# Considerations for a socio-technical systems conceptualization of the water-energy-food nexus for rural communities

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## 1. Introduction

According to the most recent UN estimates, the global population is expected to reach 8.5 million in 2013, 9.7 in 2050, and a staggering 10.9 in 2100.[1] Such population projections in an age of crisis, ranging from economic crises to the climate crisis, pose several different global challenges. Scholars and practitioners alike recognize the importance of a nexus approach, rooted in systems thinking, for framing solutions to the grand challenges of the 21st century. In particular, researchers, technologists and policy makers are increasingly exploring complex socio-environmental problems from the perspective of Water-Energy-Food (WEF) nexus.[2] Questions related to the WEF nexus are especially relevant for the world's rural and poor communities who face extreme climate-related vulnerabilities.

Developing WEF nexus solutions for rural communities calls for a socio-technical system approach that places community engagement and issues of equity, justice and sustainability at

[1] Department of Economic and Social Affairs Population Division, "World Population Prospects 2019 - Highlights," (United Nations New York, 2019), https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.
[2] Kristal Jones, Nicolas R. Magliocca and Kelly Hondula, "White Paper: An Overview of Conceptual Frameworks, Analytical Approaches and Research Questions in the Food- Energy - Water Nexus," (National Socio-Environmental Synthesis Center, 2017), https://doi.org/10.13016/M2BK10.

its center. However, the extent to which existing WEF nexus conceptual models address these issues, remain unclear. Additionally, the salient ecological and social sustainability considerations that should be incorporated into a WEF nexus conceptualizations that maybe relevant and useful for rural communities needs further examination.

We start out this paper with a review of existing WEF nexus conceptual framework to identify gaps in addressing the issues of relevance to rural communities. We then conduct semi-structured qualitative interviews with practitioners and scholars working in these areas on considerations for a new conceptual model for the WEF nexus as a socio-technical system for rural communities. Findings from these interviews are shared and discussed. In doing so, we provide important directions for a new conceptual framework on the WEF nexus, that could be used to guide not just sustainable, but rather regenerative development planning and implementation processes in rural communities.

## 2. Unpacking the nexus - definitions, linkages, and drivers for an integrated approach

Access to water is accepted as a fundamental human right. The definition on the right to water as elaborated by the UN Committee of Economic, Social and Cultural Rights (CESCR), emphasize elements of sufficiency, safety, acceptability, physical accessibility and affordability of water for personal and domestic use.[3] While this definition implies a priority in the allocation of water resources towards personal and domestic use, there is widespread acknowledgment of the different and equally important utilization of water resources beyond personal and domestic use. Of these, central to WEF nexus is the utilization of water resources for food and energy production. Energy security is defined as "the uninterrupted availability of energy sources at an affordable price", implying the importance of continuity of energy supplies, in addition to the physical availability of supplies.[4] Definitions of food security focus on elements of availability, access, affordability and stability.[5]

Definitions of water , energy , and food security focus on aspects of access, availability, safety, affordability, stability, and continuity of resources. [6] Given that the WEF nexus approach focuses primarily on achieving WEF security, these aspects identified in the respective individual definitions remain central to conceptual frameworks of the WEF nexus. Some of the more recent conceptual frameworks on the WEF nexus, places a bigger focus on sustainability positing that sustainability of WEF resources are closely tied to WEF security.

