

Approaches and challenges of the water-energy food nexus

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Concordia Institute for Water, Energy and Sustainable Systems (CIWESS)

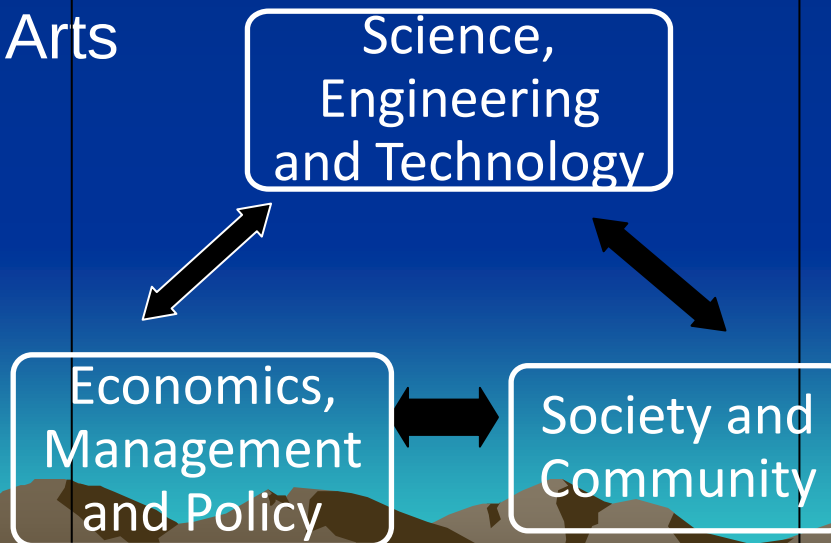
Multi-faculty approach:

- Engineering & Computer Science
- Arts & Science
- John Molson School of Business
- Fine Arts

Inter-university initiative:

- Concordia University
- McGill University
- Ecole Polytechnique
- Ecole de Technologie Supérieure
- York University
- UQAT

International collaborators



The Environment-Related Challenges

To propose long-term environmental strategies for achieving **sustainable development by the year 2000 and beyond**

The concept of sustainability as applied to the city is the ability of the urban area and its region to function at levels of quality of life desired by the community, without restricting the option available to the present and future generations and without causing adverse impacts inside and outside the urban boundary

Source: [The Guardian, 2016](#)



Climate Change

The **shift in climate patterns** mainly caused by greenhouse gas emissions (i.e., from natural systems and human activities).

About 1.0°C of temperature increase now, which is likely to reach 1.5°C between 2030 and 2052 if this continues to increase at the current rate (IPCC, 2018).

This is mainly causing:

- Changes in irradiance and UV-B levels.
- Changes in the amount of precipitation and humidity patterns,
- Alterations in the incidence of abiotic and natural disturbances worldwide.

Biosphere Impacts

Climate change scenarios are **augmenting issues** not only on organisms and ecosystems but also human systems and well-being.

Associated with contemporary anthropic disruptions (i.e., natural resources overuse, production model, population growth, inequality between nations). **Triggering disturbances in the biosphere more than its capacity to resist.**

Human species are the higher threat to the earth's environment.

Source: Kontogianni et al., 2012



Mind-map with climate change scenarios and disruptions caused

Kontogianni, A. D., et al.. (2012). How do you perceive environmental change? Fuzzy Cognitive Mapping informing stakeholder analysis for environmental policy making and non-market valuation. *Applied Soft*

Computing, 12(12), 3725-3735.

UN Sustainability Goals



SDG

Engineering contribution

2. Provide food security

- Manage the nitrogen cycle
- Provide sustainable irrigation

3. Ensure healthy lives and well-being

- Provide clean air, water, safe food production
- Develop nanotechnology and bioengineering

6. Ensure sustainable management of water and sanitation

- Provide clean water

7. Ensure access sustainable and modern energy

- Provide renewable energy
- Increase efficient use of energy

Water, Energy, Food

- Three important resources for sustaining life but interlinked
- 70% of freshwater withdrawals and 30% of energy for agriculture (pumping and fertilizers)
- Water is required for energy (44% of total withdrawal)
- Energy is required for water (extraction, conveyance, treatment, heating, desalination)
- Water and agriculture for biofuel production

