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Water-Energy-Food Nexus:

A Platform for Implementing the Sustainable Development Goals

High Level Panel, XVI World Water Congress, Cancun Mexico, June 1 2017

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This text was developed as an outcome of the “Water-Energy-Food Nexus” High Level Panel (HLP) which took place at the XVI World Water Congress, Cancun Mexico, June 1, 2017. The HLP’s goal was to demonstrate the extent of interconnection between the water, energy, and food Sustainable Development Goals (SDGs) of the United Nations. The HLP highlighted lessons learned from various thematic and regional case studies and experiences. The panel focused on exploring the possible trade-offs among possible pathways for implementation of the SDGs, and on identifying holistic assessment criteria for accounting for potential competition of multiple implementation plans at different scales. This focus led to substantial discussion about ways to improve policy coherence through improved communication between policy and science across both sectors and scales.

Why the Nexus?

Understanding the nexus

Tight interconnections exist between water, energy, and food systems. As stresses continue to increase on these resource systems, there is a growing need to better quantify and understand the trade-offs associated with their future planning and management (Figure 1).

Water and energy are tightly interconnected. Water is used to produce hydropower and to cool thermal power plants. Groundwater is impacted by hydraulic fracturing: the extraction of oil and gas carries the collateral danger of contaminating neighbouring aquifers and affecting the supply of water for drinking or irrigation. Energy on the other hand, is essential for pumping groundwater and in modern irrigation techniques; it is essential to urban water cycles, from conveyance to supply to treatment. The tight interconnection of water and food is most pronounced in agriculture’s need for water and irrigation, where water used in the agricultural sector hovers around 70–80%, but can go as high as 80–90%. Many countries legislate the hierarchy of water use, often placing irrigation just after domestic demand. Tight interconnections are also apparent between energy and food: take for example, biomass production in which plant products are a source of energy, a phenomenon that has grown substantially in recent years in some areas such as Argentina and Brazil. This new ‘renewable’ energy source is dependent upon the production of plants to generate energy, which can involve an actual decrease in food production (due to the associated reductions in agricultural land for food production); it also requires some of the water otherwise used in food production from irrigated agriculture. Biomass derived from forest waste may impact the ecological function of the forest. Another, less agreed upon consequence of plants for energy can be increased food prices.

Why consider the nexus?

The water, energy, and food nexus offers an approach to achieving water, energy and food security, helping to ensure access for basic human needs. 844 million people currently lack access to safe drinking water (WHO, 2017); 1.1 billion do not have access to energy (50% of these are in Africa) (IEA, 2017); about 815 million do not have secure access to food (FAO, 2017). Thus, the concept of nexus is also about ensuring the sustainable use of resources by avoiding waste and loss (UN ESCWA, 2016). The recognition of the complex inter-

relationships between the water, energy, and food sectors creates a basis for a new approach to integrated management and governance across sectors and ultimately, across scales.

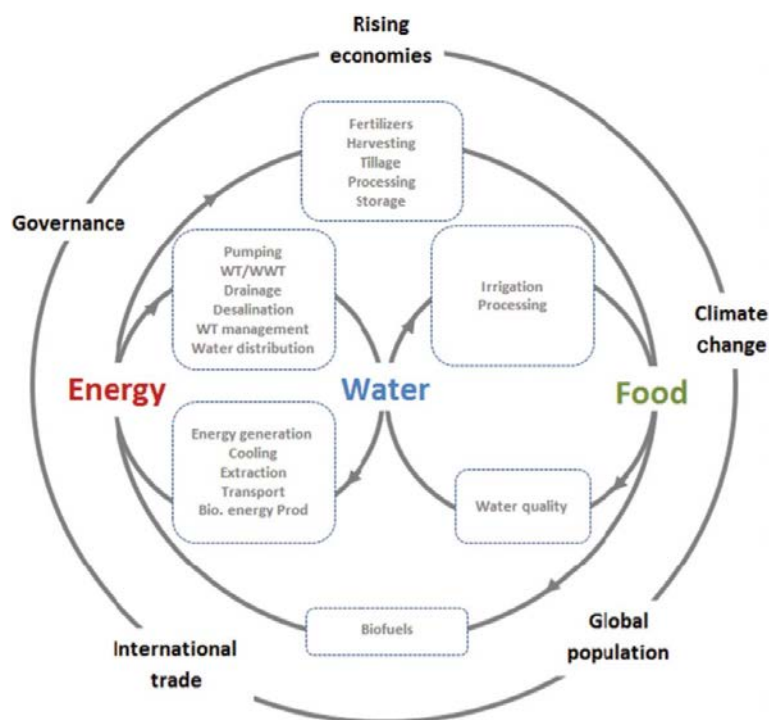


Figure 1. The water – energy – food nexus as a system of interacting systems within social, governance, technical, economic and climate change constraints and externalities (Mohtar and Daher, 2012).

