



National Technical University of Athens
School of Civil Engineering

Water-Energy and Food nexus

Methodology of research, questions and databases

G.-Fivos Sargentis and Theano (Any) Iliopoulou

September 2025

The main research goals

1. How water-energy-food nexus works
2. What we need to be functional
3. Can we achieve self-sufficiency?
 - ❑ The diet of inhabitants
 - ❑ The energy needs of inhabitants
 - ❑ The water needs (inhabitants and cultivations)
4. The resources
 - ❑ Cultivations and livestock in order to supply the dietary needs
 - ❑ Land use for cultivations and cultivations for the livestock's feed
 - ❑ Solar, wind, rain, temperature

The main research goals

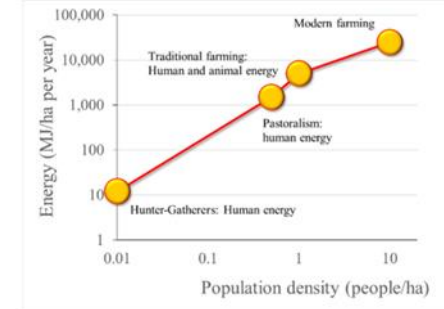
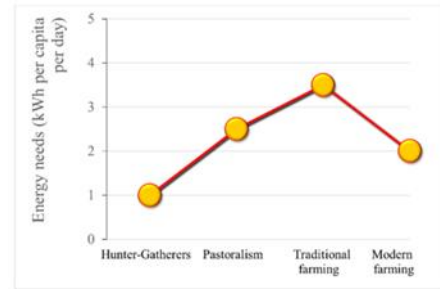
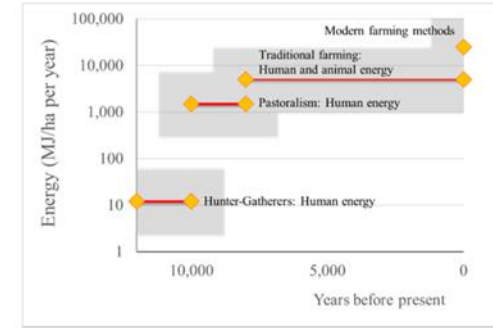
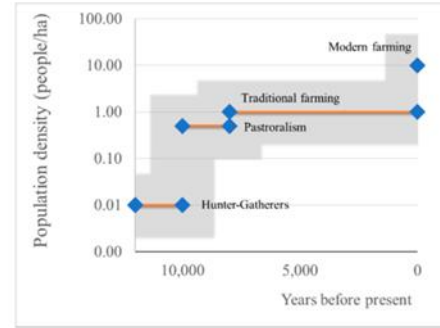
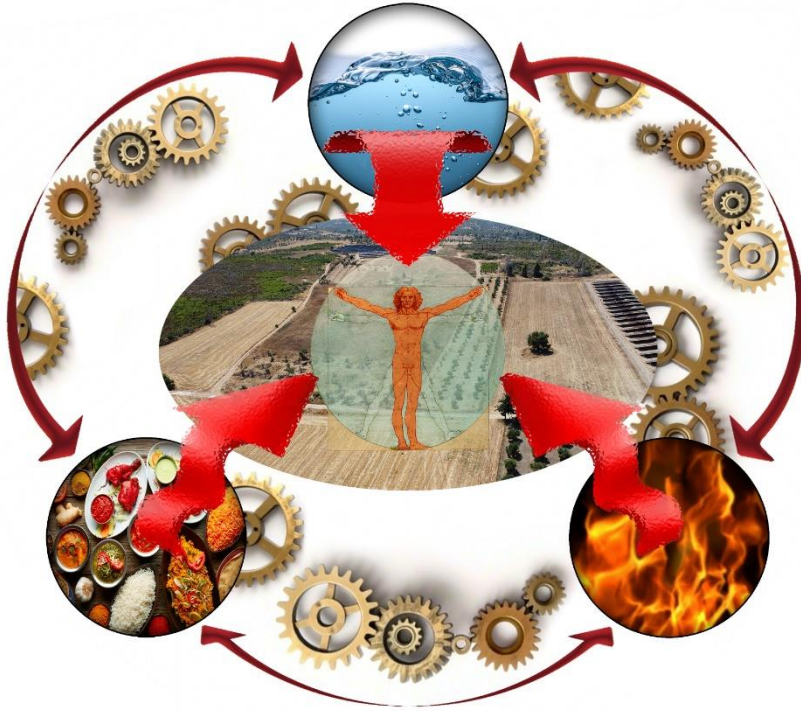
5. Research