*Linkages between WEF systems, resources and motivations for a nexus approach*

Water, energy and food systems and resources have multiple linkages across them. For instance, water and energy are crucial inputs into food production systems while runoff from fertilizers used

[3] United Nations Committee of Economic, Social and Cultural Rights, "General Comment No.15 - The Rights to Water (arts. 11 & 12 of the International Covenant of Economic, Social and Cultural Rights), (Geneva, 2003), https://tbinternet.ohchr.org/_layouts/15/treatybodyexternal/Download.aspx?symbolno=E%2fC.12%2f2002%2f11&Lang=en

[4] "Energy security - Areas of work," International Energy Association, accessed May 10, 2020, https://www.iea.org/areas-of-work/ensuring-energy-security

[5] Morgan Bazilian et al., "Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach," *Energy Policy 39*, no.12 (2011): 7896 - 7906, doi: 10.1016/j.enpol.2011.09.039

[6] Bazilian et al., "Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach," doi: 10.1016/j.enpol.2011.09.039

in food production pollutes water resources.[7] Energy production also requires water, and residues from energy production affect the water cycle. Water extraction and distribution require energy and an adequate supply of food is essential to sustain workers who run these systems.[8] Increasing demands placed on WEF resources, resulting from population growth and rapid rates of urbanization and globalization has led to a recognition of the need to better understand the linkages between WEF resources to move towards more integrated and sustainable management of these resources.[9]

One of the earliest attempts to put this matter on the global agenda was at the 2011, World Economic Forum where the failure to adopt a more integrated approach to managing WEF resources to ensure water, energy and food security for all was described as an "impediment to economic growth and social stability" and a threat to global security.[10] Consequentially, there have been several international gatherings and conferences to raise awareness about WEF nexus to allow for sharing of most recent scholarship on the topic and provide a platform for international dialogue to highlight the urgency of the challenges related to WEF nexus. In the next section, we review eight different frameworks for understanding the WEF nexus, conceptualized between 2011 to 2019.

## 3. Review of existing conceptual frameworks

This section reviews eight different conceptual frameworks for understanding the WEF nexus, conceptualized between 2011 to 2019.[11] In doing so, we look at the framework's contribution to the WEF debate, along with policy and practical implications, including what the desired outcome of a WEF nexus conceptualization is, to how issues related to governance, scale and operationalization are addressed. Viewing these frameworks from a perspective of relevance and utility for rural populations, we also consider the extent to which these frameworks consider rural livelihoods.

**Table 1** (below) provides a comparative analysis of these conceptual frameworks.

***Table 1***

*Comparative Overview of Water-Energy-Food Nexus Frameworks*

[7] World Economic Forum*, Global Risks 2011 Sixth Edition An Initiative of the Risk Response Network*, (Geneva, 2011), http://reports.weforum.org/global-risks-2011/

[8] Ibid

[9] Bazilian et al., "Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach," doi: 10.1016/j.enpol.2011.09.039

[10] World Economic Forum, *Global Risks 2011*, (2011), 28.

[11] The eight WEF conceptual framework considered for this review are: Water-Energy-Food nexus framework, **Bonn Nexus Conference**, 2011; Water-Energy-Food framework, **World Economic Forum**, 2011; Schematic showing the Water-Energy-Food nexus with effecting parameters, **Mohtar and Daher**, 2012; Water-Energy-Food framework, **International Center for Integrated Mountain Development**, 2012; Framework linking Water-Energy-Food security, **International Institute for Sustainable Development**, 2013; FAO approach to the Water-Energy-Food nexus, **Food and Agriculture Association**, 2014; The Water-Energy-Food nexus framework for integrated science-stakeholders dialogue, **Mohtar and Daher**, 2016; Water-Energy-Food nexus livelihoods adaptation and transformation framework, **Mabhaudhi et.al.**, 2019

