

# Introducing Societal Metabolism Analysis via 'MuSIASEM'

A method that allows us to explore and connect the metabolic pattern of different systems

## Overview

Many methods promise to offer insights about aspects of sustainability. The Societal Metabolism Analysis at the heart of the MAGIC project differs from most by offering a way to characterise patterns of consumption and production associated with the metabolic patterns of different systems, thus enabling analysts to look across sectors and scales. This method supports an integrative and holistic perspective that can be used to reflect on the long-term feasibility and viability of existing and alternative social-ecological systems. This helps us better understand – and plan for – Europe's contributions to the interconnected Sustainable Development Goals of UN Agenda 2030. This briefing explains some basic concepts of MuSIASEM, some examples of its application, and gives sources of further information.

## Introducing 'MuSIASEM'

**What is MuSIASEM?** "Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism" is a novel method to better understand how societies use natural and human-created resources, and how these social-ecological systems simultaneously depend on and place pressure on ecosystems. MuSIASEM works across sectoral, functional or geographic scales to identify where assumptions may be invalid, to appraise the openness and interdependence of systems, and identify where one system may place pressures on another.

**Key Concepts: funds and flows** *Funds* are the underpinning components of Social-Ecological Systems, either biophysical (e.g. soils, aquifers) or societal (e.g. available workforce, infrastructure). *Flows* are consumed resources such as freshwater or agrochemicals or produced resources such as crops or consumable products. Flows include also wastes i.e. unwanted by-products. Fund elements require flows of inputs order to maintain themselves and produce flows of outputs. Any social-ecological system can only sustain the consumption and production of flows at certain rates, without its funds becoming exhausted or degraded. For example, high rates of water extraction may deplete an aquifer, whilst requiring a workforce to work very long hours will limit their efficiency or hasten departure. MuSIASEM describes how flows and funds relate to each other, so helping to identify unsustainable use of biophysical or societal resources.

**How is MuSIASEM implemented?** MuSIASEM requires explicit reflection on the grammar of a system, i.e. how its constituent parts relate, plus datasets that allow the flows and funds to be characterised. A strength of MuSIASEM is that it uses existing datasets: though finding, connecting and repurposing them can be very challenging.

### Why use MuSIASEM?

Our planet is the only closed social-ecological system – it is possible to study systems at a smaller geographical or economic scale but to truly understand how they work, you must also understand how they nest within, and draw upon, larger systems. Temporal scales also matter, to understand how resources are allocated across generations and whether environmental funds can be sustained.

A recent review of tools for nexus assessment\* describes MuSIASEM as a macro level integrated approach that spans regional to national levels. The review identifies it within a group that covers the water-energy-food-ecosystem sectors and states the tool is designed to guide an institutional or policy response towards problems in resource management.

\*Dai, Wu, Han, Weinberg, Xie, Wu, Song, Jia, Xue & Yang. 2018. 'Water-Energy Nexus: A Review of Methods and Tools for Macro Assessment'. *Applied Energy* 210 (January): 393–408.  
<https://doi.org/10.1016/j.apenergy.2017.08.243>



## Application of MuSIASEM

The scope of applications of MuSIASEM are broad, as it is an accounting framework, rather than a model. This means its grammar and formalisation can be tailored for many topics of interest, so long as it is appropriate to analyse the interaction between environmental and human systems in terms of funds and flows. Existing examples of its application include horticulture in arid Spanish regions (Fig 1) through to an analysis of options for decarbonising Europe's energy system. Further detail about these and other cases is available from <http://magic-nexus.eu/methodological-case-studies>

Figure 1 on the right illustrates the expected relations of key flows and funds, entailed by the production of a high value crop produced in the Canary Islands using water that was desalinated via wind energy.

The flows and funds from the societal system (e.g. human society and technology) are shown top, and those to and from the biophysical environment are shown at the bottom.

The representation of these flows and funds together is called a 'processor'. The combination of datasets according to this processor can produce multiple metrics to inform discussions of the social, economic and environmental performance of this crop production process.

MuSIASEM allows several processors to be connected in sequential 'metabolic pathways' that show how different systems interconnect and influence each other. For example, in the case of the figure depicted, we could connect this with other processors to show the profile of inputs and outputs of a farm producing multiple crops, or how multiple farm types interact with energy and water providers in an overall agri-food system for a region, country or continent. This can show reliance on flows to and from external systems, indicating the sustainability and security of current arrangements.

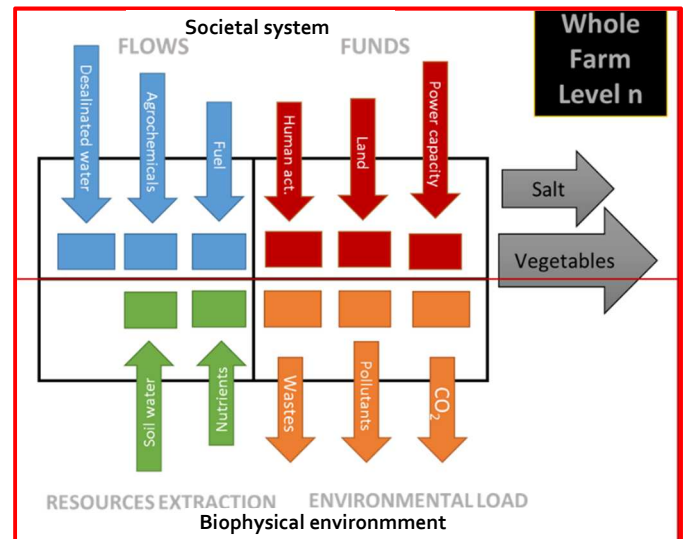


Figure 1 – A 'processor' depicting key flows and funds associated with a high-value crop.

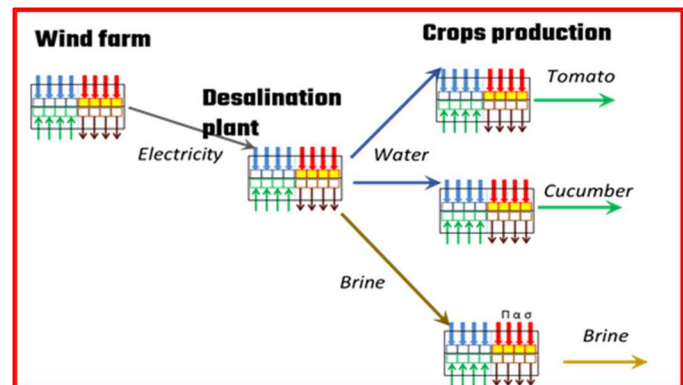


Figure 2 – An illustration of how processors can be connected in sequential pathways

## Key sources for further information

- More examples about the application of MuSIASEM within the MAGIC project are available from the knowledge hub of our website, at <http://magic-nexus.eu/knowledge-hub>
- The key academic paper introducing MuSIASEM is “Giampietro M, Mayumi K (2000). Multiple-Scale Integrated Assessment of Societal Metabolism: Introducing the Approach. Population and the Environment 22.2:109-153 available at <http://link.springer.com/article/10.1023/A:1026691623300>
- Other academic papers demonstrate the application of MuSIASEM to real-life challenges, such as how structural challenges to energy sector differ by Italian regions <http://dx.doi.org/10.1002/eet.1596>
- Of course, you are always very welcome to discuss directly with us: to ask questions or open a conversation please email Mario Giampietro ([Mario.Giampietro@uab.cat](mailto:Mario.Giampietro@uab.cat))