

The nexus: Reconsidering environmental security and adaptive capacity

R. de Grenade, L. House Peters, C.A. Scott, B. Thapa, M. Mills-Novoa, A. Gerlak, and K. Verbist

Abstract

The water-energy-food nexus has emerged as a productive discourse and methodology in academic research, science-policy dialogues, and development agendas. While the nexus provides a robust framework for interdisciplinary study, research remains focused on synergies and tradeoffs in resource “security” and fails to adequately acknowledge the environment as the set of natural processes underpinning the nexus, particularly interactions among water, energy, and food. Resource security as a reductionist discourse does not address the limitations and potential of natural processes and the dynamic nature of human processes, especially adaptation to global change. A review of recent literature highlights the need to redefine the nexus to fundamentally incorporate the environment, and, drawing on social-ecological systems thinking, to integrate considerations of adaptive capacity and resilience within nexus theory and practice. Future directions for this line of inquiry include identifying feasible ways of assessing the nexus in the context of dynamic social and ecological systems, and implications that adaptive actions have across resource-use sectors and the environment. A more holistic nexus framework enhances our options to manage environmental interactions, human activities, and policies to adapt to global-change uncertainties.

Keywords: Human-environment nexus, food-energy-water-environment nexus, social-ecological systems, adaptive capacity, environmental security

Introduction

The “nexus” concept has surged in academic, policy and development agendas as an integrative approach to analyzing and promoting sustainable development, good governance, and social equity [1, 2, 3, 4]. The nexus concept explores interactions of multiple sectors across multiple scales, specifically management of food, water, and energy security in local, regional, and transboundary settings, and the tradeoffs and synergies created by competing resource use and

policy agendas, requiring cross-sector and cross-scalar coordination and integration of resource management and environmental governance [4, 5, 6, 7, 8, 9].

The concepts of environment, land, ecosystems, ecosystem services, and climate change play a structural role in these discussions, however the context of how these concepts are integrated, at what scales, for whom, and to what end varies widely. Furthermore, within nexus scholarship, consideration of social-ecological systems theory, resilience, and adaptive capacity remain largely unexplored [10, 11]. Increasingly faced with concerns of resource scarcity, competition and conflict over resources, population pressure, and planetary boundaries, achieving resource “security” has taken precedence as an end goal [12, 13, 14], often without acknowledging the power relations that benefit from the resource security discourse, or the inherent adaptability of social-ecological systems. This has led to critiques of the Water-Energy-Food (WEF) nexus framework as dominated by economic market valuation and lacking explicit attention to social and environmental risks [15], environmental justice [16], and livelihoods [17]. The current WEF nexus discourse fails to adequately consider the politics inherent in food, water and energy. Frameworks and approaches for integrating participatory and reflexive governance processes, stakeholder engagement, and policy experimentation within nexus scholarship are needed [18]. The aim of this review is to demonstrate the need to bring environmental considerations and the potential of adaptive capacity and coupled social-ecological systems thinking into nexus research and practice.

Environment in the Nexus

Early discussions of the nexus included the environment as one of four primary elements: the water-energy-food-environment nexus, or interface [19, 20]. In the stage-setting 2011 Bonn Conference, ecosystem services, green economy, and social justice were presented as pillars of the concept, and since this time, ecosystem services continues to surface as a framing concept [21, 22] or a key focus of the nexus [23]. The nexus debate has seen its strongest proponents in the water sector: water security is often privileged within the triple-resource nexus [24] and many of the scales chosen and environmental contexts argued are water-centric [25, 26, 27, 28, 29, 30]. The definition of water security, unlike the definitions used in other sectors (food and

energy) has fairly consistently included the twin concepts of environmental justice and environmental sustainability as key components [31, 32, 33].

