Urban food-energy-water (FEW) nexus: A material and energy flow perspective

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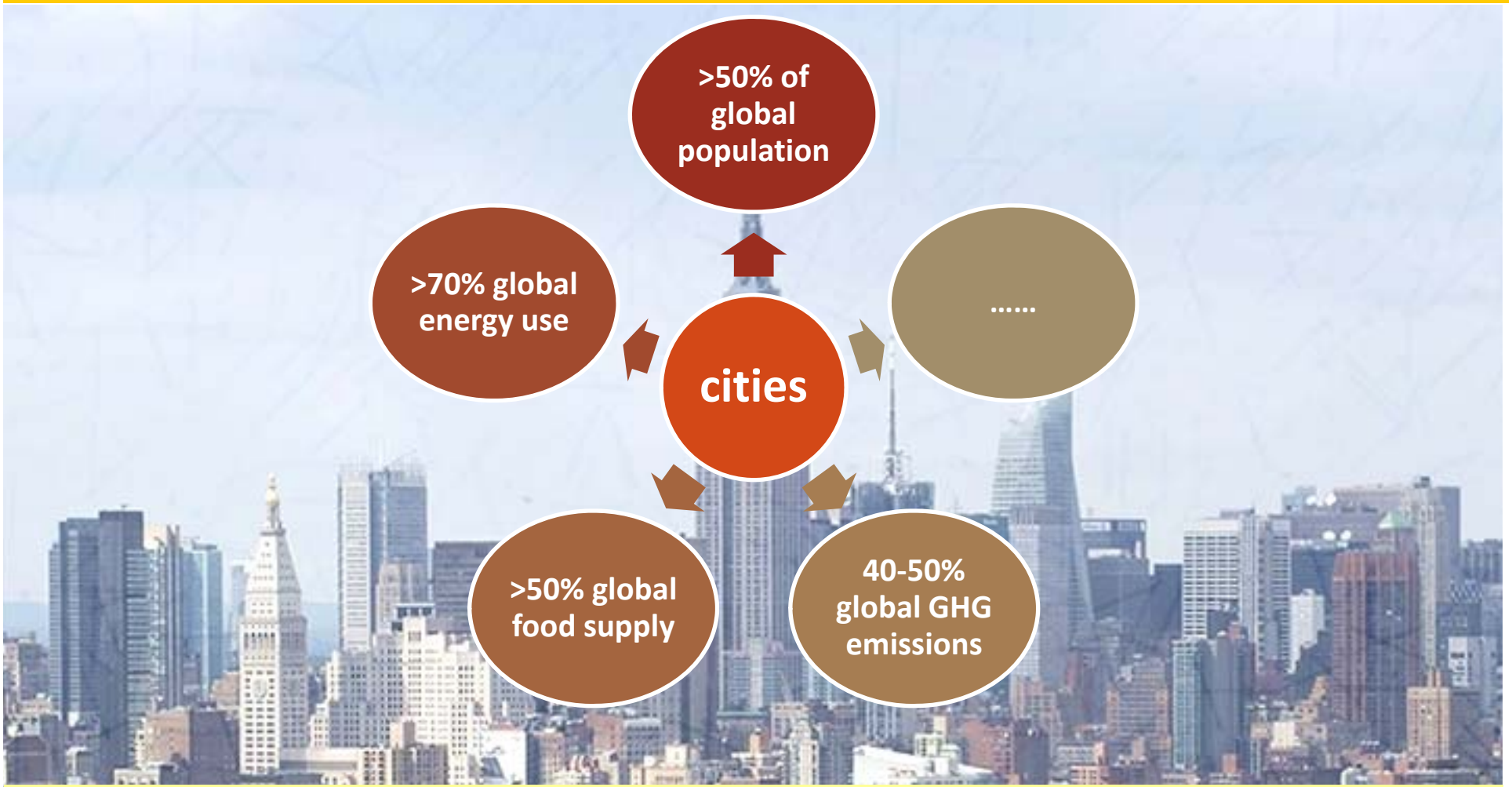
Cities are important for sustainability



- **Cities** are sink of energy and resources, and source of waste and emissions
- People living in cities interact with the environment through **infrastructure** systems

Infrastructure systems are interdependent: infrastructure ecology

ENVIRONMENTAL Science & Technology

Viewpoint

Gigaton Problems Need Gigaton Solutions[1]

Achieving sustainability requires commanding the whole problem, not just iterative efforts that barely strike a moving target.

Ming Xu, John C. Crittenden, Yongsheng Chen, Valerie M. Thomas, Douglas S. Noonan, Reginald Desroches, Marilyn A. Brown and Steve P. French
Georgia Institute of Technology, Atlanta

Environ. Sci. Technol., **2010**, *44* (11), pp 4037–4041
DOI: 10.1021/es903306e

Viewpoint

Developing a Science of Infrastructure Ecology for Sustainable Urban Systems

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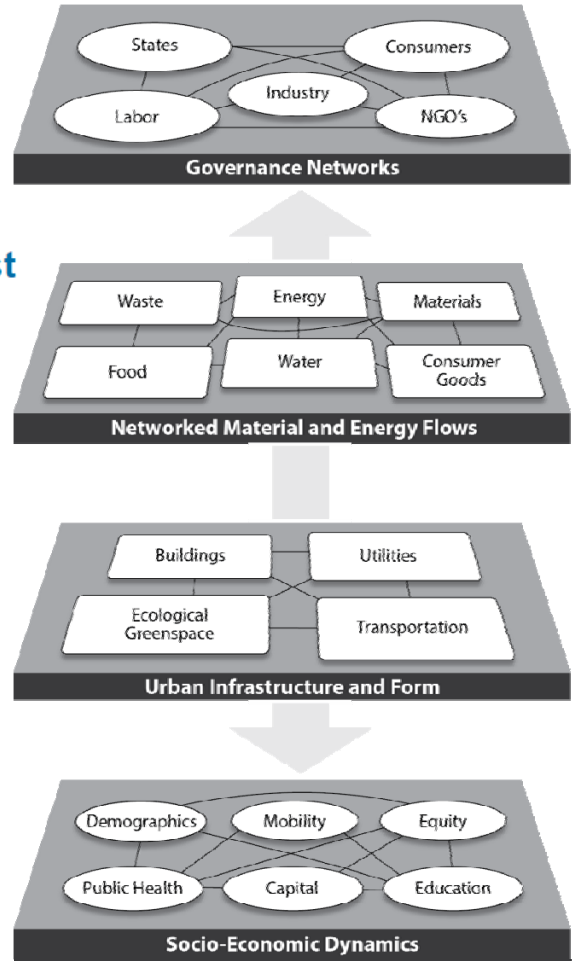
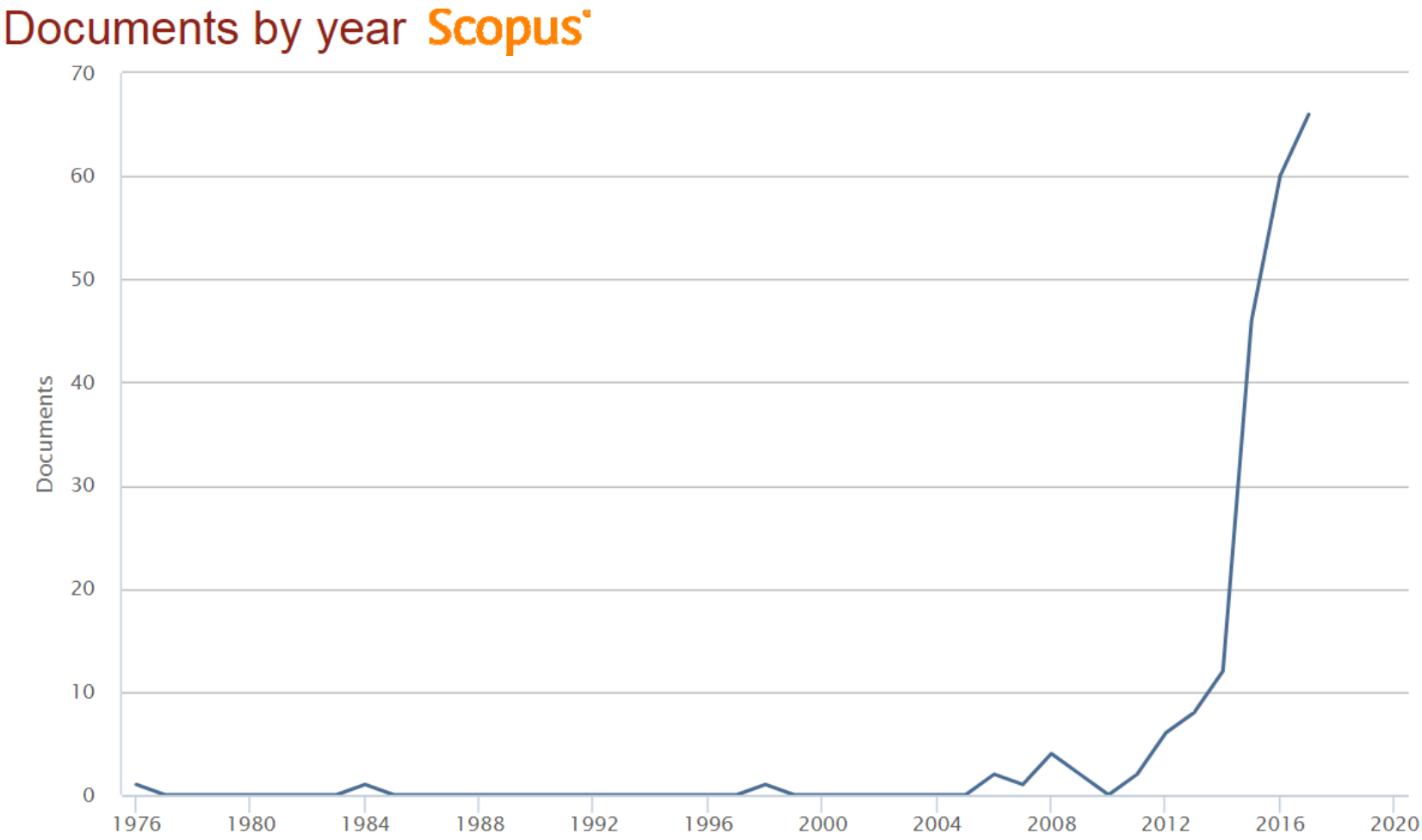
Environ. Sci. Technol., **2012**, *46* (15), pp 7928–7929
DOI: 10.1021/es3025534



