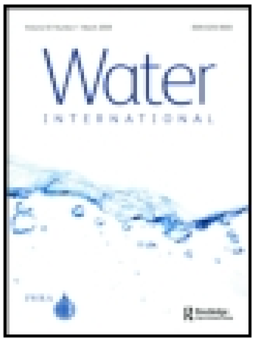

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COMMENTARY

Water-Energy-Food Nexus Framework for facilitating multi-stakeholder dialogue

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Introduction

Water, energy and food are deeply interlinked resources. Food and energy production require over 90% of our global water resources. In this time of climate change and rapid population growth, water is increasingly the limiting factor for economic development and future security of both energy and food. Present policy making often lacks the necessary mechanisms to incorporate the interlinkages between water, energy and food. The different institutions governing resource allocation often do not communicate with one another, creating a lack of integrated planning, allocation and management of these key resources. Although the scientific community has made serious efforts to identify and quantify the interlinkages between resource systems, there continues to be a wide gap between science and policy making in effectively communicating those findings for proper incorporation in planning agendas. This science-to-policy gap could be reduced through improved exchange and the integration of scientific data and policy considerations into inclusive tools that address policy objectives and are technically viable from the perspective of sustainable resource utilization.

Global debates have placed economic security, in which water, energy and food security are the main constituent pillars, on a par with physical security threats, such as terrorism and disease. Water, energy and food security are high on the agendas of global think tanks – identified as critical, interconnected risks that need to be addressed. The InterAction Council (Axworthy & Adeel, 2014) identified the water-energy-food nexus as one of the major risks facing our global community, alongside religious divides and nuclear proliferation. Moreover, Global Risk reports from 2007 through 2015 (World Economic Forum, 2015) highlight food crises, water scarcity and energy shocks among the top five risks to the modern world in terms of likelihood and impact. Awareness of the volume of present and expected challenges has grown in multiple circles, including academic, policy, business, and civil society. Nevertheless, the tools and mechanisms to ensure that these challenges are properly addressed have yet to be developed.

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In general, policy and decision makers lack access to a set of comprehensive tools that:

- are inclusive of all stakeholders and correspond to the multi-scale nature of the nexus, from local to regional, national, or global
- are able to define and quantify the interconnectivity between water, energy and food resources
- include integrative and holistic management strategies to plan for future allocation of these resources.

The Water-Energy-Food Nexus Framework for integrated science–stakeholders dialogue

This commentary introduces an integrated framework for an inclusive dialogue, catalyzed by science. It includes a knowledge-based analytical platform, cites examples of tools that can be useful for that analytical platform, and identifies the stakeholders who will participate in the dialogue that enables an effective governance of the nexus. The main elements of the integrated Water-Energy-Food (WEF) Nexus Framework (Figure 1) are:

1. *WEF nexus analytics platform*. This includes the analytics that allow quantification of the interlinkages and identification of the trade-offs, at specific hotspots, resulting from different policy decisions or actions related to any of the interconnected resource systems. A WEF Nexus hotspot could be defined as a vulnerable sector or region at a defined scale, facing stresses in one or more of its resource systems due to resource allocation at odds with the interconnected nature of food, energy, and water resources. The analytics help identify existing and projected resource hot spots which need to be understood and accounted for in future planning. The analytics provide the science-based knowledge platform to inform the dialogue.
2. *Supply chain dialogue*. One part of the dialogue is dominated by the private sector, businesses and industry in which trade and commodity movement occurs. It

