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#EU GREEN WEEK

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A Performance-Based Evaluation Model of the WEFE Nexus in the Public Utilities Sector: Advancing Circular and Resilient Cities

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THE WATER-ENERGY-FOOD NEXUS: BUILDING RESILIENCE TO GLOBAL CHALLENGES

Abstract

This paper presents a performance-based evaluation model that integrates the Water-Energy-Food-Ecosystems (WEFE) Nexus approach into the assessment of public utility services at the local level. Rooted in the disciplines of environmental protection engineering and communal engineering, the model emphasizes the critical role of municipal utility companies in advancing sustainable, circular, and resilient urban systems. It is specifically designed to evaluate the environmental protection performance of key communal sectors—water supply, wastewater treatment, waste management, and energy services—while accounting for their interdependencies within the WEFE Nexus. The model utilizes a structured set of measurable performance indicators that align with the principles of the circular economy and the United Nations Sustainable Development Goals (SDGs), particularly Goals 6 (Clean Water and Sanitation), 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities), and 12 (Responsible Consumption and Production). Applying multi-criteria decision-making (MCDM) techniques, the framework enables a comparative assessment of municipalities, supporting the ranking and benchmarking of local performance and the identification of best practices. Special focus is placed on the reuse of treated wastewater in urban areas, optimization of energy consumption in public utility operations, and integrated waste and resource management as practical levers for implementing circular economy principles. In addition, the model encourages the development of coherent, cross-sectoral strategies that take into account local potentials, trade-offs, and synergies, particularly under conditions of environmental stress and climate change. The findings aim to contribute to evidence-based policymaking and capacity-building at the local level, offering a scalable and transferable tool for planning, monitoring, and enhancing sustainability performance in cities. This approach fosters urban resilience and supports the transition toward climate-neutral, resource-efficient, and socially inclusive communities across Europe and beyond.

Fostering Development with the WEFE Nexus

Ensure availability and sustainable management of water and sanitation for all

Ensure access to affordable, reliable, sustainable and modern energy for all

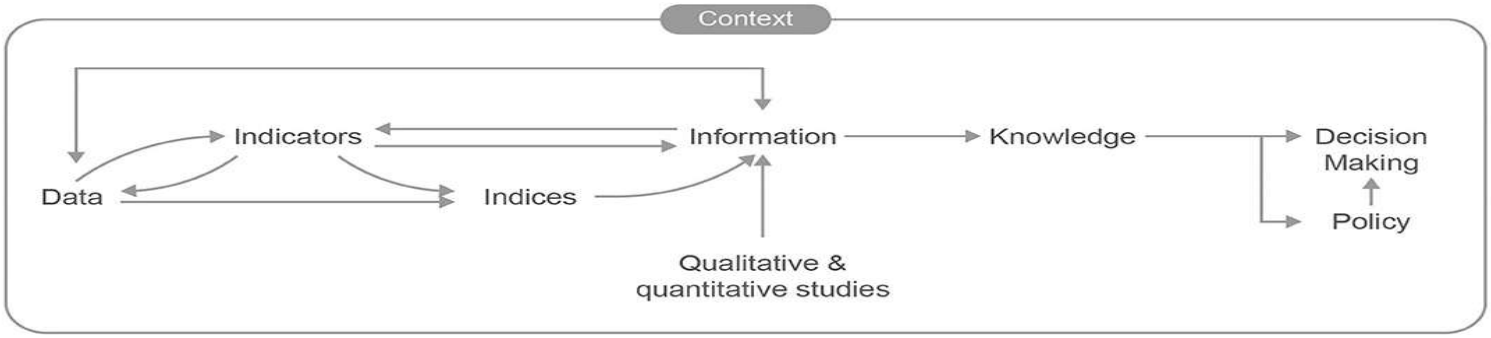
Make cities and human settlements inclusive, safe, resilient and sustainable

Ensure sustainable consumption and production patterns

End hunger, achieve food security and improved nutrition and promote sustainable agriculture

