Science of the Total Environment 574 (2017) 1131–1139

Contents lists available at ScienceDirect

Science of the Total Environment

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

Review

Towards understanding the integrative approach of the water, energy and food nexus

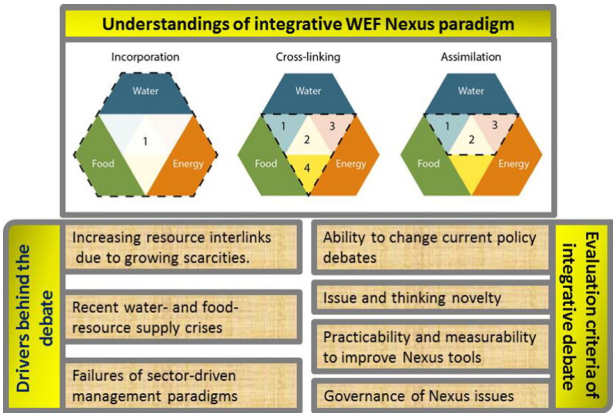
Mohammad Al-Saidi *,[1], Nadir Ahmed Elagib

Institute for Technology and Resource Management in the Tropics and Sub-tropics (ITT), TH Köln - University of Applied Sciences, Germany

HIGHLIGHTS

- Increasing interlinks, resource crises and management failures as nexus drivers
- Nexus as the newest integrated management paradigm in environmental sciences
- Incorporation, cross-linking and assimilation as three understandings of the nexus
- Nexus is a novel concept with few practical recommendations regarding governance.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form 5 September 2016
Accepted 6 September 2016
Available online xxxx

Edited by: D. Barcelo

Keywords:
WEF nexus
Integrative approaches
Sustainability paradigm
Resource security
Integrated management
Environmental policy

ABSTRACT

The water, energy and food nexus (WEF nexus) is currently quite popular in environmental management. The concept found a fertile ground in science and policymaking, but there is no consistent view on the meaning of integration within the nexus. Here, a wealth of publications is reviewed in an endeavour to: (1) reveal the lines of justification for the need of the WEF nexus debate and (2) identify the range of tools for analysing the interdependent resource issues of the nexus using an integrated framework of science and policy. There are three drivers behind the emergence of the nexus thinking. These are a) increasing resource interlinks due to growing scarcities, b) recent resource supply crises, and c) failures of sector-driven management strategies. Evaluation of the WEF nexus integrative debate can be carried out using four key criteria, namely ability to change current policy debates, issue and thinking novelty, practicability and measurability, and clearness and implementation roadmap. It is clear that, although the nexus has been quite successful in changing policy debates, issue prioritization is missing and seems to be left to specific case studies and policymakers' choices. There is a high need for 'incorporation' and 'cross-linking' of issues between the three resources. In this regard, nexus governance is the missing link in the nexus debate.

* Corresponding author at: Center for Sustainable Development, College of Arts and Sciences, Qatar University, P.O. Box: 2713, Doha, Qatar.
E-mail address: malsaidi@qu.edu.qa (M. Al-Saidi).
[1] Current author's affiliation: Center for Sustainable Development, Qatar University, Qatar

http://dx.doi.org/10.1016/j.scitotenv.2016.09.046
0048-9697/

Contents

1. Introduction

Evident in hundreds of reports and numerous proceedings of global and regional conferences and gatherings (e.g. World Forum gathering in 2011; Bonn WEF Conference in 2011; World Water Forum and the Rio Conference in 2012; the Stockholm Water Week 2014; many science-driven conferences in the same period in Bonn; Chapel Hill, etc.) that the water, energy and food nexus, often called WEF nexus, is currently quite popular in environmental management. Since its promotion, the 'WEF nexus' has related to hundreds of scientific publications. We counted more than 300 nexus-specific publications since 2009. It seems that this idea found a fertile ground in policy-making and science. This review paper found that using an integrated perspective on the management of the three resources is a new approach. At the same time, demands for such integration in the water-food, water-energy and food-energy sub-nexuses date back to programmes by the United Nations University (UNU) in the early 1980s, while explicit reference to three-way nexus appeared in the late 2000s (Scott et al., 2015). Yet, there is no consistent view on the meaning of integration within the nexus although this idea lies in the core of all nexus understandings. Further, the paper aims at outlining key understandings of the integrative approach of the WEF nexus using recent literature.

2. Drivers behind the nexus thinking

Literature on the WEF nexus reveals three lines of justification for the need for the WEF nexus debate: a) increasing resource interlinks due to growing scarcities, b) recent resource supply crises, and c) failures of sector-driven management strategies. These are also the drivers behind the emergence of the nexus thinking. The first justification is the most empirical and analytical one. The argument here is that internal drivers, such as economic and demographic changes, lead to growing demands for water, energy and land. Together with external drivers such as climate change and variability, these changes result in risks for resource security. These notions of growing demands, risks and insecurities are core arguments of World Economic Forums in 2008 and 2011 and the Bonn conference in 2011 (see Hoff (2011) and World Economic Forum (2011)). In this line, there is a risk of a "perfect storm" as the global demands for food and energy will grow by 50% and for freshwater by 30% by 2030 (see Beddington in Leck et al. (2015)). Estimations of the impact of climate change on the loss of agricultural productivity vary from 9 to 21% by 2050 while livestock and fisheries will be affected as well (Misselhorn et al., 2012). Science and policy need thus to look at the interlinks between the three resources. Examples of issues that embody this idea of increasing interlinks are those of large dams and water storage. Although many dams worldwide are primarily built for energy generation, their benefits extend to the issues of irrigation management, flood control, drought management, etc. The generated hydropower depends on the availability of water and can be threatened by climate variability. Besides, dams have considerable costs in terms of material and energy used for construction, effects on the hydrological systems, fisheries and downstream agriculture, and socio-economic costs in affected communities. The increasing incidence of large dams led to the creation of the World Commission on Dams (WCD) in order to establish guidelines that address the risks of large dam constructions. Yet, there is still no salient solution to manage the trade-offs while the guidelines and work of the WCD remain controversial, especially in developing countries (Tortajada et al., 2012). Apart from large dams, water storage provides a "plural solution" to various problems of decreasing availability of water and increasing risks to agricultural productivity (Allouche et al., 2014) and can be achieved at low cost with wider participation (McCartney and Smakhtin, 2010).

Related to this notion of increasing resource interlinks as justification for the need for a nexus approach are the lines of thoughts on the tipping points of socio-ecological systems and the risks to resource security at large. Socio-ecological systems are made up of subsystems of resource users, resource units, resource systems and governance systems (Ostrom, 2009) and are exposed to increasing shocks. Those which successfully deal with these shocks are considered as resilient (Walker et al., 2004, 2006; Folke et al., 2010; Dakos et al., 2015). The loss of the resilience characteristic moves the system to a risky threshold or tipping point. In this line, scientists have identified such tipping points for the earth system and constructed 'planetary boundaries' within which human can operate safely, i.e. systems can recover from human use (Rockström et al., 2009; Dearing et al., 2014; Scheffer et al., 2015; Steffen et al., 2015). Similarly, thresholds for resilient water systems have been identified as well as their effects on land use (Vörösmarty et al., 2010; Falkenmark et al., 2014; Rockström et al., 2014). The appreciation of socio-ecological systems and their resilience or vulnerability is seen as very critical in understanding resource security. Here, security is understood in terms of access to and availability of water, energy and food services. According to Perrone and Hornberger (2014), this notion of resource security offers an important opportunity to explore technological and non-technological options to meet