



Multi-scale water-energy-food nexus in Asia



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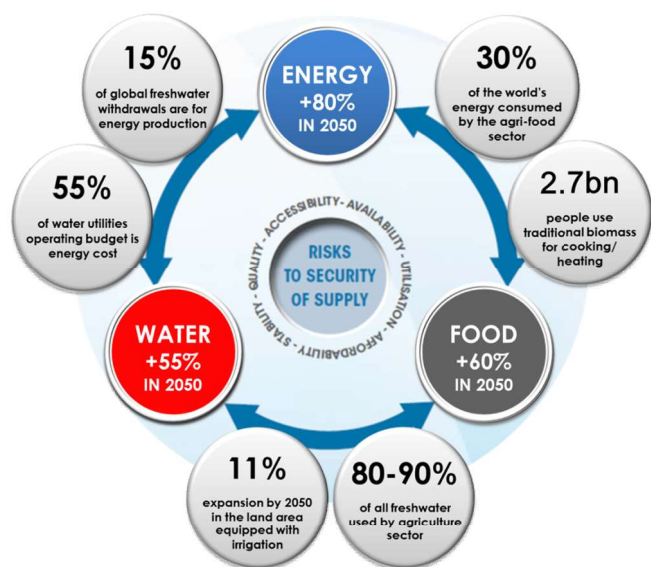
(Acknowledge to Dr. S. Lee (RIHN) & Dr. N. Masuhara (RIHN))



Sustainable Urbanisation
Global Initiative (SUGI)
FOOD - WATER - ENERGY NEXUS

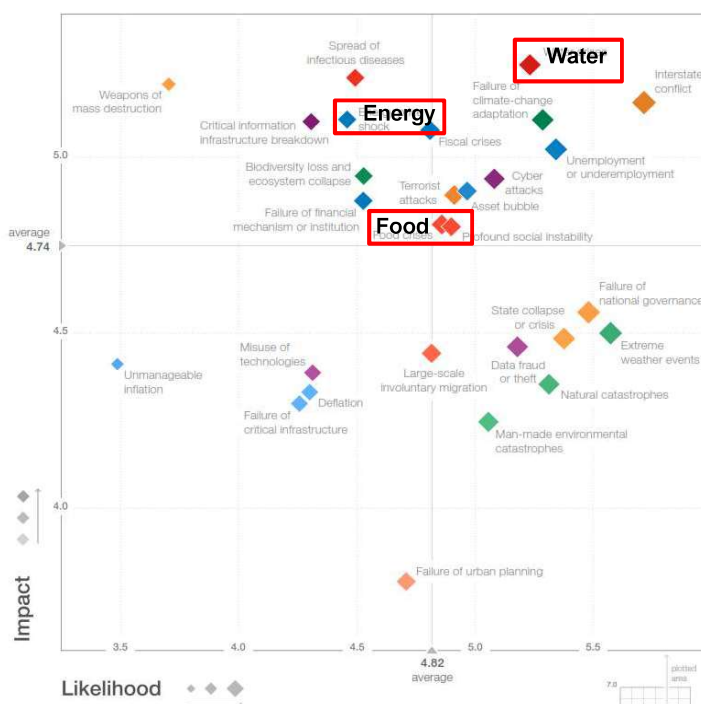


Water-Energy-Food Nexus



Ferroukhi et al., 2015

WEF Global Risk 2015 Report



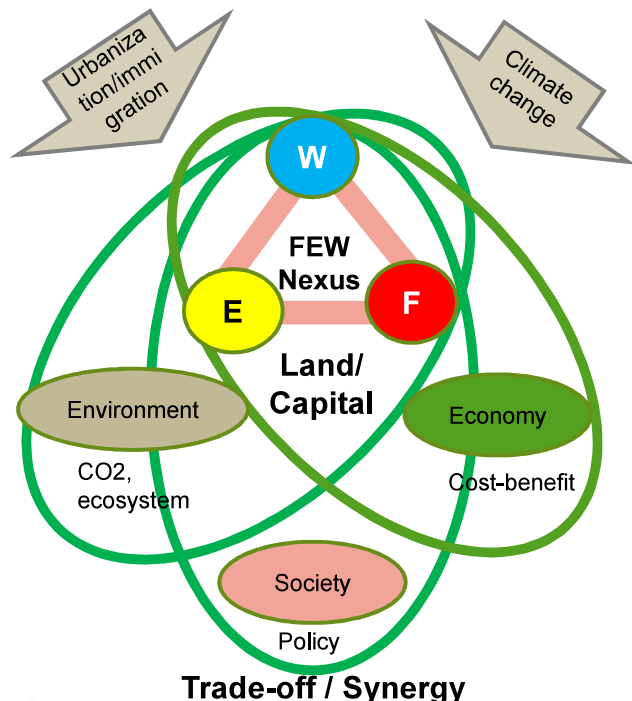
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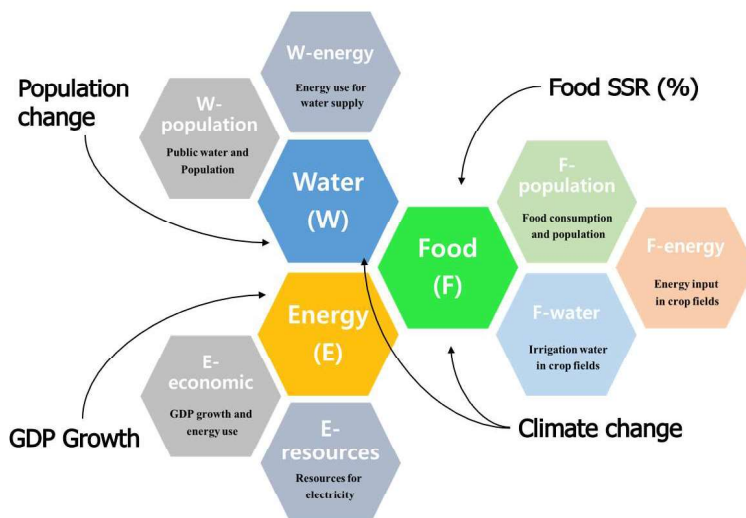
Intelligent **Urban** Metabolic Systems for Green Cities of Tomorrow: an FWE **Nexus**-based Approach

