Complex Sustainability Challenges:

The nexus between water, energy and food

Program

SUMMER SCHOOL 8-12 July 2019

Institute of Environmental Science and Technology,
Universitat Autònoma de Barcelona, Bellaterra, Spain

Co-organized by the H2020 project MAGIC and LIPHE4

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WELCOME

The LIPHE4 Summer School is a reference point for researchers and students who are eager to learn about novel approaches for the application of complexity to Sustainability Studies. The Summer School offers a critical picture, both theoretical and practical, of recently developed analytical approaches for sustainability assessments and scenarios. It shows how to integrate quantitative methodologies that analyze and characterize complex social-ecological systems and their evolution with qualitative methodologies that help structure the decision process in a social context. With these purposes in mind, both lectures and hands-on case studies form an integral part of the program.

LIPHE4 has run ten regular open editions of the summer school since 2004, and three special editions on specific request of hosting institutions.

The 2019 edition of the Summer School is co-organized by the Horizon2020 project "*Moving Towards Adaptive Governance in Complexity: Informing Nexus Security*" (MAGIC— https://magic-nexus.eu/). In this edition, we will illustrate the use of MuSIASEM to carry out relational analysis (nexus approach) of the metabolic pattern of social-ecological systems across different dimensions and scales of analysis in relation to the complex sustainability problems dealt with in the Horizon2020 research project MAGIC.

Throughout the program, cross reference is made to selected modules and/or videos of the free MOOC 'Sustainability of Social-Ecological Systems: the Nexus between Water, Energy and Food' (https://www.coursera.org/learn/sustainability-social-ecological-systems). It is recommended, but not essential, to consult these sections of the MOOC, preferably before the course as they provide either background or related relevant information. The activities of the school include lectures, discussions and the working in groups on specific topics selected by the participants.

The summer school resource team is composed of post-doctoral researchers, professors, and PhD students from the Institute of Environmental Science and Technology (ICTA) of the Universitat Autònoma de Barcelona (Spain), all of whom are involved in the H2020 project MAGIC: Mario Giampietro, Juan Cadillo Benalcazar, Louisa Jane Di Felice, Michele Manfroni, Laura Pérez Sánchez, Ansel Renner and Raúl Velasco Fernández.

Mario Giampietro

ICREA Research Professor, ICTA, Universitat Autònoma de Barcelona
Coordinator MAGIC
President LIPHE4

DAY 1 - MONDAY 08 JULY 2019

09:00–09:30 **Welcome**

Mario Giampietro, Universitat Autònoma de Barcelona

Organization of the summer school and presentation of summer school participants and resource persons.

See also the MOOC welcoming video

Facing the challenge of complexity: should we replace scientific evidence with quantitative storytelling?

09:30–11:00 **Responsible use of quantitative analysis in the discussion of sustainability challenges**

Mario Giampietro, Universitat Autònoma de Barcelona

Examples of problematic uses of quantitative analysis in the sustainability debate: ecological footprint, circular economy and energy efficiency assessments.

MOOC REFERENCE: Module 1—Introducing the basic concepts, Videos 7-9.

11:00–11:30 Coffee break

11.30-13:00 **Using "quantitative story-telling" rather than "scientific evidence" to inform policy**

Mario Giampietro, Universitat Autònoma de Barcelona

When dealing with the sustainability of human societies many different concerns/purposes and narratives/beliefs are relevant for different storytellers. To define "optimal solutions", they would have to be considered separately yet simultaneously and then prioritized in an uncontested way. This is evidently a mission impossible. In order to better understand sustainability problems, in this lecture we learn to distinguish between: (i) epistemic boxes; (ii) beliefs in knowledge claims (facts) and endorsed purposes (concerns); and (iii) narrative and story-telling, and show the importance of studying the functioning of anticipatory systems, biosemiotics and the key role of purposes, meanings and beliefs in decision-making. These concepts will be explored through different lenses: (i) the clash of reductionism against the nature of complex adaptive systems; (ii) the political dimension of the semiotic process in social systems; (iii) the (irresponsible) management of expectations raised by the "economics of technological promises".

