Progress in Disaster Science 1 (2019) 100005

Contents lists available at ScienceDirect

Progress in Disaster Science

journal homepage: www.elsevier.com/locate/pdisas

Invited ViewPoint

Optimizing Food-Energy-Water (FEW) nexus to foster collective resilience in urban-rural systems

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ARTICLE INFO

ABSTRACT

With developing concerns of climate change, population growth and rapid urbanization, there is growing need to optimize Food-Energy-Water (FEW) sectors. Subsequently, FEW nexus thinking has become a prerequisite for development planning today, as the three sectors are intricately linked to each other. This study identifies the key barriers to operationalizing FEW nexus at ground level and underlines the need for urban-rural shared perspectives in resource management. Since, urban and rural systems depend on shared stock of natural resources, the study theorizes that building integrated decision making platforms at regional level will significantly enhance their collective resilience to emerging socio-environmental challenges.

Contents

1. Introduction

Food-Energy-Water (FEW) sectors are highly interconnected: water is required for almost all forms of energy production and supply, energy is required to treat and transport water, and both water and energy are essential to produce food [20]. 'FEW nexus' refers to the intricate relationships and trade-offs between these tightly linked systems [13]. The notion of FEW nexus gained global momentum during the Bonn 2011 Nexus Conference [3,14], wherein it was established that failing to recognize the consequences of one sector on another can lead to notable inefficiencies in the entire system, for example the choices made on food and diet influence both water and energy requirements. While the current world population of 7.3 billion is expected to reach 8.5 billion by 2030 [27], the global demands for food, energy and water are estimated to correspondingly increase by 35%, 50% and 40% [9••,31]. The inter-linkages between FEW sectors further complicate the matter of addressing their growing demands. World Economic Forum [33•] has continually highlighted through the Global Risk reports that food crises, energy shocks and water scarcity are among the major risks to the contemporary world in terms of likelihood and impact. Stephan et al. [25•] stressed that currently, 844 million people lack access to safe drinking water [34]; 1.1 billion lack access to energy [15] and about 815 million do not have secure access to food [11]. Predictably, the growing FEW demands amidst the severe resource shortages could lead to social and political instability, geopolitical conflicts and irreparable environmental damage [4,22].

Driven by the unprecedented climate uncertainties, rapid urbanization and social changes including population growth, the global communities today are erratically struggling for survival and growth amidst dwindling natural resources [16]. As urbanization continues apace, the city boundaries are expanding and more forests, wetlands, water bodies etc.

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http://dx.doi.org/10.1016/j.pdisas.2019.100005
Received 8 January 2019; Received in revised form 4 February 2019; Accepted 4 February 2019
Available online 22 April 2019

surrounding the urban areas are being acquired for industrial and commercial uses [3]. Manifestly, the current trends of development are putting enormous pressures on natural resources, presenting urban and rural communities with an increasing number of trade-offs and conflicts. Therefore, managing the FEW demands of a rapidly growing population requires a better understanding of how the urban and rural areas can collectively address these concerns and optimize FEW nexus with quantifiable trade-offs at regional level. The word 'optimizing' in this context refers to making the best or most effective use of available natural resources from a nexus perspective. Apparently, Ramaswami et al. [24••] underlined that not many analytical frameworks are available to capture the interactions among the FEW sectors between urban and rural areas. This study briefly highlights the key challenges hindering the operationalization of FEW nexus thinking at regional level using a systems perspective. The term 'system' relates to totality of the complex and interconnected elements that constitute a given domain [17•]. Moreover, the study elaborates on the significance of FEW nexus in building collective resilience of urban-rural systems. As different institutions govern and impact FEW resource systems at regional scale [7•], this study stimulates for developing integrated urban-rural platforms for collective resource management.