- ❑ Which is the embodied energy of a PV panel to be constructed, transferred and installed to the case study area?
- ❑ Which is the embodied energy of a wind turbine to be constructed, transferred and installed to the case study area?
- ❑ Small-autonomous units and technical solutions to create nitrogen fertilizers
- ❑ Small-autonomous units and technical solutions to create biofuels
- ❑ Which is the impact of livestock in water-energy-food nexus?

6. Solve the nexus in different areas of Greece targeting self sufficiency for 1000 people

- ❑ Make a scenario of a typical house of the community
- ❑ Estimate the energy needs for heat (thermal comfort)
- ❑ Estimate the minimum transportation (maybe with electric vehicle) and the related energy needs
- ❑ Estimate the energy needs for agriculture with electrical tractor and machinery or calculate the needed area for the production of biofuels for tractors
- ❑ If you use PV, or wind, you have to calculate batteries or pumping storage energy systems
- ❑ The scenarios will assume
 - a) Minimal needs for survival
 - b) Present needs

The function of Water, Energy and Food nexus

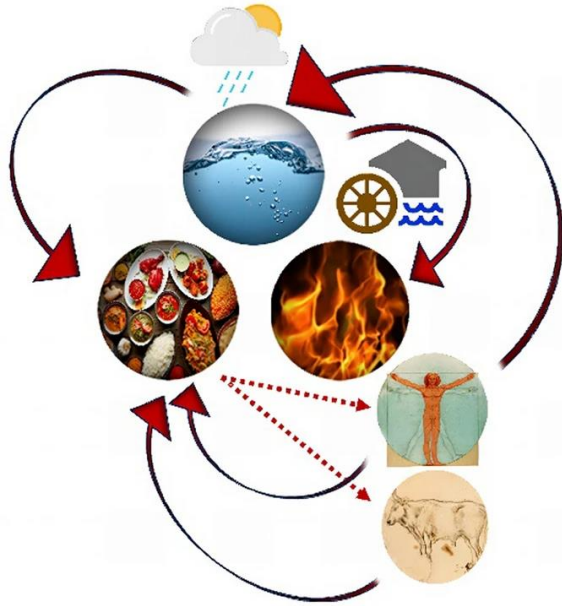


Basic formulas and average values, can be found in the paper:

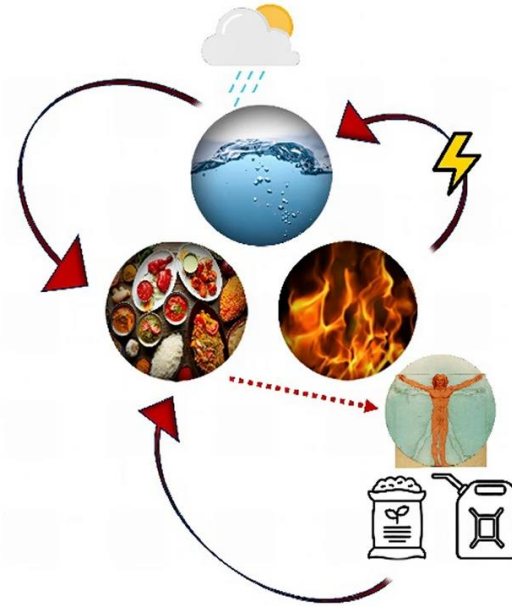
Sargentis, GF., Markantonis, D. Water-energy-food nexus and its stochastic dynamics: case study Greece. Discov Sustain 5, 511 (2024).