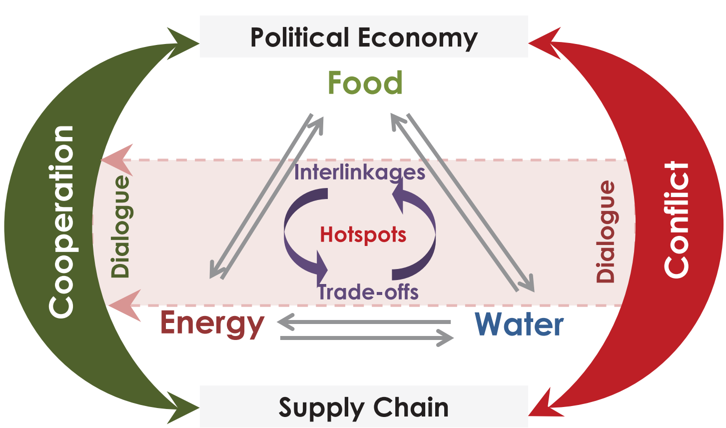

Figure 1. A resource nexus framework, demonstrating the dynamics of three communities: scientific/analytical, private sector / supply chain, and political economy / policy.

involves addressing the efficiencies and management of the different stages of the supply chain and strives to meet the greatest number of demands with the fewest unintended consequences for the interconnected systems. Another part of the supply chain dialogue includes consumers and their choices, which have a direct effect on how, what and where suppliers choose to produce.

3. *Political economy dialogue*. This is one that occurs in policy-making circles with businesses on one side and society on another. It is mostly driven by regulation and incentives. It is a result of weighing the trade-offs of different policy options, which reflect future goals and projections, and developing current policy debate and framework.

The WEF Nexus Framework, governed by the science and data tools that must be developed to quantify the interlinkages between the sectors of water, energy and food, allows us to accomplish several goals:

– identify existing and potential resource hotspots at multiple scales
– account for expected trade-offs in resource allocation strategy choices
– inform important dialogue at the policy level – dialogue which identifies and clarifies existing synergistic opportunities for cooperation
– account for allocation of resources throughout the supply chain.

The WEF nexus analytics platform allows the informed basis for the subsequent dialogues between the supply chain and the consumer, comprising the policy dialogue. Depending upon the specific stage of the dialogue at hand, these will have different dominant stakeholders, drivers and motivations. However, the goal in each case is to move the dialogue from a state of conflict towards one of cooperation informed by the platform (science driven by data and analysis). This process should be demand-driven and should focus on the key players to effectively define the problem, create the debate parameters, and become the engine of implementation for the outcomes of the process.

The WEF nexus analytics platform does not replace but rather builds upon integrated water resource management, energy efficiency and water productivity for food production (Mohtar, 2015). It provides a levelling field that makes possible an all-inclusive dialogue that is not sector-centric (i.e. not singularly water or energy or food centric).

Figure 2 represents different key players (stakeholders) that have a role in determining the levels of existing and projected stresses between resource systems, and who in turn are also able to reduce those pressures through cooperation:

– *Society (consumption/demand)* is the source of demand for goods and services. Demand patterns take shape based on population size, social breakdown, preferences and needs. This societal demand in turn activates a second set of resource-consuming supply chains. NGOs, think tanks, and civil society organizations are also part of society, and play a role in pushing its views into the discussion agenda.
– *Business (supply chain)* responds to societal demands by activating the supply chain and managing demand for critical resource systems.

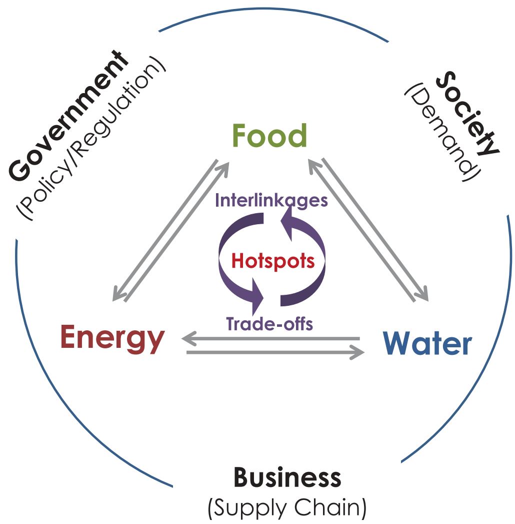

Figure 2. Water-Energy-Food Nexus Framework: the key players.