2. Significance of FEW nexus in urban-rural systems

Although, urban and rural areas are geographically dispersed, their functioning is tightly interconnected. They have different and often complementary assets which are integrated through a broad set of linkages. Recently, the concept of urban-rural linkage has been widely acknowledged in the global policy frameworks including The New Urban Agenda [28•] and Sustainable Development Goals 'SDGs' [30]. As, the SDGs aim for balanced territorial development, the concept of urban-rural linkages holds paramount importance in context of the contemporary socio-environmental changes, not only for achieving SDG 11 (Sustainable Cities and Communities), but also SDG 2 (Zero Hunger) and SDG 12 (Responsible consumption and production) among others [28•]. The exponentially increasing flow of people, capital, goods, services, technology, lifestyle and ideas between urban and rural areas is testament to their growing spatial and sectoral interdependence. With growing demands of critical resources (like food, energy and water) in urban areas, the mounting unsustainable pressures are pushing the natural systems at all scales towards critical thresholds and undermining the resilience of both urban and rural systems in the face of environmental shocks. Fig. 1 shows the conceptual understanding of FEW nexus thinking in consideration to the urban-rural systems alongside the emerging pressures and contextual differences. The study theorizes that because of the shared environmental assets, the urban-rural systems are collectively vulnerable to the repercussions of environmental degradation although at different levels. Wilbanks and Fernandez [35] also discussed how disaster impacts in distant resource areas can negatively influence the dependent urban areas and vice versa. While urban and rural systems

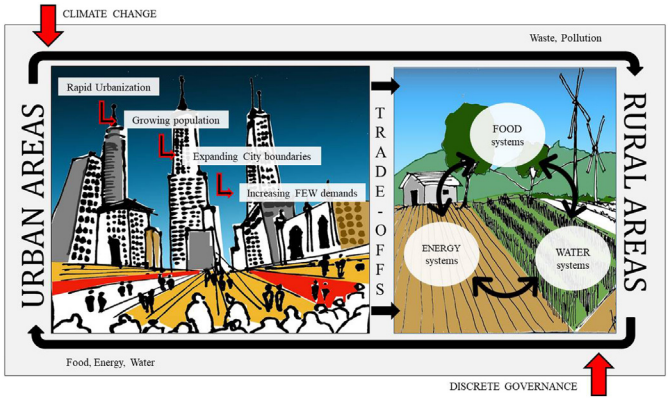

Fig. 1. Spatio-temporal viewpoint of FEW nexus thinking. (Source-author)

are becoming progressively interdependent, the notion of collective resilience, which relates with relational bonds and networks [12], has become elemental for development planning at regional level today.

In response to the growing urban population and changing social dynamics, there is increasing need to manage the regional stock of natural resources, else the urban-rural systems would end up competing with each other increasing the combinatorial complexity of FEW nexus. The dichotomist approach to urban-rural development so far and the sectoral approach to FEW nexus [18,23] has led to transformation inconsistencies due to which the rural systems today are disproportionately affected by climate change. Ensuring a secure and continuous supply of food, energy and water for urban and rural areas while maintaining a healthy environment has become the fundamental concern for regional authorities. Correspondingly, there is growing need for integrated nexus aware analytical frameworks to better quantify and model the interactions between FEW sectors at regional level, however the existing frameworks apparently fail to address the spatio-temporal scales of resource management. Further, the study speculates that the optimization of FEW resources in urban and rural areas essentially depends on the operationalization of FEW nexus thinking at ground level.