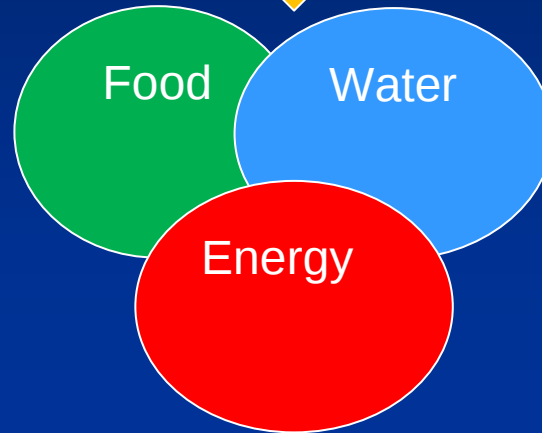


WEF Nexus

- Since 2011, Bonn conference, water, energy and food connections mentioned as WEF Nexus
 - More sustainable solutions to solve challenges of trade-offs
 - Close link to SDG challenges as mentioned
 - Holistic frameworks but lack of implementation
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Challenges

Population and economic growth
Urbanization
Climate Change



Water, food, energy security
Environmental protection

Methodology

- Characterizing and quantifying connectivity
 - Modeling of the WEF network
 - Performing future management scenarios to assist decision making
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- Nie et al. 2019

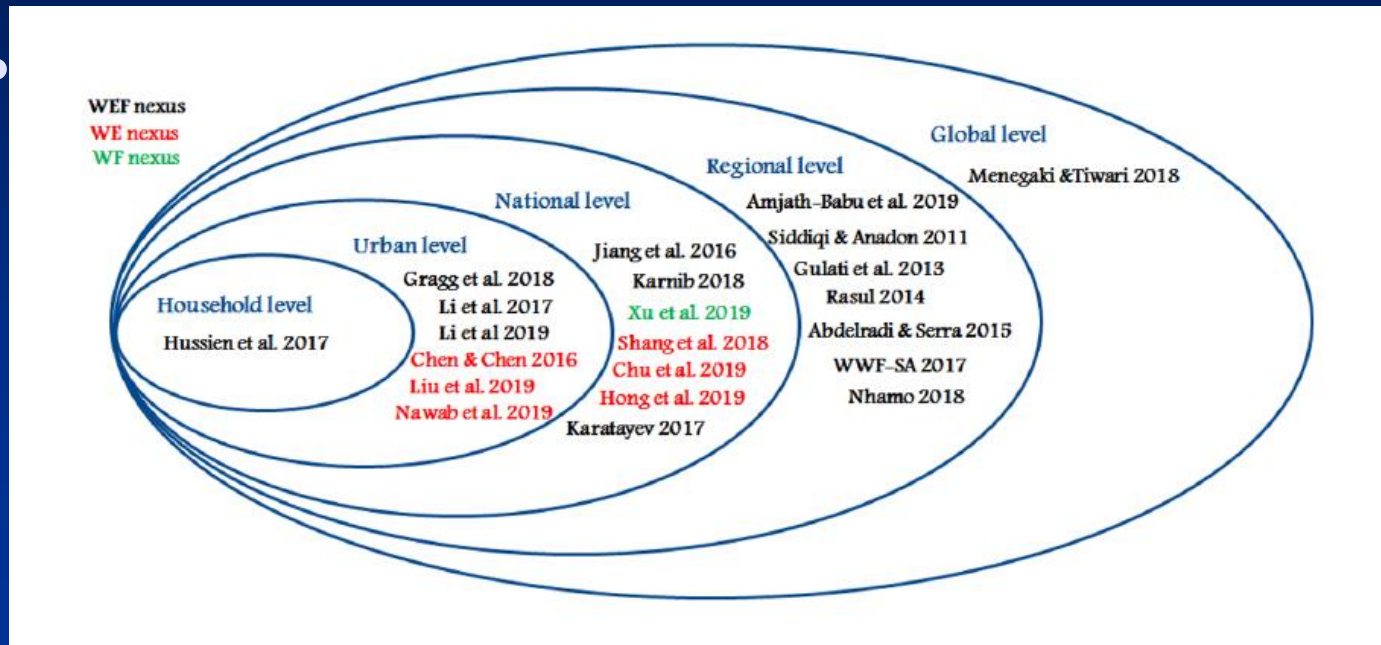


Characterization

- WEF Index
- WEF models
- Optimization models
- Life-cycle assessment
- Input-output analysis