| Conceptual Framework | Desired objectives of WEF nexus approach | | Systems approach | Governance | Climate change | Rural livelihoods | Scale | Focus on operationalization |
|---|---|---|---|---|---|---|---|---|
| | *Security* | *Sustainability* | | | | | | |
| **Water - Energy - Food nexus framework (Hoff, 2011**).[12] Initially developed for a WEF conference held in Bonn, Germany. No reiterations or revised versions of the framework since then. | Focus on achieving water, energy and food security, placing water security at the center of the model | While the policy prescriptions talk about sustainability, at a conceptual level, the model does not draw linkages between WEF security and sustainability | No explicit systems approach | Emphasizes governance aspects of WEF nexus, highlighting the geopolitical factors. | Includes climate change as a global driver affecting WEF security. | Emphasizes accelerating access to WEF resources for the global poor, through integration of WEF nexus into rural livelihoods. However, this discussion focuses mainly on technological solutions for increasing resource use efficiency. | No specific scale identified. However, most examples are national and regional level. | No guidance on operationalization of the nexus as conceptualized by the framework |
| **Water-Energy-Food framework (World Economic Forum, 2011)**[13] | Posits WEF insecurity as impediments to economic growth and social stability and as a significant global security risk. | Highlights market led resource pricing that accounts for externalities as a way of addressing sustainability concerns associated with the WEF nexus | No explicit systems approach | The model refers to global governance failures that could result from WEF insecurities, but not the other way around. Emphasizes multi-stakeholder planning as way of addressing nexus governance | Includes climate change as a global driver affecting WEF security. | Does not provide an explicitly link to rural livelihoods, but encourages engaging, empowering and incentivizing community actors to ensure that resource users also become guardians of sustainable consumption of resources | No specific scale identified. However, most examples are national and regional level. | No guidance on operationalization of the nexus as conceptualized by the framework |
| **Schematic showing the Water-Energy-Food nexus with effecting parameters, (Mohtar and Daher, 2012)**[14] | Identify WEF securities to be linked to each other. | Focuses on resource use efficiency with the intent of reducing WEF trade-offs and capitalizing on synergies | Take a systems approach, delineating trade-offs and synergies between WEF systems | Governance is identified as a driver of the model, with no critical discussion on the topic. | Includes climate change as a global driver affecting WEF security. | No focus on rural livelihoods. | No examples to indicate scale. No separate discussion on scale. | No guidance on operationalization of the nexus as conceptualized by the framework |
| **Water-Energy-Food framework, (International** | Focus on enhancing water, food and energy | Emphasizes investing in ecosystem goods and | Takes a systems approach, highlighting | No discussion on governance issues | Includes climate change as a global driver | Emphasizes the importance of locals | Regional scale | No guidance on operationalization of the nexus as |

[12] Holger Hoff, *Understanding the Nexus. Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus* (Stockholm: Stockholm Environment Institute, 2011), https://www.sei.org/publications/understanding-the-nexus/

[13] World Economic Forum, *Global Risks 2011*, (2011)

[14] Rabi H. Mohtar and Bassel Daher, "Water Energy and Food: The Ultimate Nexus," *Encyclopedia of Agricultural, Food, and Biological Engineering, Second Edition*, (Taylor & Francis, 2012), doi: 10.1081/E-EAFE2-120048376

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Center for Integrated Mountain Development, 2012)[15]** | security in the Himalayan region | services of the Himalayan mountain range to ensure WEF security | the ecosystem goods and services provided by the natural system. | | affecting WEF security. | (highlighting connections of ecosystem services to local livelihoods and culture), with no further discussion. | | conceptualized by the framework |
| **Framework linking Water-Food-Energy security, (International Institute for Sustainable Development, 2013)[16]** | Focuses on achieving and maintaining WEF security now and in the future. This temporal perspective emphasizes that externalities must not be pushed to the future. | Emphasizes restoring ecosystem goods and services as a way of maximizing WEF security | Nested systems approach, highlighting natural, built and human systems and the interactions and overlaps between these systems | Emphasizes collaborative and adaptive planning processes for addressing governance challenges | Includes climate change as a global driver affecting WEF security. | No explicit focus on rural livelihoods | Place (ecosystem) based. So, can be at different scales, depending on the scale of the ecosystem | Emphasizes operationalization and provides detailed guidance on operationalizing and implementation of a nexus approach, to inform land investment decisions. |
| **FAO approach to the Water-Energy-Food nexus (FAO, 2014)[17]** | Emphasizes WEF security as important aspects of human well-being | Combines security and sustainability through additional sustainability indicators, such as sustainable use and management of water, efficient use of energy resources, cleanliness of energy produced and consumed. | Takes a systems approach to conceptualizing the WEF nexus, to be embedded in natural and human systems | Identifies governance as a site specific internal a driver impacting WEF security | Includes climate change as a global driver affecting WEF security. | No explicit focus on rural livelihoods | Place - based, so can be applied at different scales. No pre-determined definition of place (ecosystem vs. national borders etc) | Emphasizes operationalization and provides detailed guidance on operationalizing and implementation of a nexus approach, to quantify nexus issues and assess the impact of different interventions. |
| **Water-Energy-Food Nexus framework for integrated science stakeholder dialogue** | Identifies WEF security to be important and central to global security | No explicit focus on sustainability | Focuses only on human systems relevant for trade and resource allocation | As a WEF governance conceptual framework, emphasizes dialogue across different sectors (society/business/ | No reference to climate change. | No explicit focus on rural livelihoods | No examples to indicate scale. No separate discussion on scale. | No guidance on operationalization of the nexus as conceptualized by the framework |

