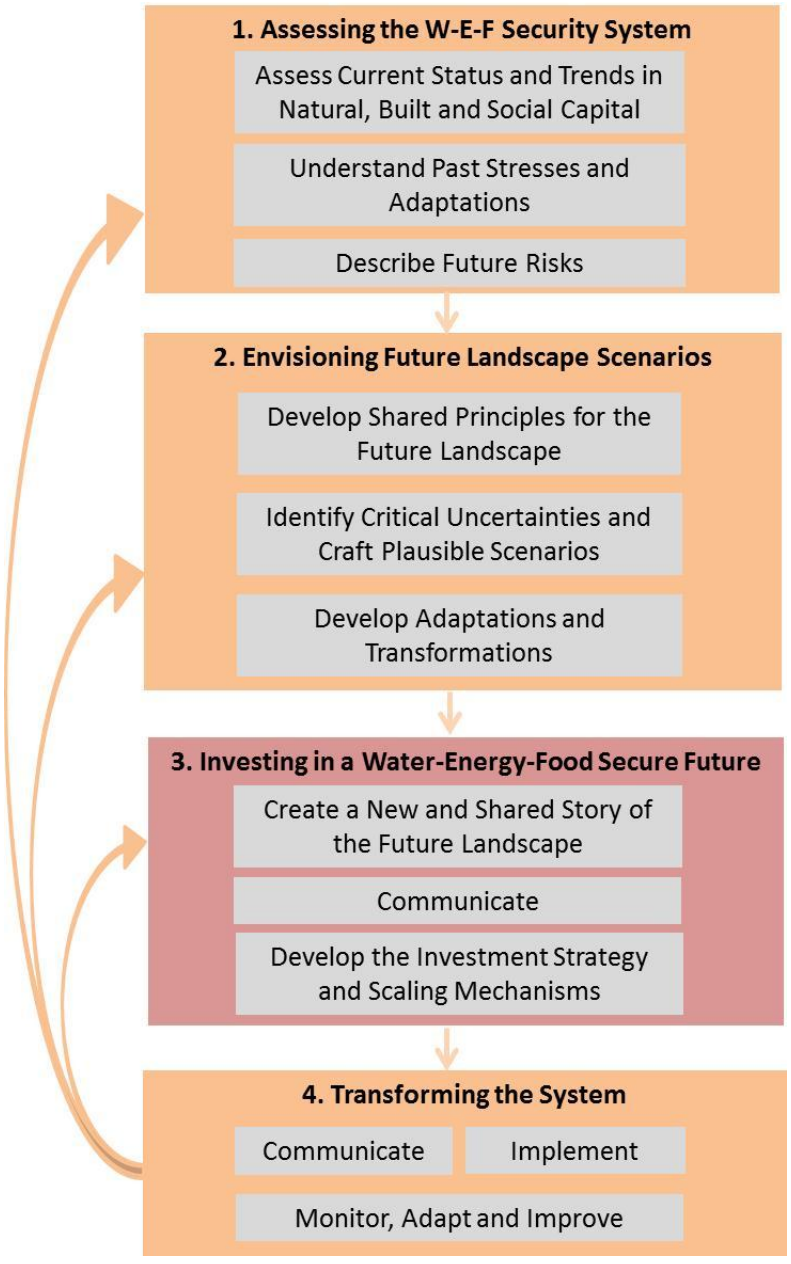

FIGURE 6. PARTICIPATORY SCENARIO PLANNING PROCESS FOR WATER-ENERGY-FOOD SECURITY

Conclusions

Presciently, the 2008 *World Bank World Development Report* focused on agriculture for the first time in 25 years as the sector crucial for global sustainability and prosperity. The renewed prominence of agriculture in World Bank thinking coincided with a massive increase in land investment in developing countries, with agricultural production as the primary objective, and access to water and bioenergy production as prominent sub-themes.

The World Economic Forum's *Global Risks 2011* report made transparent the fact that the "land-grab" phenomenon is a response to a larger structural and correlated global risk to water, energy and food systems. In highlighting the water–energy–food security nexus, The World Economic Forum's intent was to clarify for policy-makers and business leaders that the WEF nexus could be a major opportunity for integrated solutions that respond to inter-dependencies of water, food and energy systems. Our review of current WEF frameworks revealed that, while such integrated approaches are being explored conceptually, there is much less emerging to implement or operationalize such integrated approaches that optimize the three critical securities in a coherent or balanced manner. Based on the significant findings from our review, we identified a few priority areas that would help operationalize such an integrated approach in practice. In particular, we based our framework on the need to engage stakeholders through policy relevant at the regional and global levels, promote integrated and multi-sectoral planning, promote innovation, and influence policies on trade and investment in environmental and climate-related sectors and issues.

The fundamental hypothesis that IISD is advancing with our new body of work on ecosystem-based solutions to water, energy and food security is that investments in ecosystems hedge land investments against a wide variety of socio-ecological risks, and, moreover, they will be instrumental to the long-term performance of the primary investment objective (increased agricultural productivity). In this context, IISD offers an ecosystem-based, spatially-explicit framework to design and manage land investments that deliver increased water, energy and food security. An initial review of the relevant literature confirms that no such investment framework currently exists, but could be developed. This also provides a practical and implementation-oriented means of operationalizing an otherwise theoretical concept that is being explored and highlighted as a significant global risk and opportunity for integration.

As part of our goal to implement such an integrated framework in the context of watershed ecosystems, we propose a four-step approach comprising the following elements:

1. A place-based assessment of a candidate region for land investment to construct a shared narrative of the region's socio-ecological history.
2. A participatory scenarios exercise to develop geographically explicit scenarios that balance agricultural production and natural capital co-objectives.
3. An implementation strategy identifying the financial and institutional instruments for investment in the desired future landscape.
4. A spatially explicit framework for monitoring, and adaptively managing investment performance.

We envision that the next steps for developing this land investment framework to be

- A resource guidebook that illustrates and annotates best practices in conducting each of the steps.
- A place-based action research case study with local partners to demonstrate the participatory and analytical components of the approach.

Achieving long-term value in land and land investments is an essential part of the sustainable development agenda. Long-term sustainability for any community is linked inextricably to long-term clean water supplies, soil productivity and energy systems. These in turn, correlate closely with thriving communities as well as economic development. Our framework proposes that long-term value for land and investments in land use and management must also translate into new business models that reconcile the "either–or" debate of ecological limits, social benefits and economic development. These models must reflect a truly integrated management model through investments in land-use for long-term solutions for sustainable and equitable water, energy and food security. Through this conceptual paper and a following guidance document to operationalize this process, IISD hopes to integrate this thinking into decision making and implementation of global land management. Our plans to implement this framework with watershed-based partners will contribute greatly to its adaptive design, thus ensuring a product that is broadly applicable and scalable to a range of contexts.

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