Scale of various WEF nexus models



Tashtoush et al.
2019

WEFN methods

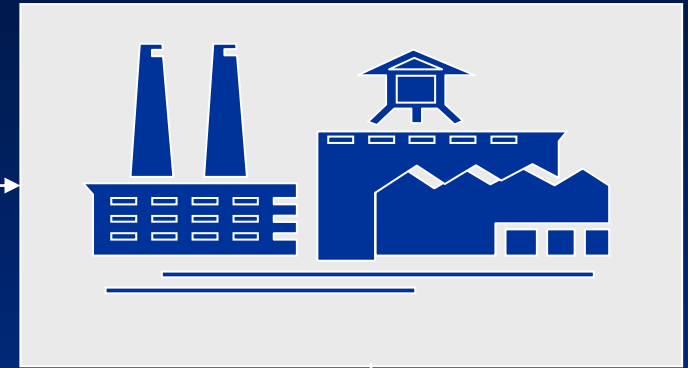
- Data Envelopment Analysis Model (DEA)
- Institutional Analysis and Development Framework (IAD-NAS)
- Nexus Assessment 1.0 developed by FAO
- WEF nexus tool 2.0 (online)
- Water, Energy, and Food security nexus optimization model (WEFO)
- ZeroNet DSS



Mining, extraction & processing

LCA concept

Production of materials

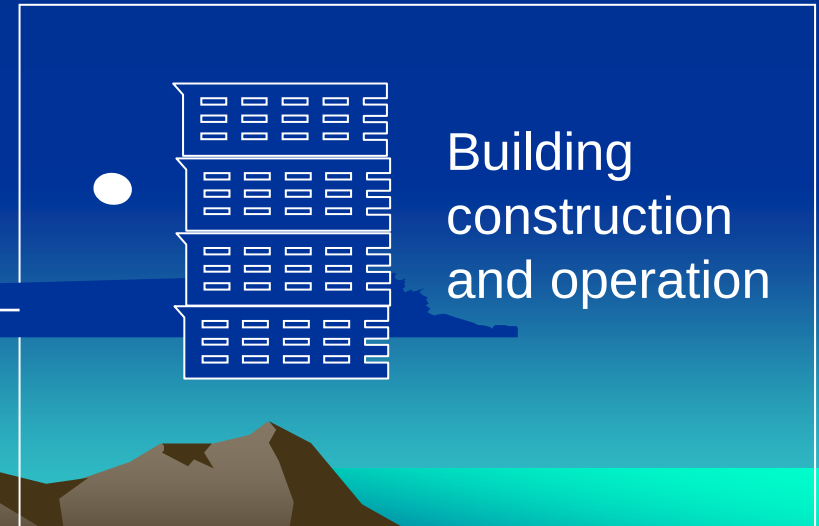


Disposal by incineration or landfill



Recycling

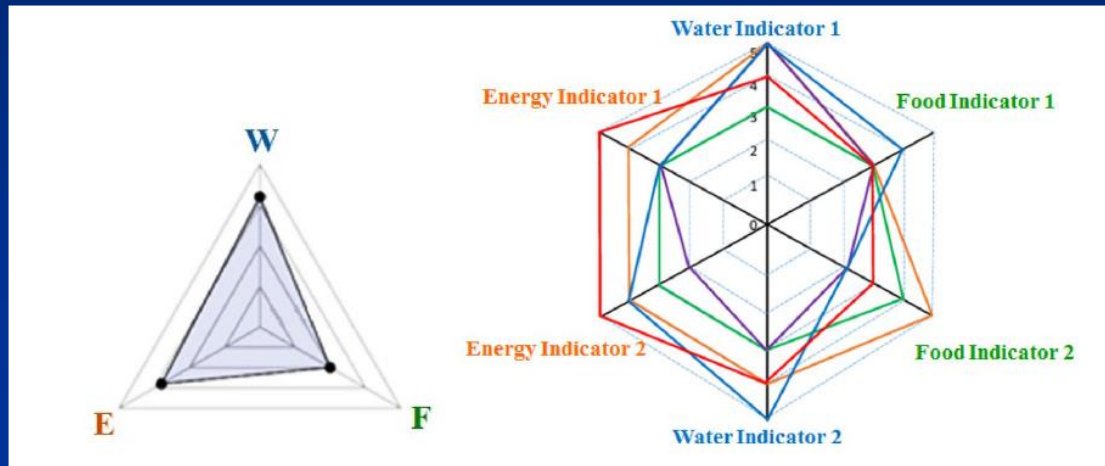
Transportation of materials for construction