[15] Golam Rasul, *Contribution of Himalayan Ecosystems to Water, Energy, and Food Security in South Asia: a Nexus Approach. Contribution of Himalayan Ecosystems to Water, Energy, and Food Security in South Asia: a Nexus Approach* (Kathmandu: International Center for Integrated Mountain Development, 2012*),* http://lib.icimod.org/record/1898/files/nexus1.pdf

[16] Livia Bizikova et.al., *The Water–Energy–Food Security Nexus: Towards a Practical Planning and Decision-Support Framework for Landscape Investment and Risk Management,* (Winnipeg; International Institute for Sustainable Development, 2013), https://www.iisd.org/sites/default/files/publications/wef_nexus_2013.pdf

[17] Alessandro Flammini et.al., *Walking the Nexus Talk: Assessing the Water-Energy-Food Nexus in the Context of the Sustainable Energy for All Initiative* (Rome: Food and Agriculture Organization, 2014), http://www.fao.org/3/a-i3959e.pdf

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **(Mohtar and Daher, 2016)[18]** | | | | government) on nexus issues | | | | |
| **Water-Energy-Food nexus livelihoods adaptation and transformation framework, (Mabhaudhi et al, 2019)[19]** | Emphasizes WEF security for all, emphasizing social equity | Focus on both social and ecological sustainability | Focus on aspects of natural and human systems | Addresses governance through integrated planning and adaptation. | Identifies climate change as an important driver and aspect around which WEF nexus strategies should be planned | Focus on improvement of rural livelihoods and health, in the face of climate variability as an entry point to the WEF nexus | Applied in the regional context of Southern Africa | Guidance on quantification of WEF nexus. No additional guidance on how to operationalize the other aspects of the framework. |

Majority of the WEF conceptual frameworks reviewed for this exercise, are applicable and relevant to a macro level. The emphasis on the WEF security aspects dominated by resource use efficiency concerns indicates that these frameworks are shaped by a western perspective of resource use that emphasizes market led, technocratic approaches to addressing the WEF nexus.

Water resources remain at the center of all of the WEF nexus conceptual frameworks. Understanding the water-energy and water-food linkages has been the focus of much of the research in the field. Scholarship to further our understanding of linkages between food-energy has been lagging behind. Given that water is essential for sustaining any form of life - the central focus of frameworks on water is understandable. However, given the emergence and increasing popularity of biofuels and the effects of climate change, there is a need to better understand the linkages between food and energy systems and resources.

WEF resources do not exist in a vacuum. Every single WEF resource exists in a large natural ecosystem. Human systems which are nested within these ecosystems interact with each other in dynamic and complex ways. With the exception of a few (framework proposed by ICIMOD, IISD, FAO and Mabahaudhi), most frameworks fail to emphasize this aspect of the nexus and does not give due consideration to the important role of ecosystem goods and services provided by WEF resources.