MOOC REFERENCE: Module 1—Introducing the basic concepts, Videos 2-5.

13:00-14:15 Lunch break

Showcasing applications of MuSIASEM: how to explore the Nexus between water, food, energy, land use and population to check the quality of existing narratives

14.15–15:30 **Applications of MuSIASEM: The case of biofuels in the Netherlands**

UAB Team

A lot of hope (and a lot of money) for a quick transition to a more sustainable future is invested in the production of biofuels. Critical analyses in MAGIC show that many narratives about biofuels are determined either by wishful thinking or personal interests. We provide here a discussion on biofuels based on the analysis of practical concerns.

15:30–15:45 Short break

15:45–17:00 **Applications of MuSIASEM: Comparing the metabolism of EU28 with China**

UAB Team

In this lecture, we critically examine the concept of "energy efficiency" from a metabolic narrative. We use a comparison of the economy of China and Europe to show that the indicator energy efficiency is meaningless, and that it would be more useful to focus on the concept of energy performance instead. To this purpose, we illustrate the factors that determine the difference in energy performance between the two economies. (i) China is still building infrastructure and technical capital (at a furious pace!), whereas Europe only performs maintenance of its existing assets. This implies that China has a much larger industrial sector than the EU. (ii) The demographic structure and workload per worker are different in the two countries; in China almost the double of paid work hours are available per capita per year compared to Europe; (iii) China exports industrial products to the EU, whereas the EU has an economy specialized in services and uses credit leverage and financial revenues to import industrial products without having to produce them.

DAY 2 - TUESDAY 09 JULY 2019

Relational analysis of the metabolic pattern of social-ecological systems across scales and dimensions

09:00–10:00 **Metabolic approaches to assess the sustainability of social-ecological systems**

UAB Team

In this session, we examine how the metabolic pattern of socio-ecological systems can be studied. Basic concepts introduced include relational analysis and hierarchy theory (four Aristotelian causes; holons and holarchies) and the foundations of metabolic analysis (state-pressure analysis, Georgescu-Roegen's flow-fund analysis). We also introduce the conceptual tool of *the processor* to study the water, energy, food and land use nexus. Finally, we will see how these concepts and tools tie together to address key aspects of sustainability through the characterization of: (i) feasibility – compatibility with processes outside human control; (ii) viability – compatibility with processes under human control; (iii) desirability – compatibility with normative values and institutions.

10:00–11:00 **The feasibility, viability and desirability of the metabolic pattern of social-ecological systems across scales and dimensions**

UAB Team

How can we effectively integrate non-reducible quantitative analyses based on observations (data sources) that describe observables on non-equivalent descriptive domains? How can the epistemological challenge of multi-scale analysis be handled? In this session, we explain how to address these issues through three levels of analysis, the macroscope, mesoscope and microscope, associated respectively with the desirability, viability and feasibility of the metabolic pattern. This integration allows the use of another analytical tool - the *Virtualscope* – to assess the level of openness of the system and the implications of externalization.

11.00–11:30 Coffee break

11:30–13:00 **The nature of the bio-economic pressure: Desirability and time allocation**

UAB Team

LECTURE: This lecture explains the relation between the societal profile of time use and the End-use Matrix affecting the viability of the metabolic pattern. The construction of the grammars for human time allocation is illustrated, and the implications of demographic variables and a 'desirable' standard of living (services) are discussed.

EXERCISE IN CLASS: Explore the impredicative relation over the sizes of the functional sectors of a society competing for the same endowment of human activity: (i) the postal service in a society; (ii) the food production on a remote island; (iii) the bio-economic pressure in modern society.

MOOC REFERENCE: Module 6—The metabolic pattern of social-ecological systems across multiple scales and dimensions; Videos 1-3, 7-8

13:00–14:15 Lunch break

14:15–15:15 **The analysis of the bio-economic pressure: The end-use matrix in MuSIASEM**

UAB Team

LECTURE: An important feature of MuSIASEM is the possibility to establish relations over the quantitative and qualitative characteristics of sectors and subsectors of the economy across different levels of organization. This can be obtained by organizing the quantitative information about *end uses* - observed across different levels of analysis and across different dimensions of analysis – into an *end use matrix*. This analysis points to a problem in the way data are organized in common statistics: the categories of accounting in available statistics tend to aggregate characteristics referring to heterogeneous activities and, as a consequence, it becomes hard, if not impossible, to track "who is using what type of flows, why, how, and how much". This issue must be addressed if we want to have an informed discussion about a quick transition of the economy towards sustainability.