<https://doi.org/10.1007/s43621-024-00751-z>

The function of Water, Energy and Food nexus



(a)



(b)

Basic formulas and average values, can be found in the paper:

Sargentis, GF., Markantonis, D. Water-energy-food nexus and its stochastic dynamics: case study Greece. Discov Sustain 5, 511 (2024).

<https://doi.org/10.1007/s43621-024-00751-z>

The main research goals

Data:

Google Earth DEM model (anaglyph), land uses, cultivated land, forests or proposed land uses

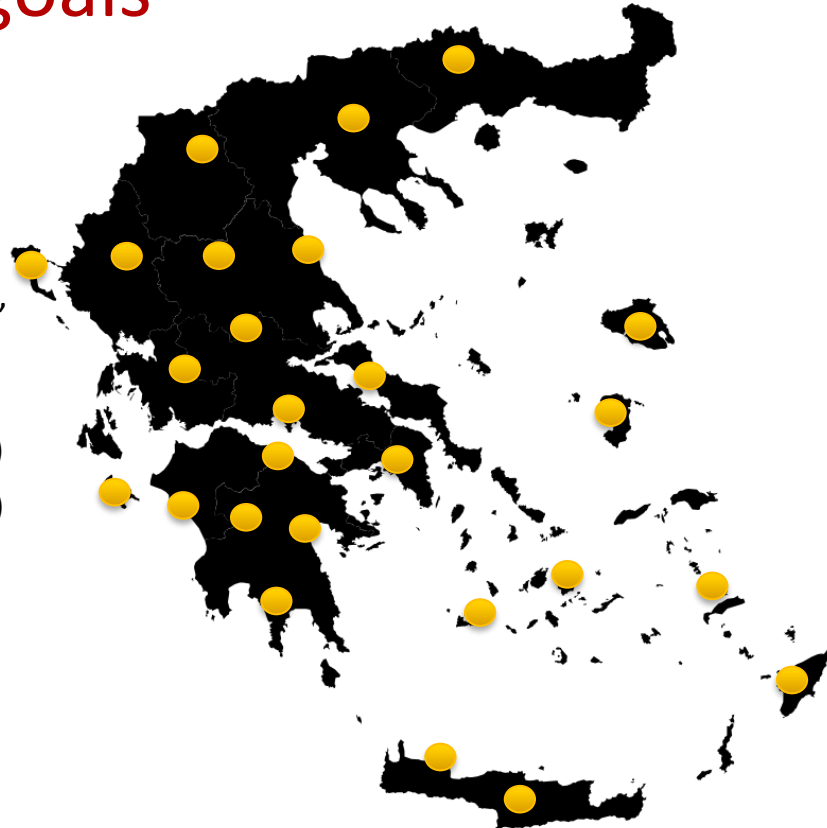
Wind, rain and solar (10 min step)

Water sources (rivers, lakes), water supply (m^3)

Temperature (thermal needs, thermal comfort)

Food resources

- ❑ Cultivation (area, production)
- ❑ Livestock (and cultivation for livestock's feed) (area, production)
- ❑ Fishery

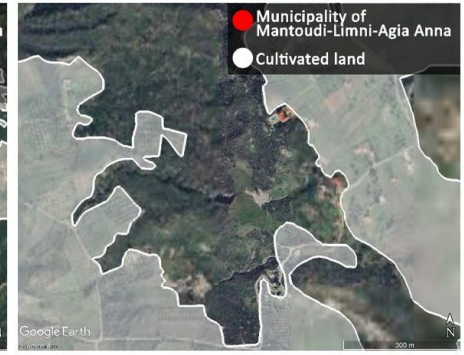


Possible areas for study

Examples of the research in land uses



(a)



(b)



(a)



(b)

Example of the land uses' research, can be found in the paper:

Sargentis GF, Ioannidis R, Dimitriadis P, Malamos N, Lyra O, Kitsou O, Kougkia M, Mamassis N, Koutsoyiannis D. Energy Self-Sufficiency in Rural Areas; Case Study: North Euboea, Greece. Adv Environ Eng Res 2024; 5(4): 025; doi:[10.21926/aeer.2404025](https://doi.org/10.21926/aeer.2404025).