However, thus far, even the most innovative nexus research, policy, and integrative management approaches -- including resource scarcity, governance and public policy, environmental risk and hazards, or general environmental sustainability in the context of economic growth and social wellbeing [34, 35, 36, 37] -- have assessed environmental sustainability from a human-centric perspective. The danger here is that research and policy decisions related to the natural world are driven by a concern for the survival of the human species, without adequate consideration for the magnitude, potential, and complexity of earth systems. This evident bias in the literature clearly indicates the need to reinforce the local and planetary scale of the ‘environment,’ and extend the definition to include the inherent, or existence value of planetary systems, in addition to their value for humanity.

Environmental Security and the Nexus

Similarly, the environmental security literature has failed to adequately acknowledge complex systems dynamics, including adaptive capacity and adaptive action. The concept of “security” assesses what is to be protected and against which dangers [38]. Environmental or ecological security was first formally expressed in relation to human security by Ullman [39] and subsequently expanded on by Mische [40], Myers [41], Litfin [42], and Dalby [43].

Environmental/ecological security research and theory recognize direct and indirect threats to human survival from natural hazards and disasters, environmental degradation, the inherent and human-induced limits to natural resources, and environmental (global) change [44, 45]. The emergent concepts of human-environmental security [46], environmental livelihood security [17] and Future Earth’s 2025 vision [URL: <http://www.futureearth.org/media/future-earth-2025-vision/>] explore social-ecological resilience, and transformative, sustainable solutions by optimizing WEF linkages and striving to achieve a balance between human demand on the environment and environmental impacts on humans.

Resource security presupposes an obtainable end goal in sustained resource availability. The concept of security, aside from debates of power, knowledge and the influence of the market [47], assumes that natural and social systems may attain equilibria. As adaptive capacity

scholarship suggests, humans and the cultures and societies they create are constantly changing, adapting to a changing environment, and developing new relationships with the natural world, with resources, and with each other [48, 49, 50, 51]. Similarly, human-induced climate change as a positive feedback cycle induces physical changes to the environment that stimulate adaptation, extinction, and evolution in natural systems. These various internal and external drivers preclude a static concept of “security”; instead, a more useful way of formulating this complexity is to think of adaptive capacity and resilience within the context of constantly changing earth systems.

Reconceptualizing the Nexus

To address these limitations, this review exposes a need to liberate nexus thinking from a restrictive focus on resource security, and environmental hazards and concerns. The strength of nexus research lies in its reliance on an integrative approach to scholarship and policy development. However, nexus research’s narrow focus on a few selected resources limits its potential to adequately engage the multiple systems needed to sustain human wellbeing in its complex interdependence with the environment. Nexus research should firmly include the environment as a fundamental conceptual framing: the environment provides the resources needed to support security and human well being; the environment is the source of multiple drivers and stressors that stimulate the need for adaptive capacity and action; and the environment is a series of complex, dynamic, interlinked systems that are affected by, but exist independent of, human actions.

Second, the review of the literature suggests nexus research would benefit from a tighter engagement with the social-ecological systems (SES) framework, which presumes an underlying integration of human and natural systems [52, 53, 54]. Particularly when SES perspectives inform nexus thinking, the dynamics of ecological processes, societal adaptation, and their mutual conditioning are seen to give rise to emergent properties of the coupled SES, while simultaneously offering opportunities for adaptive action that confer or strengthen resilience [55]. That is, it is primarily through overt consideration of interlinked social and ecological dynamics that human extraction and use of nexus resources may be able to occur within stability limits (Figure 1). Alternately, resource use **without** social and institutional “learning,” (i.e.,

without explicit efforts to assess and measure social impacts of the nexus and ecological conditions that arise), may be **maladaptive** and give rise to further loss of ecological function and erode resilience [56]. Critiques of SES thinking and related concepts of resilience and adaptive capacity focus on these concepts as being too generalized without reference to unique systems or specific contexts [57]. This raises justifiable concerns over the deeply political dimensions of nexus research particularly in terms of structural power inequities related to class, race, and gender. Further, the political ecology of nexus approaches cannot be neglected, as they highlight the historical, cultural and socio-political dimensions that underpin a given resource nexus [58, 59].

