An Overview of Conceptual Frameworks for Understanding the Water-Energy-Food Security Nexus

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What’s New about the Nexus?


A five-year programme which advocated for Integrated Food-Energy systems (IFES), a systems approach sustainable rural development:
- Rural-Urban Configurations
- Urban Development Strategies
- Urban Agriculture

Simultaneous consideration of:
- the biophysical components of resource management
- the social and ecological impacts of the technologies used,
- and of the institutional settings involved
What's New about the Nexus?

Harris (2002)

- Examines the main challenges in Energy, Water and Food with a 2020 Horizon.
- "By 2008 the most powerful nations in the world declare a global crisis. The sequence of disasters pinpoint the neglect of natural systems and how that neglect contributed to the crises. Challenges in meeting the need for fresh water resources stand out in particular because they are widespread, touching developed and developing nation alike. Led by the industrialized nations, a broad and feverish effort to address the series of crises creates a technological and political revolution with a shift in human values similar to that following World War II."

Since then...

- Rockstrom et al, 2009
The Birth of the Nexus

These developments have led:
- to the Re-discovery of the Resource Nexus (see Meadows et al, 1972), of the interconnected risk supplies of the WEF sectors (Middleton et al, 2014)
- to the spread of a new natural and economic resource realism
- within a trend of Sustainability Securitization, reframing the needs of the world economy under the paradigm of security (Leese and Meish, 2015)
- have exposed the limitations of existing institutional arrangements and market regimes which:
  - were unable to weather the “perfect storm”
  - have significantly wiped out developmental and poverty reduction achievements
- in the context of the preparation phase for RIO+20
- backed by impulses from the business community (2030 Water Resources Group, 2009)
- the conditions were met for the Nexus to be brought to political attention first by the World Economic Forum at the Davos Summit through the issuance of the Global Risks 2011 report; followed by the Bonn 2011 Nexus Conference
- the Nexus is presented as a development paradigm, a research agenda, a descriptive and prescriptive approach to sustainable development, suggesting solutions within “a green economy”

Water – Food – Energy: Some Shared Characteristics

- All three areas have billions of people without access (quantity or quality or both)
- All have rapidly growing global demand
- All have resource constraints
- All are “global goods” and involve international trade and have global implications
- All have different regional availability and variations in supply and demand
- All have strong interdependencies with climate change and the environment
- All have deep security issues as they are fundamental to the functioning of society
- All operate in heavily regulated markets
- All require the explicit identification and treatment of risks

Bazilian et al, 2011
The Nexus as a Development Paradigm and Policy Framework

- Water, energy, and food systems draw from common stocks of natural resources and require connected infrastructures to provide essential inputs to social-ecological systems.
- The interdependencies of these infrastructures create a shared set of policy spaces which have crucial implications regarding national planning and management decisions which bear the potential to cause adverse cascading effects on the security of these vital resources.
- Segmented, fragmented, and uncoordinated sectoral decision making leads to wasteful, inefficient, and unsustainable resource use.
- Systems thinking is required for the development of appropriate frameworks to manage trade-offs, target synergies and avoid tensions across sectors.
- Context-specific paths of coherent institutionalization of shared governance, and horizontal, vertical and financial governmental coordination become essential to prevent negative externalities across resources to become co-constraints of sustainable development.

World Economic Forum (2011)

A framework to support decision-makers to better analyze the global risk landscape.

Policy recommendations:

- Integrated and multistakeholder resource planning
- Community-level empowerment and implementation
- Market-led resource pricing
- Technological and financial innovation
Bonn 2011 Nexus Conference

Some approaches to the Nexus

ESCWA.
The world is moving towards absolute scarcities of certain resources and sink capacities. A radical rethink of the world’s approach to natural resources and a transformative action in addressing the demand, supply, efficiency and resilience of natural resources management, through integrated solutions. Three players are involved in the success of this transformation:

- the public sector, through the setting and coordination of policies and regulations;
- The private sector, through more inclusive and sustainable business models;
- and regional and global players, through policy, trade, global governance, and development assistance.

Coordinated action is warranted in five main areas:

- a concerted effort to reduce the environmental footprint of consumption globally
- innovation in agriculture and renewable energy
- a reform of national and global governance instruments and institutions towards a more integrated resource management
- inclusive land policies to protect the rights of the poor and most vulnerable
- and the appropriate pricing of natural resources and services
Demand-Endowment-Technology (DET) Interface Linkage Model

Resource supply attributes include:
- the types, locations, availability, and accessibility of sources and the quantity and quality of stocks and flows;
- whether the source stocks and flows are renewable, finite and depletable, substitutable
- Are the resources constrained in terms of withdrawal rates, timing and duration of withdrawals, and costs.

Demand attributes include:
- the specific types and locations of end-use applications,
- end-use requirements and constraints (compatibility with infrastructure, costs, etc.),
- quantity and quality of stocks and flows needed, and
- time frames (use rate and duration profiles).