Examples of the quantification of water resources



(a)

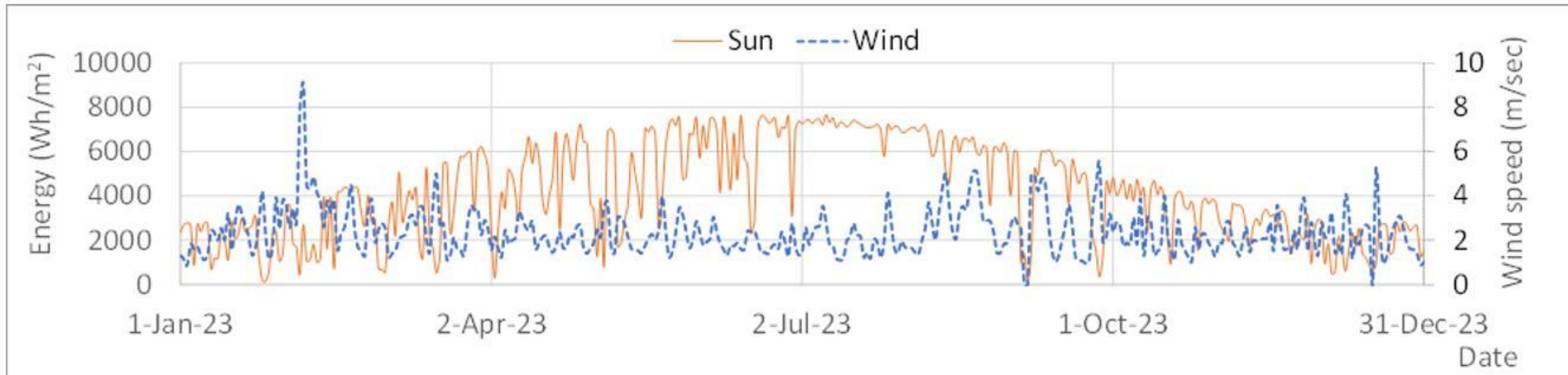


(b)

Example of the water resources' research, can be found in the paper:

Sargentis GF, Ioannidis R, Dimitriadis P, Malamos N, Lyra O, Kitsou O, Kougkia M, Mamassis N, Koutsoyiannis D. Energy Self-Sufficiency in Rural Areas; Case Study: North Euboea, Greece. Adv Environ Eng Res 2024; 5(4): 025; doi:[10.21926/aeer.2404025](https://doi.org/10.21926/aeer.2404025).

Examples of the research in wind and solar



Solar insolation and wind speed (daily average) in the study area in 2023

Example of the wind and solar data research, can be found in the paper:

Sargentis G.-F., Ioannidis R, Dimitriadis P, Malamos N, Lyra O, Kitsou O, Koukia M, Mamassis N, Koutsoyiannis D. Energy Self-Sufficiency in Rural Areas; Case Study: North Euboea, Greece. Adv Environ Eng Res 2024; 5(4): 025; doi:[10.21926/aeer.2404025](https://doi.org/10.21926/aeer.2404025).

Calculations' formulas of energy storage

$$\underline{S}_T = \max(0, \min(K, \underline{S}_{T-1} + \underline{x}_T - \underline{R}_T))$$