Belmont Forum projects “Sustainable Urbanisation Global Initiative: **Food-Water-Energy Nexus**” (2018–2020)

Taipei	Chicago
F. Chang	L. Rodriguez
Kyoto	Sao Paulo
M. Taniguchi	J. Filho



Multi-scale platform with subsystems



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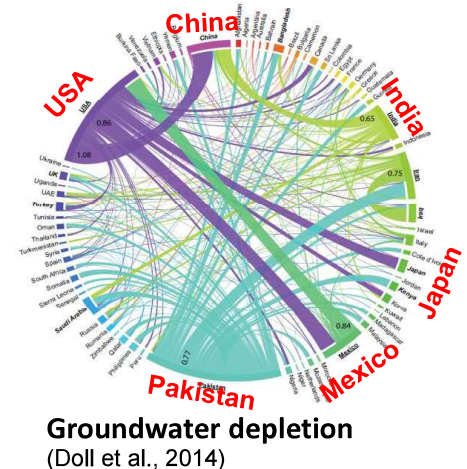
European Commission

Multi spatial scale FWE Nexus

Global

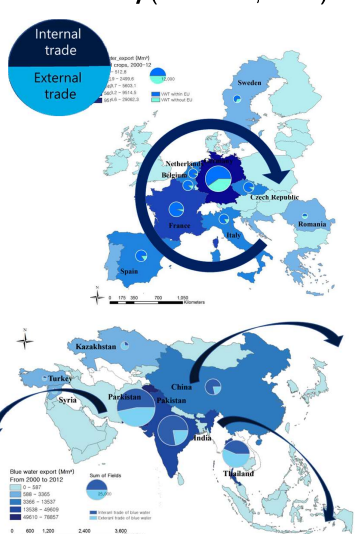
Groundwater footprint through food trade (Dalin et al., 2017)

Export: India, US, Pakistan
Import: Japan, China



Regional

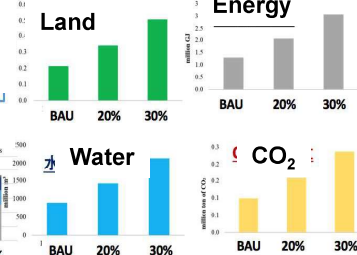
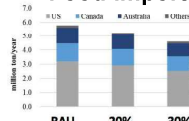
Evaluation of external virtual water export and dependency through crop trade: an Asian and EU case study (Lee et al., 2017)



National

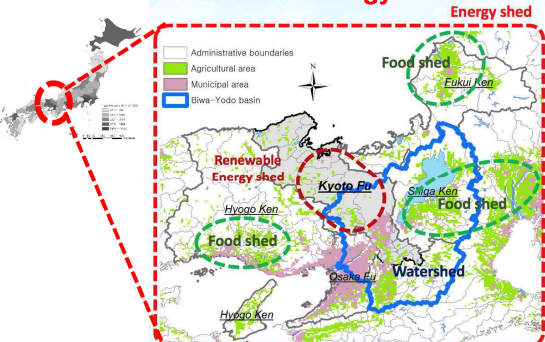
Food security
Energy security
Water security

Food import



Local

Water-shed
Food-shed
Energy-shed



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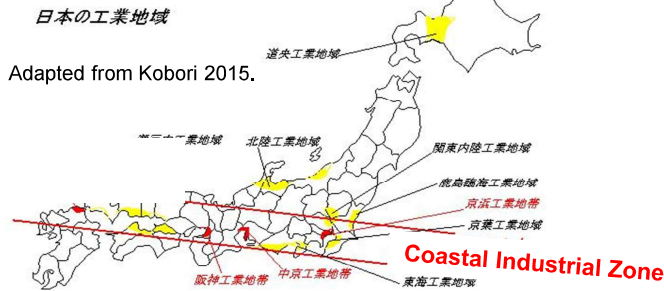
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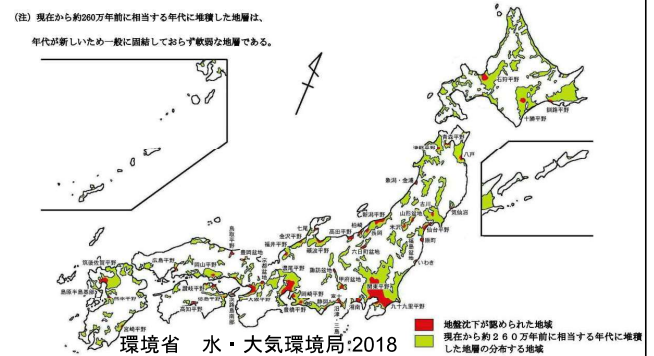
European Commission

Coastal Industrial Zone in Japan

Abundant water + imported fuel (with ports construction)
-> Industrialization



Coastal Industrial Zone in Japan

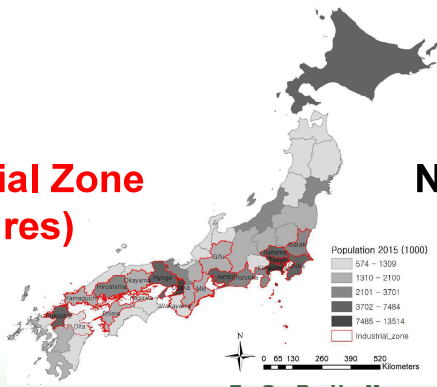


Land subsidence in Japan

Coastal Industrial Zone
(19 prefectures)

Non-Industrial Zone
(28 prefectures)

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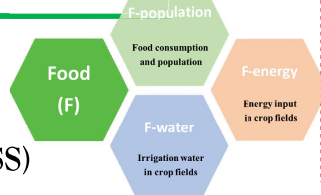