Rural livelihoods remain on the peripheries of most WEF nexus conceptual models. The one exception to this is the model proposed by Mabhaudhi and colleagues that considers a focus on improvements of rural livelihoods and health as an important entry point for ensuring WEF security for all. Addressing this gap in the WEF nexus modelling, is crucial especially in the face of increasing climate vulnerabilities.

Almost all of the model emphasized the importance of governance for addressing WEF security for all. This focus on governance highlights integrated planning, involving a broad range of stakeholders, cross sectoral and cross stakeholder collaboration and adaptive planning as ways of addressing governance gaps in WEF nexus management. However, this conversation lacks a critical look at governance with a view of understanding and addressing power differential across stakeholders.

[18] Rabbi H. Mohtar and Bassel Daher, "Water-Energy-Food Nexus Framework for facilitating multi-stakeholder dialogue," *Water International* 41, no.5, (2016): 655-661, doi: 10.1080/02508060.2016.1149759

[19] Tafadzwanashe Mabhaudhi et.al., "The Water–Energy–Food Nexus as a Tool to Transform Rural Livelihoods and Well-Being in Southern Africa," *International Journal of Environmental Research and Public Health* 16, no.16, 2019: 2970, doi: 10.3390/ijerph16162970

Most of the existing conceptual models, are applicable and relevant to a macro level and is shaped by a western perspective of resource use and emphasizes market led, technocratic approaches to addressing the WEF nexus. Additionally, the important conversation of WEF nexus has been elite-led and confined to international conferences dominated by big businesses, academia and international development organizations. Review of existing WEF conceptual models reveals that they may not be "fit for purpose" for addressing the grand challenges of the 21st century, especially when looking at the matter from the perspective of the rural poor.

As captured in the introduction of Larry Swatuk's insightful book, *Water, Energy, Food and the People of the Global South*, what is needed is "an alternative nexus approach that is, among other things grounded in local experience…"[20] According to Swatuk, what is needed, in the word of Irish academic Simon Dalby is a "nexus for the next-us".[21] We consider our work in generating insights for a new nexus as an important the foundation in the attempt to create a "nexus for the next-us" from the perspective of rural communities.

## 4. Methodology

The primary question that we explore is: **what does a WEF nexus conceptualization that is relevant and useful for rural communities look like?** In asking this question we are interested in identifying crucial aspects of the WEF nexus that are of importance to rural communities, with the aim of contributing insights to the formulation of a new WEF conceptual model for rural communities. As part of this question, we are also interested in exploring sustainability considerations that has to be taken into consideration, especially concerns related to ecological limits of the planet as well as basic social conditions that has to be met for a dignified life. In framing this question, we were especially interested in finding out the extent to which the ecological ceilings and the social floors described by economist Kate Raworth in her framework for a sustainable economy, which she calls a doughnut economy[22] are relevant and useful when looking at the WEF nexus in rural communities.

The doughnut economy framework which has had several iterations since it was first conceived in the run up to the Rio20+ Summit in 2012, is presented as a framework for sustainable development and combines planetary boundaries with social foundations.[23] The planetary boundaries work produced by Johan Rockström and colleagues in 2009, identified nine critical earth system processes and associated tipping points for the Holocene. The nine planetary boundaries are: stratospheric ozone depletion, loss of biosphere integrity (biodiversity loss and extinctions), chemical pollution and the release of novel entities, climate change, ocean acidification, freshwater consumption and global hydrological cycle, land system change, nitrogen and phosphorous flows to the biosphere and oceans and atmospheric aerosol loading.[24] Rockström and colleagues, introduced the idea of a "Safe Operating Space" for humanity arguing