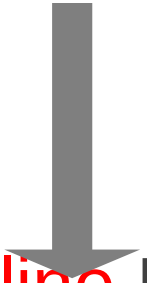
Meerow, Newell and Stults (2016)

Food-energy-water (FEW) nexus



Ultimate goals of FEW nexus studies

- Improve the efficiency of FEW resource utilization
- Enhance the security or resilience of FEW resource supplies

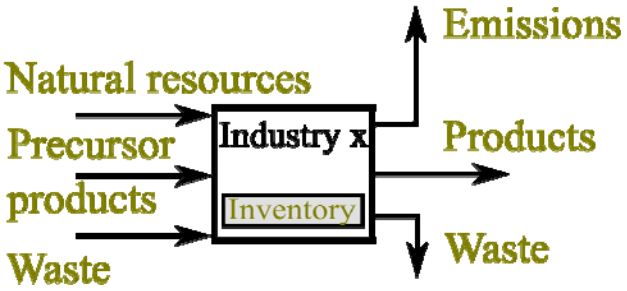


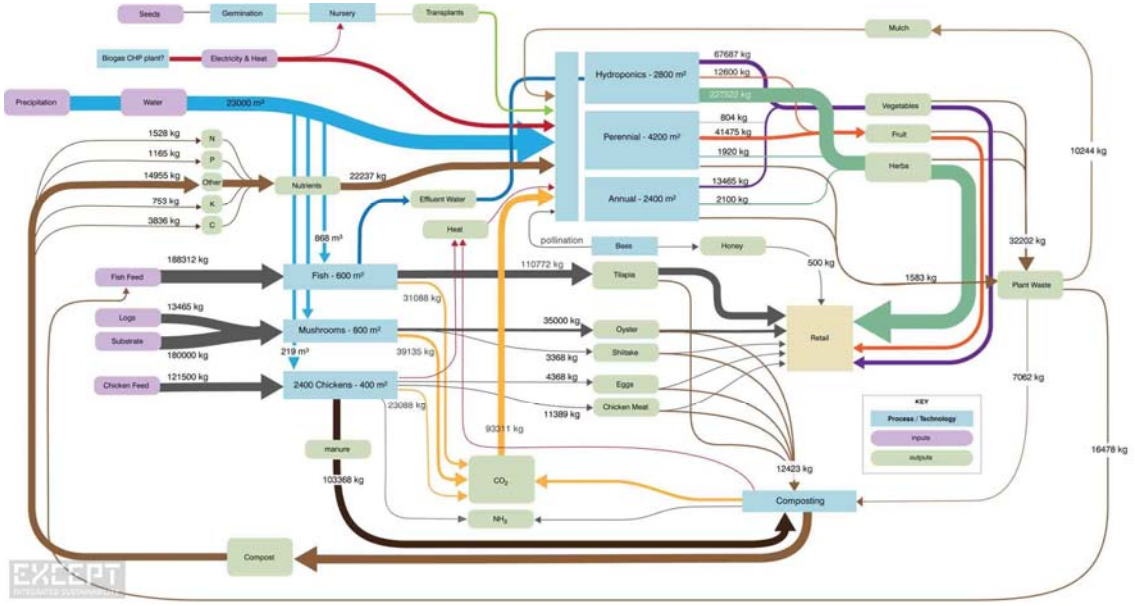
- Characterize the baseline FEW nexus for a city

Zhang et al., Concept and framework of food-energy-water nexus for urban sustainability: a comprehensive review. In prep.

Material (substance, energy) flow analysis

- Quantify flows and stocks of materials (substances, energy) of a socioeconomic system
- A wire diagram of a socioeconomic system