US DOE (2012)
Climate and Energy-Water-Land System Interactions
Interdependent Interface Linkages for Integrated Climate-EWL nexus
This approach calls for:

- A thorough characterization of Climate and Energy-Water-Land System Interactions, which is fundamental to
- understanding how risk, uncertainty, and vulnerability relate to each characteristic across sectors, and for developing solutions and strategies to reduce their impacts and cascading effects across sectors; and
- Stresses that many mitigation and adaptation options tie directly into one of the Energy-Land sectors, and are therefore tied into the Water-Energy and interfaces.
- Hence understanding the EWL nexus is therefore fundamental to the effective design, selection, implementation, and monitoring of adaptation and mitigation strategies.
CLEW (2011)

Application on Mauritius:
Development and calibration of water, energy and land use models using 10 years data (1996-2005)
WEAP - water
LEAP - energy
AEZ - land production planning

IISD (2013, 2014)

- Watershed-scale ecosystem-based approach, recognizing that restoring and managing EGS provides a practical means to optimizing WEF security

Recommends an integrated approach to:
- policy design
- land and agricultural investments, and
- adaptive management of opportunities and risks
IISD (2013, 2014)

- Framework embedded within a place-based, practical participatory scenario planning process that allows communities to identify key ecosystem services that would optimize WEF security system.

1. Accessing the WEF Security System: Framing the Initiative
   - Assess Current Status and Trends in Natural, Built, and Social Capital
   - Understand Past Stresses and Adaptations
   - Describe Future Risks

2. Embedding Future Landscape Scenarios
   - Develop Shared Principles for the Future Landscape
   - Identify Critical Uncertainties and Craft Feasible Scenarios
   - Develop Indicators and Transformations

3. Investing in a Water-Energy-Food Secure Future: Creating a New and Shared Story of the Future Landscape
   - Communicate
   - Develop the Investment Strategy and Scaling Mechanisms

4. Transforming the System: Implement and Monitor, Adapt, and Improve

Bizikova et al, 2014

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FAO (2014)

- Conceptual analysis
- Context analysis
- Stakeholder analysis
- Quantitative analysis
- Qualitative analysis

- Risk factors and driver
- Vulnerability analysis
- Resilience analysis
- Impact assessment
- Mitigation strategies
- Adaptation strategies

- Response options: strategies, policies, regulations, institutional and technological interventions
UNU – FLORES (2013)
Soil - Water - Energy - Waste - Food Nexus

- Calls for an integrative approach to the management of the Soil-Water-Energy-Waste-Food nexus, that provides an opportunity to enhance the use-efficiency of natural resources with a view of sustainability.
- Considers the interconnectivities in five sub-nexus: energy-water, poverty-environment, soil-waste, water-soil, soil-climate, and food security-natural resources.

Inter-linkages among natural resources in relation to food security, sustainability, resource use efficiency and resilience.

Soil-Water-Energy-Vegetation Nexus Affecting Food Security under a Changing Climate

- Nature does not recognize waste, from every death emerges a new life through a meticulous recycling of essential elements contained in the so-called “waste”.
- The framework examines the inter-relatedness environmental resources and their transitions and fluxes across spatial scales and between compartments.
- Calls for the optimization of the co-productivity generated by the anthropogenic use of primary resources (soil, water, climate) and secondary inputs (fertilizers, amendments, irrigation, tillage).
- Framework presents a more complete and holistic depiction of science-policy relations.
The Interdependence of Food Security and other Forms of Securities

**Food security** (availability, access, nutritional quality, retention) **strongly depends on:**
- **Soil security:** quality, resilience
- **Water security:** renewability, availability, quality
- **Energy security:** supply, price, dependability
- **Climate security:** optimal temperature and moisture regimes, and low frequency of extreme events
- **Economic security:** income and access to resources, and
- **Political stability:** peace and harmony

Overview of a Fully Integrated Systems Modeling Approach: ANEMI Model

- **Integrated** assessment model that links climate change, water resources and other physical and socio-economic issues to represent a larger society-biosphere-climate-economy-energy system of the earth and biosphere.
- **System dynamics simulation approach** that (a) allows understanding and modeling of complex global change and (b) assists in the investigation of possible policy options for mitigating, and/or adopting to global changing conditions, within an integrated assessment modeling framework.
Overview of a Fully Integrated Systems Modeling Approach: ANEMI

1. Carbon cycle
2. Climate
3. Water Use
4. Water Quality
5. Surface Flow
6. Population
7. Land Use
8. Food Production
9. Energy-Economy

The Food, Water, Energy, Land and Population nexus as a complex systems problem in sustainability science

- An approach to resource accounting for sustainability assessment which analyses food, water, energy and land systems together with environment, economics and wealth, and population growth and demographics, within multi-scale accounting framework.
- Develops an inter- and trans-disciplinary, scientific understanding and knowledge base of systems-level interactions and interrelationships of food, water, energy and land systems at multiple scales;
- The approach presents methods that cross eight boundaries:
  - between food, water, energy, and land and environment systems;
  - between spatial, temporal and organizational scales;
  - between environmental, economic and social systems;
  - between scientific disciplines and epistemologies;
  - between science and policy;
  - between scientific understanding and governance;
  - between scientists and other communities; and
  - between the challenges presented by real-world, real-time, local–national–global scale problems and the limitations of reductionist approaches to science.

Giampietro et al, 2014
The Nexus, the Post-2015 Development Agenda and the SDGs

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THANK YOU

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