A reformulation of the nexus framework moves beyond the narrowly conceived and human-centric resource security nexus to a conceptualization that explicitly acknowledges the environment as a provider of resources, a source of drivers, stressors, and feedbacks, and a highly complex and dynamic set of systems with inherent value beyond human use. While the typical nexus framework privileges an emphasis on human system-centered approaches to understanding resource security and scarcity (see Figure 1(a) below) with little attention to systems resilience, systems change, or adaptive capacity, a reconceptualized nexus (see Figure 1b below) recognizes the limits imposed by earth systems and the drivers and feedbacks between earth systems and coupled human and natural systems.

Figure 1 (a) Conventional Resource Security Nexus Conceptualization.

Figure 1 (b) Reconceptualization Toward a More Holistic Nexus.

A reconceptualized nexus framework illustrates the integration of critical earth systems functions adapted from the planetary boundary framework [60, 61], and the addition of adaptive capacity as a complementary component to the resource security nexus. Planetary boundary scholarship proposes that earth systems contain their own inherent thresholds, boundaries, and dynamics, which present complex drivers, synergies, conflicts, and limits to existing models of environmental governance [62, 63]. As a quantitative metric, the planetary boundary framework identifies nine variables critical to the operation of earth systems for the continued habitability of earth [60], with a tenth variable, terrestrial net primary production, recently quantified [64].

The assessment of adaptive capacity, derived from SES perspectives on vulnerability and resilience [65, 66, 67], is an additional class of metrics applied to environmental systems to gauge the ability of systems to cope with and recover from stress. Adaptive capacity is theorized as both affecting a system's vulnerability through the modulation of exposure and sensitivity, and as critical to managing SES resilience by regulating the maintenance of system functioning. The adaptive capacity wheel presents one assessment metric, operationalized through the identification and quantification of eight dimensions of adaptive capacity [68, 69].

An important next step will be to identify feasible ways of assessing the nexus and implications that adaptive actions have on coupled human-natural systems. Specific future challenges exist in the application of metrics to the nexus, specifically in identifying standardized metrics that apply to all spheres of the nexus as proposed in the reconceptualized diagram, across multiple scales. One approach is to think in terms of availability, quantity, and quality of resources; diversity—to include biodiversity as well as a diversity of actors involved in decision-making, modes of governance, and sources of resources; and systems functioning — to identify and integrate metrics of social and ecological metabolism [34]. Another useful approach for developing nexus metrics comes from the planetary boundaries scholarship, which has employed an integrated mixed methods approach, including measures of diversity, availability, quantity, and quality, to develop metrics that define and assess multi-scalar thresholds deemed essential for the functioning of earth systems [60, 61]. We are not advocating for the application of modeling to these systems, but rather a means of identifying baseline conditions and comparing progress in the context of social and ecological changes.

Conclusions

Our review of the literature highlights a need to reconceptualize nexus scholarship and practice to fundamentally include the environment or earth systems as a framing concept, and engage social-ecological systems and adaptive capacity research. This will not only strengthen the value of an integrative nexus concept, but will provide fertile ground for reimagining dynamic, resilient human-environmental interactions and adaptation opportunities within the context of complex earth systems. Such an approach aims to move beyond the reductionist discourse that presently fails to address the limitations and potential of natural processes and the dynamic

nature of human processes, especially adaptation to global change. This approach offers new conceptual and methodological measures to assess environmental security, resilience, and adaptive capacity in the context of dynamic systems. Ideally, the nexus should consider natural systems and flows as a fundamental underpinning of resource availability, while engaging the complex relations of human and natural systems, and acknowledging planetary boundaries. Future directions for research and study are needed to better integrate considerations of adaptive capacity and resilience within nexus theory and practice. One important line of inquiry includes identifying feasible ways of assessing the nexus in the context of dynamic social and ecological systems, and implications that adaptive actions have across resource-use sectors. Ultimately, such pathways may likely reveal how a more holistic nexus framework enhances our options to manage environmental interactions, human activities, and policies to adapt to global-change uncertainties.