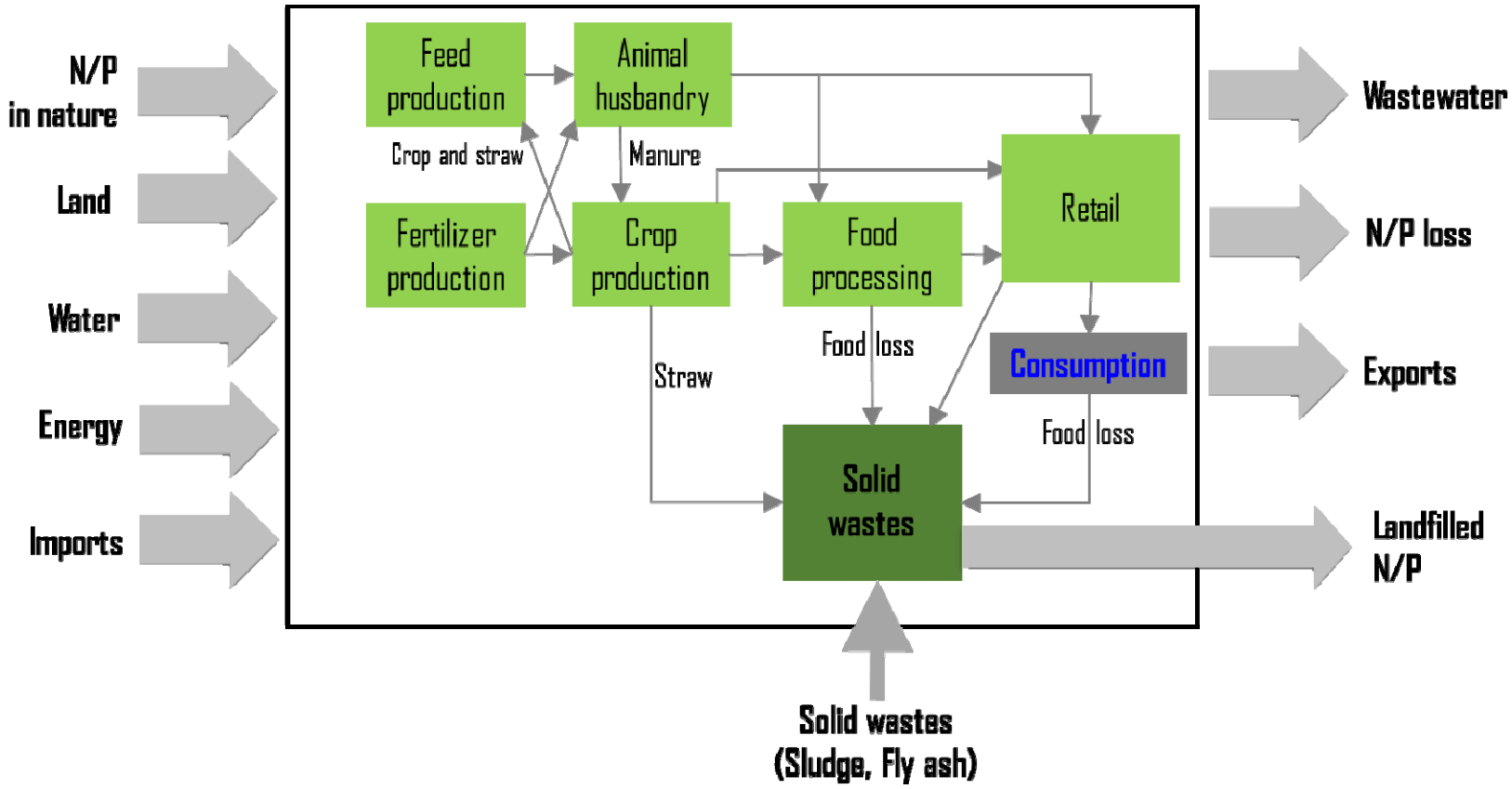




except.nl

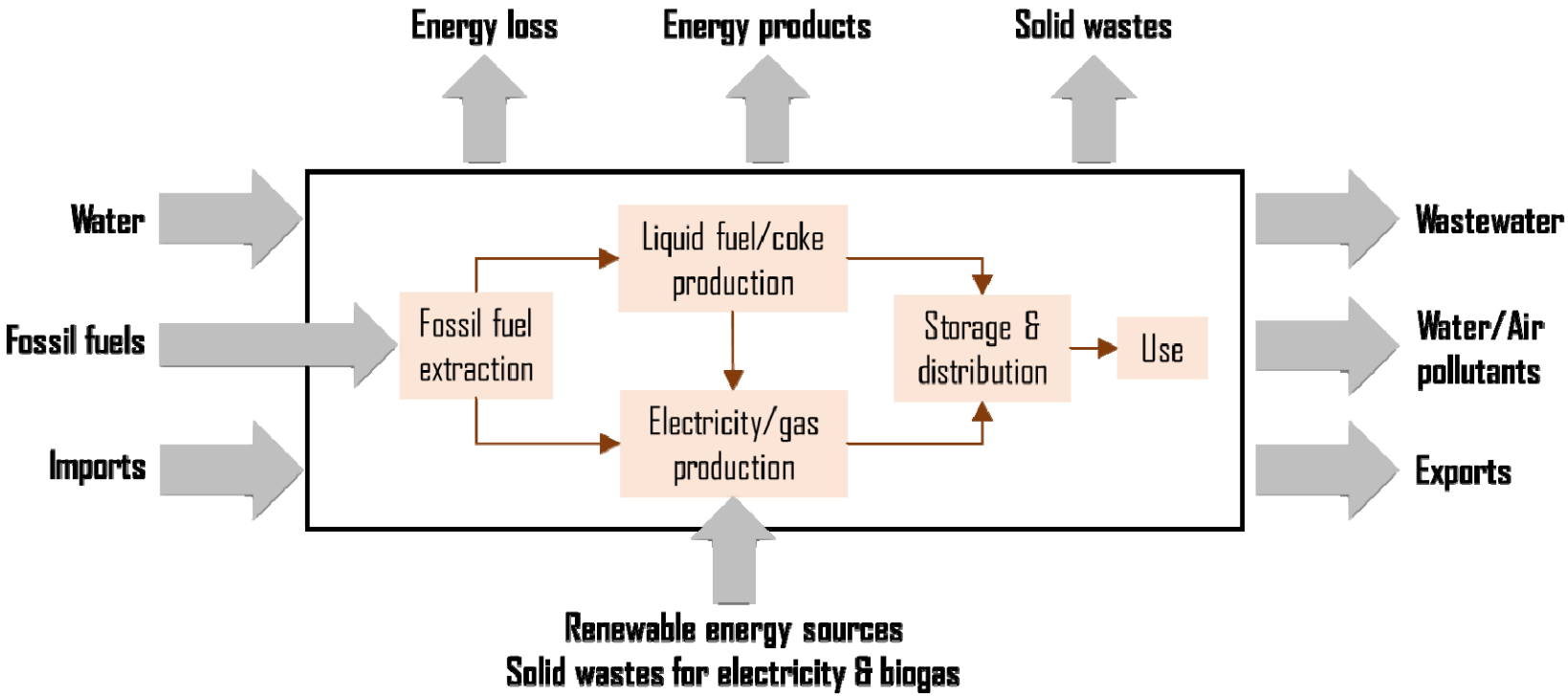
Food system

- N/P fixation, production, processing, retail, consumption, waste management



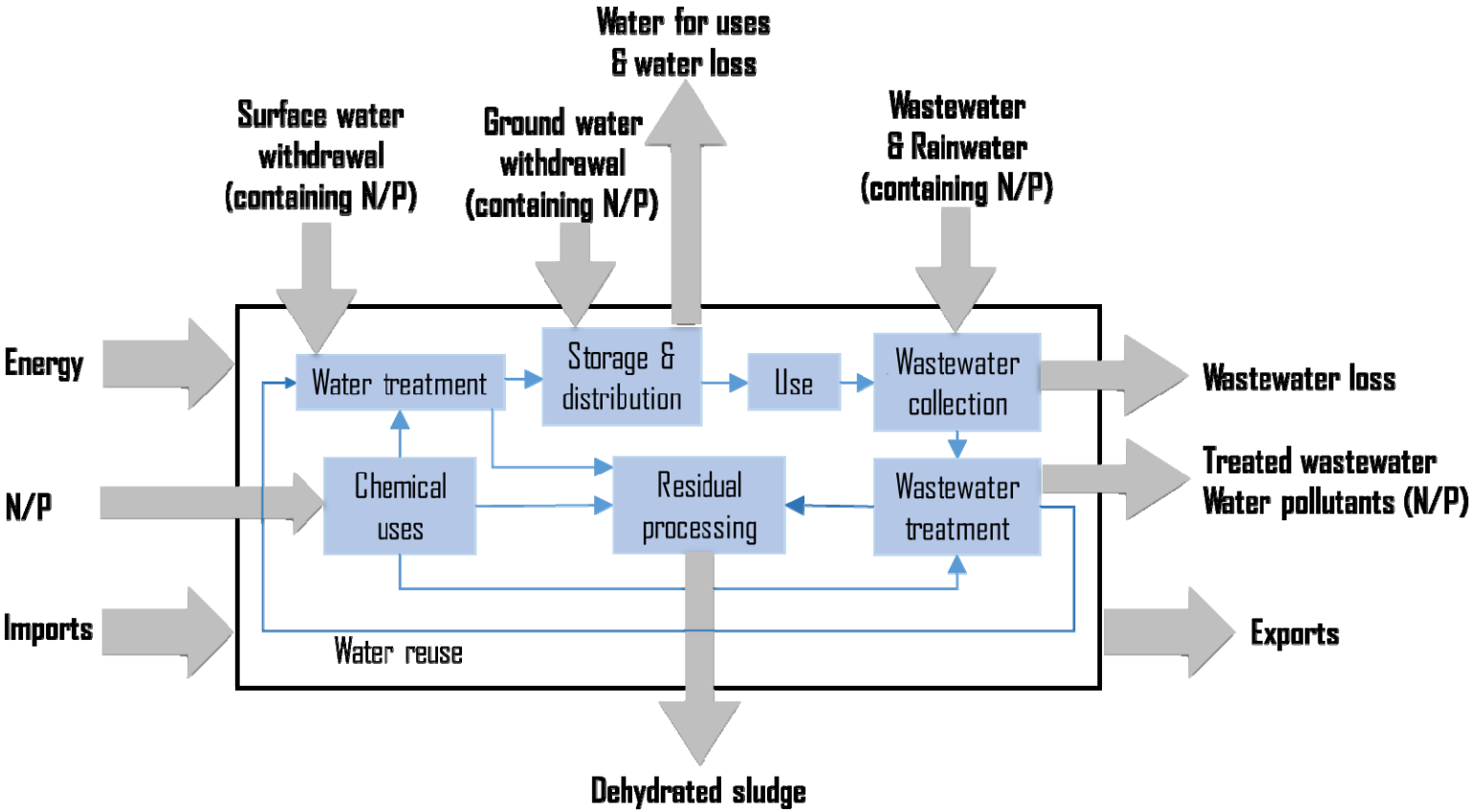
Energy system