[20] Larry A. Swatuk and Corrine Cash, "Perspective on the Nexus: Water, Energy and Food Security in an Era of Climate Change," in Water, Energy, Food and the People of the Global South, ed. Larry A. Swatuk and Corrine Cash (Cham: Springer Nature, 2018), 7.
[21] Ibid.
[22] Kate Raworth, *Doughnut Economics: Seven Ways to Think Like a 21st Century Economist*, (London: Random House: 2017)
[23] Ibid
[24] Ibid

that crossing the identified thresholds in the planetary boundaries will be disastrous.[25] Raworth posits that the planetary boundaries delineate the ecological limits for sustainable development. She builds on it a number of social foundations consisting of twelve social conditions or social floors which must be met to prevent critical depravations.[26] The twelve social floors as described by Raworth are: water, energy, food, health, education, income and work, peace and justice, political voice, social equity, gender equality, housing and networks.[27] The space between the ecological limit or ceiling and the social floor is described as the "safe and just space for humanity"; an environmentally safe and socially just space for inclusive and sustainable development.[28]

We explored these questions in semi-structured interviews with practitioners and scholars working on the WEF nexus or water, energy and food separately. Participants were identified and recruited through a purposive snowball sampling methodology, starting out with relevant individuals in the professional networks of the research team.

Given that the participants were drawn from the professional networks of individuals who hold a particular view about development processes, it is very likely for study participants to hold similar views. In the context of this specific research endeavor, such a bias may not necessarily be so detrimental as our aim is not to generate insights for a model that is based on "objective" truth but rather our aim is to shape up a model that is based on a subjective world view that places emphasis on sustainability, justice and equity.

A total of ten practitioners and scholars (eight practitioners and two individuals who could be considered scholar cum practitioner) working in the areas of food, water and energy were interviewed. This included a mix of individuals who were working on food, water and energy issues in the Global South: in the Indian subcontinent, Africa and small island national states, in a variety of spaces starting from universities, consulting firms, civil society organizations, government ministries and international development organizations. Eight of the individuals were male and two were female.

The following section provides an overview of the major insights generated through these interviews.

## 5. Findings: Insights for a new framework

### *1. Elements emphasized within water, energy and food*

Participants emphasized that in addition to understanding the trade-offs and synergies between water, energy and food resources, there was also a need to unpack the salient aspects of water, energy and food security. In this regard, participants highlighted additional aspects within water, energy and food that are missing from existing WEF conceptual frameworks.

[25] Ibid
[26] Ibid
[27] Ibid
[28] Ibid

Specifically, within water, participants emphasized water quality issues as important when approaching the nexus. Speaking specifically within the context of the Maldives, one participant described the relationship between water quality issues such as contamination and salinity and agriculture in the following way:

*"Water quality is a big issue here. When you look at water resources, salinity of ground water and contamination of ground water. The seasonability of the water table with climate induced events such as flooding and tidal surges etc. It becomes very difficult for the farmers to manage with all of this."*

As highlighted above, water quality considerations become extremely important for the nexus, especially in light of climate change.

Within energy, participants emphasized the need for considering the source of energy and how energy is generated for varying uses. Within food, participants noted that rather than talking about food security, it should be the notion of nutrition security that we should be looking at. One participant described the inadequacies of the fixations of traditional food security definitions on fulfilling a specific caloric intake in the following manner:

*"I am not a fan of food security. I have written on this topic for years academically and professionally. Where if we base everything on a 2000 calories diet. Then you can get those 2000 calories from ten soft drinks and soda pops. So, clearly when we talk about food security, we are not talking about empty calories. We are actually talking about actual nutrition security."*

With regards to the nexus, it was emphasized that that in addition to understanding the trade-offs and synergies between water, energy and food resources, there was also a need to develop a better understanding of and appreciation for competing uses and users of water, energy and food within each of these sectors individually. It was noted that often times, energy and water access projects prioritize the domestic or household uses and users of water and energy over other varying water and energy uses and users.