Global Policy Objectives and the WEF Nexus: from the perspectives of the Sustainable Development Goals (SDGs) and Human Rights

An overall guiding principle of the WEF nexus approach is the concept of achieving *sustainable development* by ensuring a balance between the three pillars: economy, the environment, and society (Rio Earth Summit 1992). The international community approved, at the global level, and committed, at the local level, to two sets of interconnected principles that must be included when developing any national policy or legal framework for implementing a WEF nexus policy. These are:

Sustainable Development Goals (SDGs)

All United Nations (UN) member States adopted the SDGs (UN General Assembly resolution 70/1) in September 2015. The resolution includes goals and targets that are specific to water, energy and food. Contrary to the Millennium Development Goals (MDGs) (UN, 2000), which were intended only for *developing* nations, the SDGs address the *entirety of the global community*. Member nations have committed to working towards achieving the SDGs by 2030; this will partly be done through integrating these goals into the development and implementation of their national policies. They have also expressed their will to “Revitalize Global Partnership for Sustainable Development” (SDG 17) (UN, 2017), in support of the

implementation of the SDGs with the goal of bringing together all concerned stakeholders (governments, civil society, private sector, and international organizations). Through this Global Partnership, the nations commit to “share knowledge, expertise, technology and financial resources” in support of achieving the SDGs and with particular emphasis on developing countries. This partnership between all stakeholders is necessary to the formulation of water, energy, and food policies which are consistent with the realities of their interconnections and interdependencies.

Human Rights

The UN General Assembly resolution adopting the SDGs (70/1) includes references to the Universal Declaration of Human Rights (UN, 1948) and other treaties. These present a solid basis for implementing the SDGs and an additional set of guiding principles for nations to include in their national policies when considering the implementation of a WEF nexus approach. The right to “adequate” food is identified in the Universal Declaration of Human Rights (1948), and specified in the International Covenant on Economic, Social and Cultural rights (OHCHR, 1966). The human right to water and sanitation are explicitly mentioned in the preamble of resolution 70/1, and were recognized by another UN General Assembly resolution in 2010 (64/292) that clarifies this as “the right to safe and clean drinking water and sanitation”. To date, no “right” to energy is acknowledged at the global level, but this could be derived from other rights such as the general right to an adequate standard of living.

National and Transboundary challenges

While the SDGs provide the first ever global commitment to universal action toward an agenda for sustainable human development that ensures access to adequate resources for the poor, “leaving no one behind” (UN, 2016), implementation occurs at national and local levels. Nations, through their national planning processes and strategies, must define their path toward achieving the SDGs. Inter-sectoral governance challenges, including those addressing WEF nexus challenges, call for a systems approach that goes beyond single sectors. This is not currently a common practice at the national level, and the challenge becomes even more complicated at transboundary levels.

National and Local Implementation

Local **implementation** of the water, energy, and food SDGs requires that:

- a. Water can act as the catalyst to achieving the Sustainable Development Goals (SDGs) using the WEF nexus systems approach;
- b. SDG criteria be the base line, representing the minimum development goals to be pursued in any WEF development plan;
- c. Any WEF development initiative be unified within national and local plans and then implemented following the assessment of SDGs achievements.

Any national policy addressing WEF nexus challenges should consider the following elements:

- *Access to basic services*, including safe drinking water, adequate sanitation, healthy food, clean, sustainable energy;

- *Productivity of resource use*: including reducing waste, limiting over-use, and increasing overall productivity;
- *Ecosystem Services Value and Biodiversity*

Devising and implementing solutions to address the WEF Nexus challenges must include stakeholders connected with each of the three resource systems. At the national level, this could be facilitated by an inter-sectoral coordinating body to ensure such representation, for example, a “Stakeholder High Council”. Such a body would have the authority to *monitor* the entire WEF nexus modeling process and *evaluate* the outcomes with regard to appropriate decision making about the allocation of resources and the required tradeoffs between the development priorities of the stakeholders. The Stakeholder High Council would consider national and local development strategies, determining the path forward to achieve the SDGs. The establishment of such an authorized stakeholder council is itself a major challenge, as discussed below.

Addressing water, energy, and food challenges through a nexus lens includes:

1. Improving the effectivity of input resources without sacrificing the development objectives by:
 - Minimizing losses throughout the entire water, energy, and food supply chains and from production to consumption;
 - Increasing the productivities of water, energy and food resources;
 - Increasing the focus on renewable and green energy;
 - Avoiding and recycling waste.