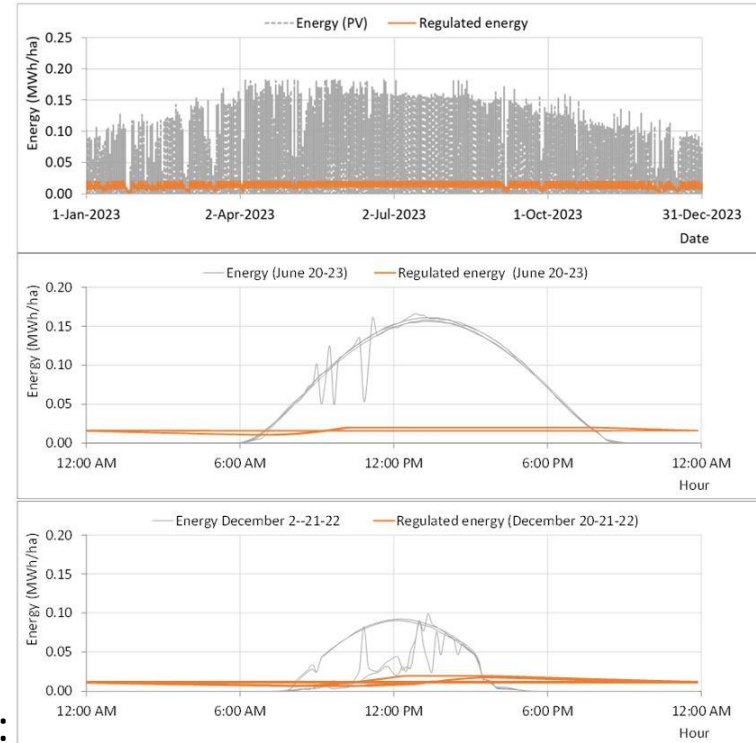
$$\underline{R}_T = a\underline{S}_{T-1}$$

Adaptation with energy needs' profile!

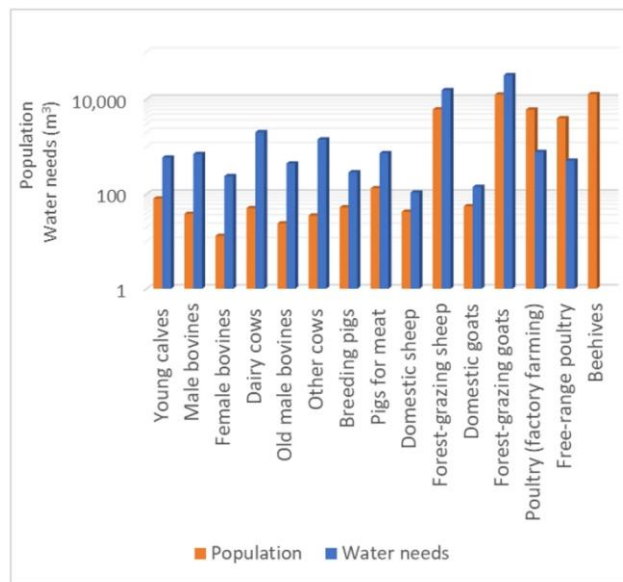
<https://transparency.entsoe.eu/load-domain/r2/totalLoadR2/show?name=&defaultValue=false>

Example of the energy storage, can be found in the paper:

Sargentis G.-F., Ioannidis R, Dimitriadis P, Malamos N, Lyra O, Kitsou O, Kougkia M, Mamassis N, Koutsoyiannis D. Energy Self-Sufficiency in Rural Areas; Case Study: North Euboea, Greece. Adv Environ Eng Res 2024; 5(4): 025; doi:[10.21926/aeer.2404025](https://doi.org/10.21926/aeer.2404025).

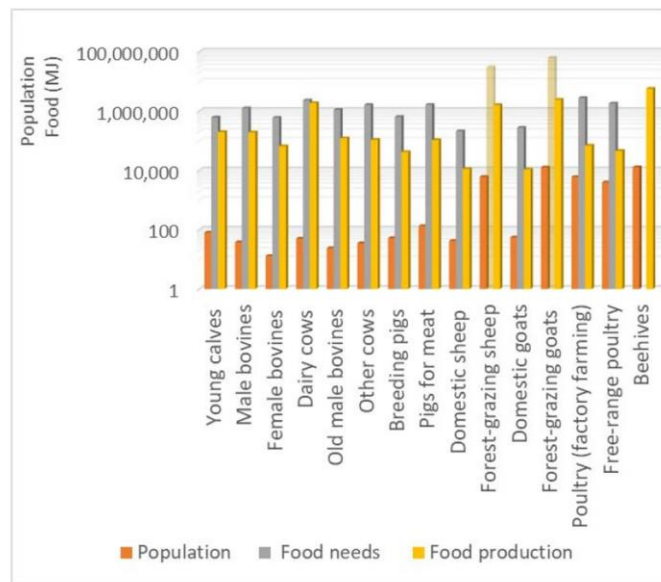


Examples of the research for food resources



(a)