- Extraction, processing, electricity generation, liquid fuel production, consumption, emissions

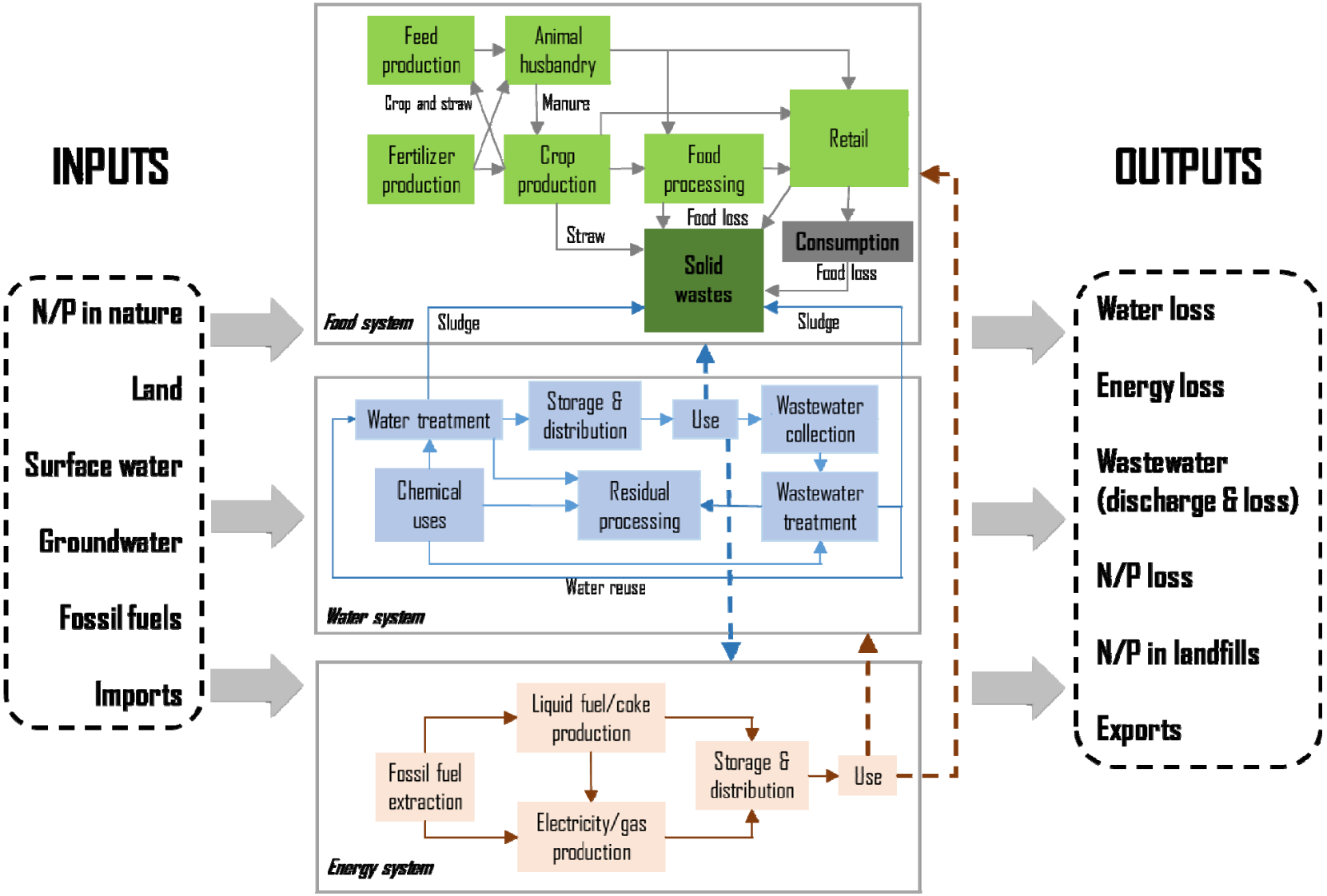


Water system

- **Water**: withdrawal, treatment, distribution, consumption
- **Wastewater**: collection, treatment, residual processing, discharge