3. Key issues & challenges in operationalizing FEW nexus

Bizikova et al. [4], UNESCWA [26] and Jones et al. [17•] summarised various inter-disciplinary and trans-disciplinary research approaches to FEW nexus which vary in their scope, goals and understanding of drivers and pressures. Mohtar and Lawford [22] also highlighted several FEW nexus tools with different analytical approaches each focusing on different dynamics and characterizations of complex FEW systems. Some prominent examples of nexus tools include The Flow-Fund Model (MuSIASEM) [10] and The Water, Energy, Food Nexus Tool 2.0 [6,20]. Notably, Endo et al. [9••] underlined that although the scientific community has advanced forward with the nexus research, the concept of FEW nexus is still not fully acknowledged on the ground. Most of the global frameworks for analysing FEW systems are not intended to be used at the local or regional levels as they do not incorporate the proper temporal and spatial scales [8,19]. Further, Mohtar and Daher [21] pointed out that there continues to be a wide gap between science and policy making as the research findings are not efficiently being incorporated in the planning agendas. The differential availability and accessibility of FEW resources along the urban-rural continuum is not being addressed and there is need for explicit risk assessments to balance resource consumption and production at different levels. Moreover, the existing frameworks of FEW nexus follow a broad-scale top-down approach and there is a noticeable ambiguity in identifying the concerned stakeholders at grass-root level which restraints its operationalization [18]. While the natural systems operate at overlapping spatial scales (e.g. river basin organizations), the limited data availability, especially in developing countries, obstructs synchronization within current administrative systems. Resultantly, the operationalization of nexus thinking at regional level has proven difficult as the poor visualization of current and future scenarios poses a major barrier in policy making. Taking into consideration the distinct decision making slabs at regional level and the organizational silos, there is dire need for rethinking our current strategies to approach FEW Nexus holistically. Few of the major challenges to the FEW nexus research in consideration with the urban-rural systems as identified from the literature review are as listed below:

a) The limited knowledge about the complexity of FEW sectors and the lack of heterogeneous data limits the applicability of nexus thinking at spatial and temporal scales.
b) The persistence of sectoral approaches to FEW resources discretely at urban and rural levels constraints the overall system efficiency.
c) There is no synchronized analytical framework for monitoring or managing conflicts and trade-offs between urban and rural systems.
d) The discrete administration of urban and rural systems poses a major constraint in addressing trans-boundary environmental issues.

4. Discussion

Weitz et al. [32] highlighted that the concerns of FEW nexus have gained global thrust in relation to the post-2015 development agenda. However, despite the growing dialogue on integrated FEW resource management, the issue is not been methodically addressed at local level. Researchers have stressed that even today majority of the policy decisions with potential effects on FEW sectors are made by separate institutions, which often lack co-ordination [5,16,18,21]. While the path to collective resilience of urban-rural systems is dependent on the optimization of environmental resources, they are often governed by distinct local entities which limit their holistic action. As, urban-rural systems are linked across sectors, space and time; the optimal use of environmental assets by urban and rural systems will principally determine their coping capacities in the wake of evolving climate-related disasters like floods and drought.

Numerous researchers [1,18,23] have emphasized that there is dire need for administrative reforms to advance the nexus agenda at grass-root level. Addressing FEW nexus in consideration with urban-rural linkages has become indispensable as the urban-rural systems are getting increasingly interconnected through various social, economic and environmental linkages that often cross traditional administrative boundaries. As the stock of FEW resources is limited, the study suggests that shared urban-rural platforms need be developed at regional level to deal with complex socio-environmental problems like optimization of FEW nexus. Although, the SDGs commit subscribing countries to new action targets aimed at achieving sustainable water use, energy use and agricultural practices [2,29]; the study theorizes that more emphasis should be put on building urban-rural synergy, shared governance structures and equitable benefit sharing. Correspondingly, the development of integrated platforms to FEW resource planning will significantly help in realising coordinated development of urban and rural systems. The integrated platforms will open up opportunities for nexus-friendly solutions based on new ideas, approaches and multi-stakeholder engagements. The platforms will bring into consideration the needs and concerns of various stakeholders and facilitate for inclusive decision making with due consideration to urban-rural collateral equilibrium at regional level. With requisite enabling frameworks and interlinked thinking at regional level, such kind of nexus-aware approach to FEW resource planning will ascertain policy implementation at local level and positively engender collective resilience in urban-rural systems.

Acknowledgements

The first author is thankful to the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan for the scholarship.

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