URBAN EUROPE

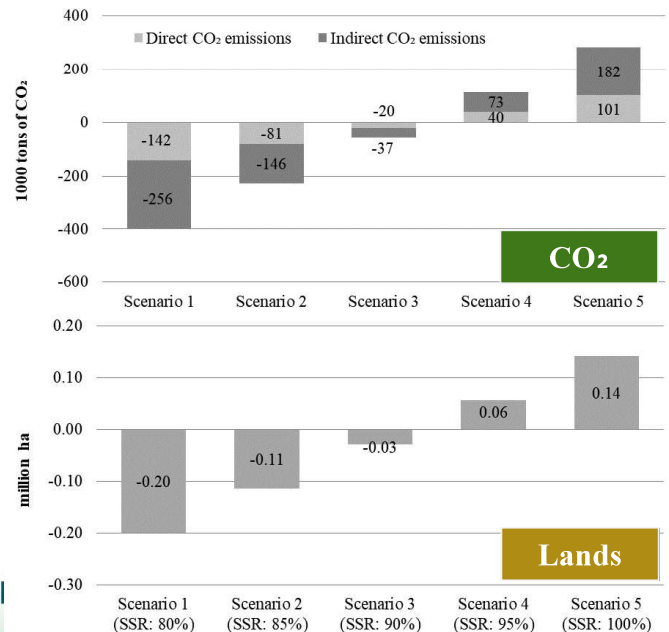
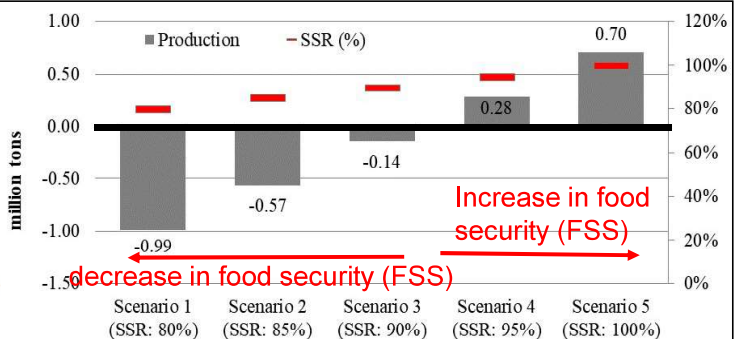
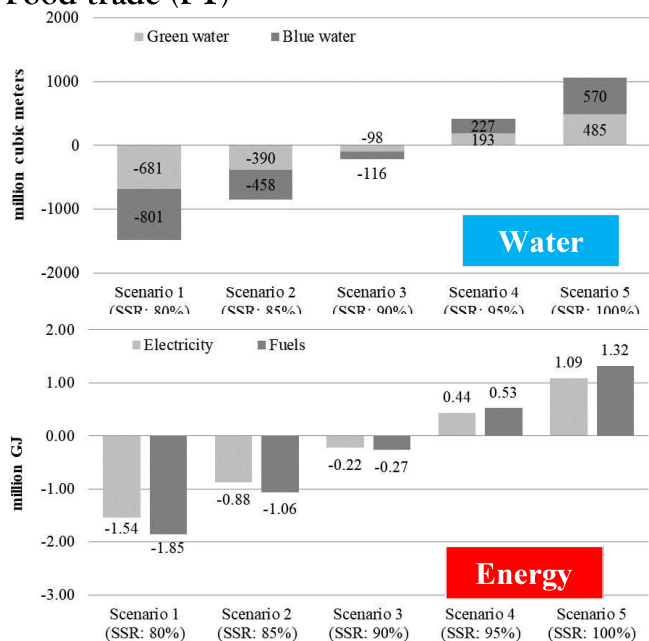
European Commission

Multi-Scale Nexus: National level

Food-centric Nexus



Crops (rice and others)
 Food self-sufficiency (FSS)
 Food trade (FT)

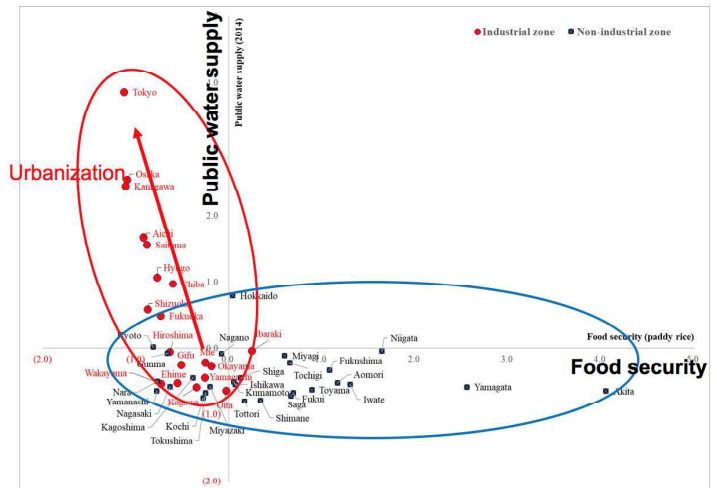
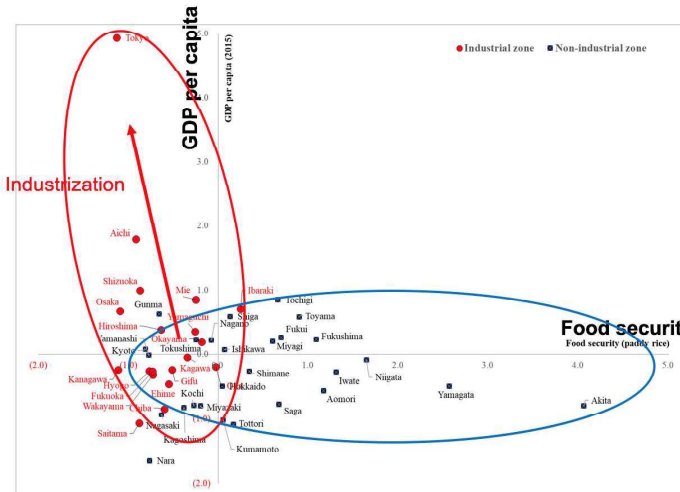
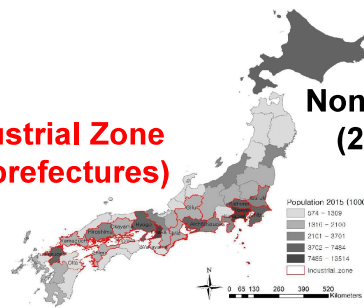