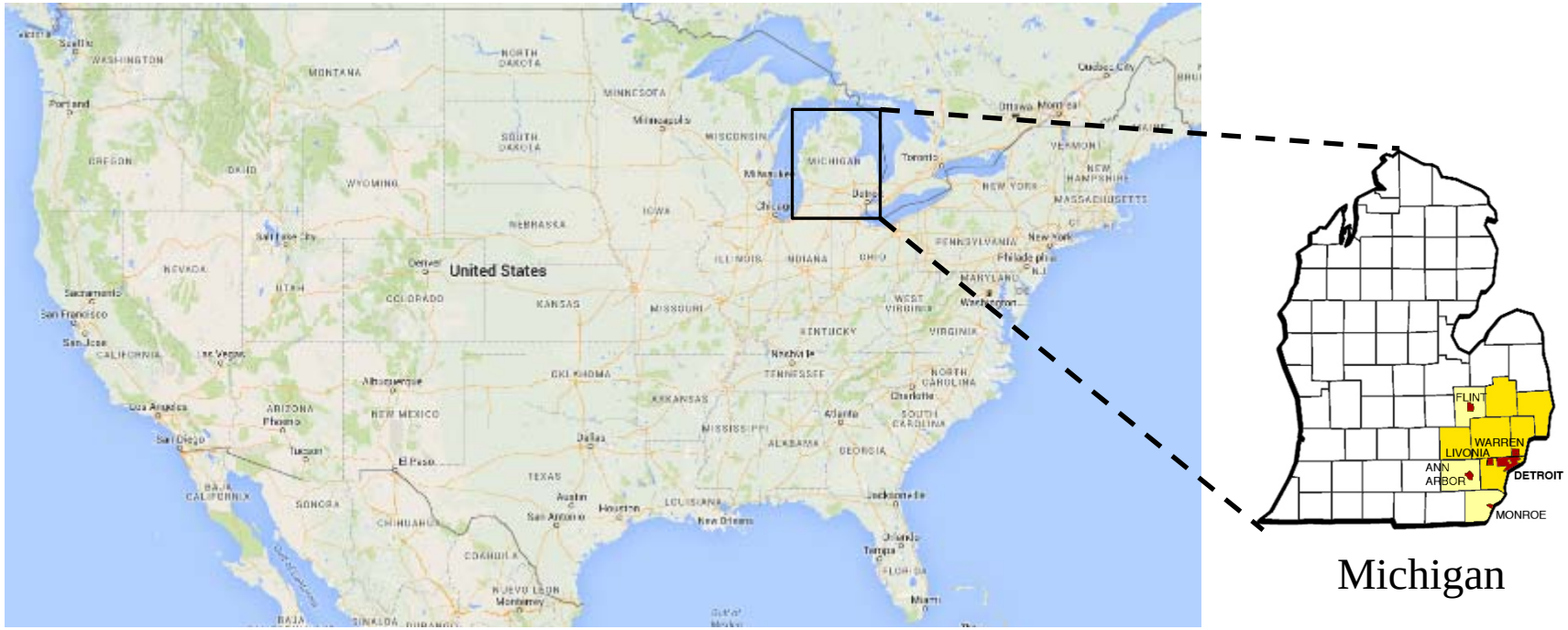


FEW nexus of a urban system: material and energy flow perspective



Case study: Detroit Metropolitan Area in 2012

- Six counties
- The 14th most populous in the US in 2012



Michigan

Inputs and outputs

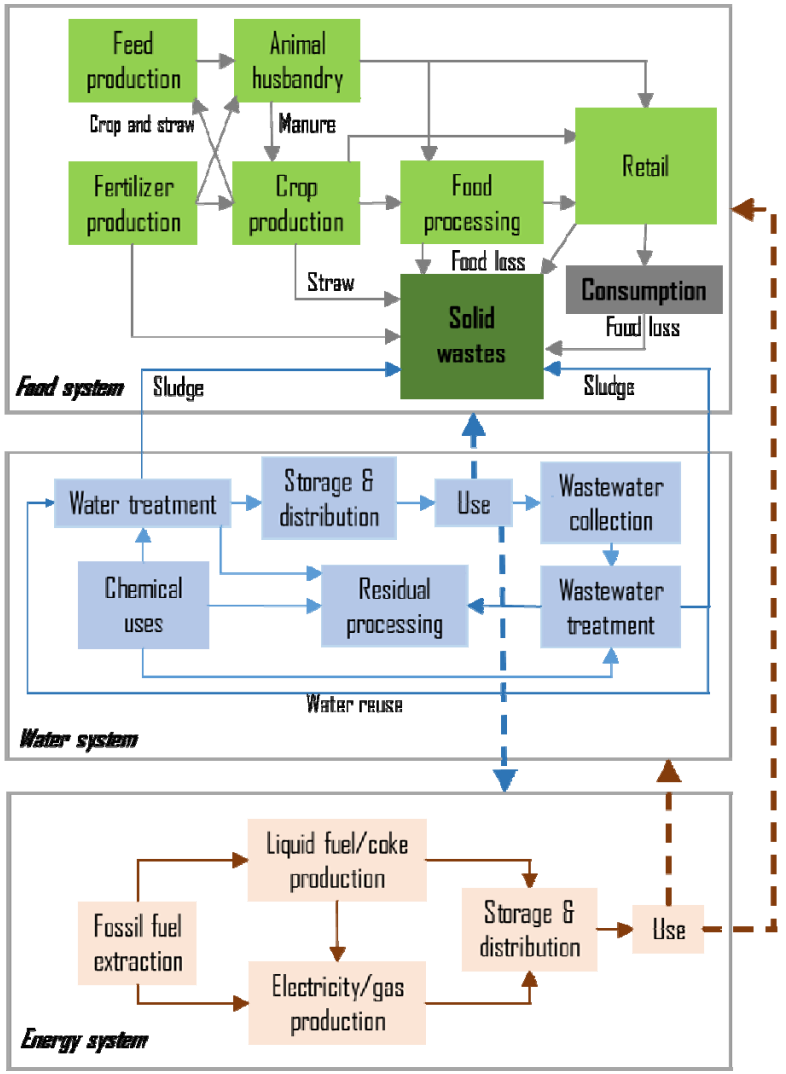
INPUTS

Domestic

N	19.2 kt
P	1.8 kt
Water	4.7 Bt
Energy	6 PJ

Imports

N	76.8 kt
P	15.3 kt
Energy	1,034 PJ



OUTPUTS

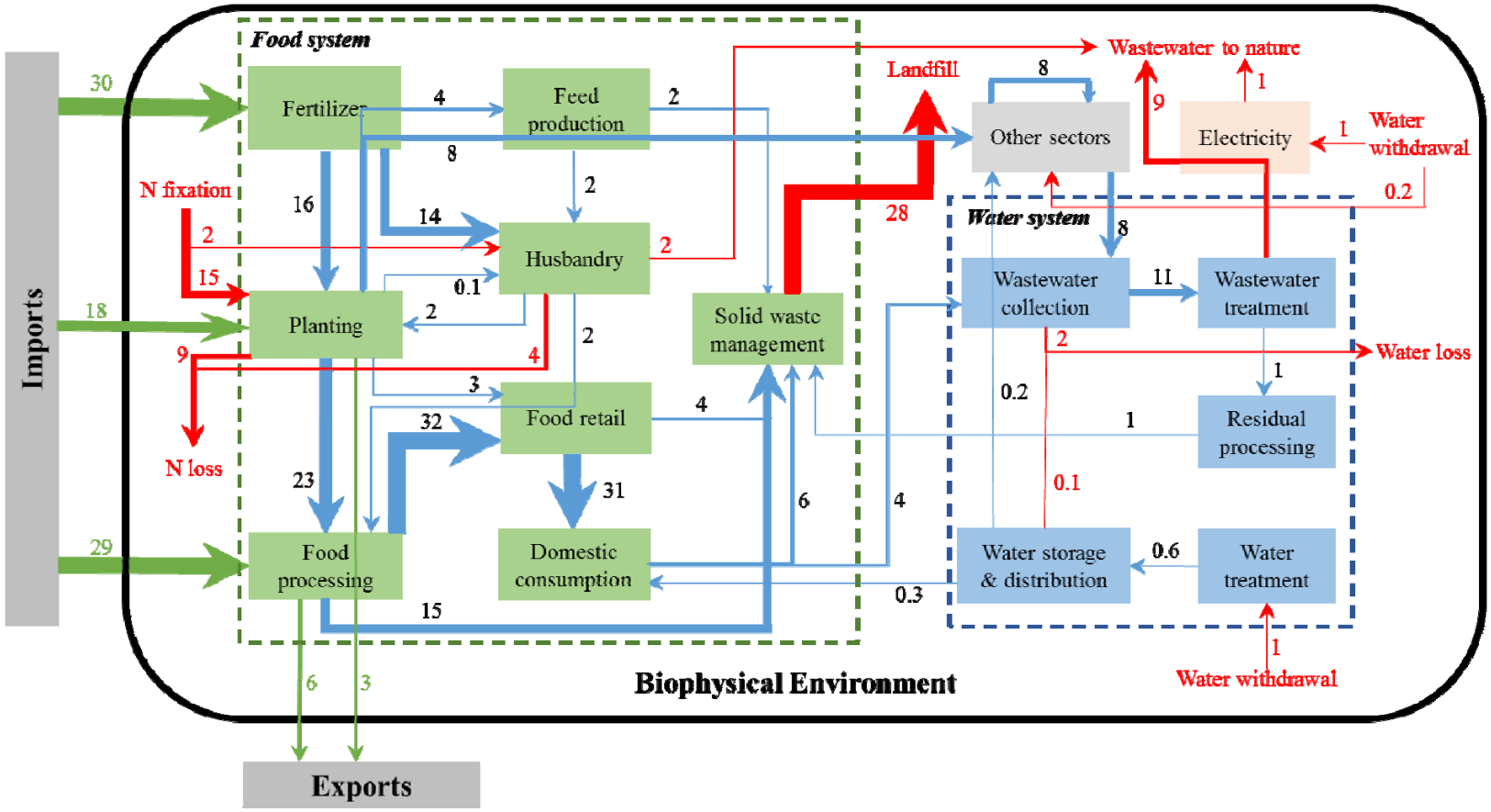
Domestic

N to nature	56.4 kt
P to nature	9.3 kt
Wastewater	4.3 Bt
Water loss	333 Mt
Heat loss	1,002 PJ