### *2. Embedded Systems Approach*

Participants emphasized the need and importance of considering the WEF nexus through the consideration of ecosystem goods and services provided by a specific ecosystem. This was identified as essential to taking a whole and embedded systems approach to the understanding the WEF nexus.

To illustrate this point, one participant gave the following example of how one may go about trying to conceptualize the WEF nexus in the context of coral islands:

*"So rather than talking about how many people are living on an island, you talk about how many people are living on a reef. Male' is a reef. Villingili is a reef. But…very often people don't relate an island to its coral reef. A coral reef produces an island. The island itself is a product of the coral reef. And there will be similar habitats within a given coral reef, just a sandbank. Many sandbanks. Many islands. And then you have many different coral habitats as well. When you treat that individual reef as a system, then together with the people living on it, then only you can really try to integrate the sectors that you are talking about."*

Related to the idea of embedded systems, participants emphasized the relevance and importance of looking at rural - urban dynamics and considering them to be complementary, nested systems within a specific natural ecosystem.

***3. Boundaries for Sustainability***

In terms of looking at ecological ceilings, participants shared that the ecological considerations are not necessarily spoken of using the language of the planetary boundaries. However, there was an acknowledgement that all of the biophysical interactions captured in the planetary boundaries concept often gets lumped under the banner of climate change.

Noting the global fixations on one or two of the planetary boundaries, one participant explained the lack of awareness of the planetary boundaries concept and the related dynamics in the following way:

*" I think there is that lack of awareness about the planetary boundary concept. Previously people used to focus on ozone depletion. That issue is less talked about these days. So that focus has slightly diminished. The awareness about recycling and reuse of material, through that process I think some and I think the emphasis on renewable resources that is supporting to some extent a few other areas so the planetary boundaries. But there is a lack of appreciation of ecosystem services and how energy and other services are being provided and how they interact with the ecosystem."*

In discussing the social floors, participants emphasized that health, income and work and education were more prominent and relevant than some of the other social floors such as peace and justice, social equity and political voice. Issues related to inequity and lack of equal political voice was discussed as important governance considerations.

Infact, one participant described the gravity of governance related considerations within the nexus in the following manner:

*"So, for me, the root to governance conundrum in this regard, is the work that has to be put in to educate communities, and that takes time, so that they can see themselves becoming empowered to make demands of public administrators and political decision makers. That is how it will change. It is an educational process. It is a slow process."*

Important governance considerations highlighted include the lack of decentralization, even when mechanisms were decentralized, there was an issue of lack of capacities and knowledge at the local level to manage the institutional arrangements related to the WEF nexus in an effective way. The same issues of lack of coordination and working in silos that is widespread across the board become more pronounced at a local level. Participants also noted that the lack of proper checks and balances, and the effective functioning of those checks and balances leads to corruption and massive losses.

In the discussions, decentralization of nexus solutions linked up with livelihood opportunities were identified as an important entry point, especially in rural communities. Describing decentralization as the only way forward, one participant explained that when it comes to social and ecological sustainability concerns it is the centralized approach that creates imbalances in the world.

***4. Incentives for action are important***

Participants emphasized the lack of appropriate incentives at the various levels to take a nexus approach, as the main reason for the gap between policy and practice in the application of a nexus approach.

As such, one participant described the challenges related to the lack of appropriate incentives in the following way:

*"We always say that eh everybody needs to change. People on the ground. Farmers need to change. Yes. But why? They are probably a small farmer who is practicing their traditional agriculture, the way they have been doing it for the last twenty years and it is producing less CO2 compared to a private enterprise that is located in the same village, but is not paying for the externalities either. What are the incentives for them to adopt?"*

Interestingly, one of the participants described the United Nations Green Climate Fund (GCF) as an important global incentive for governments, where if they wish to access the funds available through GCF they are compelled to take a more integrated approach. However, at the same time another participant spoke about the failures and the discrepancy between what is on paper in the project document and what happens on the ground even in GCF funded projects.