EXERCISE IN CLASS: Applications of the End-use Matrix to different levels of organization: city, country, economic sector and sub-sector, EU level.

15:15–16:15 **The effects of the bio-economic pressure: Environmental Pressure Matrix in MuSIASEM**

UAB Team

LECTURE: The Environmental Pressure Matrix (EPM) tracks the primary sources (e.g. fossil reserves, requirement of solar radiation, aquifers) and the primary sinks (e.g. both the global and the local atmosphere, the soil, the aquifer) associated with the secondary flows metabolized in the End-Use Matrix. To achieve this result, it uses the information available on the lower side of the processors (the profile of inputs and outputs coming from and going to the biosphere) used to describe the structural elements operating in the functional elements of the economy. Depending on the primary sources and the primary sinks associated with the metabolized flows the EPM can identify the ecological fund elements providing the required supply capacity and sink capacity and characterize the pressure they have to sustain.

EXERCISE IN CLASS: Examples of calculation of Environmental Pressure Matrix from a given End-use Matrix.

MOOC REFERENCE: Module 6, Video 9—Studying feasibility using the concepts of DPSIR and Environmental Impact Matrix

16.15–16:30 Short break

The ecological analysis of impact due to the metabolic pressure

16:30–17:30 **From pressure to impact – comparing the metabolized flows with the metabolic characteristics of ecological funds**

UAB Team

LECTURE: This lecture illustrates the difference between the Environmental Pressure Matrix and the Environmental Impact Matrix. Whereas the Environmental Pressure Matrix tracks the primary sources and the primary sinks associated with the secondary flows metabolized in the End-use Matrix, the Environmental Impact Matrix contextualizes the pressure against the characteristics of the ecological funds providing supply and sink capacity. What are the thresholds of pressure that generate impact?

EXERCISE IN CLASS: Examples of calculation of Environmental Pressure Matrix from a given End-use Matrix. Identification of the information required to assess the environmental impact starting from the information in an Environmental Pressure Matrix.

DAY 3 - WEDNESDAY 10 JULY 2019

The effect of the global market

09.00–10:00 **Addressing the complication associated with trade: Externalization in MuSIASEM**

UAB Team

LECTURE: During this lecture, we show that the energy sector, the food sector and the manufacturing sector of modern societies are heavily dependent on imports. The level of openness of an economy can be assessed by calculating: (i) an Externalization End-use Matrix; and (ii) an Externalization Environmental Pressure Matrix. These externalization matrices can then be compared with the Local End-use Matrix and the Local Environmental Pressure Matrix to assess how much a given social-ecological system can 'improve' its metabolic state by transferring its own problems of viability and feasibility to other social-ecological systems (externalization).

EXERCISE IN CLASS: Calculation of Externalization End-use Matrices and Externalization Pressure Matrices for EU countries and assessment of the level of openness; Discussion of the implications of externalization in relation to security/sovereignty and self-sufficiency.

REFERENCE: MAGIC deliverable 4.2, chapters 2-3.

10:00–11:00 **The sudoku effect across and within societies**

UAB Team

LECTURE: Modern societies face a set of constraints for the allocation of available resources: vertical, between societal functions expressed at different levels of the holons, and horizontal, between different societal functions expressed at the same levels. Energy, human time, power capacity and other biophysical flows (material products) available to the whole represent a set of finite resources to be shared by the internal constituent components. Their allocation among societal functions relate unambiguously with the metabolic pattern the society expresses, creating the sudoku effect, since different compartments are competing for consuming the same resources at given rates. We show how the sudoku effect works by integrating data related to diverse factors, such as energy,

food, water, time and space use, and demographic aspects across different levels of analysis – e.g. country level, city level for a given system.