Multi-Scale Nexus: Prefectural level

Food-centric Nexus

Industrial Zone
(19 prefectures)

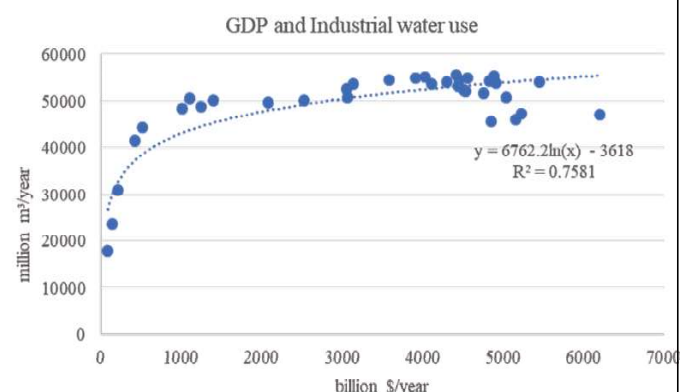
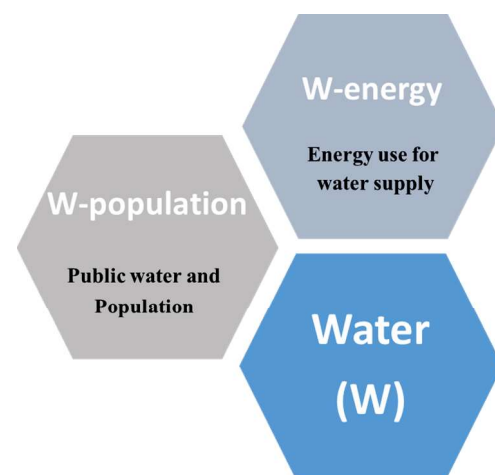
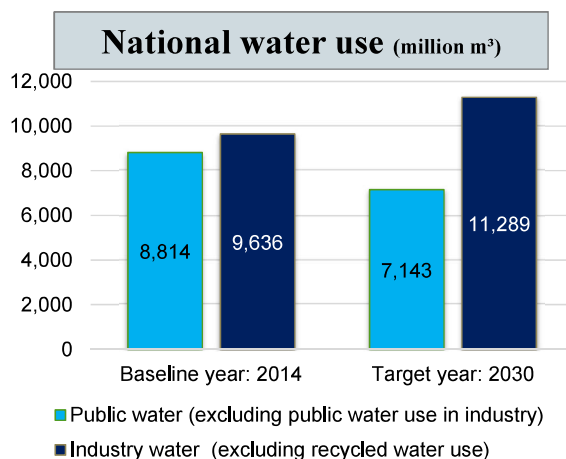
Non-Industrial Zone
(28 prefectures)



Multi-Scale Nexus: National level

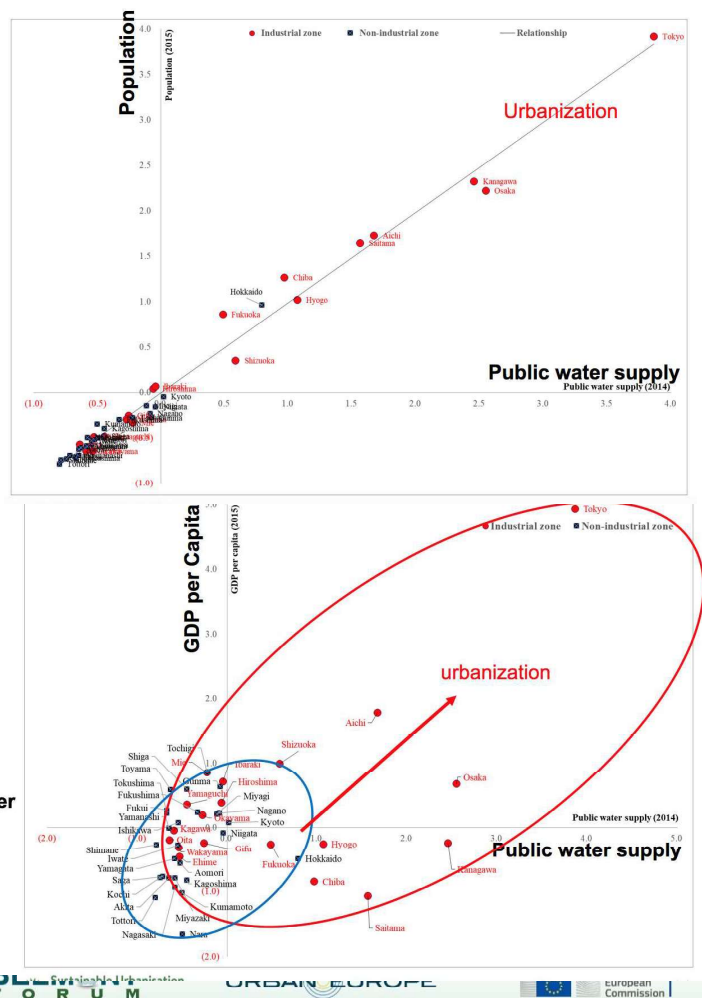
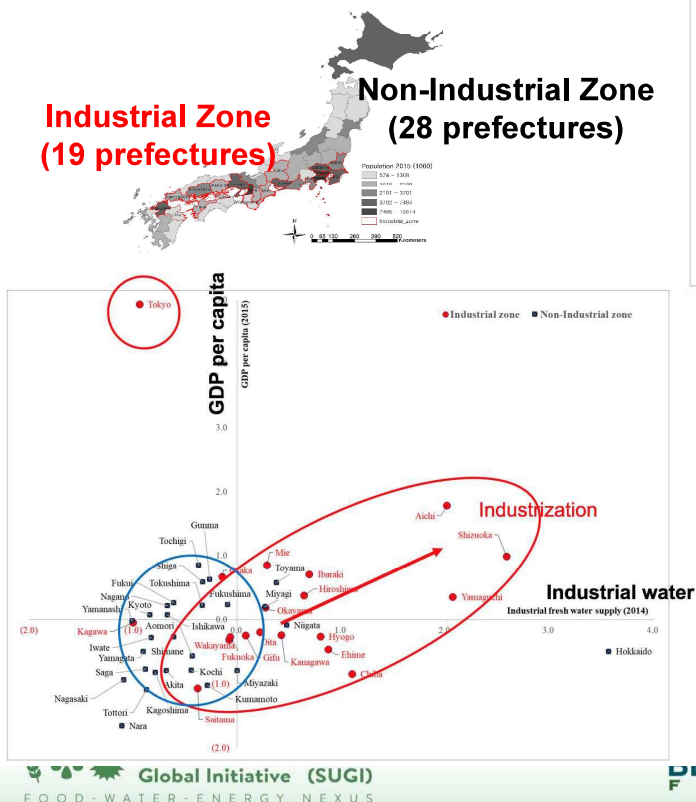
Water-centric Nexus