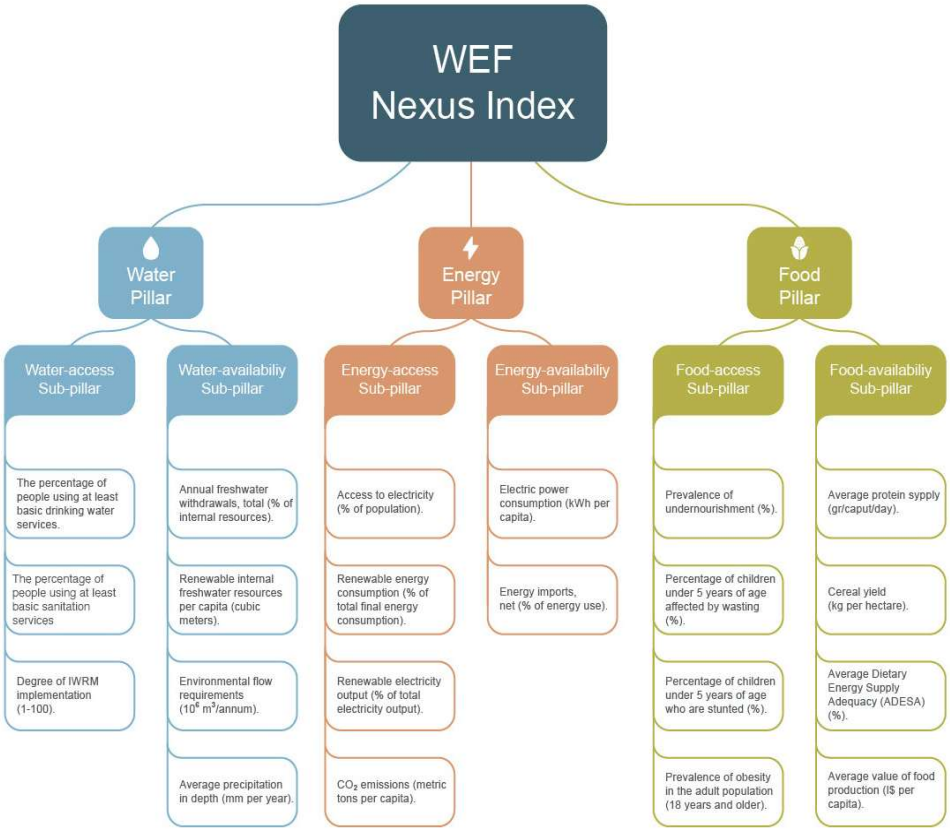
The need for WEFE Nexus Indicators

- The goal of this framework is to introduce a cross-sectoral assessment procedure, that facilitates the evaluation and the increase of resource efficiency of WEF Nexus conform projects. The availability of data and information is paramount, since without sound information WEF security Nexus interactions cannot be properly identified.
- Any proposed WEF security Nexus Indicators should be applicable across governance levels (local, basin, national, etc.) and WEF functions (water resources management, agricultural land management, and energy management).