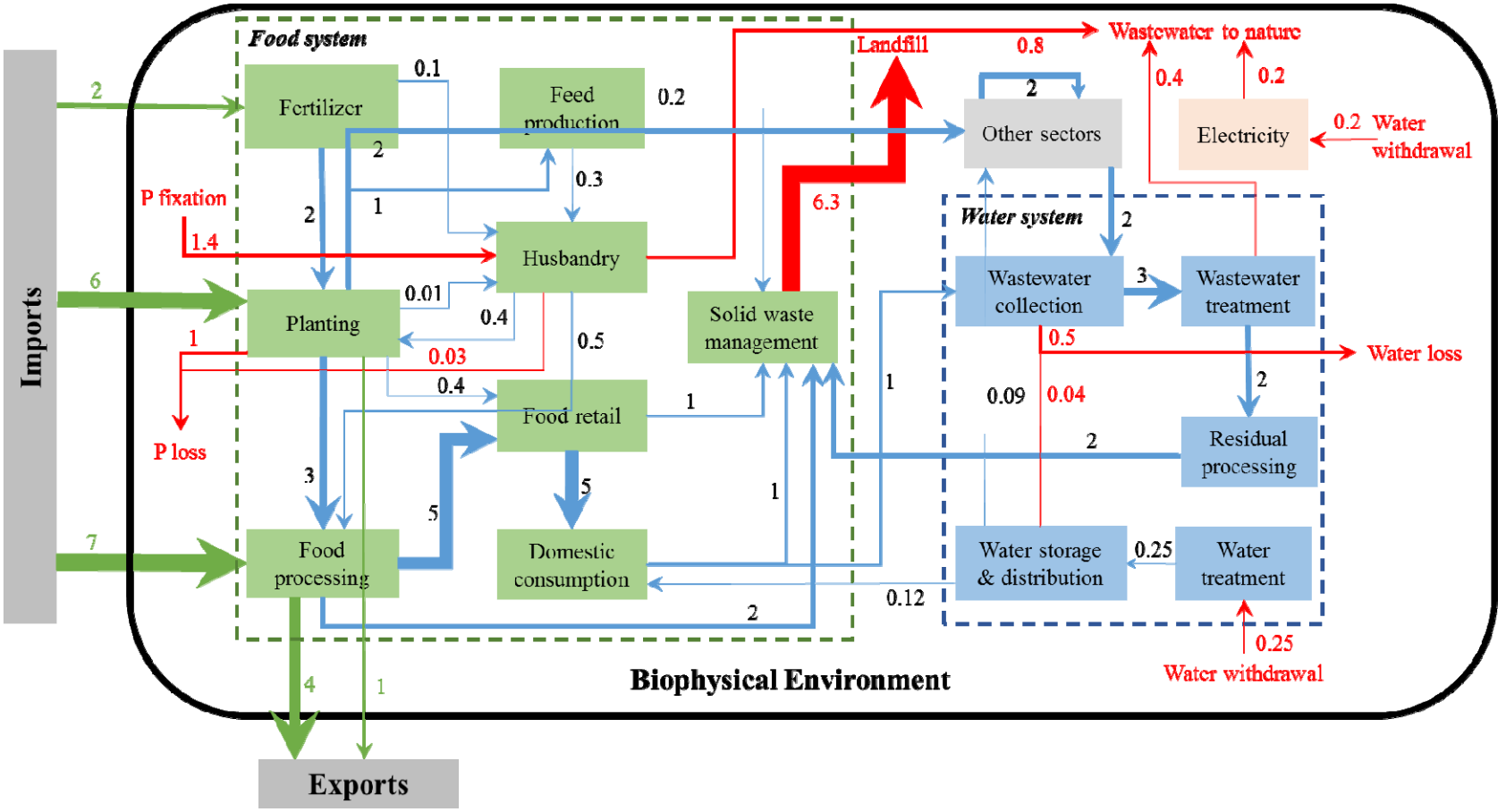
Exports

N	9.6 kt
P	5.1 kt
Energy	38 PJ

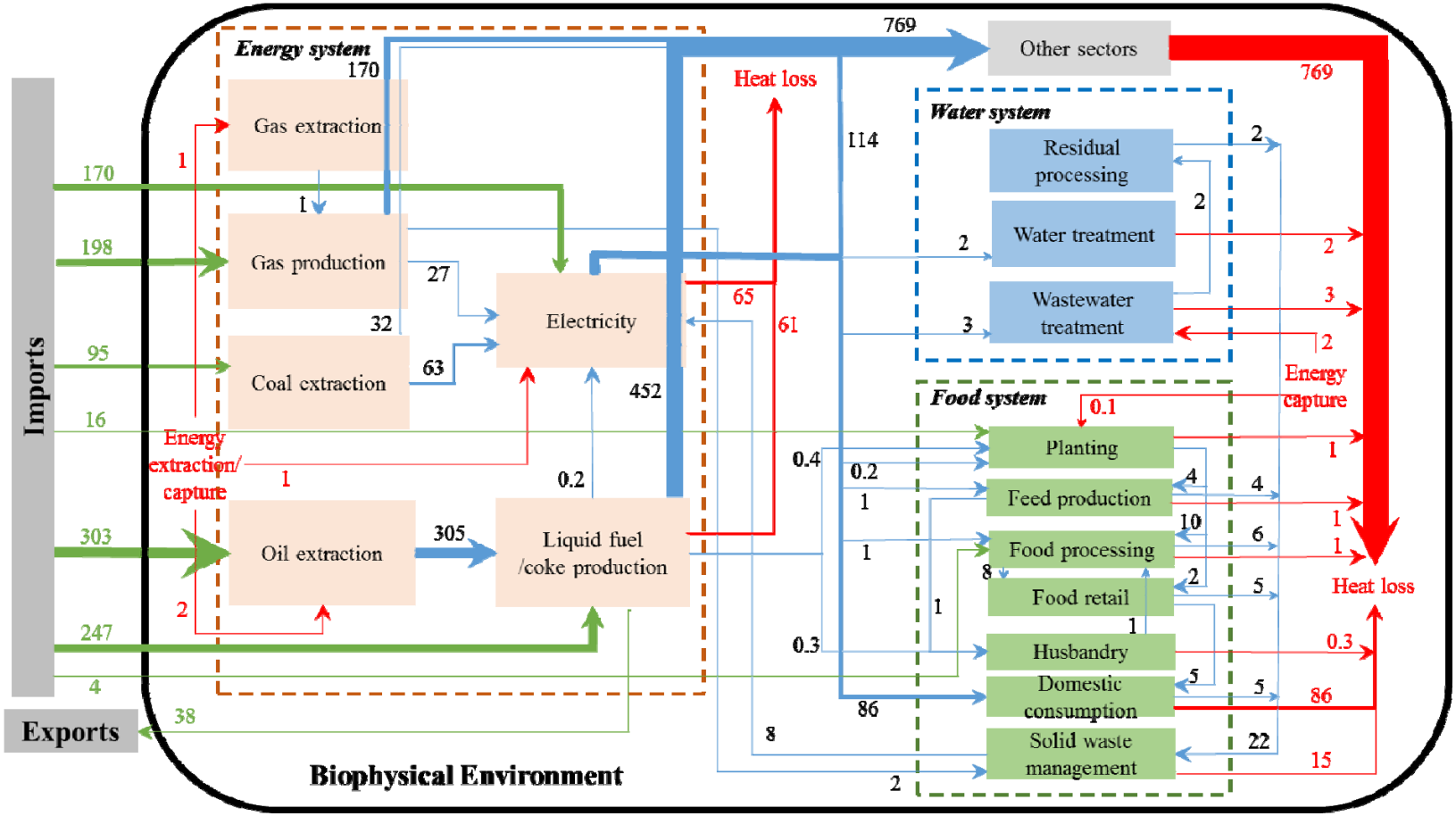
N flows


Food system
Imports
30
18
29
Fertilizer
Feed production
Husbandry
Planting
Food retail
Food processing
Domestic consumption
Solid waste management
N fixation
2
15
N loss
9
4
2
16
14
8
2
2
0.1
2
2
3
4
32
23
31
6
4
15
0.3
6
3
Exports
Biophysical Environment
Landfill
28
Wastewater to nature
8
9
1
Other sectors
Electricity
1
Water withdrawal
0.2
Water system
8
Wastewater collection
11
Wastewater treatment
2
Water loss
1
0.2
1
Residual processing
0.1
Water storage & distribution
0.6
Water treatment
1
Water withdrawal