- ✓ Public water use per capita and population changes
- ✓ Relationship between GDP and industrial water use



Multi-Scale Nexus: Prefectural level

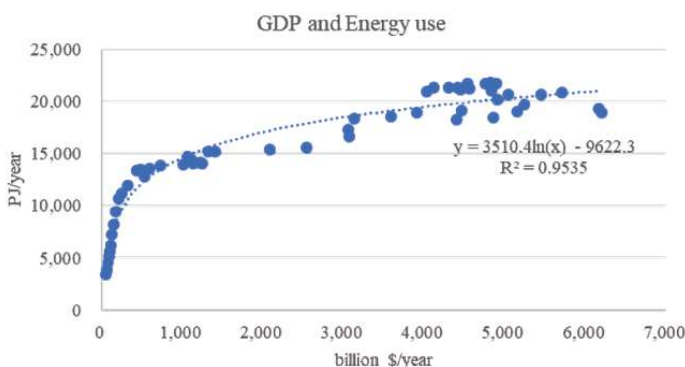
Water-centric Nexus



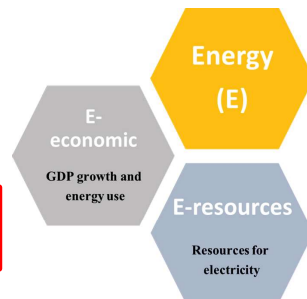
Multi-Scale Nexus: National level

Energy-centric Nexus

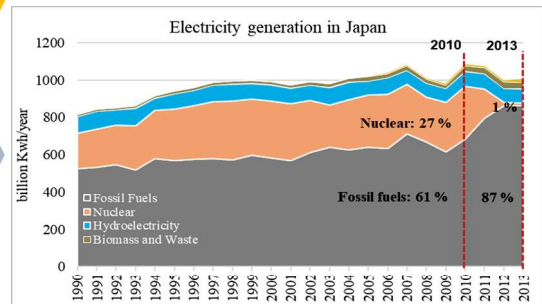
- ✓ Energy use per capita and population changes
- ✓ Energy use in industry by GDP growth
- ✓ Relationship between GDP and energy use



Source: FAO

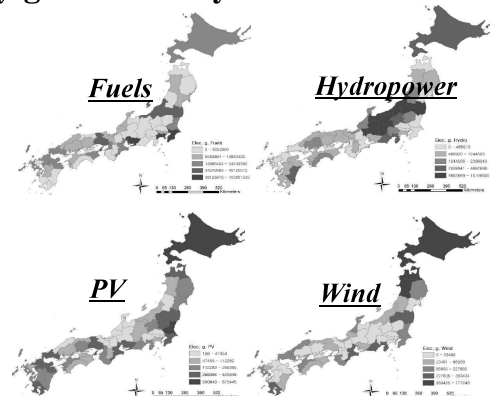


- Source of electricity generation and CO₂ emission



Source: Statistics Bureau,
Ministry of Internal Affairs and Communications

Electricity generation by sources in 2017

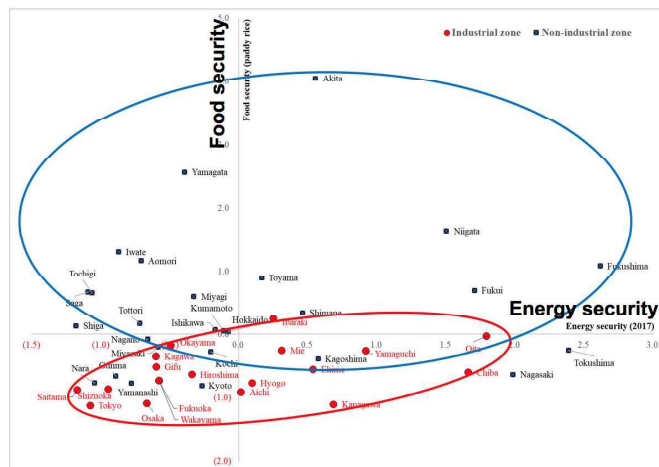
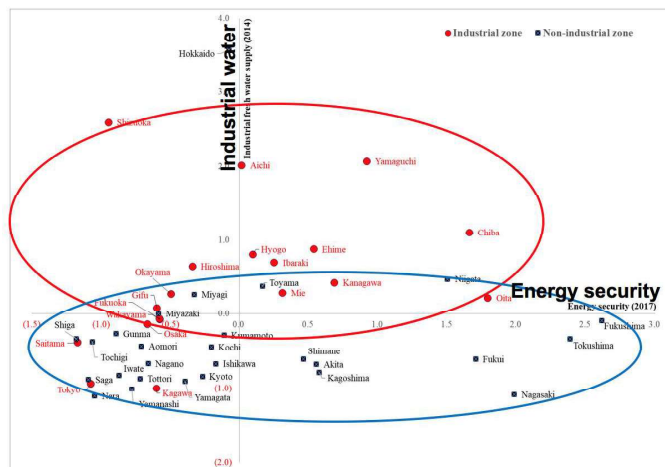
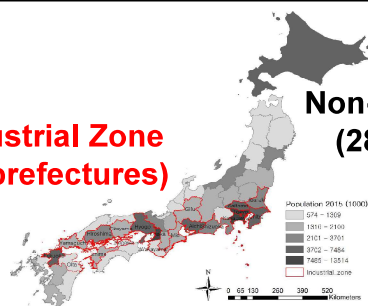