WEF Nexus Index

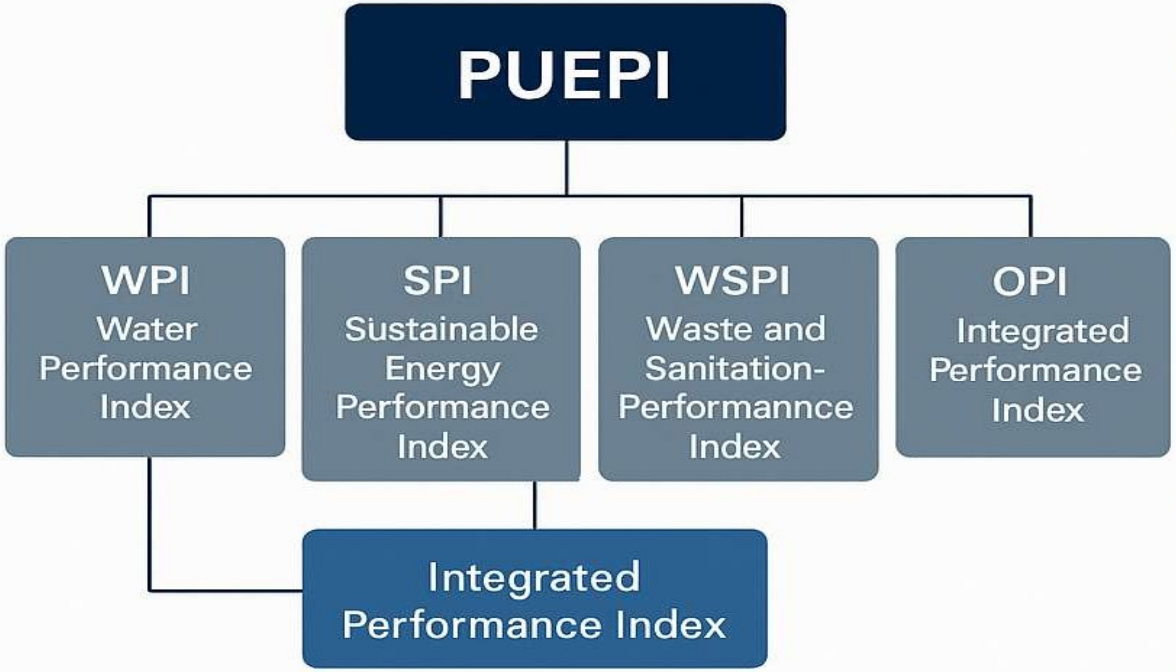
- **The water–energy–food (WEF) Nexus Index** is a quantitative measure and representation of country-level WEF security based on 21 water, energy, and food security indicators.
- **Methodology:** Joint Research Centre's Competence Center on Composite Indicators and Scoreboards
- **Development of the Framework**
- For an indicator to be included in an index, at the indicator level, at least 65% of countries should have valid data.
- These indicators are normalized, weighted and aggregated, thereby yielding a unitless index that represents the WEF Nexus framework.



WEFE Indicators Applicability to Public Utilities

- **Water Utilities**: Fluctuations in the index can affect water availability and quality. Poor performance may lead to water shortages, increased treatment costs, and health risks.
- **Energy Utilities**: The stability of energy supply is influenced by the index. Lower values may result in power outages, higher operational costs, and reliance on unsustainable energy sources.
- **Food Supply**: The index impacts food security through its influence on agricultural productivity. Lower performance can lead to food shortages, higher prices, and increased import dependence.
- **Infrastructure Investment**: A higher and stable WEF Nexus Index often correlates with better infrastructure investment in public utilities. This leads to more efficient service delivery and reduced operational costs.
- **Policy and Regulation**
- **Ecosystem utilities:** waste management, innovation and circular solutions, etc.

Performance-Based Evaluation Model Aligned with the WEFE Nexus



SDG Alignment

- SDG 6 – Clean Water and Sanitation
- SDG 7 – Affordable and Clean Energy

Link to WEFE Nexus

- Provides a structured, measurable approach to evaluating interdependencies in public utility performance
- Supports strategic planning and resource optimization across Water, Energy, and Waste sectors
- Compatible with WEF Nexus Index methodology and scalable across municipalities

SDG Alignment:

1. SDG 6 – Clean Water ancinitation
2. SDG 7 – Affordable ad Clean Energy
3. SDG 11 – Sustainable Cities and Communities

Conclusion

- By introducing the Public Utilities Environmental Performance Index (PUEPI) and its sub-indices WPI, SPI, WSPI, OPI, and IPI, the model enables a structured, multidimensional evaluation of environmental sustainability at the local level. The approach emphasizes the operational interlinkages among utility sectors and aligns closely with the SDG.
- The integration of PUEPI with the broader WEF Nexus Index contributes to a deeper understanding of how performance indicators can be used to identify synergies, trade-offs, and optimization opportunities across sectors. This cross-sectoral coherence provides a strong foundation for strategic planning in municipalities, enabling decision-makers to benchmark local performance and foster the transition toward circular and resilient urban systems.
- From a practical perspective, the model supports informed policy-making and capacity-building efforts by highlighting areas for operational improvement and investment. It offers a scalable tool for enhancing public utility efficiency, promoting sustainable resource management, and ultimately contributing to urban resilience and improved quality of life. As cities worldwide face increasing environmental and climate-related pressures, applying such performance-based frameworks becomes essential for steering sustainable transitions and supporting climate-neutral development pathways.

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