EXERCISE IN CLASS – Exploring the viability domain of the metabolic pattern of a country under different scenarios of allocation of human activity and studying how the terms of trade do affect the option space of two countries exchanging goods and services.

11.00-11.30 Coffee break

Relational analysis of social practices – a sustainability transition is not (only) about generating technical innovations, but about adopting new social practices

11:30–13:00 **Efficiency and social practices**
UAB Team

LECTURE: Currently, technical efficiency indicators play a major part in sustainability policy. However, these indicators cannot handle the complexity of activities of modern societies, which are integrated and organized across different levels and scales. Moreover, they miss social and economic aspects. Sustainability issues require a capacity of handling information beyond the reach of reductionism typical of conventional scientific disciplines. While lip services are paid to this statement, we continue to observe that scientific evidence used to inform current sustainability policies lacks an adequate semantic and quantitative integration across governance silos: transdisciplinarity. In this lecture we will explore how to move from a definition of "energy efficiency" of a technology (a more efficient refrigerator can become bigger in time: Jevons paradox) to the "energy efficiency" of a function (e.g. commuting, that can be improved by providing the same service while sharing technologies). We will apply this new approach to the characterization of households facing a set of constrains in relation to the allocating energy, time, power capacity and other resources.

EXERCISE IN CLASS – exploring the viability domain of the metabolic pattern of a household under different scenarios of allocation of human activity determined by the income, location and by the chosen social practices.

13:00–14:00 Lunch break

14:00–15:30 **Working groups - Exploring specific research questions**

15:30–15:45 Short break

15:45–17:30 **Working groups - Exploring specific research questions**

20:00 Social Dinner

DAY 4 - THURSDAY 11 JULY 2019

The plausibility of current stories about sustainability transitions

09.00–11:00 **Concerns about the sustainability transition in the energy sector**

UAB team

LECTURES: During this lecture we will explore key concerns that arise when designing a quick energy transition to renewables in the EU context from a metabolic approach: (i) Why are not all kWhs of electricity the same (the difference between peakers, baseloaders and intermittent sources)? ; How much can the supply of intermittent sources in the grid be scaled up? ; (ii) Can we rely on technological solutions, such as electric cars, to solve our problems of transport and mobility or should we rather try to change transport patterns? ; (iii) Is it feasible and viable to decarbonize our energy system by 2050? Is it reasonable to imagine that we can build a totally different energy matrix (both in production and consumption) in 25 years – using still fossil energy – while at the same time reducing emissions?

DISCUSSION

11.00–11.30 Coffee break

11.30–13:00 **Concerns about the sustainability transition in the food system**

UAB team

LECTURES: During this lecture, we will examine (worrisome) trends in the use of technical inputs for producing food and the resulting consequences on the environment. We will show the lack of encouraging signs of discontinuity: In the year 2015 we still produced the bulk of our food as we used to produce it in 1995, relying heavily on fossil energy inputs (monoculture and high external input agriculture), and the environmental impact keeps growing. The only difference is that EU countries learned how to externalize the production of crops for feed in animal production and for processing and re-exportation by agribusinesses. How dangerous is this strategy for the environment and our rural areas, and what about EU food security in 2050? What if in 2050 an increased world food demand (it may increase by 60%!) would make the option of cheap food and feed commodity imports no longer viable for Europe? We illustrate an application of the MAGIC tool-kit to study the actual level of dependency on imports (diagnostic mode) and the severe biophysical limits to an internalization of food production (anticipation mode) in Europe.

DISCUSSION

13:00–14:00 Lunch break

14:00–15:30 **Working groups - Exploring specific research questions**

15:30–15:45 Short break

15:45–17:30 **Working groups - Exploring specific research questions**

DAY 5 - FRIDAY 12 JULY 2019

09.00–11.00 **Presentation of the results of working groups and discussion**

11.00–11.30 Coffee break

11.30–12:30 **Presentation of the results of working groups and discussion**

12.30-13.00 **Roadmap for future research and the following summer school**

13.00-13.30 **Evaluation of the summer school**

13:30 Farewell