Demolition



Other approaches



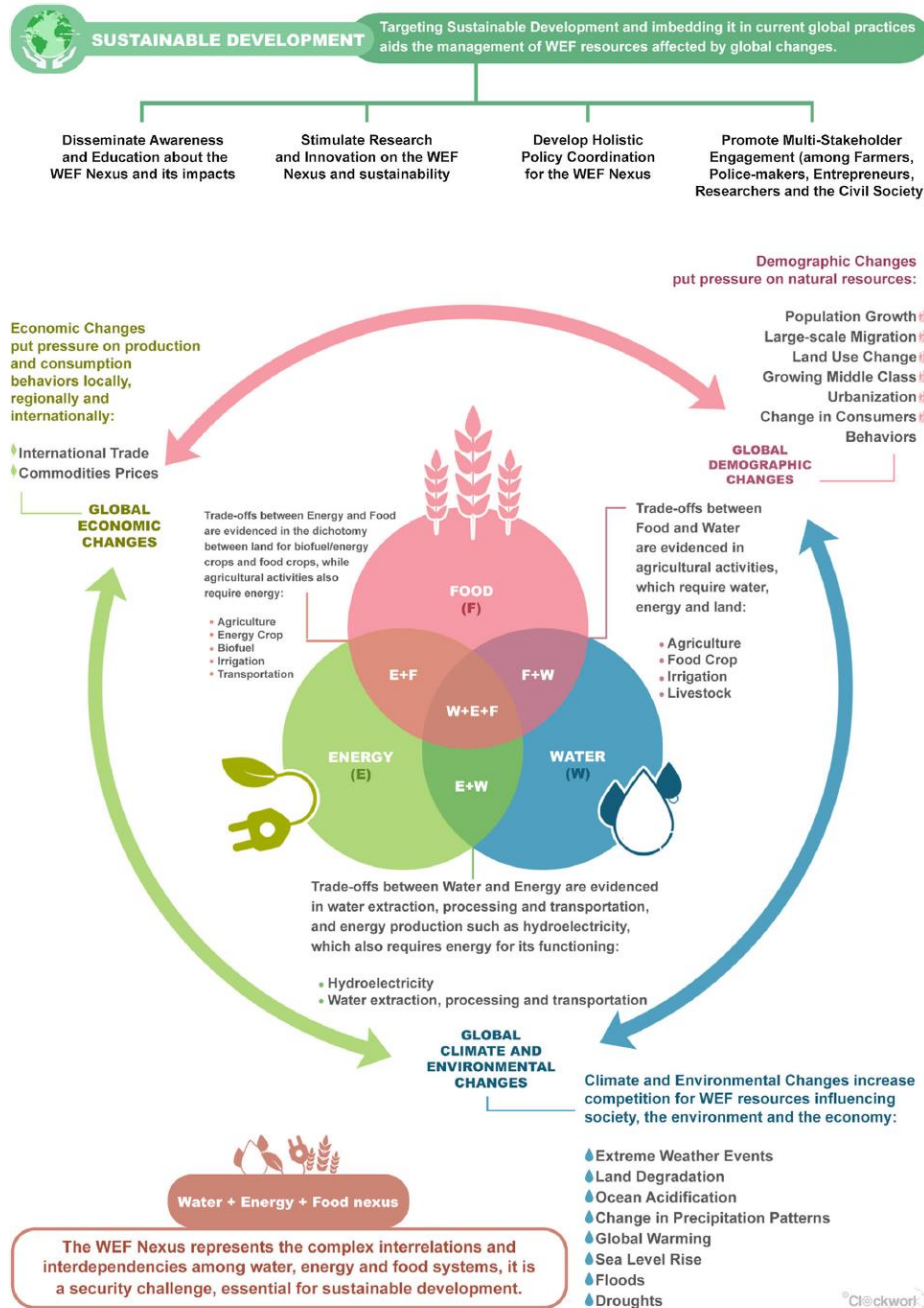


Fig. 1 The WEF Nexus for sustainable development

Concluding remarks

- (a) Strong interactions of water, energy and food resources
- (b) Research ongoing and not implemented yet widely
- (c) No single approach but common starting point needed
- (d) Social dimension should also be included via stakeholder involvement



Thank You!!



SUSTAINABLE ENGINEERING

Principles and Implementation



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