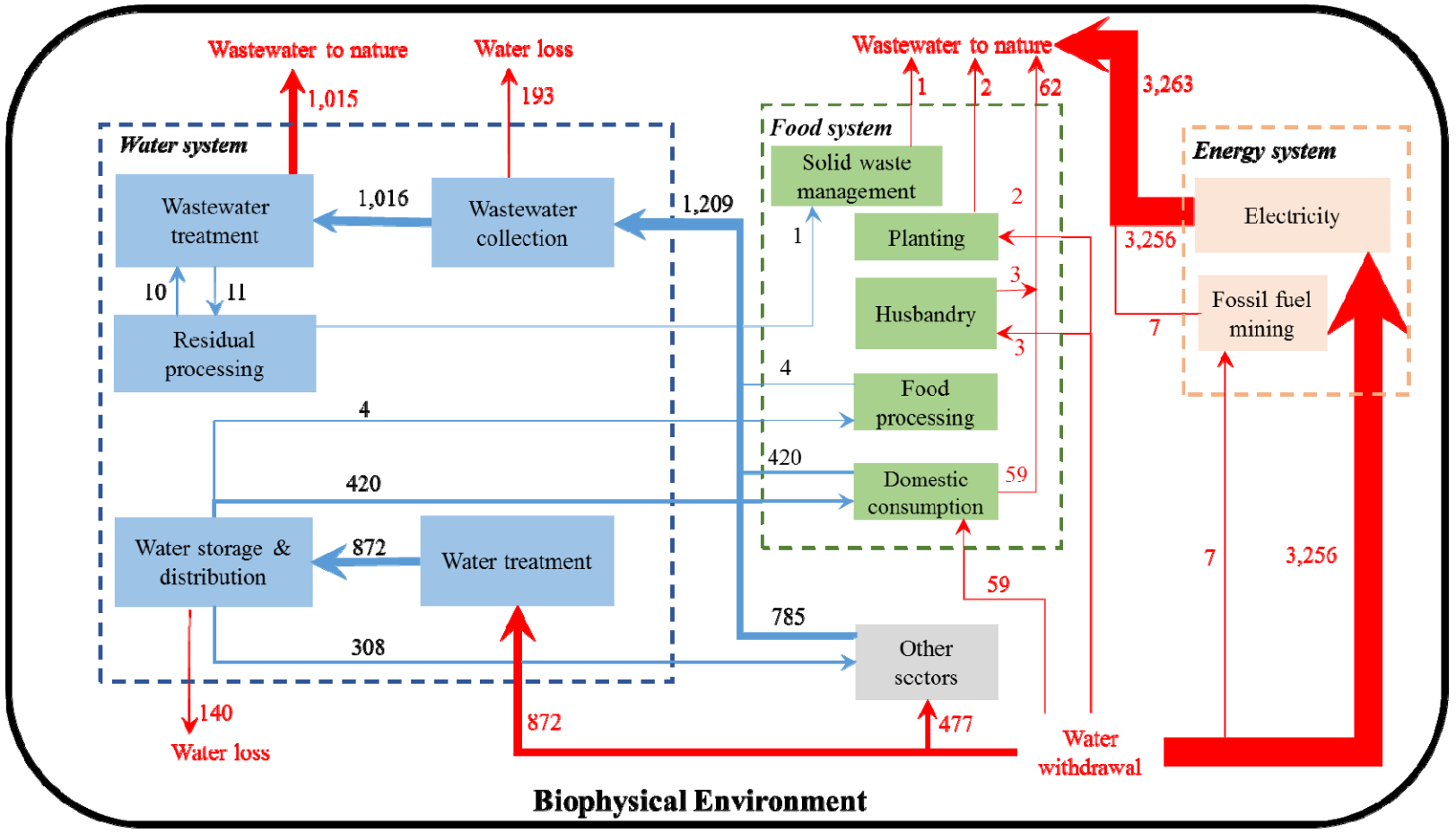
P flows


Food system
Fertilizer
Feed production
Husbandry
Planting
Food retail
Food processing
Domestic consumption
Solid waste management
Other sectors
Water system
Wastewater collection
Wastewater treatment
Residual processing
Water storage & distribution
Water treatment
Electricity
Imports
Exports
Biophysical Environment
Landfill
Wastewater to nature
Water withdrawal
Water loss
P fixation
P loss
0.1
0.2
0.3
0.4
0.5
0.01
0.03
0.8
0.2
0.25
0.12
0.09
0.04
6.3
1.4

