

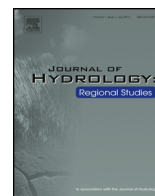


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# A review of the current state of research on the water, energy, and food nexus

Aiko Endo<sup>a,\*</sup>, Izumi Tsurita<sup>b</sup>, Kimberly Burnett<sup>c</sup>, Pedcris M. Orencio<sup>d</sup>

<sup>a</sup> Research Department, Research Institute for Humanity and Nature, 457-4 Kamigamo-motoyama, Kita-ku, Kyoto 603-8047, Japan

<sup>b</sup> Department of Cultural Anthropology, Graduate School of Arts and Sciences, The University of Tokyo, 3-8-1 Komaba, Meguro-ku, Tokyo 153-8902, Japan

<sup>c</sup> University of Hawaii Economic Research Organization, University of Hawaii at Manoa, 2424 Maile Way Saunders Hall 540 Honolulu, HI 96822, USA

<sup>d</sup> Catholic Relief Service Philippines (Manila Office) Urban Disaster Risk Reduction Department, CBCP Building 470 Gen Luna Street, Intramuros, Manila 1002, Philippines

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### ABSTRACT

*Study region:* Asia, Europe, Oceania, North America, South America, Middle East and Africa.  
*Study focus:* The purpose of this paper is to review and analyze the water, energy, and food nexus and regions of study, nexus keywords and stakeholders in order to understand the current state of nexus research.

*New hydrological insights:* Through selected 37 projects, four types of nexus research were identified including water–food, water–energy–food, water–energy, and climate related. Among them, six projects (16%) had a close linkage with water–food, 11 (30%) with water–energy–food, 12 (32%) with water–energy, and eight (22%) with climate. The regions were divided into Asia, Europe, Oceania, North America, South America, Middle East and Africa. North America and Oceania had a tendency to focus on a specific nexus type, water–energy (46%) and climate (43%), while Africa had less focus on water–energy (7%). Regarding keywords, out of 37 nexus projects, 16 projects listed keywords in their articles. There were 84 keywords in total, which were categorized by the author team depending on its relevance to water, food, energy, climate, and combination of water–food–energy–climate, and 40 out of 84 keywords were linked with water and only 4 were linked with climate. As for stakeholders, 77 out of 137 organizations were related to research and only two organizations had a role in media.

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## 1. Background and purpose

The idea of the water–energy–food nexus was launched in earnest since at least the Bonn 2011 Nexus Conference, when the German Federal Government organized the international conference “The Water Energy and Food Security Nexus—Solutions for the Green Economy” to contribute to the United Nations Conference on Sustainable Development (Rio + 20). According to the background paper prepared by Hoff for the conference, the concept of the water–energy–food nexus emerged in the international community in response to climate change and social changes including population growth, globalization, economic growth, and urbanization (Hoff, 2011). These issues are causing increased pressure on

\* Corresponding author. Fax: +81 75 707 2509.  
E-mail address: [a.endo@chikyu.ac.jp](mailto:a.endo@chikyu.ac.jp) (A. Endo).

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water, energy and food resources, presenting communities with an increasing number of trade offs and potential conflicts among these resources which have complex interactions. For example, demands for water, energy and food are estimated to increase by 40%, 50% and 35% respectively by 2030 (US NIC (United States National Intelligence Council), 2012). Although various nexus-related conferences, research initiatives and projects have been held around the world under such circumstances, water–energy–food nexus policy has not yet been initiated in Japan.

We initiated the RIHN water–energy–food nexus project in 2013 with study sites in Japan, Canada, the U.S., Indonesia, and the Philippines. The purpose of the project is to maximize human–environmental security (minimize risk) in the Asia–Pacific region by choosing policies and management structures that optimize water–energy–food connections, including both water–energy (water for energy and energy for water) and water–food (water for food) connections including tighter cooperation with the water, energy and food sectors. We will take a regional perspective to tackle these global environmental problems around the Pacific Ocean (Taniguchi et al., 2013).

