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Beyond zero sum game allocations: expanding resources potentials through reduced interdependencies and increased resource nexus synergies

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The 2030 goal for the implementation of the Sustainable Development Goals (SDGs) gives rise to challenging questions stemming from the inherent interconnections and potential competition between primary resources. '*Economic Growth*' and '*Clean Water and Sanitation*' are intimately related SDGs. Access to quality water is critical to growth, but as economies and populations grow, so does their demand for water. As pressures on water systems increase, existing and proposed economic activities are subject to growing water related stresses, such as service disruptions, droughts, floods, and contamination. Growth is dependent upon investment in critical resources to mitigate water related risks and for sustainable water allocation. Highly interdependent water, energy, and food systems are reflected in SDGs, raising questions about how to achieve the security goal for water without sacrificing that for food; and giving rise to questions of how to quantify the interconnections and assess the possible trade-offs for sustainable pathways into the future. This commentary addresses these complex and critical challenges to achieving the interconnected goals at different scales and in light of scarce or incompatible data, and the many stakeholders involved. It offers thoughts on holistic approaches to complement the SDGs and facilitate science-based decision making, monitoring, assessment and cooperation. The paper reflects on World Water Week 2016, reviews global risks and societies' perceptions of those risks. Defining 'resource nexus', the paper shares examples that illustrate the concept and calls for efforts to reduce inter-dependencies and increase synergies between the primary resources through technology, policy, and adaptations to human consumption and conservation behaviors. The paradigm shift proposed, while critically needed, is not possible without the resource nexus platform.

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Reflections from World Water Week 2016

The 2016 World Water Week [1], with the theme 'Water for Sustainable Growth' followed, by about a year, the UN General Assembly's 17 Sustainable Development Goals (SDGs) [2] and the Paris Climate Change agreement [3]. The theme highlights the extent to which SDGs 6 and 8, water and economic growth, are tightly interconnected and central to the success of other goals [4]. As economies and populations grow, so do the assets, economic activities, populations and the water-related risks faced. These risks include service disruptions, drought, floods, declining water quality (contamination), and increased pressure on water resources. Planning investments for a more sustainable future, accounting for the interlinkages between water and growth are imperative. *Water* can be both friend and foe to *growth*. Water is a key element for the growth of civilizations throughout history: an instrumental resource for both agricultural and industrial sectors, water is critical to maintain the livelihood of communities. Three out of four natural disasters in the world are water related: the annual price tag associated with flood damage to property is estimated at US$120 billion, while the annual cost of inaction is estimated to be nearly US$ 500 billion [5]. Improved water management brings the potential of reduced loss or damage while building resilience in the face of water related natural disasters [6]. Good water management underpins economic growth, enhances productivity and increases trade. Investment in information, infrastructure, and institutions, is a precursor to sustainable growth. Hence, *growth* can be both friend and foe to *water: it* provides critical resources and incentives for achieving water security, mitigating water related risks, offering opportunities for investing in sustainable water resources management. There are numerous examples of the negative impacts of growth on water resources [7–9]. Development pathways should factor in water security to avoid future liabilities at higher cost.

As the global community moves toward implementation of the SDGs, particular attention must be given to the interactions of SDG 6 (Water) and SDG 8 (Economic Growth). These two goals will sometimes generate synergistic effects, while at other times, create unintended competition. For example, more efficient water technologies are likely to impact a farmers' economic wellbeing positively, but could have a less favorable impact on available water resources. Thus, a holistic approach is needed for the implementation of

the SDG's. The challenge will be to ensure that economies grow *sustainably* without jeopardizing water security, which in turn play a role in continued growth. Understanding the trade-offs associated with different growth pathways will play a critical role in avoiding those challenges of sustainability. Moreover, water issues cross scales and are variably interconnected with different economic sectors: hence, the sustainable use of this precious resource requires local solutions [10]. Long-term infrastructural investments must likewise be interconnected, combining investment in water infrastructure, institutions and information (data). The best investments are sequenced along strategic pathways, and rely upon informed dialog among stakeholders as a key to guide joint management of water and other resources for economic growth. Continued dialog and coordinated efforts among funding agencies and recipient communities should be encouraged to bridge the expectations and goals of all the parties [11].

Global key drivers and risks

The system of the global commons of water, energy, and food resources is highly interlinked. Due to the tight interconnections between biodiversity, climate, rainforest, biogeochemical cycles, and ocean systems, all of which are threatened, the global commons are at risk. The threat is highly complex, but fortunately, several drivers exist to address that threat. The Sustainable Development Goals (SDGs), for which many countries are developing plans for implementation is one of those drivers. The challenge to implementing the SDGs and related national goals is the inability of a single sector that has typically driven these plans, whether water, food or climate, to do justice to these implementation without considering the externalities or impact of one sectoral plan upon remaining plans for other sectors. Assessing and monitoring implementation progress face challenges of data availability and convergence. A second important driver, the Paris Climate Change Agreement, places climate caps and carbon emission caps upon which the global community has also acted. Both of these are major drivers for moving forward with the nexus agenda. Better integrative management and allocation of water, energy, and food resources also represent a bottleneck for future economic growth. While the annual Global Risks Reports published by the World Economic Forum identify water as the highest risk resource, the most recent Global Risks Reports [12,13] highlight the fact that water as a resource is no longer affecting water availability and water access alone, but rather it is now an economic driver for national security plans and an engine for economic growth. According to the Global Risk Reports water, food and energy securities are on the top of the global risks with high likelihood and high impact, and ranked higher than traditional geopolitical risks [12,13].

The water–energy–food nexus defined

The water community manages water, which is demanded by all major economic sectors. Similarly, the energy and the food sectors, depend upon water (and food and energy) and are demanded by the major economic sectors. Thus, achieving water, energy, and food securities require feasible implementation mechanisms for each sector that also synergize with the other two sectors. Stakeholders from each sector must communicate, address potential constraints and limitations, better understand the complexities and trade-offs for different resource allocation scenarios, and work toward a common agenda. This would be facilitated by a 'platform' or a space that is equidistant from each of the three resource systems, yet allows for the knowledge based dialog and goals identification to move beyond sectoral efficiency and toward resources system sustainability. It must enable policy makers to understand the trade-offs between the elements of the nexus or intersections of these three primary resources. The holistic, systems level platform, offering a nexus perspective allows us to look at both the manner and degree to which these systems are interconnected, and how these interconnections form the nexus of the systems of the water, energy, and food. With such a platform it becomes possible to understand where the interdependencies might be reduced, system performance and resilience improved, and, not less, the trade-offs and costs related to both. Thus, the 'nexus' is that intersection wherein we establish the water, energy, food trade-offs between allocations and define the hotspots for which future interventions must be made [14•]. The interventions depend upon the sector and the hotspot of concern, whether geographic, temporal, or thematic. The lesson learned from nexus studies to date is that there is always a local aspect to be considered: while the underlying foundation of the processes and interlinkages between resource systems may be similar, the specific solutions will be local and will address specific challenges, at a specific scale, and defined by specific constraints, stakeholders, and goals.

The nexus platform is a science-policy platform that builds on systems theory and cuts across existing strong disciplines, including water productivity, integrated water resources management and energy efficiency efforts already accomplished by various disciplinary groups working in food, water and energy resources, respectively. The nexus platform builds on these principles to develop an analytical framework that enables the holistic assessment of levers and interventions, while identifying the trade-offs among different resource allocation pathways forward. Building upon this definition of the nexus, we can now define the systems of the nexus, and most critically, define the *scale* of the nexus system