Water needs for livestock



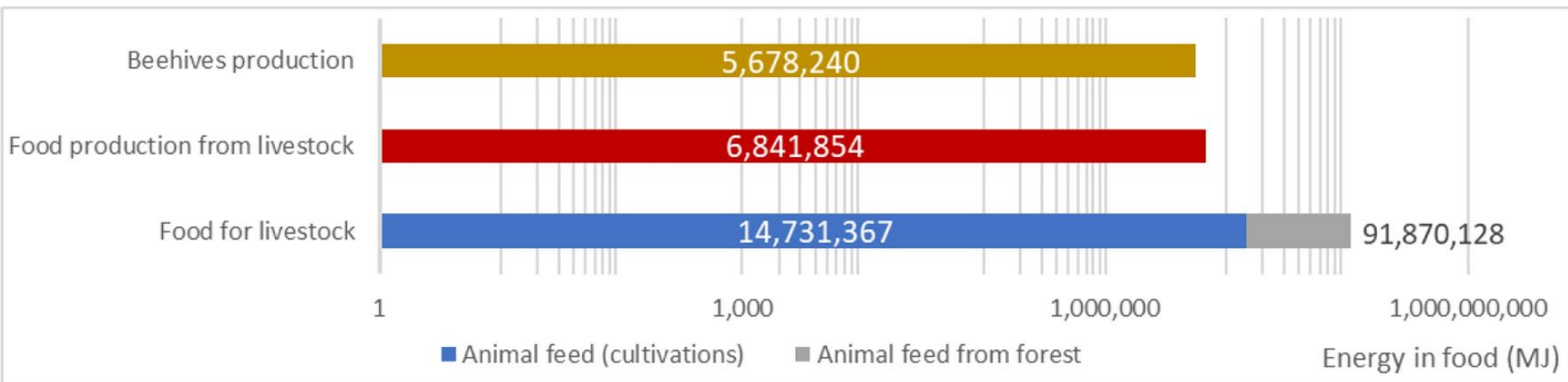
(b)

Food needs for livestock (MJ)

Example of the quantification of food sources, can be found in the paper:

Sargentis, GF., Ioannidis, R. The impacts of altering biodiversity to the Water–Energy–Food nexus: case study North Euboea, Greece. *Discov Water* 4, 105 (2024).
<https://doi.org/10.1007/s43832-024-00165-y>

Examples of the research for food resources



Food production from livestock and food needed for livestock (MJ)

Example of the quantification of food sources, can be found in the paper:

Sargentis, GF., Ioannidis, R. The impacts of altering biodiversity to the Water–Energy–Food nexus: case study North Euboea, Greece. *Discov Water* 4, 105 (2024).
<https://doi.org/10.1007/s43832-024-00165-y>

Related links and library of data

Land uses (forests, cultivated land)

<https://www.google.com/earth/about/versions/>

Temperature, wind, solar, water (rain) (calculations are required with basins of the area)

<https://power.larc.nasa.gov/data-access-viewer/>

https://climexp.knmi.nl/selectfield_obs2.cgi?id=someone@somewhere

Greek Plant Hardiness zones

<https://hardiness.inforest.gr/>

Energy needs profile (for Greece)

<https://transparency.entsoe.eu/load-domain/r2/totalLoadR2/show?name=&defaultValue=false>

Food

Present production: ELSTAT <https://www.statistics.gr/>

Calculations are required according to the dynamics of the land and scenarios of self-sufficiency