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This chapter contributes to the larger volume, [Governing the Nexus: Water, Soil and Waste Resources Considering Global Change](#) (Springer, 2015) by introducing institutional and human-environmental security dimensions of the water, food, and energy nexus. It traces the history and

background of the nexus to South Asia, and suggests that its future applicability in conceptual and operational terms is of particular salience in this region currently experiencing insecurity of water, energy, and food.

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The authors argue that operationalizing the nexus has been problematic, in part due to different systems of valuation, especially under conditions of scarcity, for each resource (water, energy, food) accounted for within the nexus. Within the grand WEF nexus, there are sub-nexi that are asymmetrically theorized, leading to poor understanding of how the sub-nexi interact within the grand nexus, especially in terms of economic valuation of the resources individually and in relation to each other.

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The authors recognize the lack of attention to sustainable livelihoods within the nexus approach, which they argue has negative implications for effectively utilizing the nexus framework to achieve sustainable development, where livelihoods are a key concern. The article advances an integrated nexus-livelihoods framework, termed “Environmental Livelihood Security” that reformulates the environmental security nexus to acknowledge the central role of sustainable livelihoods in the goal of achieving a balance between human demand on the environment and environmental impacts on humans.

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Figure 1(a). Conventional resource security nexus conceptualization.

Figure 1(b). Reconceptualization toward a more holistic nexus framework.

Figure 1: (a) Conventional resource security nexus conceptualization, with a dominant emphasis on human systems. This framework privileges human system-centered approaches to understanding resource security and scarcity. Little attention is paid to the limits imposed by earth systems and the drivers and feedbacks between earth systems and coupled human and natural systems. (b) Proposed reconceptualization of the nexus framework. The reconceptualization balances attention to human and natural system dynamics, integrates adaptive capacity and the Water-Energy-Food resource nexus, and recognizes dynamic bi-directional drivers of change originating from earth systems and planetary boundary thresholds (Adaptive capacity wheel adapted from Gupta et al. [68] and Grothman et al. [69]; Earth systems wheel adapted from Rockstrom et al. [60] and Running [64]).

EARTH SYSTEM

Atmosphere

Biodiversity

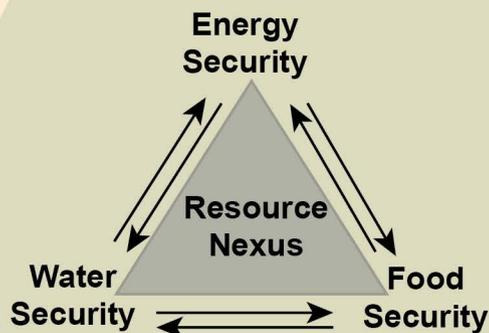
Climate

Nutrients
(Phosphorus
& Nitrogen)