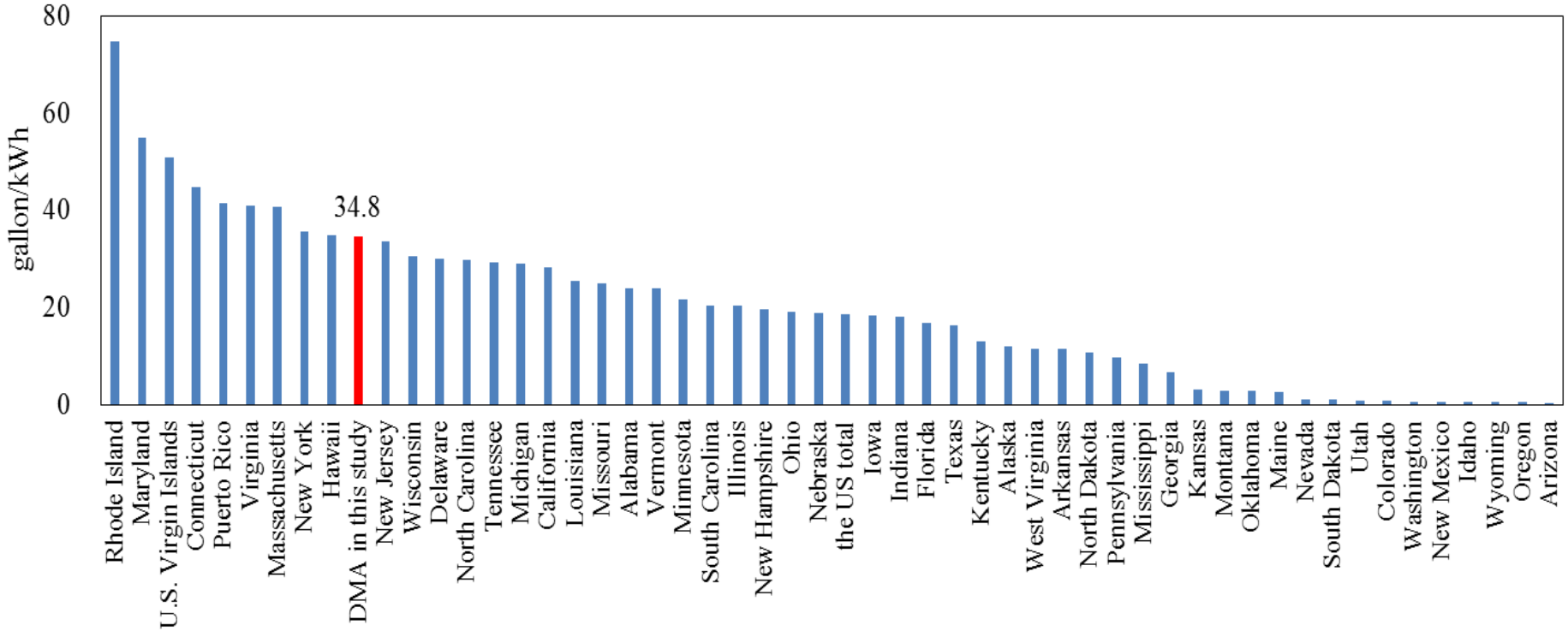
Energy flows



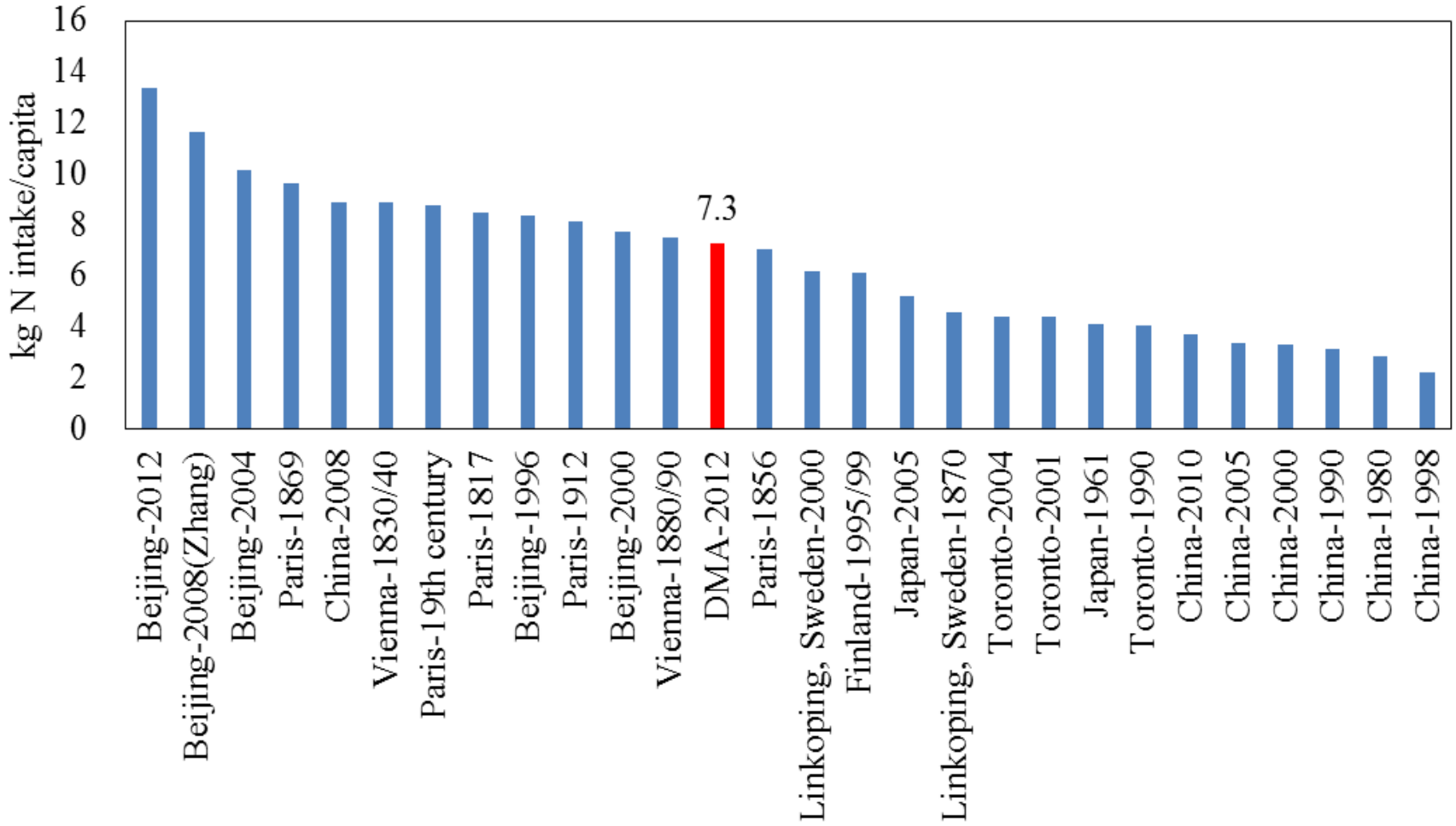
Water flows


Wastewater to nature
1,015
Water loss
193
Water system
Wastewater treatment
1,016
Wastewater collection
1,209
10
11
Residual processing
4
420
Water storage & distribution
872
Water treatment
308
140
Water loss
872
Wastewater to nature
1
2
62
3,263
Food system
Solid waste management
1
Planting
2
Husbandry
3
3
4
Food processing
420
Domestic consumption
59
59
785
Other sectors
477
Water withdrawal
Energy system
Electricity
3,256
Fossil fuel mining
7
7
3,256
Biophysical Environment

Comparison: water for energy (electricity)



Comparison: per capita N input



Next step: Streamline data collection for more case studies and more comparisons

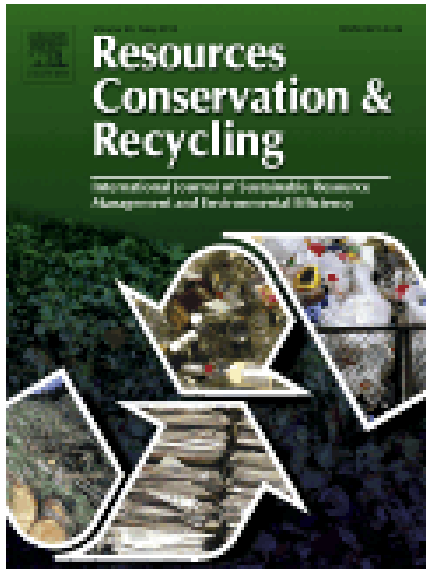
- Census of Agriculture
- Economic Research Service
- Commodity Flow Survey
- USGS
- Utilities
- Literature
- … …

- Excel-based tool
- Online tool

allowing easy data compilation and calculation

Resources, Conservation & Recycling

- Sustainable management and conservation of resources
  - Assessment of resource efficiency and environmental impacts
  - Environmental behavior
  - Resource and waste utilization systems
  - Sustainable supply chain
  - … …



2016 Impact Factor: 3.313

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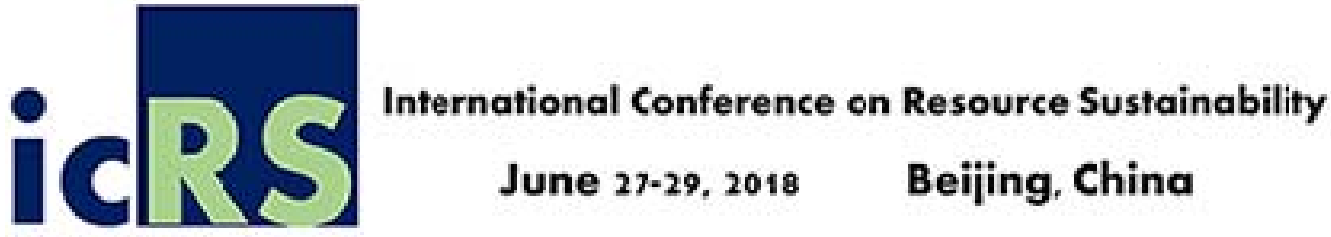
2018 International Conference on Resource Sustainability (icRS 2018)



- http://www.icrsconf.com
- Abstract due on January 15, 2018
- Conference topics:
  - Efficiency and environmental impacts of resource utilization
  - Sustainable supply chain
  - Waste reduction, reuse, recycling and recovery
  - Environmental behavior for sustainable consumption
  - Resource and waste management
  - Circular economy
  - Emissions, effects and management of air pollutants and greenhouse gases