Related papers

1. Sargentis G.-F.; Markantonis D. Water-energy-food nexus and its stochastic dynamics: case study Greece. Discover Sustainability, Springer-Nature, 2024, 5, 511. <https://doi.org/10.1007/s43621-024-00751-z>
2. Sargentis G.-F.; Mamassis N.; Koutsoyiannis D. The multifaceted importance of mediterranean pine-tree forests to social cohesion. Energy, resin, grazing, and wildfire management in North Euboea, Greece. Natural Resources Conservation and Research. 2024, 7(2): 9962. <https://doi.org/10.24294/nrcr9962>
3. Sargentis G.-F.; Ioannidis R.; Dimitriadis, P.; Malamos N.; Lyra O.; Kitsou O.; Kougkia M.; Mamassis N.; Koutsoyiannis D. Energy Self-Sufficiency in Rural Areas, Case Study: North Euboea, Greece. Advances in Environmental and Engineering Research, 2024, 2766-6190. <https://doi.org/10.21926/aeer.2404025>
4. Sargentis G.-F.; Ioannidis R. The impacts of altering biodiversity to the Water–Energy–Food nexus: case study North Euboea, Greece. Discover Water, Springer-Nature, 2024, 4, 105. <https://doi.org/10.1007/s43832-024-00165-y>
5. Sargentis G.-F.; Kougkia M. Vulnerabilities of water-energy and food nexus in cities of digital era. Insight - Civil Engineering. 2024, 7(1): 608. <https://doi.org/10.18282/ice.v7i1.608>
6. Sargentis G.-F.; Mamassis N.; Kitsou O.; Koutsoyiannis D. The role of technology in the water–energy–food nexus. A case study: Kerinthos, North Euboea, Greece. Front. Water 6:1343344, 2024. <https://doi.org/10.3389/frwa.2024.1343344>
7. Sargentis, G.-F.; Koutsoyiannis, D. The Function of Money in Water–Energy–Food and Land Nexus. Land 2023, 12, 669. <https://doi.org/10.3390/land12030669>
8. Sargentis, G.-F.; Lagaros, N.D.; Cascella, G.L.; Koutsoyiannis, D. Threats in Water–Energy–Food–Land Nexus by the 2022 Military and Economic Conflict. Land 2022, 11, 1569. <https://doi.org/10.3390/land11091569>
9. Sargentis, G.-F.; Defteraios, P.; Lagaros, N.D.; Mamassis, N. Values and Costs in History: A Case Study on Estimating the Cost of Hadrianic Aqueduct’s Construction. World 2022, 3, 260-286. <https://doi.org/10.3390/world3020014>
10. Sargentis, G.-F.; Siamparina, P.; Sakki, G.-K.; Efstratiadis, A.; Chiotinis, M.; Koutsoyiannis, D. Agricultural Land or Photovoltaic Parks? The Water–Energy–Food Nexus and Land Development Perspectives in the Thessaly Plain, Greece. Sustainability 2021, 13, 8935. <https://doi.org/10.3390/su13168935>
11. Sargentis, G.-F.; Iliopoulou, T.; Dimitriadis, P.; Mamassis, N.; Koutsoyiannis, D. Stratification: An Entropic View of Society’s Structure. World 2021, 2, 153-174. <https://doi.org/10.3390/world2020011>
12. Kirkmalis, G.; Sargentis, G.-F.; Ioannidis, R.; Markantonis, D.; Iliopoulou, T.; Dimitriadis, P.; Mamassis, N.; Koutsoyiannis, D. Fertilizers as batteries and regulators in the global Water-Energy-Food equilibrium, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-11915, <https://doi.org/10.5194/egusphere-egu23-11915>, 2023.
13. N. Mamassis, A. Efstratiadis, P. Dimitriadis, T. Iliopoulou, R. Ioannidis, and D. Koutsoyiannis, Water and Energy, Handbook of Water Resources Management: Discourses, Concepts and Examples, edited by J.J. Bogardi, T. Tingsanchali, K.D.W. Nandalal, J. Gupta, L. Salamé, R.R.P. van Nooijen, A.G. Kolečkina, N. Kumar, and A. Bhaduri, Chapter 20, 617–655, https://link.springer.com/chapter/10.1007/978-3-030-60147-8_20, Springer Nature, Switzerland, 2021.
14. M. Chalakevaki, P. Stamou, S. Karali, V. Daniil, P. Dimitriadis, K. Tzouka, T. Iliopoulou, D. Koutsoyiannis, P. Papanicolaou, and N. Mamassis, Creating the electric energy mix in a non-connected island, Energy Procedia, 125, 425–434, <https://www.sciencedirect.com/science/article/pii/S1876610217335713>, 2017.