– *Government (policy/regulation)* uses incentives and regulation to shape the preferences and availability of resources to both society and business.

All these players become stakeholders who contribute to the nexus dialogue. The interactions among them lead to the development of new trends, which in turn need to be assessed using the nexus analytics platform to create adapted feedback that either reinforces existing trends, if deemed sustainable, or suggests ways of curbing those trends in the event that they are deemed unsustainable. Such dialogues would play a key role in highlighting bottlenecks and risks, thus getting them placed high on decision-making agendas at different scales. These stakeholders play an important role in activating the analytics platform discussion. It should be noted that the outcomes (choices) of a given dialogue may be influenced by the conveners of that dialogue, but the data will be the same regardless.

Nexus governance

Governance of the water-energy-food nexus is complex and relatively under-studied. The complexity results from the need to respond to the scale at which resources are governed, while simultaneously acknowledging the uneven distribution of power among the key players and decision-making focal points. In an effort to respond to the need for integrative governance of the water, energy and food resource systems, some governments have combined resource ministries. However, even when merged, many of those ministries continue to have very separate protocols for each of the silos, thus perpetuating the same challenges and begging the question of how we should move forward in governing these tightly interlinked systems so urgently in need of integrative policies to minimize unintended future consequences. This also leaves unaddressed the challenge of how to transition from short-term reactive tactics to long-term preventive, integrative and synergistic strategies.

The best option for integrative policy may not be dissolution of existing centres of decision making for each of the resource systems or their incorporation into a single

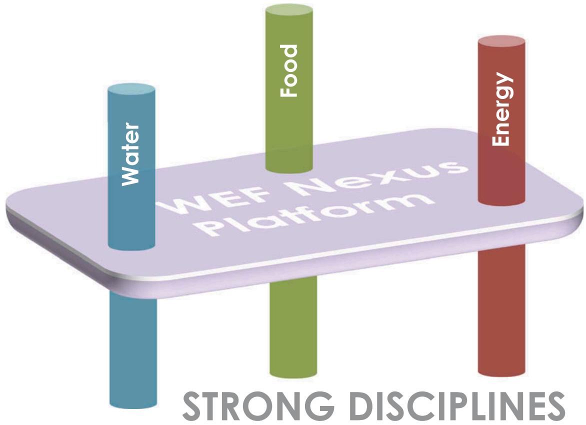

Figure 3. Cross-cutting governance.

body that takes care of integrative policy. A more pragmatic, sustainable option lies in having strong disciplinary pillars that are supported by the necessary cross-cutting mechanisms and protocols (Figure 3). These mechanisms would catalyze integration in the decision-making processes and allow the presence of a cross-sectoral platform that facilitates clarity in the identification of trade-offs between the interconnected resources. The resulting integrative policies would impact both the players, and the analytics developed by the scientific community – fine tuning, if you will, in a manner that allows policy revision and assessment in response to newly evolving situations.

Sample of existing tools

Decision makers need tools that identify trade-offs between nexus components in order to support the development of effective, integrative resource allocation strategies. Multiple tools are currently available and under continuous development to better address this challenge. Available tools include the following.

1. *WEAP*. The Water Evaluation and Planning system is a user-friendly software tool developed by the US Centre of the Stockholm Environment Institute. It uses an integrated approach to water resources planning with the goal of incorporating the issues into a practical, yet robust, tool for integrated water resources planning (Yates, Sieber, Purkey, & Huber-Lee, 2005).
2. *LEAP*. The Long-range Energy Alternatives Planning system is a widely used software tool for energy policy analysis and climate change mitigation assessment, also developed by the Stockholm Environment Institute (SEI, 2013).
3. *MuSIASEM*. Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism analyzes the nexus between energy, food and water, considering heterogeneous factors such as population dynamics, greenhouse gas emissions and land-use changes to characterize the metabolic pattern of social systems (Giampietro, Mayumi, & Ramos-Martin, 2008).
4. *CLEWS*. The Climate, Land, Energy and Water Strategies tool investigates inter-connections between resource sectors and identifies the effects that changes in one

sector might have upon another sector. CLEWS also provides insights regarding trade-offs between different natural resources and highlights synergistic solutions while providing policy-relevant information (Howells et al., 2013).