Multi-Scale Nexus: Prefectural level

Energy-centric Nexus

Industrial Zone
(19 prefectures)

Non-Industrial Zone
(28 prefectures)

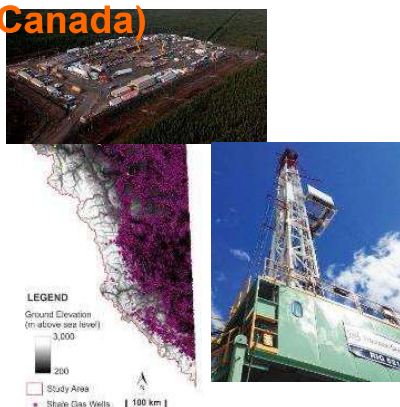


Multi-Scale Nexus: Local level

Water for Energy

How much energy can be
produced per kg of water?

Shale gas NE BC
(Canada)



Fracking water in Montney Basin
2.79 million m³/year
Gas production: 18,946 million m³/y

66,000 kcal/kg-water

Hot spring power
generation
in Beppu (Japan)



Energy production: 8,000kW
Hot spring water discharge

16.3 kcal/kg-water

Small hydro-power
plant
in Beppu (Japan)

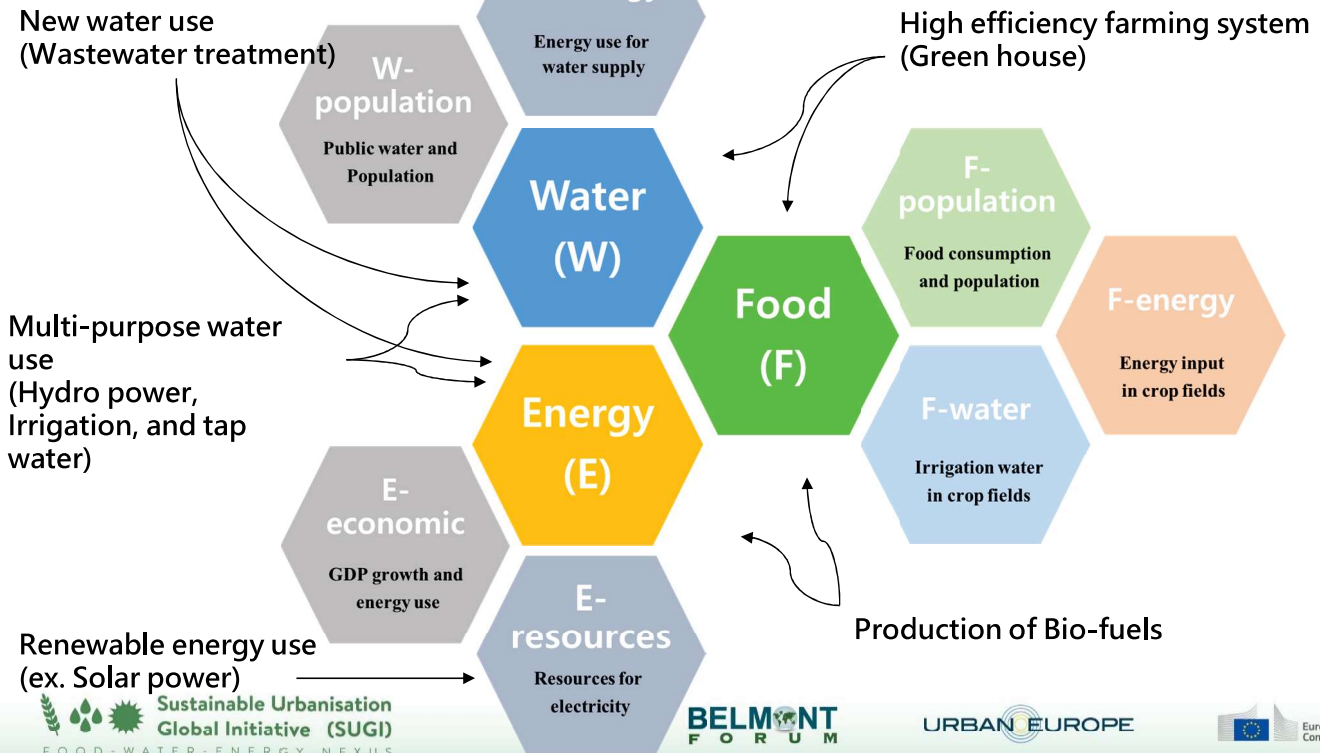


Energy production : 93 kW
River discharge : 1.1 m³/s

0.0164 kcal/kg-water

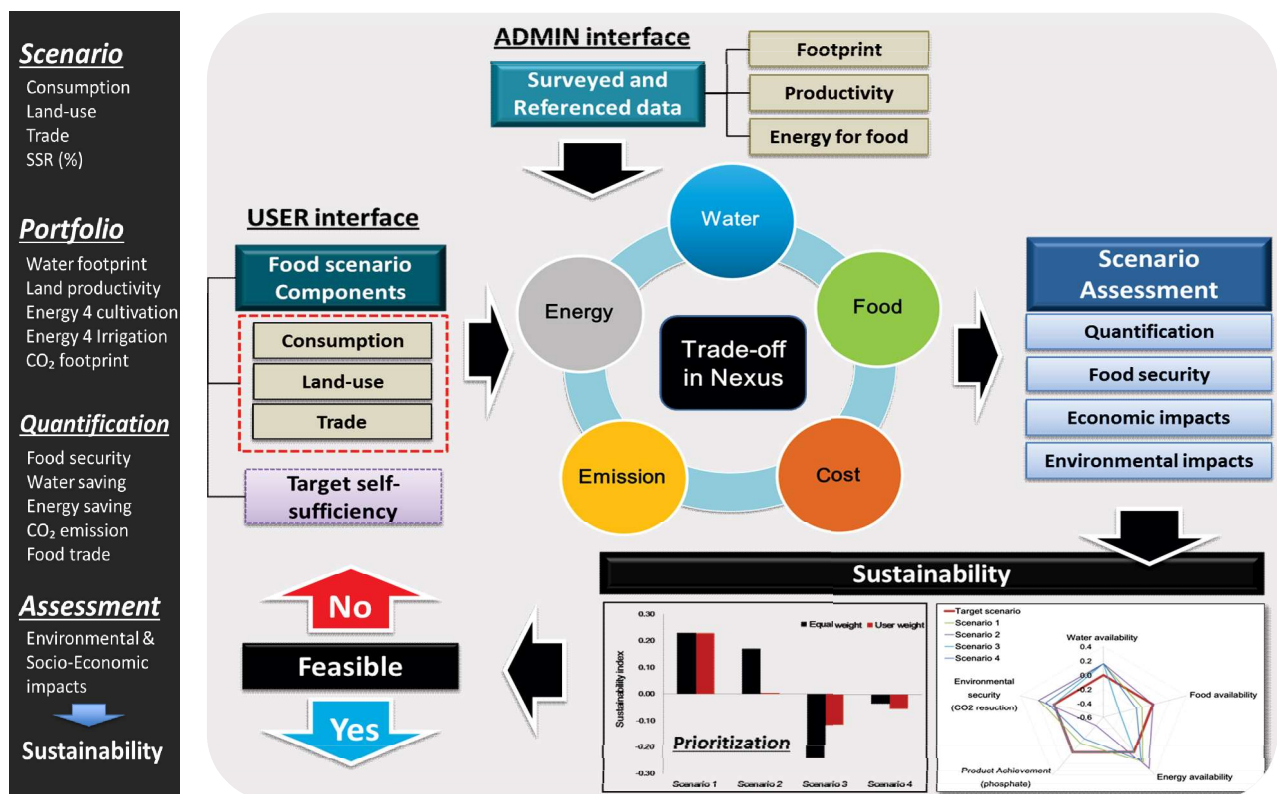
Integrated Assessment of Nexus with subsystems in each scale