These steps will result in the creation of new resources for consumers and at the same time, will not compromise the availability of existing resources (Mohtar and Daher, 2017).
2. Adopting trade-off options to implement the objectives of the SDGs and of national or local development goals require tracking the following steps:
 - Identify interdependencies (nexus) of water, energy and food and their impacts on people and environment throughout the production to consumption process. These interdependencies must be quantified and ranked based on their importance. Water is at the core of such evaluation;
 - Eliminate the less important, less effective links for simplification, accessibility, and applicability of the required models;
 - Select the appropriate models for the remaining links and available data to be considered.
 - Calibrate the resulting model or models.

The intervention of the Stakeholder High Council is very helpful to the decision making process, particularly where changing the strategies and adopting the trade-offs is required. The Council’s role is to synergize the optimum use of the environmental resources and assure

targeted development outcomes while minimizing the extent trade-offs impacting the SDG targets and national or local development.

Transboundary considerations

The need for cooperation between riparian states with shared river basins and aquifers is anchored in the SDGs (SDG 6.5) as essential for effective integrated water resources management. Cooperation within these basins and aquifers is critical not only for access to water, but also for food, energy, and ecosystems security and the related dimensions of each nation. The WEF nexus offers an entry point for dialogue and cooperation between the nations in a shared basin (Kibaroglu & Gürsoy, 2015).

Transboundary cooperation on water is not easy: it involves a lengthy process developed over time and hinges on basic issues: trust, exchange of information, capacity differences, political support, all of which come into play to engage contentious agendas with co-riparian countries. It touches on national sovereignty issues, and the more so when additional sectors, such as energy and food, are involved. Functional regional legal and institutional frameworks of cooperation are essential for nations to agree, implement, and attract finance for investments that, in the long term, will result in regional (transboundary) benefits that exceed the sum of unilateral or single-sector action.

Most river basin organizations are headed by ministries of water and comprised of water experts. Ministries of energy and agriculture, among the major water users, are not usually represented. Regional economic commissions often offer a needed entry point for engaging and planning across sectoral borders and to address differences in scale. There are differences such as watershed, energy-shed, and ‘food-sheds’ differ in reach and in regional dimension. Multi-sector analyses, conducted in many basins and under many different ‘labels’, need to take account of the increasingly wider regional and cross-regional trade of energy and food.

Messaging and communication

Engaging Stakeholders and Positive Messaging

The discussion of the nexus can be reframed to more effectively identify and deploy solutions to address the associated challenges. Business as usual is no longer acceptable: it is necessary to engage *new* and *current* stakeholders in novel ways. The nexus challenge needs to be represented *an opportunity for innovation* that will drive economic development, business expansion, ecosystem health, and social well-being. This is an opportunity to move stakeholders toward a “can-do” mind-set that provides win-win benefits for societies, economies and for the environment. A shift in thinking is proposed to accomplish several goals, including:

- *Broad Stakeholder Engagement* in developing innovative solutions to address the energy–water–food nexus challenges;
- *Defining “nexus innovation”* in terms of technology, partnerships, funding/financing, and of business, consumption/production models;
- *Framing a vision and strategy* to effectively address nexus challenges.

- *Leveraging* new governance modalities and exponential technologies to accelerate innovations toward achieving energy–water–food security for all.

Tools for informing the policy process: Challenges to a process inclusive of different stakeholders

Quantitative tools and models can provide a clear understanding of the interconnectedness of the nexus by identifying the trade-offs and the potential synergies involved. These tools and models also serve to identify the challenges and interconnectedness across multiple actors and sectors, for example, in assessing policy coherence, testing the potential of various policy mechanisms, identifying current and future challenges and offering solutions pertaining to resources planning, implementing impacts of specific technologies and infrastructures at large scale. The modelling framework provides the opportunity to engage key stakeholders, thereby offering a cross sectoral understanding of associated challenges and opportunities (Daher et al., 2018). Stakeholder participation in the modelling processes contributes to local ownership of these tools. Similarly, decision-makers can also be involved: because their interest is more focused on the *outcomes*, rather than *applications*, of the tools. Therefore decision-makers can play a prominent role in co-creating model scenarios and interpreting model results.

The joint development and learning that derives from this process contributes to strengthening dialogue and improving understanding of the issues faced by the various actors. Beyond sector-specific goals, it moves the focus toward the interdependence of resources and production of goods and services in the other sectors. Doing so facilitates the dialogue and helps create a shared agenda, enabling the identification of options for its realization.