5. The *WEF Nexus Tool 2.0* identifies the interlinkages among energy, water and food systems at multiple levels (international, national, regional, watershed, etc.) and provides sustainable resource management strategies governed by a scenario-based WEF nexus framework. The tool assesses scenarios that reflect different resource allocation strategies by quantifying their resource requirements – water, energy, land, financial requirements and environmental impacts (Daher & Mohtar, 2015; Mohtar and Daher, 2014).

More tools, with further explanation of the questions they address, the systems they cover and their data needs, can be found in IRENA (2015) and FAO (2014).

How do tool analytics support dialogue?

The literature lists tools that address various aspects of resource allocation problems, including accounting for resource systems at different scales. While current tools are data-intensive, they lack complexity; further work is needed to utilize the WEF Framework presented in Figure 1 and to build on and benefit from existing work. The strength of a WEF nexus analytical platform lies in its comprehensive use of inputs from existing tools as data sources. The proposed platform will use outputs from tools such as SWAT (the Soil and Water Assessment Tool), Kamel, LEAP and WEAP. Following the 'number crunching' of those outputs, tools like the WEF Nexus Tool (Daher & Mohtar, 2015) would be used to assess scenarios and trade-off analyses that integrate all these elements to provide a new paradigm that includes complex sets of variables, such as green water, water for energy production, transport factors, etc. This would offer an instrument for trade-off analysis protocols focused on thematic topics, regions and centricities to provide a basis for informed dialogue and decision making. The WEF Nexus Tool 2.0 also offers a dynamic model that enables systematic integration of policy preferences, comparison of possible scenario outcomes and consideration of respective resource requirements, thus allowing comparison and cost-benefit analyses.

The choice of which tools provide the necessary analytics to address a specific issue depends on the needed outputs, resources and time available, and the players involved in the dialogue. The platform then offers a common ground for communication. In addition to the analytics, the framework involves enabling a dialogue between constituents of society, business and government. That is where trade-offs can be discussed and alternatives towards cooperation and sustainable resource utilization can be introduced.

Conclusions

This commentary introduces a generalized water-energy-food nexus platform outlining the dynamics of the three communities: scientific, private sector / supply chain, and government. It builds on the science and the analytics, using these as a catalyst for policy analysis, technology assessment and trends, increasing awareness and possibly inducing changes in consumer behaviour. The commentary describes governance options for the nexus, building on existing disciplinary structures, and includes existing tools needed for trade-off analysis and analytics.

The existing and projected stresses facing interconnected resource systems, coupled with the need to respond to pressures from multiple supply chains to meet growing demands, make it critical to consider a new paradigm in understanding and planning for the allocation of these resources. Crisis avoidance will require the active, inclusive involvement at different scales of all relevant stakeholders: horizontally across the resources, and vertically within each resource system.

We live in a non-stationary world. The ability to react to unanticipated pressures and put forward proper policies and management practices requires an understanding of the nexus, including its multiple governance and planning mechanisms, that better reflects the reality of the interconnectedness of resource systems. Our better understanding of the way in which these resources are interconnected across the spectrums (biophysical, policy, social and economic) will be an outcome of an active dialogue facilitated by science-based analytics and guided by the overall WEF nexus platform. Developing this understanding and incorporating it into integrative plans will help us be better prepared to guide future development in an informed manner, without jeopardizing the security of one resource over another.

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