HUMAN
SYSTEMS

NATURAL
SYSTEMS

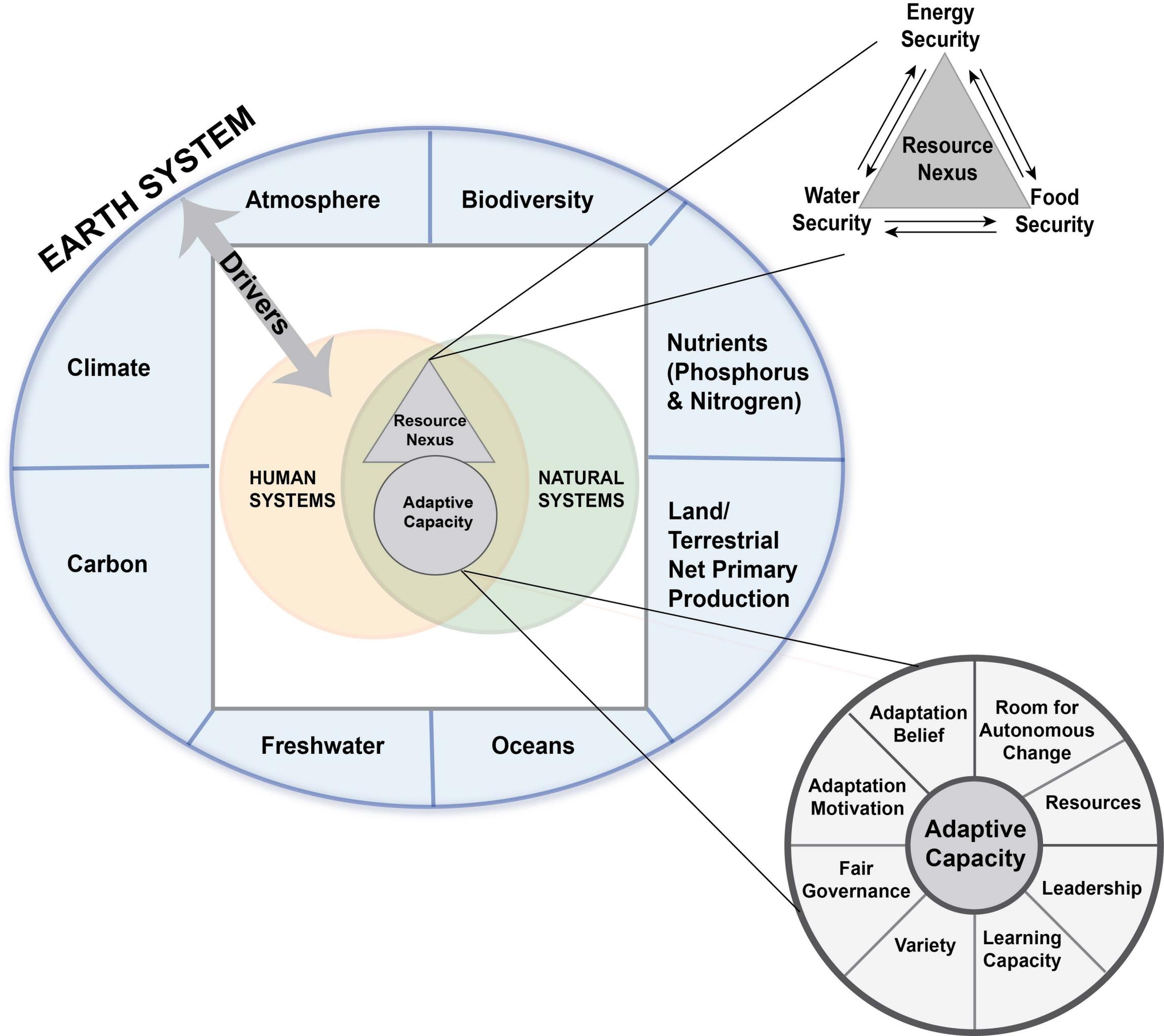
Carbon



Land/
Terrestrial
Net Primary
Production

Freshwater

Oceans



EARTH SYSTEM

Atmosphere

Biodiversity

Climate

Carbon

Freshwater

Oceans

Drivers

HUMAN SYSTEMS

NATURAL SYSTEMS

Resource Nexus

Adaptive Capacity

Nutrients (Phosphorus & Nitrogen)

Land/ Terrestrial Net Primary Production

Energy Security

Water Security

Food Security

Resource Nexus

Adaptive Capacity

Adaptation Belief

Room for Autonomous Change

Adaptation Motivation

Resources

Fair Governance

Leadership

Variety

Learning Capacity