### *5. Nature's Design*

Participants highlighted the value of taking inspiration from nature when it comes to innovating for integrated solutions to the nexus. Related to the notion of taking inspiration from nature, was also the need to simplify the conversation on the WEF nexus so that it becomes easier to communicate these conceptual frameworks and understandings to both the layman as well as politicians and policy makers. In fact, participants noted that the simplification of the frameworks, approaches and tools was a pre-condition for their operationalization and application.

Another design consideration that was highlighted is the need for adaptation and flexibility, based on the local context. Participants noted that there are several frameworks already but what is lacking is implementation. In this regard, participants noted that rather than trying to come up with a new conceptual model, the focus should be on identifying the elements that are common and important for the operationalization of nexus approaches in a number of varying contexts.

One participant articulated the above in the following way:

*"Just to say that, because of my long working in this sector I am now asking myself the question as to whether the emphasis on trying to come up with a magic bullet framework is the right way to go……So I think we need to question development thinking and strategy, as to whether or not or what effort we place on creating a framework in order to allow us to do things or whether we need to understand the elements that can create a framework and create the environment that allow those elements to organically and with the magnet effect come together to do something great of its own. For me that is the only sustainable way."*

## 6. Discussion

Conversations with practitioners and scholars working on water, energy and food, points to some important additional elements that one needs to take into consideration in the respective definitions of water, energy and food security. These include a consideration for: the quality of water, the source of energy and nutritional value of food produced. These considerations become

even more urgent when one considers the bio-physical impacts of crossing the various planetary thresholds, including that of climate change.

While the planetary boundaries are identified to be integral to WEF conversations, the lack of the use of the language of planetary boundaries in discussions related to the WEF nexus indicates that there is a need to feature ecological ceilings more prominently in WEF nexus frameworks. A more explicit consideration of the planetary boundaries is important for a whole systems approach to the WEF nexus that highlights ecosystem goods and services. WEF nexus operates at the conjunction of natural and built systems, including socio-economic and cultural systems. In this regard, the nexus between urban - rural communities and systems is an important element that needs to be incorporated into WEF conceptualizations.

The emphasis placed on governance challenges related to the WEF nexus points to the need for the WEF nexus conceptualization and the application of WEF nexus approaches to engage in more meaningful analysis of power within the nexus. Additionally, efforts to decentralize governance of the nexus should be guided by deeply engaged community processes that focuses on enhancing and adapting local knowledge and capacities. At an operational level there was also a lot of emphasis placed on the importance of incentives as well as looking to nature for inspiration when innovating for the nexus. Improvement of rural livelihoods could be considered an important incentive for rural population to adopt a nexus approach. The emphasis on looking at nature for solutions could be taken as an important entry point for placing a higher importance on traditional and indigenous knowledge when tackling issues related to the WEF nexus. Furthermore, in terms of design, it is important for WEF conceptual frameworks to be flexible, and adaptive to local realities.

Finally, all of the points highlighted in the discussions illustrates that a focus on processes are just equally if not more important than the outcome, if one is to operationalize a nexus approach that focuses on sustainability, equity and justice.

## 7. Conclusion

The linkages between water-energy-food systems and resources cannot be ignored in the context of climate change, population growth, and urbanization. Not only are they directly related to the question of ensuring water, energy and food security for all, but also have a significant bearing on all of the global goals of the sustainable development agenda. The scholarship on WEF conceptual frameworks in the past eight years have provided much insight into the considerations for analyzing WEF trade-offs and synergies. However, it is clear that a stronger focus on rural livelihoods and governance and operational approaches guided by deep rooted community engagement practices that are adaptive to the local context is essential to make conceptualizations of WEF nexus relevant and useful to rural populations. Such a focus guided by a lens that aims to treat issues related to the nexus as socio-technical could provide new and innovative avenues for establishing more formal roles for the rural poor in the management of WEF linkages and elevating the voices that often get neglected in WEF resource allocation decisions.

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