Application of new management

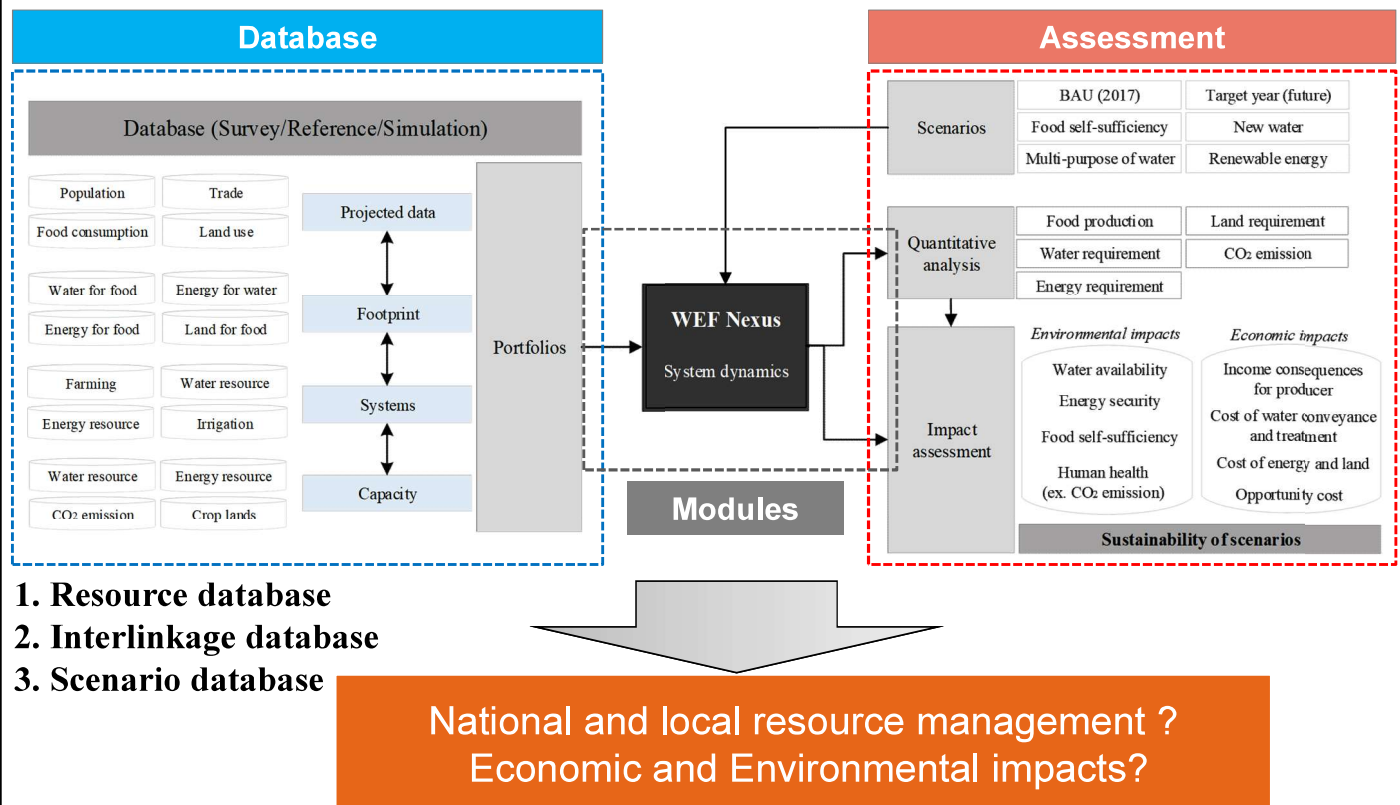


Platform of Water-Energy-Food Nexus

Decision support system through the Nexus



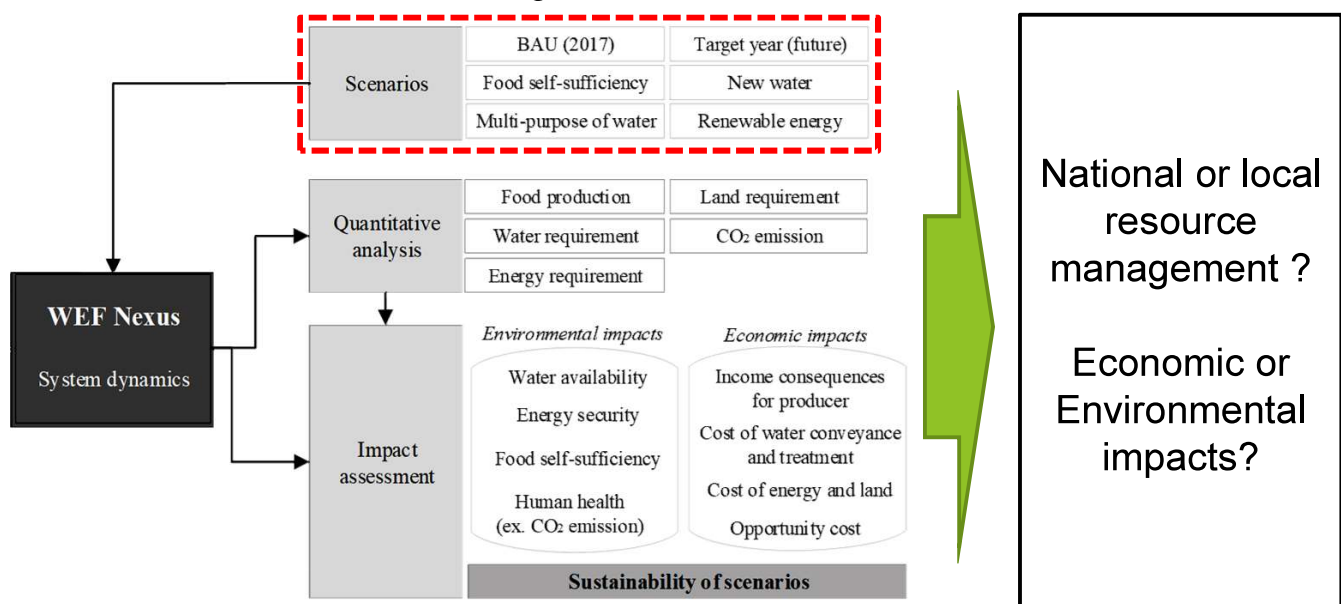
A platform of the Nexus



Assessment of scenarios and impacts

What do we want to assess?

- Relating to critical question
- National resource management or local ?



Sustainability Assessment

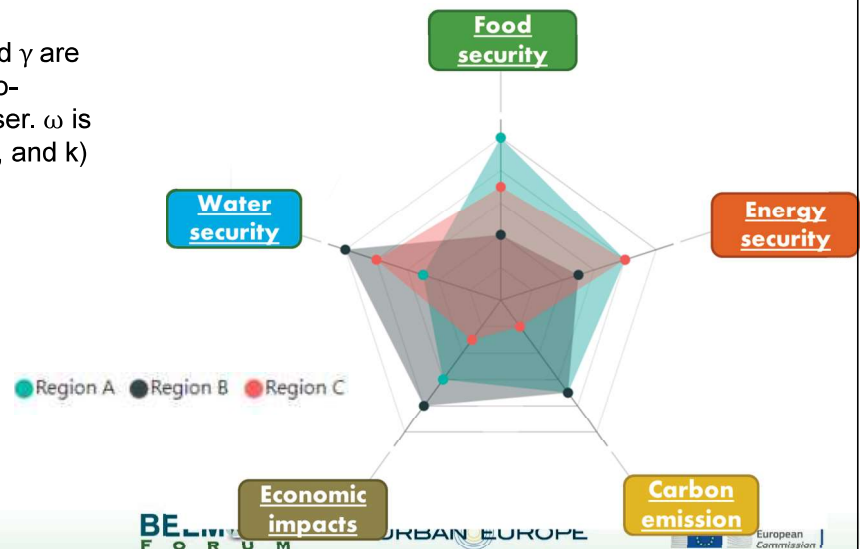
Sustainability index

- Normalized index of environmental, social, and economic impacts
- Trade-of among indices considering weight values

Sustainability index (SI)

$$= \alpha \sum \omega_i NI_{environmental} + \beta \sum \omega_j NI_{socio-economic} + \gamma \sum \omega_k NI_{other}$$

- NI is normalized index, and α , β , and γ are weight value of environmental, socio-economic and other impacts by a user. ω is the weight value of components (i, j, and k) considered in each impact.



Water-Energy-Food Nexus Platform

- 1) Nexus Research has **many entry points** such as water, energy, food, land, climate change, trade, etc., therefore more integrated studies will be achievable for sustainable society and SDGs.
- 2) **Multi-scale** is important to analyze the trade-off and synergy of the Nexus
- 3) Future Earth **Nexus** KAN (Knowledge Action Network) promotes a global platform for sharing "Nexus Tool Box" including the Nexus concept, modeling, databases, et
- 4) **Regional platform** is useful by sharing the similarity of the Nexus (Regional Center of Future Earth in Asia (RIHN) identify **Nexus** is one of Strategic Research Agenda in Asia)

*Similarity of Nexus in Asia e.g. W: monsoon, F: rice, E: hydropower
Thailand, Japan, Korea, China (south), and more*