Challenges in modelling WEF Nexus hotspots are not limited to those that are technical. Other challenges may include: i) institutional fragmentation; ii) disincentives within the regulatory, legal and policy frameworks that fail to incentivize cross sectoral collaboration in planning and investment design; iii) short term planning horizons driven, in many cases, by political cycles; iv) lack of data and short time frames for providing results; and v) lack of incentives that promote collaboration and identify synergies for improved planning and decision making. Other challenges related to this process may include varying power relations between the different actor groups; the location of different actor groups at various levels (local to national); finding a host institution for the stakeholder interaction process; the time needed to follow implementation and policy processes in relation to a research project (which may only have the duration of a year or two).

Failing to involve stakeholders in the modelling process increases the likelihood that outputs will be neither relevant nor demanded by the actors, who are intended to benefit from them. Nexus exercises conducted in the past few years have provided learning opportunities to an array of disciplines that meet and discuss impacts and trade-offs of sector based policies and investments. These exercises allow analysts to develop realistic frameworks based on clear understandings of the different constraints faced by different nations or sectors. This results in the development of inclusive objectives that are feasible to be achieved. The objective moves

away from developing a *model* and toward developing a *tool* that provides a set of practical recommendations potentially to be mainstreamed into policy and investment decisions.

Current experience with modelling frameworks for the nexus result in valuable exercises that begin to identify and illustrate not only the trade-offs, but also the synergies that can be achieved, particularly in budget constrained environments. These exercises have demonstrated the value of modelling to identify and quantify the trade-offs and synergies of collaboration. These are reflected in better planning frameworks and, more importantly, in understanding the financial gains from joint investment planning and design. Models can provide clear policy guidance to enable maximization of financial, economic, social, and environmental benefits across sectors.

References:

- Daher, B., Mohtar R. H., Pistikopoulos, E. N., Portney, K. E., Kaiser, R., and Saad, W. (2018). Developing Socio-Techno-Economic-Political (STEP) Solutions for Addressing Resource Nexus Hotspots. *Sustainability* 2018, 10, 512; doi:10.3390/su10020512.
- FAO (2017). *The State of Food Security and Nutrition in the World*. Retrieved from: <http://www.fao.org/3/a-I7695e.pdf>
- IEA (2017). *Energy Access Outlook 2017. From Poverty to Prosperity*. Retrieved from: https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccessOutlook.pdf
- Kibaroglu, A., & Gürsoy, S. I. (2015). Water–energy–food nexus in a transboundary context: the Euphrates–Tigris river basin as a case study. *Water International*, 40(5-6), 824-838. doi:10.1080/02508060.2015.1078577
- Mohtar, R. H. and Daher, B. (2017). Beyond zero sum game allocations: expanding resources potentials through reduced interdependencies and increased resource nexus synergies. *Current Opinion in Chemical Engineering*. 18:84-89.
- Mohtar, R. H. and Daher, B. T. (2012). Water, energy, and food: The Ultimate Nexus, *Encyclopedia of Agricultural, Food, and Biological Engineering*, Second Edition. DOI: 10.1081/E-EAFE2-120048376.
- OHCHR (1966). International Covenant on Economic, Social and Cultural Rights Retrieved from: <http://www.ohchr.org/EN/ProfessionalInterest/Pages/CESCR.aspx>
- United Nations Economic and Social Commission for Western Asia (UN-ESCWA) (2016). Developing the Capacity of ESCWA Member Countries to Address the Water and Energy Nexus for Achieving Sustainable Development Goals, Regional Policy Toolkit. United Nations, Beirut. 219 pg
- UN (1948). Universal Declaration of Human Rights. Retrieved from: <http://www.un.org/en/universal-declaration-human-rights/>
- UN (1992). Rio Earth Summit. Retrieved from: <http://www.un.org/geninfo/bp/enviro.html>
- UN (2000). Millennium Development Goals. Retrieved from: <http://www.un.org/millenniumgoals/archive.shtml>

UN (2015). Sustainable Development Goals. Retrieved from:

<http://www.un.org/sustainabledevelopment/sustainable-development-goals/>

UN (2016). The Sustainable Development Goals Report 2016. Retrieved from:

<https://unstats.un.org/sdgs/report/2016/leaving-no-one-behind>

UN (2017). Sustainable Development Goal 17. Retrieved from:

<https://sustainabledevelopment.un.org/sdg17>

WHO (2017). Drinking-water. Fact sheet. Retrieved from:

<http://www.who.int/mediacentre/factsheets/fs391/en/>