Under the RIHN nexus project, this paper attempts to understand the current status of research on the water–energy–food nexus, with the hypothesis that to date the research in this area has been somewhat fragmented. Although there were more than 53,000 hits recorded during a Google search of the phrase ‘water–energy–food nexus’ (as of June 2014), there is no clear definition of the term ‘nexus’. Unlike biodiversity conservation or climate change research and policies led by specific United Nations Conventions, the nexus has yet to be officially facilitated, implemented, and acknowledged in a uniform way. In addition, the relationships of all three resources such as water–energy, water–food and/or water–energy–food are interrelated and interdependent, which implies that the complexity of the nexus system has not yet been clarified. Furthermore, there seems to be very few reviews on the nexus, as the concept consists of multiple disciplines, as well as interdisciplinary and transdisciplinary research results.

We narrowed the search by keeping only the research items containing: (1) the kind of nexus being conducted such as water–food nexus, water–energy nexus, or water–energy–food nexus; (2) what part of the world nexus projects were being conducted; (3) what kinds of nexus activities have been conducted; (4) who is leading the nexus projects; (5) who is involved in the nexus projects; (6) who funded the nexus projects and the budget size; (7) the purposes of the various nexus projects; (8) methodologies used for the nexus study; (9) outcomes of the projects; and (10) the project’s launching year and period of study. Moreover, we examined the challenges and the outlook of future nexus studies.

## 2. Methodology

We took a quantitative approach using secondary data included in publically available academic publications in journals and on the web for: (1) selecting the target nexus projects; (2) reviewing the documents of the selected projects historically, including a timeline of nexus activities, nexus concepts, and the position of the nexus project in global environmental research; (3) and conducting quadrat analysis from the perspective of the type of nexus (water–food nexus, water–energy nexus, water–energy–food nexus, and climate related nexus), nexus region and type, nexus keywords, and stakeholders. Although there is no clear definition of the term nexus so far as mentioned above, nexus is internationally interpreted as a process to link ideas and actions of different stakeholders from different sectors for achieving sustainable development. In addition, based on the fact that the water–energy–food nexus was launched in earnest since at least the Bonn 2011 Nexus Conference, we selected projects ( $n=37$ ) on the condition that: (i) projects highlighted the interactions of water, energy, and food; (ii) different stakeholders from different sectors were involved in the process of the projects; (iii) projects with a close linkage to the Bonn 2011 Nexus Conference were introduced at the NEXUS Resource Platform (<http://www.water-energy-food.org/en/calendar.html>) to screen the data and to acquire more reliable data.

## 3. Research outcomes

### 3.1. Historical review and timeline of nexus activities

#### 3.1.1. Timeline of nexus activities

Various nexus-related conferences, research initiatives and projects have been held around the world. In 1983, the United Nations University (UNU) launched a Food–Energy Nexus Programme to acknowledge the important interconnectedness between the issues of food and energy (Sachs and Silk, 1990). In the following year, the conference on “Food, Energy, and Ecosystems”, was held in Brasilia, Brazil by UNU. In 1986, the Second International Symposium on “the Food–Energy Nexus and Ecosystems” was held in New Delhi, India, again by UNU. In terms of research, the western United States focused on the interlinkages between water and electricity in the mid-1980s, and in the 1990s, the term “nexus” was used by the World Bank to link water, food, and trade (MaCalla, 1997). In the mid to late 1990s to early 2000, India’s water–energy–agriculture nexus was studied by Colombia Water Center of the Earth Institute at Colombia University, and then the electricity for water nexus was applied to Mexico by Scott, C.A. (Scott, 2011). The idea of the nexus further developed under the discussion of “virtual water” and “water footprints” (Allan, 2003). With increasing international discussions such as the Kyoto World Water Forum 2003, scholars and practitioners around the globe acknowledged the need to include energy as a pillar in the nexus (Hussey and Pittock, 2012). Finally the importance of the three nexus pillars of water, energy, and food was officially announced at the Bonn Nexus Conference in 2011 in order to contribute to the Rio plus 20, which highlighted the concept of the “green economy”. Following Bonn Nexus, the Water, Energy, and Food Security NEXUS Resource Platform was established by the

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